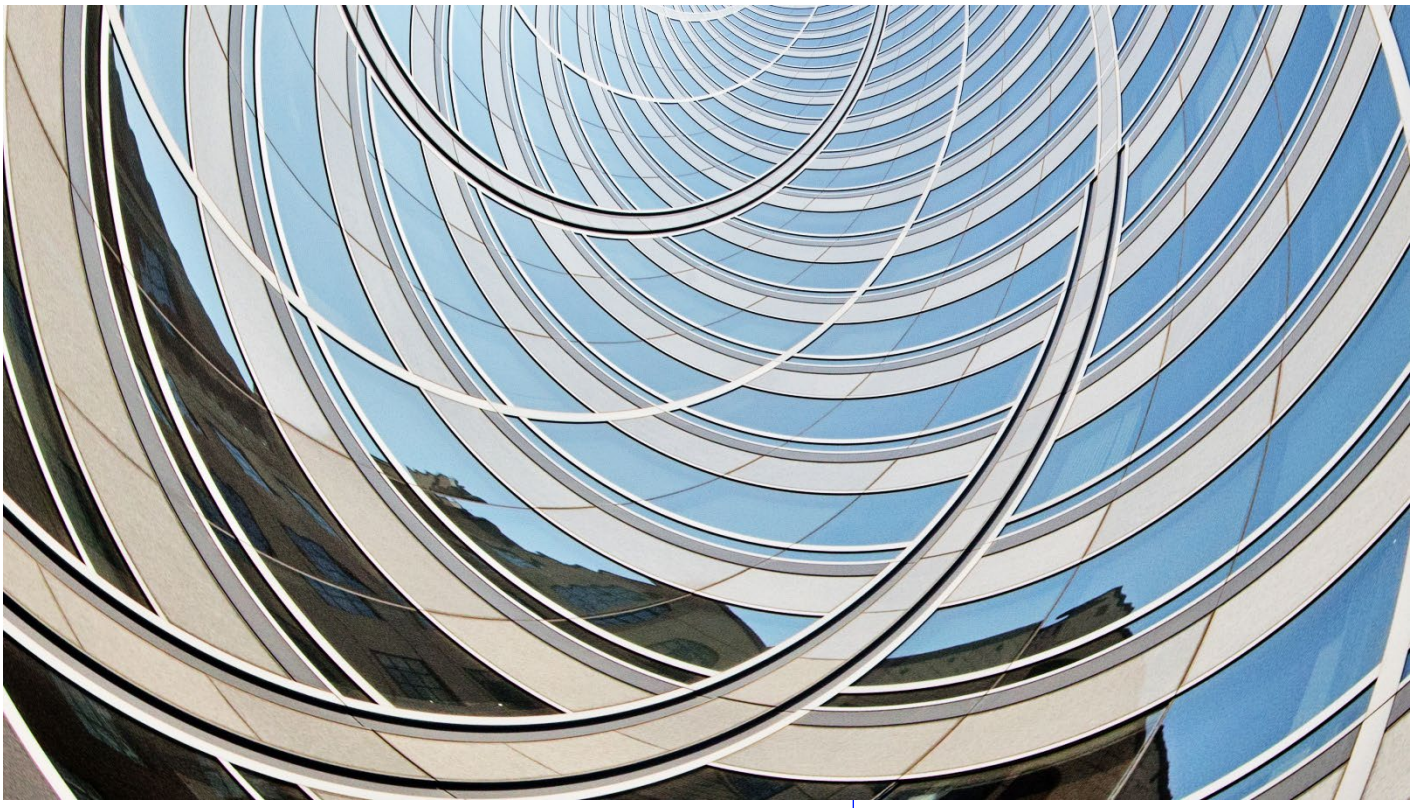

Global Investment Research | Equities

Managing risk exposures to private equity through public equity

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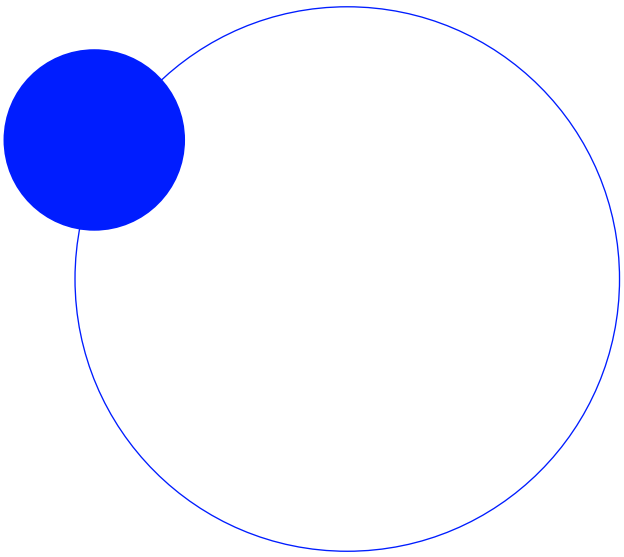
Executive summary

- **A joint paper by researchers at FTSE Russell and Cboe** finds that private and public equities have higher co-movement than it seems at first glance, and that Russell 2000® Index options can be used to hedge US private equity risk.
- The FTSE Russell authors find **correlations between public and private equity have been higher more recently** than during the period before 2000. Also, correlations are unnaturally depressed due to the "smoothing" of private equity returns. Together these suggest that public and private equity returns are more related than overall correlations typically imply.
- The Cboe author shows there are both **tactical and systematic strategies using Russell 2000 Index options** that can hedge private equity exposures over the recent period, including during the Global Financial Crisis.
- **A battery of efficacy tests** is used to generate optimal tactical and systematic strategies to hedge private equity exposures.



Contents

Introduction

In this two-part paper, researchers from FTSE Russell and Cboe collaborate to examine the relationship between private equities (PE) and Russell public equities. Ultimately, the question is whether private equity can be hedged using public equity options. The researchers use a dataset that combines US private equity performance from the Cambridge Associates dataset with Russell index data.

In the first section, De and Barnes from FTSE Russell give a description of the private equity data and point out how the private equity landscape has changed over the last few decades. The central question they address is whether private and public equity are as different as often described in terms of return co-movement. They use common measures of return similarity including correlation and tracking error. They arrive at two important conclusions

– The relationship between private and public equity has changed over time and most recently they are more similar than they were in the early decades of private equity.

– By taking into account the “smoothing” of private equity returns, the two asset classes can be shown to be more similar than they seem at first glance.

Both of these findings support the view that the two asset classes have been more similar recently than they were in the distant past, which would suggest more similarity going forward. This conclusion feeds into the second section in which Tom (Cboe) looks rigorously at the question of whether public equity derivatives can be used to hedge private equity risk. Tom provides an overview of Cboe options based on the Russell 2000 Index (ticker: RUT) that could be used to hedge private equity risk. He then conducts a battery of backtests to test whether Russell 2000 Index options can be used to hedge private equity risk using a number of tests of efficacy.

He examines various types of hedging strategies including tactical and systematic hedge strategies. Among his findings are that a tactical Russell 2000 Index Put-spread was able to fully hedge seven of the ten largest private equity drawdowns over the recent test period, including the largest decline during the Global Financial Crisis (2007–2009). This ability to hedge seems to be relatively stable and was also able to hedge a recent decline in 2022. The systematic hedge strategy was able to offer some downside protection in eight of the 10 worst quarterly PE drawdowns over the test period and during certain drawdowns generated outsized hedge returns. In both cases, Tom discusses the optimal hedging strategy.

PART 1

Private and public equity: How different are their returns?

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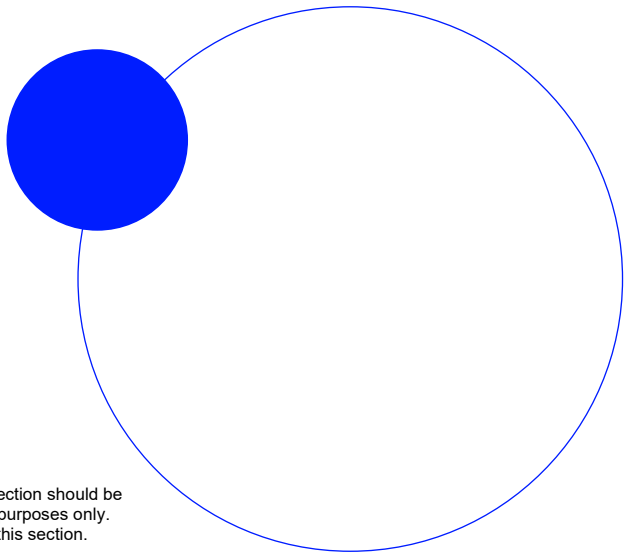
INDRANI DE AND MARK BARNES, GLOBAL INVESTMENT RESEARCH, FTSE RUSSELL[1]

This section of the paper is an empirical section intended to describe some relationships between private and public equity using private equity data from Cambridge Associates and public equity data from FTSE Russell. We restrict the analysis to US private equities, for which we have the longest history and the best data coverage.

While there are a number of papers that analyze performance of private equities, here we take a different approach. We take the private equity performance numbers as given, and we analyze the public market indexes to understand how the two sets of indexes are related. Whereas private equity returns are somewhat opaque, investors are familiar with the public equity indexes, and so we hope this gives readers some intuition of private equity return patterns.

Because we are interested in the possibility of hedging private equity exposures with public equity, we will focus on the co-movements of the two asset classes.



[1] FTSE Russell is not an investment firm and none of the material in this section should be construed as investment advice; the material is presented for educational purposes only. We would like to thank Alex Nae for his help in conducting the analysis in this section.

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Data description

The private equity data is from Cambridge Associates (CA). From their datasets on private equity, we use only the US equity portion. While we do show some descriptive statistics on the number of firms and assets under management in this section, the bulk of the analysis uses the quarterly internal rates of return (IRR). The actual calculation and reporting of the IRRs is outside the scope of this analysis, and we simply take them as returns for the specific quarter.

In describing the private equity data, we use Cambridge Associates' labeling:

- **Private equity**. This is broken down into the two sub-components below. In this paper we sometimes use "private equity", "US PE", or "PE" in labeling exhibits to refer to this private equity index.
- **Growth equity** is a component of private equity. Here we use "growth equity", "US GE", or "GE" in labeling the exhibits.
- **Buyout** is the other component of the private equity aggregate. Here we use "buyout", "US BO", or "BO" to refer to this component.

