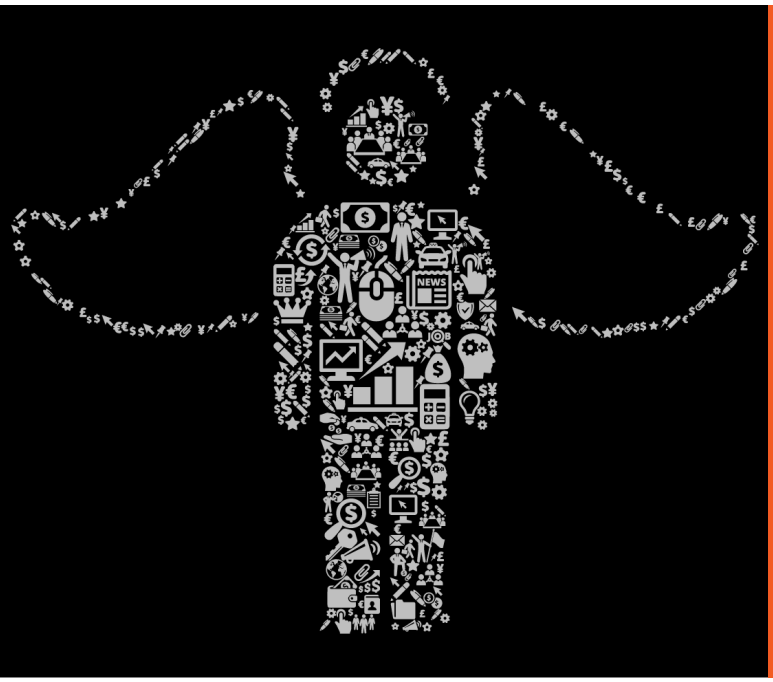

Alternative Investment Analyst Review

Call for Articles

Article submissions for future issues of Alternative Investment Analyst Review (AIAR) are always welcome. Articles should cover a topic of interest to CAIA members and should be single-spaced. Additional information on submissions can be found at the end of this issue. Please e-mail your submission or any questions to: **AIAR@CAIA.org**.

Chosen pieces will be featured in future issues of AIAR, archived on **CAIA.org**, and promoted throughout the CAIA community.

Editor's Letter

An Alternative Examination of the Costs and Benefits of Allocations to Alternatives

The benefits of allocating to alternative investments are by now well documented. Unfortunately, almost all studies of the benefits of allocating to alternatives, including the one published in each issue of this journal under the title "The List: Alternative Indices," are somewhat flawed. The primary flaw of these studies is the assumption that the asset allocator can invest in a diversified index of alternatives such as CISDM's Equally Weighted Hedge Fund Index or Cambridge Associates' Private Equity Index. Of course, none of these alternative asset class benchmarks are investable and, in some cases, may not accurately represent the performance of the asset class. For example, many of the underlying funds used to create these benchmarks might be closed to new investors and/or may be subject to self-selection or backfill biases.

The main problem stemming from the use of indices is the performance dispersion of the underlying investment managers is ignored. Unlike traditional asset classes where one can invest directly in a benchmark, such as the MSCI World Equity Index, investments in alternatives require allocations to managers, and there are substantial dispersions in the performance of managers of alternative asset classes. Even if an allocator were to use investment managers for traditional asset classes, the performance dispersion of these managers is only a fraction of that of alternative investment managers.

Exhibit 1 displays the median, top-quartile, and bottom-quartile investment manager performance for various asset classes. The estimated dispersions displayed here come from different sources and cover slightly different periods. Therefore, there are bound to be some estimation errors. However, the message conveyed by this exhibit is clear. There is significant dispersion, or manager selection risk, associated with allocating to alternative investments, and studies that use benchmarks or indices to measure benefits of allocating to these asset classes ignore this important risk.

In Exhibit 1, it's obvious that the dispersion of performance is not uniform among various asset classes. Not surprisingly, the dispersion is the smallest for traditional equity and fixed income managers. On the other hand, the dispersion is quite substantial for most alternative asset classes. The implication of this exhibit is that, because of luck or skill, some investors may allocate to top managers while others, because of bad luck or poor skills, may end up with bottom quartile managers. Of course, all allocators start the process with the goal of investing in top-quartile managers, but some ended up allocating to bottom quartile managers.

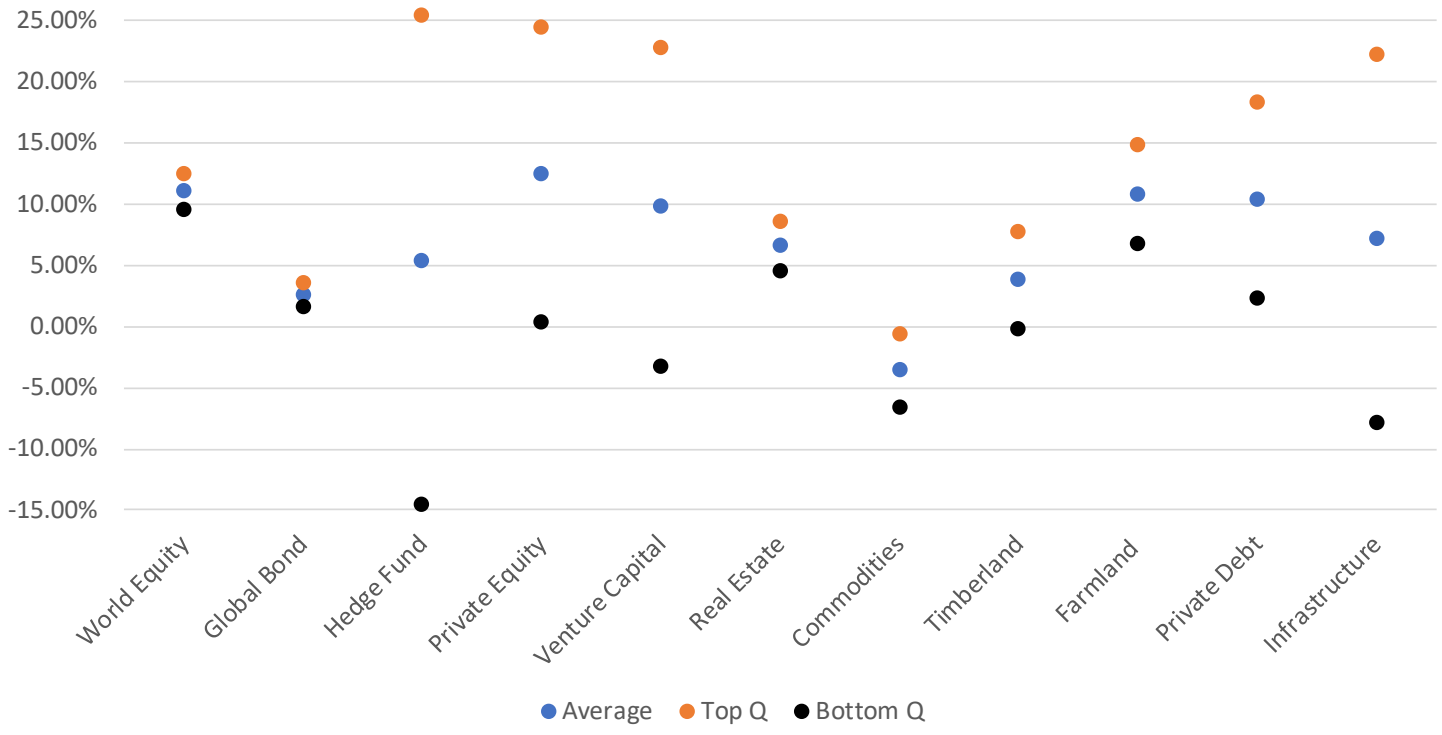

Exhibit 1: Average, Top Quartile, and Bottom Quartile Performance of Managers
Source: See Appendix

It's worth noting that this exhibit and its return information comes with three important caveats:

1. It does not reveal the type of investors (e.g., individual, institutional, etc.) that end up with allocations to poor performing managers or how much they allocate to these managers.
2. It does not account for the presence of autocorrelation (i.e., price smoothing) in the underlying indices.
3. It does not account for manager diversification within the indices (i.e., how correlated are managers that are included in an index.)

We will address the last two bullet points, as they are more important to this study.

Autocorrelation: Unlike public markets, where pricing data is available daily, private markets and other alternative investment asset classes are usually appraised and reported quarterly. Less frequent appraisals can increase the likelihood of price smoothing. Quarterly appraisals are subject to an anchoring effect, meaning current appraisals are heavily influenced by the previous quarter's appraisals. Over multiple quarters, recent prices become highly correlated to previous prices, which gives rise to autocorrelated return series. When autocorrelation is present in a series of prices, it can understate traditional risk metrics, such as standard deviation, maximum drawdowns, and correlation to other asset classes.

Sub-Manager Diversification: Many alternative investment indices are constructed by aggregating managers within the same asset class and/or those following a similar investment strategy (e.g., core real estate or venture capital). Not every manager in the index is doing the same thing, which means the performances of these managers are less perfectly positively correlated with each other. As a result, alternative indices will have much lower volatility than the average single manager because the less than perfect correlations amongst them create an additional level of diversification.

The next two sections of this piece will focus on comparing traditional investments with alternative investments, specifically how portfolio characteristics change when adjustments for smoothing and manager selection risk are included. The Traditional Approach does not adjust for autocorrelation or sub-manager diversification, but the Alternative Approach addresses both issues.

Summary of Findings

We use a simulation approach and then employ the risk-adjusted performance measure used by Morningstar for ranking mutual funds to measure the benefits of allocating to alternative asset classes. Our findings are:

- When adjusted for smoothing, the return volatility of all alternative asset classes increases. The increases are most significant for private equity, venture capital and private debt, which are less liquid than commodities or hedge funds. Other illiquid asset classes such as infrastructure, timber, and farmland also display higher volatility but not as much.
- For an average investor, the benefits of allocation to alternative asset classes are reduced by 17% when the return smoothing effect is accounted for. The decline in the benefits of allocating to alternatives is much larger for investors who have above average risk aversion. However, these investors display a much larger benefit, to begin with.
- For an average investor, the benefits of allocating to alternatives are reduced by 13% when managers' return dispersion is considered. The decline is more than twice as much for investors who are above average risk-averse.
- Finally, when both return smoothing and return dispersion are considered, the benefits of allocating to alternatives are cut by more than 50%.
- The results show that investors would benefit from allocating more capital to the due diligence process as lower manager selection risk will have a significant impact on the potential benefits of allocating to alternative asset classes.
- To the degree that funds of funds may reduce the manager selection risk and potential return dispersion, the results reported here could be used to justify the use of funds of funds as a way of accessing alternative assets.

Traditional Approach

Exhibit 2 provides the summary statistics for the traditional and alternative asset classes discussed in Exhibit 1. These statistics span a 11-year period from December 31, 2007, to December 31, 2018. Over this period, almost every asset class was positive since this was a strong period for financial markets. Across rolling one-, three-, five-, and ten-year periods, private equity was the best-performing asset class, while commodities were worst performing asset class over the same periods.

Asset Class	Return Measures					Risk Measures**			
	1-Year	3-Year	5-Year	10-Year	11-Year	Volatility	Skew	Kurt	Max DD
World Equity	-7.4%	7.3%	5.5%	11.1%	5.8%	17.5%	-0.6	0.7	-47.4%
Global Bonds	-1.1%	2.9%	1.2%	2.6%	2.8%	6.1%	0.1	0.2	-7.2%
Hedge Funds	-4.7%	3.6%	2.9%	6.0%	3.6%	8.1%	-0.5	1.8	-19.2%
Private Equity	10.4%	12.8%	12.0%	12.4%	9.0%	7.9%	-2.4	8.0	-26.6%
Venture Capital	13.3%	8.2%	10.1%	9.8%	7.2%	6.8%	-1.1	3.5	-19.8%
Real Estate	6.3%	9.5%	10.4%	6.6%	3.1%	9.7%	-3.3	13.4	-45.9%
Commodities	-11.4%	2.3%	-12.6%	-3.6%	-6.6%	27.8%	-0.9	1.7	-80.0%
Timerland	3.2%	3.1%	4.9%	3.8%	4.3%	3.6%	0.8	4.2	-5.7%
Farmland	6.6%	6.5%	8.3%	10.8%	11.2%	4.7%	1.7	2.1	0.0%
Infrastructure	9.1%	9.1%	9.7%	7.2%	8.4%	7.3%	-2.8	12.4	-23.2%
Private Debt	3.7%	7.3%	7.1%	10.4%	7.0%	8.4%	-2.0	7.2	-26.3%
Global 60/40 Portfolio	-4.9%	5.5%	3.8%	7.7%	4.6%	11.2%	-0.2	0.6	-30.5%
Alternative Portfolio*	3.4%	6.9%	6.3%	8.1%	5.7%	6.7%	-2.2	6.4	-21.1%
30% World Equity, 20% Global Bond, 50% Alternatives Portfolio	-0.8%	6.2%	5.1%	7.9%	5.2%	8.6%	-0.9	1.5	-25.4%

Exhibit 2: Asset Class Returns and Risk Measures from December 31, 2007 – December 31, 2018
Source: See Appendix
* Alternatives Portfolio is an equal-weight portfolio of hedge funds, private equity, real assets, and private debt
** Risk is measured over the entire period

A traditional, moderately aggressive portfolio consisting of 60% global stocks and 40% global bonds returned 7.7% over a rolling 10-year period. Traditional assets experienced a strong decade of performance, as global equity markets soared, and bond prices rose due to falling global interest rates. However, by looking back an additional year to include some of the worst months of the Global Financial Crisis, traditional asset returns become much more muted. A traditional global 60/40 portfolio over this time period returned 4.6%, much lower than the 10-year return of 7.7%.

Most alternative investments had a strong decade as well. For simplicity, we created a portfolio that equally weighted hedge funds, private equity (PE and VC), real assets (real estate, commodities, timberland, farmland, and infrastructure), and private debt. This "Alternatives Portfolio" outperformed a global 60/40 portfolio over rolling one-, three-, and five-year periods, while almost matching it over a rolling 10-year period. All of this is done with significantly less risk. Similar to traditional investments, a portfolio comprised of alternative investments saw a decrease in returns when we include 2008. However, the alternative portfolio actually outperformed the traditional portfolio by over 1% and did so with a fraction of the volatility of the drawdown.

We then created a portfolio comprised of 30% global stocks, 20% global bonds, and 50% alternatives. This combined portfolio generated a very similar performance to a 60/40 portfolio over the entire period. While these returns are impressive and expected given the performance figures of the two separate portfolios, the combined portfolio of traditional and alternatives reduced the global 60/40 portfolio's standard deviation and maximum drawdown by approximately 40%. In other words: similar returns, lower risk, higher risk-adjusted measures.

Now, this approach still only considers alternatives at the index level. The next section, aptly named the "Alternative Approach," will consider allocating to alternatives at the manager level, and account for variables such as autocorrelation and sub-manager diversification.

Alternative Approach

The Alternative Approach uses the following simulation to measure the potential benefits of allocating to alternative asset classes.

First, historical means, correlations, covariances, volatilities, and autocorrelations of the asset classes in Exhibits 1 and 2 are estimated from the 2007-2018 data.

Second, the estimated covariances and volatilities are adjusted for data smoothing. To perform this adjustment, we used the following equation:

$$\sigma_{ij} = \gamma_i \gamma_j \times k_{ij} \times \left(\frac{1+\rho_i}{1-\rho_i} \times \frac{1+\rho_j}{1-\rho_j} \right)^{1/2}$$

Here, σ_{ij} is the unsmoothed covariance between asset *i* and asset *j*. Note that when *i*=*j*, the unsmoothed variance is obtained. The reported (i.e., smoothed), standard deviation of asset *i* is represented by γ_i, the autocorrelation of return series of asset *i* is represented by ρ_i, and the reported correlation between asset *i* and asset *j* is represented by k_{ij}. Again, note that when *i*=*j*, k_{ij}=1.

Exhibit 3 displays the same risk measures that appeared in Exhibit 2 in their original form, but also adds an additional column that adjustments for return smoothing. As expected, we see significant increases in risk measures associated with alternative investments, both on a standalone basis and as part of a portfolio. It is important to note that while unsmoothing the returns will always lead to an increase in estimated volatility, there are occasions where the estimated maximum drawdown could actually decrease (e.g., see infrastructure investment below). This could happen especially when the sample size is not long or unsmoothing the returns makes large positive returns even larger.

Third, to generate simulated returns on asset classes, we need to account for the possibility that each asset class return could come from three different groups of managers: top quartile, bottom quartile, and median. We account for this by randomly changing the mean of the distribution from which returns are generated. Specifically, for each asset class, we assume 25% of returns come from a distribution where the mean return corresponds to the performance of a bottom quartile manager. Similarly, 25% and 50% of the returns will come from distributions corresponding to the top and median managers, respectively. When generating the simulated results, one critical assumption we make is that top quartile, bottom quartile, and median managers have the same covariance matrices, as we lack the information to calculate the covariance matrices of these groups of managers.

Fourth, the simulated returns are then used to create the portfolios that appear in Exhibit 2 and Exhibit 4 (see below). To measure the performances of these portfolios on a risk-adjusted basis, we use the expected utility approach, an approach employed by Morningstar to rank mutual funds, to rank these portfolios and, more importantly, to measure the certainty equivalent return of each asset allocation strategy.

Asset Class	Risk Measures			
	Volatility (Smoothed)	Volatility (Unsmoothed)	Maximum Drawdown (Smoothed)	Maximum Drawdown (Unsmoothed)
World Equity	17.5%	21.5%	-47.4%	-49.5%
Global Bonds	6.1%	5.3%	-7.2%	-6.8%
Hedge Funds	8.1%	11.0%	-19.2%	-23.0%
Private Equity	7.9%	15.4%	-26.6%	-40.3%
Venture Capital	6.8%	12.4%	-19.8%	-29.3%
Real Estate	9.7%	18.8%	-45.9%	-58.2%
Commodities	27.8%	33.2%	-80.0%	-84.9%
Timerland	3.6%	4.4%	-5.7%	-6.7%
Farmland	4.7%	4.9%	0.0%	0.0%
Infrastructure	7.3%	12.1%	-23.2%	-32.9%
Private Debt	8.4%	15.0%	-26.3%	-32.9%
Global 60/40 Portfolio	11.2%	13.4%	-30.5%	-31.9%
Alternative Portfolio*	6.7%	10.6%	-21.1%	-28.8%
30% World Equity, 20% Global Bond, 50% Alternatives Portfolio	8.6%	11.8%	-25.4%	-27.6%

Exhibit 3: Adjusted Asset Class Risk Measures from December 31, 2007 - December 31, 2018
Source: See Appendix

Morningstar's approach consists of applying the following model to the return series of a mutual fund or a portfolio.

$$CE = \left(\frac{1}{T} \sum_{t=1}^{T} \left(\frac{1+R_{pt}}{1+R_{ft}} \right)^{-\gamma} \right)^{-\frac{12}{\gamma}}$$

Here $\gamma > 0$ is a measure of risk aversion where a higher value of γ indicates a higher degree of risk aversion on the part of the investor. The per period return on the portfolio is given by R_{pt} while the per-period rate of return on the risk-free asset is represented by R_{ft}. Finally, *CE* is one plus the annual excess certainty equivalent return of the portfolio. For example, if *CE* = 1.05, it means that the investor will be indifferent between earning the rate of the return on the portfolio and earning a safe return of 5% per year in excess of the riskless rate. Like Morningstar, we use the calculated certainty equivalents to measure the performance of each asset allocation strategy.

The advantage of this approach is that it accounts for quarterly variation in returns. Therefore, it can account for changes in the return distribution of each asset class as mean returns are randomly changed to reflect the dispersion of performance amongst the underlying managers.

	Common Approach: No Adjustments		Adjusted Only for Dispersion		Adjusted Only for Smoothing		Adjusted for Both Smoothing and Dispersion	
Allocations	**30/20/50**	**60/40**	**30/20/50**	**60/40**	**30/20/50**	**60/40**	**30/20/40**	**60/40**
	Moderately Risk Averse Investor							
Measure of Performance	1.0274	1.0162	1.0252	1.0162	1.0230	1.0162	1.0211	1.0162
Relative Risk Adjusted	69%		56%		42%		30%	
	Above Average Risk Averse Investor							
Measure of Performance	1.0211	1.0065	1.0198	1.0065	1.015	1.0065	1.013	1.0065
Relative Risk Adjusted	225%		205%		131%		100%	
	Below Average Risk Averse Investor							
Measure of Performance	1.0363	1.0207	1.0292	1.0207	1.0283	1.0207	1.0255	1.0207
Relative Risk Adjusted	75%		41%		37%		23%	

Exhibit 4: Measures of Risk-Adjusted Performance for Various Allocation Strategies.
Source: Authors' Calculations.

Exhibit 4 presents our simulation results, which were generated using 10,000 simulations of returns on a 10-year investment horizon. The first two rows display the results when the investor's measure of risk aversion is 2, often considered to be the average degree of risk aversion. Under various scenarios, the multi-asset portfolio consisting of traditional and alternative asset classes outperforms the 60/40 portfolio that consists of only traditional asset classes.

This is the good news for investors who hold such portfolios. Using the traditional approach, the CE for the 30/20/50 portfolio is 69% greater than that of the 60/40 portfolio when no adjustments for smoothing and manager selection risk are made. However, the traditional approach uses benchmarks and indices to create the multi-asset portfolio, which significantly overestimates the benefit of holding multi-asset portfolios of traditional and alternative asset classes. When the return series is adjusted to account for manager dispersion, the CE for the 30/20/50 portfolio is greater than the 60/40 portfolio by 56%. Further, when both smoothing and manager dispersion are considered, the CE of the 30/20/50 is only 30% greater than the 60/40 portfolio.

The second set of results presents the same set of calculations when the measure of risk aversion is above average ($\gamma = 4$). We see a similar decline in the relative performance of the 30/20/50 portfolio as we account for both smoothing and manager dispersion. However, notice that the relative outperformance increases with the level of risk aversion. The reason is that the 30/20/50 portfolio has much lower volatility and, therefore, its certainty equivalent is higher than that of the 60/40 portfolio. It is worth noting that, relative to the investor with average risk aversion, the certainty equivalents are lower for the investor with above-average risk aversion.

The final set of results considers an investor with below-average risk aversion ($\gamma = 1.25$). In this case, the diversification benefits of alternatives are as highly valued, and the impacts of the return smoothing and manager selection risk are muted as well.

Implications

The analysis presented here has three broad implications. The first, and more obvious, implication is that manager dispersion, or "manager selection risk," reduces the benefits of allocating to alternative asset classes. However, even in the presence of manager selection risk, there are significant benefits to the allocating to alternative asset classes, and these benefits are even more substantial for investors with above-average risk-aversion.

The second implication is that we can measure the potential benefits of improved due diligence. For example, for average-risk aversion, there is a 0.022% decline in the certainty equivalent when manager selection risk is considered. We can use this to measure to justify the amount that we should be willing to spend on due diligence to reduce manager selection risk. For instance, for each $100 million that we plan to allocate to alternative asset classes, we could spend up to $220,000 on manager due diligence and selection costs, not an insignificant amount.

The third implication is that there are circumstances under which an asset allocator will be better off to invest in a fund of funds, reducing the manager dispersion risk of the portfolio. For example, an investor who plans to make a small allocation to a certain set of alternative asset classes would find it beneficial to select a fund of funds manager rather than assuming a significant amount of individual manager selection risk.

Appendix

As mentioned in the text, the manager dispersion figures were obtained from various sources. The following is a list of sources and time periods covered by various strategies.

1. "Guide to Alternatives, 3Q 2019," JP Morgan Asset Management. This is used as a source of dispersion of global equity, global fixed income, US core and US non-core real estate, global private equity, US venture capital, and hedge fund managers. The time period covered is 1Q 2009-1Q 2019.
2. Preqin Database. This is used as the source for infrastructure and private debt managers. In addition, we used this source to run additional checks on private equity, venture capital, and hedge fund managers. The time period covered is 1Q 2009-4Q 2018.
3. CISDM Hedge Fund Database: This is used as a source to run an additional check on the dispersion of hedge fund managers. The time period covered is 1Q 2009-1Q 2019.
4. "Insights into Efficiency and Manager Selection: A Look at Quartile Returns of Timberland Funds," Chung-Hung Fu, Timberland, and Investment Resources, 2014. This is used as a source for timberland fund managers. The time period covered is Q2 2002-Q2 2014.

We did not have reliable sources for the dispersion of commodity and farmland managers. For commodity managers, we assumed they have the same cross-sectional dispersion relative to their means as that of the global equity fund managers. For farmland fund managers, we assumed they have the same cross-sectional dispersion relative to their means as that of the timberland fund managers.

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Dr. Hossein Kazemi is the Senior Advisor to the CAIA Association's Program. Dr. Kazemi has been involved with the CAIA Association since its inception as a senior advisor and a managing director. In his current role, he helps with the development of the CAIA program's curriculum and directs the CAIA Association's academic partnership program. In addition, he serves as the editor of *Alternative Investment Analyst Review*, which is published by the Association. He has worked with universities and industry organizations to introduce them to the CAIA program. Dr. Kazemi is Michael and Cheryl Philipp Distinguished Professor of Finance at the Isenberg School of Management, the University of Massachusetts - Amherst. He is the Director of the Center for International Securities & Derivatives Markets, a nonprofit organization devoted to research in the area of alternative investments, a co-founder of the CAIA Association, and home to CISDM Hedge Fund/CTA Database and the *Journal of Alternative Investments*, the official research publication of the CAIA Association. He has over 25 years of experience in the financial industry and has served as consultant to major financial institutions. His research has been in the areas of valuations of equity and fixed income securities, asset allocation for traditional and alternative asset classes, and evaluation and replication of active management investment products. He has a Ph.D. in finance from the University of Michigan.

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Aaron Filbeck is the Associate Director of Content Development at CAIA Association. In his role, Aaron is involved with the development of the CAIA program's curriculum, supports the Association's academic partnership program, and serves as Content Director and Assistant Editor of Alternative Investment Analyst Review, a practitioner focused journal published by the Association. Prior to his role at CAIA, Aaron was a portfolio manager for a registered investment adviser where he oversaw portfolio construction and manager research efforts for high net worth individuals. Aaron holds the Chartered Financial Analyst (CFA), Chartered Alternative Investment Analyst (CAIA), and Certificate in Performance Measurement (CIPM) designations. He is a member of the CFA Institute and Vice President of CFA Society Columbus.

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Wozu (Whereto) Hedge Funds? The Case of Equity Long-Short Strategy

Masao Matsuda, *CAIA*
Crossgates Investment and Risk Management

Since Alfred W. Jones started his collective investment vehicle in 1949, hedge funds have come a long way, covering an array of strategies and investments in financial securities, derivative contracts, and other assets. The original hedge fund, the Jones Hedge Fund, had a relatively narrow focus and "invested in US stocks, both long and short," with the aim of "limit[ing] market risk while focusing on stock selection."[1] It was quintessentially a US equity long-short fund.

Although the basic premise of equity long-short strategy remains unchanged, the strategy has progressed in terms of implementation. The evolutionary changes that the strategy has embraced stem from the growing sophistication of investors and narrowing of the definition of alphas that can be attributed to hedge fund managers' investment capability. The ready availability of liquid alternatives and factor investments today has compounded a challenge to the equity long-short strategy. This paper argues that in order for a larger universe of hedge funds to remain competitive and relevant, these funds are compelled to find ways to bring true value to investors, which investors cannot realize by themselves. This paper is, in large part, based on and motivated by an educational event hosted by the CAIA New York Chapter in June 2019.[2]

Wozu (Whereto)[3] Hedge Funds?

As of March 31, 2019, hedge fund assets under management (AUM) totaled $3.18 trillion[4] which, along with private equity,[5] constitute one of the two largest categories of alternative investments. These days, hedge funds engage in extremely varied strategies, including those historically been deemed the domains of private equity, private debt and private real estate investments. As hedge fund assets rise and their investor base broadens, expectations toward hedge funds have become wide-ranging and, at times, overblown. For instance, some investors become disillusioned when a certain hedge fund does not beat the S&P 500 Index every year, even though the fund's explicit objective may be to extract alphas and lessen the return gyrations stemming from beta exposure to equity and other markets.

Such an inflated expectation aside, there are reasons hedge fund investors ought to be concerned. Exhibit 1 shows the cumulative returns of the Barclay Hedge Fund Index from January 2015 to March 2019. The exhibit also shows the cumulative returns of a portfolio that is intended to replicate the index by allocating 50% of assets to the iShare MSCI World ETF (URTH), 20% to the iShares U.S. Treasury Bond ETF (GOVT), and 30% to U.S. T-bills.[6] Note that the replicating portfolio consists of highly liquid instruments only, and any investor can actually implement the trades involving these ETFs and T-bills easily.[7] Each month, the replicating portfolio is rebalanced so that weights for each asset will remain at 50%, 20%, and 30% respectively at the beginning of every month.[8]

It is remarkable how closely the replicating portfolio tracks the Barclay Hedge Fund Index, based on the simple rebalancing rule just described. The replicating portfolio has somewhat larger volatility (σ=1.69%) than the index (σ=1.32%), but most of the turning points have occurred at the same time. The correlation coefficient between monthly returns of the index and the replicating portfolio is very high (r=0.90). Insofar as the average hedge fund performance during the four year period is concerned, it is difficult to claim that those hedge funds represented by the index added value as a group. In fact, the average monthly return of the replicating portfolio was 0.26%, and outperformed that of the hedge fund index by 0.03%.

One of the reasons for the disappointing result of the Barclay Hedge Fund Index during the past few years is that the index averages the performances of more than several thousand hedge funds. Hedge funds are characterized by highly uneven abilities, and when the performances of a large number of funds are averaged, the results are predictably mediocre. Another reason for less than stellar results lies in the fact that hedge funds employ diverse strategies, and cover a wide investment universe such as the one this replicating portfolio represents. When exposure to all the assets in which a variety of hedge fund strategies invest is aggregated, the investment universe is likely to resemble a globally diversified portfolio. While some hedge funds may be able to generate excess returns from exposure to a certain asset, other hedge funds may be incurring losses from exposure to the same asset. Thus, on average, performance is expected to be similar to that of the relevant investment universe.

There is no doubt that behind the rising popularity of liquid alternatives lie the often mediocre performances of hedge funds relative to what is available in traditional investments. Indeed, if hedge fund investments can be replicated by a static combination of ETFs and Treasury bills and no leverage is necessary, as was just demonstrated, there is no need to pay high management fees and performance fees to hedge funds.[9] For this reason, hedge funds need to add true value to investors.

Let us now examine how hedge funds perform in the long run. Exhibit 2 lists various categories of hedge fund strategies and each strategy category's cumulative return from January 2000 to December 2018, compiled by Eurekahedge, along with the S&P 500 Index's cumulative return for the same period.[10]

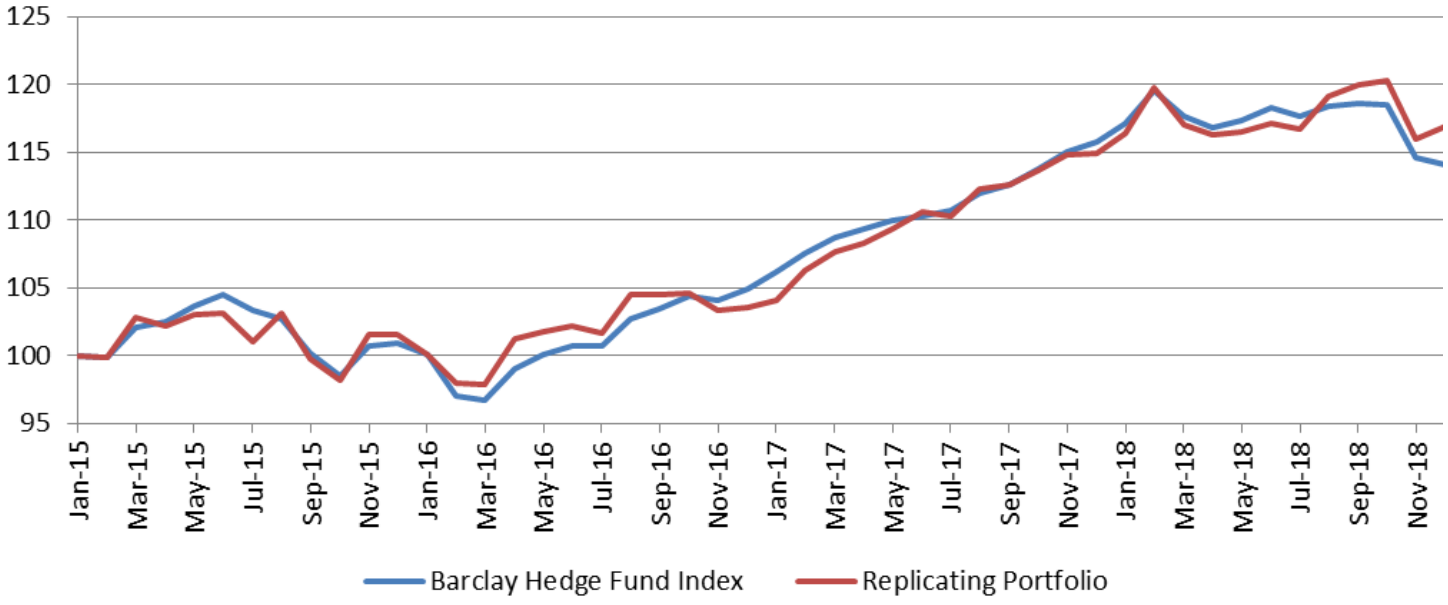


Exhibit 1: Cumulative Returns of the Barclay Hedge Fund Index and its Replicating Portfolio
Source: BarclayHedge, Ltd., Yahoo Finance, and Federal Reserve Board. Calculation by author.

Eurekahedge Strategy Indices	Cumulative Return
Arbitrage	248.79%
CTA/Managed Futures	376.10%
Distressed	542.02%
Event Driven	411.11%
Fixed Income	298.10%
Long-Short Equity*	334.96%
Macro	306.54%
Multi-Strategy	396.45%
Relative Value	388.21%
S&P 500 Total Return	**144.70%**

Exhibit 2: Hedge Fund Performance by Strategy (from 2000 to 2018)
Source: Eurekahedge and Yahoo Finance
Note: *Eurekahedge uses the expression "Long-Short Equity" in reference to "Equity Long-Short."

Whereas the S&P 500's cumulative return was 144.70%, the Arbitrage strategy index, which had the lowest performance among the different strategy indices compared, recorded a cumulative return of 248.79%, adding more than 100% to the equity index. In fact, every hedge fund strategy index substantially outperformed the S&P 500 index over the 19 year period. Although replicating the Barclay Hedge Fund Index for the past nine quarters was surprisingly easy, a question remains as to whether one can create a liquid portfolio that tracks the performance of a certain specific hedge fund strategy.

There are several approaches to pursuing hedge fund replication. One approach focuses on a mechanical method whereby "managers populate portfolios with position characteristics [similar to] particular hedge fund strategies to attempt to reproduce such strategies' returns."[11] This type of replication approach works best with strategies such as merger arbitrage, as information details of a merger may be publicly available.

Another approach to replication focuses on the statistical properties of hedge fund return distributions. Here, the underlying assumption is that the "return profile of hedge funds stems from 'dynamic' trading in standard assets, as represented by indices on traditional asset classes."[12] Dynamic trading alters the distribution of investment outcomes, even if the returns of underlying assets are normally distributed.[13] For instance, managed futures strategies have been considered to generate "straddle-like" payoff patterns, which potentially bring gains in extreme market moves. More generally, some hedge fund strategies employ strategies akin to selling out-of-the-money put options, and are able to generate stable returns for an extended period of time, but potentially with sudden large losses.[14]

Yet another approach is based on a version of linear factor models. Typically, a set of factors that explain the return patterns of a single or a group of hedge funds are identified first. Then, a replicating portfolio is created by linearly combining these factors. Many proprietors of replication products employ this approach. This approach seems to work best with strategies that have directional exposure such as equity long-short and event driven strategies. On the other hand, the approach tends to fall short of generating satisfactory replication results for strategies such as equity market neutral, relative value, and global macro strategies.[15]

Hence, at least some hedge fund strategies can be replicated to a reasonable degree by using liquid instruments or through factor exposure. However, this raises some questions: First, are these hedge fund strategies destined to be replaced by factor investments and/or other liquid alternatives? Second, can these strategies continue to add value for investors beyond what quantitative approaches generate? The answers to these questions are critical when contemplating the future of hedge funds.

As strategy replication and factor-based approaches gain greater acceptance in the investment management community, the pressure on hedge funds to outperform these approaches inevitably increases. Skills that cannot be easily substituted by liquid alternatives or a predetermined set of factor exposure are going to be critical. Unless these skills, along with the generation of true alphas, are emphasized, it will become increasingly difficult to convince investors that hedge fund investing is a positive value proposition. In the section that follows, we will examine the case of Equity Long-Short Strategy with these challenges in mind.

Equity Long-Short Strategy

Among hedge fund strategies, the Equity Long-Short (ELS) strategy accounts for 36% of assets under management (AUM), and it is by far the largest strategy category.[16] Challenges that the strategy faces are likely to affect the overall hedge fund industry significantly. As discussed in the previous section, ELS strategies tend to have directional equity exposure. For this reason, it may be appropriate to compare its performance to that of the equity market. However, one needs to keep in mind an important caveat that most hedge funds, including those employing ELS strategies, are absolute return-oriented and not structured to beat a long-only index such as the S&P 500 every year. It is therefore misleading to consider the S&P 500 as a benchmark in the way commonly accepted in traditional investments.

Exhibit 3 compares the performance of the ELS and the S&P 500 from January 2000 to December 2018, as well two sub-periods: 2000 to 2008 (Panel A) and 2009 to 2018 (Panel B).[17] During the entire 19 year period (Panel C), the ELS strategy outperformed the S&P 500 Index substantially in terms of average monthly returns (0.54% vs. 0.35%), with less than half the risk, i.e., standard deviation (2.02% vs. 4.22%) of the index. This resulted in a much higher Sharpe ratio for the ELS strategy than that of the S&P 500 Index (0.94 vs. 0.29).

	Panel A		Panel B		Panel C	
	From 2000 to 2008		From 2009 to 2018		From 2000 to 2018	
	ELS	S&P 500	ELS	S&P 500	ELS	S&P 500
Mean	0.52%	-0.45%	0.55%	1.07%	0.54%	0.35%
Standard Deviation	2.24%	4.39%	1.82%	3.94%	2.02%	4.22%
Skewness	-0.38	-0.65	0.12	-0.43	-0.33	-0.58
Excess Kurtosis	1.83	1.28	1.03	0.7	1.69	1.11
Maximum	8.51%	9.32%	6.08%	10.93%	8.51%	10.93%
Minimum	-6.70%	-16.85%	-4.70%	-10.67%	-6.70%	-16.85%
95% VaR	-3.16%	-7.67%	-2.45%	-5.40%	-2.79%	-6.59%
Sharpe Ratio	0.82	-0.35	1.08	1.00	0.94	0.29

Exhibit 3: Performance Comparison between the Eurekahedge Long-Short Equity Strategy and the S&P 500 Index
Source: Eurekahedge and Yahoo Finance

It is noteworthy that the ELS maintained similar performances in the two sub-periods in terms of average returns, as well as of risk, measured by standard deviation (Panel A and Panel B). Other distributional properties such as skewness and excess kurtosis were within a reasonable range for both periods. However, in the second sub-period the strategy had a slightly higher return and a lower risk than in the first sub-period, resulting in a better Sharpe ratio (1.08 vs 0.82).

By contrast, the S&P 500 index had drastically different performances in the two sub-periods. From 2000 to 2008 (shown in Panel A), the S&P 500 Index had a negative average monthly return of -0.45%, while from 2009 to 2018 (shown in Panel B), the index showed a large average monthly return of 1.07%. In the latter period, the S&P 500 index outperformed the ELS strategy nearly by 2 to 1 on average, but with over two times the level of risk.

In the second sub-period (Panel B), despite the great performance of the S&P 500, the Sharpe ratio for the ELS strategy was slightly higher than that of the index. The magnitude of the largest monthly loss for the ELS strategy (-4.70%) was much smaller than that of the index (-10.67%). In addition, the 95% value at risk (VaR) was much smaller for the ELS strategy (-2.45%) than the index (-5.40%), confirming that the strategy was exposed to much lower risk than the index. Unless one focuses solely on returns and ignores non-return characteristics such as the levels of risk, it is difficult to conclude that the S&P 500 outperformed the ELS during the second sub-period. In fact, by simply using leverage, the strategy could have generated higher risk-adjusted returns than the equity market.

Exhibit 4 summarizes the regression results of the Eurekahedge Long-Short Equity Index and S&P 500 excess returns for the entire period, as well as for the two sub-periods. Panel C indicates that for the entire period the slope coefficient was 0.367 and it was statistically significant at the 7.00E-45 level. The intercept term was 0.407 and significant at the 5.09E-06 level. With R square of 0.584, one can surmise that nearly 60% of the variations of the index's excess returns were explained by the market excess returns.

		Panel A	Panel B	Panel C
		From 2000 to 2008	From 2009 to 2018	From 2000 to 2018
R Square		**0.513**	**0.723**	**0.584**
	Coefficient	0.365*	0.394*	0.367*
Slope	**t Statistics**	10.569	17.56	17.797
	P Value	2.90 E-18	1.04 E-34	7.00 E-45
	Coefficient	0.686*	0.125	0.407*
Intercept	**t Statistics**	4.527	1.372	4.674
	P Value	1.57 E-05	0.173	5.09 E-06

Exhibit 4: Regressions of Equity Long-Short Returns on S&P 500 Excess Returns
Source: Eurekahedge and Yahoo Finance
Note: *Statistically significant at below 1% level.

Importantly, Panel B indicates that the market factor played a more significant role during the second sub-period than in the first period (Panel A) with an R square of 0.723, leaving only 27.7% of variation of returns unexplained. Since both the independent variables and dependent variable were measured in the form of excess returns, the slope coefficient can be interpreted as "beta" and the intercept as "alpha," as defined by the Modern Portfolio Theory.[18] In this sense, the ELS strategy had a beta of 0.394, but not a statistically significant alpha.[19] On the other hand, Panel A shows a smaller value of R square and a slightly lower beta than those in Panel B. In addition, the strategy had a high alpha value of 0.686 in the first sub-period.

Panel A of Exhibit 5 lists descriptive statistics for various risk factors. The data for many of these factors are available from 2009 onwards and the sample period corresponds to the second sub-period in previous analyses.[20] The first two, "Size" and

Panel A - Descriptive Statistics

	Factors	Mean	Standard Deviation	Skewness	Excess Kurtosis	Maximum	Minimum	95% VaR
Traditional Factors	Size	0.12	2.41	0.65	2.01	10.64	-4.64	-3.85
	Value	0.1	3.28	2	10.21	19.72	-8.27	-5.31
	Momentum	-0.21	4.68	-3.53	23.61	10.28	-34.39	-7.9
HFR Equity Factors	Congestion	0.36	1.91	0.07	2.98	6.9	-6.27	-2.78
	Cross Sectional Mementum	-0.41	2.24	0.3	1.07	7.52	-6.54	-4.11
	EU Dividend Carry	0.48	1.73	1.07	4.87	8.45	-5.05	-2.37
	Merger Arbitrage	0.42	1.95	0.31	0.78	5.78	-4.68	-2.8
	Thirteen F Long-Short	0.28	3.13	-0.29	-0.09	7.31	-7.87	-4.87
	Trend	0.04	2.58	-0.25	0.75	6.8	-8.18	-4.22
	US Gamma	0.87	3.68	-1.15	2.51	8.95	-13.62	-5.18
	US Long Volatility	-0.55	2.41	1.87	6.77	11.87	-5.9	-4.53
	US Mean Reversion	0.07	1.67	-0.97	6.26	4.93	-8.31	-2.67
	US Vega	0.98	3.56	-2.58	10.2	7.55	-18.49	-4.88

Panel B - Regressions of Equity Long-Short Strategy's Residual Returns on Risk Factors

	Factors	R Square	Slope Coefficient	t Statistic	P Value
Traditional Factors	Size	0.072	0.107**	3.044	0.003
	Value	0.005	0.021	0.795	0.428
	Momentum	0.056	-0.048**	-2.651	0.009
HFR Equity Factors	Congestion	0.009	0.046	1.027	0.306
	Cross Sectional Mementum	0.004	-0.025	-0.658	0.512
	EU Dividend Carry	0.104	0.172**	3.721	0.0003
	Merger Arbitrage	0.0002	-0.007	-0.144	0.886
	Thirteen F Long-Short	0.055	0.071**	2.628	0.0097
	Trend	0.057	0.089**	2.685	0.008
	US Gamma	0.094	0.078**	3.514	0.0006
	US Long Volatility	0.035	-0.073*	-2.086	0.039
	US Mean Reversion	0.018	0.078	1.497	0.137
	US Vega	0.029	0.044	1.874	0.063

Exhibit 5: Equity Risk Factors (From 2009 to 2018)
Source: Size, value and momentum factors are from Kenneth F. French-Data Library. Other factors are courtesy of Hedge Fund Research. The data for the "Trend" factor starts in February 2009, and the value of "0" was assigned to January 2009.
Notes: * Statistically significant at the 5% level. ** Statistically significant at the 1% level.

