



# Should DC Plan Sponsors Add Private Equity To Target-Date Funds?

Andres Reibel  
Pantheon

## Executive Summary

In this paper, we studied how the inclusion of Private Equity in custom Target-date Funds (TDFs) affects the return profile of TDFs – more specifically, our approach focused on including Private Equity in TDFs while keeping their risk profile unchanged. From a practical point of view, this analysis allowed us to research whether adding Private Equity to TDFs has the potential to enhance investors' retirement returns without assuming additional risk. Our results suggest that a pension plan member could potentially increase the total amount saved and distributable in year 45 by approximately 8.7%.<sup>1</sup>

There are two ways we could have performed this analysis, retrospectively using actual historical Private Equity returns or, as we have conducted it, prospectively using assumed forward returns for which we have used the J.P. Morgan Asset Management's 2016 Long-term

Capital Market Assumptions.<sup>2,3</sup> We have taken this approach because it is more conservative than using historical returns as the J.P. Morgan forecast factors in declining excess private equity returns.

We based our analysis on the data of two financial institutions. We sourced the return, variance and correlation data from J.P. Morgan Asset Management's 2016 Long-term Capital Market Assumptions as mentioned above. This is an annual publication that represents one of the industry's most established and comprehensive sets of expectations for how risk, return, and correlations across asset classes may develop over the coming decades. Further, we sourced our TDF glide path data (i.e. TDF asset class weights) from Fidelity, a leading TDF provider. The TDFs we sourced from Fidelity had maturity dates between 2020 and 2060.<sup>4,5</sup> Since the maturity dates of the sourced TDFs lie in the future, the glide path data represents Fidelity's current expectations

of future asset allocations. We then used a well-established financial framework<sup>6</sup> that allowed us to quantitatively measure and demonstrate that adding Private Equity to a 45-year custom TDF had the potential to enhance expected returns, while keeping risk constant.

In particular, we were interested in determining whether we could increase the return potential of custom Target-date Funds ("TDFs") by changing the asset allocation mix to include assets with higher return potential, including Private Equity, whilst not changing the risk profile of the TDF. Our results show that we could improve the return potential of TDFs, while not increasing risk, which could potentially enhance investors' retirement income by 8.7%.

## Key Findings

This study showed that investors may potentially increase expected returns over the 45-year life of a TDF by including Private Equity, while not increasing risk. We found that plan sponsors would need to have allocated 7.1% of their portfolio to Private Equity during the first 30 years (first six rebalancing periods) of the TDF and then reduce the allocation to Private Equity to 6.98%, 6% and 5.28% in years 30, 35 and 40, respectively. We found that we could indeed achieve potentially improved outcomes through changing the asset allocation mix. Depending on the annual contributions made by plan participants, the additional savings over the 45 year period vary. This is illustrated in the table to the right, "Additional Savings over 45 years." Specifically, we found that a pension plan participant who invests \$6,424 annually<sup>7</sup> could potentially increase the total amount saved and distributable at maturity by approximately 8.7%, or in dollar terms, from \$1,982,038 to \$2,154,832 or by approximately \$172,7948 .

We further found, through extension of the study, that higher allocations to Private Equity in the first 30 years of the TDF, could potentially increase the TDF's performance further still, while not significantly increasing risk<sup>9</sup>. These results may be of particular interest to Plan Sponsors that are interested in committing higher allocations to Private Equity<sup>10</sup>. The key results of this extension can be found later in this paper.

## Introduction

Over the last decade, custom TDFs have grown in popularity among DC Plan Sponsors and experienced strong inflows in assets – the persistence of this trend indicates that TDFs are likely to play an ever-increasing role in the future DC market.<sup>11</sup>

As discussed in the Executive Summary, Defined Contribution (DC) Plan Sponsors could, in our view, reassess their approach to strategic asset allocation by considering high-yielding asset classes such as Private Equity.

To derive intelligible conclusions, we asked ourselves two fundamental questions:

1. Could adding Private Equity to TDFs potentially improve the performance of TDFs?
2. Could this potentially be achieved without altering the risk profile of TDFs?

## Additional Savings over 45 years

Annual Retirement	Additional Savings
\$6,424	\$172,794
\$12,000	\$322,779
\$18,000	\$484,168

In the analysis that follows, we described our scientifically rigorous approach to addressing these important questions in which we applied financial models that measured the effects on risk and expected returns of custom TDFs when adding Private Equity.<sup>12</sup>

## Comparing Risk and Return of a TDF Including Private Equity to a TDF Excluding Private Equity

In our view, investors interested in adding Private Equity to their TDF would likely be seeking to increase expected returns without incurring additional expected risk.

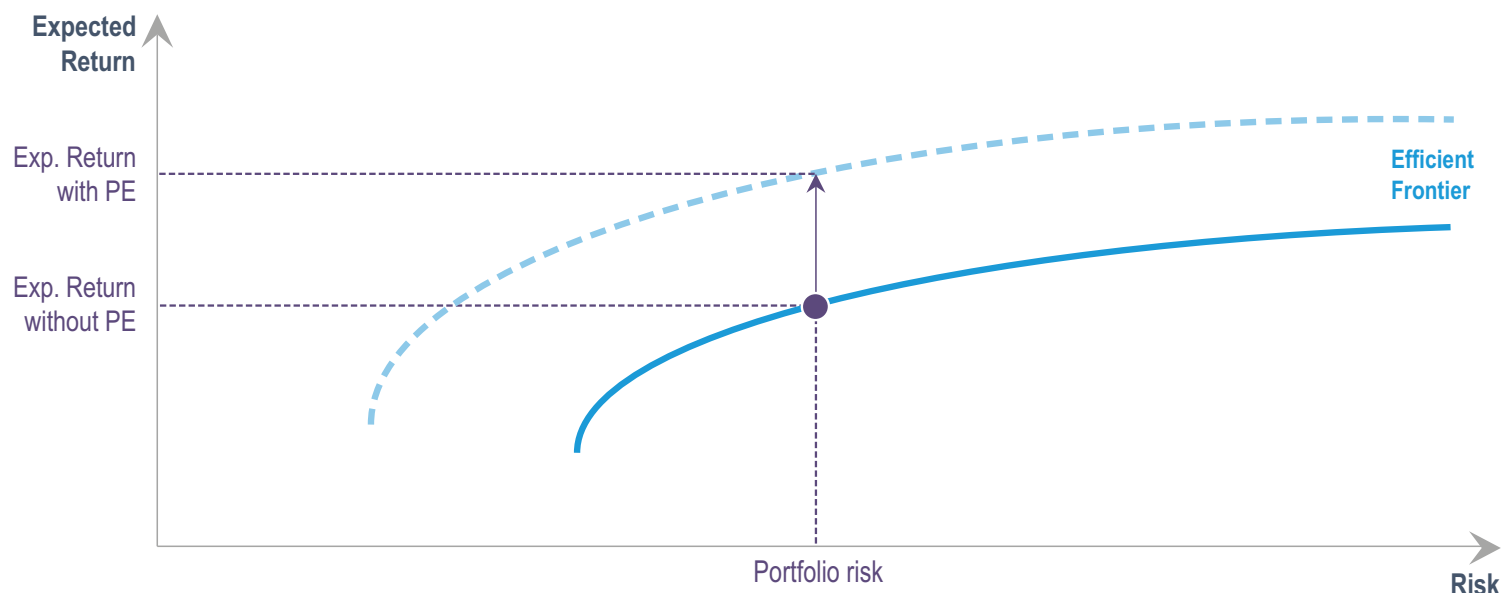
Therefore, we believe that the approach we chose would most likely be of particular relevance to these investors.

