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Abstract

This is the first empirical paper investigating a comprehensive sample of *listed* (i.e. publicly traded) private equity companies, covering 287 companies in the time period 1986 to 2003. After imposing liquidity constraints, and after correcting for non-surviving vehicles, we get a sample of 114 instruments. The risk and return characteristics of three portfolio strategies, two partially rebalanced and one fully rebalanced, are compared. We moreover address potential biases resulting from thin trading, the bid-ask spread, and sample selection. We show that the adjusted performance figures differ substantially from standard estimates. But even after correcting for these biases, we find a high risk-adjusted performance of this asset class before 2000, and dramatic different results between the three indices if we extend the time period to 2003.

Keywords: Listed private equity, Private equity, Performance biases

JEL classification code: G24

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[e] An earlier draft of this paper was presented at the SwissRe Private Equity Conference in Rüschlikon, September 2003. An updated version was also presented at a seminar of the Abu Dhabi Investment Authority, in Abu Dhabi, March 2004. Some first results of the study got attention by the following newspapers: TagesAnzeiger, 10th October 2003; Real Deals, 6th November 2003; Börsen-Zeitung, 17th February 2004; FAZ.NET (Frankfurter Allgemeine Zeitung Online), 2nd April 2004; and Neue Zürcher Zeitung, 8th April 2004. We would like to thank David Rey, Markus Schmid, and Christian Zenkner for valuable comments. Financial support from the Ecoscientia Stiftung is gratefully acknowledged. Please do not refer to statements or figures in this paper without *full* citation.

1. Introduction

Private Equity has become an important asset category in recent years. However, as with other alternative investments, the determination of reliable risk and return characteristics is complicated by several specific investment characteristics: Typically no market prices are available or the liquidity of the instruments is very limited rendering conventional risk measures virtually meaningless. Moreover, Cochrane (2005) shows that commonly computed venture capital performance measures are affected by a strong selection bias. This paper addresses some of these topics from a somewhat different perspective. Our contribution is threefold:

- We investigate a sample of *listed* (i.e. publicly traded) private equity (LPE) companies where market prices are available, and where we are able to impose certain minimum liquidity constraints;
- In contrast to other studies on alternative investments, we demonstrate the difficulties and biases in computing basic *portfolio* returns: rebalancing is a particularly important issue in this asset class due to the heterogeneity of the individual vehicles in terms of market capitalization, share price performance, and liquidity;
- We moreover correct for these biases and compute adjusted estimates of risk and return by investigating two liquidity biases: the volatility bias related to the autocorrelation structure of portfolio returns, and the bid-ask bias related to rebalancing.

We analyze the risk and return of a comprehensive sample of *listed* private equity vehicles which constitute an attractive and rapidly growing segment within the overall private equity market. From a practical perspective, this market segment is a particularly important and viable asset class for institutional investors, who are mostly restricted to invest in non-traded financial vehicles. Even though the vehicles in our sample may not necessarily be representative for the

private equity market as a whole, private equity investors accept indices (such as the LPX, the listed private equity index) of traded instruments as a benchmark for their performance Obviously, the advantage of this market segment is the availability of market prices which enables more reliable performance measures. Since private equity is by definition a business area that deals with investments in non-listed companies, we were surprised to identify a total of 287 private equity vehicles listed on worldwide stock exchanges. We were thus able to construct representative portfolios which can be used to study the risk and return characteristics of this asset class, and which potentially serve as valid benchmarks for comparisons with traditional investments. There are several papers on risk and return characteristics of *non-quoted* private equity[1], but only a few studies on the risk and return characteristics of listed private equity companies. They moreover date back to the 1980s. Martin/Petty (1983) identify 37 venture capital firms during 1970 and 1980, but only 17 have price data available from 1974-1979. Another six companies are not analyzed due to inactive trading. Their sample finally includes