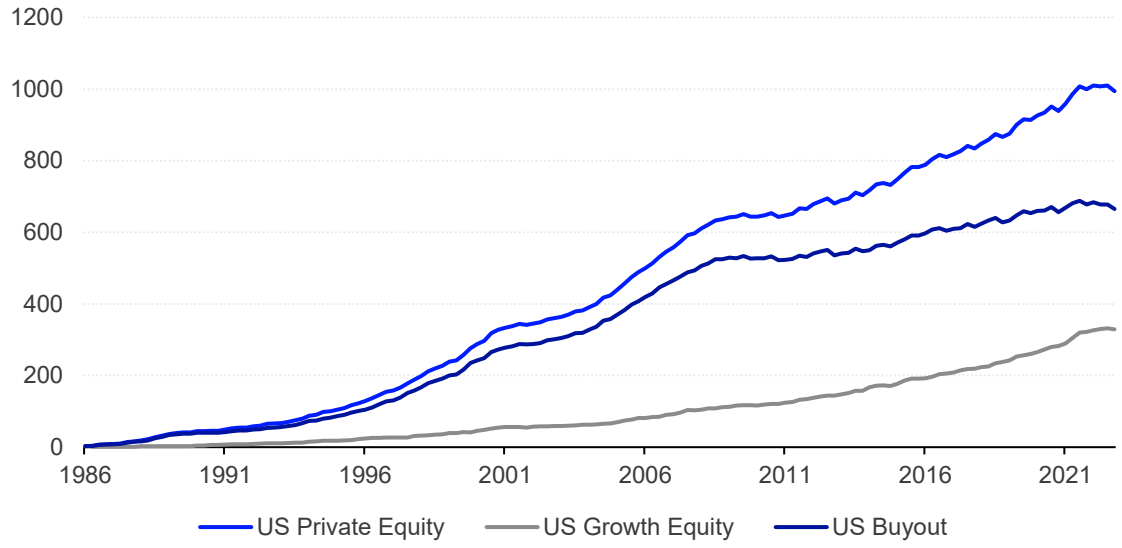
The datasets are quarterly and cover the period Q2 1986 through Q1 2023, or 148 quarters of data (37 years). In the sections below, we describe the full dataset before focusing on a later period covering Q2 2000 through Q1 2023 or 23 years of data.

The public equity data is from FTSE Russell and is based on the Russell 1000® Index and Russell 2000 Index, including the Value and Growth variants of those two core indexes. In all cases, we refer to these as indexes rather than benchmarks to avoid an implication of how these are used.

All returns are in USD.

To better understand the current context of private equity, it is instructive to give some historical description of the private equity industry as described by the Cambridge Associates dataset. Exhibit 1 shows the number of funds overall (private equity) and the two subsets. The first decade or so saw a gradual rise in the number of funds to a little over 100, with the number at the end of the period around 1000.

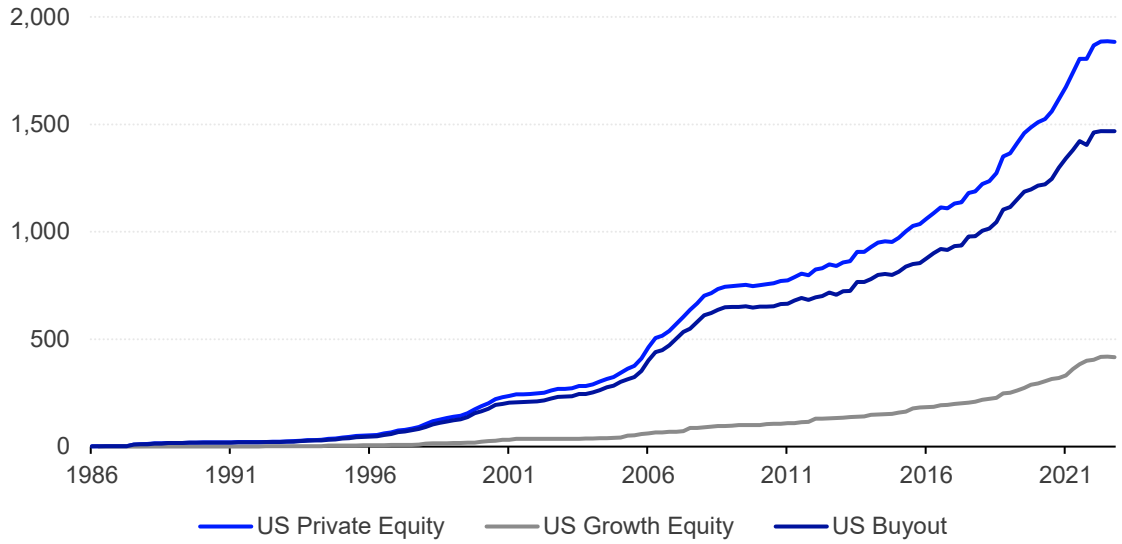
Exhibit 1. Number of funds, 1986Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

Exhibit 2 shows a similar increase in assets under management from approximately $52B in 1996Q2 to approximately $1.9T at the end of the period. Of this, approximately 77% of the total is in buyout funds with the remaining 23% in growth equity.

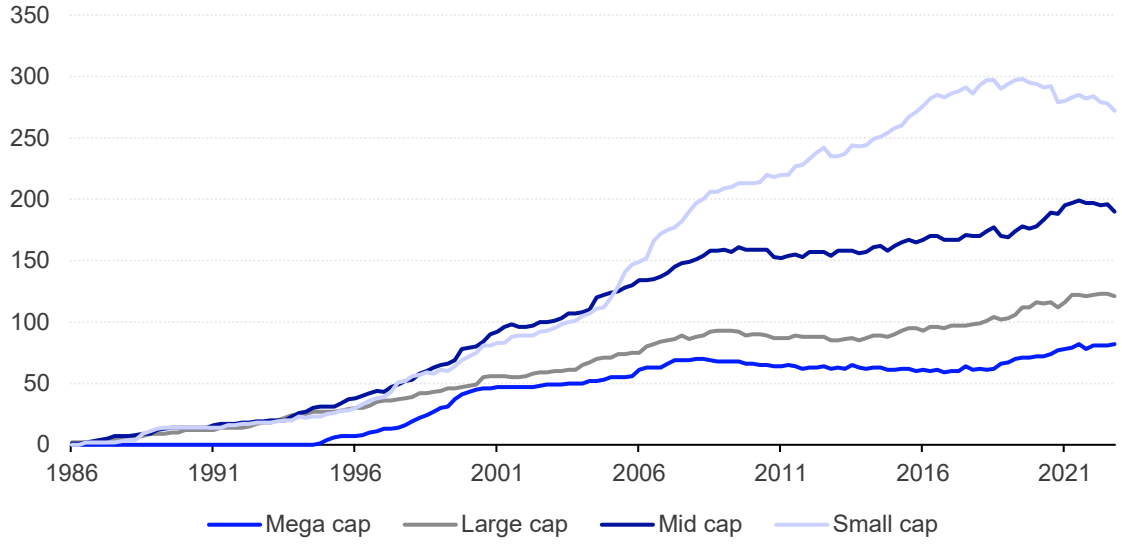
Exhibit 2. Assets under management (billions USD), 1986Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

In addition to the growth of the industry, another important change can be seen in the composition of the assets. Within the buyout group, CA shows breakdowns into four market capitalization buckets, with the breakpoints between groups adjusting over time (see Cambridge Associates documentation). Exhibit 3 shows that while small, mid, and large cap funds have been growing steadily since the beginning of the data, the mega caps category was split off from the large cap category in 1995 and grew rapidly.

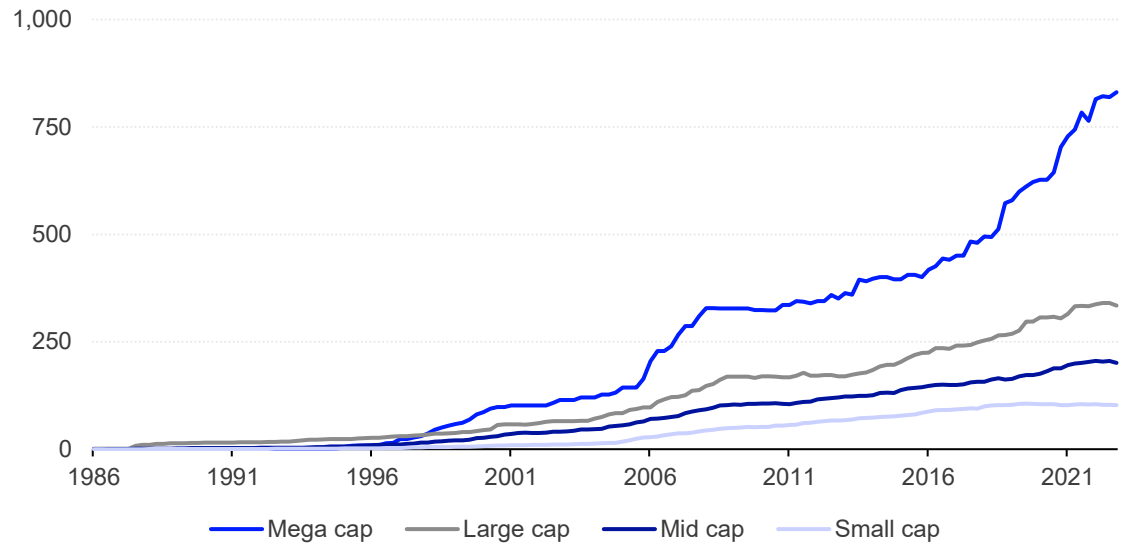
Exhibit 3. Number of US buyout funds, by capitalization group, 1986Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

While small cap funds are still the largest group in terms of number of funds and the mega cap the smallest, exhibit 4 shows that mega caps have come to dominate the assets under management.

Exhibit 4. US buyout assets under management, by capitalization group (billions USD), 1986Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

Historical description

Performance statistics

Some general statistics can give an indication of the appeal of private equity from a performance standpoint. Exhibit 5 shows that US growth equity over the entire period has had an annualized return of approximately 18.7% on an annualized standard deviation of 17.9% for a return/vol ratio of 1.05. The bfuyout group has lower return but considerably lower volatility, giving a return/vol ratio of 1.51 for the period.

Exhibit 5. Private equity performance, 1986Q3–2023Q1

	US PE	US GE	US BO
Geo mean	14.7%	18.7%	14.1%
Std. dev.	9.8%	17.9%	9.4%
R/V	1.49	1.05	1.51

Source: FTSE Russell and Cambridge Associates.

We can compare this to the standard Russell indexes over the same period. We see that the large cap Russell 1000 has volatility just slightly higher than that of growth equity. The small cap Russell 2000 has higher volatility across the board, with average returns lower than private equity, resulting in a lower return/vol ratio in comparison to the Russell 1000.

Exhibit 6. Russell index performance, 1986Q3–2023Q1

	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Avg. (geo.)	10.3%	9.8%	10.3%	8.5%	9.5%	7.1%
Std. dev.	16.6%	16.0%	19.0%	21.6%	20.7%	24.3%
R/V	0.62	0.61	0.54	0.39	0.46	0.29

Source: FTSE Russell and Cambridge Associates.