To conduct our analysis we used a well-established financial framework<sup>13</sup> that we applied to two datasets of financial institutions.<sup>14,15</sup> Our analysis quantitatively measured and demonstrated that adding Private Equity to a 45-year custom TDF, the typical glide path for a TDF, had the potential to enhance expected returns, while keeping expected risk constant.<sup>16</sup> To understand our approach we think it is insightful for the reader to consider the illustration below. The graph illustrates how adding Private Equity to a portfolio can potentially shift the efficient frontier to the upper left corner, essentially increasing investors' return potential, while keeping risk unchanged and therefore improving the portfolio's risk- return ratio (i.e. Sharpe ratio<sup>17</sup>):

In order to analyze how adding Private Equity to a TDF changes the risk and expected returns of the TDF, we compared a TDF including Private Equity to a TDF excluding Private Equity. We approached this comparison using the below three-stage procedure.

1. Measure the risk of the TDF excluding Private Equity.
2. Fix the risk of the TDF including Private Equity to that of the TDF excluding Private Equity and find the portfolio weights that optimize returns.<sup>18</sup>
3. Compare the returns of the TDF excluding Private Equity to that of the TDF including Private Equity.

First, we defined the core composition of our standard TDF; the standard TDF has a life span of 45-years with a glide path that rebalances in five-yearly periods and has no allocation to Private Equity.<sup>19</sup> In other words, our standard TDF presented the standard solution that is generally available to DC plan members



**Graph 1: CAPM**

and we therefore refer to it as the “standard TDF” throughout this paper. We measured the risk and expected returns that our standard TDF is expected to yield.

In the second step, we added Private Equity as an asset class that may be included in the TDF’s glide path. Our financial framework decided the weight each asset class was assigned in a way that it produced the highest risk-return ratio.<sup>20</sup> Should Private Equity be able to enhance the risk-return profile of the standard TDF, then some of the weight of the standard TDF’s glide path was reallocated to Private Equity. We followed this procedure for each of the nine rebalancing periods and so reallocated weights across all asset classes over the entire 45-years of our standard TDF. Since the risk of the TDF including Private Equity was kept equal to that of the standard TDF (excluding Private Equity), observing the change in returns allowed us to assess the benefits of adding Private Equity to a standard TDF.

### Time-horizon Considerations

Note that this study’s return, volatility, correlation data, and portfolio analysis used five-year time-horizons and as such the performance of the TDF should only to be judged over five-year horizons. We chose the five-year time horizon as it is aligned with the five-yearly rebalancing periods of the TDF.<sup>21</sup> It is important to note that the performance of the TDF for time periods of less than five-years may substantially differ from the five-year performance statistics.

This is important to understand as, for example, public markets tend to be more volatile than private markets over shorter time periods; therefore, while investors may experience substantial under or overperformance in Private Equity in any individual year due to volatility differences between asset classes, the excess performance potential of Private Equity investments should result in an outperformance over longer time periods. Note that we chose to express our results in terms of annualized numbers where appropriate.

### Results and Conclusion

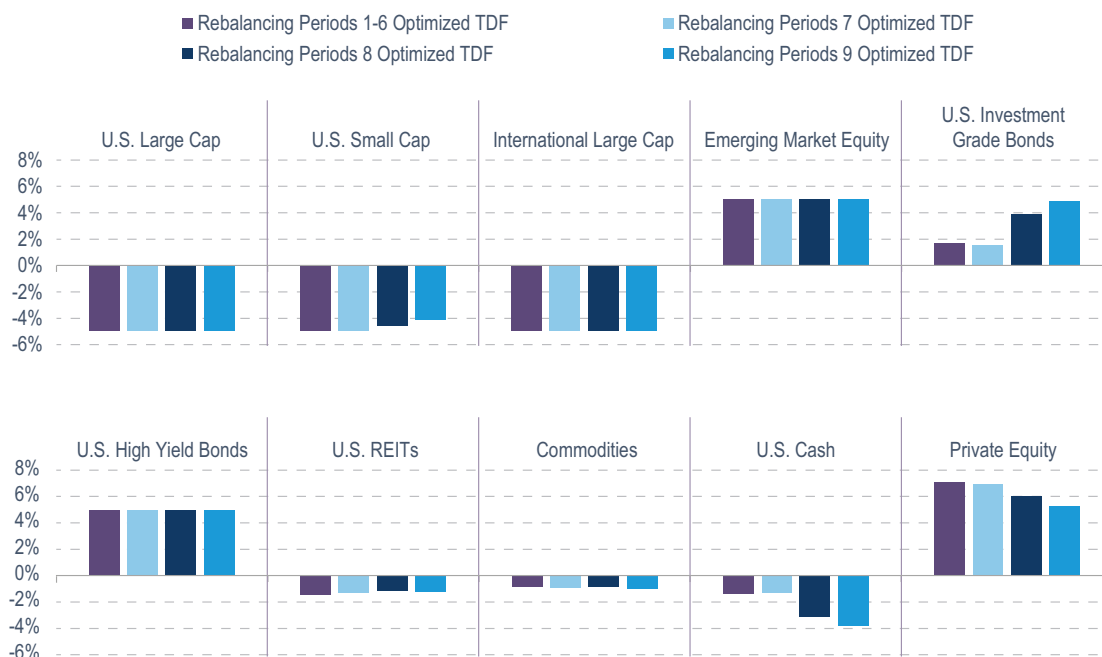
*What is the impact on the expected returns of the standard TDF if we fix its risk and add Private Equity as an investment option?*

To answer this question, we were interested in understanding how the portfolio optimization affected the portfolio allocation (glide path) across rebalancing periods and performance of an optimized TDF when including Private Equity and fixing risk to that of a TDF excluding Private Equity.<sup>22</sup> We summarized the results of our analysis in Graph 2 and Graph 3 on the following pages. Having fixed the risk as a key parameter, the optimization selected the asset allocation that would maximize portfolio returns – an increase in allocation to higher-yielding asset classes, such as equities and a decrease in allocation to lower-yielding asset classes, such as investment grade bonds, was therefore also expected.

Below we set out the resulting change in the allocation and performance statistics across rebalancing periods and asset classes in more detail:

1. Importantly, the optimized TDF experienced a shift in weights in the first six rebalancing periods in favor of Emerging Market Equity (+5.0%), U.S. High Yield Bonds (+5.0%), and Private Equity (+7.1%).<sup>23</sup> Further, the optimized TDF experienced an increase in annualized expected return of 0.27% (i.e. the TDF’s annualized expected return increased from 5.0% to 5.3%), while risk was kept constant by definition.
2. Further, the optimization of the TDF in the first six rebalancing periods resulted in a sharply reduced allocation to U.S. Large Cap (-5.0%), U.S. Small Cap (-5.0%), International Large Cap (-5.0%), while U.S. REITs (-1.5%), U.S. Cash (-1.4%) and Commodities (-0.9%) were moderately reduced. Interestingly, the allocation to U.S. Large Cap, U.S. Small Cap and International Large Cap decreased noticeably, even





**Graph 2: Reallocation of Asset Class Weights When Adding Private Equity to the Standard TDF**

Graph 2 shows, based on the study, the percentage change in portfolio weights across asset classes between a standard TDF excluding Private Equity and an optimized TDF including Private Equity. The optimized TDF maximizes returns, while keeping the same risk profile as a standard TDF excluding Private Equity.

though these asset classes tend to be relatively high-yielding; these results showed that for an optimized TDF including Private Equity, U.S. Large Cap, U.S. Small Cap and International Large Cap needed to be de-emphasized in order to achieve the highest possible risk-return ratio. These changes in asset allocation were fairly persistent throughout the life of the TDF; please see Graph 2 for details regarding rebalancing periods 7, 8, and 9.