[1] *Bygrave and Timmons* (1992) study the performance of venture capital funds for 1974-1989. They calculate an internal rate of return of these funds of 13.5% without providing any risk calculations. *Gompers and Lerner* (1997a) examine the investments of one venture capital firm for 1972-1997 and report an arithmetic average annual return of 30.5%. Long (1999) studies nine VC investments and comes up with a standard deviation of 8.23% per year. *Moskowitz/Jorgensen* (2002) report that the risk and return trade-off to private equity is worse than to public equity. They conclude that non-pecuniary benefits, a preference for skewness, or overestimates of the probability of survival could potentially explain an investment in private equity. *Ljungqvist and Richardson* (2003) base their calculations on actual cash flows of venture capital and buyout funds. They find an internal rate of return of 19.8% and state that this excess return compensates the investor for holding an illiquid investment for a certain time period. *Cochrane* (2004) measures the mean, standard deviation, alpha and beta of venture capital investments for 1987 to 2000 after correction for selection bias. He finds a mean log return of about 15% and an arithmetic average return of 59%. *Peng* (2001) using the same database as Cochrane reports a geometric average return for 1987 to 1999 of 55.18%. However Peng does not correct for selection bias.

only eleven companies, and the authors do not investigate portfolio strategies. Brophy/Guthner (1988) provide estimates of risk and return and compute beta relative to the S&P500 index for twelve funds using weekly data from 1981 to 1985. They compute returns of different portfolios and conclude that they achieve superior returns compared to the S&P500 and to growth-oriented mutual funds. But none of these studies investigates the risk and return characteristics or the investment behavior of LPE for a larger sample size and for a longer time period. Also the impact of the "down market" after 2000 has not been subject of any study. One major contribution of this paper is to investigate the risk and return characteristics of various *portfolio* strategies, which is of special relevance due to the weighting and rebalancing issue. In this context we investigate three potential biases in computed risk and return figures, caused by thin trading, the bid-ask spread, and sample selection/survivorship. The nature of these biases is not new in the academic literature, but their impact for private equity returns is very important to recognize, as will be shown.

The structure of the paper is as follows: In Section 2, we provide a detailed description of our database which covers the most complete sample of LPE vehicles analyzed in the literature so far. This Section also contains our definition and selection criteria for LPE which is consistently used throughout the sample period from 1986 to 2003. At the end of this Section, we define and evaluate several minimum liquidity conditions that reduce the basic sample of 287 vehicles to a restricted portfolio of 122 liquid instruments. In Section 3 we investigate basic risk and return characteristics of three different portfolio strategies (indices) applied to the restricted sample. In Section 4 we discuss the three potential biases in computed risk and return figures. Section 5 concludes the paper.

2. Database and sample construction

In this paper, instruments are classified as LPE if the underlying business is PE investing, but the funds themselves are quoted on an exchange. Companies which only partly invest in private equity, e.g. investment banks, holding companies, venture capital pools and the likes are excluded. The respective instruments fall into three categories:

- listed companies whose core business is private equity (e.g. 3i),
- quoted investment funds, which invest a predetermined proportional equity share to specific private firms together with the company's private funds (i.e. Schroder Ventures Trust),
- specially structured investment vehicles which invest in private equity directly (e.g. investing into private companies), and/or indirectly through various private funds. (i.e. Castle Private Equity).

The underlying private equity investments of these instruments include all kinds of financing stages and styles. Portfolio companies of these vehicles receive financing in the early, later and expansion stage, but also buyouts and turnaround situations are financed. Based on this definition, we find a total of 287 listed companies between 1986 and 2003. At the beginning of the sample period, only eight companies were listed, which shows the dramatic growth in this market segment. From the 287 instruments, only 237 match our definition over the whole observation period. The remaining 50 vehicles were either acquired, delisted from the exchange, or changed their businesses.

The temporal behavior of the number of listings is displayed in **Table 1**. Most vehicles (i.e. 173 of the 287) have been listed over the past six years only, many of which concentrating on the financing of young technology firms. In contrast, only five were listed in 1973. In the late

eighties, there was a wave of listings (35), mainly in Europe, concentrating on management buyouts. With respect to the regional characteristics of the vehicles, over 50% are listed in Europe, most of them in the UK (113) where Investment Trusts and Venture Capital Trusts are widely spread because of tax alleviation. Almost 30% are listed in North America and more than 10% in Asia. In terms of (average) market capitalization 38.23% of the overall market value is quoted in Europe and 24.90% in North America. The median of only $22 million shows that most companies have a rather small market capitalization.