Co-movement

The ability to hedge private equity with public equity largely comes down to co-movement patterns, or whether the returns of private equity are related to public equity returns. Exhibit 7 shows the correlations of the three private equity indexes with the six public equity indexes used here. For this time period (1986Q3–2023Q1), the correlations run from a high of 0.73 for the US PE vs Russell 1000 to a low of 0.41 for the correlation of US GE to the Russell 2000 Value Index.

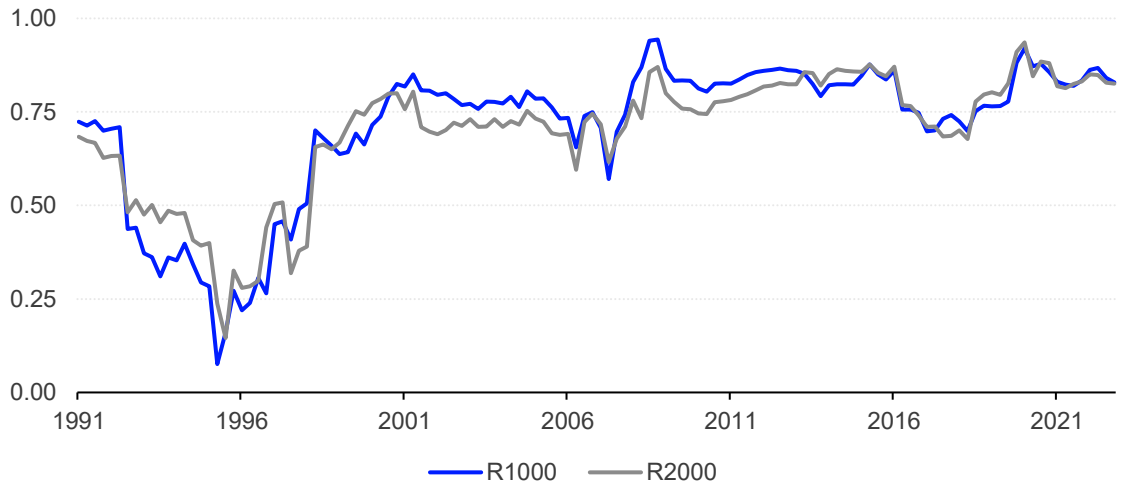
Exhibit 7. Correlations of Russell indexes to private equity indexes, 1986Q3–2023Q1

	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
US PE	0.73	0.66	0.72	0.69	0.59	0.71
US GE	0.58	0.45	0.62	0.55	0.41	0.62
US BO	0.73	0.67	0.70	0.67	0.60	0.68

Source: FTSE Russell and Cambridge Associates.

These correlations are for the entire period. To get an idea of the stability of these correlations, Exhibit 8 shows a 20-quarter rolling correlation of the overall private equity index with the two core indexes. Indeed, we do see that correlations in the earlier part of the history dipped sharply before rising again and stabilizing around a correlation of approximately 0.80.

Exhibit 8. 20-quarter rolling correlations with private equity index, 1986Q3–2023Q1



Source: FTSE Russell and Cambridge Associates.

Given that we are interested in understanding the current co-movement of public and private equity, it makes sense to focus on the more recent history. With that in mind, we recalculate the statistics for the period up through 2001Q1 and the period after that. A noticeable difference between the two periods is that US GE has a much lower average return and volatility in the later period. US BO has a lower return and *higher* volatility, leading to a lower reward ratio. The two Russell indexes see a drop in average return and an increase in volatility, also leading to large drops in return/vol ratio.

Exhibit 9. Performance statistics for private equity and Russell indexes, 1986Q3–2000Q1 and 2000Q2–2023Q1

Through 2000Q1

	US PE	US GE	US BO	R1000	R2000
Avg (geo)	18.5%	30.3%	17.2%	16.8%	11.4%
Std. dev.	8.7%	24.0%	7.6%	15.2%	20.9%
RR	2.14	1.26	2.28	1.10	0.54

2000Q2 and after

	US PE	US GE	US BO	R1000	R2000
Avg (geo)	12.4%	12.3%	12.3%	6.6%	6.8%
Std. dev.	10.3%	11.8%	10.2%	17.2%	22.0%
R/V	1.20	1.05	1.20	0.38	0.31

Source: FTSE Russell and Cambridge Associates.

Analyzing the reason for these changes in the markets, in particular the US BO market, is beyond the scope of this paper. It should be noted, this break occurred right after the collapse of the dot-com bubble which roughly coincides with the increase in mega cap deals. In any case, in the rest of this paper we will focus on this later period, as we are not trying to understand the history of private equity but rather its current co-movement with public markets.

Smoothing

Even though the correlations of private and public markets are higher in this later period (2000Q2–2023Q1), it is still relatively low at around 0.65–0.80. Exhibit 10 shows the correlations for the period after 2000Q1.

Exhibit 10. Correlations between private equity and Russell indexes, 2000Q2–2023Q1

	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
US PE	0.81	0.74	0.79	0.75	0.67	0.76
US GE	0.77	0.68	0.77	0.73	0.64	0.75
US BO	0.80	0.74	0.77	0.74	0.66	0.75

Source: FTSE Russell and Cambridge Associates.

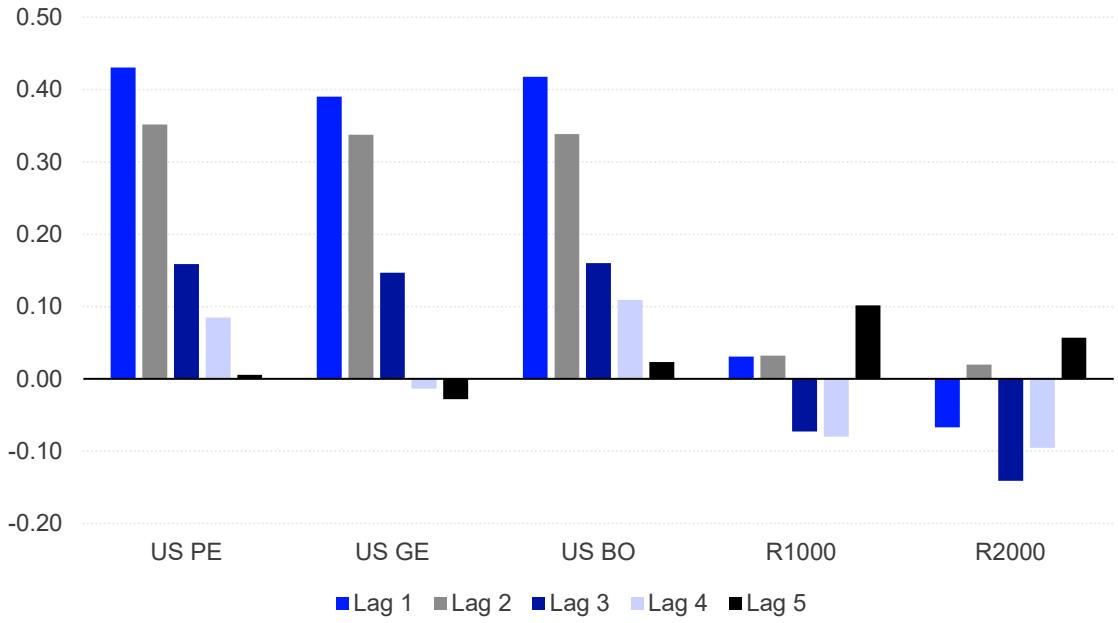
One possible reason for these relatively low correlations is well-known: private equity returns are "smoothed," in that they are not marked to market. Private equity funds report their internal rates of return and have some discretion on how to measure.

There are a number of papers that analyze and try to decompose these smoothed returns to understand what the private equity return-generating function actually looks like. For discussions on smoothing of private equity returns, see Anson (2013), Ilmanen (2020), and Baz (2022).

This paper approaches the issue from the opposite side. We take the private equity returns as a given, generated by a black box process. Instead, we start with the public equity returns and see if we can determine how they can be related to the private equity returns.

One effect of smoothing is that the private equity returns tend to be autocorrelated. Exhibit 11 shows that the private equity indexes have positive autocorrelations up to a lag of five quarters over this period, whereas the public equity indexes show autocorrelations that are negative or close to zero. This makes sense because positive autocorrelations are an indication of return predictability that would be arbitraged away in a liquid market. The illiquidity and the lack of marking to market allows private equity returns to deviate.

Exhibit 11. Autocorrelation and private equity and Russell indexes, 2000Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

Exhibit 12 shows the first four moments for each of these return series. As we would expect to see with smoothing, the private equity returns show more excess kurtosis as the distribution is more "peaked".

Exhibit 12. Private equity and Russell index moments, 2000Q2–2023Q1

	US PE	US GE	US BO	R1000	R2000
Avg. (arith)	3.10%	3.12%	3.07%	1.98%	2.28%
Std. dev.	5.17%	5.88%	5.11%	8.62%	10.98%
Skewness	-0.69	-0.37	-0.79	-0.67	-0.41
Kurtosis	1.98	1.21	2.40	0.45	0.97

Source: FTSE Russell and Cambridge Associates.

One way to understand the distribution of the black box private equity returns is to try to match the distribution of those returns using the public equity returns at our disposable, which is what we do in this section. Our starting point is the autocorrelation structure of the private equity returns. We do this by building a smoothing function for the public equity indexes based on the autocorrelation function of a specific private equity index. To start, we will focus on the US PE index and the Russell 1000 and then present more results below.