3. In rebalancing period 7, the optimal portfolio allocated 6.98% to Private Equity and the TDF yielded a 0.26% higher expected return than the standard TDF. In rebalancing period 8 with a 6% Private Equity exposure, the TDF yielded a 0.27% higher expected return than the standard TDF. Finally, in rebalancing period 9 with a 5.28% Private Equity exposure, the TDF also yielded a 0.27% higher expected return than the standard TDF.

### Key Conclusion

When optimizing the asset allocation of a TDF including Private Equity and fixing risk to that of a standard TDF excluding Private Equity during the first 30 years of the TDF, Private Equity obtained a 7.1% allocation; the return potential of the TDF may be improved by approximately 0.27% annually.

Further, optimizing the allocation to Private Equity while keeping the risk constant to that of the standard TDF in the last three rebalancing periods resulted in an allocation to Private Equity of 6.98%, 6.0%, and 5.28% in rebalancing periods 7, 8, and 9, respectively. The optimized TDF including a Private Equity allocation resulted in an increase in expected returns of 0.26%, 0.27%, and 0.27% in rebalancing periods 7, 8, and 9, respectively.

On average, the performance of the optimized TDF including Private Equity increased by 0.27% p.a. over its 45 year life. As

explained in the Executive Summary, by compounding this additional return, a retiree's total amount saved potentially would have increased by approximately 8.7%.<sup>24</sup>

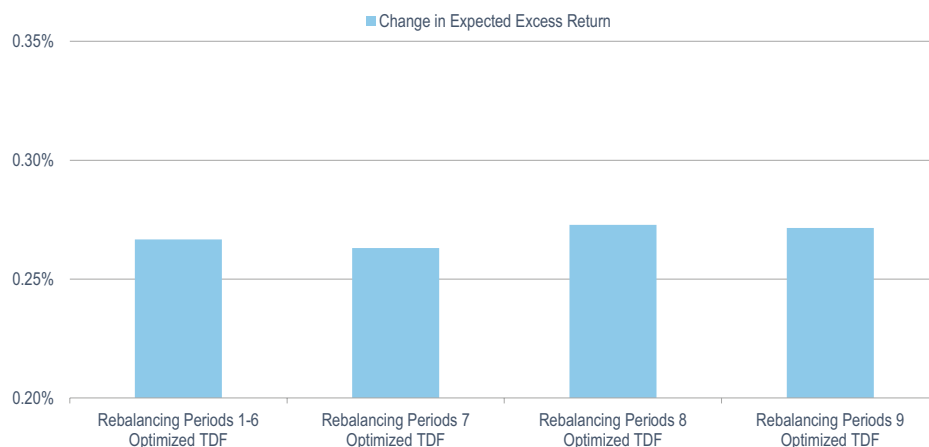
### Study Extension – Higher Allocations to Private Equity in the First 30 Years

In this section of the study we analyzed how higher allocations to Private Equity may affect the performance of the TDF in the first 30 years of its life (first 6 rebalancing periods). To conduct our analysis, we first optimized the TDF's performance when including Private Equity and assuming that risk was fixed to that of the standard TDF. From the allocation of the optimized TDF with 7.1% exposure we then adjusted the allocation to non-Private Equity asset classes as we increased the allocation to Private Equity to 8%, 9.4% and 10%, respectively.<sup>25</sup>

We found that for Private Equity allocations of 8%, 9.4%, and 10% the expected return potential of the TDF when compared to the standard TDF improved by 0.28%, 0.3%, and 0.3% p.a. respectively.<sup>26</sup> Further, we found that despite the reallocation of asset class weights, we did not observe considerable increases in the TDF's risk profile. We therefore concluded that investors that seek exposure to Private Equity of up to 10% may potentially do so without incurring significantly higher risk, while substantially increasing their return potential, which ultimately resulted in an improvement of the TDF's risk-return profile when compared to the standard TDF.

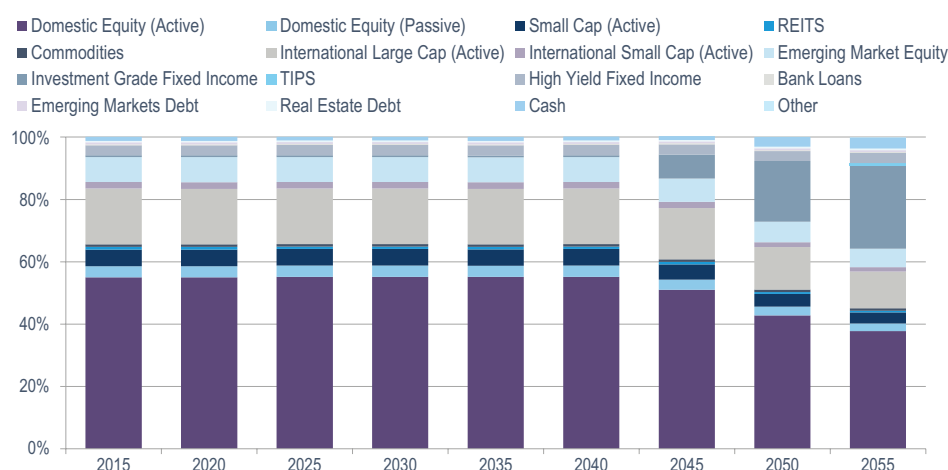
### Data and Methodology

First, we required the glide path of a representative TDF. We obtained our glide path data from standard Fidelity TDFs with maturity dates between 2020 and 2060.<sup>27</sup> We derived the weights for our standard TDF's glide path from this data and so generated a TDF with inception in 2015 and the last rebalancing period in 2055. The glide path is rebalanced every five years and



### Graph 3: Change in TDF Performance When Adding Private Equity (and Keeping Risk Constant)

Graph 3 depicts the difference in annualized excess returns between a TDF including Private Equity and a standard TDF. Our analysis showed that including Private Equity in a TDF has the potential to increase expected (excess) returns by approximately 0.3% – this increase can be achieved without assuming additional risk.