"Value," are well-known Fama-French factors. Along with the third factor, "Momentum," these factors are considered to be "traditional" factors. The fourth through the twelfth factors are additional equity factors published by Hedge Fund Research (HFR), generally considered to be "alternative betas" (For a brief definition of HFR equity factors, see the appendix). Note that some risk factors experienced negative returns in the 10 year period from 2009 to 2018. From the perspective of portfolio and risk management, it does not necessarily mean that these risk factors are "loss" factors. In light of the fact that risk factors are constructed using a long position in certain securities/contracts and a short position in different securities/contracts, one can easily reverse the positions to create an opposite payoff-pattern.

Many of these factors are by no means normally distributed. For instance, "Momentum" and "US Vega" have a strong negative skewness, and "Value" and "US Long Volatility" have noticeably positive skewness. In addition, many factors have an extremely large excess kurtosis, indicating that their distributions are strongly fat-tailed. To illustrate, "Momentum" has the excess kurtosis of 23.61 with a negative skewness of -3.53, culminating in a large monthly loss of -34.39%. "Value" and "US Vega" also have a large value of excess kurtosis. When performing portfolio optimization using a mean-variance optimization (MVO) approach, one must be mindful of non-elliptical distribution of these factors. MVO focuses only on the first two moments of the distribution, mean and variance, and ignores the third and fourth, skewness and kurtosis.

Panel B summarizes the results of a series of bi-variate regressions, each using a different risk factor as an independent variable. The dependent variable consists of residuals from regression of the market factor (S&P 500 Total Return) on the ELS as measured by the Eurekahedge index, and represents the portion unexplained by the market factor.[21] Since the dependent variable has a mean value of zero, the intercept term was forced to be zero in each regression analysis.[22]

Six of the thirteen factors are statistically significant at the 1% level and one factor is significant at the 5% level. The "EU Dividend Carry" factor explains the largest variation of the residual returns (10.4%), and the "US Gamma" factor explains the second largest variation (9.4%), followed by the "Size" factor (7.2%). This suggests that other risk factors have some explanatory power over the residuals of regression of the ELS strategy, in addition to the market factor. Therefore, there should be opportunities to extract alphas from these factors and/or utilize them for risk management for hedge funds, as well as for some liquid alternative products.

It is worth noting that this analysis is cross-sectional, meaning the regression results shown in the exhibit represent static relationships with the assumption that exposure to each factor remains constant. When time-varying exposure is taken into account, however, these factors can potentially play a much larger role than the statistics in Panel B indicate. Such a possibility will be discussed in a later section.

Beyond Fundamental Research

To the degree that equity markets are efficient, it is difficult to generate alphas based on fundamental research alone. Hedge fund managers, including those pursuing Equity Long Short (ELS) strategies, have engaged in various niché types of investments. In this section, we will discuss focusing on micro and small cap stocks, activist investing, as well as quantitative investing. In addition, some funds of hedge funds (FoHFs) have sought to co-invest with underlying hedge fund managers in selected stocks in order to deliver additional value to investors. These sources of potential alphas are discussed below. One should be cognizant of the fact that hedge fund managers have the capability to create value beyond what static factor investments and liquid alternatives can bring to investors.

Focusing on Micro and Small Caps

The validity of a long-standing academic argument for the size premium aside, ELS hedge funds have extracted, or have attempted to extract, returns out of smaller companies that are not broadly covered by analysts. This suggests that relative to micro and small cap companies[23] the price discovery process is less efficient than that for larger companies.[24] Hence, opportunities for alphas through active investing are expected to be greater.

The size of the investment portfolio becomes critical when trying to extract alphas from investing in micro and small capitalization companies. For a large-sized portfolio, even a fractional allocation can cause market disruptions and exceed available liquidity of the company to invest. While any size hedge fund can attempt to identify these opportunities, smaller hedge funds have an increased ability to be nimble and create a portfolio where each investment has meaningful impact on the portfolio's performance. In sum, smaller managers can better take advantage of alpha opportunities among smaller capitalization stocks than large managers.[25]

The most striking example of why staying small and nimble is important is maintaining their ability to short. While a manager with a high conviction long may not hesitate owning shares in a company that represent multiples of the company's Average Daily Trading Volume (ADV), most hedge funds that short a stock are more likely to short a number of shares that represent a fraction of its ADV. Assuming a hedge fund can trade 20% of ADV effectively per day, it would take five days to get out of a position size of 1 times ADV (long or short). In a short position where one faces unlimited losses and has other considerations such as borrowing costs, position sizing becomes even more critical.

To illustrate this point, suppose that a manager has $250MM in AUM and plans to place a 4% short position ($10MM) in a basket of stocks. In this example, the rule of thumb of trading 20% of ADV applies. Under these conditions, only 3% of the Russell 2000 stocks would have 1 day liquidity and roughly 35% would have less than 5 days liquidity, which most managers consider to be the maximum number of days allowable. This means that even a manager with only $250MM in AUM would be seriously constrained in his/her shorting of Russell 2000 stocks, and needs to be extremely selective in shorting. Thus, for many investment managers, successfully pursuing the ELS strategy in micro and small cap stocks poses a challenge. To maintain a competitive edge, such a manager needs to be disciplined in growing the size of his/her portfolio.

Activism

Over the past few decades, shareholder activism has increased substantially. In recent years, the number of companies targeted by activist managers has increased by 8% per annum, and the amount of assets managed by these managers has increased by 9% per annum.[26] Some funds classify themselves as activist strategies while others will become "active" on companies selectively. Funds that are classified as activist strategies typically have a more concentrated portfolio and higher net exposure to the market than the average ELS manager.

Simply put, an activist hedge fund "identifies a company with unrealized value that it believes can be unlocked, and seeks to release that value by working with management and other shareholders, or in some cases advocates for a change in management direction."[27] Most activist funds focus on how a company is structured from a financial perspective. Often, activists work behind the scenes with the company, trying to convince to take certain steps to unlock shareholder value. For example, an activist fund might request that company sell off a division in a non-core operation and return that money to shareholders.

The rise in popularity of the activist strategies has created competition among hedge fund managers. Crowding in activist strategies is not necessarily undesirable, as more activists will request that a company make certain changes will increase the likelihood of those changes occurring. In addition, activists can often convince long only money managers and institutional investors[28] to vote for, or otherwise support, their resolutions and objectives[29]

While there are a handful of well-known activist hedge funds that often engage in headline-grabbing public pronouncements and transactions involving large corporations, many activist managers focus on below-the-radar opportunities. In addition, activist style investing need not be hostile to the management of the company. In fact, a report by Alternative Investment Management Association (AIMA) states "most activism by alternative investors takes the form of low-profile interventions and 'soft' strategies, such as seeking board representation with management support. Collaborative engagement also appears more likely to achieve success than more assertive approaches."[30]

Investments in micro-cap stocks share some of the desirable features of private equity investments.[31] This is particularly true if an activist style is pursued. Specifically, value can be created out of the active involvement of fund managers in corporate reorganizations, through actions such as M&A activities and enhanced corporate governance. For example, in 2018, a small-cap activist investor acquired a stake of over 5% in a provider of weight loss products and services, and "brought in marketing experts to help it lower its customer acquisition costs."[32] The activist investor collaborated with the "management and the board of directors to 'significantly accelerate and improve' the company's digital strategy efforts in order to 'drive a substantial increase' in profitability."[33] The company was sold for multiples of acquisition cost for the activist investor in a short period of time.

Quantitative Investing

To the extent that ELS managers attempt to hedge away at least part of equity beta, these managers have utilized some quantitative techniques even if the sources of returns are based on fundamental research capability. As a greater number of drivers of equity return (i.e., smart or alternative betas) are identified, some long-short managers have further adopted quantitative techniques.

For instance, around 2012 a well-known ELS hedge fund, which previously focused on fundamental analysis, brought in a quantitative discipline in order to perform the following tasks and gather the following data/information:

- Analysis of portfolio exposures to common risk factors;
- Performance attribution analysis based on portfolio risk-factor exposures;
- Contribution of each sector, region, and individual security to the portfolio risk budget;
- Outlier reports highlighting potentially aggressive assumptions;
- A proprietary economic activity indexes tracking regional activity on a weekly and monthly basis;
- Position-sizing capabilities;
- Screens to identify potential long and short investments; and
- Information regarding portfolio positioning of the long-short equity hedge fund category.[34]

It is worth emphasizing that unlike focusing on micro and small cap stocks, sophisticated quantitative investing requires a sufficiently large scale operation as the capability to process massive amount of data and to make an extensive use of computer algorithms is required. It is unlikely that regular investors, including institutional investors with a massive amount of assets, can pursue state of the art quantitative investing as efficiently as some of the large hedge funds. This is an area where large hedge funds can deliver value to investors.

Co-investments

Co-investments occur when a hedge fund offers institutional investors the opportunity to invest in a specific company or sometimes a group of companies. Co-investments have been part of the private equity landscape for much longer than the hedge fund landscape. To run co-investments, the hedge fund will set up a special purpose vehicle (SPV), create a customized structure, or use a separately managed account.

According to a recent survey, 41% of institutional investors have co-invested with hedge fund managers. Sixty-eight percent (68%) of large investors - those with assets over $ 5 billion, have made co-investments, compared to 34% of those with assets under that threshold. In a similar survey conducted in 2013, only 11% of investors indicated that they co-invested.[35] Thus, co-investing has clearly risen in popularity, especially among large investors.

Co-investments give investors the opportunity to capitalize on hedge fund managers' best ideas. Thus, a fund of hedge funds (FoHFs), acting as an investor in a hedge fund, can take advantage of the opportunity to add extra value. To illustrate, suppose a relatively small hedge fund with AUM of $100MM has an investment idea where the fund believes its edge is quite high but given that the fund needs to limit any long positions to under 5% of its portfolio, the fund can only invest $5MM. By offering the ability to invest alongside the fund, it is providing to a limited number of investors the opportunity to create outsized returns.

In turn, the FoHF with the proper expertise to evaluate best ideas can put a certain portion of assets into a co-investment, leveraging best ideas. It should be noted that not all co-investments come with a fee. Some FoHFs have agreements with underlying managers that they can invest in their best ideas without charge. Typically, these arrangements are with small funds that have a strong desire to grow AUM and relationships.[36]

Value Creation through Risk Management

There are at least three ways that hedge fund managers can generate alphas: (1) allocation alphas by altering beta exposure, (2) controlling factor exposure; and (3) extracting true alphas.[37] Various methods to extract true alphas in the Equity Long-Short Strategy (ELS) have been discussed in the previous section. In the following paragraphs, we will focus on the first two ways and their relation to risk management. Note that risk management is considered to be a means of active value creation, and not just a means of passive risk mitigation or control, though the latter means can also help improve risk-return payoffs.

A regression analysis shown in Panel B of Exhibit 5 assumed that exposure (or coefficient) to an independent variable remains static. Since it was based on a cross-sectional framework, it could not incorporate a dynamic element without relying on more complex statistical procedures incorporating time-varying components. In reality, hedge funds have freedom to dynamically adjust exposure to market risk. It is unlikely that the equity long-short managers "in toto" intended to maintain a 0.394 exposure to the market factor. Either through the changes in long positons and/or short positions, or with hedging or leveraging of the market risk, these managers have adjusted such an exposure. It is important to recognize that the dynamic adjustment can be a source of returns (or losses).

Exhibit 6 summarizes the result of a simple experiment based on naïve forecasts of volatility. Starting January 2000, the volatility of returns of the US equity markets (NYSE, AMEX, and NASDAQ)[38] for a given month was used as a forecast for the next month's volatility, which then was compared to the historical volatility for the 30 year period from January 1970 to December 1999. The ratio of the forecasted volatility to the historical volatility was used as a leverage ratio. For instance, if the forecasted volatility were half of the historical volatility, the ratio would be 2. Conversely, if the forecasted volatility were twice the historical volatility, the ratio would be 0.5. The decision rule was applied to the S&P 500 Index, as many low-cost tradable products that track the index are available.

This historical simulation demonstrates that the dynamic allocation strategy would have added, on average, 12 basis points to monthly returns while lowering the average volatility by 0.91%.[39] Over the course of 19 years, the cumulative return of the dynamic strategy would have brought an additional 105% return to the buy and hold strategy. The additional return can be viewed as "allocation alpha." The leverage ratio ranged from 0.16 to 2.81, and the average leverage ratio was less than 1. Thus, by using a very simple decision rule, the above strategy would have improved the performance substantially. This was literally an exercise in risk management, as adjusting the level of risk, i.e., volatility, was a means of value addition. The forecasts themselves were so naïve as to supplement no new information.

In contrast to traditional investment mandates and products, hedge funds have freedom to choose the locus, extent, and timing of exposure to assets or factors. By exercising judicious risk management, hedge fund managers can clearly improve risk-return payoffs. This is where hedge fund managers can pursue competitive advantages vis-à-vis traditional portfolio managers and private equity managers. They have both opportunities and capabilities to add value by "controlling factor exposure." This fact needs to be emphasized to investors; otherwise, a large group of investors may assume that the lower return of the ELS than that of the S&P 500 in the past 10 years is indicative of lack of investment acumen not worthy of high fees (See Panel B of Exhibit 3). In a similar vein, unless dynamic factor exposures are taken into consideration, the performance of hedge fund managers will appear to be increasingly dominated by these risk factors, and investors are likely to opt for liquid alternatives including smart beta products because of the lower fees.

	S&P 500	Volatility Adjusted Investments in S&P 500
Average Return	0.48%	0.60%
Standard Deviation	4.20%	3.29%
Cumulative Return	145%	250%
Leverage Range	N/A	0.16-2.81
Average Leverage	1	0.97

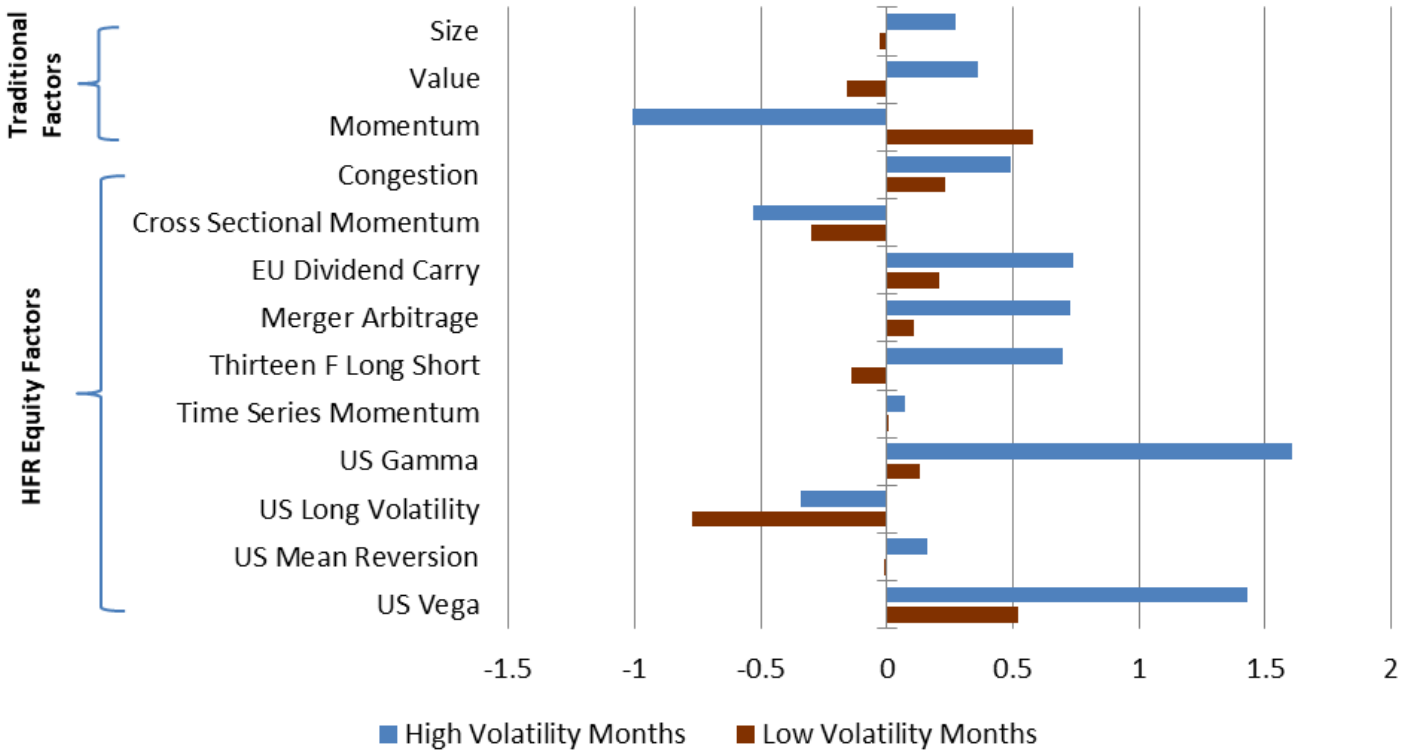
Exhibit 6: Allocation Based on Naïve Volatility Forecast (From 2000 to 2018)
Source: Yahoo Finance and Kenneth F French-Data Library. Calculation by Author.

Suppose that instrumental variables such as volatility changes also affect the performance of various risk factors. Exhibit 7 lists the same set of factors as were shown in Exhibit 5, but graphically demonstrates the differences in mean returns (Panel A) and standard deviations (Panel B) of these factors between high volatility months and low volatility months for the 120 month period from January 2009 to December 2018.[40] In order to differentiate between volatility regimes, the same naïve forecasts of volatility as were used for Exhibit 6 were utilized. This means that when the previous month's volatility was lower (higher) than the average volatility, the current month is classified as a low (high) volatility month. In order to have an equal number of months between the two regimes, a value close to the in-sample mean was utilized to represent the average volatility.[41] By so doing, the average return and volatility for each risk factor between the two regimes corresponds to those shown in Panel A of Exhibit 5.[42] This analysis is done for illustration purposes only, and none of the figures or relationships among the risk factors in the exhibit should be used for actual allocations.[43]

Examining Panel A, one may find it extraordinary how such a naïve volatility forecast can lead to different mean returns between the two volatility regimes for most factors. For many factors such as "US Gamma," a return in one regime is many times larger than that in the other regime. What is more, for four factors,[44] the sign of the returns are opposite; while the high volatility regime generated positive returns, the low volatility regimes resulted in negative returns. For another factor, the high volatility caused a negative mean return but the low volatility brought a positive mean return. In addition, for the majority of factors, the high volatility regime added more value than the low volatility regime did. This fact is important as many traditional assets tend to suffer in the high volatility environments. The use of these factors can help raise average returns, mitigate large drawdowns, and contribute to diversification.

Some alternative beta factors such as "US Gamma," "US Long Volatility," and "US Vega" make explicit use of equity derivatives. It is not surprising that these factors strongly respond to the movements in equity volatility, as volatility is an important component of derivative pricing. As discussed previously, one of the approaches to replicate a hedge fund strategy relies on dynamic trading. The use of these factors can bring about effects similar to dynamic trading. This also means that hedge fund

Panel A: Mean Return (in % per month)



Panel B: Standard Deviation (in % per month)

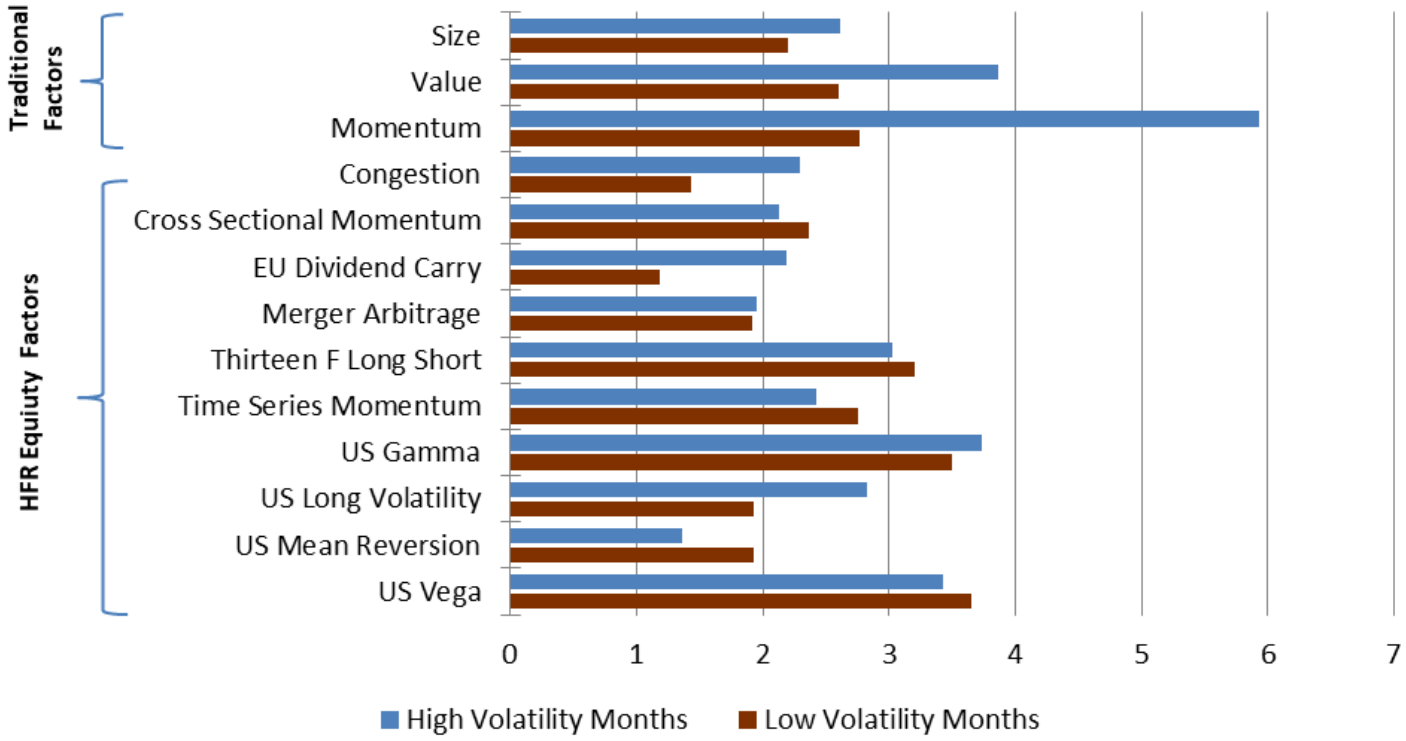


Exhibit 7: Differences in Risk and Return between Forecast Volatility Regimes
Source: Kenneth R. French - Data Library, and HFR. Calculation by Author.

managers can use these factors to control risk or add returns (Caveat emptor – some of these factors are susceptible to large losses as shown in Panel A of Exhibit 5).

Panel B compares the standard deviation of each risk factor between the two volatility regimes. In the case of "Momentum" the standard deviation is twice as high in the high volatility months as in the low volatility months. With a few exceptions including "Momentum," however, most risk factors have similar levels of standard deviation. In addition, five out of twelve risk factors have lower levels of standard deviation in the high volatility regime. This means that having exposure to some risk factors during a time of high market volatility does not necessarily lead to higher portfolio volatility. In fact, depending on the covariance structure among selected factors and the market factor, it can help lower the portfolio volatility.

Thus, it is important to note that if these risk factors are used strategically and dynamically by hedge funds, exposure to these factors can become a source of alphas as managing exposure to the factors will be interpreted as these funds' abilities to improve risk-reward ratio. The current trend is to view the increasing use of smart betas as a primary cause for narrowing the range of alphas that hedge funds can generate. However, managing such exposure systematically can make an abundance of factors an opportunity to fully utilize hedge fund managers' abilities to choose the locus, extent, and timing of various factor exposures.

Exhibit 8 shows the different domains of betas and alphas. The left side chart is adapted from an Alternative Investment Management Association's publication.[45] The chart is a classification scheme of manager universe and is labeled "The New Hedge Fund Product Taxonomy." It highlights the increasing importance of smart betas and alternative betas. It also implies that the domain of alphas, which can be extracted through security selection and market timing, has become very narrow. It can be interpreted as a "view of manager universe based on sources of returns." A series of regression analyses shown in Exhibit 5 were a static representation of relationships between risk factors (smart betas and alternative betas) and the excess returns of the ELS. Since many risk factors have explanatory power over the excess returns, it gives an impression that the domain to pursue alphas is indeed very small.

By contrast, the right side chart represents the "risk management centered view of alpha generation opportunities." It emphasizes the fact that dynamic exposure to indices, factor betas and alternative betas can be a source of alphas. Exhibit 7 demonstrated that dynamic exposure to selected risk factors, either long or short, can deliver returns much higher than the mean return of each factor shown in Panel A of Exhibit 5. Thus, from the perspective of risk management, alpha generation opportunities envelop all three types of betas (pure betas, smart betas, and alternative betas) and broaden alpha opportunities. In this sense, the rising popularity of smart betas and alternative betas should not be viewed as a threat to the future of hedge funds. Rather, it represents greater availability of means of alpha generation and risk management. Hedge funds should embrace these additional opportunities.

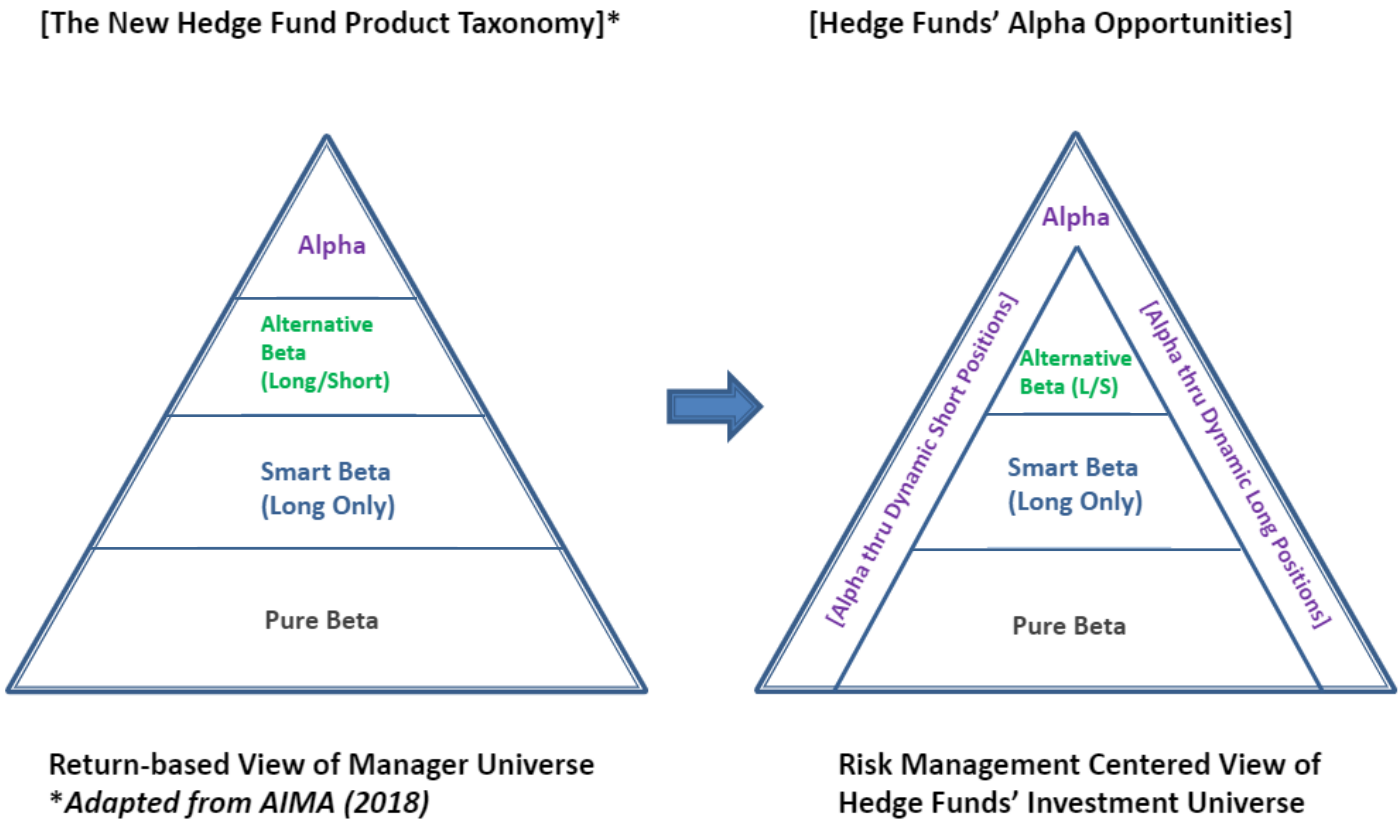


Exhibit 8: Domains of Alphas and Betas

Conclusion

Though hedge funds remain one of the major categories of alternative investments, their growth has slowed compared to private equity funds. Hedge funds face some challenges as some of what once were deemed alphas are now classified as some types of betas. These challenges are well embodied in the difficulties that Equity Long-Short Strategy faces. Using the Equity Long-Short Strategy as an example, this paper has discussed several means by which hedge funds can stay competitive and provide true value to investors.

Two potential areas of value addition can be found in the places where the reach of market efficiency is not as strong, such as in smaller capitalization stocks and activist investments. Smaller hedge fund managers can be effective in both these areas. The third area can be found in employing quantitative strategies where managers make use of alternative data, machine learning, and artificial intelligence. The well-capitalized hedge fund managers can be strong players in this field. The fourth area is where hedge funds offer co-investment opportunities to investors. Often, a FoHF can function as a conduit to deliver extra return opportunities through such an arrangement.

Together, the areas where Equity Long-Short managers have thrived recently indicate that hedge funds need to further diversify in terms of sources and methods of alpha generation. In terms of hedge fund business models, smaller managers may need to stay small and nimble, whereas larger managers may need to further hone their ability to deliver value that investors themselves cannot pursue. The rising use of replication techniques, liquid alternatives, and factor investments may appear to narrow hedge funds' domain for alphas and to present competitive threats to these funds. However, by embracing these risk factors, hedge fund managers can add value and broaden the scope for alpha generation. Specifically, dynamic use of factor exposure not only serves as a means of risk mitigation, but can help improve risk-reward ratios substantially.

Appendix

Congestion	The risk premium associated with the price dislocations caused by systematic index rebalancing.
Cross Sectional Momentum	Buying indices with the most positive relative reutrns, selling those with the most positive.
EU Dividend Carry	The risk premium associated with the systematic underestimate of dividends by dividend futures.
Mean Reversion	The tendency of stock index returns to mean revert.
Thirteen F Long-Short	The returns associated with tracking the top stock holdings of large hedge funds.
Trend	Time-series momentum.
US Gamma	Volatility carry using delta-hedged strangles.
US Long Volatility	Long vega using VIX futures.
US Vega	Volatility carry, exploiting the implied-to-realized volatility risk premium.

- *The author would like to acknowledge the welcome and valued support provided by T.J. Theodorsen, who moderated the educational event organized by the New York Chapter of CAIA Association on June 10, 2019. In particular, his input based on his practical knowledge and experience in managing a fund of hedge funds was extremely valuable for the section titled "Beyond Fundamental Research."*

Endnotes

1. Anson (2006). Page 36.
2. The event titled "Fundamental Equity Long-Short Strategy---Where is the Alpha?" was held on June 10, 2019 and was moderated by T.J. Theodorsen. The panelists were Kieran Cavanna, Eric DeLamarter, James Mitarotonda, and Chris Buonafede.
3. "Wozu" is a German word denoting "what for," "why," "to what," or "where to." There is a German philosophy book titled "Wozu Philosophie?"
4. Pension and Investment (2019).
5. The private equity industry had an AUM of over $3.06 trillion at the end of 2017. See Preqin (2018).
6. Monthly returns are calculated based on the month-end prices of two ETFs and the month-end value of the index for treasury bills.
7. Treasury bills are deemed risk free assets, and the index is used to estimate monthly returns.

8. These weights were chosen to assimilate a similar experiment conducted by Maneesh Shanbhag. Shanbhag used the HFRI index instead of the Barclay Index. See Shanbhag (2016).

9. A part of the difference in monthly returns (0.03%) comes from the higher fees that hedge funds charge relative to ETFs.

10. The S&P 500 is not an appropriate benchmark for many hedge funds. However, it often represents the best performing traditional asset class in terms of historical returns.

11. Italics mine. Freed (2013).

12. Italics mine. Amenc and Shröder (2008). Page 12.

13. However, it is important to note that this approach does not aim to follow "dynamically" the time series of hedge fund returns. Rather, it tries to match the statistical properties of return distributions such as means, variance, skewness, and kurtosis. See Chapter 7 of Jaeger (2008).

14. A study shows that 6% OTM puts on the S&P 500 Index had negative returns every month between 1991 and 1997. This means that writing such put options would have resulted in profits for every month during the 8 year period. See Brodie et al. (2009).

15. Jaeger (2008). Page 176.

16. Eurekahedge (2009).

17. In a later analysis, HFR risk factors are utilized. The data for these factors starts at January 2009, and in order to maintain consistency with this analysis, the second sub-period was chosen to start at this month.

18. In reality, there is an important conceptual slippage here. The hedge funds included in the Eurekahedge Long-Short Equity Index invest in equities outside of the US equity markets, but the independent variable is S&P 500's excess returns. In this sense, both alphas and betas are inexact.

19. One cannot say that alpha was 0.1.25 as the intercept was not statistically significant.

20. The traditional factors such as "size," "value," and "momentum" have longer historical data. Many factors compiled by Hedge Fund Research start at around the beginning of 2009.

21. There is a controversy as to the correctness of this type of two stage regression. See Chen et al (2018). However, the purpose of Exhibit 6 is not to construct an econometric model of Equity Long-Short Strategy. The factors are introduced to show that there are potential explanatory powers for these factors, but not to verify their explanatory powers.

22. Even if the intercept term is not made zero, it has a virtually zero value, and the slope coefficient does not change much. One disadvantage is that Equity Long-Short Strategy was assumed to maintain a constant exposure to the market factor. In reality, it is likely that hedge funds have changed the beta exposure, either adding to or subtracting from allocation alphas.

23. The companies with market capitalization of less than $300 million are generally considered to be micro-caps. See Blum (2018). Those with market cap of between $300 million to $2 billion are considered to be small caps. See Yahoo Finance (September 16, 2019). However, these thresholds can vary. For instance, as of August 2019, the Russell Microcap Index reported the average market cap of $488 million, but the largest company in the index had over $2.8 billion. See FTSE Russell (August 31, 2019). In this case, "small cap" stocks by a common definition are part of Russell's Microcap index. For this paper, the distinction between micro and small caps is not critical.

24. While a large cap stock has coverage by 22 analysts on average, a micro cap stock has coverage by 2.2 analysts. See DGHM & Co. (June 2019). Page 7.

25. In theory, a manager working for a large investment management company can focus on micro and small stocks. However, impact of such a portfolio on a large pool of investments will be too small to be meaningful.

26. McKinsey & Co. (2019).

27. German (2015).

28. See Institutional Investors (2018) for how institutional investors can aid activist hedge funds.

29. Companies have increased their defenses against activist campaigns. This is often done by making sure that certain ratios, such as expense ratios, do not exceed a certain level that investors in their industry would consider excessive.

30. Alternative Investment Management Association (2015).

31. See, for instance, Boston Partners (2015).

32. Barron's (2019). Legion Partners Asset Management acquired a stake in Nutrisystem.

33. The Fly.com (2018).

34. Pensions & Investments (2015).

35. Institutional Investors (2019).

36. Generally speaking fees are much lower than those for a normal fund. Though there is no official average figure, the author estimates that the average fee is 1% management fee and 10% incentive fee. Lockups can vary from quarterly with 30 day notice to several years of initial investment. Where most of the longer lockups occur is in activist situations.

37. There are at least two more ways. They are: (1) extracting liquidity premium, and (2) generating uncorrelated returns. All five ways are discussed in Matsuda (2019).

38. The standard deviation of "the excess return on the market value-weight return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or NASDAQ that have a CRSP share code of 10 or 11 at the beginning of month t, good shares and price data at the beginning of t, and good return data for t minus the one-month Treasury bill rate." See https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html.

39. T-bill rates were used both as rates of returns on cash and as the cost of leverage.

40. While only equity related HFR factors were chosen for comparison purposes in Exhibit 7, there is no reason to avoid non-equity factors such as rates factors and commodity factors. In fact, some non-equity factors can be expected to bring about greater diversification benefits than equity factors.

41. The value of 0.766 was used. The actual mean value was 0.785. The difference occurred because the distribution of volatility was not completely elliptical.

42. For a verification purpose, the 30 year average mean value of the volatility, which was utilized in exhibit 6 (0.915), was also applied. While the number of low volatility months rose to 70 and the number of high volatility months declined to 50, the overall tendency was very similar.

43. There have been a number of empirical analyses involving the traditional factors in the exhibit. It is known that depending on the sample period, these factors respond to volatility differently. For instance, Abdymomunov and Morley (2011) uses a two-state Markov switching process between low and high volatility regimes.

44. These are the "Size," "Value," "Thirteen F Long Short," "US Mean Reversion" factors. The "Time Series Momentum" factor had 0.004% mean return.

45. See Page 21 of AIMA (2018).

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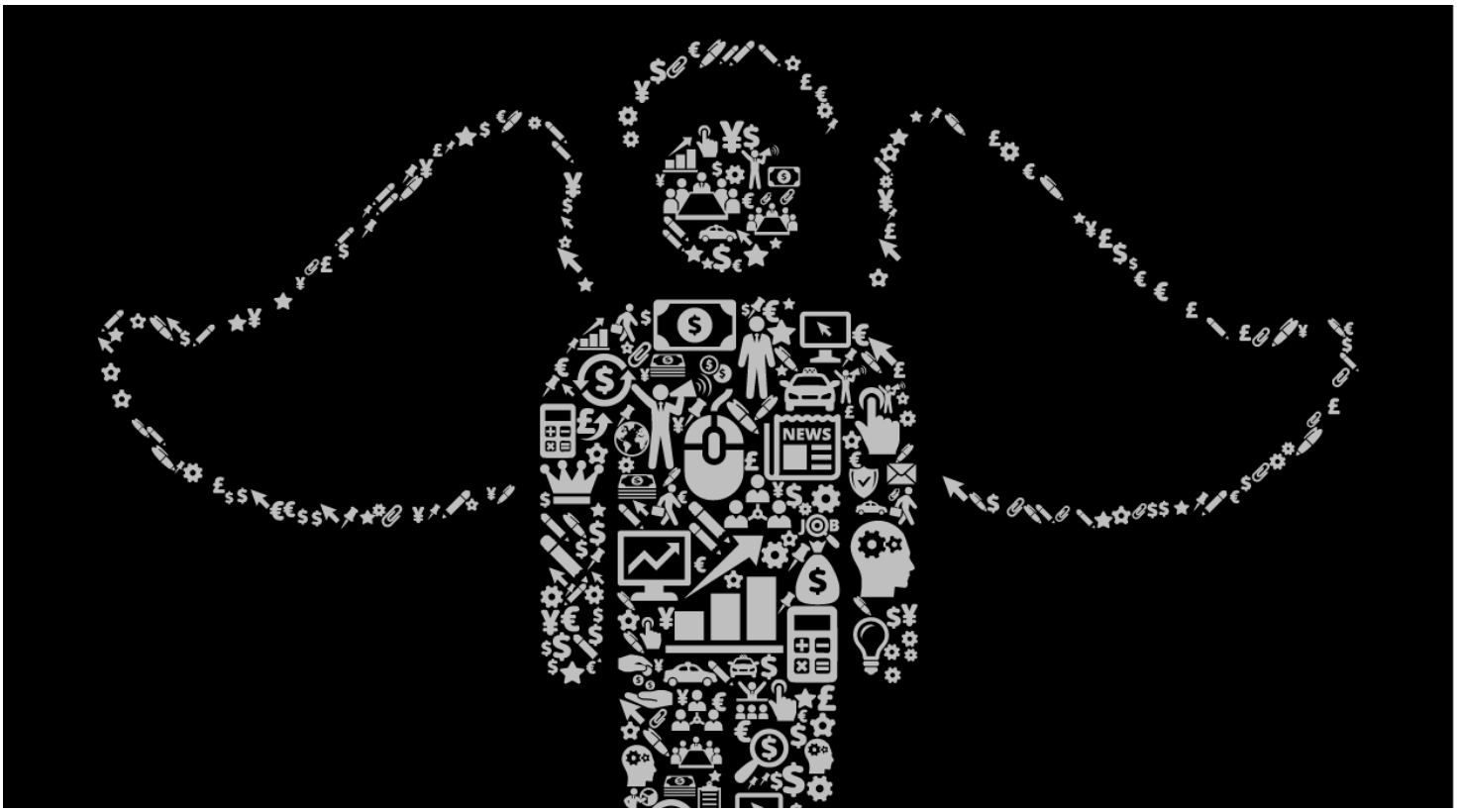
Masao Matsuda is President and CEO of Crossgates Investment and Risk Management. He has nearly three decades of experience in the global financial services industry. He has acted as CEO of a US broker-dealer and CEO/CIO of a number of investment management firms. In addition to his broad knowledge of alternative investments and traditional investments, he also possesses a technical expertise in financial modeling and risk management. He is experienced as a corporate director for operating and holding companies, and as a fund director for offshore investment vehicles.

Prior to founding Crossgates Investment and Risk Management, Masao spent 18 years with the Nikko group of companies of Japan. For the last seven years of his career at Nikko, he served as President/CEO of various Nikko entities in the US, and as a director of Nikko Securities Global Holdings. He received his Ph.D. in International Relations from Claremont Graduate University. He holds CAIA and FRM designation. He is a member of the Steering Committee of CAIA's New York Chapter.



Fallen Angels: The Last Free Lunch

Paul L. Benson, *CAIA*
Mellon

Manuel Hayes
Mellon

A defining characteristic of markets is that structural alpha opportunities are arbitraged away over time. What if there was an area where market mechanisms actually bolstered a structural alpha opportunity? We think this would be the last free lunch for investors. Welcome to the world of fallen angels—investment grade credits that have been downgraded to high yield.

Unlike their namesakes that were expelled from heaven, fallen angels, as represented by the Bloomberg Barclays US High Yield Fallen Angel 3% Capped Index, have outperformed major asset classes since the index was introduced in January 2005 (see Exhibit 1). The primary reason for fallen angels' strong performance is that they enter the index at oversold prices. Selling by investment grade managers, both in anticipation of and after a downgrade, distorts prices relative to original-issue high yield bonds. Our research shows that fallen angels enter the index priced 150 basis points cheaper than high yield peers, on average.

While a fallen angel allocation may appear straightforward, there are impediments to successfully capturing the risk premium, resulting in few investment vehicles devoted to the asset class. A narrow universe, high trading costs, and low dealer inventory create significant implementation challenges. In our view, a strategy that exploits the mispricing amongst fallen angels and minimizes trading costs can overcome these obstacles.