Rather than rely on a complex optimization algorithm, we start with the simplest approach which is to build weights using the autocorrelations themselves. Starting with the autocorrelations reported above, we calculate

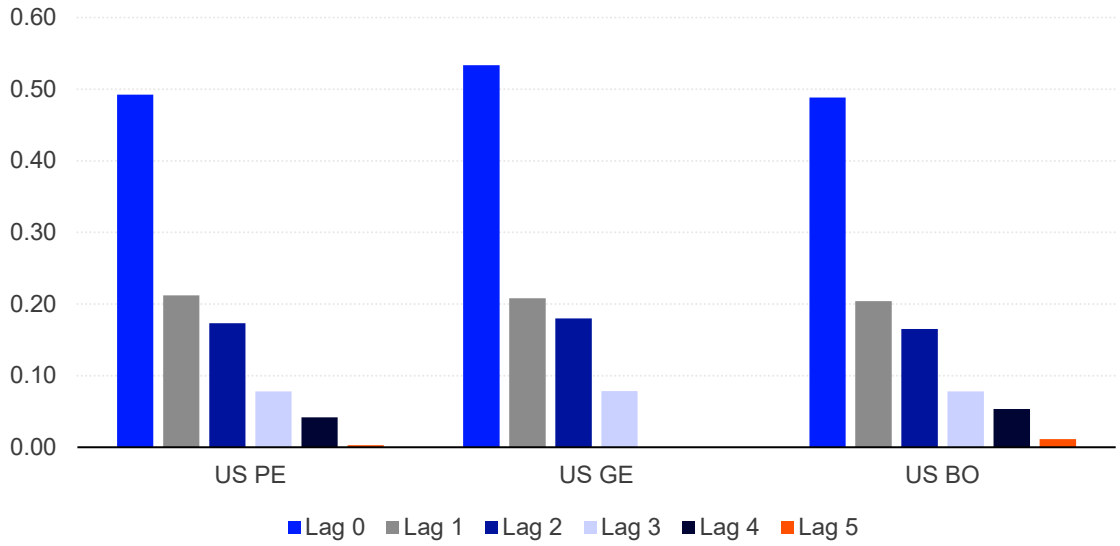
$$wt_{Li}^{raw} = \max(0, AC_{Li}),$$

For lags = 0…5, where AC_{Li} is the autocorrelation at lag *i*. Note that this uses only the positive autocorrelations and stops at the fifth lag, which is the maximum consecutive positive autocorrelation shown in this sample. Also note that we start at lag = 0, where the autocorrelation = 1. We then simply renormalize these weights so that they sum to one.

$$wt_{Li} = \frac{wt_{Li}^{raw}}{\sum wt_{Li}^{raw}}$$

The resulting weights are shown in exhibit 13. Using these weights we smooth the public equity indexes, with wt_{L0} being applied to the contemporaneous return, and so on. The resulting return stream, then, would be equivalent to an instrument that at the end of each quarter gives out this weighted average of the current and last five quarters of public equity returns.

Exhibit 13. Renormalized weights calculated using autocorrelations from 2000Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

To check whether the smoothing has the desired effect, exhibit 14 shows that both Russell 1000 and Russell 2000 indexes have considerably more autocorrelation than the unsmoothed returns shown above. Furthermore, the smoothed Russell 1000 autocorrelation subjectively looks similar to the PE returns, although the Russell 2000's is more different with only two lags of positive autocorrelation.

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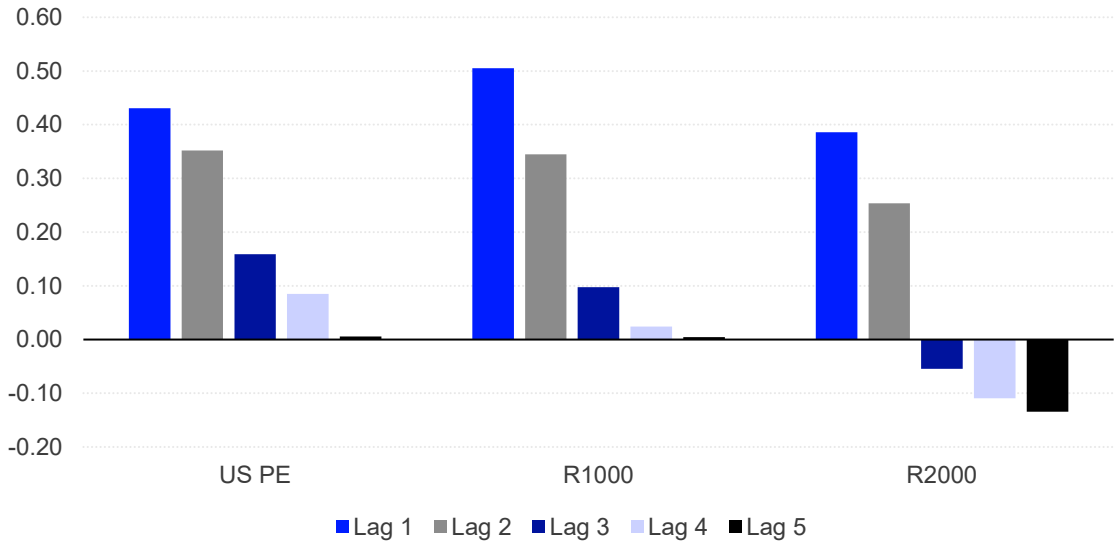
Exhibit 14. Autocorrelation of US PE and Russell indexes using weights calculated from PE autocorrelations, 2000Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

Next, we compare the performance statistics of the public equity returns with their smoothed version, here using the weights based on the PE autocorrelation. First notice that there is a dramatic decrease in volatility, which is not a surprise given that we are intentionally building in smoothness. This drop in volatility naturally increases the geometric return a bit, making the return/vol ratio looking more attractive. This reduction in volatility brings volatility closer to that of private equity, but the returns continue to be lower. (See exhibit 15 for reference.) A similar pattern can be seen using weights based on the growth equity and Buyout autocorrelation patterns.

Exhibit 15. Russell index performance statistics, unsmoothed and smoothed using PE weights, 2000Q2–2023Q1

	Unsmoothed		Smoothed (PE wts)	
	R1000	R2000	R1000	R2000
Avg. (geo.)	6.6%	6.8%	7.7%	9.0%
Stdev	17.2%	22.0%	10.0%	11.9%
R/V	0.38	0.31	0.78	0.75

Source: FTSE Russell and Cambridge Associates.

Co-movement

To see the effects of smoothing on correlations with the private indexes, exhibit 16 shows correlations of private equity indexes to public equity indexes before and after they have been smoothed.

Exhibit 16. Correlations between private equity and Russell index unsmoothed and smoothed returns, 2000Q2–2023Q1

PE correlations	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Unsmoothed	0.81	0.74	0.79	0.75	0.67	0.76
Smoothed	0.87	0.79	0.85	0.82	0.69	0.85

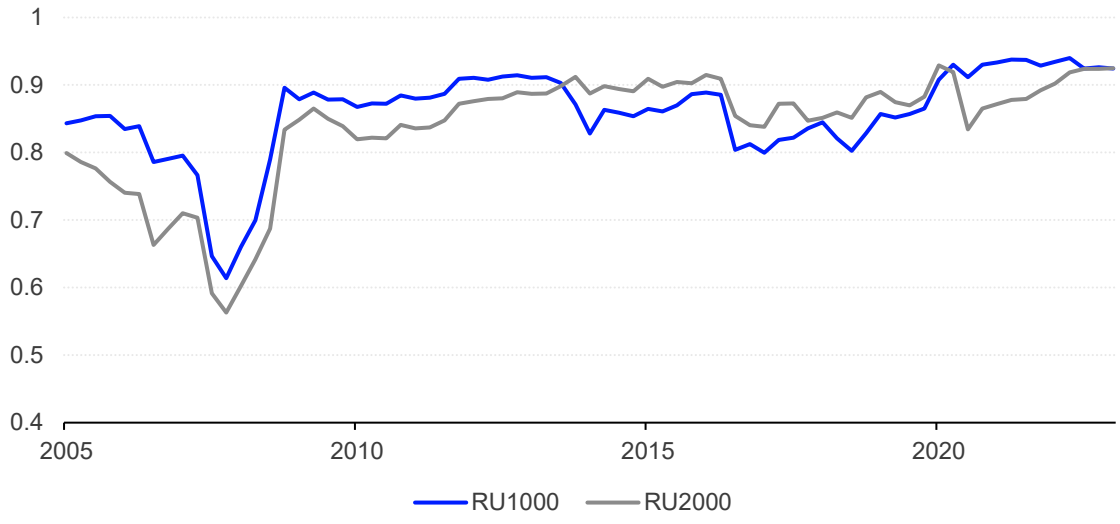
GE correlations	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Unsmoothed	0.77	0.68	0.77	0.73	0.64	0.75
Smoothed	0.84	0.71	0.86	0.80	0.64	0.86

BO correlations	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Unsmoothed	0.80	0.74	0.77	0.74	0.66	0.75
Smoothed	0.86	0.80	0.82	0.81	0.69	0.83

Source: FTSE Russell and Cambridge Associates.

These correlations are for the full period 2000Q2–2023Q1, but if we look at a time-series of the correlations, we see that there is quite a bit of variability, and in particular there is a dip in correlations around the time of the GFC.

Exhibit 17. 20-quarter rolling correlation of PE and smoothed Russell index returns, 2000Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

Exhibit 18 shows correlations over the last ten years, and, despite the volatility of the COVID crisis, omitting the GFC results in higher correlations. During this period, both the Russell 1000 and Russell 2000 indexes are about equally correlated with the Buyout index and the overall private equity index. However, the US GE has the highest correlation with the Russell 2000 Growth Index, followed by the Russell 1000 Growth Index, and, for both small and large caps, correlation to the Value style indexes are much lower.

Exhibit 18. Correlations between private equity and Russell index unsmoothed and smoothed returns, 2013Q2–2023Q1

Last 40 quarters only

PE correlations	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Unsmoothed	0.82	0.79	0.76	0.80	0.79	0.76
Smoothed	0.90	0.81	0.87	0.90	0.83	0.89

GE correlations	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Unsmoothed	0.73	0.67	0.71	0.74	0.71	0.73
Smoothed	0.85	0.71	0.86	0.86	0.76	0.88

BO correlations	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
Unsmoothed	0.83	0.82	0.76	0.81	0.80	0.76
Smoothed	0.90	0.83	0.85	0.89	0.83	0.87

Source: FTSE Russell and Cambridge Associates.

Another way to think of co-movement is to consider the standard deviation of the difference between the return streams, usually thought of as tracking error, although in this case there is no active management relative to a benchmark. The tables below show the tracking error for each of the private indexes against the unsmoothed and smoothed public equity indexes for different periods of time.

Exhibit 19. Tracking error of indicated private equity index with the unsmoothed (top table) or smoothed (bottom table) Russell equity index

TE PE	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
2000Q2–2023Q1	10.8%	11.6%	12.9%	15.7%	16.5%	17.5%
2013Q2–2023Q1	9.8%	10.0%	12.2%	15.2%	15.9%	16.2%

TE (smoothed)	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
2000Q2–2023Q1	5.1%	6.4%	6.2%	6.8%	8.8%	6.9%
2013Q2–2023Q1	3.7%	5.1%	4.7%	5.5%	6.9%	5.9%

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TE GE	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
2000Q2–2023Q1	11.2%	12.4%	12.8%	15.7%	16.6%	17.1%
2013Q2–2023Q1	10.6%	11.4%	12.3%	14.9%	16.0%	15.7%

TE (smoothed)	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
2000Q2–2023Q1	6.4%	8.5%	6.4%	7.9%	10.4%	7.3%
2013Q2–2023Q1	5.9%	7.8%	5.8%	6.5%	8.5%	6.2%

TE BO	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
2000Q2–2023Q1	11.0%	11.7%	13.2%	16.0%	16.7%	17.8%
2013Q2–2023Q1	9.9%	9.8%	12.5%	15.5%	16.1%	16.6%

TE (smoothed)	R1000	R1000 Value	R1000 Growth	R2000	R2000 Value	R2000 Growth
2000Q2–2023Q1	5.3%	6.3%	6.5%	7.0%	8.7%	7.3%
2013Q2–2023Q1	3.6%	4.5%	5.0%	5.7%	6.8%	6.4%

Source: FTSE Russell and Cambridge Associates.