### Graph 4: Original Fidelity Standard TDF Glide Path

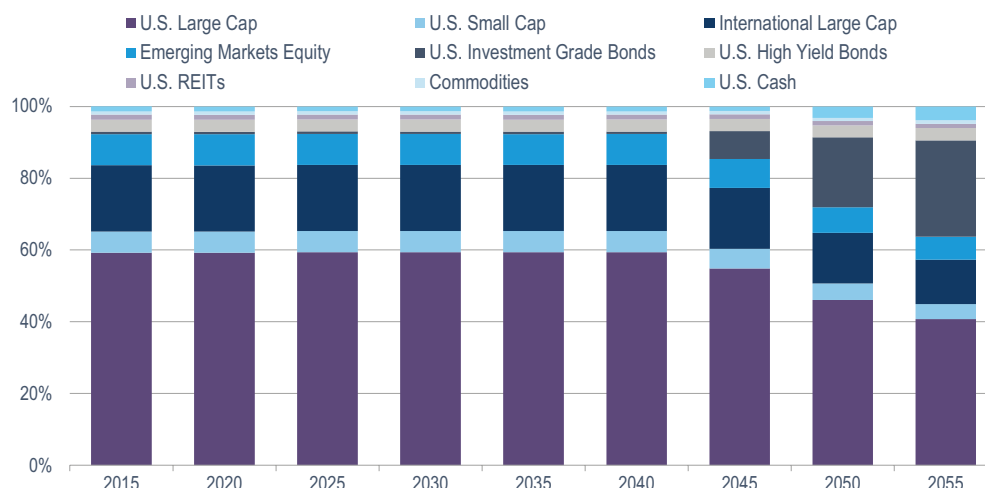
Graph 4 depicts the allocation across asset classes in each of the nine rebalancing periods of the original TDF glide path data (Fidelity) that we used in this study. Since the maturity dates of the sourced TDFs lie in the future, the TDFs glide path data represents Fidelity's current expectations of future asset allocation.

de-risks over time by shifting weight toward less risky assets. Graph 4 represents the asset allocation according to the original Fidelity TDF. (See Table 2 in Appendix)

Second, we sourced the corresponding return and correlation data that we needed to conduct our analysis from J.P. Morgan Asset Management's 2016 Long-term Capital Market Assumptions.<sup>28</sup> J.P. Morgan's Long-term Capital Market Assumptions have been published for the last 20 years – this dataset provided the annual assessment of the long-term outlook across all major asset classes and markets. Note that we proxied for the risk-free asset using the return on U.S. Cash as provided in the J.P. Morgan dataset. The J.P. Morgan asset class definitions do not exactly match those of the Fidelity glide path and therefore we needed to make some simplifying assumptions in order to aggregate some of the asset classes described in the latter to match the former. For purposes of this study, we chose to reallocate weights as follows: we aggregated (U.S.) Domestic Equity (Passive) and (U.S.) Domestic Equity (Active) to U.S. Large Cap. We renamed (U.S.) Small Cap (Active) to U.S. Small Cap and International Large Cap (Active) to International Large Cap. Further, we reallocated International Small Cap (Active) equally to U.S. Large Cap, U.S.

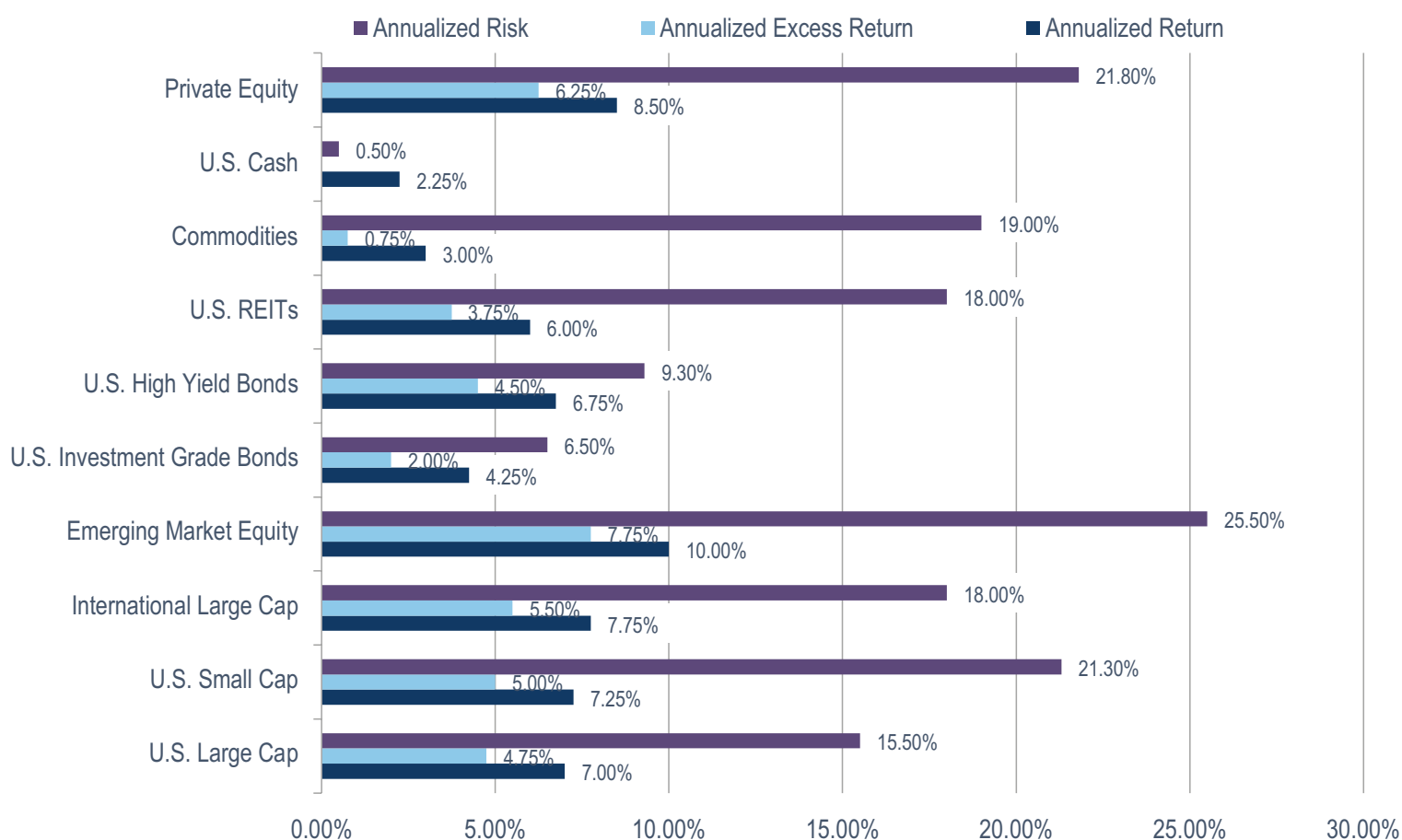
Small Cap, International Large Cap and Emerging Market Equity. We merged REITs with Real Estate Debt to cover both Equity REITs and Mortgage REITs and named this asset class U.S. REITs. TIPS, Bank Loans, Emerging Market Debt, and others were equally reallocated across all asset classes. In aggregate, the sum of the weights of all reallocated asset classes was less than 10% in any given rebalancing period. In Graph 5 we presented the reallocated TDF glide path that we used to conduct our analysis. Our analysis covered all nine rebalancing periods in the glide path represented in Graph 5; (See Table 3 in Appendix) however, due to the similarity of the asset allocation across the first six rebalancing periods, we used the 2015 rebalancing period to represent the rebalancing periods from 2015 to 2040 in a parsimonious way.