As with other alternative investments, a major practical restriction of LPE investments is illiquidity. We define a set of minimum liquidity conditions in order to assess the risk and return characteristics of LPE and to compare them with traditional stock market investments. However, unlike with other alternative investments, the availability of market information makes it possible to compute various liquidity measures. Specifically, our selection process is based on the following criteria:

1. We require a minimum of 30 weekly price observations in order to ensure accuracy of parameter estimates.

2. The vehicles must have a minimum average market capitalization of $2 million.

3. To assure a minimal trading activity, we impose a minimum average trading volume of 0.1% per week[2]; the (relative) trading volume is defined by the ratio of the trading volume multiplied by the price, and the market value of the vehicle.

[2] Compared to the relative trading volume of 2.1% per week of AIM companies in the first 6 months of 1996 which was analyzed by Board/Vila/Wells (1998).

4. Minimum trade continuity must be satisfied. This is measured by the percentage of weeks (here, 15%) within which at least one transaction occurs.[3]

5. Finally, we require a maximum average bid-ask spread of 20%, which is defined relative to the arithmetic average of the bid and ask quotes.

Based on these constraints, 165 or 57% of the vehicles are excluded from the original sample resulting in a total of 122 instruments. It is apparent that illiquidity is a serious issue even in the segment of listed private equity investments. The impact of the most sensitive liquidity constraint, the bid-ask spread, is documented in **Table 2.** A total of 62 vehicles which fulfill four out of five liquidity constraints are eliminated solely due to an average bid-ask spread of more than 20%.

From the 122 companies satisfying our constraints, eight have been liquidated, changed their businesses, or have been acquired by another company over the sample period. Therefore, the empirical analysis of Sections 3 and 4 will be based on 114 companies.

[3] Board/Vila/Wells (1998) find that in the first 6 months of 1996 AIM companies were traded on 52% of all days, on average.

3. Basic risk and return characteristics of LPE portfolios

In this Section, we investigate the risk and return characteristics of portfolios, or indices, constructed from the 114 vehicles included in our liquid sample. There are several topics to be addressed in this context: First, as shown in Section 2, the number of listings steadily increases over the sample period (starting from just eight observations in 1986). In order to analyze portfolio returns over the whole observation period, the portfolio must be *rebalanced* whenever new listings take place. Second, the sample is extremely heterogeneous with respect to the *market capitalization* of the individual firms. Also, the evolution of capitalization over time (i.e. the performance of the companies) is very heterogeneous, including the whole range from high-fliers to flops. Third, although we have imposed minimum liquidity requirements as a selection criterion, the typical instrument in our sample is less liquid than a "traditional" stock. This fact substantially affects the measurement of performance; this issue is separately addressed in Section 4. We investigate three different portfolio strategies, or indices, in order to capture the first two topics adequately:

- *A value weighted portfolio, buy-and-hold (partially rebalanced): VW-BH*

  The weights are determined by the relative market capitalization of the individual instruments. This basically represents an unbalanced strategy, except if a new listing occurs: capital is taken out of the existing vehicles and reinvested in the new portfolio constituent. A characteristic of the portfolio is that market capitalization varies considerably over time, and across different vehicles. The portfolio naturally allocates excessive weight to only a few companies, which is regarded as a disadvantage by many investors.

- *An equally weighted portfolio, fully rebalanced: EW-RB*

  An equal fraction of wealth is allocated to the individual instruments. In order to maintain constant equal weighting over time, the portfolio is rebalanced on a weekly basis.

- *An equally weighted portfolio, buy-and-hold (partially rebalanced): EW-BH*

  The portfolio constituents are equally weighted at the beginning of our observation period (1986), without weekly rebalancing, except when new vehicles are listed.

The risk and return statistics such as means, standard deviations, Sharpe ratios, alphas, betas, and autocorrelation coefficients are displayed in **Table 3a**. All figures refer to continuously compounded rates of return. It is apparent that the volatility of the (partially rebalanced) VW-BH portfolio is more than twice as large as for the (fully rebalanced) EW-RB index, and is still substantially larger than the (partially rebalanced) EW-BH portfolio. This can be explained by the inferior diversification of the value weighted strategy. In fact, 79.39% of the average market capitalization of the 114 vehicles in the VW-BH index is represented by only ten vehicles, while the 72 smallest instruments account for only 5% of the market cap. The diversification effect of the rebalancing strategy is also reflected in a higher beta of the VW-BH index (which computed with respect to the MSCI World index). It is thus questionable whether a value-weighted portfolio, or index, is regarded as a valuable benchmark by investors seeking diversification in this asset class.