A few observations:

– In all cases, smoothing significantly decreases tracking error.

– While the Russell 1000 has the lowest tracking error of the smoothed indexes relative to the US PE and US BO, the Russell 1000 Growth Index has slightly lower tracking error for the US GE. That lower tracking error (US GE vs Russell 1000 Growth) may give an indication of the fundamental link in performance.

– In all cases, the tracking error is lower in the most recent 10-year period than the full 23-year period. As exhibit 17 above shows, this is affected by the lower correlations around the GFC period, which will be addressed in the next section.

Extensions

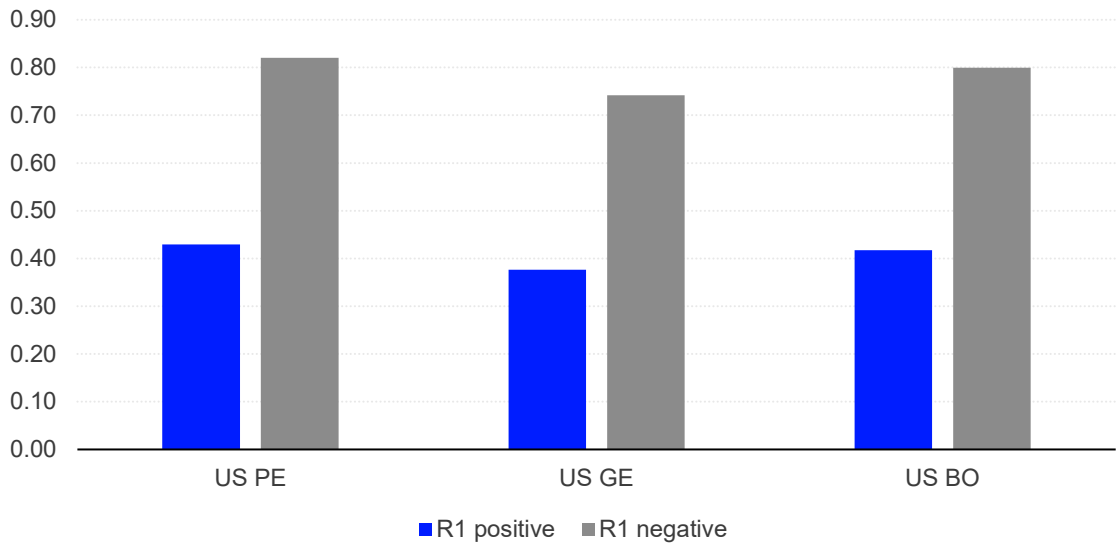
Asymmetry

The analysis so far assumes symmetry in the smoothing function, which can be thought of as a "return announcement function". Once the weights are set up, the smoothed return is simply a weighted average of current and lagged public equity returns. However, Anson (2013) reports that in previous papers, he

> [f]ound that private equity managers marked down their portfolios quickly in down markets, demonstrating a smaller lagged beta effect, and marked up their portfolios slowly in up markets – a longer lagging effect. (Anson, 2013, p. 28).

Exhibit 20 shows that there is considerable difference in the contemporaneous correlation of private equity indexes to the Russell 1000 when the public index is positive or negative. This introduces not only an asymmetry into the smoothing process, but also a conditionality that disrupts the correlation with the mechanical smoothing.

Exhibit 20. Contemporaneous correlations of private equity to Russell 1000 when Russell 1000 is positive or negative, 2000Q2–2023Q1



Source: FTSE Russell and Cambridge Associates.

An illustration of this behavior can be seen in the period around the GFC when correlations did drop. When the Russell 1000 fell dramatically in Q3 and Q4 of 2008, private equity returns were about 72%–74% of the public market drop. However, when markets were up about the same amount in Q2 and Q3 of 2009, private equity returns where about 30%–40% of the magnitude.

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Summary of return co-movement analysis

At first glance, it looks like hedging private equities with public equities is a lost cause. The overall correlation between the Cambridge Associates' Private Equity index and the Russell 2000 index is 0.69 and it drops to 0.55 for the US GE index. However, in this paper we show that these low correlations misrepresent the current relationship between the asset classes. Specifically, we make some adjustments to the comparison in a few ways.

We focus on the period since Q1 2000 for much of the analysis and then present numbers over the last 10 years. The period before Q1 2000 has very different behavior in both assets classes and so is less relevant for the task at hand.

Investors are familiar with the idea that private equity internal rates of return are smoothed in the sense that they are not marked to market. Rather than trying to disentangle the private equity returns, we show that by smoothing the public equity returns based on simple autocorrelations of the private equity returns, we can generate a return stream that is much closer to that of private equity. By doing this, we find correlations between the US PE index and the Russell 1000 Index of about 0.9. We also find tracking errors between the two indexes to be around 3.7% over the last ten years.

Finally, we point out that there may be other directions for reducing the tracking using conditional smoothing of the public equity based on interesting asymmetries in the public equity return series.

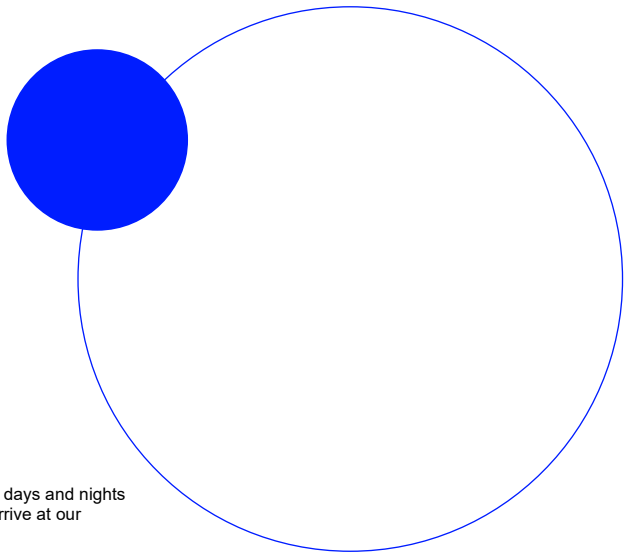
PART 2

Can private equity be hedged with public equity?

EDWARD K. TOM, SENIOR DIRECTOR—DERIVATIVES MARKET INTELLIGENCE, CBOE[2]

While part 1 highlights how Russell 2000 returns can be a close proxy for private equity returns, in the following we draw upon the methodology described by De & Barnes to formulate a framework by which one can utilize options on the Russell 2000 to hedge private equity risk.

We will begin with a background on Russell 2000 Index (RUT) options liquidity, provide an overview of the hedging structure one can employ to facilitate the hedge, describe the aspects of the Russell 2000 implied volatility surface one must take into account to design the trade, and provide an analysis of hedge efficacy during the largest drawdown in PE returns.



[2] We would like to acknowledge Jeff Nguyen at Cboe who spent countless days and nights sifting through the data and performing hundreds of backtests to help us arrive at our conclusions.

Russell 2000 options alternatives

Investors who wish to access exposure to R2000 options typically trade RUT Cboe standard Index Options, RUTW Cboe weekly/monthly expiry Index Options, or IWM ETF options. The RUT(W) Cboe Index options are cash-settled, European exercised options while the IWM is an American exercised option and delivers the underlying shares of the ETFs. The table below summarizes the key differences between the three alternatives.

Exhibit 21. Comparison of Russell 2000 Index products

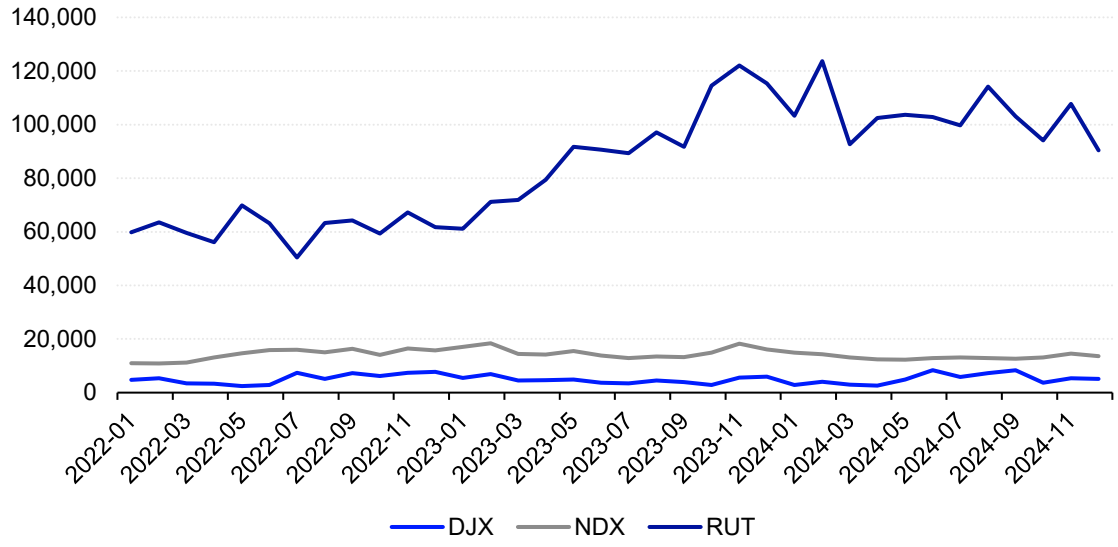
Description	Russell 2000 Index options: traditional	Russell 2000 Index options: weeklys and end of months	iShares® Russell 2000 Index fund (IWM) options
Options chain	RUT	RUT	IWM
Root ticker symbol	RUT	RUTW	IWM
AM or PM settlement	AM-settled	PM-settled	PM-settled
Approximate notional size	$214,000	$214,000	$21,200
Exercise style	European	European	American
Settlement type	Cash	Cash	Physical shares of ETF

Source: Cboe Global Markets.

General Liquidity

On the whole, Russell 2000 options are amongst the most liquid US index options and have a daily delta-adjusted open interest averaging 100K per day.

Exhibit 22. Average daily delta-adjusted open interest across major broad market indexes



Source: Cboe Global Markets.