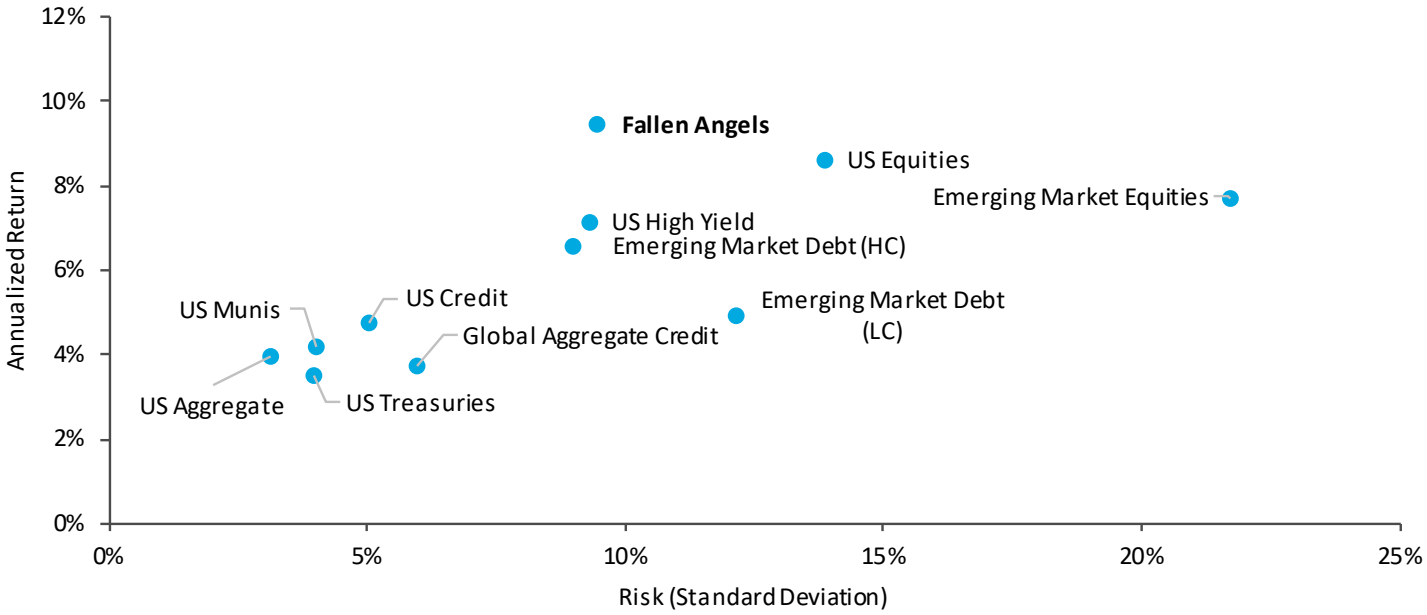


Exhibit 1: Fallen Angels Have Outperformed Major Asset Classes
Source: Bloomberg Barclays, MSCI, BofA Merrill Lynch. January 1, 2005 to March 31, 2019

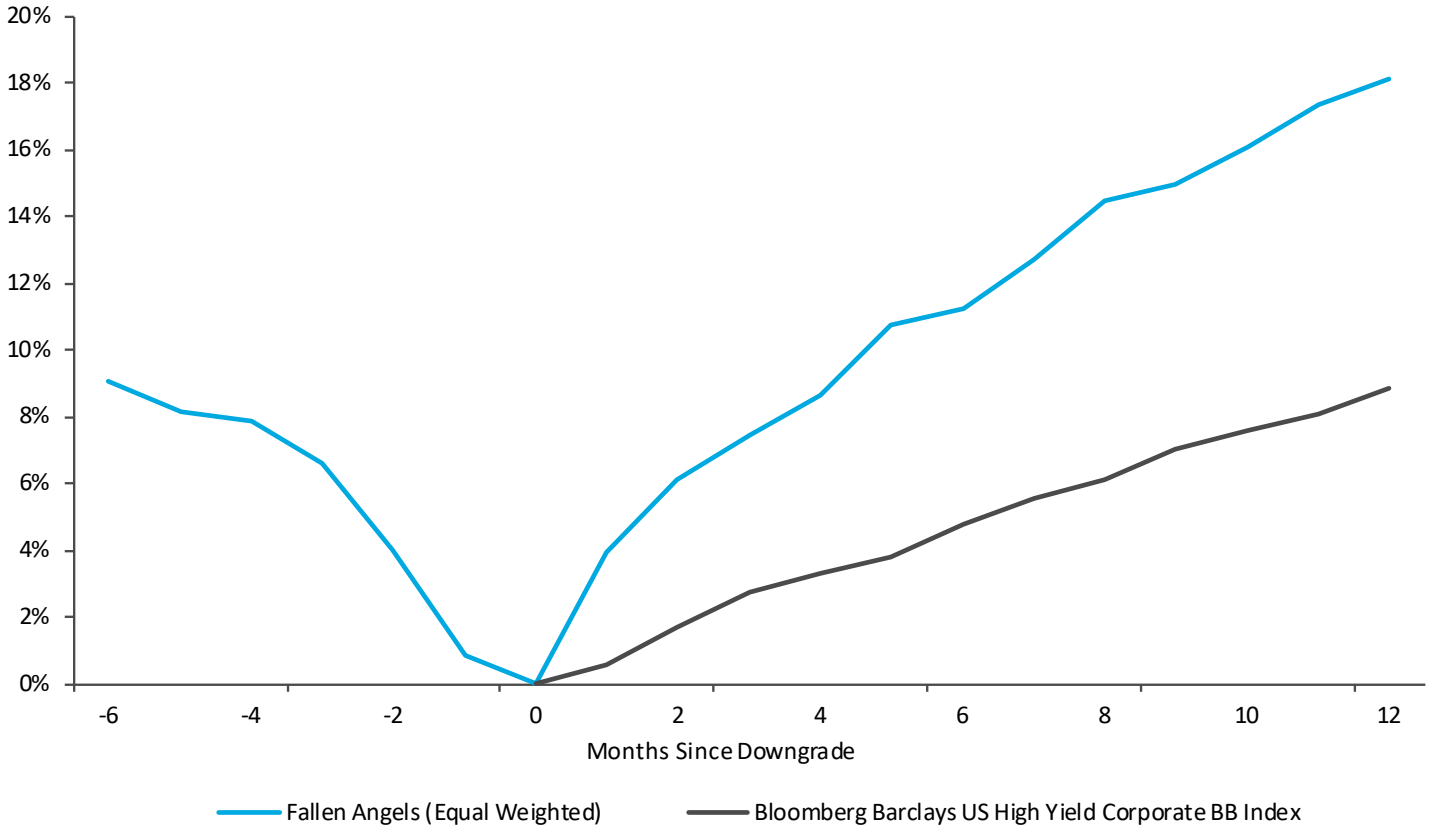


Exhibit 2: Initial Overreaction Leads to Subsequent Outperformance
Source: Bloomberg Barclays, Mellon Analysis

Fallen Angel Gets No Love

There is a clear divide between investment grade and high yield investors. On the investment grade side, passive managers tend to sell fallen angels when they drop from the index the manager is tracking, as holding downgraded issues introduces credit risk and increases tracking error. In many cases, selling is mandatory to avoid violating guidelines against holding non-index securities. Passive managers typically sell at or near month-end when index providers rebalance. With the growth of passive investing, index-related selling may increase.

Some active managers have leeway to hold fallen angels, but large downgrades increase portfolio risk and can appear unattractive relative to other opportunities. Further, active managers typically keep a close eye on ratings and are more inclined to sell in anticipation of a downgrade.

Demand for fallen angels does not improve at the time they enter the high yield universe. The investment grade universe is approximately two and a half times larger than the high yield universe. When large downgrades occur, the high yield market cannot absorb these issues due to high trading costs and downward price momentum associated with newly fallen angels.

Our research finds that the technical selling pressure overshoots fallen angels' intrinsic value versus high yield peers and undervalues their ability to regain their investment grade credit rating. Additionally, our research indicates that recovery from oversold prices tends to be stronger than bonds with similar credit quality (see Exhibit 2).

Clipped Wings, but Not Junk

With their sterling investment grade reputation, tarnished, fallen angels are lumped into a bucket of junk bonds. However, fallen angels compare favorably to their high yield peers in three aspects: quality, performance, and potential upgrades.

Quality

Relative to the broad high yield universe, fallen angels are higher credit quality. This makes sense as the vast majority of fallen angels enter the Index at a BB rating, the most creditworthy high yield rating and a step below investment grade. Historically, the Bloomberg Barclays US High Yield Fallen Angel 3% Capped Index has comprised of more than 70% BB-rated issuers, relative to 40% in the Bloomberg Barclays US Corporate High Yield Index. The higher average credit quality translates into a lower default rate. Since the index's inception in 2005, fallen angels have experienced a lower average default rate of 0.39% versus 0.99% for high yield.

Performance

As noted above, fallen angels produced the highest total returns across most major asset classes since the Index's launch in 2005. Relative to their high yield peers, fallen angels have delivered a lower maximum drawdown and outperformed the Bloomberg Barclays US Corporate High Yield Index in 10 of the 14 calendar years since 2005. While the duration of fallen angels is typically longer, they have generally outperformed during periods of rising interest rates, such as 2006, 2009, 2013, and 2015-2016 (see Exhibit 3).

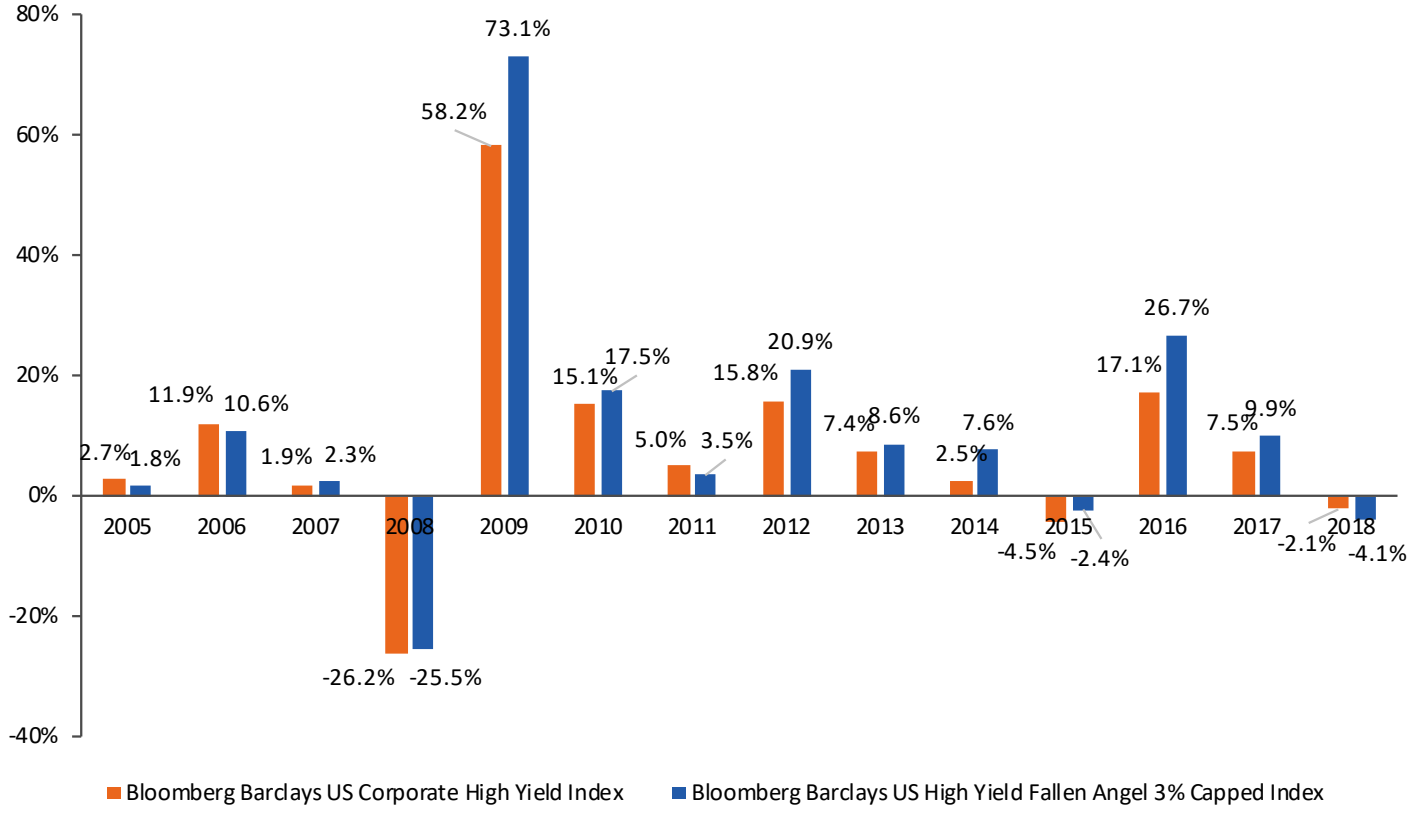


Exhibit 3: Fallen Angel and High Yield Calendar Year Returns
Source: Bloomberg Barclays, Grey shading denotes rising rate periods

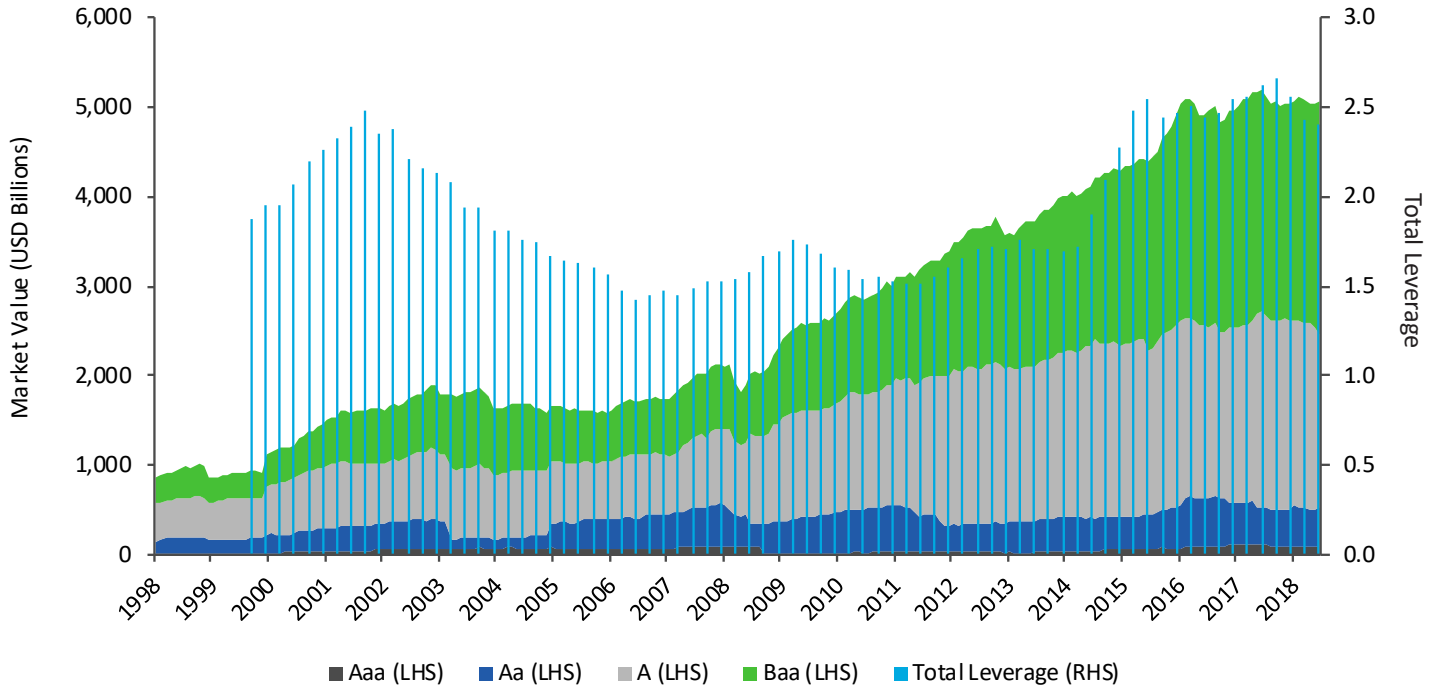


Exhibit 4: BBBs Have Grown Since Global Financial Crisis Growth of US Investment Grade Corporate Universe
Source: Bloomberg Barclays, Mellon Analysis

Potential Upgrades

In addition to the value proposition that makes fallen angels compelling, the asset class has more potential for upgrades than the general high yield market. Most fallen angels are large brand names that have better access to capital markets than original-issue high yield companies, allowing them to fund both operations and any restructurings that may occur. Further, management tends to be motivated and incentivized to regain investment grade status, which is not typically the goal of original-issue high yield companies.

Catching Fallen Angels

As fallen angels take on high yield bond characteristics, three significant trading challenges emerge. The first is high costs, which average approximately 65 basis points per transaction. The second is the narrow universe, which currently contains approximately 250 bonds with a market cap near $150 billion. Finally, in the wake of Dodd-Frank and Basel banking regulations, dealers have become unwilling to commit risk capital to trading, which caused a steep reduction in dealer inventory and higher bid/ask spread volatility. Due to these challenges, both active and passive (including exchange-traded funds, ETFs) managers have experienced difficulty in capturing the full return potential of the asset class.

The Future Looks Bright

We expect the fallen angel universe to expand. The growth of the BBB sector, combined with the latter stages of the credit cycle, may increase downgrades, which would enlarge the opportunity set. As shown in Exhibit 4, bonds rated BBB now make up a significant portion (about 50%) of the investment grade corporate market. Along with increasing concerns of excess leverage, a number of large upcoming maturities could put pressure on companies to either raise more debt, spend down cash or face downgrades/defaults. Nearly 20% of bonds in the BBB bucket have leverage metrics similar to high yield, and rating agencies announced they will start downgrading if current BBBs do not execute on their stated financial plans to reduce leverage. These data points imply an increased pool of potential downgrades and an expanded universe of fallen angels. For these reasons, now is a particularly opportune time to consider a fallen angel strategy.

A Place for Fallen Angels

Fallen angels have a number of compelling features that warrant close examination. While the strong historical return of the asset class is enticing on its own, the idiosyncratic nature of the market creates potential for adding alpha to a diversified portfolio. We believe a systematically driven fallen angel strategy, one that can overcome frictional headwinds and harvest the available alpha opportunities, deserves a permanent allocation within a broader asset allocation framework.

Disclosure

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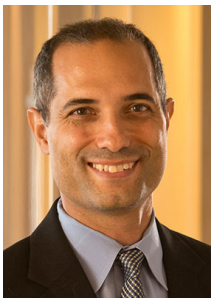

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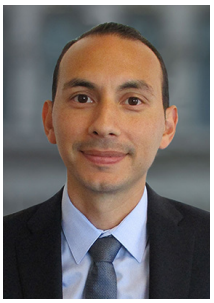
Paul is the head of multi-factor and index fixed income portfolio management. In this role, he leads a team responsible for managing the team's multi-factor and fixed income index strategies, including the High Yield Beta strategy. Previously at the firm, Paul was a senior portfolio manager responsible for the yield curve arbitrage strategy within global asset allocation portfolios. Additionally, he engineered and built the process to automate fixed income portfolio rebalancing and improve operational risk control.

Prior to joining the firm, Paul was a senior fixed income portfolio associate at PIMCO, where he analyzed portfolios, and implemented and managed active US and global fixed income portfolios. Previously, he was a trader at Westdeutsche Landesbank Tokyo, where he built the interest rate swaps trading desk, and a trader at Bankers Trust Tokyo, where he ran the Japanese government bond book. Both positions included market making and proprietary trading. Paul has been in the investment industry since 1994.

Paul received a BA from University of Michigan at Ann Arbor. He holds the CFA® designation and is a member of CFA Institute.



Manuel Hayes
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Manuel is a senior portfolio manager responsible for managing investment grade and high yield cash strategies. He actively works with credit researchers to develop new investment grade and high yield strategies. Additionally, Manuel has pioneered innovation in bond trading with "bond basket" trading to enable lower transaction costs, scalability and enhanced liquidity in the credit space.

Previously at the firm, he served as the primary credit trader on all Global Investment Corporate, High Yield, Emerging Market Hard Currency, Sovereigns and Municipal bonds.

Manuel has been in the investment industry since 2004. Before joining the firm in 2009, he was a credit portfolio associate with Pacific Investment Management Company (PIMCO). Prior to that, he was a fixed income trading associate with Metropolitan West Securities (Wachovia, now Wells Fargo).

Manuel earned a BS in economics from the University of California at Berkeley.

Value is Dead, Long Live Value

Chris Meredith
O'Shaughnessy Asset Management

Value investing is a bedrock principle for quantitative and fundamental equity managers, as there is long-term efficacy to buying cheap stocks over expensive growth stocks. While Value investing remains attractive over the entire history of available data, it has been under extraordinary pressure since the beginning of 2007. As of June 30, 2019, the Russell 1000 Value has underperformed the Russell 1000 Growth by a cumulative -136%, for an annualized return gap of -4.3% over twelve and a half years. Since the middle of 2017 alone, Value has trailed an additional -21%. This recent underperformance has left the investment community on its heels, as Value managers struggle to explain why their style has been out of favor for so long, and allocators question overweight positions in Value.

The severity and length of Value's underperformance will entice some to capitulation. This may take the form of terminating a manager with a sound investment process, and proven track record, or adjustments to strategic allocations because "Value is dead."

We believe that the key principle to investment success is maintaining one's discipline in periods when performance works against you. Discipline is fostered from a conviction in the investment process. And conviction is born out of extensive research. This research piece attempts to answer the questions about Value's underperformance by setting this most recent period within a larger historical context, providing some explanations for why we are in a Growth Regime, and try to set expectations for, if, and when, Value investing will return to favor.

Growth Regime(s)

The main question investors face is whether this underperformance is structural or episodic; is Value investing broken forever or simply in an extended bad run. Part of the challenge in answering this question is that most investment research does not include any periods of Value underperformance lasting over twelve years, leading investors to believe that it's different this time.

In our search for perspective, we extended the research to include new time frames. Most research starts in 1963 because that's when Compustat, the main data provider for historical financial statements, has quarterly availability for income statements. There is also a data set collected by Ken French providing the Book Value of Equity back to 1926, which does allow for some extended research. We like to utilize multiple valuation metrics in our research. To try and gain new insights into whether this Regime of Growth is structural or episodic, we created a new set of fundamentals, which we call Deep History, that extends revenue and earnings data for individual companies back to June-1926.[1] The combination of these datasets with the CRSP pricing database allows us to conduct ninety-two years of historical research on Value Investing for three ratios: Book-to-Price, Earnings-to-Price and Sales-to-Price. In order to ensure that we are working with investible and replicable universes, we also utilize the S&P 500 constituents available through CRSP to create Value and Growth portfolios. For specifics on Data and Methodology, see appendices A & B.

The broad conclusion is that across the entire 92-year time frame, Value investing has been an effective investment strategy generating higher returns than Growth stocks. But by including the earliest time frame back to 1926, we discovered another period where Value investing struggled as badly as it has today: a second Growth Regime from July of 1926 through 1941, shown in Exhibit 1.

	B/P	E/P	S/P
Jul-1926 to Dec-2018	1.06%	3.15%	3.63%
Jun-1926 to Dec-1941	-6.13%	-4.82%	2.14%
Dec-1941 to Dec-2006	4.29%	6.07%	5.12%
Jan-2007 to Dec-2018	-5.97%	-0.87%	-2.03%

Exhibit 1: Difference of Annualized Returns of S&P 500 Value over S&P 500 Growth
(Top (30% minus bottom 30% for each Factor))

Attribution[2] on these time frames shows there were specific sectors[3] in Value and Growth that had significant contributions to the return of the portfolio. For the Growth portfolios, Manufacturing stocks from 1926-1941 were primarily in the Growth portfolio, as were Technology stocks from 2007-2018. For the Value portfolios, Utilities[4] were primarily in the Value portfolio for the earliest Growth regime, while Financials were clustered in Value in the most recent portfolio. This is shown in Exhibit 2.

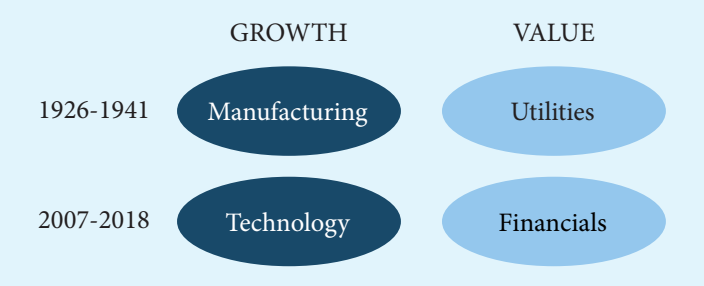


Exhibit 2

Technological Revolutions

The history of these two periods is complex and difficult to summarize, but economic models are useful for simplifying large scale trends into something digestible and applying one may provide insights. With both Growth regimes lasting twelve to fifteen years, but sixty-seven years apart, they are best studied through the lens of the long-term economic cycle of Technological Revolutions.[5]

Technological Revolutions are clusters of new technologies that cause economic upheaval over periods lasting 45 to 60 years. The cycles start with the discovery of ideas, an installation of infrastructure to make it scalable, followed by a deployment with strong growth that eventually results in maturity, where growth slows down. In her work "Technological Revolutions and Financial Capital" (2002), Carlota Perez identifies the phases of a revolution as two halves: the Installation phase and Deployment phase.

In the Installation phase of a new technological revolution, the previous revolution is nearing exhaustion of profitable opportunities. Then, through experimentation new social and economic norms are established for the utilization of ideas. As these concepts take shape and the form factor for utilization is established, people see the potential growth and infrastructure is laid for their widespread adoption. This Installation phase is one of creative destruction, as the new standards replace those from preceding revolutions. It is a period where wealth becomes skewed as innovators are rewarded.

As the new technology shifts to becoming the new norm, the Deployment phase begins. It takes advantage of the infrastructure laid in the Installation phase and expands to broad societal acceptance. This begins with a high growth phase, where real growth occurs, and the technological revolution diffuses across the whole economy. Entrepreneurial activity moves from building infrastructure to the application layer on top. This is a time of creative construction. Winners emerge to form oligopolies, and this growth eventually slows to the Maturity phase, where market growth stagnates.

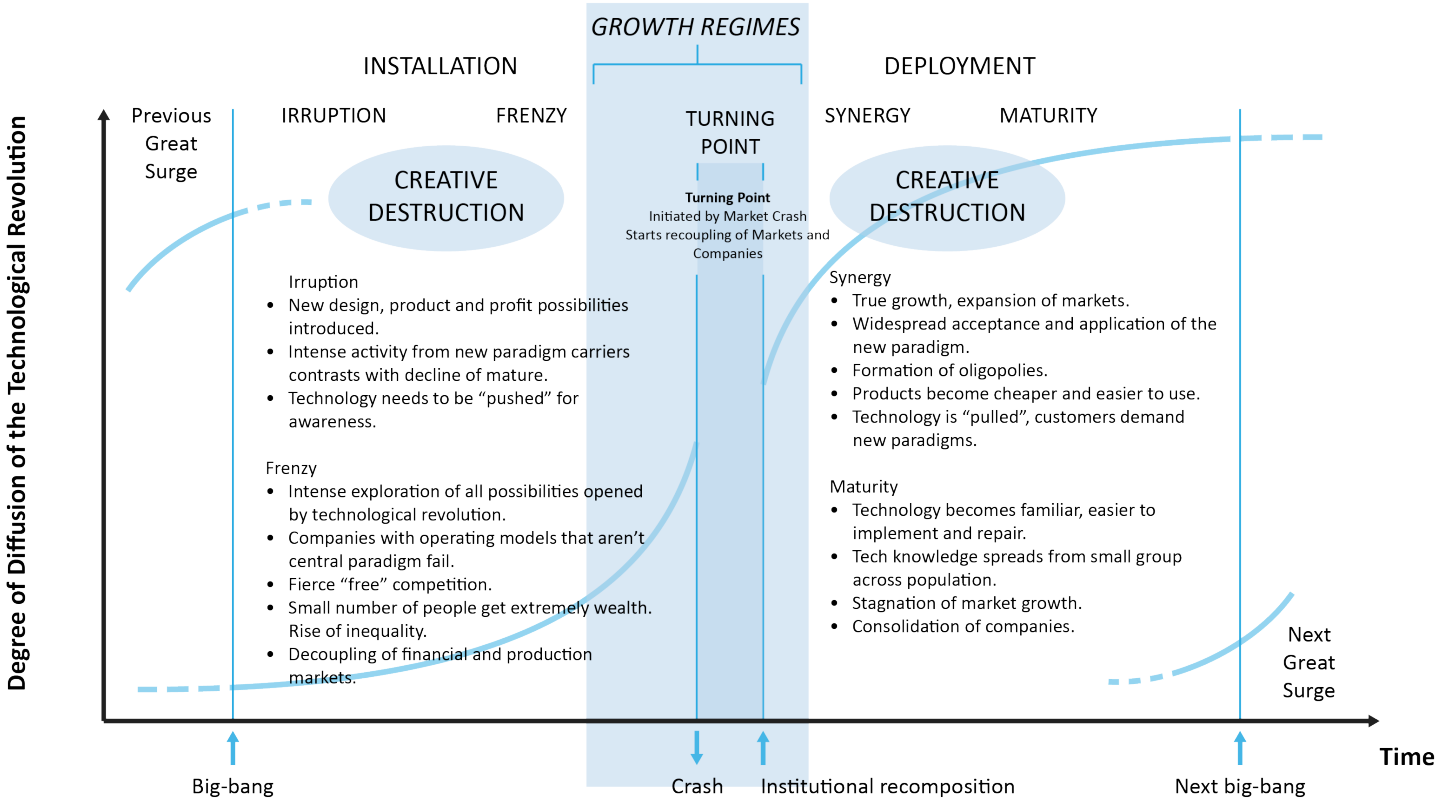


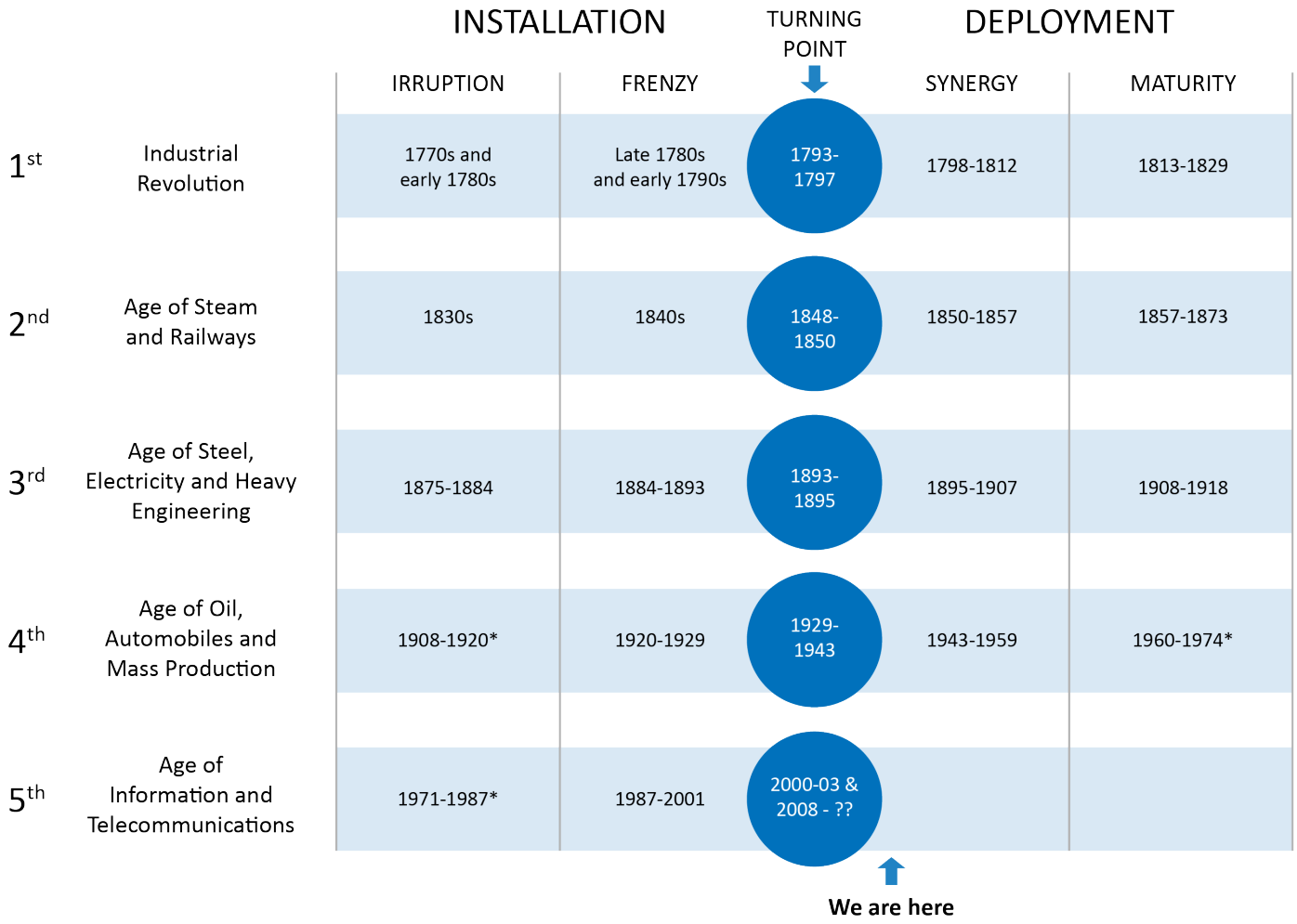
Exhibit 3: Phases of a Technological Revolution
Source: "Technological Revolutions," Perez

This framework has played out several times in history, with technologies like the light bulb. Experimentation occurred over decades with electric arc lamps and vacuum tubes, until Thomas Edison perfected the carbonized filament bulb in 1880, setting the form factor for electric lighting. The coincident innovations of power generation and electrical infrastructure were also required, but after the Installation of the paradigm, there was a rush of applications for it: longer business shifts, the first night-time baseball game. Once the applications were discovered, it was simply a matter of Deployment to electrify the country and change how we lived. Eventually the ideas reach maturity and commoditization, and dozens of light bulbs are now in every house. These phases are illustrated in Exhibit 3.

Timing when these revolutions start and end is subject to interpretation, but Perez's model incorporates some specific timing for phases through a couple of key observations. The first is a "big-bang" event of technological innovation, highly observable events of technological progress. The second timing signals market bubbles that naturally occur from a technological revolution. Perez makes a distinction between production capital and financial capital: "Financial Capital represents the criteria and behavior of those agents who possess wealth in the form of money or other paper assets. Production Capital embodies the motives and behaviors of those agents who generate new wealth by producing goods or performing services."[6] As the norms begin to scale, a "Frenzy" begins where financial capital outstrips production capital, producing valuation bubbles. These bubbles indicate the beginning of the Turning Point. Financial capital eventually relinks, reestablishing normal valuations of the real production of companies, but this can take several years. There are significant failures during this period, as the winners are established.

Between the big bang initiations and the market bubbles, Perez can assign approximate time frames for phases of technological revolutions. She has identified five main technological revolutions, starting with the Industrial Revolution. The two most recent are the Age of Oil, Automobiles and Mass Production (1908-1974) and the Age of Information and Telecommunications (1971-present).

In her model, the two Growth Regimes we have identified are right in the middle of the turning points for the 4th and 5th Technological Revolutions, as shown in Exhibit 4.



Techno-economic paradigm "Common-sense" innovation principles

- Factory production
- Mechanization
- Productive/timekeeping and time saving
- Fluidity of movement (as ideal for machines with water-power and for transportation through canals)
- Local networks

- Economies of Agglomeration/Industrial cities/National markets
- Power centers with national networks
- Scale as progress
- Standard parts/machine-made machines
- Energy where needed (steam)
- Interdependent movement (of machines and transport)

- Giant structures (steel)
- Economies of Scale of plant/vertical integration
- Distributed power for industry (electricity)
- Science as a productive force
- World wide networks and empires (including cartels)
- Universal Standardization
- Cost accounting for control and efficiency

- Mass production/mass markets
- Economies of scale/horizontal integration
- Standardization of products
- Energy intensity (oil based)
- Synthetic materials
- Finctional specialization/heirarchal pyramids
- Centralization/metropolitan centers/suburbanization

- Information-intensity (microelectronics-based ICT)
- Decnetralized integration/network structures
- Knowledge as capital/intangible value added
- Heterogeneity, diversity, adaptability
- Segmentation of markets/proliferation of niches
- Economies of scope and specialization combined with scale
- Globalization/interaction between the global and local
- Inward and outward cooperation/clusters
- Instant contact and action/instant global communication

Exhibit 4: Timing of the Five Technological Revolutions
Source: Combination of Table 2.3 and Figure 5.2 in "Technological Revolutions," with an adaptation of the 5th turning point from Perez's blog post at http://beyondthetechrevolution.com/blog/second-machine-age-or-fifth-technological-revolution-part-2/

The Age of Oil, Automobiles, and Mass Production

Understanding how the innovation from a Technology Revolution changes societal behavior is central to comprehending how a Technological Revolution might affect Value investing. Any survey of a technological revolution in this piece will be superficial, but to gain perspective on what these phases look like, it's informative to review what we know from the two previous revolutions.

The key innovation from the 4th Technological Revolution was the convergence of internal combustion engines and cheap energy through gasoline to create the automobile. The production of automobiles started through craftsmen in the 1880s, where one commissioned a car to be custom made. At the time, the industry was trying several configurations to determine the best model for widespread adoption. At the turn of the century, in fact, steam and electric vehicles accounted for about three-quarters of the estimated four-thousand automobiles produced by 57 American firms.[7]

The big-bang in the automobile industry was Henry Ford's new Highland Park Plant in Detroit. This plant set the manufacturing standards for automobiles by introducing the moving assembly line, where the body of cars were constructed while being transported along a moving platform. As the process evolved, Ford was eventually producing a car every two minutes. This innovation produced a host of organizational, managerial, social and technological changes resulting in the advent of mass manufacturing.

The automobile's rise, however, was only possible because of the ubiquitous, cheap power from gasoline. Established in 1913 after Standard Oil developed the thermal cracking process through experimenting with the refinement of crude oil at various temperatures and pressures, oil became a core input to the rise of automobiles. The creation of an assembly line for mass production, and the commoditization of energy through gasoline are hallmarks of the Irruption phase.

The ensuing frenzy phase began with mass adoption of the automobile, which was fueled by Henry Ford's focus on selling automobiles at low prices. Ford's Model T was introduced in 1908 at $850 and was $360 by 1916, undercutting more expensive options like the electric car which cost $2,800 in 1913.[8] Additionally, General Motors invented GMAC in 1919 to provide financing to auto purchasers, which solidified GM as the industry leader. Lower prices and access to capital resulted in mass adoption of the automobile and established the form factor still in existence today: gas powered internal combustion engine, a gear box, four wheels, control through pedals, and a steering wheel. By 1929, the number of automobiles per U.S. household in the had risen to 0.80 per household.[9] With Chrysler, these rounded out the "Big Three" that would dominate automobile manufacturing for years to come, and it should come as no surprise that General Motors is the Growth portfolio's top contributor from 1926 to 1941.[10] Both of these relationships are illustrated in Exhibits 5 and 6.

Growth wasn't limited to just one product. Change was widespread as several other industries grew in tandem. These came directly from the inputs for manufacturing cars, but also indirect socioeconomic changes stemming from the automobile's

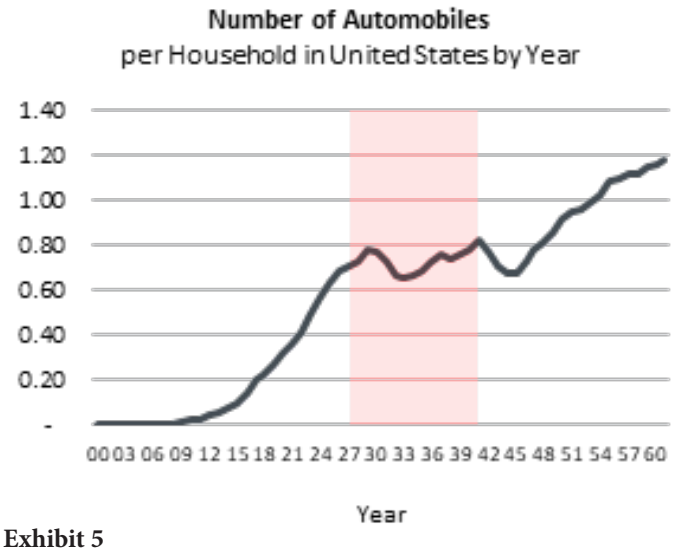


Exhibit 5

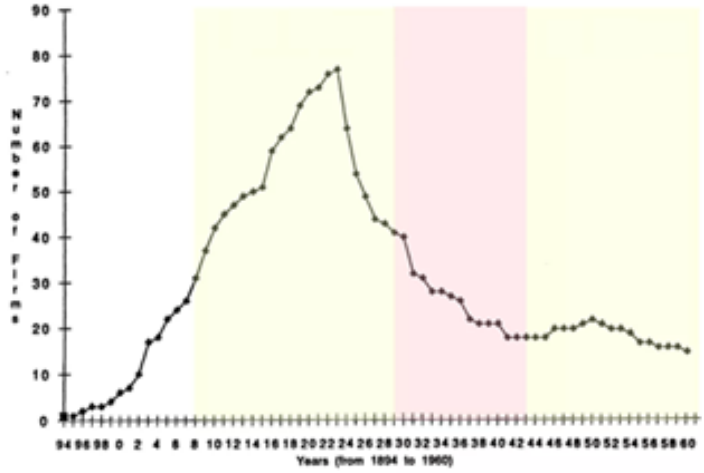


Exhibit 6

introduction. Focusing on the direct raw inputs for cars, by 1929, automobile production consumed 73% of the plate glass, 60% of strip steel, and 84% of the rubber, 52% of the malleable iron, and 37% of the aluminum produced in the United States, as well as significant amounts of copper, tin, lead, and nickel.[11] Consequently, companies producing those basic materials all experienced significant growth.

As the Technological revolution moved to Deployment, the scope of the social after-effects from the automobile and mass manufacturing is so wide that it is difficult to capture. For example, the application of organizational and managerial strategies from the moving assembly line created other industries like home appliances. This was possible because of transportation infrastructure from trucking and the ability for shipment of goods to the household. These appliances changed everyday life; with the average number of hours each household spends on housework plummeting from 58 hours a week in 1900 to 18 hours by 1975.

	Electric Light	Mechanical Refrigerator	Washing Machine	Vacuum Cleaner
1900	3	0	n/a	0
1920	35	1	8	9
1940	79	44	n/a	n/a
1960	96	90	73	73
1970	99	99	70	92

Exhibit 7: US Families Owning Various Appliances (% all families)[12]

In the same vein, the automobile altered how people shopped. Previously, the consumer experience had been limited to goods provided by local craftsmen and mail order catalogs. Everything changed in 1924 when Robert E. Wood joined Sears, Roebuck and Co. While Sears had only operated as a mail-order catalog business, Wood recognized that people in outlying areas would have greater access to urban retail areas because of the automobile. Sears created the first retail store in Chicago in 1925, and by 1929 the company had 300 locations. In 1931 retail sales topped mail-order catalogs for the first time and continued to grow. By the "middle of the twentieth century Sears' domestic annual revenue was about 1% of U.S. GDP, equivalent of $180bn. (In 2016, Amazon's… North American revenue was 'only' $80bn)."[13] Sears' primary and most successful innovation was its consolidated stores of mass-produced goods. The company knew that customers across a wide geographic radius could reach its locations, establishing the standard for American consumerism.

The Turning Point of 1926-1941

Think of the Installation phase as the long process of establishing the technologies that make a car work, as well as the process of building and financing them at a price point for mass consumption, and the Deployment phase as the refinement and mass adoption and maturation of the industry. The "Turning Point" is between these two phases, where the growth is the highest because the trend is just beginning, and the eventual winners from the industry are established. This is when Value underperformed Growth for a prolonged period.

Attribution for the Value and Growth portfolios helps quantify this shift. First, we can see a stark difference in sector allocations. 65% of the Growth portfolio is in Manufacturing stocks, contrasted to only 19% of the Value portfolio. Additionally, 74% of the Value portfolio was in Utilities, while the Growth portfolio only had a 12% allocation to this sector. This is illustrated in Exhibit 8. Taken together, these add up to a little over half of the reason why Growth outperformed Value from 1926-1941.[14]

Looking at individual stocks, we mentioned that General Motors is Growth portfolio's top contributor, but other Manufacturers (e.g. General Electric, Eastman Kodak) and retailers (e.g. Sears, Woolworth) are large contributors as well. For the Value portfolio, Utilities and Railroads were the main detractors, as the railroads faced multiple headwinds: declining infrastructure from nationalization back in 1917-1920, and a structural competitive disadvantage from the comparative cost to run steam locomotives versus trucking. Oil also helped the Growth portfolio, as Standard Oil of NJ and Standard Oil of California (i.e. Exxon and Chevron) were top contributors. The rise of mass food production through National Biscuit, Standard Brands and General Foods also helped the Growth portfolio. 'Old' productions of the capital world like coal, iron, steel, shipbuilding and cotton had flat to decreased demand from 1905 to 1936, while 'new' industries like gasoline, aluminum, nitrogen and artificial silk tripled in size or more, generating strong growth for companies like Union Carbide & Carbon (now a part of Dow Chemical) and Allied Chemical & Dye (AlliedSignal became Honeywell).

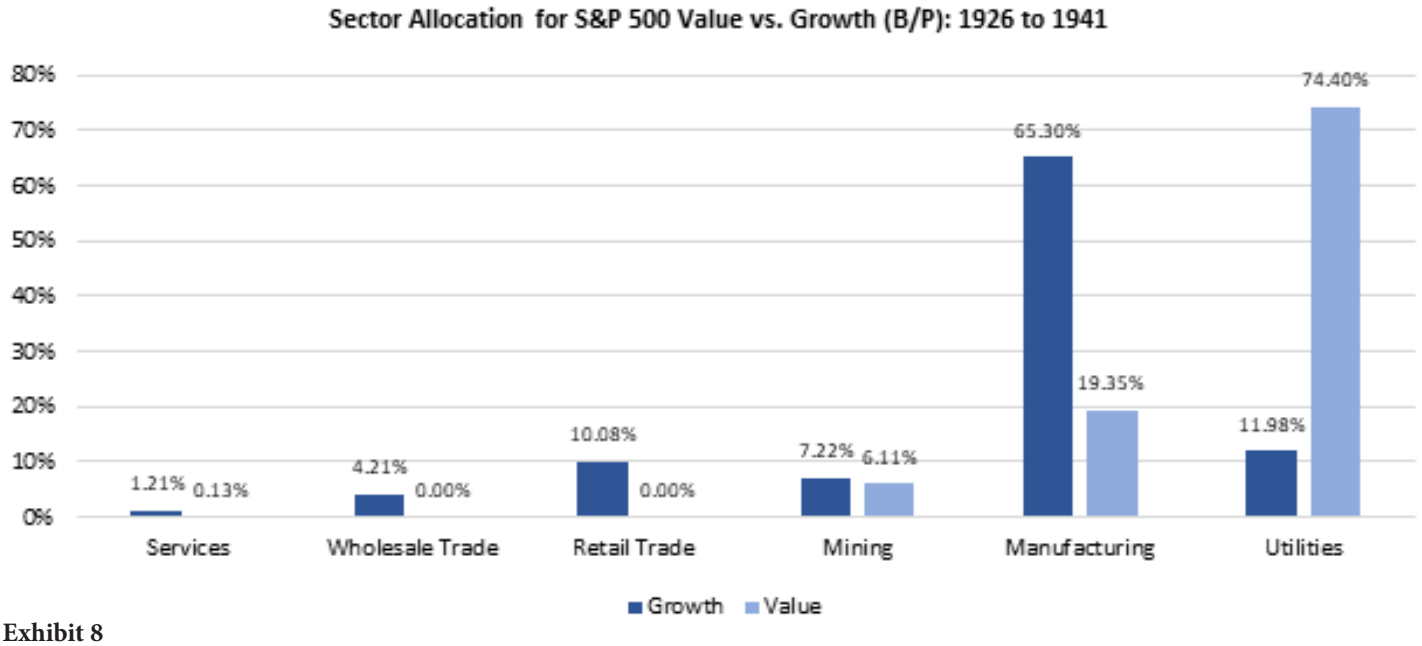


Exhibit 8

The Age of Information and Telecommunications

The similarity between these two ages, and of Manufacturing and Technology, is the broad societal changes introduced through innovation. The technology revolution started with the microprocessor back in 1971, but a steady pace of development has led to convergence for mass utilization over roughly the last fifty years. A popular statistic people quote to scale the advances in processing power is that the iPhone 6 can perform instructions 120 million times faster than the computers that landed Apollo on the moon. It's akin to comparing the Wright brothers' first plane in 1903 to a World War II "flying fortress" bomber. The areal density of disk space doubled every 13 months driving down the price of storage for digital content. Microsoft was founded in 1975, creating an operating system to develop software for productivity and entertainment. In 1977, Apple, Tandy and Commodore bundled these together to offer desktop computing at affordable price points for individual households. Like the Model T, having a price point that was affordable for individual households led to mass adoption. Routers and networking protocols started in the 1980s, followed by HTTP and HTML protocols for standardized development on top of them, which led to the explosion of internet services in the late 1990s.