In Graph 6 below, we represent J.P. Morgan's return and risk estimates by asset class. We matched the J.P. Morgan data to the asset classes in our reallocated glide path by name; all names matched apart from International Large Cap, which corresponded to EAFE Equity and U.S. Investment Grade Bonds, which corresponded to U.S. Investment Grade Corporate Bonds in the J.P. Morgan data set.



**Graph 5: Reallocated Fidelity Standard TDF Glide Path**

Corresponding to Graph 4, Graph 5 depicts the allocation across asset classes in each of the nine rebalancing periods (or over the entire 45- year time span of the TDF) of the reallocated Fidelity TDF glide path data that we used in this study. Therefore, Graph 5 reflects the standard glide path used in this study. Since the maturity dates of the sourced TDFs lie in the future, the TDFs glide path data represents Fidelity's current expectations of future asset allocations.



**Graph 6: J.P. Morgan Return and Risk Estimates<sup>29</sup>**

Graph 6 depicts J.P. Morgan's annualized risk (standard deviation), annualized excess return and annualized return assumptions that we based our study on.<sup>30</sup> (see table 4 in Appendix) Note that excess returns were defined as expected returns minus the risk-free rate. The J.P. Morgan Asset Management's Long-term Capital Market Assumptions is an annual publication that represent one of the industry's most established and comprehensive sets of expectations for how risk, return, and correlations across asset classes may develop over the coming decades.

## Appendix

Variance-covariance Matrix	U.S. Large Cap	U.S. Small Cap	International Large Cap	Emerging Market Equity	U.S. Investment Grade Bonds	U.S. High Yield Bonds	U.S. REITs	Commodities	U.S. Cash	Private Equity
U.S. Large Cap	1									
U.S. Small Cap	0.91	1								
International Large Cap	0.88	0.77	1							
Emerging Market Equity	0.76	0.7	0.88	1						
U.S. Investment Grade Bonds	0.26	0.17	0.38	0.37	1					
U.S. High Yield Bonds	0.69	0.66	0.72	0.69	0.56	1				
U.S. REITs	0.74	0.78	0.66	0.55	0.38	0.63	1			
Commodities	0.45	0.37	0.59	0.62	0.25	0.45	0.26	1		
U.S. Cash	-0.06	-0.07	0.04	0.09	-0.11	-0.13	-0.04	0.12	1	
Private Equity	0.87	0.95	0.76	0.69	0.19	0.69	0.7	0.4	-0.1	1

**Table 1: J.P. Morgan 2016 Estimates – Correlation Matrix in USD**

Table 1 depicts J.P. Morgan's correlation assumptions that we based our study on. The J.P. Morgan Asset Management's Long-term Capital Market Assumptions is an annual publication that represents one of the industry's most established and comprehensive sets of expectations for how risk, return, and correlations across asset classes may develop over the coming decades.<sup>31</sup> Please note that the table was converted to a variance-covariance matrix in order to conduct our analysis.

		Rebalancing period 1	Rebalancing period 2	Rebalancing period 3	Rebalancing period 4	Rebalancing period 5	Rebalancing period 6	Rebalancing period 7	Rebalancing period 8	Rebalancing period 9
<b>US Large Cap Equity (Active)</b>										
Fidelity Series Equity-Income Fund	FNKLX	9.75%	9.69%	9.65%	9.66%	9.64%	9.65%	8.90%	7.49%	6.55%
Fidelity Series Growth Company Fund	FCGSX	7.48%	8.20%	8.60%	8.53%	8.66%	8.58%	8.02%	6.71%	6.00%
Fidelity Series Growth and Income Fund	FGLGX	7.46%	7.43%	7.41%	7.41%	7.40%	7.41%	6.84%	5.74%	5.07%
Fidelity Series All Sector Equity Fund	FSAEX	7.32%	7.41%	7.40%	7.41%	7.39%	7.40%	6.82%	5.71%	5.02%
Fidelity Series Stock Selector Large Cap Value Fund	FBLEX	6.49%	6.43%	6.41%	6.41%	6.40%	6.41%	5.89%	4.95%	4.36%
Fidelity Series Blue Chip Growth fund	FSBDX	6.08%	5.82%	5.83%	5.84%	5.82%	5.83%	5.38%	4.51%	3.98%
Fidelity Series Intrinsic Opportunities Fund	FDMLX	5.42%	5.12%	5.00%	5.00%	4.99%	5.00%	4.61%	3.87%	3.41%
Fidelity Series Opportunistic Insights Fund	FWWSX	4.95%	4.91%	4.91%	4.91%	4.91%	4.91%	4.52%	3.79%	3.33%
<b>Total</b>		<b>54.95%</b>	<b>55.01%</b>	<b>55.21%</b>	<b>55.17%</b>	<b>55.21%</b>	<b>55.19%</b>	<b>50.98%</b>	<b>42.77%</b>	<b>37.76%</b>
<b>US Large Cap Equity (Passive)</b>										
Fidelity Series 100 Index Fund	FOHIX	2.32%	2.30%	2.28%	2.28%	2.27%	2.28%	2.11%	1.77%	1.55%
Fidelity Series 1000 Value Index Fund	FIOOX	1.30%	1.29%	1.27%	1.28%	1.27%	1.27%	1.18%	1.00%	0.87%
<b>Total</b>		<b>3.62%</b>	<b>3.59%</b>	<b>3.55%</b>	<b>3.56%</b>	<b>3.54%</b>	<b>3.55%</b>	<b>3.29%</b>	<b>2.77%</b>	<b>2.42%</b>
<b>Small Cap US Equity (Active)</b>										
Fidelity Series Small Cap Opportunities Fund	FSOPX	4.03%	3.99%	3.96%	3.97%	3.96%	3.96%	3.66%	3.07%	2.71%
Fidelity Series Small Cap Discovery Fund	FJACX	1.30%	1.29%	1.30%	1.30%	1.29%	1.30%	1.20%	1.02%	0.88%
<b>Total</b>		<b>5.33%</b>	<b>5.28%</b>	<b>5.26%</b>	<b>5.27%</b>	<b>5.25%</b>	<b>5.26%</b>	<b>4.86%</b>	<b>4.09%</b>	<b>3.59%</b>
<b>REITS</b>										
Fidelity Series Real Estate Equity Fund	FREDX	0.88%	0.86%	0.81%	0.82%	0.80%	0.81%	0.75%	0.63%	0.54%
<b>Commodities</b>										
Fidelity Series Commodity Strategy Fund	FCSSX	0.78%	0.78%	0.79%	0.79%	0.79%	0.79%	0.89%	0.78%	0.80%
<b>International Large Cap Equity</b>										
Fidelity Series International Growth Fund	FIGSX	8.96%	8.93%	8.94%	8.94%	8.94%	8.94%	8.22%	6.86%	5.94%
Fidelity Series International Value Fund	FINVX	8.89%	8.86%	8.87%	8.86%	8.86%	8.86%	8.14%	6.78%	5.88%
<b>Total</b>		<b>17.85%</b>	<b>17.79%</b>	<b>17.81%</b>	<b>17.80%</b>	<b>17.80%</b>	<b>17.80%</b>	<b>16.36%</b>	<b>13.64%</b>	<b>11.82%</b>
<b>International Small cap Equity</b>										
Fidelity Series International Small Cap Fund	FSTSX	2.12%	2.10%	2.12%	2.11%	2.11%	2.11%	1.98%	1.64%	1.42%
<b>Emerging Markets Equity</b>										
Fidelity Series Emerging Markets fund	FEMSX	8.03%	8.06%	8.00%	8.01%	7.99%	8.00%	7.46%	6.56%	5.87%
<b>Investment Grade Fixed Income</b>										
Fidelity Series Investment Grade Bond Fund	FSIGX	5.70%	6.00%	6.00%	6.00%	5.80%	5.90%	7.70%	19.43%	26.66%
<b>TIPS</b>										
Fidelity Series Inflation-Protected Bond Index Fund	FSIPX	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.83%
<b>High Yield Fixed Income</b>										
Fidelity Series High Income Fund	FSHNX	3.21%	3.23%	3.25%	3.25%	3.25%	3.25%	3.25%	3.23%	3.22%
<b>Bank Loans</b>										
Fidelity Series Floating Rate High Income Fund	FFHCX	0.25%	0.28%	0.28%	0.28%	0.28%	0.28%	0.28%	0.26%	0.28%
<b>Emerging Market Debt</b>										
Fidelity Series Emerging Markets Debt Fund	FEDCX	0.60%	0.61%	0.62%	0.62%	0.62%	0.62%	0.63%	0.62%	0.63%
<b>Real Estate Debt</b>										
Fidelity Series Real Estate Income Fund	FSREX	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%	0.47%
<b>Cash</b>										
Fidelity Institutional Money Market - Money	FNSXX	0.93%	0.89%	0.81%	0.83%	0.86%	0.85%	0.76%	2.07%	2.57%
Fidelity Series Short-Term Credit fund	FYBTX	0.39%	0.43%	0.40%	0.40%	0.43%	0.41%	0.40%	0.98%	1.05%
<b>Total</b>		<b>1.32%</b>	<b>1.32%</b>	<b>1.21%</b>	<b>1.23%</b>	<b>1.29%</b>	<b>1.26%</b>	<b>1.16%</b>	<b>3.05%</b>	<b>3.62%</b>
<b>Other</b>		<b>0.02%</b>	<b>0.02%</b>	<b>0.02%</b>	<b>0.02%</b>	<b>0.02%</b>	<b>0.02%</b>	<b>0.03%</b>	<b>0.06%</b>	<b>0.07%</b>