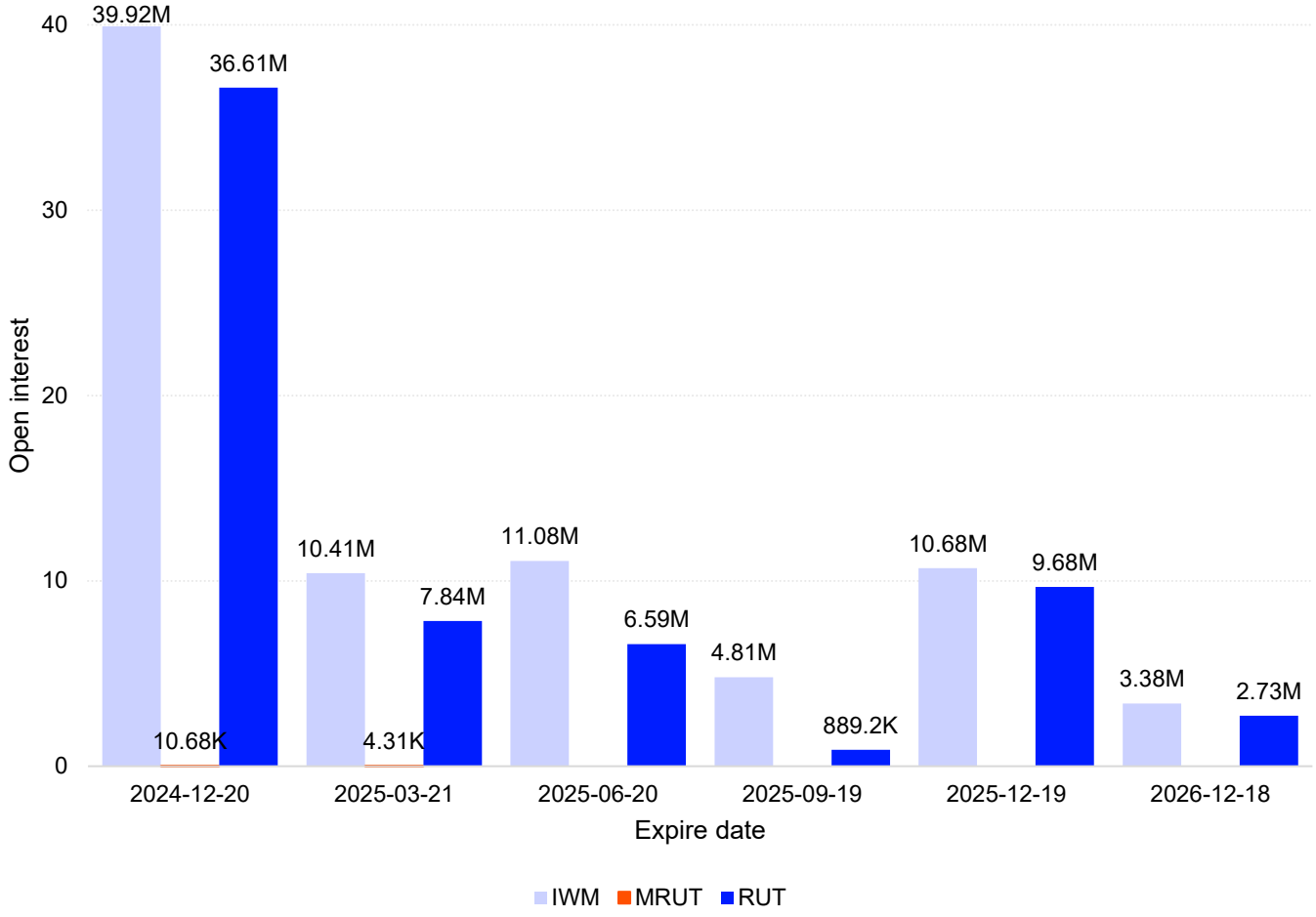
Hedge structure

Two alternative types of derivatives structures can be used to hedge private equity drawdowns. The first is a structure that closely matches the methodology described by De & Barnes which outlines a sequential series of exponentially weighted, forward starting hedges extending out 5 quarters called a cliquet. A cliquet or rachet option is an over-the-counter instrument that is commonly used by insurance companies to hedge long-dated variable annuities. Cliquets are purchased at trade inception and are structured using a series of at-the-money forward starting options where each successive option becomes active when the previous one expires. The second exchange-traded alternative is a simple short-dated put-spread.

Cliquet constraints

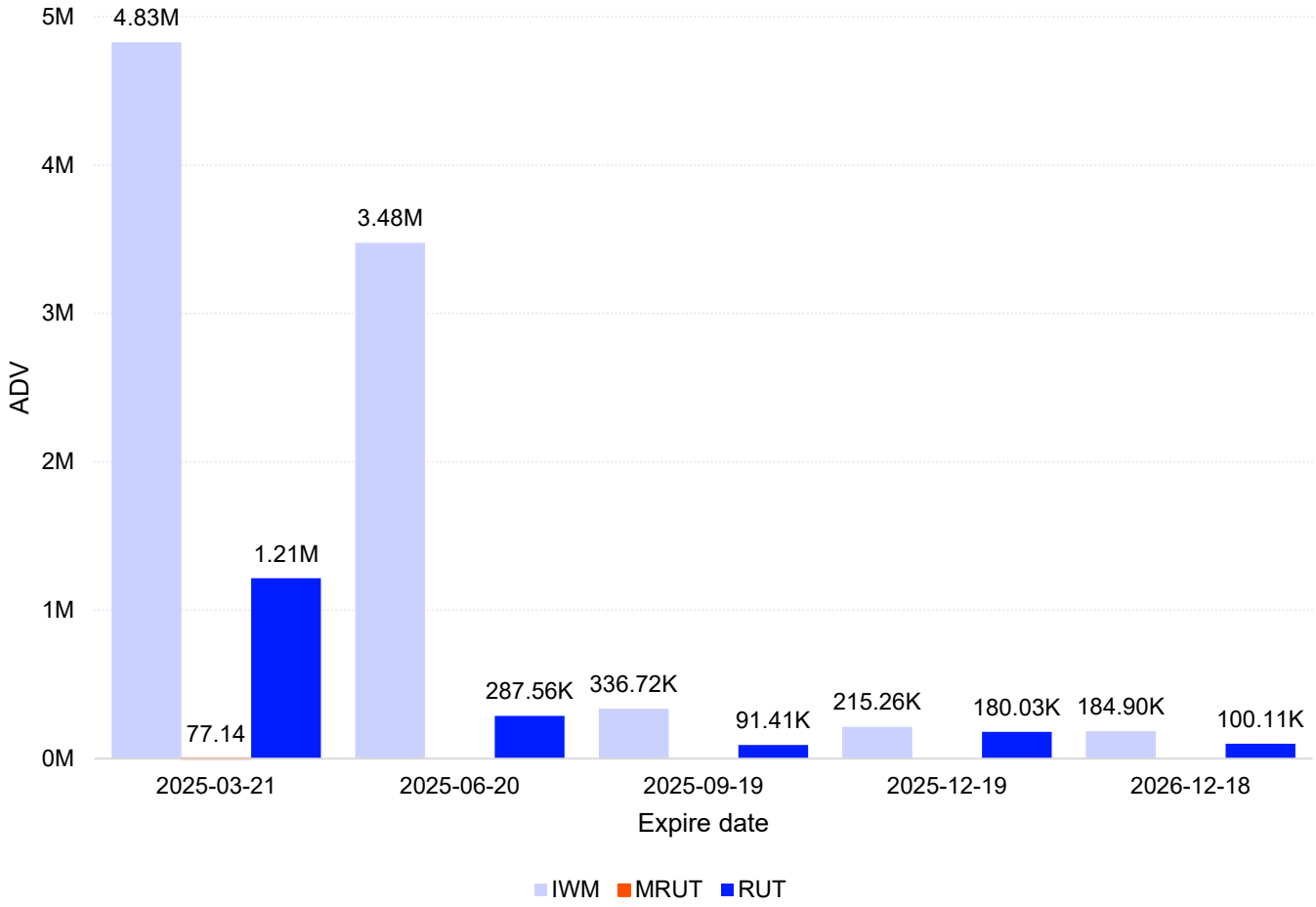
To obtain a sense of the potential scalability for employing a cliquet as a universal hedge solution for the $5T private equity market, we examine the liquidity of R2000 options along option expiries extending out 2 years. As shown in exhibits 23 and 24, although the first 3 months are extremely liquid with a combined open interest of 100M contracts ($18.8T dollar notional) with an average daily volume of 10M ($2T dollar notional), the sizing of a cliquet-type hedge will be constrained by the distant expiry contracts with an open interest of 7MM contracts (~$1.65T in dollar notional), roughly the equivalent of the combined AUM of the top 10 largest private equity firms.

Exhibit 23. Normalized OI IWM vs RUT & MRUT as of 10 December 2024



Source: Cboe Global Markets.

Exhibit 24. Normalized ADV IWM vs RUT & MRUT as of 10 December 2024



Source: Cboe Global Markets.

However, in our backtests, we find that a simple short-dated 3-month RUT put-spreads provides a comparable degree of hedge efficacy while simplifying the logistics and maintenance of the hedge.

Backtest and results

In this section, we investigate the historical performance using R2000 options as

1. A systematic hedging strategy and
2. An opportunistic in hedging the largest quarterly drawdowns in private equity.

Data and estimation

The data on Russell 2000 index options are obtained from Cboe and are standard European put options on the spot index. The index options data in our study uses the actual bid and ask price as of the close and encompasses the period from January 2005 to December 2024.

Test of efficacy

Our fundamental test of efficacy is centered on an examination of the central tenet underlying De & Barnes' proposal – are R2000 options able to hedge material drawdowns in private equity? To that end, we test the performance of various iterations of a static R2000 put/put-spreads under two tests of efficacy: a tactical hedging test of efficacy and a systematic hedging test of efficacy.

Tactical hedging

Tactical hedging is an opportunistic strategy whereupon the hedger only hedges periodically when he/she feels that there is a high likelihood that an asset is likely to decline (to avoid the negative decay associated with holding a hedge systematically). The two most important factors in the success of such a hedge are that 1) the hedge reacts contemporaneously with the asset to be hedged and 2) the magnitude of the move of the hedging instrument is material enough to offset the decline in the hedged asset. Accordingly, our test of tactical hedging efficacy is designed to answer the question, "Are R2000 options able to hedge *material* drawdowns in private equity?"

As previously mentioned, the purchase of options requires the outlay of a premium which erodes the benefits of a hedge. Assuming that options are able to provide a positive premium-adjusted return during drawdowns in private equity, the inherent basis risk implies that even for two strongly correlated assets, the hedging instrument typically offsets drawdowns in the instrument to be hedged to varying degrees. For the purposes of hedging we are more concerned that the two assets are strongly correlated during times in which private equity experiences large drawdowns and less concerned with the correlation of the assets when private equity experiences negligible drawdowns.