Amazon was the early winner from the internet boom, as the leader in eCommerce. They created the business template, establishing trust so people would enter their credit card into a site. Comparing the fourth revolution to the fifth, Sears and retailers of the 1930s disrupted the craftsman market because the automobile allowed people to travel to department stores where they could shop for anything. Amazon partially unwound the retail model of the fourth age by offering a retail experience where you order online, and the goods are shipped to you. Some retail models (i.e. groceries) are still being established in the eCommerce age, indicated by Amazon purchasing Whole Foods.

Broadband changed the internet experience, as people migrated from dial-up connections over telephone lines to cable modems, allowing for richer media and higher interaction with sites. 3G wireless networks were introduced in 1998, followed by 4G in 2008, extending cellular service beyond voice and messaging to wireless data.

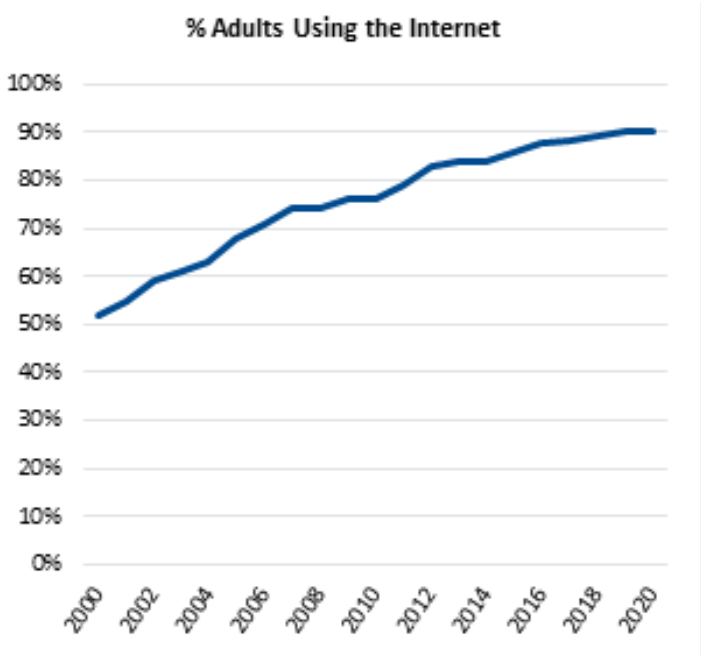


Exhibit 9

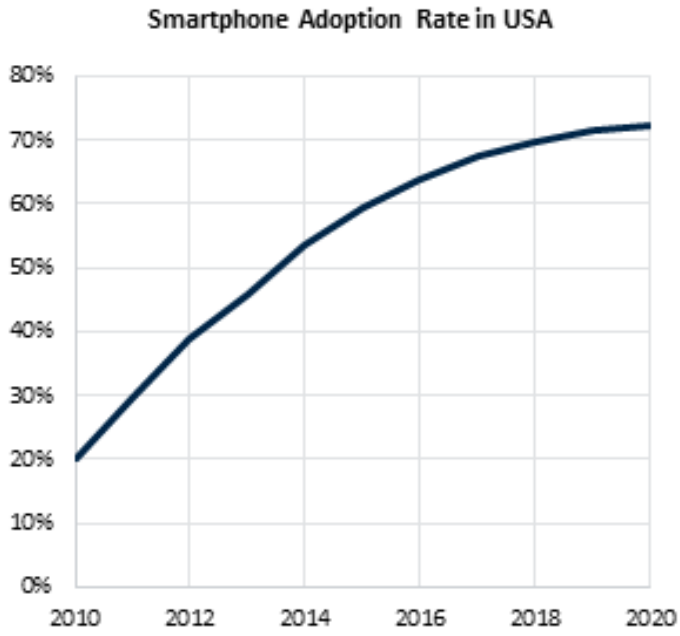


Exhibit 10
Source: Statista, % of Entire Population

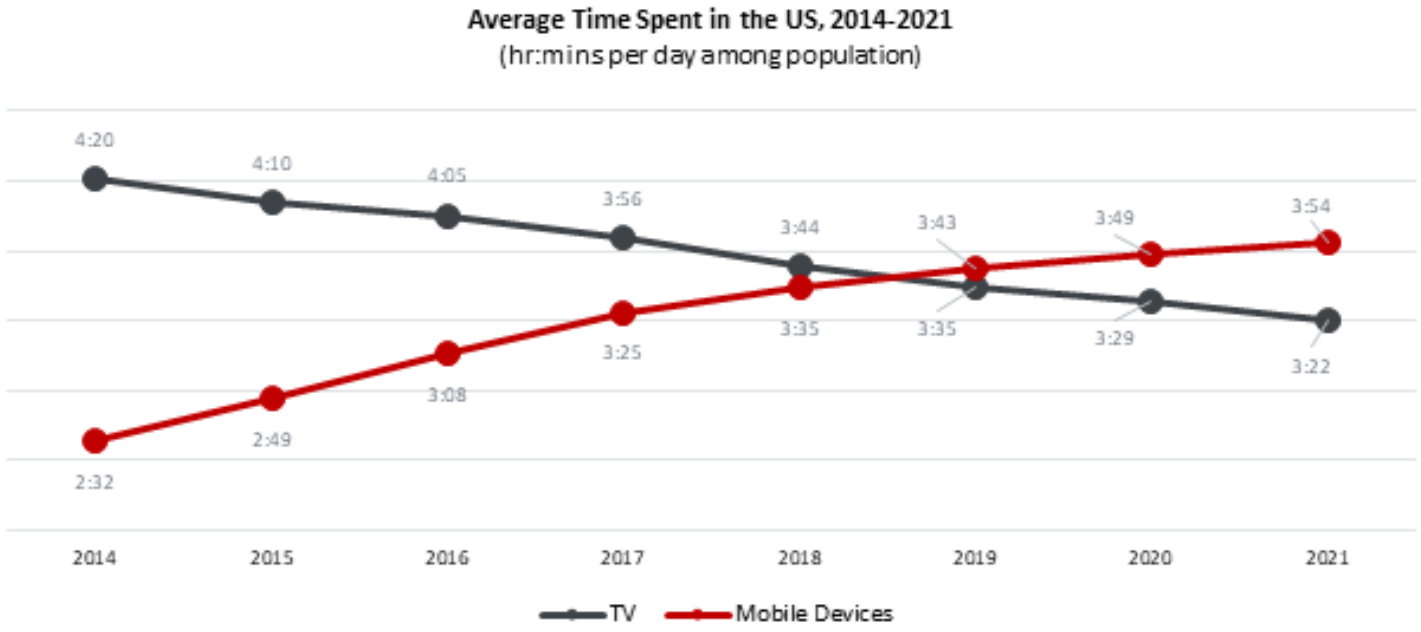


Exhibit 11

Source: eMarketer April 2019, ages 18+; time spent with each medium includes all time spent on that medium, regardless of multitasking.

Far from slowing down, Innovation continued with the introduction of smartphones. There were some initial attempts at such devices in the 1990s, but by the early 2000s, RIM had established itself as a market leader in the business community with the Blackberry, which focused on email as its primary use. Then, in January of 2007, Steve Jobs introduced the iPhone. "We are going to… get rid of all these buttons and use this giant screen."[15] The iPhone wasn't a technological innovation in itself, rather a new form factor of several established pieces of technology: computer processing, flash memory, battery storage, touch screen, and operating system. It established a new paradigm for how people interacted with their phones, and connected people to the internet, for information, communication, and entertainment, regardless of geographical location.

The iPhone first shipped in June of 2007, and with its intuitive interface, the smartphone adoption rate grew significantly, from 20% to 72% of the US population from 2010 to 2018. Normal market competition ensued, with Samsung releasing a competitive product at a lower price point, and the overall market continued to expand. Blackberry failed to adopt the touchscreen format and started posting quarterly losses in 2012. Smartphone sales finally peaked in 2018, the first year that sales ever declined. To put it in perspective of the market penetration, 18% of the population is aged 14 or under, [16] meaning almost every adult now has a smart phone. In addition, usage of the devices has increased steadily, where daily iPhone usage surpassed TV for the first time in 2019. At almost four hours a day, the average person spends more than a full day on their phone each week. Over this time, Apple went on to become at one point the most valuable company in the world, and the number one contributor to Growth outperforming Value from 2007-2018.[17]

Value investing generates excess return by an over-discounting of future earnings relative to trailing earnings. But it requires a stabilization and recovery, alongside a rerating of valuations to the new expectations. A good example is Seagate Technology, which a number of short-sellers openly bet against in 2013. The investment thesis was that the PC market was declining with the advent of mobile computing and cloud computing, hard disk drives would be in structural decline. What wasn't accounted for was that hard disk drives were still the best solution for large scale data centers, so demand would not decline as far as predicted. The stock began 2013 with a P/E around 4x,[18] and price went on to more than double over the next two years through a rerating back to a P/E of 14x. Seagate's story is not yet complete, but those two years squeezed the short-seller while the Value investor was rewarded.

Blackberry looked increasingly like a Value investment in the middle of its creative destruction. The P/E ratio of Blackberry company after the iPhone launch reached as low as a P/E in the 3x range until earnings went negative in 2012. Technology revolutions work through creative destruction, which in the case of Blackberry, offers no stabilization for the rerating to occur. OSAM mitigates the risk of Value traps by using quality factors to confirm the health of the company, themes like Earnings Growth, Earnings Quality, Financial Strength, Momentum. But even with quality controls, the clustering of innovation from Technological Revolutions creates more potential traps for Value portfolios.

The Turning Point of 2007-2019

A similar sector weighting imbalance also occurs between the Value and Growth portfolios, with Technology stocks belonging primarily to Growth. The technology stocks that contributed in Value are those taking advantage of the infrastructure laid starting in the 1970s. We discussed Apple's ability to revolutionize mobile computing, and Amazon setting the standard of eCommerce, and they are the two top contributors from Technology. Facebook built a social media empire on top of the internet and mobile computing and contributed strongly. The technology companies that laid the infrastructure like Intel didn't figure into Value or Growth as they tended to be more core valuations with relative maturity in their business cycle. Microsoft is the only stock from the Irruption phase that remains a top contributor, as it has positioned itself well within the shift to cloud computing through Azure.

While the rise of technology stocks is a significant component of the reason that Growth outperformed Value over this turning point, about three quarters of the underperformance comes from Financials.[19] In the Turning Point of the 4th age, a similar negative impact came from Utilities, so it becomes useful to understand the impact of these sectors on the Value portfolios.

Two Crashes of Financial Capital

Although not well known, Samuel Insull might have had more effect on the utilities industry than anyone else in the country. Insull was originally hired as Thomas Edison's personal secretary and had risen to become the number three person at General Electric by 1892. At the age of 32, he left to take over Chicago Edison which was about 2% of the size of GE. At Chicago Edison, he established several business paradigms for utilities that exist in today's utility markets, including the use of AC/DC in distributing power.

As he built out the utility business, Insull aggressively purchased several other utilities, creating a gas and electric empire extending over thirty-two states. The basis for his ability to purchase so many companies was a pyramid holding company structure that heavily favored bonds and preferred stock with a guaranteed dividend. His aggressive acquisition spurred others to similar action, resulting in "eight holding companies controlling 73 percent of the investor-owned electric business."[20] As cash dried up, Insull also switched from cash dividends to stock dividends, using the inflated stock valuations in lieu of cash to keep the machine going. After a takeover attempt, Insull created two additional layers of holding companies to try and retain control. Stacking these structures created massive amounts of leverage, to the point where he controlled an empire of $500m in assets with only $27m in equity.[21] This leverage was fine in the upmarket, but a market decline would cause significant problems. When asked in a Forbes interview about the leverage in his holding company, Insull responded that "a slump or calamity that would be disastrous [for electric utilities] is practically inconceivable." [22]

During the decline of the Great Depression, utility revenues did hold up better than manufacturing, but even a slight decline caused significant pressure on the company. Insull's company had pledged its stock as collateral to New York banks, and eventually the company went under when England announced that it was leaving the gold standard. As the banks started uncovering the issues with leverage, the state initiated criminal proceedings, and Insull immediately fled the country, believing there was no way he could get a fair trial. He was eventually extradited and faced trial but was exonerated on all charges. One juror that had served as a sheriff commented he had "never heard of a band of crooks who thought up a scheme, wrote it all down, and kept an honest and careful record of everything they did." [23]

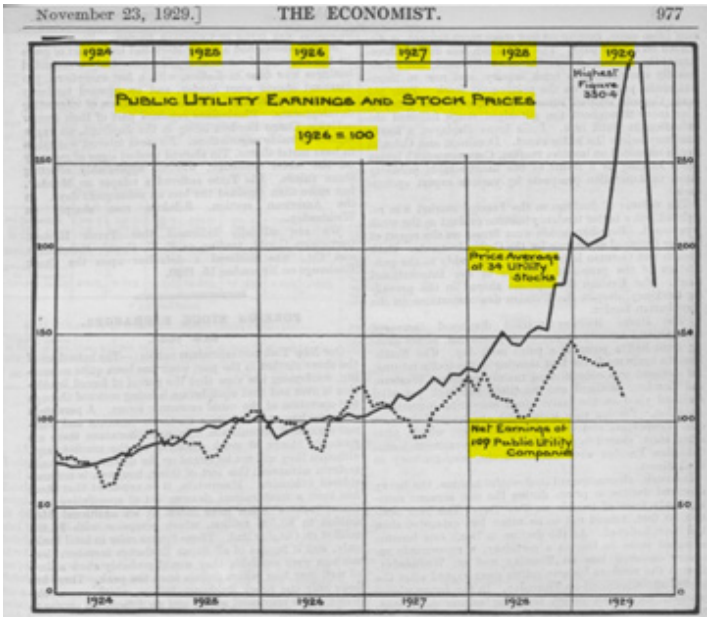


Exhibit 12
Source: The Economist, 1929

The criminal system might have determined Insull wasn't culpable, but the political process did not, resulting in the federal Securities Act of 1933, Securities Exchange Act of 1934, and the Public Utility Holding Company Act of 1935. The last act broke up the holding companies, and forced them to register with the SEC. In addition, the companies were ordered to specialize in one service (such as gas or electricity), and divest all unrelated holdings. This era of tighter regulation created a barrier for utility companies in achieving economies of scale and generating supernormal earnings for the foreseeable future.

We don't need to revisit the financial crisis, so long as the reader understands the similarities to what happened with utilities from 1926-1941: the belief that a market would never go down, combined with leverage, led to a bubble and subsequent collapse, which was followed by public outrage and tighter regulation.

Carlota Perez's model accounts for both of these collapses in Part II of her book, where she introduces the relationship between financial capital and production capital. As the Frenzy and Turning Point part of the cycle occurs, the success from investing causes financial capital to "believe itself capable of generating wealth by its own actions, almost like having invented magic rules for a new sort of economy."[24] In this case, the leverage used from Insull's scheme, and the easy money from subprime credit, both fueled by the belief that the demand for electricity and housing prices would never collapse.

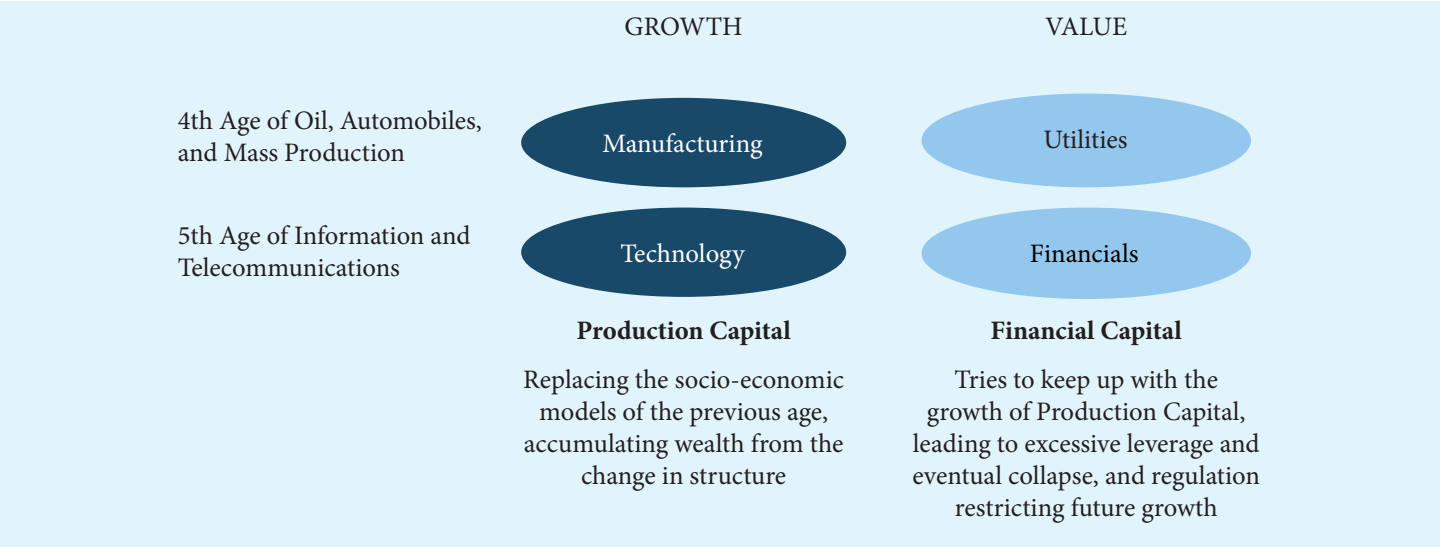


Exhibit 13

Moving Along the Curve

Hopefully by this point we have established that while this may be a long-term market dynamic, the last twelve years are something we have gone through before. There are periods of innovation clusters that change the standards of our society, the consumption patterns of the economy and how the value from those economic actions are distributed across public companies. These clusters of innovation have periods of transition from widespread Installment to Deployment are aligned with regimes when Growth outperforms Value. The insight provided by this analysis is that as the economy transitioned out of the turning point to the Deployment phase, the economy enjoyed broad growth from the expanded utilization of the framework, during which Value returned to outperforming Growth. There is no guarantee this pattern will continue, but the rationale is compelling.

Looking at the 4th Technological Revolution, we can see that Value Investing returned to form fairly quickly as we moved along to Deployment and the high growth of Synergy. All three Value factors generated higher spreads within that period than across the entire 92-year period. The chart showing the decline for Price-to-Book across the two periods looks remarkably similar, and one can see the sharp rebound starting in 1942.

Attribution of the Synergy phase of 1942-1959 shows that some of the outperformance came through Manufacturing as companies like Goodyear Tire, Texas Co and International Paper moved to from Growth to Value, similar Apple moving towards Value (based on earnings) over the last few years. But the main contributor to Value outperforming was from railroads and utilities, the companies of the third Technology Revolution that dragged so badly during the turning point of 1929-1941. The railroad industry began a transformation from Steam to Diesel in the 1930s, moving away from the third revolution and fully into the Fourth. This change dramatically changed their cost structure, where dieselized railroads created a competitive cost advantage over trucking for mass transport of goods. Southern Railway, the railroad with the strongest returns over this time period, started adopting diesel in 1939, and became the first major carrier to have a complete diesel fleet by 1953.[25]

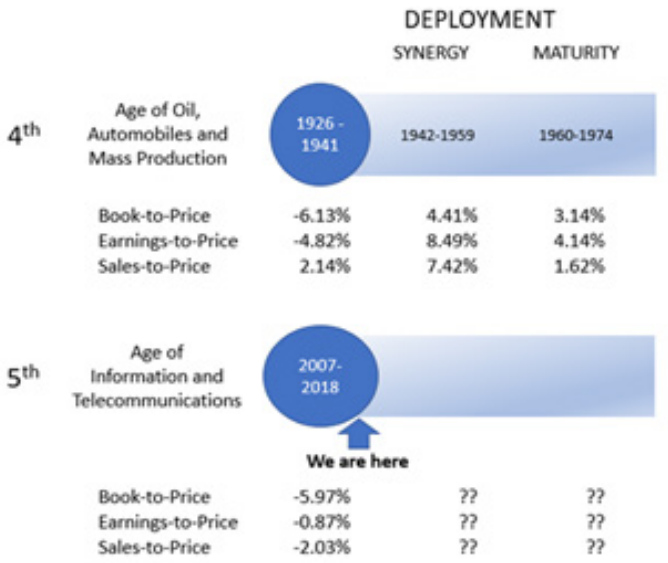


Exhibit 14: Annualized Spread of Value over Growth by Phase of Technological Revolution

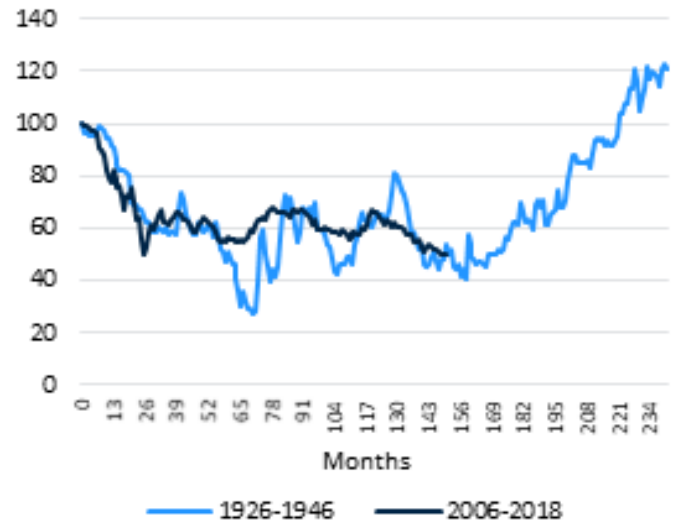


Exhibit 15

NAME	Jun-1926 to Dec-1941	Jan-1942 to Dec-1958
SOUTHERN RAILWAY CO	-78.3%	8876.3%
NORTHERN PACIFIC RAILWAY CO	-91.0%	6878.9%
SOUTHERN PACIFIC CO	-85.7%	4338.9%
NEW YORK CHICAGO & ST LOUIS RR	-78.3%	3957.0%
ATCHISON TOPEKA & SANTA FE RY C	-61.4%	3434.3%
S&P 500	34.11%	1484.0%

Exhibit 16

If we believe that this long-term historical narrative will play out, the important question is when are we moving into the Deployment phase? For allocators of capital, we want to know how much longer this Growth Regime can last.

We do have the timing mechanisms of the market crashes. The problem is that there is no prescribed passage of time after the bubble correction when you move into Deployment. That said, given that it's been twelve years, it certainly seems like this period is getting a bit long in the tooth.

One key pivoting point in any technology is when the standards are set for how the technology will be deployed across society. In the case of technology, one could argue that the introduction of the smartphone disrupted the consumption patterns of information, and we are still figuring out the matching of platform to consumption. The societal habits for whether people will use their desktop, laptop, gaming console, smart speaker, tablet, or phone for communicating, shopping, gaming, and business productivity. But with the smartphone adoption curve shown before, the platform is established for delivery of information to anyone anywhere, and with embedded cookies, canvas fingerprinting, and geolocational tracking, the delivery of information on everyone to anyone.

Another key sign in standards being set are the formation of oligopolies and monopolies. For every one of the previous

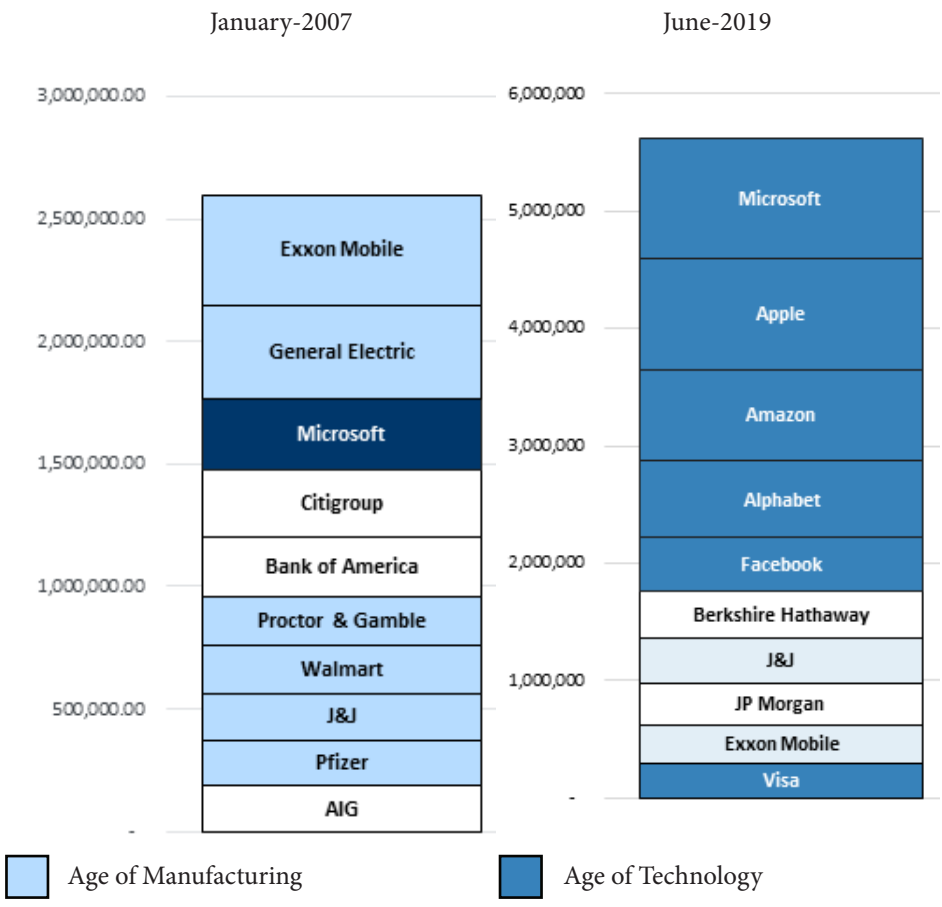


Exhibit 17: Largest Ten Names in S&P 500

technological revolutions, there have been winners that have established the standards accumulated market share and became synonymous with the technology itself. Exhibit 17 shows the shift in the market leadership over the last twelve years, with the Age of Technology forming oligopolies through the FAANG stocks.

It should be mentioned that because these oligopolies are so large, one would suspect that they can't get bigger. Amazon's market share is 49% of online retail and 5% of total retail. While it's one of the largest companies in the world, there's still potential to grow. Sears didn't grow to become 1% of GDP until the 1950s, well into the Deployment of the cycle. General Motors and Sears were the top two contributors to the Growth Portfolio[26] during the synergy phase of 1942-1959, but the Value portfolio outperformed during the creative construction of deployment, where the overall economy grew and the value cycle of stocks being overly discounted and rerated was the norm.

One should not underestimate the role of regulation in how the Age of Technology plays out. The Senate hearings regarding Facebook highlight the idea that privacy rights are far from established and could create structural issues for technology companies. Additionally, anti-trust legislation always rears its head as near monopolies exert power.

If Value investors take nothing else from this piece, hopefully it gives perspective. Technological revolutions are one framework for looking at history, but they offer a lot of insight into what our world and our markets are going through right now. The introduction of the internet and mobile computing has been broad and swift, introducing change at a far greater pace than the automobile. And it makes sense that these changes will cause distress on businesses from the previous paradigm. These are long cycles that have played out before, starting with the Industrial Revolution in the 1770s. What we have offered here, as our ability to gather historical data continues to improve, is the possibility that long regimes where Growth outperforms Value are part of these arcs. We have also seen that eventually as the innovations move to maturity, Value investing has also returned towards a longer-term trend of outperforming.

Disclosure

The material contained herein is intended as a general market commentary. Opinions expressed herein are solely those of O'Shaughnessy Asset Management, LLC and may differ from those of your broker or investment firm.

Appendix

Appendix A: OSAM Deep History

The OSAM Deep History dataset was created through several steps. OSAM procured digital copies of the entire history of Moody's Manuals for Transportation, Industrials and Railroads. A list of companies available through CRSP with a market cap over $200m (inflation-adjusted) and a stock price over $1 were supplied as the companies to generate data for. These files were sent to an offshore third party, where the entirety of the income statement and balance sheet were typed into spreadsheets.

In order to determine which items were Sales, Net Income and Book Value of Equity, a supervised machine learning algorithm (Support Vector Machine) was used. We classified about 5% of the data manually and used those as the training data set. Any items with sufficient confidence level of classification was incorporated into the dataset. Another round data entry was performed to get almost 100% coverage of S&P index constituents. A data outlier algorithm (Isolation Forest) was used to look for additional outliers within the data, which were subsequently cleansed.

Appendix B: Value Portfolios

For the investment universe we limited ourselves to the S&P 500 constituents available through CRSP. The idea was for 1) an investible universe of stocks so the research would reflect real world conditions and 2) have our methodology be replicable to other researchers could verify findings. The S&P 500 constituents became 500 stocks in 1957, so from 1926 to 1957 there are only 90 stocks in the universe for investment.

Pricing and market capitalization are provided by CRSP. Sales and Net Income were sourced from OSAM Deep History and Compustat, with Deep History being the primary source for fiscal years of 1956 and before, and Compustat thereafter. Book Value was sourced primarily through Compustat, followed by the dataset provided on Ken French's website, and lastly through the OSAM Deep History. The reason for using Ken French's data for Book Value first was to allow for replication of the time series on Book-to-Price by others.

Portfolios are formed using a similar methodology as Fama-French (1993), fundamentals are formed at the end of June every year to ensure full reporting of annual reports. This also coincides with the release of the Moody's manuals the new dataset is based on, to ensure there is no lookahead bias.

Because of the limited number of stocks in the universe, we build Value and Growth portfolios based on the Fama-French 1993 methodology of Top 30% and Bottom 30% for each valuation metric. This ensures an appropriate number of stocks in each portfolio to achieve diversification of stock-specific risk. We use value-weighted (i.e. market-cap weighted) returns for each test. Equally-weighted returns of S&P 500 constituents were also run, and showed similar underperformance during the time frames discussed.

	Growth	Core	Value	Spread
S&P 500 MArket Cap Weighted	3.00%	2.42%	-3.13%	-6.13%
Market Cap > $200m Market Cap Weighted	3.46%	0.64%	0.07%	-3.39%
Market Cap > $200m Equally Weighted	2.19%	0.97%	0.65%	-1.54%
Market Cap > $50m, Eq wt	2.24%	2.05%	1.01%	-1.23%
Market Cap > $20m, Eq wt	2.01%	3.19%	1.19%	-0.82%
Market Cap > $10m, Eq wt	2.20%	3.81%	2.29%	0.09%
Market Cap > $5m, Eq wt	2.38%	4.81%	4.08%	1.70%
No Limits, Eq wt	2.70%	5.32%	8.63%	5.93%

Appendix B: Book-to-Price Portfolios (July-1926 to Dec-1941)

One note: while our S&P 500 portfolios aligned generally with the Value-Weighted portfolios on Ken French's website, we saw significant differences in the equally-weighted universes. We believe this is due to the inclusion of microcap stocks in the French portfolios. The following table shows the returns on the 30/40/30 portfolios formed on Book-to-Price using various market cap limits (inflation adjusted) for the 1926 to 1941 time period. The inclusion of a small number of very small companies dramatically shifted the equally-weighted Value portfolio. This is particularly true in 1932, where small companies like the Manati Sugar Co, with a total market capitalization of thirty-one thousand dollars, was up 800% over the next twelve months. We believe including these companies provides an inaccurate representation of how Value investors would have done from 1926-1941.

Appendix C : Attribution Calculation

In this paper, a multi-period Brinson Attribution methodology was applied to account for relative performance contributions. For every period, group weights, returns and contributions were calculated for each portfolio. The relative performance for every group was then decomposed into Allocation, Selection, and Interaction effects following the Brinson approach:

Portfolio contributions and relative performance decompositions were linked across periods using a geometric linking method. Group allocation, selection, and interaction effects were then summed to arrive at total effects. The residual of actual excess performance and linked excess performance was distributed equally across all final composed effects.

$$Allocation = (w_i^p - w_i^b) \times (R_i^b - R^{-b})$$
$$Selection = w_i^b \times (R_i^p - R_i^b)$$
$$Interaction = (w_i^p - w_i^b) \times (R_i^p - R_i^b)$$

, where

w_i^p = Portfolio weight for group i

w_i^b = Benchmark weight for group i

R_i^p = Portfolio return for group i

R_i^b = Benchmark return for group i

R^{-b} = Total Benchmark return

Endnotes

1. See Appendix A on the data collection methodology.
2. See Appendix C for attribution methodology.
3. Broad SIC classifications were used to define sectors. Using two-digit codes, Manufacturing is 20-39, Utilities are 40-49, Financials are 60-69, Technology stocks are predominantly in code 73.
4. Note: the Utilities sector includes power Utilities such as Gas and Electric, as well as Railroads.
5. Also known as Kondratiev waves, first observed by Nikolai Kondratiev in *Major Economic Cycles* 1925.
6. Perez 72.
7. Freeman and Louca *As Time Goes By*, 274.
8. Freeman and Louca *As Time Goes By*, 275.
9. OSAM Research. Source: Number of Firms Participating in the Auto Industry in the U.S.: Utterback, JM, and FF Suarez. "Innovation, Competition, and Industry Structure." Research policy. December (1993).
10. Note: Ford was a private company until 1958. Value based on Book-to-Price.
11. Freeman and Louca *As Time Goes By*, 265.
12. Freeman and Louca *As Time Goes By*, 289.
13. https://www.theatlantic.com/business/archive/2017/10/amazon-sears-mistakes/541926/
14. OSAM Research.
15. McNish and Silcoff. 2015 *Losing the Signal*, 129.
16. https://en.wikipedia.org/wiki/Demography_of_the_United_States
17. Note: Apple was in the Growth portfolio for Book-to-Price for almost the entirety of 2007-2018, but was not consistently in the Growth portfolio on Earnings. By the middle of 2013 it actually moved into the Value portfolio, and is a contributor for the difference in performance between B/P and E/P over that time period.
18. OSAM Research.
19. The impact of financials is slightly higher in S&P 500 portfolios because it is using just the top 30% and bottom 30% on Book-to-Price, but it's not far off from contribution for the Russell 1000 Growth and Value, where Financials accounted for about 56% of the total underperformance from Jan-2007 to Dec-2018.
20. Hyman, Leonard S. (1988), America's Electric Utilities: Past, Present and Future, Public Utility Reports, p. 74. As cash dried up, Insull also switched from cash dividends to stock dividends, using the inflated stock valuations in lieu of cash to keep the machine going.
21. https://www.nytimes.com/2006/03/19/business/yourmoney/before-there-was-enron-there-was-insull.html.
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23. Henderson and Cudahy. 2007. "From Insull to Enron," *Energy Law Journal*: 71.
24. Perez 75.
25. https://en.wikipedia.org/wiki/Southern_Railway_(U.S.).
26. Valuation based on Book-to-Price.

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Hedging the Real Risk of Private Equity

Peter van Dooijeweert
Man Institute

Most hedging conversations with investors focus on hedging the public portion of their equity portfolios. However, more recently, there is an increasing focus on hedging private equity ("PE.")

These questions come even as allocations to PE have been increasing as a percentage of overall assets. Public pensions awarded 64% more mandates in PE in 2018 than they did in 2017.[1] Typically, little to no capital is allocated to managing PE risk, even though underlying assets are effectively leveraged public equity. In part, risk mitigation in PE poses a challenge as cash flows generally do not support much capacity to spend on option premiums.

However, investors may also be taking comfort from the low volatility of the reported returns and seemingly relatively benign drawdowns during crises.[2] While these very smooth returns imply low risk, we believe investors would be wise to judge those reported results cautiously.

Indeed, recent data may be altering the perception of PE risk among investors. First, with relatively low-cost financing available in the leveraged loan market, the percentage of companies acquired at 7x leverage has, once again, reached 2007 highs of 40%. Meanwhile, the average EBITDA[4]-to-purchase price multiple of acquisitions remains at historically high levels (Exhibits 1, 2) with more than USD 2 trillion of buying power at PE firms potentially being deployed at current valuations.[5]

As such, tail risk in new investments may be greater than the previously very smooth track records may suggest. Further, there is the possibility in a large-scale crisis that high valuation premiums turn into discounts if investors are forced to monetize PE holdings.

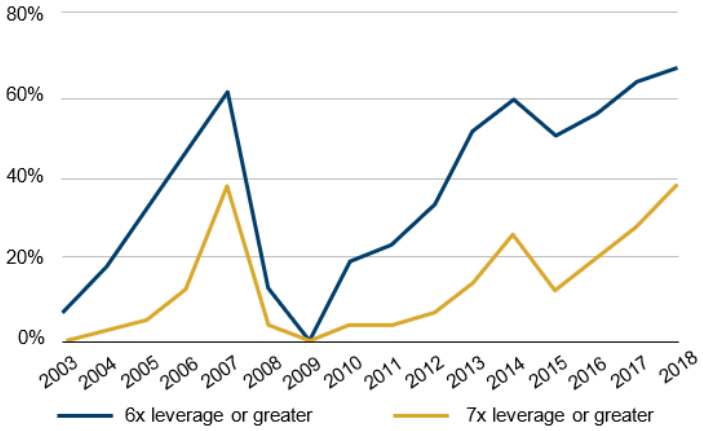

Exhibit 1: Leverage is Increasing
Source: Bain & Co. (citing Loan Pricing Corp data); as of end 2018

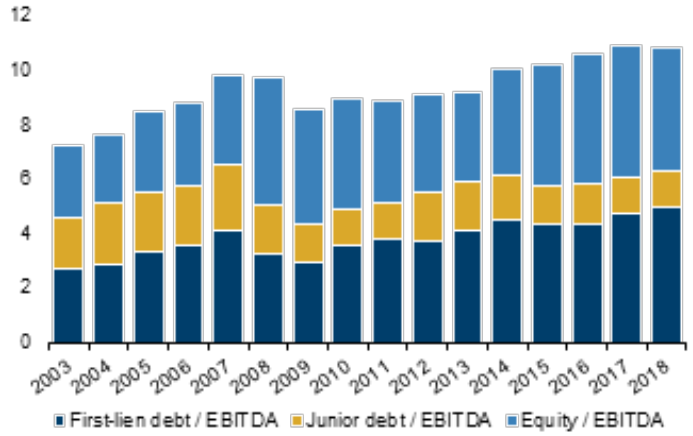

Exhibit 2: Multiples are at a High
Source: Bain & Co. (citing Loan Pricing Corp data); as of end 2018

One of the challenges in discussing hedging PE is determining what the true risk of the investment really is. Drawdowns in 2008/2009 appear to be quite low at 25%, according to the Cambridge Private Equity Index. Additionally, systematic and total risk seems almost non-existent in long-term returns, with a calculated beta to the S&P 500 Index of 0.5 and realized volatility of 9% since 2005 (versus 16.5% in S&P 500).[6]

A number of academics have attempted to come up with calculations of beta and volatility that more accurately reflect the true risk of PE, with a recent study reaching a beta of 0.8[6] and MSCI-BARRA finding a beta closer to 1.0; however, these results still seem rather unsatisfying. While beta may be an interesting qualitative measure of risk, we believe investors should be most concerned with potential drawdowns.

The first part of this paper will provide some framework for determining whether the downside risks of PE are accurately reflected in PE indices. While leveraged exposure to public equity indices is frequently used as a proxy for PE, this paper will present three other approaches that can be used in evaluating PE risk using public securities. That analysis then naturally leads to potential hedging solutions and may illuminate whether the excess returns demanded by investors for illiquid assets are high enough versus the risks taken.

Measuring Tail Risk and Volatility of PE

There is no shortage of debate regarding the actual risk of PE versus the perceived risk generated by the smoothed effects of how PE stakes are marked to market. A number of papers have been published on the topic, with Stafford and Jurek (2015) demonstrating that "over the period from 1996 to 2014, return smoothing in just two key months (August 1998 and October 2008) is sufficient to statistically obscure the exposure to downside market risks".[7] Returns benefit from book value-reporting methods used by PE firms, which result in much lower volatility than marked to market methods in public equities. Given the typical PE transaction increases a target firm's leverage by between 30% and 70%,[8] one could conclude that a PE index with a daily mark to market might look more like a leveraged investment in the S&P 500.

Further, given the smaller capitalization of companies taken private, a better benchmark index may well be the Russell 2500 (the smallest 2,500 companies of the Russell 3000). The implication of both the leverage employed and the indices referenced as benchmarks may be that potential drawdowns and volatility of portfolios are greater than presently perceived or reported.

Replication of PE Using Public Proxies (Liquid PE)

The S&P 500 is a poor proxy for PE given the weighting of mega-cap companies. As a result, investors may prefer the Russell 2500. However, the index has many factors that may detract from it being a fair equivalent for PE, not the least of which is significant weighting in biotechnology companies, utilities, and real estate investment trusts (REITS).

A better approach to replicate PE investments may be made by looking for publicly traded equities within these indices that best mimic private companies. An approach to this is discussed in an article written by Man Numeric, "Private Equity Goes Public," in July 2018. PE risk can be approximated via public equity using "statistical replication approaches that rely on regression based techniques to identify key drivers of PE returns and tilt the portfolio towards those." Strategies looking to invest in public equities in this manner are frequently referred to as liquid PE with marketed benefits of higher liquidity and lower fees.

The Summer Haven Private Equity Strategy Index (based on the work of Erik Stafford) uses these sorts of techniques and thus forms a potential reference point in evaluating PE risk. The history in Exhibit 3 shows a similar slope and return structure to the Cambridge Private Equity index. Note, however, the significant drawdown in 2008/09 and the episodic drawdowns that stand out in the Summer Haven index, but not in the Cambridge series.

The Summer Haven return series also appears more volatile over time. Exhibit 4 compares the annualized realized volatility of this index with the Cambridge PE index.

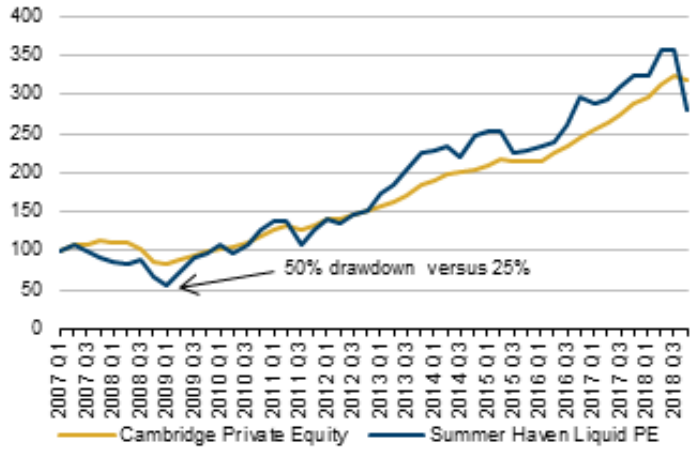

Exhibit 3: Long-Term Returns Comparison
Source: Bloomberg, US Private Equity Index, Benchmark Statistics Cambridge Associates; as of December 31, 2018

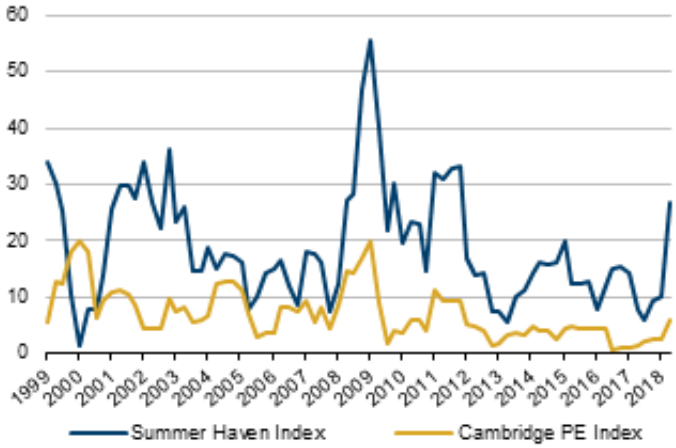

Exhibit 4: Comparative Volatility Analysis
Source: Bloomberg, US Private Equity Index, Benchmark Statistics Cambridge Associates; as of December 31, 2018

Marking to Market Versus Book Value Accounting

Given the index is meant to replicate PE, one could make an argument that the Cambridge PE return series may be understating risk. The mark-to-market practice of PE tends to use their valuation estimates based on future cash flows and earnings or based on book value without respect to what may be happening in the public market. In fact, in a November 2008 conference call, Blackstone President Tony James stated: "We take public [comparables] into account, but often we don't exit into the public market by doing IPOs, so they're sort of irrelevant."