**Table 2: Details of Original Fidelity TDF Glide Path**

The information for the Fidelity glide path came from the following Fidelity-hosted website. The individual funds that make up the glide path came from the same source: <http://fundresearch.fidelity.com/mutual-funds/category-performance-annual-total-returns/FREE>. Link accessed on 8/19/2015. The weights in the below table are expressed in terms of percentages. Since the maturity dates of the sourced TDFs lie in the future, the TDFs' glide path data represents Fidelity's current expectations of future asset allocation. We show the breakdown of the individual Fidelity funds used in our analysis to provide transparency. Note that we used the glide path reported in Table 3 to conduct our analysis.

Asset Classes	Rebalancing period								
	1	2	3	4	5	6	7	8	9
U.S. Large Cap	59.20%	59.23%	59.39%	59.36%	59.38%	59.37%	54.87%	46.05%	40.74%
U.S. Small Cap	5.96%	5.91%	5.89%	5.90%	5.88%	5.89%	5.46%	4.60%	4.15%
International Large Cap	18.48%	18.42%	18.44%	18.43%	18.43%	18.43%	16.96%	14.15%	12.38%
Emerging Market Equity	8.66%	8.69%	8.63%	8.64%	8.62%	8.63%	8.06%	7.07%	6.43%
U.S. Investment Grade Bonds	0.67%	0.70%	0.70%	0.70%	0.68%	0.69%	7.81%	19.53%	26.86%
U.S. High Yield Bonds	3.31%	3.33%	3.35%	3.35%	3.35%	3.35%	3.36%	3.33%	3.42%
U.S. REITs	1.45%	1.43%	1.38%	1.39%	1.37%	1.38%	1.33%	1.20%	1.21%
Commodities	0.88%	0.88%	0.89%	0.89%	0.89%	0.89%	0.90%	0.88%	1.00%
U.S. Cash	1.42%	1.42%	1.31%	1.33%	1.39%	1.36%	1.27%	3.15%	3.82%

**Table 3: Details of Reallocated Fidelity Standard TDF Glide Path<sup>32</sup>**

Asset Classes	Annualized Return	Annualized Excess Return	Annualized Risk
U.S. Large Cap	7.00%	4.75%	15.50%
U.S. Small Cap	7.25%	5.00%	21.30%
International Large Cap	7.75%	5.50%	18.00%
Emerging Market Equity	10.00%	7.75%	25.50%
U.S. Investment Grade Bonds	4.25%	2.00%	6.50%
U.S. High Yield Bonds	6.75%	4.50%	9.30%
U.S. REITs	6.00%	3.75%	18.00%
Commodities	3.00%	0.75%	19.00%
U.S. Cash	2.25%	0.00%	0.50%
Private Equity	8.50%	6.25%	21.80%

**Table 4: J.P. Morgan Risk, Return and Excess Return Assumptions**



	Rebalancing Periods 1-6 Optimized TDF	Rebalancing Periods 1-6 Standard TDF	delta	Rebalancing Periods 7 Optimized TDF	Rebalancing Periods 7 Standard TDF	delta	Rebalancing Periods 8 Optimized TDF	Rebalancing Periods 8 Standard TDF	delta	Rebalancing Periods 9 Optimized TDF	Rebalancing Periods 9 Standard TDF	delta	Mean delta
U.S. Large Cap	54.20%	59.20%	-5.00%	49.87%	54.87%	-5.00%	41.05%	46.05%	-5.00%	35.74%	40.74%	-5.00%	-5.00%
U.S. Small Cap	0.96%	5.96%	-5.00%	0.46%	5.46%	-5.00%	0.00%	4.60%	-4.60%	0.00%	4.15%	-4.15%	-4.86%
International Large Cap	13.48%	18.48%	-5.00%	11.96%	16.96%	-5.00%	9.15%	14.15%	-5.00%	7.38%	12.38%	-5.00%	-5.00%
Emerging Market Equity	13.66%	8.66%	5.00%	13.06%	8.06%	5.00%	12.07%	7.07%	5.00%	11.43%	6.43%	5.00%	5.00%
U.S. Investment Grade Bonds	2.31%	0.67%	1.64%	9.31%	7.81%	1.51%	23.38%	19.53%	3.85%	31.76%	26.86%	4.90%	2.23%
U.S. High Yield Bonds	8.31%	3.31%	5.00%	8.36%	3.36%	5.00%	8.33%	3.33%	5.00%	8.42%	3.42%	5.00%	5.00%
U.S. REITs	0.00%	1.45%	-1.45%	0.00%	1.33%	-1.33%	0.00%	1.20%	-1.20%	0.00%	1.21%	-1.21%	-1.38%
Commodities	0.00%	0.88%	-0.88%	0.00%	0.90%	-0.90%	0.00%	0.88%	-0.88%	0.00%	1.00%	-1.00%	-0.89%
U.S. Cash	0.00%	1.42%	-1.42%	0.00%	1.27%	-1.27%	0.00%	3.15%	-3.15%	0.00%	3.82%	-3.82%	-1.86%
Private Equity	7.10%	0.00%	7.10%	6.98%	0.00%	6.98%	6.00%	0.00%	6.00%	5.28%	0.00%	5.28%	6.76%
<b>Performance Stats</b>													
5y Excess Return	29.53%	27.90%	1.63%	28.23%	26.63%	1.60%	25.60%	23.98%	1.63%	24.02%	22.41%	1.60%	1.62%
5y Variance	0.12	0.12	0.00	0.11	0.11	0.00	0.08	0.08	0.00	0.07	0.07	0.00	0.00
5y Standard Deviation	35.13%	35.13%	0.00%	32.90%	32.90%	0.00%	28.60%	28.60%	0.00%	26.13%	26.13%	0.00%	0.00%
5y Sharpe Ratio	0.84	0.79	0.05	0.86	0.81	0.05	0.90	0.84	0.06	0.92	0.86	0.06	0.05
Annualized Excess Return	5.31%	5.04%	0.27%	5.10%	4.84%	0.26%	4.66%	4.39%	0.27%	4.40%	4.13%	0.27%	0.27%
Annualized Variance	0.025	0.025	0.000	0.022	0.022	0.000	0.016	0.016	0.000	0.014	0.014	0.000	0.000
Annualized Standard Deviation	15.71%	15.71%	0.00%	14.71%	14.71%	0.00%	12.79%	12.79%	0.00%	11.69%	11.69%	0.00%	0.00%
Annualized Sharpe Ratio	0.3381	0.3211	0.0170	0.3465	0.3286	0.0179	0.3647	0.3434	0.0213	0.3764	0.3532	0.0232	0.0182