Over the whole observation period from 1986 to 2003, the average annual return is clearly highest for the (fully rebalanced) EW-RB portfolio (15.99%), compared to the average returns of the other two strategies (5.43% and 5.91, respectively). These figures show the dramatic impact of rebalancing in this market segment. Splitting the sample in two subperiods (the first representing the boom market up to the year 2000, the second representing the down market after

March 2000), reveals the dramatic downturn of the private equity market, but again, confirms the substantial benefit from rebalancing. The loss represented by the weekly rebalanced EW-RB portfolio (-35.39%) is substantially smaller than for the equally weighted buy-and-hold portfolio (-58.39%) or the value weighted buy-and-hold portfolio (–68.93%)[4].

Adjusting for risk basically confirms these findings. The Sharpe ratio of the EW-RB portfolio is 1.19 for the time period 1986 to 2000 and clearly exceeds the ratio found for the MSCI World index (0.47). The Sharpe ratios of the other two portfolios are virtually zero. Jensen's alpha for the time period 1986 to 2003 is 10.18% for the EW-RB portfolio, essentially zero for the EW-BH portfolio, and even negative (–1.20%) for the VW-BH index. The MSCI World index is again used as the benchmark portfolio. The R^2-coefficients of the underlying regression are rather small. This shows that private equity exhibits a large, specific and thus, diversifiable variance component with respect to standard equity investments. This is also reflected in the beta coefficients, which are, for the EW-RB and EW-BH portfolio returns, significantly below one (0.60 and 0.70, respectively). One is tempted to conclude that LPE is not exposed to so much risk as generally assumed.[5]

Table 3b finally displays the autocorrelation structure of the portfolio returns. Interestingly, the EW-RB portfolio exhibits statistically significant positive serial correlations up

[4] See e.g. Bernstein/ Wilkinson (1997) for a more detailed characterization of the rebalancing bonus.

[5] Risk of private equity investments is often stated as rather high: See French (1988). Yet, measuring risk with the volatility of private equity is very problematic when estimated from private investments because accounting data does not reveal the relevant risk exposure. Therefore, volatility of private equity is usually underestimated in *the generally understood* sense. Estimations of risk from listed equity give us a better indicator for the real risk exposure. However, volatility from observed market prices still does not account for the whole risk exposure. Compared to the highly liquid stock market indices our LPE index is rather illiquid. This issue is discussed in section 4.

to five lags, which is the consequence of a thin trading effect due to the relatively large weights of small firms in equally weighted indices. Consistent with this interpretation, the value weighted portfolio (VW-BH) exhibits much less serial correlation. The bias induced by serial correlation for estimating return volatility will be discussed in Section 4. Finally, it is not surprising that the results of the two buy-and-hold portfolios (EW-BH and VW-BH) are rather similar, despite their different weighting scheme: This is due to the fact that over time, the weighting of the buy-and-hold strategy converges to the value-weighted equity mix.[6] Therefore, some of the shortcomings of the VW-BH portfolio also apply to the equally weighted counterpart. This is especially true in the period after 2000, when only a few new listings are observed.

4. Performance biases

4.1 Limited liquidity, and the volatility bias

Although we have already imposed several liquidity constraints on our original sample, the limited liquidity of many instruments is still a serious problem in our sample. The serial correlation of portfolio returns can be used as a statistical measure for this problem; this is shown by Getmansky/ Lo/ Makarov (2003) for a sample of hedge funds. The authors also demonstrate that the estimated volatility of portfolios containing illiquid securities is lower than the true volatility. It is shown in **Table 3b** that the equally weighted portfolio returns reveal strong autocorrelation: For the EW-RB portfolio, we find statistically significant positive autocorrelations at the first five lags, and the EW-BH portfolio exhibits significant positive

[6] See Roll (1983).

autocorrelations at the second, fourth and fifth lag.[7] The Ljung-Box Q-statistic clearly rejects the null hypothesis of zero autocorrelation for the first five lags. In contrast, there is no significant autocorrelation in the weekly returns of the MSCI World index. There is a vast body of literature on autocorrelation patterns in stock returns. For *weekly* returns, Campbell/Lo/MacKinlay (1997) report statistically significant first-order autocorrelation for the CRSP equally-weighted index of 0.203 from July 1962 to December 1994.