In his work, Stafford points out that an equivalently levered portfolio in public securities would hypothetically show a maximum 15% drawdown based on book-value accounting methods versus an 85% decline when marked to market.[9] This may account for why, during the global financial crisis, exchange traded funds with PE holdings managed by KKR and Apollo traded as low as 70-88% discounts to the reported values of their holdings.[10] These are the same holdings and reported values that form the basis of the long-term Cambridge PE index. The debt of some private companies was trading at pennies on the dollar even as equities were held at only minimal markdowns in PE portfolios. Debt markets and exchange traded fund levels were signalling significantly larger markdowns than were being reflected in PE returns.

PE Firms

The arguments against public equity replication techniques include the following: new management teams put in place by PE firms create value; PE firms are buying inexpensive companies with real potential cost savings; and being out of the glare of public markets gives companies room to become more efficient and less worried about quarterly earnings. As such, replicating a PE portfolio with public equities may miss these key factors (which come at a very high cost of fees) and thus a true liquid PE index may not be possible.

Another approach would be to observe how stocks of PE and leveraged loan managers perform during periods of stress. Using the largest publicly traded PE and private credit management companies, one can create a synthetic index consisting of PE investment managers.[11] The only dissatisfying aspect of doing so is that some of the larger PE managers have only gone public by issuing their own equities in the last 5-10 years. As such, there is limited track record prior to 2011 and less data for the global financial crisis.

However, we can look at two windows of some stress: the credit meltdown in energy of 2015/2016 and the fourth quarter of 2018. From June 2015-2016, this PE managers index underperformed the S&P 500 by 24 percentage points, with a max drawdown of 36%. In the fourth quarter of 2018, the index performed a bit better, drawing down 24%, while the S&P 500 fell 19%. Neither period seems to be delivering the smoothed returns implied by Cambridge Private Equity Index which showed returns of -0.77% between the third quarter of 2015 and the first quarter of 2016, and -1.66% in the fourth quarter of 2018.[12]

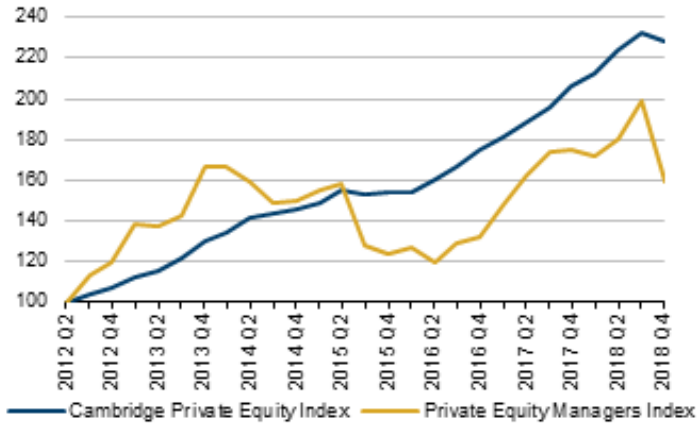

Exhibit 5: Long-Term Returns of PE Versus a Basket of PE Managers
Source: Bloomberg, US Private Equity Index, Benchmark Statistics Cambridge Associates; as of December 31, 2018
Note: Simulated Performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations, and should not be relied upon.

Viewing through the prism of realized volatility, we find much consistently higher volatility for the PE managers synthetic index than the S&P 500. We have added the Russell 2500 to the analysis as well given that the profile of PE investments is more closely aligned with that index. The realized volatility of this basket is higher than the S&P 500 and the Russell 2500 over time. This once again highlights the smoothing effect in book value accounting and suggests that calculated Sharpe ratios for PE may be overstated versus the actual risk.

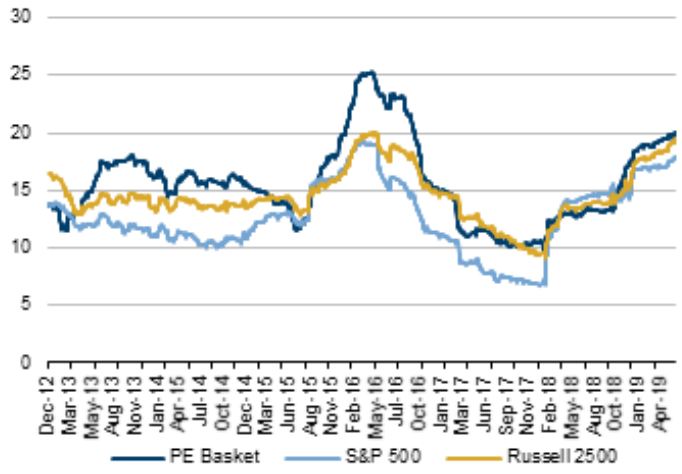

Exhibit 6: Realized Volatility Analysis
Source: Bloomberg; as of June 12, 2019
Note: Simulated Performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

Leveraged Loans

A few things work against using PE managers as a benchmark for true returns of the asset class. First, PE firms are more sensitive to initial market declines as performance fees evaporate quickly and monetization opportunities diminish. Second, asset managers, in general, are facing wider challenges, including fee compression. Third and finally, some PE managers have been adding substantial exposure to real estate, which may (or may not) prove diversifying in a crisis. As such, we may need to look toward other assets. Leveraged loans may address the objections against replicating via public equities or using a basket of PE managers as they are direct obligations of companies held in many PE funds. In fact, loans should be less at risk than equity given their senior status in the capital structure.

The S&P/LSTA Leveraged Loan price index experienced a drawdown of 38% in 2008,[13] which was much larger than the 25% reported decline in the Cambridge PE Index. That alone should be informative. However, many of the underlying loans of the index are not frequently traded and thus, true market values may not always be known. As such, another approach may be to look at the publicly traded stocks of companies primarily investing in loans of private companies as a more liquid proxy. To that end, we can create another synthetic index consisting of a basket of business development companies that hold these loans.[14] Although some companies launched after 2009, there were enough in existence to form a basket that existed during the crisis and then a wider, more inclusive basket from 2011 onwards. The two histories, along with the Cambridge Private Equity Index, are shown in Exhibit 7. Once again, drawdowns are severe, with 2008 showing a 60% drawdown (versus PE index -25%) and then 2015/16 peak to trough of -30+% (Cambridge PE index -15%).

Regardless of the leverage taken by these investment vehicles, the drawdowns on their loan portfolios suggest equity mark to market during the crisis may have been worse than implied by Cambridge data. In any case, we should not expect loan portfolios to draw down more severely than equity portfolios. Note that no attempt has been made to evaluate the evolving nature of the leveraged loan industry either positively (more liquidity and foreign investors) or negatively (re-emergence of covenant light loans and leverage levels of issuers). The objective is just to look at PE risk through the window of leveraged loan returns.

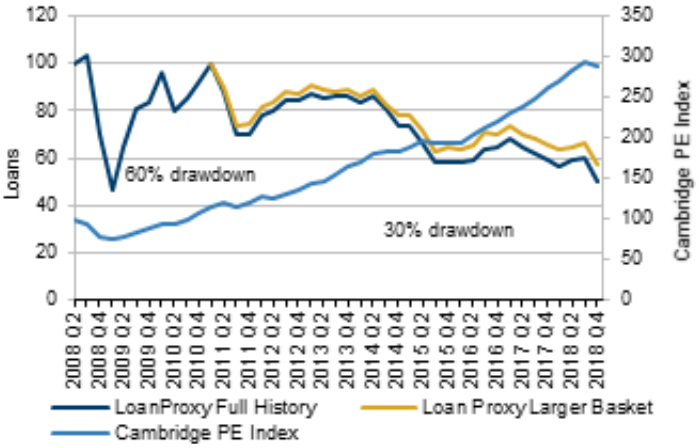

Exhibit 7: Business Development Companies Versus PE
Source: Bloomberg; US Private Equity Index, Benchmark Statistics Cambridge Associates; as of December 31, 2018
Note: Simulated Performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

Hedging

Having shown that other valuation techniques suggest that both drawdown and volatility risk of PE portfolios are potentially more significant than suggested by the return history of the Cambridge PE index, the next logical step is to consider hedging.

The most liquid hedges to equity tail risk are clearly in options on the S&P 500. However, with PE weightings already growing in their portfolios, investors using S&P 500 put options to hedge would effectively be decreasing public equity exposure in their attempt to reduce tail risk of their PE allocation. Further, as any value investor might tell you, hedging value stocks has been quite difficult with equity index options. This same problem may arise with PE.

Given we are unable to hedge PE directly, to the extent PE valuations are 'rich' when compared with public equities, there is little we can do to directly hedge that valuation differential. However, our goal is to hedge the tail risk of PE as best as possible without concentrating hedges in ways that diminish intentional allocations to public equities – passive, active, or otherwise.

Using S&P 500 and Russell Small Cap Index

If the risk is defined as tail risk, why not simply use the S&P 500? A 1-year 85% strike put as of June 30, 2019 costs 2.2% and pays off in most significant drawdowns. Small cap puts via the Russell 1000 index cost about 2.7% and offer similar characteristics in a crash.

Without knowing what the next crisis will look like, the first problem may be that the S&P 500 simply is not very similar to PE. Second, while a small cap index might be better than the S&P 500 as a reference index, it still leaves investors unnecessarily short sectors including utilities, biotechnology stocks, and REITs, which are part of the index. However, they do form useful hedging benchmarks and offer scalability.

For now, we will focus on the previous three approaches to evaluating risk of PE to come up with potential hedges.

Hedging Via Liquid PE Strategies

Having established several different approaches to evaluating risk of PE allocations via public equities, we now turn our focus to using these same strategies as a base line for tail hedges.

Starting with Liquid PE, we could use the Summer Haven Liquid PE Index to develop hedges; however, without full transparency on constituents of the index or its construction methodology, using it to build hedges would be difficult. With assistance from colleagues at Man Numeric, we were able to create our own basket of stocks[15] to mimic a liquid PE strategy. The goal is to create a reasonable proxy to use for potentially hedging PE holdings, albeit with some tracking error. In our view, this means "avoiding large-cap stocks and using top-down industry tilts that match PE's industry exposures with bottom-up proxies for buyout managers' methods of identifying potentially undervalued companies".[16] In short, this means less utilities, less biotechnology, and less financials than the weightings in typical equity indices while, at the same time, avoiding 'obvious' non-targets such as low-profitability or high-valuation companies. An advantage of designing our own liquid PE basket is that by knowing the exact construction, hedges can be readily priced. Additionally, the basket can be modified to reduce the cost of hedging by removing components that are hard to borrow, hedge or otherwise impair the ease of trading for sellers of the options. One could also make the argument that in using these criteria, we are identifying companies that are likely known by investors as fitting into the "PE mold" and may already be valued at a potential premium to other stocks.

As shown in Exhibit 8, although based on a different construction method, the basket tracks the Summer Haven PE Index, with similar drawdowns throughout. Based on monthly returns, both show very large drawdowns in 2008 and then periodic shocks ranging from 19% to 25% in 2011, 2015, and 2018. Note that this proxy is a static index, while a typical liquid PE strategy would be dynamically managed through time. As such, returns of this static proxy will differ from an actively managed strategy. However, on the basis of 1 to 2-year tail protection, the proxy is sufficient.

Exhibit 8: Proxy Basket Versus Summer Haven Index Over Time

Source: Man Numeric; as of June 20, 2019. Normalised to 100 as of December 29, 2006

Note: Simulated performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

In terms of hedging cost, a 1-year 85% put on the proxy basket can be purchased for a premium of 2.8%, similar to the cost of small cap indices like the Russell 2000, but with less tracking error to PE. The put would end up in the money in the previously mentioned drawdowns in 2008, 2011, 2015, and 2018. In the event of the basket declining 20%, on a mark-to-market basis, the put would be valued at approximately 13% (or 17% if the basket were to be down 25%).[17]

Using put spreads rather than outright puts may be more interesting. In a put spread, the investor defrays some of the cost of buying puts by simultaneously selling a further out of the money put. The lower strike put typically trades at a volatility premium due to high demand for the option. The strike sold, while capping protection, may well be a level at which investors would be content buying equities again. For example, buying a 1-year 90% put while selling a 70% put in S&P 500 reduces the cost by 75 basis points, compared with buying a 90% put outright. Investors are assuming market risk again at down 30%.

As hedges to public equity, often one worries that the mark to market of a put spread does not yield enough protection in a crisis, even if payoff at maturity is compelling. A 1-year 90/70% put spread might gain only 10% on a mark-to-market basis in a 30% decline, but a full 20% at maturity. However, in the context of PE which itself marks to market more slowly, this may be more acceptable. An 85/65% put spread on the liquid PE proxy basket would reduce cost to 1.94%. Alternatively, the 90/70% put spread costs 2.6% resulting in a higher put strike of 90%.

We can also consider selling a call on the liquid PE basket to fund the put. By selling a 1-year 115% call to fund the 85% put, we reduce the cost to 1.1%. The upside call sale does introduce potential risk that markets might rally significantly even before monetization occurs. However, it may fit in the context of portfolio rebalancing, especially with return expectations for global equities in the 5-7% range.[18] Returns above 15% may be easier for investors to forego given those expected returns. The proxy basket shows drawdowns that exceed those of the S&P 500

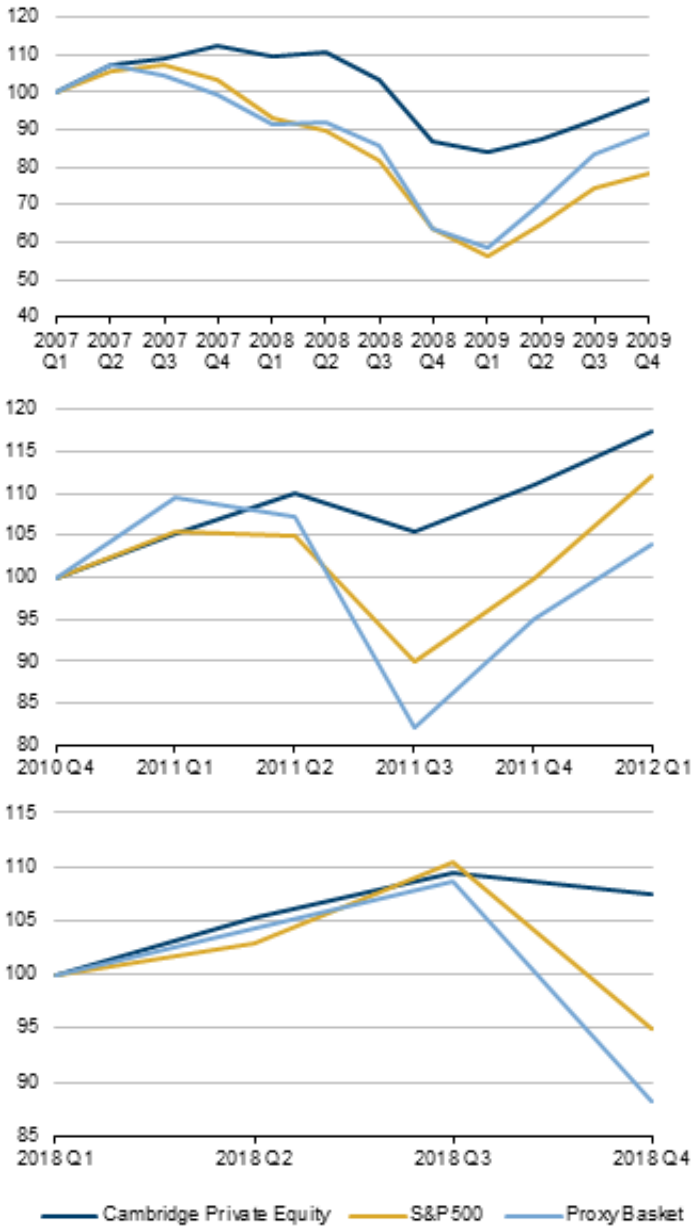

Exhibit 9: Drawdowns in Market Corrections
Source: Bloomberg, US Private Equity Index, Benchmark Statistics Cambridge; Between 2007 Q1 and 2018 Q4
Note: Simulated performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

in both 2011 and 2015. So, we have better protection for only a marginal increase in price and theoretically, more correlated to the assets being hedged (especially in 2015, when liquid PE declines far exceeded those of S&P 500).

Using PE Managers as a Proxy Hedge

There is a compelling aspect to using a basket of PE managers to hedge. The sensitivity to markets is very high and thus tail risk protection would historically have been robust. The erosion of performance fees directly impacts revenues of the PE investment managers and thus re-rating lower of managers happens relatively quickly. Although the firms have moved toward diversifying their revenue streams, the bulk of earnings continues to come from PE and credit with some diversifying into real estate.[19] The cost of the 85 put climbs to a less satisfying 3.4% per annum; however, with historical drawdowns of 28% during the 2015 sell-off, the payoff remains relatively attractive even during less stressed broader market periods. The 85/65 put spread shows a cost of 2.4%.

While relying on complex options for tail hedging is something we approach cautiously, in this case, an underperformance option may be a useful tool; it allows hedges to benefit from industry-specific risk factors, causing greater drawdowns than broader markets. An underperformance option is one that profits when the target index underperforms the reference index. For example, we could strike an option based on how much this PE basket underperforms the S&P 500. (In 2015, that underperformance was as high as 25%. See Exhibit 10.) Striking the option at 5%, the put costs 1.94% contingent on S&P 500 being down. Using the 2015 underperformance of 20%, this means the option would be worth 15% at maturity (20% underperformance less 5% strike). Like other asset managers, PE may also face fee compression, which could lead to further underperformance even in benign drawdowns.

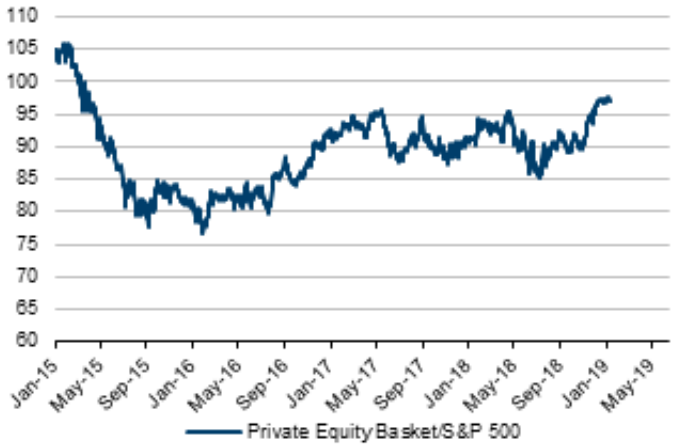

Exhibit 10: 2015 PE Managers Drawdown
Source: : Man Group, Bloomberg; as of June 18, 2019.
Note: Simulated performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

Leveraged Loans

Finally, we can look to hedging using leveraged loans. Loans were the subject of much press coverage late last year due to performance but also due to weakening covenants.[20] When the leverage loan market starts to suffer, refinancing for existing deals and capital for future deals becomes scarce. This is a condition that may be worth hedging. We start with the leveraged loan index (S&P/LSTA Leveraged Loan Index) despite showing some poor drawdowns for leverage loans management companies above.

Although historical drawdowns have been significant, an objection may be that current liquidity conditions may mean loans are likely to stay well bid. However, from a tail risk hedging perspective, the loan market offers risk and opportunities. Demand for riskier loans has jumped as collateralized loan obligations ('CLO') managers hunt for yield, allowing for cheaper financing for riskier companies. Presently, the share of debt in CLOs rated B or B- has grown to 40%, with a total of USD 1.4 trillion in below-investment grade loans outstanding.[21] Downgrades could force CLOs to sell riskier loans and/or leave

issuers without the ability to refinance. Weakening covenants and lower-quality issuers has led Moody's to lower recovery expectations to 61% from a historical average of 77%.[21] Another concern that is harder to quantify is concentration of ownership. Japanese buyers have bought between 60% and 75% of all senior CLOs, with Norinchukin Bank alone owning $61 billion.[22] While they seem to have weathered the December sell-off, even a hint of them stepping back seems to send shudders through the leveraged loan industry.[23] Further, that buying may be supporting issuance by lower quality companies who would otherwise pay more.

Despite the risks previously mentioned, puts on the index should, and do, trade much lower in cost than equity puts. Simply stated, loans are supposed to be less risky than equity and thus, hedging should be cheaper. A 90% crash put is 1.45% and 90/75% put spread is only 1%. Drawdowns near 40% in 2008 and 10+% in 2011 and 2015 suggest the hedge provides protection with outsize gains in a 2008-style crisis.

While using the same index of business development companies ('BDC') from above increases the cost, the potential payoff soars as the basket of BDCs shows declines of 60% in 2008 and 30+% in 2011 and 2015. In this case, the value added for moving from the loan index to BDCs may be worth the cost, especially given the magnitude of the drawdown in 2015 when broader markets did not fall nearly as much. Both speculators and holders of illiquid loans may again seek to short BDCs as the only liquid securities available in a crisis.

Exhibit 11: Business Development Company Return History
Source: Man Group, Bloomberg; as of July 2, 2019
Note: Simulated performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

Divesting or Reducing Allocations: Illiquidity Premium Over Time

One of the difficulties of advising clients on hedges has been that clients want to reduce downside, but without changing their investment allocation. For example, low-volatility stocks have recently had a period of strong performance and have become expensive to hedge (currently 80th percentile in terms of expensiveness versus S&P 500 puts). In fact, given the cost, the better asset allocation choice may not be hedging, but rather selling and increasing allocations to other assets. Similarly, investors may consider asking themselves if current valuations in overall markets suggest that they should be demanding more for the illiquidity premium associated with PE.

A recent trend toward mega-cap PE funds has done little for returns, with PE funds greater than USD10 billion in size showing returns only 0.3% higher than the S&P 500.[24] Potentially, the illiquidity premium meant for investors has flowed to PE managers in the form of fees. At the same time, as discussed above, investors are being asked to take more leveraged equity risk at historically high valuations. As return expectations come down in all asset classes, the spread between expected private and PE returns has fallen to a range of 2-2.5%.[25] Investors are left with more risk and lower return expectations. At this stage of the cycle, keeping investments liquid such that they can be actively risk managed may well be worth more than the diminished return expectations of PE (especially when considering the fees paid). In other words, the best hedge may simply be reducing investments in PE.

	Global Financial Crisis	2015/16	1-Year Put*	Hedge P/L GFC	Hedge P/L 2015/16	Put Spread**	115/85 Collar	Underwrt Option
S&P 500	-53%	-11%	2.2%	38%	0%	1.9%		
Liquid PE (Private Equity Replicating Strategies)	-58%	-28%	2.8%	43%	10%	1.9%	1.1%	
Private Equity Managers	-	-36%	3.4%	-	18%	2.4%		1.9%
Leveraged Loans	-39%	-14%	1.5%	38%	4%	1.0%		
Loan Proxies via BDC's	-60%	-33%	2.6%	57%	21%	2.1%		

Exhibit 12: Hedging Costs, Return Data
*Source: Man Group, Bloomberg*85/65 put spread for Liquid PE and PE managers, 90/75 for Loans and 90/70 Loan Proxies**85% put for Liquid PE and PE managers, 90% for Loans and Loan Proxies*
Note: Simulated performance data and hypothetical results are shown for illustrative purposes only, do not reflect actual trading results, have inherent limitations and should not be relied upon.

Liquidity and Choosing From Among Hedge Alternatives

Exhibit 12 shows hedging costs and some return data for some of the hedging strategies described earlier. Using PE-specific hedges improves upon S&P 500 hedges during periods when factors relating to PE or private credit are under stress. While each hedge approach is supported by past returns and perhaps convincing narratives, choosing from among them is not very straightforward. Loans may remain well-bid even as the economy sours, and investment fees may support PE managers through a downturn. Given the idiosyncratic risk of each, the simple solution to deciding among these hedges may be to use a combination of them as disaster protection. This picks up the lower cost of hedging loans, while maintaining the efficacy of the other PE proxies. Diversifying hedges may result in a more sustainable long-term program as the portfolio is not reliant on any one hedge.

Liquidity will be a key determinant in hedging. As implied by its name, liquid PE may offer the best liquidity as baskets can be continuously optimized to allow investment bank counterparties to provide option protection. This brings public market liquidity to PE hedging and allows for customization of proxy baskets based on investor exposures. A further possibility would be the creation of a basket of securities that track PE well. However, based on some other metrics, this may be riskier, more highly valued or otherwise a 'better' basket to short. No attempt was made in this paper to optimize the hedging properties of the basket in that manner.

Leveraged loans may also offer more depth for hedging given the size of the loan market. On the other hand, the indices of business development companies and PE managers may offer less liquidity and thus higher costs. As with any hedge plan, trade-offs are many and thus, the key is to develop a program taking all factors into account.

A variety of potential hedges have been introduced in this paper; however, other alternatives may be available as proxies, including baskets of recent initial public offerings ('IPOs') to hedge venture capital or an index composed of companies increasing leverage to fund stock buybacks as a leveraged buyout ('LBO') proxy.

As with any program, there is much to consider in designing the right set of measures, implementation timelines and monetization goals. The right hedge may well change from one market regime to the next so investors will need to be flexible.

Conclusion

Whether long-term excess returns of private over public equities are due to leverage, due to improved management of target companies or due to an illiquidity premium is open for debate. The goal of this paper is not to analyze the quality or source of those returns, but rather to consider the risks of the investments and the availability of hedges for those risks. That said, in theory, hedging would isolate the contribution of the illiquidity premium and contribution of improved management to total returns.

While PE has offered the appearance of stability in previous crises based on reported drawdowns and returns, the public market proxies above have shown markedly different risk profiles with higher volatility and drawdowns than PE indices. From liquid PE replicating strategies and loan indices to PE managers themselves, mark-to-market losses far exceeded those of the Cambridge Private Equity index. This is consistent with academic literature attempting to assess the nature of PE risk. We believe that the profile of the underlying investments held by PE firms should be the criteria used to determine the relative riskiness of the investment, not just a track record which for idiosyncratic reason may potentially understate risk. As discussed above, the increasing leverage and higher valuations of acquisitions being undertaken today may be indicative of greater risk ahead. While realized volatility of the smoothed PE return stream may lead to interesting Sharpe ratios, we believe that the most relevant risk to be considered is drawdown or crash risk.

If an investor believes in the return differential of PE over public equity persisting in the years ahead, then that leaves open the possibility of using some of that excess return to mitigate tail risk. This may add further stability to the portfolio and potentially allows investors to avoid testing the liquidity of private markets in times of crisis. It may seem ironic, but it is important that the hedges outlined above are mark-to-market securities and, therefore, potentially monetizable in large market declines. It may appear that investors would be receiving all the benefits of smoothing on their PE investments and of marking to market on their hedges; however, we believe the risks are aligned with differences being marking and timing issues.

By viewing the track record in isolation, investors may be ignoring drawdown risk at their peril. It would be akin to assuming that since public equities have not experienced losses similar to those of 2008/2009 in the last 10 years, that the next 10 years should look the same; however, a risk manager would not presume to model risk going forward using only these more positive 10 years of data. Given the risk, if investors are thinking to hedge or reduce their portfolio exposures, we believe that PE should be included in these discussions.

Endnotes

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7. Erik Stafford (2015); Replicating Private Equity with Value Investing, Homemade Leverage, and Hold-to-Maturity Accounting.
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10. "Ka-Boom!" *Barrons*, February 2009, Andrew Bary.
11. Constituents of the index (equal-weighted in dollar terms) as of May 13, 2019 are: 3I Group PLC, Intermediate Capital Group, Apollo Global Management, KKR & CO, Inc, Ares Capital Corp, IAC/Interactive Corp, the Blackstone Group, Partners Group Holding AG, Oaktree Capital Group and The Carlyle Group.
12. US Private Equity Index and Benchmark Statistics, Cambridge Associates, December 31, 2018.
13. Source: Bloomberg.

14. Constituents of the loan index consists of equal weighting of following equities as of June 15, 2019: Apollo Investment Corp, Eaton Vance Floating rate Income Trust, Hercules Capital, Prospect Capital Corp, Oaktree Specialty Lending, Portman Ridge Finance Corp. Shorter term history Loan Index includes the aforementioned plus FS KKR Capital Corp, TPG Specialty Lending, Golub Capital BDC Inc, Horizon Technology Finance, and Apollo Senior Floating Rate Fund.
15. Proxy basket's top 15 holdings, in no particular order are: Cadence Design Systems, Inc., CDW Corporation, Charles River Laboratories International, Inc., Encompass Health Corporation, Fair Isaac Corporation, Genpact Limited, Hill-Rom Holdings, Inc., KAR Auction Services Inc, Keysight Technologies Inc, Outfront Media Inc, PVH Corp, Qiagen NV, Steris PLC, US Foods Holding Corp, The Wendy's Company.
16. Greg Bond and John Lidington (2018); "Private Equity Goes Public."
17. Mark-to-market assumption based on sell-off occurring over 3-month period, with volatility increasing 5 points. In all periods, volatility increased by more than 5 points; however, we assume only 5 here. Vol data based on Bloomberg data.
18. JPM Asset Management Captial Market Assumptions for 2019.
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20. "Leveraged Loans Not as Safe as They Once Were," *Wall Street Journal*, August 15, 2018.
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24. "Private Equity Firms are Raising Bigger and Bigger Funds. They Often Don't Deliver," *Wall Street Journal*, June 18, 2019.
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Author Bio

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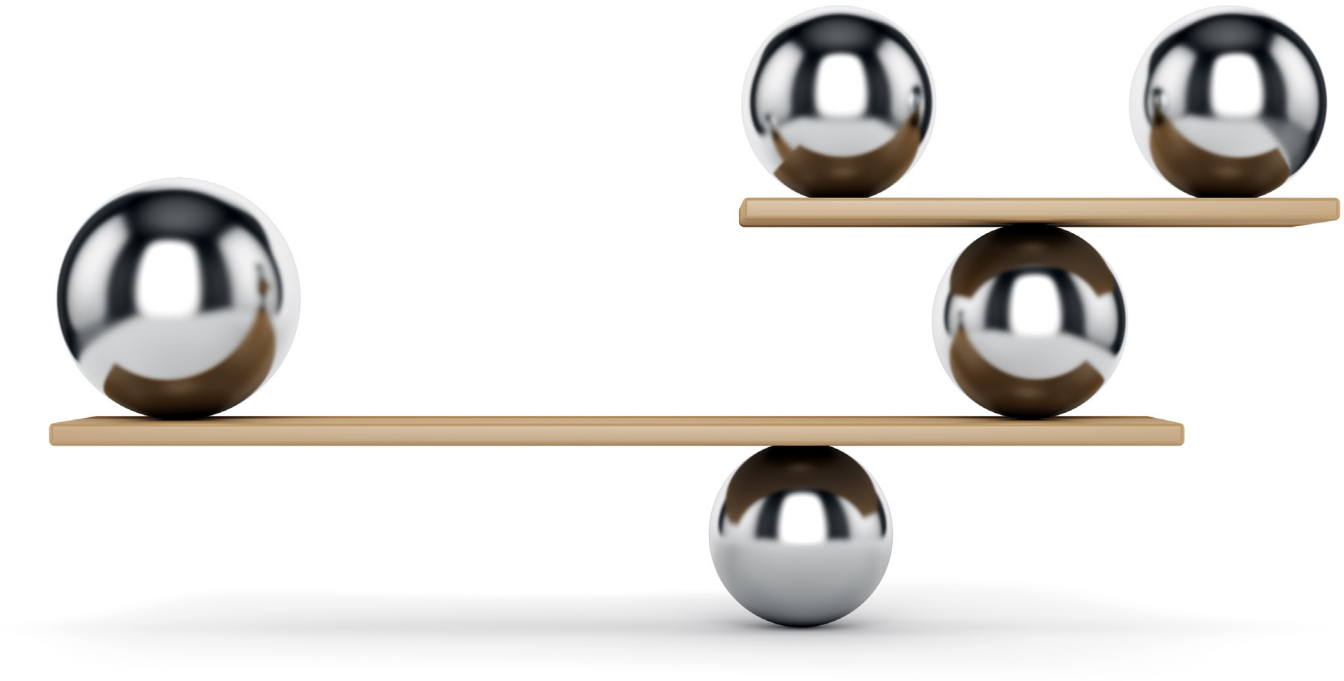
Man Institute

Peter van Dooijeweert joined Man Group in June 2018 to develop the Institutional Hedging Platform.

Prior to Man Group, Peter was a portfolio manager at Paloma Partners from 2013-2017, where he was responsible for managing a global volatility portfolio and a multi-asset tail hedge protection plan. He started his career with Goldman Sachs in Tokyo in 1995, before moving on to Soros as a volatility portfolio manager, after which he launched and managed a USD400-million volatility hedge fund seeded by Tudor Investment.

Peter holds a degree in accountancy from Wake Forest University and also studied at Tokai University in Japan.



Diversification Study – Trend Towards More Concentrated Primary Portfolios

Andrea Carnelli Dompé
Pantheon

As time goes on, I get more and more convinced that the right method in investments is to put fairly large sums into enterprises which one thinks one knows something about and in the management of which one thoroughly believes. It is a mistake to think that one limits one's risk by spreading too much between enterprises about which one knows little and has no reason for special confidence – John Maynard Keynes, August 15, 1934.

The birth of Modern Portfolio Theory (MPT) in 1952 by Harry Markowitz brought about a shift in the investment management industry towards embracing diversification as a way of reducing portfolio risk. However, scholars such as Cremers & Petajisto (2009) and Yeung et al. (2012) are now arguing that the industry may have moved to a point of over-diversification – where securities are added to a portfolio based on the premise of reducing risk rather than strong conviction of fundamentals. While there is merit in both arguments, the question remains for managers of private equity primary funds of funds (PFoFs) "What is the optimal size that is required to construct a sufficiently diversified primary portfolio?"

In our 2013 study "Diversification Study: Less is more" we sought an answer to this question by looking at venture and buyout funds from 1997-1999. We found that adding more funds to a PFoF always increases diversification but starts having a negligible impact on risk reduction once an optimum point is reached. In the case of PFoFs with a three-year commitment period, we found an optimal range of 25-30 and 40-45 funds for pure buyout and venture programs, respectively. However, selecting managers with the objective of delivering the best performance can be a challenging task to achieve given the historically wide dispersion in private equity returns, and limited access to the best managers. Qualitatively, one could argue that PFoF managers with the

ability to consistently identify top performing managers should pursue a concentrated strategy while those that have little conviction regarding selected managers should diversify in order to minimize the probability of underperforming.

Since our 2013 study, the private market has developed; more funds data have become available for analysis, and the dispersion of private equity returns has reduced (see, for instance, Cavagnaro et al. (2018)). The evolution of the market has prompted the need to revisit optimal diversification in light of the changed environment and the additional information available. In this paper, we both update the evidence and extend the analysis to multi-stage portfolios, which more appropriately represent PFoFs.

Key Points

- This study looks at optimal fund diversification in the context of a primary fund of funds (PFoF).
- Adding more funds to a PFoF will increase diversification, but once an optimum point is reached, adding more funds has a negligible impact on risk reduction.
- Diversification can make a major contribution to minimizing portfolio risk, but achieving a diversified PFoF can sometimes overshadow manager selection abilities.
- Our updated analysis shows that 20-25 funds is the optimum size for a PFoF that is diversified across different stages, vintages and geographies.

Data

The study uses fund data from Preqin as of December 2018. The investment universe includes all buyout, growth, venture, and turnaround funds from the U.S., Europe and Asia/ROW; funds that are not close-ended and commingled are excluded from the analysis. Fund vintages span the 1990 – 2013 range; funds in later vintages are excluded as they are still largely in the investment period. Exhibits 1 and 2 contain summary statistics about the sample dataset.

A few features of the dataset are worth mentioning. First, the Preqin investment opportunity dataset increases significantly over time: there is a steady increase in the funds raised every year from a few dozens in the early 1990s to over 100 in the latter part of the sample, with notable peaks above 200 around the Global Financial Crisis.

Second, after the first few vintages, the average performance of PE stabilizes around the 1.50x – 2.00x range; we include both the median TVPI and the size-weighted ('SW') mean TVPI, which can be interpreted as the performance on a 'passive' PFoF strategy (please see box for an explanation of active and passive strategies).

Thirdly, there is a lot of variation in the dispersion of returns, as proxied by the spread between the 75th and 25th percentiles, with a general decrease over the sample.[1]

On the back of this data, it is natural to surmise that optimal PFoF size may be a challenge to define. In particular, how does time variation in the opportunity set and dispersion of returns affect the optimal portfolio size? We address these questions in the next section.

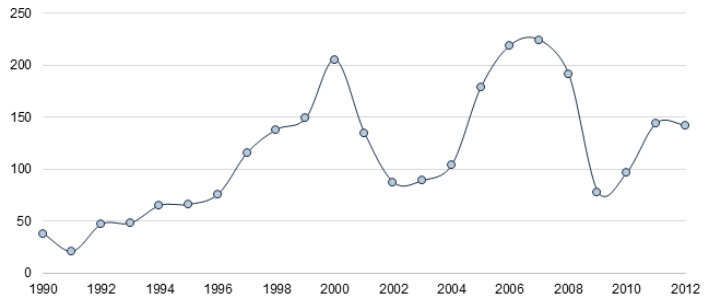


Exhibit 1: Number of Underlying Funds in Sample by Vintage
Source: Preqin data as of December 2018

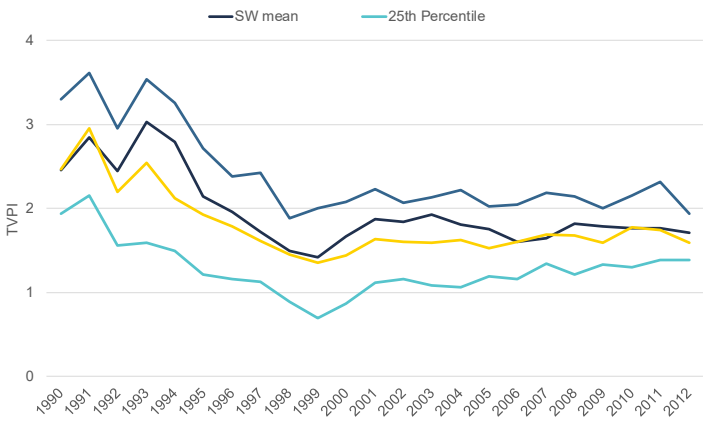


Exhibit 2: Performance of Underlying Funds by Vintage
Source: Preqin data as of December 2018

Active and passive investment strategies

An investment strategy is 'passive' with respect to an index if it invests in the same constituents and in the same proportions as the index. Indices for public equities are typically built on a 'value-weighted' basis, meaning that individual stock weights are proportional to their market capitalization, and 'passive' strategies are those that track the performance of such indices. By analogy, a 'passive' PFoF strategy can be thought of as one that invests in all funds available in a vintage, where the weight of each fund in the PFoF is proportional to the fund's size. As a consequence, the SW mean TVPI of the cohort of funds in a vintage represents the performance on a 'passive' PFoF strategy. The size-weighting scheme is realistic as it takes into account the capacity of the investment opportunities, which is especially relevant for large PE allocators.

Methodology

Consider the scenario of an investor that can choose among any of the funds that have been raised in a vintage. At one extreme, the investor may decide to allocate to all funds: this portfolio is maximally diversified but also maximally passive, in that its performance will track the benchmark. At the other extreme, the investor may decide to allocate only to the fund he or she has most conviction for: this portfolio is minimally diversified but also maximally active, in that there is a very high probability that its performance will differ from that of the benchmark. These extreme examples, and the continuum of possibilities in between, indicate how the number of constituents impacts active risk, and how active risk covers both a notion of upside (the opportunity to outperform the benchmark) and downside (the risk of underperforming the benchmark).

In this paper, we tackle the question of how many constituents should a PFoF have by studying the impact that PFoF diversification[2] has on active risk. The relationship between PFoF diversification and active risk is complex as it is influenced by the number of funds in the opportunity set and the dispersion in their returns, which tend to vary from vintage to vintage. To see why, consider the data in Exhibit 1. Relative to the Preqin universe, a PFoF investing in 30 constituents in 1990 (assuming a one year investment pace) would have carried very little active risk in 1990, when the opportunity set included only 38 funds, but would have been considered a high conviction portfolio in 2012, when the fund universe included 142 funds. The dispersion of returns is another important factor. For instance, the opportunity sets in 1996 and 2009, despite having an almost identical number of funds (76 in 1996 and 78 in 2009) presented a significantly different dispersion in returns, as proxied by the difference between the 25th and 75th percentile breakpoints (1.23x in 1996 and 0.68x in 2009), suggesting that, ceteris paribus, the same portfolio size would have carried more active risk in 1996 than it would have in 2009.

We analyze the time-varying relationship between PFoF size and active risk via Monte Carlo historical simulations. We run over 3000 Monte Carlo PFoF experiments: for all PFoF vintages between 1990 and 2011,[3] and for all PFoF sizes from 5 to 150 constituents. In each experiment, 5000 portfolios are simulated by randomly picking funds from the relevant investment opportunity set; each opportunity set includes funds from all stages and geographies from three consecutive vintages. For instance, to simulate 5000 PFoFs with 25 constituents for the 1990 vintage, we randomly select 25 funds from the 106 Preqin funds in the 1990-1992 vintage range, and repeat the procedure 5000 times. Running simulations for different vintages allows us to dissect how the impact of portfolio size on diversification has evolved over time; building PFoF portfolios from funds spanning three consecutive vintages is consistent with a PFoF commitment pace of three years, which is typical in the PFoF industry. We calculate the performance of each simulated PFoF portfolio as the weighted average of the TVPI (total value to paid in capital multiple) of its constituents, using fund sizes as weights.[4] To estimate active risk, we take the standard deviation of the difference between simulated PFoF TVPIs and the size-weighted average TVPI of all funds in the investment opportunity set.

How do size-weighted PFoFs compare with equally-weighted PFoFs?

There are two key differences between the two weighting schemes. First, the two weighting schemes differ in the level of diversification they achieve. In particular, EW portfolios have always better weight diversification than a SW portfolios. In fact, common measures of weight diversification such as (1 minus) the Herfindahl index or entropy achieve their maximum when weights are equally weighted. Consequently, ceteris paribus, simulated PFoFs tend to have a higher dispersion in returns under EW than SW.

Second, the two weighting schemes differ in the weights assigned to large vs small underlying GP funds. EW PFoFs assign relatively more (less) weight to small (large) underlying GP funds than SW PFoFs do: in other words, EW PFoFs feature a 'small fund' bias, while SW PFoFs exhibit a 'large fund' bias. Since SW PFoFs effectively take into account the 'investment capacity' of each underlying GP funds, they better approximate the investment opportunity set of large LPs than EW PFoFs do. For example, with the 2012 vintage, the Preqin sample includes 142 funds with a cumulative size of $116b; of these funds, the smallest half represents only 8% of the cumulative fund sizes: the EW and SW approaches would assign these funds 50% vs 8% weight in our simulations, respectively.

In this paper, we have decided to use a SW scheme because we believe it to be more realistic for large LPs.

What Makes a Well-Diversified Private Equity Portfolio?

The addition of more funds to a portfolio reduces its active risk. While this is beneficial to some extent as it reduces the risk of the portfolio underperforming its peers, it also decreases the probability of the portfolio achieving top quartile performance. In Exhibit 3, we summarize the output from the Monte Carlo simulations by plotting active risk as a function of PFoF size for portfolios from different vintages.

The exhibit reveals two key patterns. First, PFoF size impacts active risk, but the effect is non-linear and becomes marginal for large PFoF sizes. For instance, looking at 1990 PFoFs, moving from 5 to 50 constituents decreases active risk by 0.67x, while moving from 50 to 100 constituents decreases active risk by only 0.08x. Second, PFoF vintage is a key driver of active risk levels. In particular, the exhibit indicates that recent vintages can achieve much lower levels of active risk for the same PFoF size. This effect is largely driven by the shrinking dispersion in performance that we have discussed in the previous section.

To determine the optimal PFoF size, we ask at what point adding 5 funds yields less than a 0.02x reduction in active risk. Since the exact level of active risk depends on the risk appetite and conviction of individual managers, this criterion is necessarily subjective, but provides a level-playing field to assess the effects of diversification across PFoF vintages. Exhibit 4 illustrates optimal fund sizes based on simulated data: it is evident that fewer funds

are needed to construct a sufficiently diversified portfolio than previously suggested in our 2013 study, and that recent data indicates that optimality is reached around 20-25 funds.[5]

More complex variations of this exercise would account for the pace of capital deployment, portfolio allocation to the different stages or manager quartile rankings. Deploying capital across several vintage years instead of a single year can act as an additional source of diversification, while accounting for portfolio allocation to various private equity stages can yield disproportionate risk-mitigating effects depending on the size focus of the fund.

This study focuses on the perspective of a classic primary FoF portfolio with a limited life span. A natural extension would be to analyse optimal diversification in the context of evergreen vehicles, and for PE programs that invest in secondaries and/or co-investments; for such programs, optimal fund diversification may also be driven by other factors such as propensity for liquidity and the pricing environment.