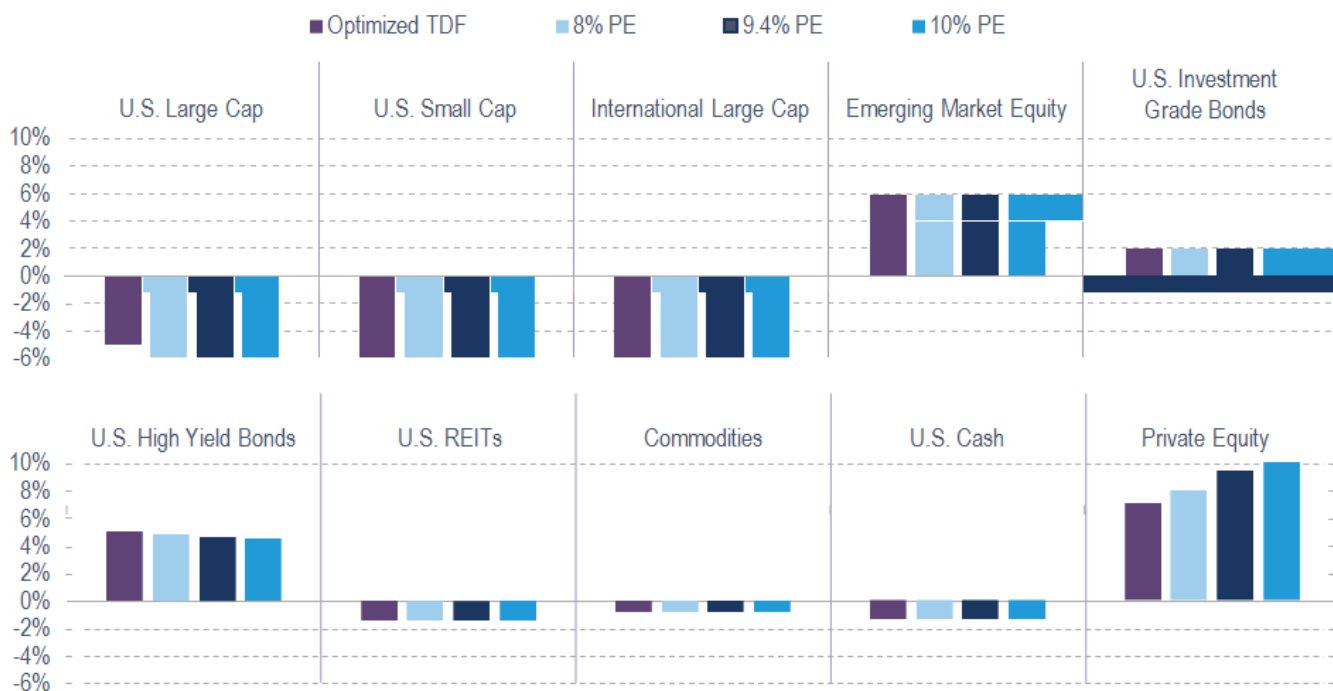
**Table 5: Optimization of TDF Performance (and Keeping Risk Constant)**

Table 5 shows, based on this study, the details to the portfolio reallocation and performance statistics when optimizing the TDF including Private Equity as compared to the standard TDF excluding Private Equity. In particular, the table shows these results for Private Equity exposures of 7.1%, 6.98%, 6% and 5.28% in rebalancing periods 1-6, 7, 8 and 9, respectively.

	Standard TDF	Optimal TDF	delta	TDF @ 8% PE	delta	TDF @ 9.4% PE	delta	TDF @ 10% PE	delta
U.S. Large Cap	59.20%	54.20%	-5.00%	54.05%	-5.15%	53.81%	-5.38%	53.71%	-5.48%
U.S. Small Cap	5.96%	0.96%	-5.00%	0.81%	-5.15%	0.57%	-5.38%	0.47%	-5.48%
International Large Cap	18.48%	13.48%	-5.00%	13.33%	-5.15%	13.09%	-5.38%	12.99%	-5.48%
Emerging Market Equity	8.66%	13.66%	5.00%	13.51%	4.85%	13.27%	4.62%	13.17%	4.52%
U.S. Investment Grade Bonds	0.67%	2.31%	1.64%	2.16%	1.49%	1.93%	1.26%	1.83%	1.16%
U.S. High Yield Bonds	3.31%	8.31%	5.00%	8.16%	4.85%	7.92%	4.62%	7.82%	4.52%
U.S. REITs	1.45%	0.00%	-1.45%	0.00%	-1.45%	0.00%	-1.45%	0.00%	-1.45%
Commodities	0.88%	0.00%	-0.88%	0.00%	-0.88%	0.00%	-0.88%	0.00%	-0.88%
U.S. Cash	1.42%	0.00%	-1.42%	0.00%	-1.42%	0.00%	-1.42%	0.00%	-1.42%
Private Equity	0.00%	7.10%	7.10%	8.00%	8.00%	9.40%	9.40%	10.00%	10.00%
<b>Performance Stats</b>									
5y Excess Return	27.90%	29.53%	1.63%	29.60%	1.70%	29.71%	1.81%	29.76%	1.86%
5y Variance	0.1230	0.1230	0.0000	0.1242	0.0012	0.1254	0.0024	0.1259	0.0029
5y Standard Deviation	35.13%	35.13%	0.00%	35.24%	0.11%	35.41%	0.28%	35.49%	0.36%
5y Sharpe Ratio	0.7940	0.8410	0.0470	0.8400	0.0460	0.8391	0.0451	0.8387	0.0447
Annualized Excess Return	5.04%	5.31%	0.27%	5.32%	0.28%	5.34%	0.30%	5.35%	0.30%
Annualized Variance	0.0246	0.0246	0.0000	0.0248	0.0002	0.0251	0.0005	0.0252	0.0006
Annualized Standard Deviation	15.71%	15.71%	0.00%	15.76%	0.05%	15.84%	0.13%	15.87%	0.16%
Annualized Sharpe Ratio	0.3211	0.3381	0.0170	0.3378	0.0167	0.3373	0.0162	0.3370	0.0159