Positive autocorrelation in returns leads to a downward bias in estimated risk parameters. A formula to adjust for this bias is suggested by Hamilton (1994).[8] **Table 4a** shows the adjusted variance estimates, as well as the adjusted Sharpe ratios, betas[9] and alphas, as compared to the standard measures. The adjusted risk estimates are considerably higher for both portfolios: the standard deviation for the full 1986-2003 period is 33.69% (37.09%) instead of 19.34% (26.93%) for the EW-RB (EW-BH) portfolio. The respective beta coefficient is 0.99 (1.09) instead of 0.57

[7] We only measure the *linear* dependence of concurrent returns on lagged returns. For the first and third week, we do not find statistical significance for linear dependence of concurrent returns which does not exclude any non-linear dependence.

[8] See Hamilton (1994), p.188. A problem arises since it is not possible to set K=infinite since the number of observations is limited. French/Schwert/Stambaugh (1987), for example, set K=1. They argue that in the case of non-synchronous trading, daily returns are autocorrelated particularly at lag one. For weekly returns, Lo/McKinlay (1990) report (small) positive autocorrelation at lags two to twelve, but negative autocorrelation (mean-reversion) for measurement intervals over one quarter. This leads to the difficulty of identifying the appropriate number of lags. Including too many lags could lead to excessive noise in the estimated variances. We somehow arbitrarily choose K=20.

[9] We run the regression of LPE portfolio returns against three lagged, matching and three leading returns. See Dimson (1979).

(0.47). The adjusted Sharpe ratio is 0.33 (0.03) instead of 0.57 (0.04), while the alpha is virtually unchanged: 10.43% (-0.05%) instead of 10.18% (-0.09%).

We conclude that the adjustment for autocorrelation has a substantial impact on the risk estimates of private equity, as well as on the Sharpe ratio. However, compared with a Sharpe ratio of 0.09 for the global stock market (from 1986 to 2003), the performance of the EW-RB LPE portfolio is still by far superior even after correcting for the volatility bias.

4.2 Rebalancing – and the bid-ask bias

We have shown in **Table 3a** that the EW-RB portfolio exhibits a considerably higher average return than the other two portfolios. This could be due to the so called "rebalancing bonus". Early papers of Blume/Stambaugh (1983) and Roll (1983) discuss the problem of estimating and comparing returns from rebalanced and buy-and-hold strategies. In particular, Blume/Stambaugh attribute differences in mean returns to the use of closing prices which differ from (unobservable) market clearing prices: This is due to the fact that observed closing prices bounce arbitrarily between the effective closing bid and ask price. A typical investor who implements a rebalancing strategy is forced to buy at the ask price and to sell at the bid price. The bid-ask effect leads to an upward bias of closing price returns compared to the returns computed from actual market prices. Unfortunately, effective daily bid-ask spreads are not available for our sample. Therefore, our estimate of the bias is based on averages for each vehicle. We assume that investors lose half of the average BAS in each transaction. This amount is subtracted from the weekly EW-RB portfolio returns throughout the sample period. For the EW-BH portfolio, the adjustment is only done after new listings. Based on the fact that 25% (31) of the vehicles in our sample have a BAS of 10% or more, we expect a considerable impact of the bid-ask effect.

The characteristics of the adjusted portfolio returns are displayed in **Table 4b.** It is apparent that the BAS-effect for the EW-RB index is substantial. For the overall sample period, it amounts to a mean bias of 8.33%, in the down market from 2000-2003 the bias is even 10.95%. In contrast, the bias is only 0.39% for the EW-BH index. The interesting observation is that even after controlling for this bias, the EW-RB portfolio shows a clearly higher return compared to the EW-BH portfolio in the down-market from 2000 to 2003. It appears that the benefits of the diversification effect of a rebalancing strategy outweigh the additional cost in an adverse market environment.