Thus, under the tactical hedging test of efficacy, we would consider a hedge that successfully mitigates the many small drawdowns in private equity but is unable to hedge the few large private equity drawdowns to be unsuccessful. Similarly, we would consider a hedge that successfully mitigates all or many large drawdowns in private equity but is unable to hedge minute private equity drawdowns to be a successful hedge. A significant component of this scenario is the strength of Russell 2000 vs private equity correlations during periods of private equity drawdowns.

To conduct the tactical test of efficacy, we conducted a grid search of liquid Russell 2000 options with varying parameters, with the goal of gauging the ability of R2000 options to hedge the 10 largest PE drawdowns which ranged from -16.7% in Dec 2008 to -6.5% in 2001. Leveraging the work by De and Barnes in which they exponentially weight 6 quarters of prior returns, we determined that the mean density of the temporal weighting was seven months. We then analyzed every possible combination of R2000 put and put-spread parameters by varying:

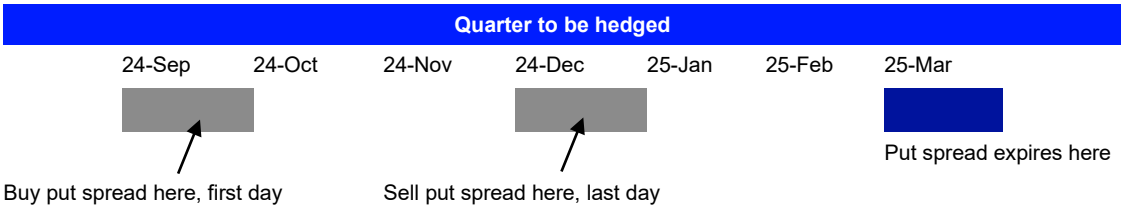
– The moneyness of both legs of the put-spread
– The expiry of the put-spread structure

The start date for each individual path of the backtest thus ranged from one month to nine months ahead of the drawdown. At each starting date, we backtest the most liquid options expiries with maturities of less than one year. At each trade date, we buy a put option ranging from 50 delta (AKA an at-the-money option) to 5 delta (AKA a deep-out-of-the-money option) and test whether performance is aided by funding the long position with the sale of out of the money 5, 10, 20, 30, and 40 delta put (thereby creating a put-spread). The put-spread is purchased at the first trading date of the holding period and systematically unwound at the last date with one quarter prior to expiry to avoid the theta burn associated with holding short-dated options. The option strikes themselves are chosen to be the closest listed strike

to the corresponding target delta. We normalize the option prices and returns as percentages of the underlying index level at the trade date.

Exhibit 25 below shows a visualization of the strategy to hedge Q4 2024. In this case we would purchase/sell monthly options expiring on March 2025 (1Q25) on the 1st day of September, and sell them on the last day of December with 3 months remaining to expiry.

Exhibit 25. Visualization of strategy to hedge Q4 2024



Source: Cboe Global Markets

Tactical test of efficacy results

The table below shows (1) top 10 largest PE drawdowns from 2007 to 2023 (2) the returns of a R2000 hedge using the optimal moneyness parameters and 3) private equity returns netted with the hedge. Our results were actually consistent with De and Barnes findings in which they determined that R2000 returns have a 70% correlation with private equity return returns. Using the R2000 put-spread in the most optimal way, the hedge portfolio was able to fully hedge 7 of the 10 largest private equity drawdowns. Most notably, this structure was able to hedge the largest PE drawdown over this period – the -16.7% decline in Dec 2008. In this case, the R2000 put-spread returned 18.9% for a net gain of 2.3%.

In 3Q08, an R2000 put-spread was able to mitigate nearly 50% of the -6.71 drawdown. Finally, in the 2 remaining cases in which R2000 put-spreads produced negative returns, (2Q08 and 1Q09), the negative R2000 put-spread return was only -0.05% and -0.07% respectively. As a matter of fact, in certain time frames such as 1Q20, 3Q11 and 4Q18, the optimally hedged portfolio was not only able to offer full downside protection but also generate outsized returns at 15.27%, 10.45% and 16.65%, respectively. On the whole, the optimal tactical put-spread hedge generated a mean return of 5.32% with a standard deviation of 4.34%.

Exhibit 26. Top 10 largest PE drawdowns tactically hedged returns. Strategy: tactical hedge

Quarter	Unhedged PE returns	Tactical hedge returns	Tactically hedged PE returns
4Q08	-16.69%	18.96%	2.27%
1Q20	-8.89%	24.16%	15.27%
3Q08	-6.71%	3.06%	-3.65%
2Q22	-4.95%	7.47%	2.52%
3Q11	-4.45%	14.90%	10.45%
1Q09	-3.64%	-0.05%	-3.69%
1Q08	-2.66%	4.07%	1.41%
4Q18	-1.12%	17.77%	16.65%
2Q08	-0.28%	-0.07%	-0.35%
3Q15	-0.18%	6.79%	6.61%

Source: Cboe Global Markets

Below is a table showing the parameters of the optimal R2000 put-spread hedges for the top 10 largest drawdowns. Interestingly, although the moneyness parameters were discerned via an optimal grid search, in the case of 8 of the 10 largest drawdowns, the long leg of the put-spread was close to 40 delta. By contrast, the optimal short leg is close to 5 delta. We can infer therefore that a "general" moneyness parameter for a R2000 put-spread to hedge private equity is a 40–5 delta put-spread.

Exhibit 27. Top 10 largest PE drawdown tactical hedge structure

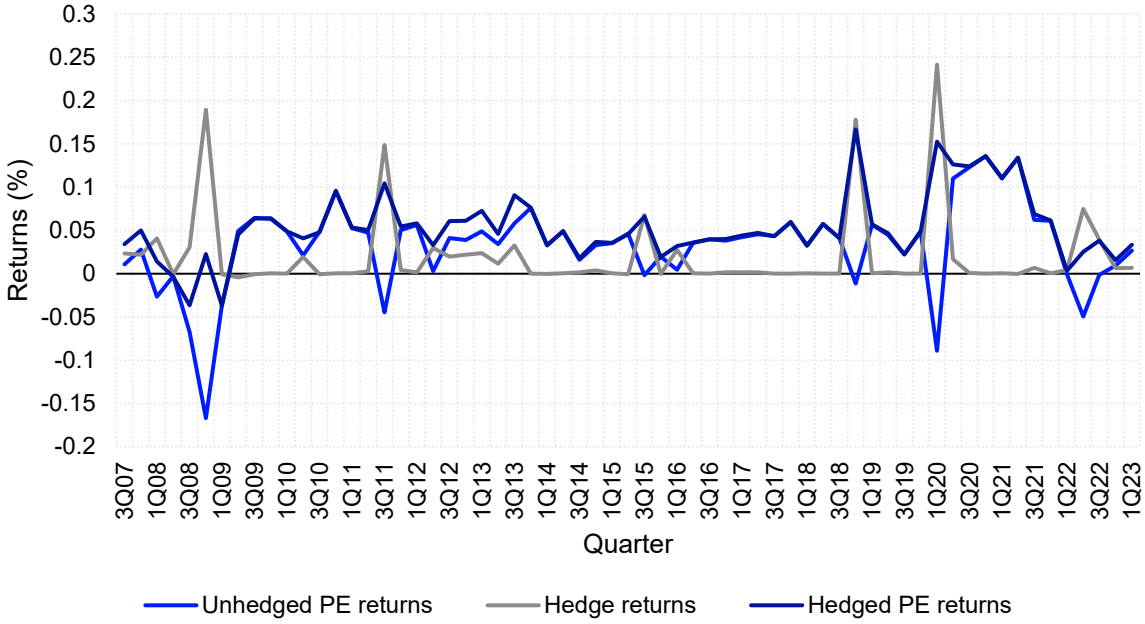
						Put spread structure					
	R2000 spot price		Trade dates			Long			Short		
Quarter	At opening	At closing	Opening date	Closing date	Expire date	Strike price	Delta	Moneyness	Strike price	Delta	Moneyness
4Q08	738.51	499.45	9/2/2008	12/31/2008	3/21/2009	730	-0.42515	Near ATM	500	-0.01718	30% OTM
1Q20	1607.58	1153.10	12/2/2019	3/31/2020	6/19/2020	1600	-0.43404	Near ATM	500	0.00000	70% OTM
3Q08	741.02	679.58	6/2/2008	9/30/2008	12/20/2008	740	-0.43897	Near ATM	490	-0.00545	30% OTM
2Q22	2008.51	1707.99	3/1/2022	6/30/2022	9/16/2022	2000	-0.43591	Near ATM	1300	-0.04162	40% OTM
3Q11	821.4	644.16	6/1/2011	9/30/2011	12/17/2011	820	-0.46085	Near ATM	200	0.00000	80% OTM
1Q09	417.07	422.75	12/1/2008	3/31/2009	6/20/2009	410	-0.37501	Near ATM	400	-0.35891	Near ATM
1Q08	759.97	687.97	12/3/2007	3/31/2008	6/21/2008	750	-0.42500	Near ATM	570	-0.07511	20% OTM
4Q18	1733.38	1348.56	9/4/2018	12/31/2018	3/15/2019	1730	-0.43053	Near ATM	720	0.00000	60% OTM
2Q08	684.22	689.66	3/3/2008	6/30/2008	9/20/2008	680	-0.43095	Near ATM	670	-0.40656	Near ATM
3Q15	1251.05	1099.85	6/1/2015	9/30/2015	12/19/2015	1250	-0.47240	Near ATM	500	0.00000	60% OTM

Source: Cboe Global Markets

Tactical test of efficacy across economic regimes

To obtain a sense for cyclicality of returns for the tactical hedges under different economic regimes, we show a chronological time series of the returns of private equity, the optimal R2000 put-spread hedge and the hedge private equity return from 2Q07 to 1Q23. From this perspective, we note that the optimally hedged portfolio generates positive returns in all but 3 quarters during the Great Financial Crisis: 2Q08, 3Q08, and 1Q09. It is worth noting that during the worst quarter of the GFC 4Q08, the tactically hedged PE portfolio using R2000 put-spread was able to cover the entire downside and generated a positive return of 2.27%.

Exhibit 28. Tactically hedged returns by quarter



Source: Cboe Global Markets

Tactical test of efficacy (most recent drawdown)

The final consideration in the test of efficiency is the determination of whether the hedge relationship is stable through time. Given that the largest and arguably most successful result occurred 16 years ago, we examined whether R2000 options were able to hedge the most recent private equity drawdown in Jun 2022, which was the 8th largest in our dataset in which PE declined -5%. In this case, the R2000 put-spread returned 11.5% for a net gain of 6.5%.