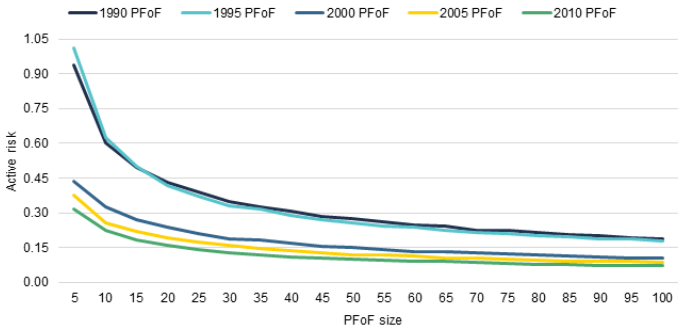


Exhibit 3: Active Rick by Vintage
Source: Pantheon analysis based on Preqin data

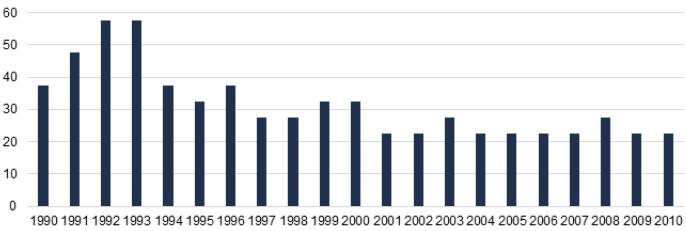


Exhibit 4: Optimal PFoF Size by Vintage
Source: Pantheon analysis based on Preqin data

Conclusion

This study finds that a well-diversified primary portfolio across different stages, vintages and geographies has an optimal size of around 20-25 funds for more recent vintages. Beyond that number, little diversification benefit is derived from adding additional funds to the portfolio, and the prospect of achieving top-quartile returns diminishes. However, it is important to note that a more risk averse investor, or one just starting to invest in private equity, may favor more fund diversification.

As highlighted in our 2013 study, there has historically been a particular vintage, stage or geography that has outperformed others, but lack of perfect foresight supports the rationale of diversification across different stages, vintages and geography. This study presents a case for investors to consider a more concentrated strategy to capture a manager's best ideas without diluting performance with over-diversification.

Endnotes

1. For more recent vintages, the narrowing dispersion in returns may be to some extent artificially reduced by the presence of unrealized investments.
2. Throughout this paper, when clear from context, we use the term 'PFoF diversification' as short hand for 'the number of funds included in a PFoF'.
3. A 2011 'PFoF vintage' includes funds from 2011 to 2013.
4. Please refer to explanatory shaded box, "How do size-weighted PFoFs compare with equally weighted PFoFs?
5. As mentioned in the data section, the dispersion in returns for more recent vintages may be partly attenuated by unrealized investments. The conclusion of this paper relies on such dispersion not being materially affected as unrealized investments are exited.

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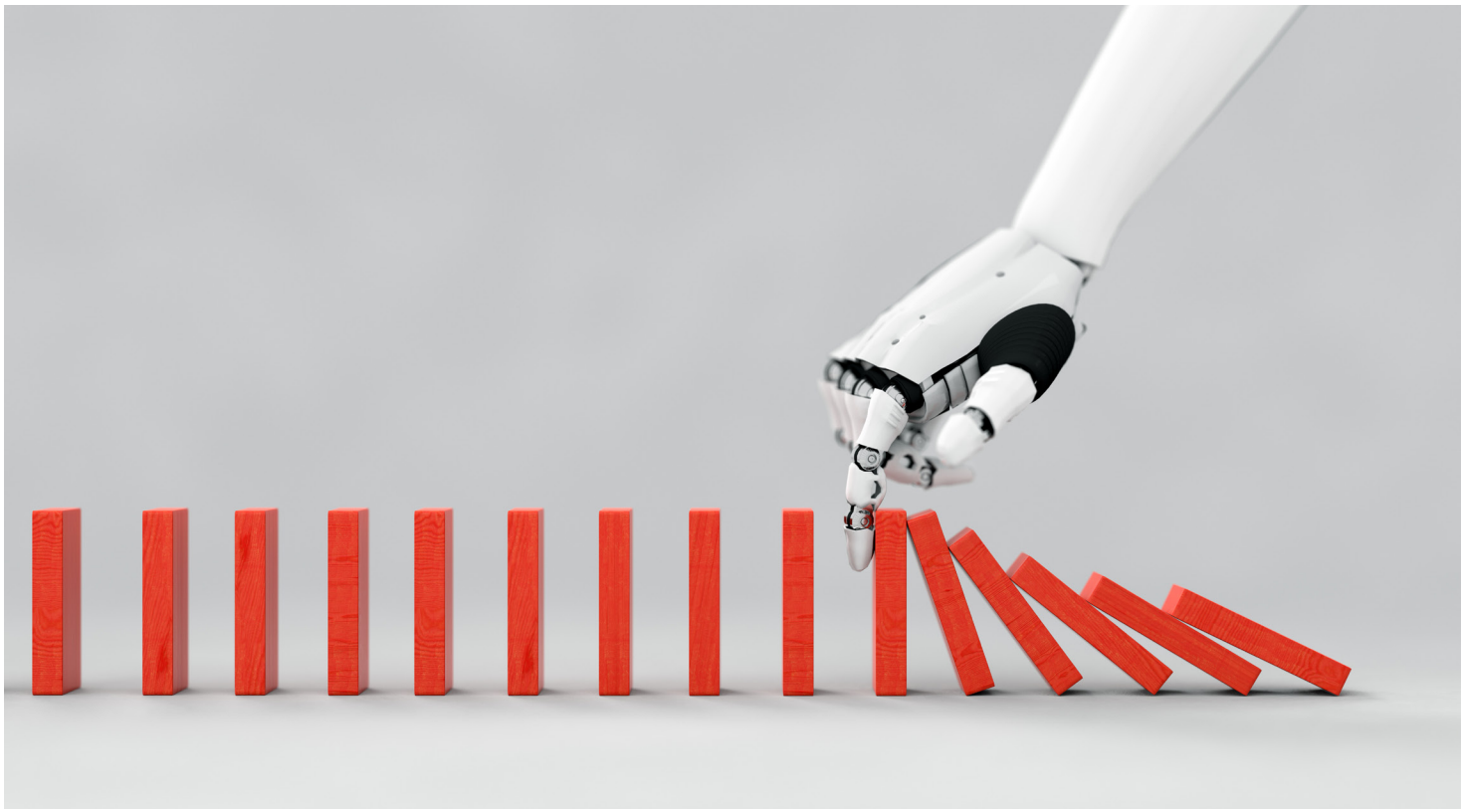
Andrea joined the Quantitative Research Team in London as a Vice President and focuses on the empirical analysis of private equity markets. Before joining Pantheon, Andrea obtained a PhD in Financial Economics at Imperial College London, where he worked on asset pricing models and monetary policy while assisting in teaching postgraduate courses in Finance and Financial Econometrics. He also holds a BSc in Economics from Bocconi University and MSc in Financial Engineering from Imperial College. Andrea is fluent in Italian and English. Andrea is based in London.



The Technology Frontier: Investment Implications of Disruptive Change

Taimur Hyat
PGIM

David Klausner
PGIM

Technological progress predates Silicon Valley by at least one million years, when humans first lit a controlled fire in the Wonderwerk Cave in South Africa – generating warmth, cooked food, and protection from predators.[1] Since then, the pace of technological change has been highly non-linear – the flute was invented over 35,000 years ago, the wheel only 5,500 years ago – with accelerations and decelerations in between.[2]

While we do again appear to be in an era of rapid technology-driven disruption, one might ask whether this era of technological change is truly different. We believe the answer is a categorical "yes", for three distinct reasons.

First, the pace of technological change is unprecedented. While it took on average 121 years for countries to adopt steam and motor ships after they were first invented, it took only 16 years for personal computers and 7 years for the internet (Exhibit 1).[3]

Second, technological innovation has gone global. Tightly integrated cross-country supply chains have fostered "reverse innovation."[4] Firms in industries as varied as advertising and healthcare have been using technology developed in emerging markets to drive growth in developed markets, for example, where mobile-advertising platforms developed in India have been rolled out globally and mobile healthcare delivery services developed in Kenya are being introduced to patients in Europe.

Cross-country collaboration has been further enabled by the speed and cost-efficiency with which code and IP can be transferred between countries, relative to the traditional model of foreign direct investment and large-scale talent transfers to emerging markets. Building off this local knowledge base, China in particular has taken the lead in a number of high-tech fields. China leads the world

in the mass implementation of AI-enabled facial-recognition, and China's share of the highest performing supercomputers globally is up from 15% in 2014 to 32% in 2017.[5]

Third, technologies today are merging previously disparate fields between the physical and digital worlds, in areas such as biogenomics, the internet-of-things and 3D printing. Imagine, for example, the prospect of a "neural bypass" surgery in which an AI-driven chip inserted into a quadriplegic patient's brain allows them to control limb movements with their thoughts. Ten years ago, this would have seemed like science fiction. Yet, as first reported by the journal *Nature* back in 2016, today this is possible.[6] Similarly, farming – perhaps the oldest, most physical industry humans have undertaken – is beginning to digitize, with smart sensors and satellite imagery being used to increase productivity and conserve water and energy.

A world in rapid technological flux will profoundly change many aspects of human life and work. Our focus is on the investment implications of disruptive technological change. To date, the investor lens has been somewhat narrowly focused on the tech sector itself and venture capital-backed startups. We believe institutional investors should broaden their aperture and view technological change across at least three dimensions:

Macroeconomic implications. Why are we not seeing rapid technological change translate into rising productivity? We argue in Section 1 that the boost in productivity is coming, but there is an inevitable lag between technological innovation and the spread of tech-enabled productivity improvements to a wide number of firms – a lag that has been exacerbated in this technology cycle by the fact that several near-term technological benefits are being captured by a few "winner take all" firms, while other companies lag significantly behind the adoption curve.

Industry implications. Since technological change is impacting companies far beyond the formal IT sector itself (think Amazon's impact on retail or Netflix's on media), the very idea of a "tech sector" may no longer make sense. In this new environment, how should we think about the investment implications of technological change on other sectors of the economy? In Section 2, we illustrate new investment opportunities in the real estate, energy, and consumer goods sectors.

Portfolio implications. Beyond specific sectors and asset classes, technological disruption can impact the fundamental nature of how portfolio-wide opportunities and risks are assessed. We believe the current wave of technological change will reshape how chief investment officers (CIOs) evaluate the risks and rewards of investing in companies at risk of tech-driven disruption, the investment strategies and vehicles they choose, how they assess their in-house teams and external managers, and how technological, regulatory, and political risk are increasingly interconnected. This is the focus of our concluding section.

While technological disruption may pose risks to investors' portfolios, it also opens a new set of investment opportunities. We hope that institutional investors find the next three chapters a useful and informative guide to navigating this current wave of rapid technological change.

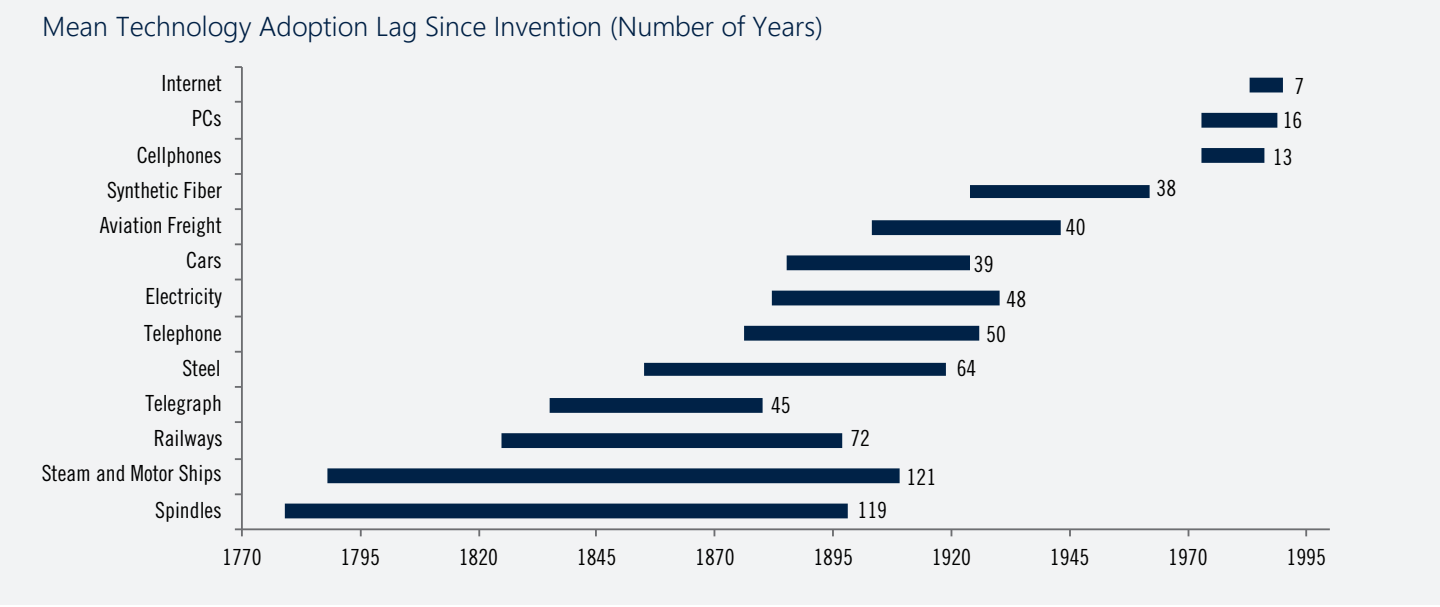


Exhibit 1: Technologies are Being Adopted Across Countries at an Accelerating Pace
Source: Diego Comin & Martí Mestieri, 2018. "If Technology Has Arrived Everywhere, Why Has Income Diverged?," American Economic Journal: Macroeconomics, volume 10(3),pages 137-178
Note: The adoption lag represents the average number of years that it has taken for a representative set of countries to begin using new technologies from their date of invention.

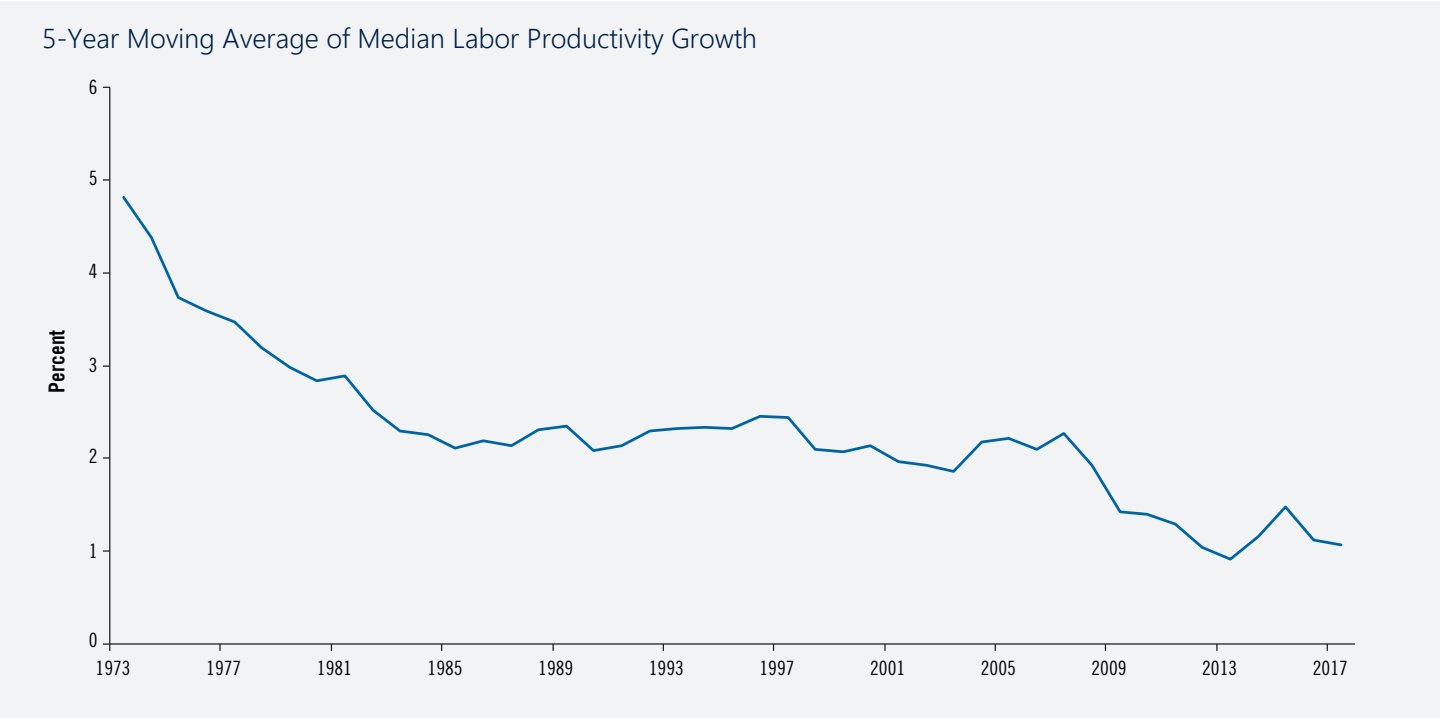


Exhibit 2: Global Labor Productivity Growth has been Declining Since the 1970s
Source: Conference Board, as of September 4, 2018
Note: Labor productivity is defined as GDP per hour worked, by country.

Section One: Technology and the Productivity Puzzle

How can technology transform every aspect of our world and yet not reveal itself in the productivity statistics (Exhibit 2)?[7] Why aren't the multitude of powerful innovations – smartphones, cloud computing, big data, artificial intelligence, genomics, and more – lifting labor productivity in the U.S. and other advanced economies? The answer to this question is of great importance as productivity is critical in determining long-term macroeconomic growth, real wages, and the attractiveness of assets and prospective returns available to investors.[8]

We believe rapid technological change and digitization will in fact drive significant labor productivity growth globally but have not yet been picked up in the aggregate productivity statistics for four primary reasons.

Slow Diffusion of Technology Across Sectors

First, the adoption of new technologies is still highly uneven across sectors, driven by the time and investment required (both in the technology itself, and the business process and personnel changes required to take advantage of new technologies) by firms outside of the IT sector. McKinsey's Industry Digitization Index highlights this divide: while some sectors are on the forefront of digitization (e.g., information and communications technology, media, professional services, advanced manufacturing, and oil and gas) other major industries (such as construction, agriculture, healthcare, and government) lag far behind.[9]

The wave of technological advancement in the late 1990s is a useful reference point. From 1995 to 2000, IT-producing firms represented nearly 60% of overall productivity growth, as they developed cutting edge technologies built on the Internet. From 2000 to 2007, IT-using firms began adopting these new technologies, and together the two sectors combined represented ~90% of productivity growth over that period.[10] We may very well see a similar story play out in the current wave of innovation: technology is invented in the IT sector, and only over time do a critical mass of firms in other industries reap the benefits of adoption.

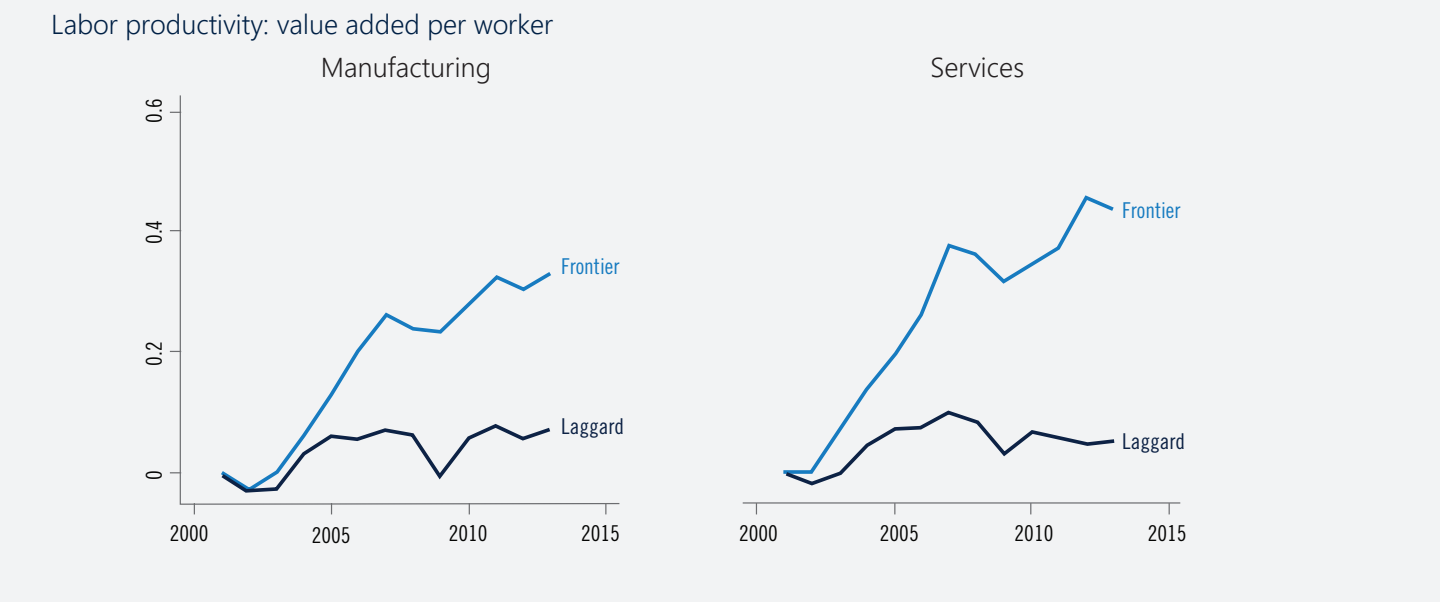


Exhibit 3: The Labor Productivity Gap Between Global Frontier Firms and Laggards is Widening
Source: Dan Andrews, Chiara Criscuolo and Peter Gal, 2015. "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries," OECD Future of Productivity: Main Background Papers

Winner Takes All

Second, the productivity gains from many recent technologies have been concentrated in a small group of firms while the rest of their sectors have remained largely undigitized or unable to compete against the superstar firms. These "frontier firms" – younger, more profitable, and more patent-intensive – tend to be the first to adopt cutting-edge technologies, and fundamentally diverge from the rest of their sector in terms of productivity growth (Exhibit 3).[11]

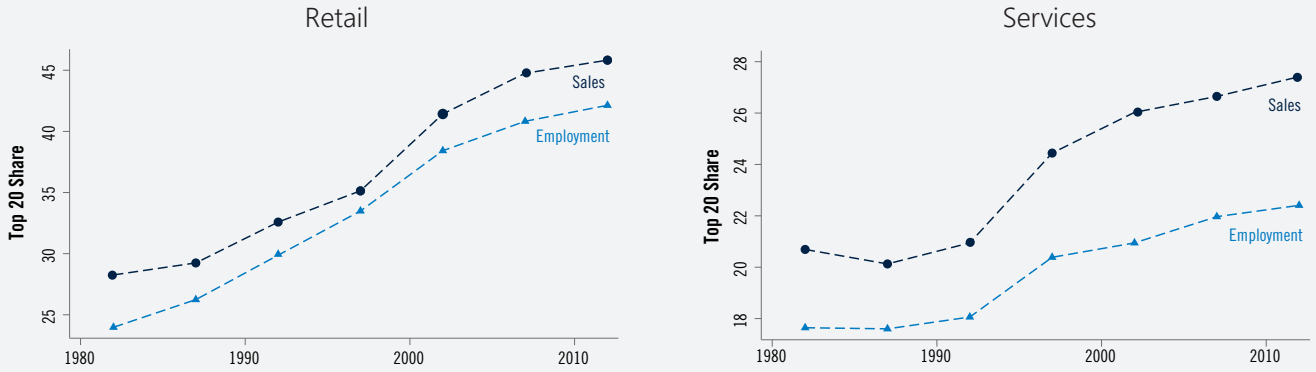
Under these conditions, a single firm often emerges with a dominant market share (e.g., Amazon in retail and as a third-party platform, Uber in transportation, AirBnB in home sharing, Google in search, and Netflix in streaming content). This "winner takes all" model means new entrants can rapidly displace long-lived institutions and blaze a trail of destruction. Indeed, sectors with leading digital firms have begun to see significant concentration – with this rising concentration positively and significantly correlated with investments in proprietary IT systems and the growth of patent intensity.[12] This is already playing out in the U.S., where there has been significant industry concentration across major sectors since the 1980s both in terms of sales and employment (Exhibit 4). For example, digitization of the U.S. retail sector has led to significant industry concentration: Amazon's 2017 e-commerce sales were 2.3x more than those of Walmart, Target, Best Buy, Nordstrom, Home Dept, Macy's, Kohl's, and Costco combined, and accounted for 43% of total U.S. e-commerce sales, up from 33% in 2015 and 25% in 2012.[13]

This "winner take all" trend is not just playing across the large digital platforms. As information and communications technology prices continue to decline, larger firms have proven more capable of exploiting technology-driven opportunities. For example, large retailers have invested in proprietary technology and complementary human and organizational capital to develop deeply integrated supply chain networks, allowing them to offer more variety at a lower cost than smaller "mom-and-pop" stores.[14]

By capturing productivity gains from new technologies in a single, dominant player with network or scale benefits, this trend towards a "winner takes all" economy acts as a near-term dampener on broad productivity gains among the other firms in a sector. And unfortunately for new entrants, while patents and large legal teams can be used by leading firms such as Apple or Netflix to defend their IP, it is difficult for smaller firms to prevent their advancements such as algorithms or knowledge-based capital from spreading.[15] As a result, leading firms can sometimes undercut new entrants by copying their approach. One example is Instagram's launch of the Stories feature, replicating a key feature of Snapchat – and leading to a significant decline in Snapchat usage growth.[16]

Over time, the most productive firms will steadily win out. While this outcome is not predetermined, as these firms – either the monopolistic giants or new attackers – take a larger share of the global economy, aggregate productivity should increase in-step.

4A: Industry concentration has increased across key sectors in the U.S.



4B: Industry concentration has increased across key sectors in Europe

Share of gross output produced by the top decile of firms (as measured by sales)

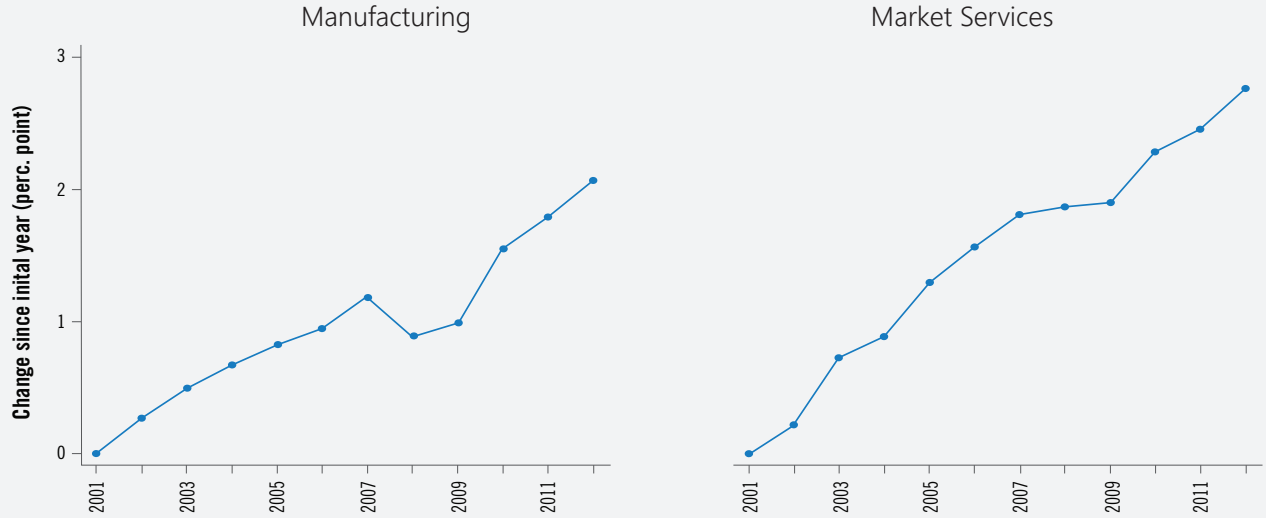


Exhibit 4

Source: David Autor et al., 2017. "The Fall of the Labor Share and the Rise of Superstar Firms." National Bureau of Economic Research Working Paper Series. OECD Multiprod, Criscuolo (2018) via Van Reenen, John, "Increasing Differences between firms: Market Power and the Macro-Economy", Kansas City Fed, August 31, 2018

Note: Countries included in the study include Belgium, Germany, Denmark, Finland, France, Norway, Portugal and Sweden. Gross output measures the value of products produced or sold to a firm's customers, including both intermediate users and final consumers. The measure may differ slightly from 'total sales' due to accounting rule differences across industries.

Measuring Productivity Gains from Technological Change: An Army of Red Herrings?

An often heard view is that slow productivity growth is simply an issue of mismeasurement: the benefits from technology are real, just not appropriately captured in the national accounts. While there is some truth to this argument, we believe this explanation is largely a red herring. Yes, there are measurement concerns, but they have always existed and are in no way unique to this current wave of technological change.

Two hypotheses are generally raised. The first argument is philosophical. Many benefits from technological change are felt in social welfare, but not captured in GDP: our smartphones can capture and share photos at zero cost, and with GPS can prevent even the navigationally challenged from getting lost, but the value and personal satisfaction is not captured by GDP.* The second argument is technical: some economists worry that the price indices underlying national accounts data do not appropriately capture new products or quality improvements from one generation of technology to the next, suppressing true GDP and productivity growth. It is estimated this effect leads GDP growth in the US and the UK to be underreported by 0.35 to 0.66% annually.[17]

Both of these concerns clearly have merit; however, neither phenomenon is unique to the current wave of technological change and have been longstanding sources of measurement error. For example, in the mid-20th century GDP captured the direct sales and advertising revenues from the advent of television, but failed to account for the broader benefits of having a new form of entertainment in our homes. Similarly, while it is inarguably difficult to capture quality improvements in price indices, this problem has also existed for decades. Most recently during the dot-com era, new goods and services were regularly introduced (and the computers that powered these advances were updated yearly, if not more often), yet technology-driven productivity growth showed up and indeed accelerated through the late 1990s and early 2000s.[18]

We do not question whether GDP or productivity is mismeasured – it almost certainly is. But while there are no doubt longstanding biases in the calculation, to account for the recent deterioration in productivity growth those biases must have become markedly worse. There is currently no compelling empirical evidence to suggest that is the case.

* According to Hal Varian, chief economist at Google, the number of photos taken worldwide has increased from 80 billion in 2000 to 1.6 trillion in 2015, while the price per photo has declined from 50 cents to 0 cents. However, this doesn't show up in GDP measures since the price index for photography includes the price of film, photos are mostly shared and not sold, and GDP declined when cameras were absorbed into smartphones.

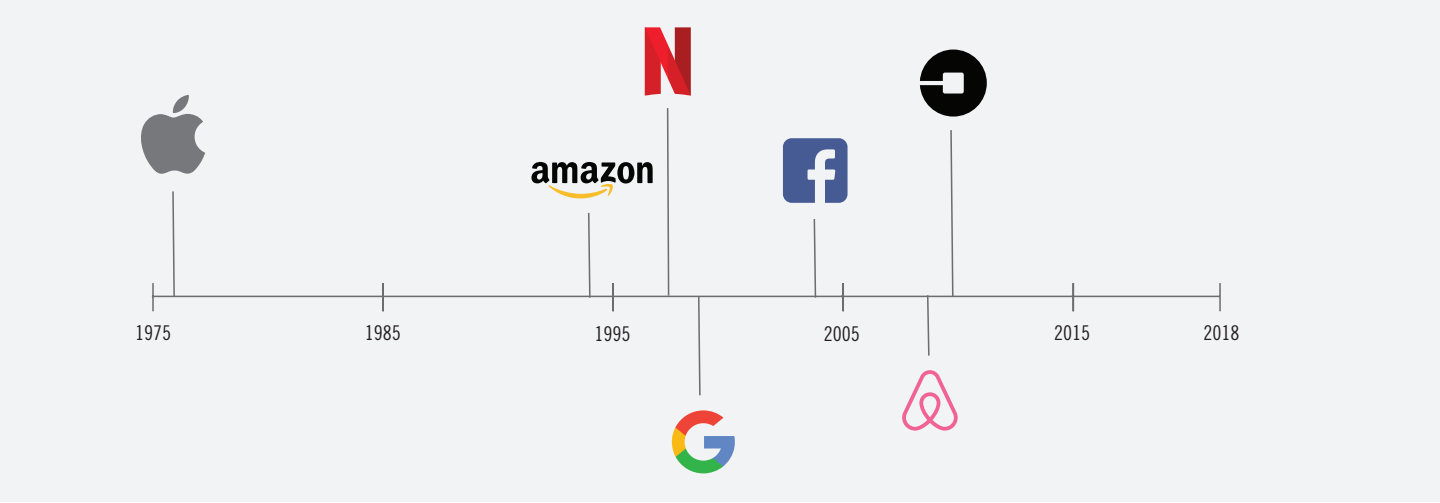


Exhibit 5: Today's Technology-Intensive Corporate Giants Have Taken Years to Reach Their Current Size
Source: Company Websites

Productivity as a Lagging Indicator

The history of technological change tells us to be patient: converting new technologies into productivity gains requires new business investment as well as ancillary changes in processes, personnel and behaviors that have always taken longer than expected (Exhibit 5). It also requires firms to figure out how to apply new technologies, which often get stuck in the R&D phase, to their industries.

Similarly, e-commerce has taken longer than originally anticipated to reach its current impact. With much hype, Phil Brandenberger fundamentally changed the retail sector by making the first ever online purchase in 1994, using his credit card to buy a compact audio disk.[19] Analysts spoke about how e-commerce would drive down margins, increase customization, and, at some point, expand into a "really big business."[20] Yet, even though e-commerce was first adopted in 1994, it took nearly 25 years for sales to approach 10% of total retail volume, as complementary investments in distribution infrastructure, secure payment systems, and customer "retraining" took quite a long time.[21]

This generation of technology will likely play out in a similar fashion. For example, according to a 2017 study by MIT and BCG, almost 85% of executives believe AI will help their companies obtain or sustain a competitive advantage – and yet only 20% actually incorporate AI in any of their products or processes.[22]

The Global Digital Divide

The slow spread of new digital technologies, and the potential productivity gains from them, is exacerbated by the limited global penetration of even basic Internet access. Nearly 60% of the world's people are still offline and do not participate in the digital economy, with a sharp divide between Asian emerging markets such as Korea, which has among the highest broadband usage in the world, and many sub-Saharan African economies where less than 10% of the population has Internet access.[23]

Furthermore, even in some emerging markets with high rates of technology adoption, digital adoption has not led to a digital dividend. This is due to a lack of the ancillary "analog" investments, unequal access to the Internet, and a lack of foundational regulations that create a robust business climate and let firms leverage digital technologies effectively (Exhibit 6). The absence of these required reforms limits the ability of a range of countries to benefit from the leapfrogging power of new digital technologies. However, we believe that over time they will catch up and drive productivity upwards, as seen with prior technologies such as the green revolution or globally integrated supply chains.

Despite the long lags and slow diffusion, it is important for long-term investors not to lose sight of the most likely end outcome: since 1995, industries either producing IT or using it intensively have accounted for nearly all US productivity growth.[24] This current wave of technological innovation will be equally important in driving global productivity and growth – and while we will need to be patient to see this impact accumulate over time, it is coming, and investors need to be prepared.

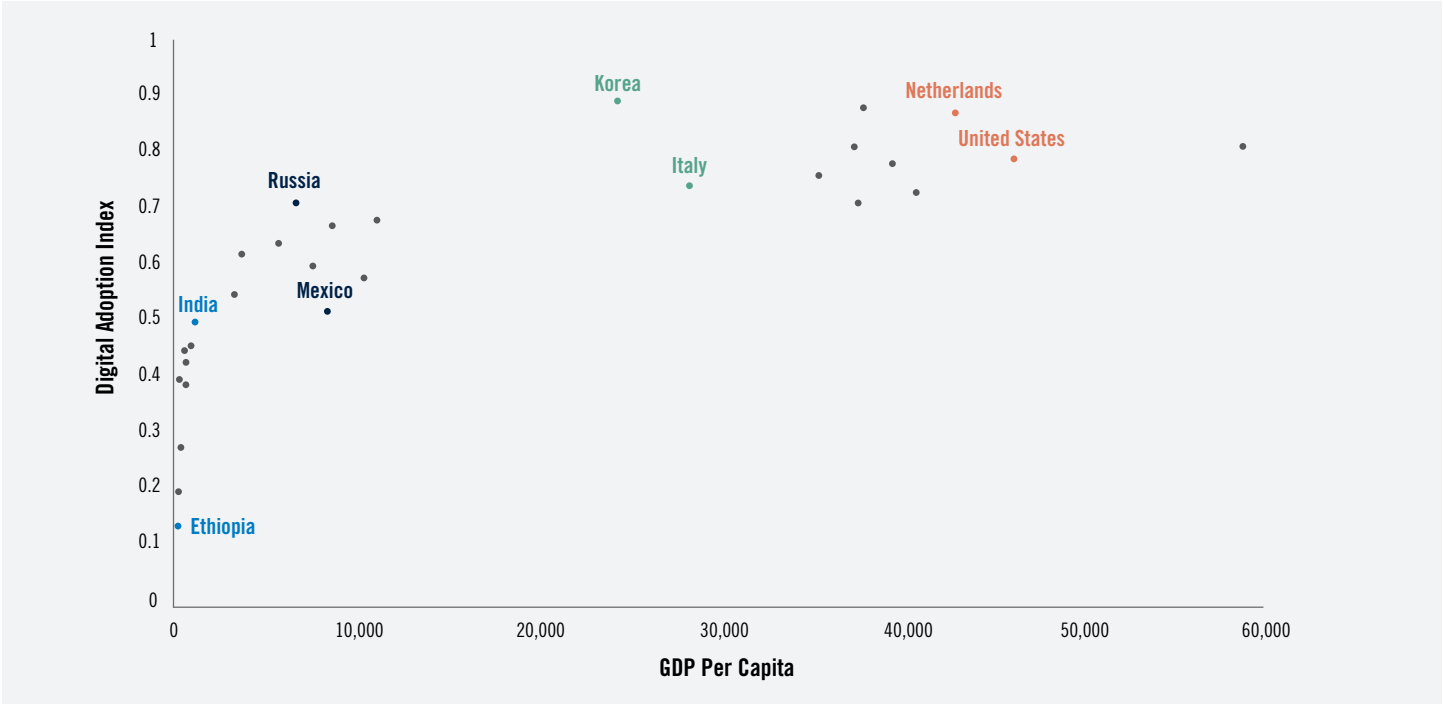


Exhibit 6: Digital Adoption Varies Significantly Even at Similar GDP Per Capita Levels
Source: World Bank Databank, as of August 17, 2018
Note: The Digital Adoption Index represents an estimated rate of adoption of new technologies by governments, people and businesses in a given country.

Section Two: Technology Beyond Tech's Borders

Rapid technological change is vital to understand because its impact extends far beyond small start-ups – and indeed far beyond the formal "tech" industry. The current wave of new technologies will radically reshape the business and investment opportunity set across all industries globally, and across companies both small and big.

While this broad diffusion will take time, ultimately this is where the power of technological change will be unleashed. The initial investments required are already being made: companies as diverse as Caterpillar, FedEx, Under Armour and Domino's Pizza are investing in artificial intelligence capabilities, while at one point in 2017 UnitedHealth Group was hiring the largest number of tech workers – nearly 15x the number being hired by Amazon.[25] Sectors as diverse as payments, entertainment, gaming (e.g., e-sports), transportation, logistics, and media and content are likely to be transformed as they adopt new technologies.

We illustrate the wide-ranging and sometimes unexpected investment implications of technological change through deep-dives into three sectors that collectively comprise over 30% of US private sector real GDP: real estate, energy, and consumer products – three "real world" sectors where the current wave of technological change is creating new investment opportunities and risks.[26]

Real Estate

New technologies are changing how we work and how we live – changes that will, in turn, fundamentally transform how real estate is developed, used, and repurposed. While some of these changes in real estate could be slow-moving at first, the cumulative impact will be immense.

The elastic mile. Technology is fundamentally altering the "time-distance value proposition". Historically, there has been a premium paid for real estate that optimizes the tradeoff between time and distance. For example, people are willing to pay more to live close to where they work, shop, or go to school, or to commuter hubs that get them to these destinations. Yet, emerging technologies may dramatically change the opportunity cost of traveling. For example, flexible and remote work schedules and locations are on the rise, enabling employees and entrepreneurs to potentially structure their residential choices around entertainment and comfort, rather than access to the office. Similarly, the shift from bricks-and-mortar retail to e-commerce may reduce the benefits of multifamily housing adjacent to major retail outlets but increase the value of last-mile distribution centers and warehouses. As a result, investors will need to evaluate investment opportunities keeping in mind the shifting time-distance trade-offs in a world with a higher share of flexible work locations and online delivery options. While proximity to friends and community will always be important, developments such as flexible work locations and online shopping – as well as autonomous vehicles that will allow riders to use their commuting time more productivity (e.g., working, sleeping, or leisure) – might, for example, significantly reshape the relative importance of measures such as "walk scores" and "transit scores" in evaluating real estate opportunities.

From car ownership to car travel. While still in their early stage of adoption, autonomous vehicles are expected to accelerate the changes in the time-distance tradeoff described above. Furthermore, car ownership could be radically down when combining automated cars with the rise of a sharing economy (as epitomized by companies like Uber) – America's current parking footprint, often in prime real estate, is estimated at over 500 million parking spaces, consuming more land than Delaware and Rhode Island combined.[27] Cars in the US stand unutilized 95% of the time.[28] The effects of the broad adoption of autonomous cars – both passenger vehicles and commercial vehicles – on the movement of people and goods could have quite dramatic effects on real estate (Exhibit 7).

"Future proofing" real estate. While some of these technological changes might seem far off, investors must begin adapting their investment strategies today to navigate an evolving, and inherently illiquid, real estate market. This will require building in the flexibility to convert assets, potentially through higher capital costs or more thorough planning. In turn, owners of such newly constructed, flexible, state-of-the-art assets will experience greater demand and will be compensated by higher rents from tenants that are able to extract more value out of their spaces. Parking garages offer a prime example. Given the eventuality of technologies such as autonomous vehicles, garages are now being designed with level floors (rather than ramps) and higher ceilings to allow for easy conversion to alternate uses such as delivery terminals. Industrial and logistics warehouses globally are another example, where it may be prudent to construct buildings with clear heights in excess of near-term tenant demand to meet future demand for higher racking systems. And in the U.S., there is potential value in ground-up investing in state-of-

Potential Winners	Potential Losers
Larger logistics distribution hubs	Car dealerships and some related businesses
Suburban multifamily housing	Transit hubs
Tech related markets	Paid parking garages
Repurposed garage spaces in malls and condos	Transit-oriented hotels

Exhibit 7: Potential Impact from Autonomous Vehicles

the-art multifamily housing, with building infrastructure that has package space to store e-commerce deliveries and cold storage for delivered groceries; retrofitting these elements would often be cost prohibitive or physically impossible.

Retail, reinvented. We have seen a "tale of two sectors" playing out between physical retail and logistics markets. As e-commerce sales have grown, the demand for physical retail has weakened, with a likelihood of further store closures, bankruptcies and nonrenewal across most developed markets.[29] In contrast, demand for the logistics centers that enable online sales has been growing in most parts of the world. Logistics providers are taking space to meet increasingly challenging consumer-oriented supply chains, notably relating to rising demand for same-day delivery – leading to a demand for infill and "last mile" locations that serve major population centers.

However, not all is doom and gloom in the retail sector. Amazon's purchase of Whole Foods in mid-2017 will be an interesting experiment in the potential value of a strong physical retail presence in an omnichannel model. Increasingly, landlords are looking for ways to differentiate by offering a mix of service and experience-oriented tenants in their malls and centers, such as restaurants, salons, and fitness centers. At the same time, online retail platforms are increasingly opening physical stores, blurring traditional lines and demonstrating that retail asset owners need to actively respond to ongoing changes in retailer business models and consumer shopping habits. Meeting the needs of increasingly impatient consumers may well require retailers to shift from "same day" to "one hour" delivery – leading the old-fashioned retail storefront to be reinvigorated and reinvented as part brand experience, part "last mile" warehouse for seamlessly meeting the physical and digital demands of a customer base looking for near-instant retail gratification. Zara has begun experimenting with this concept, enabling its retail locations to ship directly to consumers that have made online purchases; other retail firms may follow.[30] Overall, online retail may help streamline "over-retailed" markets (such as the U.S.), but it is likely a smaller group of forward-looking, higher quality bricks-and-mortar stores will continue to thrive.

Tokenization. The combination of blockchain ledger technology and smart contracts could, in theory, allow the securitization of real estate assets at the single asset level, broken down into practically limitless fractionalized units accessible to retail or institutional investors. Examples of tokenization or unitization in the real estate market already exist. BrickX, an Australian real estate company, breaks down properties into 10,000 fractional units which are sold to investors via an initial offering and can then be traded on an in-platform secondary market, reducing the illiquidity often associated with real asset investments. The adoption of tokenization is likely far off in markets such as the U.S. that have more liquid investment markets, established regulatory environments, and deeply entrenched ownership and transfer processes. But investors may find greater future opportunity in markets that don't have deep, liquid REIT markets and that might benefit from the additional title security of distributed ledger technology. While tokenization of the real estate market is nascent at this point, long-term institutional investors will want to monitor developments in this space.