4.3 The "ex ante" selection bias and "ex post" survivorship bias.

Two potential selection biases could affect our results: The first bias could emerge from our selection rule. LPE was a new and not well defined asset class in the mid-eighties; while our definition and selection rule (see Section 2) is adequate for the past few years, applying the same criteria *in retrospect* to the vehicles which were available 20 years ago, is to some extent arbitrary. However, the associated ex-post selection bias can at least be minimized if the selection rule is applied consistently over the whole sample period. We not only traced all new listings which fit our definition of a LPE vehicle, but also assured that the selected vehicles still fit this definition throughout the entire time period.

The second type of selection bias is generally known as survivorship bias. Excluding delisted vehicles generally leads to an upward bias in computed returns as has been demonstrated in various studies in the literature. The focus of most studies was on mutual fund performance,

where the survivorship bias accounts for 0.1% to 1.5% annualized return bias, depending on the instruments (stocks, bonds), the time period, and the sample of funds.[10]

We have noticed in Section 2 that from the overall sample of 287 firms, only 237 vehicles survived our observation period. 50 vehicles disappeared from the sample for the following reasons:

- Nine vehicles were acquired by other companies; in four cases they were acquired by another LPE company which was already included in our sample.
- A group of 18 vehicles changed their businesses. Often these companies merged with one of their subsidiaries and decided to concentrate on the business of the latter.
- We found 15 vehicles that were delisted from the exchange or whose trading was suspended. In eight cases we could not exactly trace either the reasons for delisting or the exact date of disappearance from the stock exchange. Thus we excluded these eight vehicles from the analysis.

The remaining 42 vehicles were all delisted in the years 2000, 2001 and 2002. To be consistent with our analysis in this paper, we will only estimate a survivorship bias for those vehicles out of the 42 which satisfied our liquidity criteria.[11] Eight vehicles satisfy our liquidity constraints while the other 34 vehicles did not, especially in the time period right before they disappeared from the sample. Four out of these eight vehicles were delisted or trading was suspended, two vehicles were acquired, and the remaining two changed their businesses.

[10] See e.g. Grinblatt/Titman (1989), Blake/Elton/Gruber (1993), Brown/Goetzmann (1995), Malkiel (1995), Elton/Gruber/Blake (1996), Carhart (1997), Carhart/Carpenter/Lynch/Musto (2000).

[11] An indication of the survivorship bias for the overall sample will be given in section 5.

In order to quantify the survivorship bias caused by the eight vehicles, we adopt the "follow the money" procedure of Elton/Gruber/Blake (1996) with raw returns.[12] This means that if a vehicle is delisted for whatever reason, the capital is equally allocated across all remaining vehicles. The survivorship bias is then measured by comparing the returns of a survivorship-free index which includes the eight delisted vehicles (i.e. contains all 122 liquid vehicles) with our previous index which is just based on the 114 (liquid) surviving vehicles.

The results are displayed in **Table 4c** for three different time periods. The surprising result is that both the EW-RB and the EW-BH portfolios exhibit a "positive" survivorship bias over the entire sample period: including the non-surviving vehicles leads to higher (!) returns. To our knowledge, no similar result has been reported in the performance literature. A possible explanation is that bad company performance explains only four of the eight delistings. In two cases, two high performing instruments were subsequently acquired, and two vehicles that changed their business also demonstrated a better performance than the surviving ones. This could explain the positive survivorship bias. We conclude that the adjustment for survivorship bias is not as important as correcting for autocorrelation and the bid-ask spread.

5. Conclusion

In contrast to former studies estimating the performance of private equity investments, this paper is based on market prices of listed, or publicly traded, private equity vehicles – not book values. Our sample includes a total of 287 LPE vehicles over the time period 1986 to 2003, which represents all listings on international exchanges for which stock price data are available. In order

[12] Elton/Gruber/Blake (1996) reported risk adjusted measures of survivorship bias in addition to measures based on raw returns.

to get accurate measures of risk and return, several liquidity constraints are imposed. They have a strong impact on the size of the resulting sample. The major part of the empirical work conducted in this paper is based on a subsample including 114 liquid stocks. We moreover address the problems and biases in computing *portfolio* returns for this asset class; rebalancing turns out to be a particularly important issue, and strongly affects the reported risk and return figures.