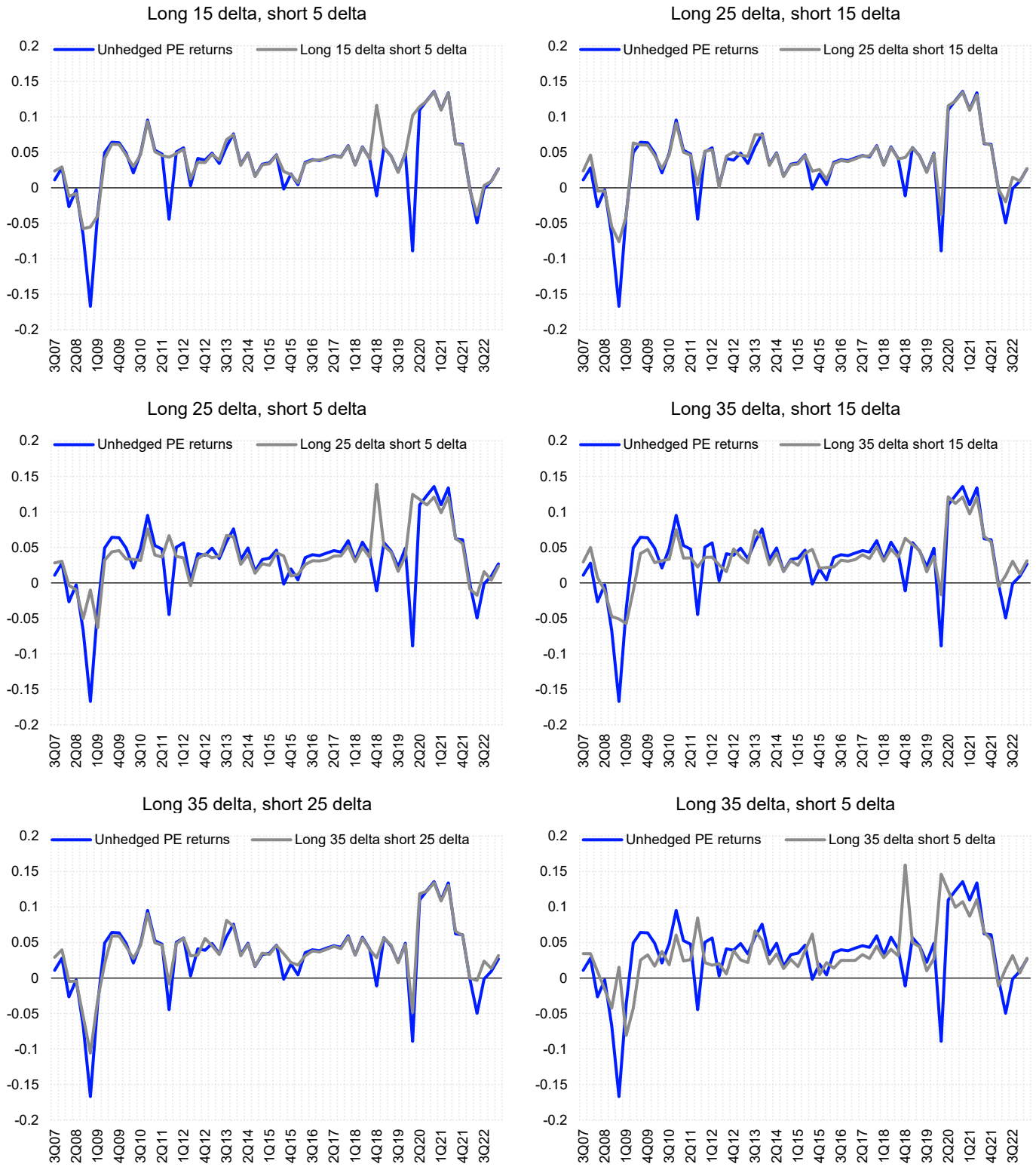
Test of efficacy: systematic hedging

Given the encouraging results from the tactical hedging test of efficacy, the Systematic Hedging test of efficacy is designed to answer the question, “Does there exist a standard set of moneyness parameters that are able to hedge material drawdowns in private equity?” For this scenario, we hold every combination of put-spreads in 10 delta increments static throughout the entirety of our sample period from 2007–2024 and examine its overall performance in hedging the 10 largest drawdowns as well as its overall annualized performance over the entire sample period. The challenge in this scenario is to minimize theta decay when private equity advances while simultaneously maximizing hedging performance during private equity drawdowns.

Systematic test of efficacy across economic regimes

Because this strategy is systematic, we begin this analysis by performing a grid search in which we vary the moneyness parameters of the put-spread to determine the optimal “buy and hold” hedge from 2Q07 to 1Q23 as shown below.

Exhibit 29. Systematically hedged portfolio performance



Source: Cboe Global Markets

Systematically test of efficacy results

Exploring multiple combinations of long & short delta, we find that the portfolio of long 15 near the money delta and short 5 deep OTM delta, is the most successful buy and hold (AKA “always on”) hedging strategy for private equity from 3Q07 to1Q23. This structure was able to generate positive returns for 57 out of 64 quarters and generated a mean return of 0.90% with a standard deviation of 3.35%.

In the table below, we find that out of the 10 worst quarterly PE returns over the 16 years period, the systematically hedged portfolio was able to offer some downside protection for all but two quarters of the 2008 Great Financial Crisis: 1Q09 and 2Q08. It is worth noting that during the worst drawdown of 4Q08, where the unhedged PE portfolio fell 16.69%, the put-spread hedge returned 11.18%, protecting a significant % to the downside. Furthermore, in certain period such as 1Q20—the 2nd worst PE drawdown—and 4Q18, the systematically hedged PE portfolio was able to generate outsized returns at 10.18% and 11.2%, respectively.

Exhibit 30. Top 10 largest PE drawdowns systematic hedge returns. Strategy: systematically long 15 delta and short 5 delta

Quarter	Unhedged PE returns	Systematic hedge returns	Systematically hedged PE returns
4Q08	-16.69%	11.18%	-5.51%
1Q20	-8.89%	19.07%	10.18%
3Q08	-6.71%	0.95%	-5.76%
2Q22	-4.95%	1.11%	-3.84%
3Q11	-4.45%	8.75%	4.30%
1Q09	-3.64%	-0.32%	-3.96%
1Q08	-2.66%	1.46%	-1.20%
4Q18	-1.12%	12.74%	11.62%
2Q08	-0.28%	-0.50%	-0.78%
3Q15	-0.18%	2.47%	2.29%

Source: Cboe Global Markets

Below is the hedge structure of the systematically hedged portfolio:

Exhibit 31. Top 10 largest PE drawdown optimal hedge structure.
Strategy: systematically long 15 delta and short 5 delta

	R2000 spot price		Trade dates			Put spread structures	
Quarter	At opening	At closing	Opening date	Closing date	Expire date	Long strike	Short strike
4Q08	738.51	499.45	9/2/2008	12/31/2008	3/21/2009	730	-0.42515
1Q20	1607.58	1153.10	12/2/2019	3/31/2020	6/19/2020	1600	-0.43404
3Q08	741.02	679.58	6/2/2008	9/30/2008	12/20/2008	740	-0.43897
2Q22	2008.51	1707.99	3/1/2022	6/30/2022	9/16/2022	2000	-0.43591
3Q11	821.4	644.16	6/1/2011	9/30/2011	12/17/2011	820	-0.46085
1Q09	417.07	422.75	12/1/2008	3/31/2009	6/20/2009	410	-0.37501
1Q08	759.97	687.97	12/3/2007	3/31/2008	6/21/2008	750	-0.42500
4Q18	1733.38	1348.56	9/4/2018	12/31/2018	3/15/2019	1730	-0.43053
2Q08	684.22	689.66	3/3/2008	6/30/2008	9/20/2008	680	-0.43095
3Q15	1251.05	1099.85	6/1/2015	9/30/2015	12/19/2015	1250	-0.47240

Source: Cboe Global Markets

Concluding remarks on backtests

Using an empirical grid search, we were able to confirm De & Barnes' research that R2000 options can provide a viable solution to hedge quarterly drawdowns in private equity. Our results show that for tactical hedges, the optimal trade is to buy a 40–5 delta put-spread 2 quarters ahead of the period of drawdown uncertainty. Alternatively, one can implement a systematic "always on" hedge buying a 15–5 delta put-spread, bearing in mind that in this case, one is trading off superior performance during material drawdowns in exchange for mitigating decay risk during market advances.

In conclusion

This study contributes to the growing literature on private equity as an asset class and how it is related to public equity, with implications for asset allocation and risk management. By understanding the relationship between private and public equities, investors can better understand how they relate to each other in portfolios.

Using private equity data from Cambridge Associates and Russell index data, De and Barnes from FTSE Russell describe how the private equity landscape has evolved, particularly with the shift from small-cap to mega-cap funds in terms of assets under management. By focusing on measures of co-movement, they explore whether private and public equity are as distinct as often described. Using correlation and tracking error, they find:

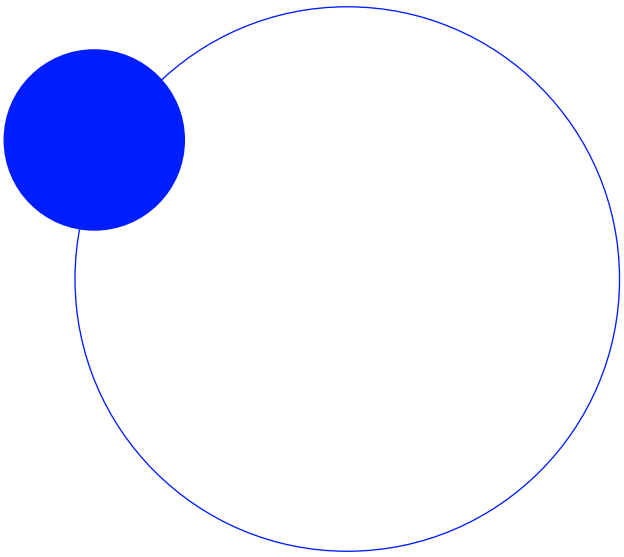
– Private and public equities have become more correlated over time.

– Adjusting for “smoothing” in private equity returns reveals even greater similarity.

These findings suggest increasing convergence between the two asset classes. This sets the stage for whether private equity derivatives can hedge private equity risk.

Tom analyzes Cboe options based on the Russell 2000 Index and conducts backtests on tactical and systematic hedging strategies. He finds that a tactical Russell 2000 put-spread fully hedged seven of the ten largest private equity drawdowns, including during the Great Financial Crisis. The systematic strategy provided downside protection in eight of the ten worst quarterly drawdowns and, in some cases, generated strong hedge returns.

Together, these studies point to both a changing private equity landscape and to the interconnectedness of private and public equity in terms of co-movement and risk. This study is limited to US private equity; future research should test the findings within different segments of the private markets and in non-US markets.



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