Energy

The energy sector has long been at the forefront of technology, both analog and digital. In the 21st century, the combination of horizontal drilling and hydraulic fracturing has opened access to vast oil and gas reserves and fundamentally changed the role the U.S. plays in global energy markets. Going forward, the introduction of new energy extraction and power generation technologies will continue to reshape the sector – radically lowering the cost of accessing energy, while enabling renewables to play a larger role.

Diversifying across production methods and geographies. The most disruptive – and environmentally controversial – innovation in the oil and gas industry in the last decade, shale fracking with horizontal drilling, has reshaped the exploration and production industry. By opening access to reserves in Texas, Pennsylvania and North Dakota, fracking has shifted the balance of pricing power away from traditional OPEC energy producers and helped give rise to independent operators such as EOD and Anadarko. These players can respond rapidly to price spikes and dips and have helped transform the industry's slow multiyear boom-bust cycles to faster, shallower price fluctuations.

Among traditional producers that now must navigate these shorter cycles, investors may want to focus on firms that are diversifying their production in two ways. First, investors should look for producers that have taken steps to complement long-term, capital-intensive projects like deepwater exploration with shorter-cycle (and capital light) shale opportunities in North America. Second, investors may want to closely monitor fracking developments outside North America, such as projects in Argentina, Russia, China, and select Middle Eastern countries. BP, for example, recently invested over $12bn on a horizontal drilling and fracking project in Oman.[31] Investors should recognize, however, that there is a robust debate on the global expansion of fracking, as key infrastructure – including access to water and sand, copious data on subsurface geology, a built-in pipeline network, and ownership structures that incentivize development – are limited outside of North America.

Capturing cost advantages beyond fracking. With further cost reductions from fracking likely limited in the near-term, firms have begun turning to advanced robotics, automation and big data to drive production costs down and increase productivity still further – essential in an environment of lower crude prices and rising labor costs.

Advanced drilling systems are a key piece of the puzzle. For example, automated pad drilling systems allow rig operators to drill groups of wells more efficiently by "walking" a drilling rig to the next drill site, instead of having to break the rig down and reassemble it at the new location.[32] Advanced drilling technologies such as steerable drills and measurement-while-drilling systems allow operators to pinpoint exact locations of reserves, make real-time adjustments to drilling paths to reach those reserves, and as a result extract increasing volumes of oil and gas while using fewer workers (Exhibit 8).[33] And as more drilling processes become remote or fully automated, small teams of technical specialists sitting in operation centers miles away are beginning to replace skilled laborers on the ground.[34] These tools are already being put

into practice; Norwegian oil company Equinor recently developed an offshore drilling rig designed to run without a single human on board.[35]

Underlying the success of these advanced drilling techniques are analytical capabilities that can capture vast amounts of geological information, process it quickly, and provide actionable insights to rig operators on the front lines. Some of the largest operators are choosing to develop this knowledge base in-house: EOG Resources, for example, has developed over 60 in-house apps to boost returns and increase production by aggressively hiring data scientists and computer-science graduates from the University of Texas at Austin.[36] In other cases, oilfield services firms are looking to sell data analytics tools to the sector; for example, in 2017 Schlumberger launched a cloud-based platform that aims to be a central clearinghouse for industry data and a platform for advanced analytics.[37]

These and other advanced technologies will continue to drive global production costs lower – and firms that are unable to keep up will have trouble surviving over the long term. Against this backdrop, asset owners should carefully evaluate their investments in the sector to ensure their portfolio companies are investing appropriately in cost-saving technologies and staying ahead of the sector's relentless cost pressures.

Emergence of cost-effective renewable power. Even as the cost to recover traditional energy sources comes down, cost effective access to renewable energy sources (such as biofuels, geothermal energy, solar, and wind) is growing at a rapid pace – contributing to a nearly ten-fold increase in global renewable energy consumption since 2000.[38] While renewables do not pose a direct threat to the oil and gas market in the near term – global energy demand is simply too high and the declining production of many mature oil fields will likely curtail global supply – the development of renewable power generation, paired with advanced battery technologies, is altering the energy landscape.

Even though costs have dropped significantly (solar power production costs, for example, have dropped by over 50% in the last five years), the intermittent nature of many renewables have prevented them from taking a larger place in the grid. Advances in both battery technology – enabling longer-term storage – and an emerging "smart grid" that can better balance power supply and demand will help make the contribution from renewables more stable. And network firms such as Cisco and ABB are developing smart grid technologies that will allow utilities to automatically identify and isolate outages, helping them get power back up and running more quickly. This combination of increased supply, better storage, and more-efficient demand management will allow renewable power to take a more central role in power grids.

For investors, the increasing demand for energy storage technologies may create attractive investment opportunities. Metals used in advanced batteries – such as cobalt and lithium – are generally sourced from a limited number of emerging market countries such as the Democratic Republic of Congo, while demand is expected to increase; McKinsey expects there to be nearly 140mn electric vehicles, a major user of advanced batteries, on the roads by 2030. The stage may be set for significant price volatility and the emergence of new competing materials in the coming years. At the same time, renewables are changing the types of financing needed in the utility space. Unlike a traditional power plant, battery projects often have lifespans of less than five years – and by the end of that time, new technologies have emerged that make older projects obsolete. Similarly, grid modernization projects incorporating new communications technologies only have lifespans of 5 to 10 years. Investors used to much longer-duration opportunities in the utility space will need to adjust their expectations accordingly as they aim to identify the right mix of duration, yield and risk for investments in the sector.

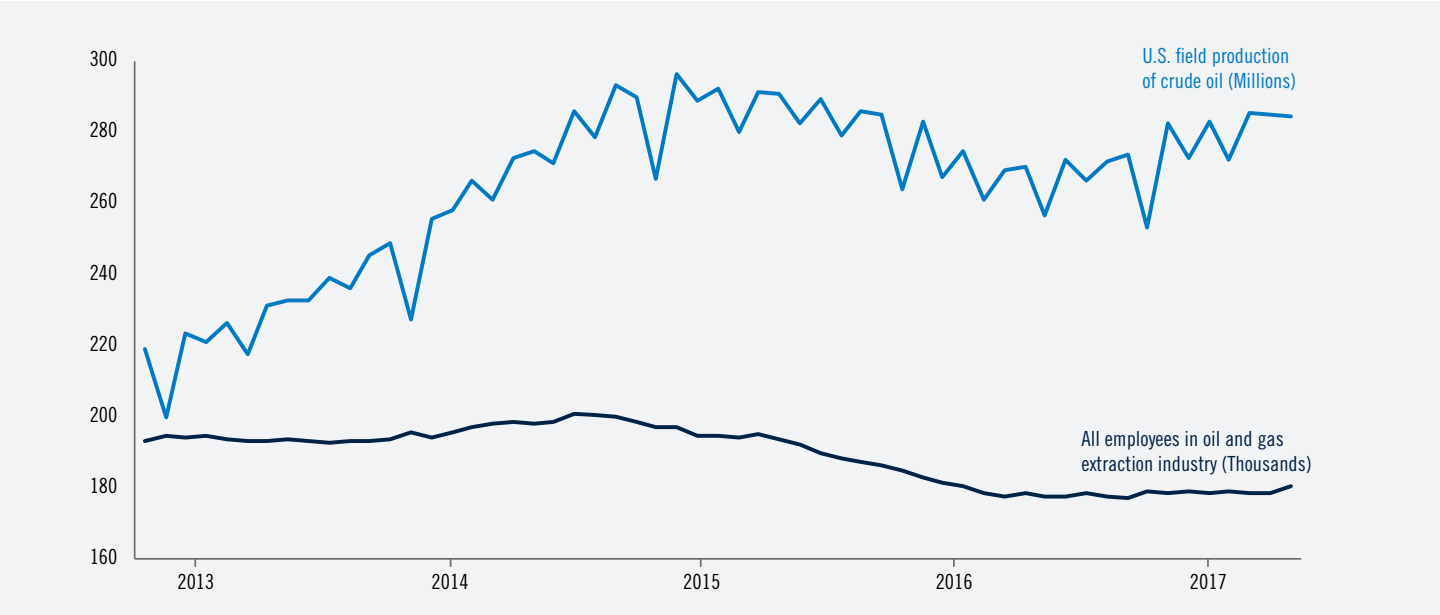


Exhibit 8: U.S. Oil Producers are Growing More Efficient, Extracting More with Fewer Workers
Source: Bureau of Labor Statistics and U.S. Energy Information Administration, as of May 3, 2018.

Consumer Goods

From social media to predictive analytics, the technological table stakes for consumer goods firms have never been higher. There are opportunities and challenges for small brands and global retailers alike, and investors will need to carefully choose where to place their bets based on a detailed evaluation of the firms that are best positioned to execute against that opportunity.

Small brands go global – and wholesalers suffer. Social media platforms such as Instagram and YouTube are allowing users to discover and build an emotional connection with brands from around the globe; witness the rise of Kylie Jenner's billion-dollar makeup brand in just three years. And globally integrated shipping networks developed by Amazon and other distributors mean that once the customer connection is made, brands can reach their consumers anywhere in the world – even remote villages in the Himalayas.

As a result, the power of traditional brick-and-mortar stores over consumer decisions is waning. Instead, as brick-and-mortar stores become showrooms, born-online brands are expanding from the digital into the physical world: firms like Bonobos and Warby Parker have actively built real-world storefronts or kiosks to drive online sales. Select traditional luxury brands that have prioritized maintaining a close connection with their consumers have succeeded here as well – for example, premium brands such as Bottega Veneta and Burberry have successfully gained market share in countries such as Brazil.[39]

As a greater share of customers' brand discovery moves into the digital world, investors will need to carefully evaluate the firms in their portfolios – culling firms whose role as gatekeeper is being disrupted and ensuring the firms they do invest in can successfully maintain a brand connection to their customers both online and offline.

Predictive analytics become table stakes. Just as technology is enabling consumers to find new brands, artificial intelligence – swiftly becoming the plumbing of the retail sector – enables brands to discover and understand the needs of their consumers globally, potentially even before the consumer knows. Advanced analytics can take in information about consumers' desires from a growing range of sources – their online purchases, social media interactions, Google and Alexa searches, smartphone and health device data, GPS routes on walks and commutes, etc. – and enable companies to create personalized messages and targeted advertisements, pushing information to the consumer based on their mood, preference, location and behavior rather than having to wait for them to request it in a store visit or online search. Amazon has even obtained a patent for "anticipatory shipping," a process for delivering products before a customer has even ordered them.[40]

As exponentially more data is collected and analyzed to deliver a seamless experience to consumers, scaled companies with the analytical resources and capabilities to mine that data are likely to drive consolidation in the market, moving ahead of older firms less able to leverage technology in understanding their customers' needs across their online and offline lives. Amazon's dominance of e-commerce sales is just one example.[41] Strong-branded, vertically integrated consumer product companies with direct-to-consumer distribution, speed-to-market advantages, flexible supply chains, and pricing power are likely to thrive.[42]

In this era of rapid digital evolution, investors need to understand how their portfolio companies – smaller, niche brands and global retailers alike – are investing in, and executing on, the cutting-edge technologies that hold the promise of cementing customer loyalty over the long term.

The shifting ground beneath investors' feet in real estate, energy and consumer goods are examples of a broader trend: the rapid creative destruction that disruptive technological change is unleashing across the global economy. In Section 3, we suggest actions institutional investors might want to consider as they explore these broader, portfolio-wide implications of the current wave of technological change.

Section Three: Portfolio-Wide Implications of Technological Change

While the current wave of technological change is intense, the pace of diffusion and potential impact varies significantly across sectors, regions and asset classes. How then should CIOs think about the implications across their portfolio? We believe long-term institutional investors should evaluate five possible actions to reap the benefits and avoid the risks of the current wave of disruptive technologies.

Position the Portfolio for Growing Obsolescence Risk

The economies of scale and network effects embedded in new technologies can rapidly displace traditional incumbent firms or even digitally-savvy firms late off the block. A single firm often emerges with a dominant market share (e.g., Amazon in retail and as a third-party platform, Uber in transportation, AirBnB in home sharing, Google in search, and Netflix in streaming content). This "winner takes all" model means new entrants can rapidly displace long-lived institutions and blaze a trail of destruction, with small differences in quality or cost creating large variations in success. This is not just happening in the tech sector. Industry concentration has increased across manufacturing, finance, services, utilities, transportation, retail trade, and wholesale trade alike.

Ironically, at the same time that new technologies have accelerated the death of traditional models, investor demand for longer-term investments has risen. In the U.S., for example, the average maturity of U.S. corporate bonds has increased from 9.5 years in 1996 to more than 15 years in 2017.[43] And investors are facing pressure to further lengthen the duration of their investments, for example as people are living longer and pension plans and life insurers adjust their portfolios to match the lengthening liabilities.[44] Additionally, the low-yield environment post-crisis has put pressure on investors to reach for additional yield by lengthening loan duration.

While lengthening maturities is not a new phenomenon, today's unprecedented pace of technological change can exacerbate the risks investors must weigh when making long-term buy-and-hold debt investments or illiquid investments in private assets, real estate or infrastructure. Those risks can include whether or not a

firm survives long enough for a successful exit or to repay their debts: fixed income investors may recall that Eastman Kodak issued $250mn of eight-year duration senior secured bonds – $50mn more than originally planned – less than twelve months before the firm filed for Chapter 11 bankruptcy.

Faced with growing obsolescence risk, there are two concrete steps that asset owners should consider. First, CIOs may consider forming a cross-asset-class team to evaluate the impact of technological change across all their holdings. This could include a combination of periodic market studies to see which asset types, securities, or sectors face a higher risk of obsolescence from disruptive technology as well as case-by-case qualitative assessments of individual portfolio companies that may be underinvesting in technology and have a higher likelihood of being left behind.

Second, long lock-up or long-duration investments (in particular those with credit portfolios – where investors may bear the risk, but not the upside, of technological change) may require a closer look to build in adequate safeguards given the fast pace of technology driven disruption. Asset owners should work closely with their investment managers to understand what the risks to their portfolio could be, and to identify tools (such as covenants or secured debt in the private markets that provide extra protection against secular shifts, or structured products in public markets) that could help limit the impact of such an event while still ensuring portfolio goals are adequately met.

Develop an Investment Framework to Identify Technology-Driven Leaders

Leading firms not only outperform laggards in their stock market returns, but also drive returns of the market overall. Indeed, since 1926, the top-performing 4% of companies have been responsible for all of the net wealth creation generated by U.S. equity markets.[45] As we discussed in Section 2, in recent years the best performing firms in a given sector have radically diverged from those at the bottom (Exhibit 9).

Going forward, we believe the select subset of firms able to integrate technology to create lasting competitive advantage and high-earnings growth will be the ones driving a disproportionate share of investment returns. For investors, the key is not to bet on the companies in a sector or geography, but to proactively identify these higher probability technology-driven winners early on. Though this might require investors to invest in several firms initially, the goal is to steadily consolidate positions into the likely winner, based on tracking five characteristics demonstrated by companies well-positioned to succeed:

- **Firms that can capture network effects in their product offering.** While traditional barriers to entry such as capital constraints will always remain, network effects appear to be more significant barriers to overcome. This is not just true for social media platforms or digital products and services. As large firms amass more proprietary data by selling more products or services, they become even more efficient at providing customers the products or services they want, creating a greater incentive for consumers to use their product or service.[46] For example, airlines are now working to use data generated from prior flights to personalize passenger experiences and improve the quality of their flights, potentially leading passengers to pick the airline that best serves their needs.[47] And while consumer tastes will change and a new service or product might supplant incumbent firms, firms like Facebook that have created deep network effects appear more deeply entrenched and less prone to disruption. Under these conditions, small variations in quality can create the difference between a dominant firm that enjoys high profits and a losing firm that eventually dies out.[48]

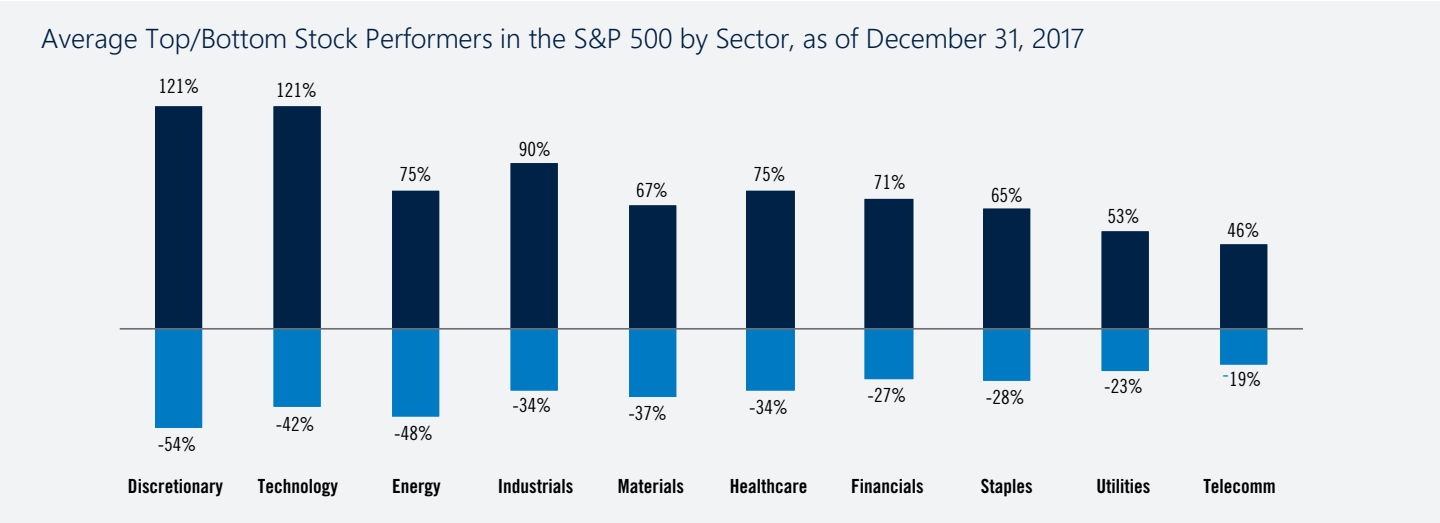


Exhibit 9: There is a Wide Divergence Between the Top and Bottom Performing Stocks
Source: IMF World Economic Outlook via Oyedele, Akin, "'The winner takes all': A $17 billion investor breaks down the huge opportunities lurking in a corner of the market that has spooked Wall Street," Business Insider, June 1, 2018

- **Firms that disproportionately invest in research & development, especially in proprietary mission-critical IT systems that others can't replicate.** Successful firms have placed a premium on developing proprietary technology, integrating it into their business processes, and planning for future technological disruption.[49] One measure is the level of investment in research and development: in the past five years, investment into R&D by the 1,000 largest firms has increased by over 50% to reach $700 billion.[50] This is no moon-shot exercise: ongoing investment into R&D has directly translated into strong investment returns for the firms that sustain it over time (Exhibit 10).
- **Firms that actively supplement in-house tech development with technology-driven M&A.** It's unrealistic to expect that every new technological advancement will be organic for every firm. M&A can play a key role – in effect, allowing firms to obtain both cutting-edge technology and the human capital needed to develop it further. Firms outside of the tech sector are embracing M&A to accelerate their development. In fact, in 2016 more technology firms were acquired by nontech companies than by other technology firms (excluding private equity deals) for the first time since the internet era began.[51] Whether looking at Ford's acquisition of Autonomic, a transportation architecture and technology provider, or L'Oreal's acquisition of ModiFace, a beauty tech company offering augmented reality solutions, non-tech firms are using strategic acquisitions to help digitize their products and services.
- **Firms that consciously structure their business models around the adoption of technology.** Investors should seek to understand how firms are structuring themselves to effectively integrate technology into their business processes and enhance their competitive advantages. Artificial intelligence, blockchain or big data are not effective in isolation; they require a deep ecosystem spanning areas such as legal, human resources, and operations to achieve the productivity enhancements that help firms emerge as leaders. Investors will want to understand how effectively portfolio companies are preparing for a technology-driven future by investing in complementary skills, management practices and business models.[52] For example, investors might want to ask if their portfolio companies have a Chief Technology, Chief Data, or Chief Transformation Officer, and if so, who occupies those roles. Additionally, investors might want to ask if the Chief Financial Officer is committed to deploying capital for technology projects, and if so, what is the funding approach (e.g., the share of funding going to technology maintenance versus technology development, investment in manager training to increase innovation). Given the competitive edge from proprietary cutting-edge IT systems and software, it is also revealing to diligence the spend on inhouse software developers rather than off-the-shelf technologies that other firms can more easily replicate.

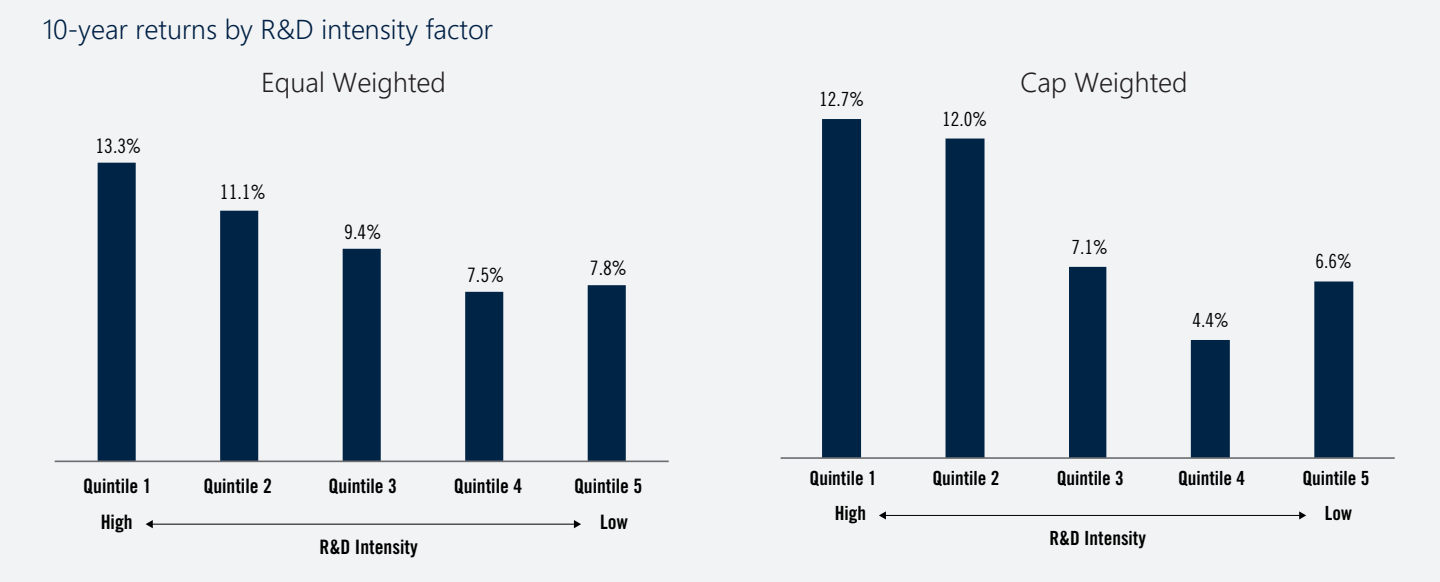


Exhibit 10: R&D Intensive Firms Tend to Out-Perform in the Equity Markets Over the Long Run
Source: S&P, as of June 22, 2018
Note: Return data is from 6/30/2008-5/31/2018 and captures the S&P Global Broad Market Index. R&D intensity factor is defined as the ratio of trailing four quarter R&D expenses to trailing four quarter sales.

- **Firms that disrupt new markets with defensible business models.** In many cases, the most disruptive, leading firms are those that enter an industry unencumbered with legacy structures or revenue streams that might be threatened by their innovative product or service. Yet, while entering a market with a disruptive product or service is a precondition for success, it is not necessarily enough for firms to emerge as the dominant player. Sustaining durable growth and long-term competitive advantage often requires an ability to capture more revenue streams from adjacent products or services.[53] Even if a blockbuster technology may create first-mover advantage, it is a firm's ability to continuously innovate and pivot that will protect it from competition. Netflix is a clear example. When Netflix began, it disrupted the movie rental market by creating a new DVD rental-by-mail service. Yet, it was Netflix's ability to offer streaming services and eventually generate original content that has allowed it to defend its market position and grow to a userbase of over 130 million subscribers.

However, a word of caution: while these characteristics will be important in determining the leading technology-driven winners of the future, they are necessary but not sufficient for long-term outperformance. In fact, research has shown that the market will regularly overpay for firms that appear to be poised for exponential long-term growth (the "lottery ticket" premium). Building a portfolio of all the firms that could potentially "hit the ball out of the park" can be quite costly. The dot-com bubble of the late 1990s provides a cautionary tale for investors: an over-emphasis on new growth metrics (such as clicks or "eyeballs") led to unsustainably high prices and the subsequent crash for many unsustainable business models. Successfully investing in technology-intensive sectors will require either skilled active fundamental managers who can gauge early signals of "winner takes all" even while the broad market may still be skeptical and consolidate stock or bond selections into the likely winners. Or it will take quantitative managers who can systematically proxy and exclude firms with "lottery ticket" type characteristics by identifying firms that are too expensive, have poor quality scores (e.g., weak profitability levels or balance sheets) and high volatility.

Look Beyond Venture Capital to Capture Technology-Driven Investment Opportunities

Of course, simply identifying technology leaders will not be enough; investors will need to work with their in-house teams or asset managers to figure out the optimal vehicle to access these investment opportunities. This is not purely a conversation about startups and disruptors; instead, investors will need to broaden their lens to ensure that opportunities are captured across a wide range of access points and investment vehicles.

- In public markets, although smaller tech firms may garner headlines, it is the adoption of technology by larger – often public – non-tech companies that drives a significant portion of overall long-term growth. For example, while startup wealth management platforms such as Wealthfront or Betterment have gained significant attention in the press, AI tools developed by the leading wirehouses and broker-dealers are already having a much broader impact. To participate in this growth, investors will need to identify which public companies (many outside of the IT sector) are best positioned to build, buy or adopt cutting edge technologies over the long term.
- While more difficult to access, investors should also take note of the large number of scaled technology companies that have chosen to remain private and are developing cutting-edge technologies away from the glare of the public eye. This is a growing pool: late-stage investments represented nearly $60bn in the second quarter of 2018, up nearly 150% year-on year and accounting for nearly two-thirds of global venture investments that quarter.[54] Whether by taking direct stakes or by working through asset managers, investors that want direct exposure to the latest technologies under development may want to consider late-stage private companies as a viable alternative to startups.
- The physical and digital infrastructure enabling the rapid growth of technology is another area for investors to consider. Real assets such as cellphone towers, distribution centers, and renewable power may offer attractive ways for investors to participate in the growth of technology without taking direct exposure to tech firms themselves. CIOs will want to understand how their real asset investments are poised to benefit (or are at risk) from technology trends.
- Finally, while asset owners have used venture capital (VC) investments to access new technology, as a whole the VC space may not always be the best way to do so. Among private equity firms, VC has on average delivered both the highest risk and lowest returns – averaging only 3% returns and generating effectively zero net alpha since 2000.[55] While select leading VC firms may deliver outsize returns, the long-term return data suggest that as a whole VC is not the best way for investors to access the long-term growth potential provided by disruptive technologies.

Evaluate how Alternative Data and Predictive Analytics are Being Used by Fundamental Managers

While some technologies may be less relevant for investment managers – it may take a more radical change than we forsee before investors can 3D print an asset allocation – predictive analytics, big data, and machine learning could have important implications for fundamental managers, and ones that institutional investors will want to consider carefully.

First, it is important to recognize that quantitative managers have been using new data, both big and small, for decades and have come to realize that big data are valuable as a new data source but clearly not a panacea.[56] The primary issue is that the bigger the datasets and the more complex the predictive analytics techniques, the greater the chances of data-mining: that is, of finding spurious patterns where there is no cause and effect and therefore no underlying predictive rationale.[57] These spurious correlations are wonderful to behold in back-tests but clearly less useful in a forward-looking investment context since an investor has no idea when the historical relationship will breakdown and fail to hold.

These tools hold promise for fundamental managers as well, but unlike quantitative firms, fundamental managers will also need to solve for the real risk of cultural clash between traditional analysts and data scientists trained to work with these new datasets. For successful fundamental managers that can bridge the gap, opportunities exist to improve both public and private investment strategies – for example, using natural language processing for sentiment analysis of earnings calls, using cellphone location data to measure retail foot traffic, or marrying proprietary real estate operating cost data with satellite imagery to provide insights on the drivers of tenant behavior. In the future, as available datasets grow and predictive models improve, managers may even be able to use predictions of climate change to drive better decisions on, for example, building placement and valuation.

As the lines between fundamental and quantitative approaches to portfolio management become increasingly blurred, investors will need to carefully evaluate how to effectively integrate predictive technologies into their investment process while avoiding the pitfalls. For asset owners that aim to bring some of these capabilities in-house, having a qualified team of skilled data scientists with access to high-quality datasets will be essential. Investors may want to consider partnering with specialized data clearinghouses – where traditional platforms like FactSet and new providers such as 1010Data have built platforms – to ensure that they can track, source, clean and use these new sources of information, while mitigating the associated risks such as material non-public information or potential privacy violations in individual-level data.

Whether applied to public or private portfolios, investors need to be thinking about ways that alternative data and predictive analytics can potentially help them identify new sources of alpha. As these tools become more commonplace, effectively integrating them into the portfolio management process will become key. Asset owners may want to spend time with their fundamental managers understanding if, where and how they expect to incorporate alternative data and predictive analytics into their investment process. Specifically, CIOs might want to add a section on technology preparedness in their request for proposals or due diligence agenda when evaluating fundamental managers. For example, CIOs might ask their prospective managers:

- How, if at all, has technology changed the front office investment management process in your organization over the past 5 years?
- How do you think about investments-oriented technology talent? Have you considered (or do you have) a data science team, and if so, how are your fundamental portfolio managers integrating the data scientists' perspective into their investment decisions?
- Have you evaluated, or do you already subscribe to, alternative or big data? If you are using alternative or big data, is the application primarily to produce quantitative trading signals or for generating additional investment insights that are then incorporated into a fundamental analyst's discretionary views?

Brace for a "Techlash"

The light or outdated regulations for many technology companies has led to several technology-centric firms aggressively taking advantage of limited local rules and regulation in a bid to win customers, reduce tax burdens and outmaneuver governments. Uber and AirBnB were among the first to take this actively combative approach, but they were certainly not the only firms to do so – some of whom (such as HR benefits provider Zenefits, which actively designed software to evade state licensing requirements) have spectacularly, and publicly, flamed out.[58]

As governments attempt to tighten regulation, technology firms could face significant regulatory uncertainty. The rise of social media-driven "fake news" has re-opened the question of content ownership, especially after Russia's alleged efforts to spread disinformation during the 2016-2017 US and French national elections. Data privacy is another key concern, and governments around the world have launched efforts to protect individuals' data, from the EU's General Data Protection Regulation (GDPR) to new laws in places such as India, Morocco, Brazil, South Africa and Taiwan.[59] Questions such as the optimal way to manage quasimonopolies, who owns the end data (firms, or the individuals whose data is collected), how that data is distributed, and who should take responsibility for content uploaded to social media continue to mount.[60] It remains to be seen how much appetite technology-driven firms have to self-regulate versus waiting for regulators to impose new regulations.[61]

Equally concerning, the race to develop advanced technology – and related disputes over intellectual property – now appears to be driving a significant portion of the tension between the U.S. and China. China has declared AI to be a strategic technology and has launched Made in China 2025 to spur local high-tech development.[62] As for the Americans, the White House has declared that "China has targeted America's industries of the future" and has acted to block Chinese tech firms from gaining a foothold in the U.S. by, for example, rejecting Ant Financial's acquisition of MoneyGram and by moving to block China Mobile's application to operate in the U.S.[63]

Faced with these growing geopolitical challenges, institutional investors will want to place "techlash" risk high on their agendas, ensuring regulatory risks are explicitly captured in their investment frameworks. CIOs may want to speak with their asset managers about how the entire portfolio is impacted by these regulatory changes: an investment thesis built around the benefits of capturing network effects could be undermined by antitrust litigation forcing a company to cap the size of its network, while portfolio companies that depend on accessing and leveraging user data could be threatened by aggressive data privacy restrictions. Investors should pay close attention to management discussions on areas such as data use or pricing strategies to ensure that their portfolio companies are both compliant with existing regulations and well-placed to respond to the changing regulatory landscape; in this fast-evolving environment, due diligence will be vital.

Investors will also need to incorporate the regulatory environment into their evaluation of new technologies and opportunities. As these cutting-edge technologies continue to emerge, governments will again play a role in determining which succeed and which fail. Even technologies explicitly designed to operate outside of governments' reach – most notably bitcoin – raise numerous legal and regulatory challenges for their users. Regulators' decisions of how to respond to these issues will shape the emergence of the technology for years to come – and investors will want to monitor both policymakers and the lobbying organizations that are seeking to influence the debate.

Conclusion

We are living in an age of rapid technological change. The impact of artificial intelligence, autonomous vehicles, augmented reality, and other disruptive technologies are just beginning to be felt – but whether at the macroeconomic level or within individual industries, the implications for investors' portfolios will be profound. As these advances become more deeply integrated into the global economy; investors will need to carefully evaluate their assumptions around economic growth and industry concentration; opportunities and risks in both digital and real-world industries; and their portfolio's overall exposure to the firms poised to capture the benefits of, or fundamentally at risk from, technological change. Longer term, these technologies have the potential to drive incredible societal progress. It is up to investors and their asset managers to capture the benefits while navigating the risks of our new technology frontier.

Appendix: Disruptive Technologies

	Breakthroughs	Defined As
	Mobile Internet	A combination of mobile computing devices, high-speed wireless connectivity and applications
	Adaptive / Artificial Intelligence	Software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments
	Internet of Things	Network of physical objects that can communicate, sense and interact with their internal states or external environment
	Cloud Technology	Computer architecture enabling network access to a shared pool of computing resources.
	Advanced Robotics / Automation	A new generation with greater mobility, dexterity, flexibility, adaptability and ability to learn from and interact with humans
	Autonomous & Near Autonomous Vehicles	Vehicles that can maneuver with reduced or no human intervention; machine vision is a key enabling technology
	Genomics	Combination of gene sequencing techniques, big data analytics and technologies with the ability to modify organisms
	Energy Storage	Improvements in the size, power and cost of systems that convert electricity into a form that can be stored for later use
	3D Printing	A device to create physical objects from digital models
	Advanced Oil & Gas Exploration & Recovery	Accessing previously impossible-to-reach reserves of oil and gas
	Virtual Reality / Augmented Reality	An interactive, computer-generated environment that either is in place of, or is overlaid on top of, the real world
	Blockchain / Distributed Ledgers	An approach for maintaining consistent records among multiple counterparties without a centralized clearinghouse
	Nanotechnology	Artificial manipulation of matter on an atomic or molecular scale

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Taimur Hyat is the Chief Operating Officer for PGIM. PGIM manages public equity, public fixed income, private fixed income, real estate and alternative strategies for a broad array of institutional and retail clients. Mr. Hyat has global oversight for Strategy, Thematic Research, Technology, Marketing and Communications across PGIM. He also oversees the Institutional Advisory & Solutions group, which provides portfolio-level advice to institutional clients globally.

Mr. Hyat joined PGIM from Credit Suisse Asset Management, where he was global Head of Strategy & Product Development, as well as a member of the Operating Committee. Prior to Credit Suisse, he was Head of Joint Ventures and Americas Strategy for Lehman Brothers. Earlier in his career he was an associate partner at McKinsey & Company in New York.

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David received his Master's in Public Policy from the Harvard Kennedy School with a focus on International and Global Affairs and his BA in Economics, with a minor in Political Science, from Tufts University. He is currently pursuing a Master of Science in Global Finance jointly offered by New York University and the Hong Kong University of Science and Technology.

Why the Market Gets Sustainable Investing Wrong

Wendy M. Cromwell
Wellington Management

Active Managers, Who Seek to Identify Assets with the Potential to Beat or Lag A Benchmark, Love Market Inefficiencies.

When market participants lack, discount, or ignore relevant data, the resulting information gaps create asset mispricing that active managers may exploit to generate alpha for clients. We believe sustainable investing, including environmental, social, and governance (ESG) integration and engagement, impact investing, and other approaches is a particularly inefficient market segment. This paper addresses several key inefficiencies and explains how we believe investors can take advantage of them:

1. The market's focus on short-term growth
2. Inconsistent, backward-looking ESG ratings
3. Emerging market (EM) indices' underexposure to structural development
4. Blind spots in climate risk analysis
5. An undefined impact investing universe

The Sustainable Investing Ecosystem

Sustainable investing approaches vary widely, from philanthropies that provide capital without seeking financial profit, to market-based, "nonconcessionary" strategies that aim to outperform benchmarks and produce competitive returns.[1] All of Wellington's sustainable investment approaches are nonconcessionary. Each has a defined philosophy and process for identifying market inefficiencies, and a repeatable method for exploiting them.

Our market-based sustainable investing strategies include:

Negative screening: Also called exclusionary investing, these strategies avoid exposure to businesses perceived as having negative effects on society or the environment. This is the only category of sustainable investing defined by what investors exclude from a portfolio.

ESG integration and engagement: Portfolio managers of these strategies aim to understand how various ESG practices can affect a company's fortunes and invest in companies whose positive ESG traits they believe can enhance its long-term relative value. They typically engage with managements and boards to improve these practices and unlock that value.

Thematic investing: Certain themes or megatrends, such as climate change or economic development, are another avenue for sustainable investing. Companies with well-defined strategies for mitigating or adapting to climate change may be good long-term investments, and many of the structural forces supporting development – improving productivity, inclusiveness, and living standards – encompass sustainable issues and have the potential to generate differentiated returns.

Impact investing: Impact investors seek to own securities of companies whose core goods and services address major global social and environmental problems, such as food insecurity, lack of access to technology, resource degradation, and many others. Impact investors intend to create positive outcomes for the world while seeking to generate a financial return.

SDG investing: Aligning a portfolio in accordance with the United Nations' 17 Sustainable Development Goals (SDGs) is another approach to sustainable investing. The SDGs are a framework for identifying – and addressing – major social and environmental issues, to secure a peaceful, prosperous world for future generations.

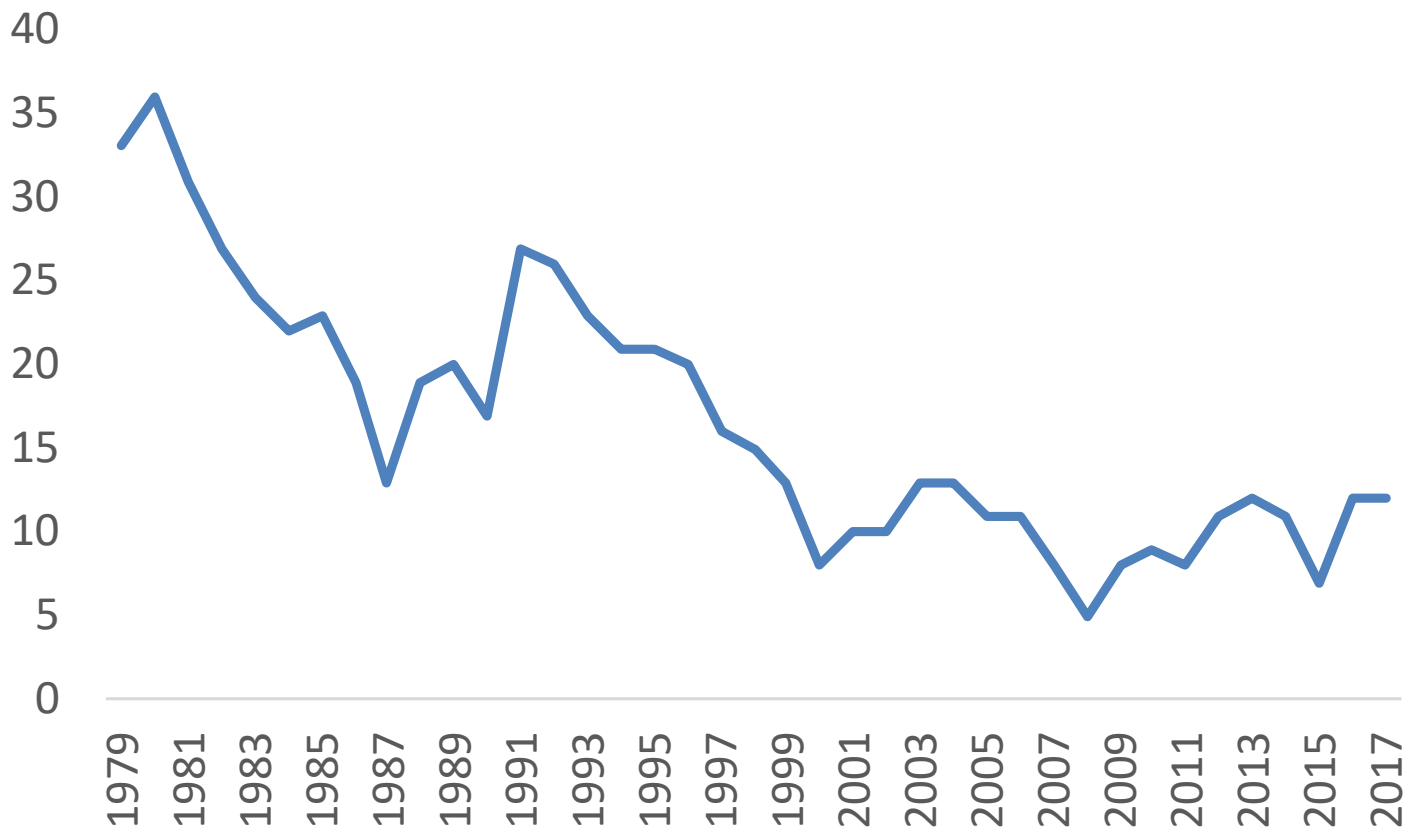


Exhibit 1: Short-Term has Taken Hold
Source: The World Bank, World Federation of Exchanges Database

Inefficiency 1: The Market's Focus on Short-Term Growth

Over the past 40 years, the average equity holding period has declined from three years to less than one (Exhibit 1). While many market participants focus on quarterly earning guidance, profit margins, or growth rates, sustainable investors can explore longer-term, sustainable growth opportunities. We have found evidence to suggest that investing differently from a benchmark and holding stocks for longer periods can result in outperformance.

Exhibit 2 shows the results of one study conducted in 2015 in which researchers at Notre Dame and Rutgers universities divided a set of investment funds into four groups according to their degree of active share and their "duration," or investment holding period. (High active share implies differing from a benchmark; low active share implies similarity to it.) The analysis looked at regression of turnover and active share between 1994 and 2012 for US-specific, actual data, comparing the fifth and first quintiles. The study found that the funds with high active share and long duration significantly outperformed the funds with either lower active share or shorter duration.

Exploiting Inefficiency 1: Engaging with Companies to Unlock Value

Sustainable investors have an opportunity to extend investment horizons and engage with companies on material ESG issues that may potentially unlock value over time. In our view, short-term-focused investors do not bother to understand a company's long-term strategy or meet with the board to discuss issues like capital allocation decisions or corporate culture. In addition, since they may not be in the stock long enough to vote a proxy, a company may not care what they think. We believe material ESG issues are strategic business issues that can affect performance, and that understanding them can lead to better investment decisions. By extending investment horizons and engaging with companies to better understand and advise them, we believe active managers can help unlock long-term value and thus generate added value for asset owners.