In order to measure the performance of these vehicles adequately, we investigate the risk and return characteristics of two partially rebalanced portfolios (equally-weighted and value-weighted) and a fully rebalanced (equally weighted) portfolio. Not surprisingly, the performance of LPE is high in the period from 1986 to 2000. The Sharpe ratios of 1.19 and 0.74 exceed the respective value of the MSCI World stock market (0.47). The results dramatically change if the subsequent years (up to March 2003) are included in the analysis. Compared with a Sharpe ratio of 0.09 for the world stock market, only the fully rebalanced equally weighted strategy has a clearly superior performance (Sharpe ratio 0.57) – the two other strategies exhibit ratios close to zero. This demonstrates the importance of the selected investment style (in terms of weighting and rebalancing) in studying the performance of LPE.

Because the liquidity of most LPE vehicles is small compared to traditional stock market investments, several performance biases are investigated. Our analysis reveals that standard volatility estimates are strongly downward biased due to the artificial autocorrelations in LPE returns. Taking into account adjusted risk estimates, the Sharpe ratio for the fully rebalanced strategy decreases from 0.57 to 0.33 and is still above the world stock market. We moreover investigate the bid-ask bias in our rebalancing strategies. For the equally-weighted portfolio, the average annual return bias 8.33% over the entire sample period, which is dramatic. Thus, essentially the full return premium of the rebalanced strategy disappears if the bid-ask spread is taken into account in implementing the portfolio adjustments. We finally report estimates of the

survivorship bias by including the eight (liquid) non-surviving vehicles in our analysis. Surprisingly, and in contrast to the standard performance literature, we find a small positive bias in essentially all periods.

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Table 1
Number of listings over time

The table shows the descriptive statistics on the number of listings that occurred until 2002. Before 1986 13 vehicles were listed and in 1986 only 3. The table moreover shows the listings in a two year time frame.

year of listing	number of companies	Percentage
prior to 1986	13	4.53%
1986	3	1.05%
1987/1988	17	5.92%
1989/1990	18	6.27%
1991/1992	6	2.09%
1993/1994	15	5.23%
1995/1996	42	14.63%
1997/1998	54	18.82%
1999/2000	98	34.15%
2001/2002	21	7.32%
Total	287	100.00%

Datasource: Primark Datastream

Table 2
Impact of the bid-ask spread constraint on sample size

The table highlights the impact of the average bid-ask spread liquidity constraint on sample size. The second row of the table (overall sample) contains the number of vehicles that belong to the quantiles specified in row one. In the third row (after liquidity constraints) we report the vehicles that fulfill four out of five liquidity criteria i.e. the minimum number of weekly observations, the minimum average market capitalization, the minimum relative trading volume and the minimum continuity of trade. The last row (difference) is the difference between the second and third row. For example 124 vehicles out of the total sample have a bid-ask spread greater than 20%. Out of these 124 a total of 62 vehicles fulfill the remaining four liquidity criteria which shows the dramatic impact of the bid-ask spread constraint on sample size.

Average bid-ask spread	overall sample	after liquidity constraints w/o average bid-ask spread	difference
smaller than 5%	82	66	16 (20%)
5% - 10%	36	25	11 (31%)
10% - 15%	25	18	7 (28%)
15% - 20%	20	13	7 (35%)
20% - 25%	15	4	11 (73%)
25% - 50%	23	4	19 (83%)
greater than 50%	86	54	32 (37%)
total	287	184	

Table 3a
Risk and return of three LPE portfolio strategies

All figures are based on weekly (annualized) returns of the different LPE portfolios (114 vehicles) computed from 1st January 1986 - 19th March 2003, 1st January 1986 - 16th February 2000 and 16th February 2000 – 19th March 2003 (these returns are also basis for the figures presented in Tables 3b and 4a-c).

value weighted buy-and-hold (VW-BH)

USD	Mean	SD	Sharpe Ratio	Alpha	Beta	R^2
1986 - 2003	*5.43%*	*43.18%*	*0.01*	*-1.20%*	*1.2*	*0.17*
1986 - 2000	19.37%	40.77%	0.35	7.16%	1.08	0.18
2000 - 2003	-58.39%	52.07%	n.c.	-31.18%	1.41	0.13

equally weighted fully rebalanced (EW-RB)