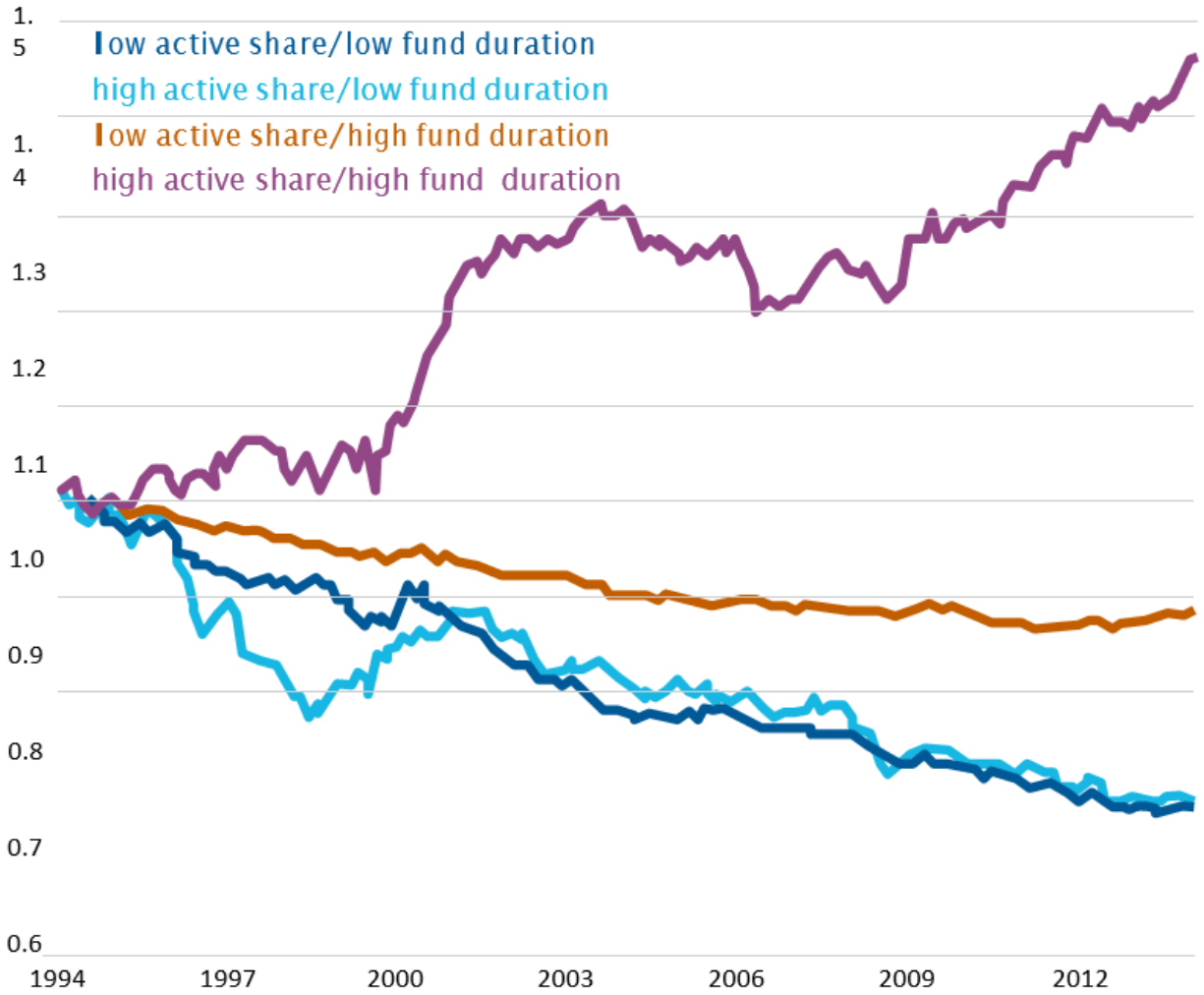
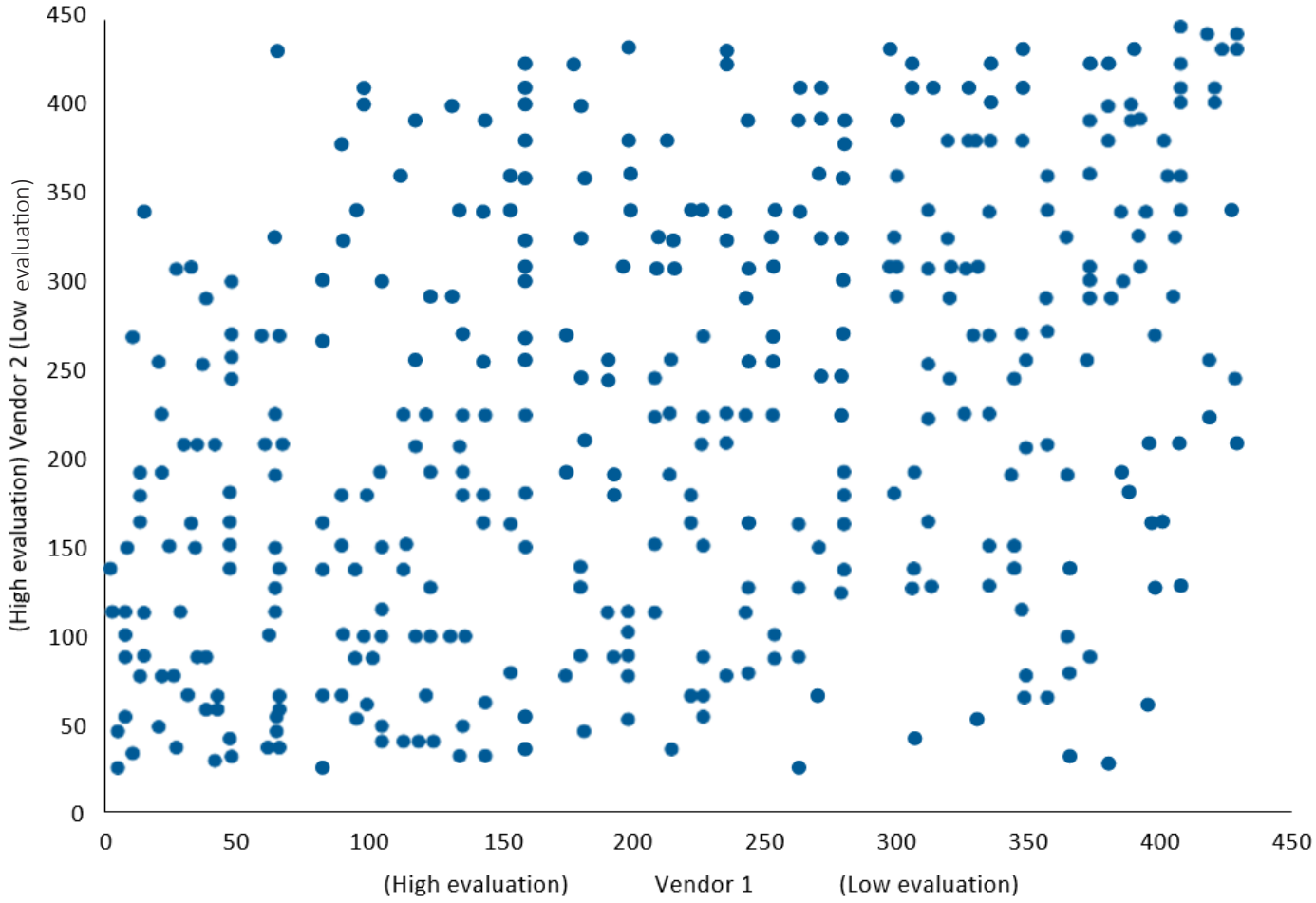


Exhibit 2: Active Share and Holding Period can Make a Difference
Source: "Patient Capital Outperformance: The Investment Skill of High Active Share Managers Who Trade Infrequently" by Martijn Cremers (Notre Dame,Ankur Pareek (Rutgers Business School), December 2015



Comparison of 400 ESG Scores from Third-Party Vendors
Exhibit 3: Third-Party ESG Ratings are Backward-Looking and Don't Always Agree
Sources: CLSA, GPIF, 4Q18

Inefficiency 2: Inconsistent, Backward-Looking ESG Ratings

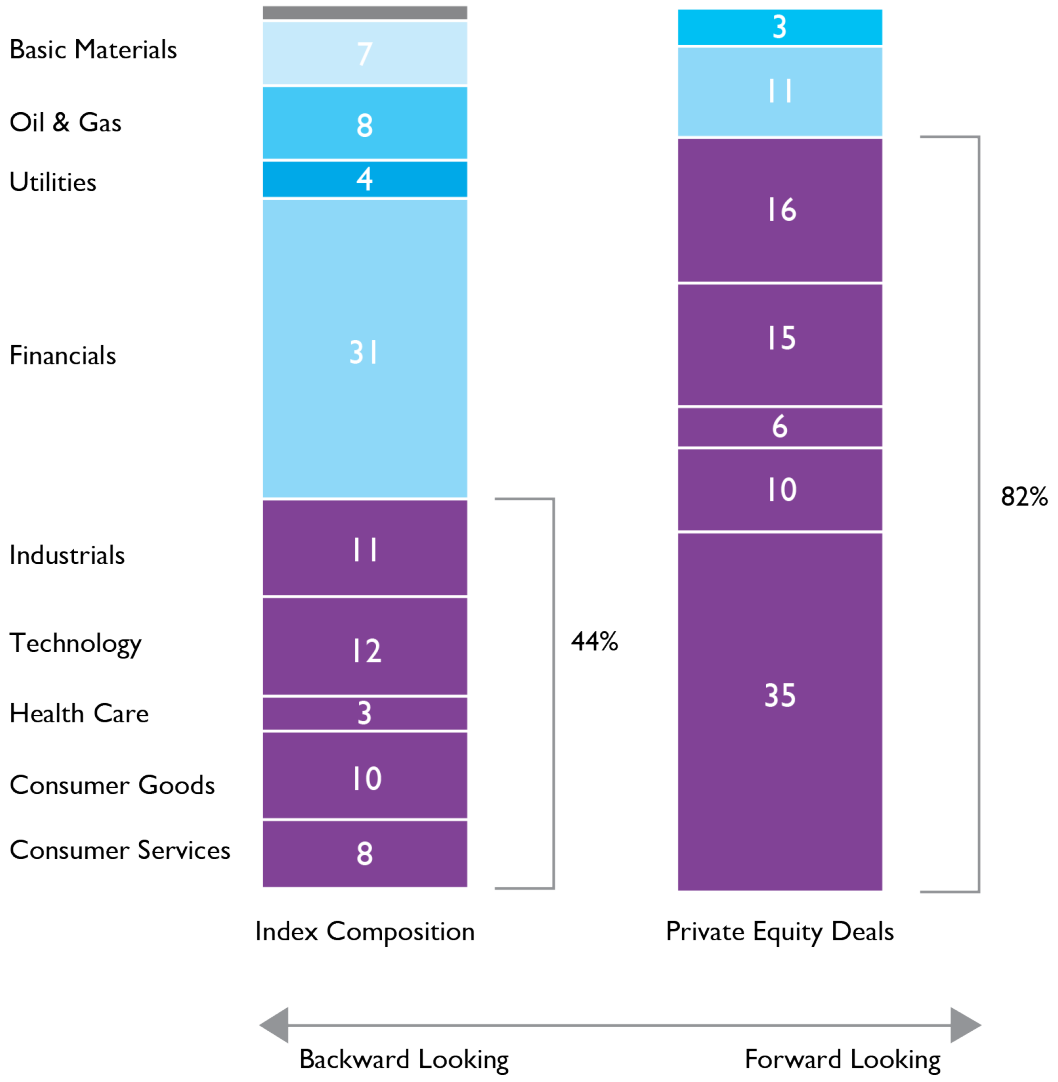
A relatively large number of vendors develop ESG scores and ratings. While these vendors perform a valuable service, the scores are based on disclosure data and thus are backward-looking. Moreover, each vendor has its own emphasis, which results in inconsistent scoring. While some market participants may use this as a reason to discount ESG data, we see this discrepancy as a potentially exploitable inefficiency.

The retroactive nature and lack of correlation among third-party ESG ratings presents another opening for active investors to deliver for clients – particularly those investment firms with proprietary research capabilities. Exhibit 3 plots ESG scores from two prominent data vendors for the same set of 400 companies. Vendor one's scores are along the horizontal axis, with high-scoring companies (with good ESG practices) toward the left and low-scoring companies on the right. Vendor two's scores are along the vertical axis, with high-scoring companies farther down and low scoring companies farther up. If the vendors' ratings on each company were identical, then the dots would form a 45-degree plot line. However, the dots are scattered, meaning these vendors have very different ESG assessments of the same companies. In addition, because third-party ratings are disclosure-based, they are retroactive assessments that do not forecast a company's trajectory.

Exploiting Inefficiency 2: Multidisciplinary Research and Extensive Engagement

Our equity, credit, and ESG research teams collaborate in a multidisciplinary approach that allows us to triangulate the value of individual securities, gaining a deeper, more holistic, and forward-looking understanding of the investment mosaic. We believe that by having multiple specialists engaged in the analysis and dialogue with company managements and boards, a manager can derive differentiated insights. Further, we feel that multifaceted proprietary research is a more accurate path to assessing a company's trajectory or a security's future value.

We consider ourselves to be constructivist in our engagement approach, with the goal of producing positive results by helping companies improve their ESG practices. For example, by encouraging board diversity and independence, highlighting the potential to lower production costs by increasing water-use efficiency, or advocating for better health and safety practices, we think active managers can guide companies to better financial performance and long-term outcomes.



FTSE Emerging Market Index data is as of October 31, 2015. Private equity deals shown are for the first half of 2015 to 30 June 2015 and are the number of PE deals monitored by EMPEA covering all EM countries within the survey. Purple highlights underrepresented industries within public markets.

Exhibit 4: EM Market Capitalization is Skewed to Past Winners

Sources: FTSE, EMPEA, Wellington Management

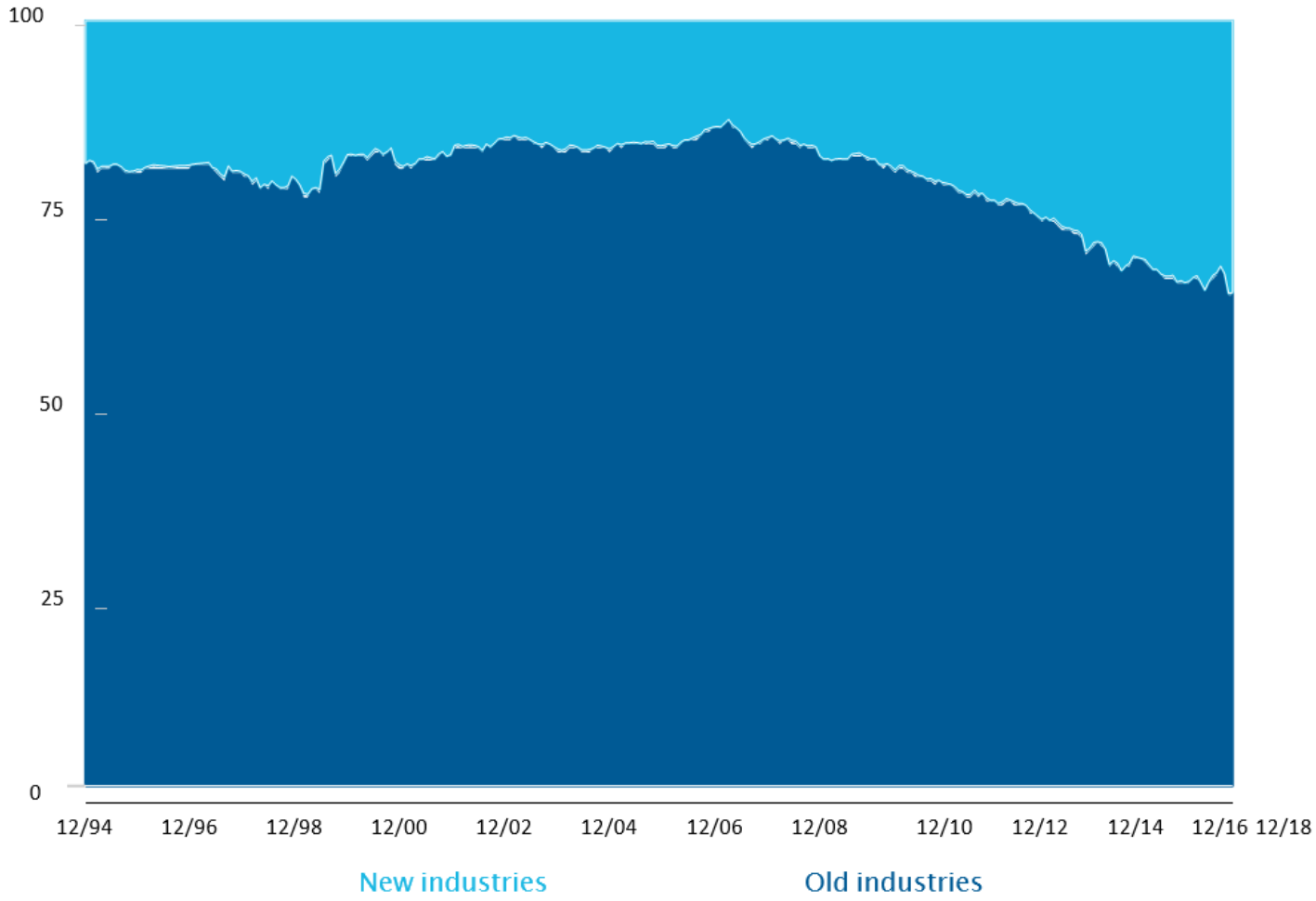
Inefficiency 3: Emerging Market (EM) Equity Indices' Underexposure to Structural Development

For most of the past two decades, above-trend growth shaped emerging market economies and skewed market-cap-weighted EM equity indices toward industries associated with high, cyclical growth. In recent years, however, EM governments have reoriented policy priorities to support economic development rather than a growth-at-all-costs approach. The effect of this divergence results in another inefficiency that can potentially be exploited.

Economic growth is often conflated with economic development, but the concepts are distinct. While quantitative metrics such as a change in GDP or national income measure growth, economic development refers to the quality of those changes. Across EMs, structural forces like greater inclusiveness, enhanced productivity, improved living standards, and better sustainability are gaining traction. Sectors closely tied to those forces, such as health care, consumer products, and technology, are benefiting.

As Exhibit 4 shows, financials, utilities, telecommunications, energy, and materials accounted for more than half of total EM equity market cap in late 2015. In that same year, private equity – forward-looking capital – was flowing to areas with the potential to benefit directly or indirectly from secular development trends, such as health care, technology, industrials, and consumer goods and services.

A more recent survey of private-equity intentions,[2] as well as anecdotal evidence, indicates that private equity allocations continue to favor those sectors; however, EM index composition is still largely weighted toward past growth drivers like natural resources and financials (Exhibit 5). This suggests that EM equity indices are misaligned and that investors who hug the benchmark are underexposed to development-related segments with the potential to outperform.



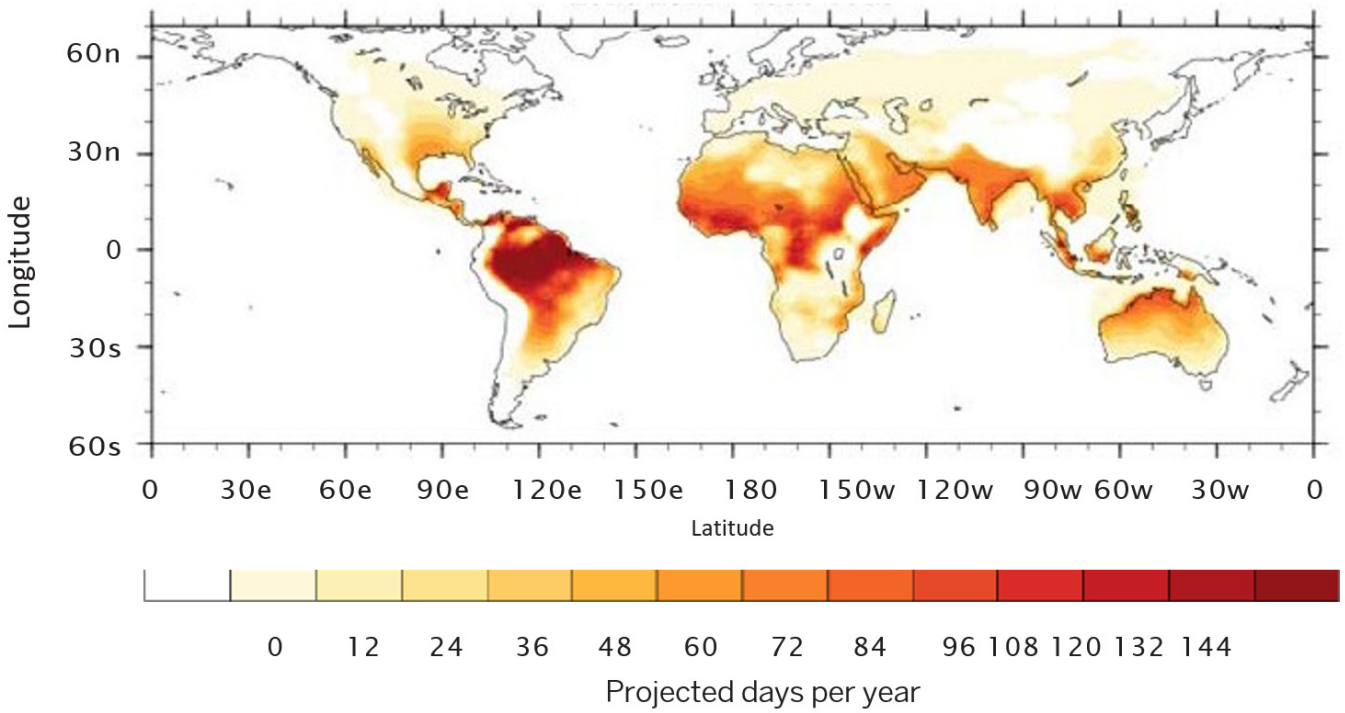
Based on MSCI Emerging Markets Index, December 1994 – December 2018. | New industries defined as consumer related (consumer staples, consumer services, media, retailing, household durables, leisure products, software, internet software and services), health care (heath care equipment and services, biotechnology, life sciences tools and services), broadening financial markets (thrifts and mortgage finance, consumer finance, capital markets, insurance), and clean power (gas utilities, water utilities, independent power, renewable electricity producers). Old industries defined as natural resources (energy and materials), exporters (industrials, automobiles, auto components, textiles and apparel, luxury goods, pharmaceuticals, technology hardware and equipment, IT services, semiconductors, semiconductor equipment), and state-owned enterprises (banks, diversified financials, real estate, electric utilities, multi-utilities).
Exhibit 5: Industry Composition in MSCI Emerging Markets Index: 1995 - 2018
Sources: MSCI, Wellington Management

Exploiting Inefficiency 3: Focus on Secular Development Themes

We believe that markets underappreciate the political determination that exists to make economic progress more stable and inclusive. Two of our sustainable investing portfolio managers have collaborated with Professor Maryann Feldman of the University of North Carolina on the construction of a proprietary index to study and track progress along each of these four forces of structural change. By focusing on development rather than on cyclical growth, they seek to take a longer-term, differentiated approach to EM equity investing. Consequently, they invest more heavily in the sectors aligned with the structural development forces identified above.

Inefficiency 4: Blind Spots in Climate Risk Analysis

Climate change presents two types of financial risks: transitional risks posed by changes in climate-related policy, regulation, and legislation; and physical risks posed by environmental threats from drought, flooding, rising sea levels, and more. In our view, most climate risk analysis currently focuses on transition risks, with less attention to the impact of physical risks on capital markets and investment portfolios. To us, this is a massive information blind spot, as we believe the physical risks of climate change, including heat, drought, rising sea levels, and several others will have profound effects on asset prices around the world.



Additional days per year in National Weather Service danger zone throughout the 2020 – 2029 decade. World based on 1951 – 1980 reference period. Danger zone is defined as the National Weather Service Heat Index danger and extreme danger zones, which include heat index values above 103°F. This is the source for heat advisories. The target data presented is hypothetical in nature. No assurance or guarantee is made that any target data can or will be achieved. Actual experience may not reflect all of the data or may be outside of stated ranges. For illustrative purposes only.

Exhibit 6: Many Regions will get Hotter

Sources: National Weather Service

Exploiting Inefficiency 4: Bridging the Gap Between Science and Finance

In September 2018, we began a multiyear collaboration with Woods Hole Research Center (WHRC), the top-ranked independent climate research institute for the past four years by the International Center for Climate Governance, to understand the implications of physical climate risk on securities, industries, and economies. Working side by side with climate scientists, we are studying the implications of six climate factors: heat, drought, wildfire, hurricanes, floods, and water availability.

For each climate variable, we conduct a scientific literature review and determine which metric is most relevant for answering capital market questions. These climate scientists then create granular maps showing how these variables are likely to affect various geographic areas over time. We then overlay these maps with various securities and their characteristics to assess whether or not we believe these climate outcomes are appropriately priced.

In the study of heat, for example, we chose a measure that combines temperature and humidity into an index, because above certain levels, heat endangers human health. The map in Exhibit 6 shows the additional number of days per year that various geographies will experience danger-zone readings, as determined by our metric of heat and humidity, over the next decade. Locations in orange will experience two more months of dangerous heat whereas the deepest red colors mean almost five additional months. We think this will have profound effects on capital markets with regard to migration, agriculture, and infrastructure. While some places will need to spend massive amounts of money to adapt to rising temperatures, others may experience migration, as people relocate to more livable places.

These eventualities have considerable implications for securities associated with fixed physical locations, such as regional banks, theme parks, farmland, municipal bonds, or real estate investment trusts (REITs). In our work, we aim to answer macro questions such as, "Will India get rich before it gets too hot?" and micro questions like, "What is the revenue hit to a theme park forced to close 20 days per year because of high temperatures?" We also aim to determine through engagement how well management teams understand and appreciate the effects of climate change on their business, and whether they are deploying capital proactively to stay competitive.

Inefficiency 5: An Undefined Imact Investing Universe

The basic inefficiency with impact investing is that the universe of publicly traded securities to choose from remains undefined. While industry groups like the Global Impact Investing Network (GIIN) have made great progress on impact measurement and reporting standards, and the United Nations Sustainable Development Goals offer an important framework, impact investors have to establish their own impact criteria and research for themselves which companies qualify.

Exploiting Inefficiency 5: Deepening our Analysis to Uncover Value Drivers

Our research estimates that, on the equity side, nearly 500 publicly traded companies across a range of sectors, geographies, and market caps qualify for our impact approaches. In fixed income, we have identified a broad universe totaling approximately US$1 trillion. While named categories of green bonds and impact bonds are options, these require analysis to determine whether they meet our criteria for impact. In addition, some corporate, agency, municipal, and commercial mortgage-backed securities may meet our materiality criteria — the majority of bond proceeds must be aimed at an impact goal like affordable housing or zero-carbon-emissions transport. We see the tendency to limit the fixed income investment universe to named green bonds and impact bonds as another inefficiency.

We believe companies whose products and services help solve the world's biggest problems may be global growth engines in coming years. By defining the universe and studying these stocks through the impact lens, we believe we can arrive at differentiated insights that may add value for clients.

While a first step is to define and hone the definition of the impact universe, we believe it is also critical to analyze impact companies with a nontraditional lens. For example, while traditional analysis may compare a company that converts solid waste into energy to a traditional waste management business model, we take a different view. The fortunes of waste-to-energy companies depend more on the prices of recycled metal and energy than on traditional inputs, so the traditional analysts' miscategorization can lead to asset mispricing. Similarly, many telecommunications companies are helping to broaden access to financial services in emerging markets. We find that voice and data pricing drive these stock prices much less than prices for mobile money and mobile credit. Traditional telecommunications analysts tend to cover these companies, but we believe their capabilities as nonbank financial services will determine their level of success.

Conclusion

Rapid evolution in the sustainable investing universe creates market inefficiencies. The most significant information gaps we see are focusing on near-term growth, relying on third-party ESG ratings, ignoring physical climate risks, failing to appreciate opportunities in EM economic development, underutilizing engagement with companies as a means of unlocking value, and misunderstanding the impact investing opportunity set.

We believe active investors, with thorough analysis and proprietary research, have ample opportunities to generate alpha in this space by identifying and exploiting the inefficiencies that exist.

Principle Risks: Common Stock Risk, Concentration Risk, Emerging Risk, Currency Risk, and Liquidity Risk.

Disclosure

Any views expressed here are those of the authors as of publication, are based on available information and are subject to change without notice. All investors should consider the risks that may impact their capital, before investing. The data shown in the Exhibits is for informational purposes only, is subject to change, and is not indicative of future portfolio characteristics or returns. Actual results may vary for each client due to specific client guidelines, holdings, and other factors.

Endnotes

1. In the middle are approaches that emphasize values alignment, offering below-market or "concessionary" returns; with catalytic capital investing, for example, investors are willing to take lower returns and assume disproportionate risk to encourage investment by others who may have higher return expectations.
2. 2017 Global LP Survey.

Author Bio

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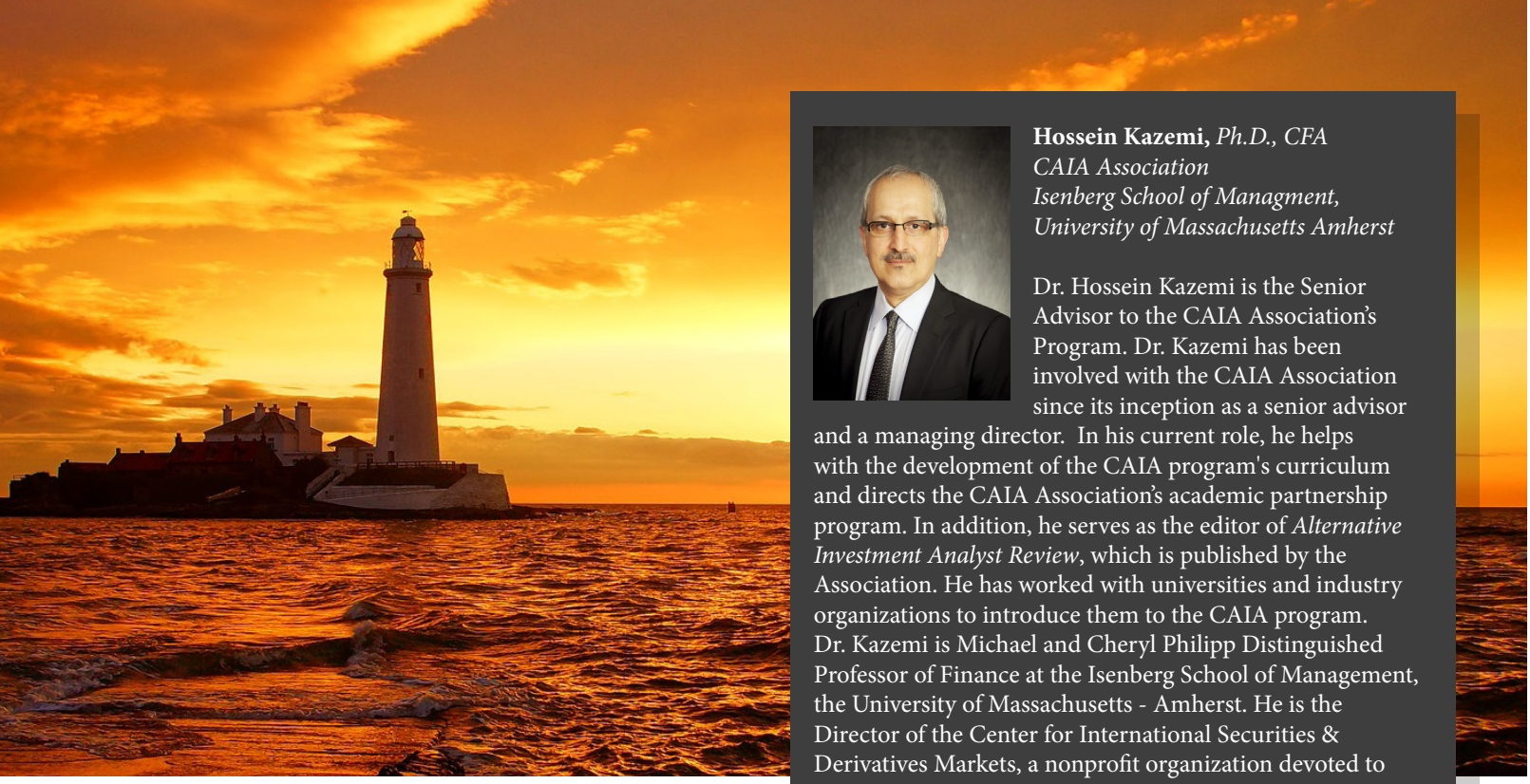
Wellington Management

Wendy is the director of Sustainable Investment, setting the research agenda and strategies for the firm's sustainable investment practice, including impact, climate, and long-term engagement strategies. As vice chair, she is a senior member of the firm's management team and works with the CEO with respect to strategic initiatives and external affairs of the organization.

In addition, she is a member of the firm's Investment Stewardship Committee, and Hedge Fund Review Group, and serves as vice chair of the Compensation Committee and chair of the Strategic Relationship Advisory Committee and the Wellington Management Australia Board. She also serves as a director on the board of the United Nations-supported Principles for Responsible Investment.

Previously, Wendy conducted research on long-term multi-asset themes and led the development of multi-asset portfolios for the firm's global client base as the director of Global Multi-Asset Strategies.

Wendy received her MBA, with honors, from Vanderbilt University and her BBA, summa cum laude, from the University of Mississippi. She also holds the Chartered Financial Analyst designation.



The CAIA Endowment Investable Index

Hossein Kazemi

Kathryn Wilkens, *CAIA*
Pearl Quest

We present the historical weights, allocation as of month-end September 2019, and historical performance to the replication portfolio that was introduced in our AIAR publication Volume 6 Issue 1.

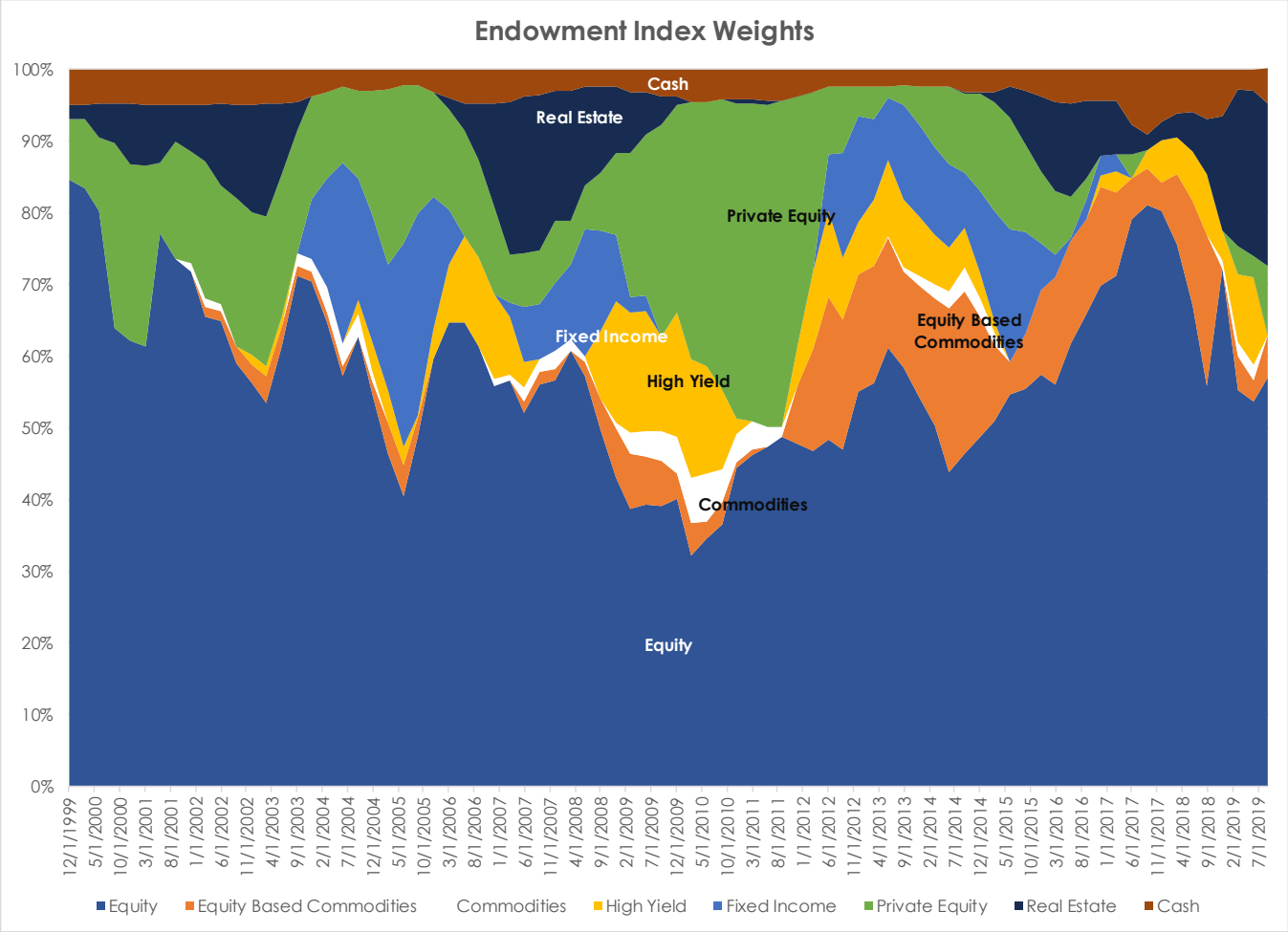
The graph on the following page shows the exposures of the Multi-Asset ETF portfolio through time. It is important to note that the volatility displayed by these exposures does not imply that endowments alter their asset allocations as frequently as the Multi-Asset ETF portfolio. While an endowment may hold a fixed allocation to various asset classes, the underlying assets/manager may display time-varying exposures to different sources of risk. For instance, a hedge fund manager may decide to increase her fund's exposure to energy stocks while reducing the fund's exposure to healthcare stocks. Though the endowment's allocation to that manager has remained unchanged, its exposures to energy and healthcare sectors have changed. Also, if returns on two asset classes are highly correlated, then the algorithm will pick the one that is less volatile. For instance, if returns on venture capital and small cap stocks are highly correlated, then the program will pick the small cap index if it turns out to be less volatile.

Hossein Kazemi, *Ph.D., CFA*
CAIA Association
Isenberg School of Managment, University of Massachusetts Amherst

Dr. Hossein Kazemi is the Senior Advisor to the CAIA Association's Program. Dr. Kazemi has been involved with the CAIA Association since its inception as a senior advisor and a managing director. In his current role, he helps with the development of the CAIA program's curriculum and directs the CAIA Association's academic partnership program. In addition, he serves as the editor of *Alternative Investment Analyst Review*, which is published by the Association. He has worked with universities and industry organizations to introduce them to the CAIA program. Dr. Kazemi is Michael and Cheryl Philipp Distinguished Professor of Finance at the Isenberg School of Management, the University of Massachusetts - Amherst. He is the Director of the Center for International Securities & Derivatives Markets, a nonprofit organization devoted to research in the area of alternative investments, a co-founder of the CAIA Association, and home to CISDM Hedge Fund/CTA Database and the *Journal of Alternative Investments*, the official research publication of the CAIA Association. He has over 25 years of experience in the financial industry and has served as consultant to major financial institutions. His research has been in the areas of valuations of equity and fixed income securities, asset allocation for traditional and alternative asset classes, and evaluation and replication of active management investment products. He has a Ph.D. in finance from the University of Michigan.

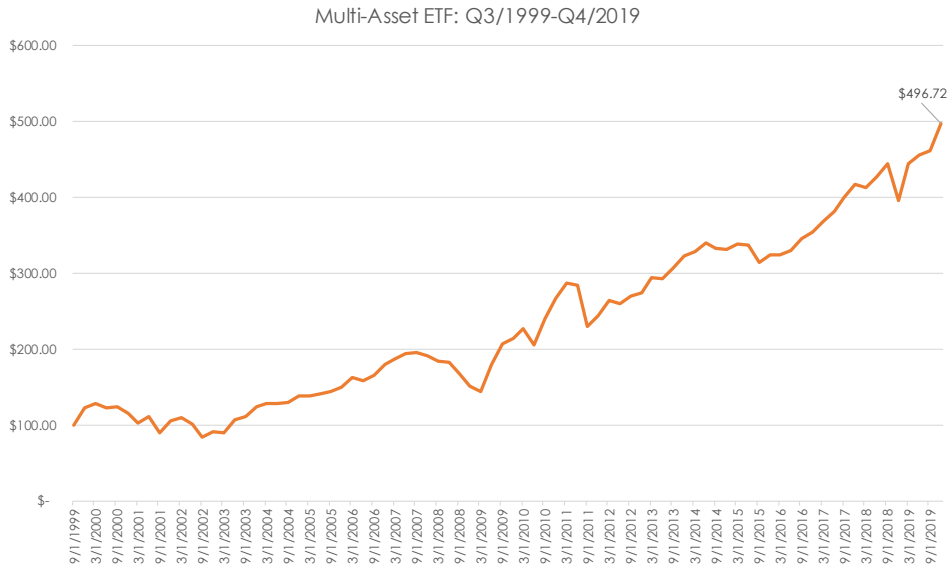
Kathryn Wilkens, *Ph.D., CAIA*
Pearl Quest LLC

Kathryn Wilkens, Ph.D., CAIA is a curriculum and exam advisor to the Financial Data Professional Institute and the founder of Pearl Quest LLC, a consulting firm. She is also a copy editor for the Journal of Alternative Investments and subject matter expert for the Chartered Alternative Investment Analyst exams on Wiley's Efficient Learning Platform. Kathryn has published several journal articles and book chapters on investments and edited the first edition of the CAIA textbooks. Pearl Quest was founded in 2011 and creates data science applications for investments.



Allocation Suggested by Algorithim								
iShares Russell 2000 ETF	PowerShare sQQQ ETF	Vanguard FTSE Emerging Markets ETF	Technology Select Sector SPDR® ETF	Energy Select Sector SPDR® ETF	Health Care Select Sector SPDR® ETF	Invesco Global Listed Private Equity ETF	SPDR® Dow Jones Global Real Estate ETF	Cash
15.7%	5.6%	15.2%	5.9%	16.2%	4.3%	9.7%	22.6%	5.0%

Historical Performance



The List: Alternative Indices

The performance table, on the following page, is a collection of both traditional and alternative indices for the 1, 5, and 10-year period annualized through September 2019. Both the annualized volatility and draw-down figures are calculated using a 10 year quarterly return series.

Alternative investments have been growing markedly over the past few years, creating a multitude of opportunities for owners and allocators alike. As the number and type of alternative asset classes continue to proliferate, we believe they are playing a more unique role in assisting investors achieve their desired investment outcomes. As we expect this trend to continue, we found it necessary to structure a pure alternative assets portfolio to have visibility in this exciting marketplace.

We set out to strike a balance between available assets in proportion to their market value, and to reflect the average "alternative investor". We defined the investment opportunity to simply be the following three assets classes: Real Asset, Private Equity/Venture Capital, and Hedge Funds. Real assets are comprised of real estate, commodities, timberland, farmland, and infrastructure; within real asset the weights were structured to reflect the market portfolio[1] within that universe. To arrive at our weight's, we researched various endowments and foundations, as well as surveys conducted by Willis Towers Watson and Russell Investments. Based on our research, alternative historical allocations have not had material deviation and therefore we decided to implement a market weight of 1/3 across each of those asset classes. A few of the constituents are not investable, and some may be reported gross or net of fee.

Ending September 2019

	Annualized Returns				Volatility	Max Drawdown	
	1 Yr	5 Yr	10 Yr	July 2008	10 Yr	10 Yr Max Drawdown	July 2008
MSCI World Free	4.19%	8.15%	10.13%	8.12%	12.99%	-16.52%	-41.35%
Barclays Global Agg	7.41%	2.12%	2.44%	3.00%	5.07%	-7.17%	-7.17%
MSCI Emerging Markets	-1.19%	3.33%	4.64%	4.31%	16.15%	-23.90%	-47.11%
Barclays Global High Yeild	5.15%	4.63%	7.46%	8.18%	6.96%	-8.27%	-26.20%
HFRI Fund Weighted Composite	0.63%	2.96%	4.04%	3.37%	5.42%	-7.63%	-17.91%
CISDM EW Hedge Fund	1.22%	3.87%	4.72%	4.37%	5.74%	-7.84%	-17.95%
CISDM CTA EW	11.78%	5.59%	4.47%	4.51%	6.85%	-7.94%	-7.94%
CISDM Distressed Securities	-2.65%	2.28%	5.52%	4.79%	5.05%	-7.08%	-17.97%
CISDM Equity Long/Short	-1.78%	3.56%	4.97%	4.59%	6.61%	-8.79%	-11.90%
Cambridge Associates US Private Equity*	11.60%	13.67%	15.16%	12.06%	4.80%	-4.47%	-25.14%
Cambridge Associates US Venture Capital*	25.18%	22.04%	24.59%	18.99%	15.29%	-5.10%	-30.79%
LPX Mezzanine Listed Private Equity	15.31%	9.84%	13.57%	10.91%	17.84%	-21.23%	-70.95%
FTSE NAREIT All Equity REITs	20.63%	11.41%	13.82%	12.02%	13.48%	-15.07%	-58.31%
NCREIF Property	6.25%	8.54%	8.97%	6.16%	2.82%	-5.36%	-23.88%
S&P Global Property	9.22%	3.90%	5.95%	4.59%	12.51%	-18.08%	-52.76%
S&P Global Infrastructure	10.41%	2.15%	4.21%	1.89%	12.24%	-18.18%	-45.13%
Bloomberg Commodities	-6.11%	-6.52%	-3.38%	-7.29%	14.35%	-53.55%	-65.91%
NCREIF Timberland	2.28%	4.44%	3.91%	3.85%	3.51%	-4.79%	-5.69%
NCREIF Farmland	5.81%	7.85%	10.75%	11.01%	4.65%	0.00%	0.00%
Alternative Assets Portfolio*	**7.02%**	**8.13%**	**9.66%**	**7.44%**	**4.63%**	**-3.56%**	**-17.18%**
Global 60/40 Portfolio	**5.48%**	**5.73%**	**7.06%**	**6.07%**	**8.34%**	**-9.52%**	**-21.96%**
60% Alternative* / 40% Global 60/40	**6.41%**	**7.17%**	**8.62%**	**6.90%**	**5.65%**	**-5.95%**	**-21.20%**

NOTE: All returns are calculated using arithmetic mean

* Returns for Cambridge Associates Indices are preliminary as of 9/30/2019.

Source: CAIA, CISDM, HFRI, Cambridge Associates and Bloomberg

1. Global Investment Capital Market by Hewitt EnnisKnupp, an Aon Company

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