USD	Mean	SD	Sharpe Ratio	Alpha	Beta	R^2
1986 - 2003	*15.99%*	*19.34%*	*0.57*	*10.18%*	*0.6*	*0.22*
1986 - 2000	27.21%	18.44%	1.19	18.21%	0.58	0.18
2000 - 2003	-35.39%	21.68%	n.c.	-25.83%	0.6	0.30

equally weighted buy-and-hold (EW-BH)

USD	Mean	SD	Sharpe Ratio	Alpha	Beta	R^2
1986 - 2003	*5.91%*	*26.93%*	*0.04*	*-0.09%*	*0.74*	*0.17*
1986 - 2000	22.26%	22.81%	0.74	12.37%	0.72	0.13
2000 - 2003	-68.93%	39.24%	n.c.	-56.74%	0.72	0.29

Table 3b
Autocorrelation structure

The table shows the weekly autocorrelation up to five lags and the Ljung-Box Statistics for five lags with its p-value for the different LPE portfolios. For comparison, the statistics of the MSCI (World) are reported as well.

Autocorrelations
01/1986 - 03/2003

	VW-BH 114	EW-RB 114	EW-BH 114	MSCI (World)
AC 1	0.114**	0.151**	0.058	-0.022
AC 2	-0.012	0.159**	0.150**	0.06
AC 3	0.053	0.115**	0.007	0.049
AC 4	0.037	0.099**	0.072*	-0.061
AC 5	0.075*	0.077*	0.098**	-0.014
Q 5	20.588	69.337	36.518	9.234
p-value	0.001	0	0	0.1

*/** denotes that the correlation is significant at the 5%/1% level.

Table 4a
Volatility bias

The table shows the risk and return, the alpha and beta as well as the Sharpe ratio of the EW-RB and EW-BH portfolios with and without adjustment for autocorrelation.

EW-RB USD	Standard Estimates					Adjusted Estimates USD			
	Mean	SD	Alpha	Beta	Sharpe Ratio	Adjusted SD	Adjusted Sharpe	Dimson Alpha	Dimson Beta
1986 – 2003	15.99%	19.34%	10.18%	0.6	0.57	**33.69%**	**0.33**	**10.43%**	**0.99**

EW-BH USD	Standard Estimates					Adjusted Estimates USD			
	Mean	SD	Alpha	Beta	Sharpe Ratio	Adjusted SD	Adjusted Shape	Dimson Alpha	Dimson Beta
1986 – 2003	5.91%	26.93%	-0.09%	0.74	0.04	**37.09%**	**0.03**	**-0.05%**	**1.09**

Table 4b
Bid-ask spread bias

Return figures are provided before the adjustment for the bid-ask spread (standard mean) and after the adjustment for the bid-ask spread (adjusted mean) for both the EW-RB and the EW-BH LPE portfolio.

EW-RB USD	Adjusted Mean	Standard Mean	Difference	EW-BH USD	Adjusted Mean	Standard Mean	Difference
1986 – 2003	***7.65%***	*15.99%*	*8.33%*	*1986 – 2003*	***5.52%***	*5.91%*	*0.39%*
1986 – 2000	**19.45%**	27.21%	7.76%	1986 - 2000	**22.04%**	22.26%	0.21%
2000 – 2003	**-46.34%**	-35.39%	10.95%	2000 - 2003	**-70.12%**	-68.93%	1.20%

Table 4c
Survivorship bias

This table shows the impact of the survivorship bias in our (liquid) sample. For example we report a (positive!) survivorship bias of 1.81% for the EW-BH portfolio for 1986-2003.

EW-RB USD	Adjusted Mean (n=122)	Standard Mean (n=114)	Difference	EW-BH USD	Adjusted Mean (n=122)	Standard Mean (n=114)	Difference
1986 – 2003	***16.35%***	*15.99%*	*0.36%*	*1986 - 2003*	***7.72%***	*5.91%*	*1.81%*
1986 – 2000	**27.85%**	27.21%	0.64%	1986 - 2000	**22.44%**	22.26%	0.18%
2000 – 2003	**-36.29%**	-35.39%	-0.90%	2000 - 2003	**-59.68%**	-68.93%	9.25%