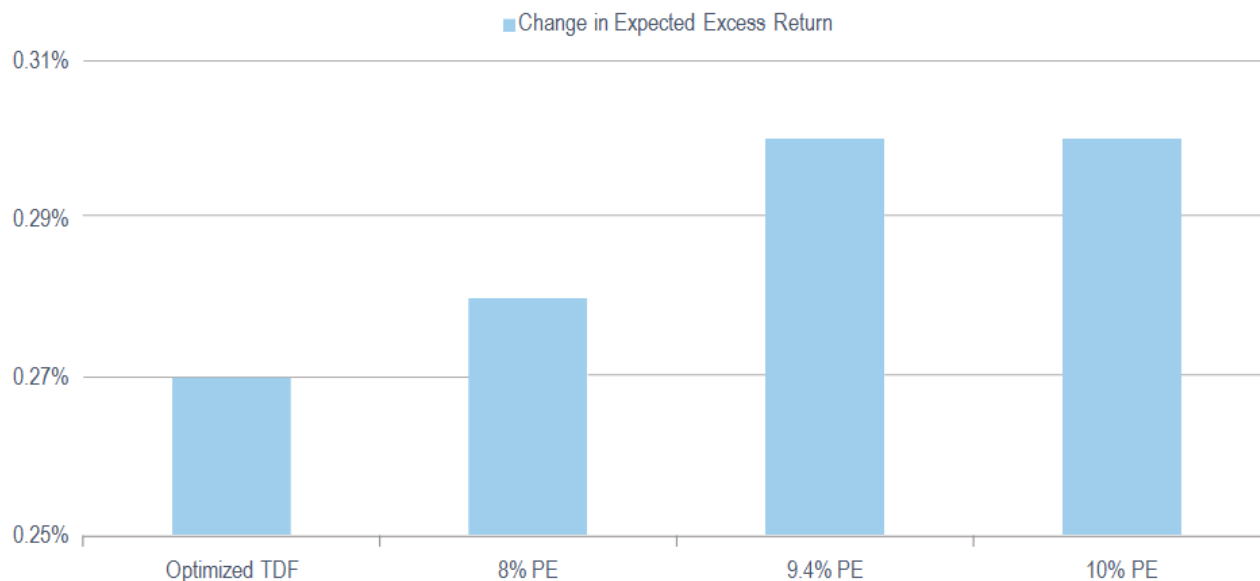
**Table 6: TDF Performance for Higher Private Equity Exposures in the First 30 years**

Table 6 shows, based on this study, the details to the portfolio reallocation and performance statistics when optimizing the TDF including Private Equity as compared to the standard TDF excluding Private Equity. In particular, the table shows these results for Private Equity exposures for 7.1%, 8%, 9.4% and 10% in rebalancing periods 1-6.



**Graph 7: Reallocation of Asset Class Weights for Higher Private Equity Exposures in First 30 Years**

Graph 7 is analogous to Graph 2 – however, note that this graph only depicts the analysis for rebalancing periods 1-6 for higher exposures to Private Equity.



**Graph 8: Change in Performance of TDF for Higher Private Equity Exposures in First 30 Years**

Graph 8 is analogous to Graph 3 – however, note that this graph only depicts the analysis for rebalancing periods 1-6 for higher exposures to Private Equity.

Rebalancing period	Age	Excess Return TDF w/o PE	Excess Return TDF w PE	Investment (t)	FV Standard TDF (t)	FV Optimized TDF (t)
1	1	5.04%	5.31%	\$6,424	\$6,892.31	\$6,909.65
1	2	5.04%	5.31%	\$6,424	\$14,287.07	\$14,341.68
1	3	5.04%	5.31%	\$6,424	\$22,220.91	\$22,335.56
1	4	5.04%	5.31%	\$6,424	\$30,733.12	\$30,933.79
1	5	5.04%	5.31%	\$6,424	\$39,865.87	\$40,182.04
2	6	5.04%	5.31%	\$6,424	\$49,664.40	\$50,129.45
2	7	5.04%	5.31%	\$6,424	\$60,177.25	\$60,828.89
2	8	5.04%	5.31%	\$6,424	\$71,456.48	\$72,337.21
2	9	5.04%	5.31%	\$6,424	\$83,557.97	\$84,715.56
2	10	5.04%	5.31%	\$6,424	\$96,541.65	\$98,029.71
3	11	5.04%	5.31%	\$6,424	\$110,471.85	\$112,350.41
3	12	5.04%	5.31%	\$6,424	\$125,417.56	\$127,753.76
3	13	5.04%	5.31%	\$6,424	\$141,452.81	\$144,321.59
3	14	5.04%	5.31%	\$6,424	\$158,657.03	\$162,141.96
3	15	5.04%	5.31%	\$6,424	\$177,115.43	\$181,309.55
4	16	5.04%	5.31%	\$6,424	\$196,919.46	\$201,926.20
4	17	5.04%	5.31%	\$6,424	\$218,167.19	\$224,101.48
4	18	5.04%	5.31%	\$6,424	\$240,963.89	\$247,953.21
4	19	5.04%	5.31%	\$6,424	\$265,422.47	\$273,608.12
4	20	5.04%	5.31%	\$6,424	\$291,664.08	\$301,202.55
5	21	5.04%	5.31%	\$6,424	\$319,818.70	\$330,883.12
5	22	5.04%	5.31%	\$6,424	\$350,025.79	\$362,807.54
5	23	5.04%	5.31%	\$6,424	\$382,434.98	\$397,145.44
5	24	5.04%	5.31%	\$6,424	\$417,206.80	\$434,079.29
5	25	5.04%	5.31%	\$6,424	\$454,513.49	\$473,805.34
6	26	5.04%	5.31%	\$6,424	\$494,539.83	\$516,534.68
6	27	5.04%	5.31%	\$6,424	\$537,484.09	\$562,494.35
6	28	5.04%	5.31%	\$6,424	\$583,558.99	\$611,928.58
6	29	5.04%	5.31%	\$6,424	\$632,992.75	\$665,100.04
6	30	5.04%	5.31%	\$6,424	\$686,030.23	\$722,291.25
7	31	4.84%	5.10%	\$6,424	\$741,549.24	\$782,275.82
7	32	4.84%	5.10%	\$6,424	\$801,004.54	\$846,669.26
7	33	4.84%	5.10%	\$6,424	\$864,675.22	\$915,795.62
7	34	4.84%	5.10%	\$6,424	\$932,860.16	\$990,002.76
7	35	4.84%	5.10%	\$6,424	\$1,005,879.41	\$1,069,664.12
8	36	4.39%	4.66%	\$6,424	\$1,079,520.35	\$1,150,445.81
8	37	4.39%	4.66%	\$6,424	\$1,158,051.06	\$1,236,809.52
8	38	4.39%	4.66%	\$6,424	\$1,241,796.20	\$1,329,140.95
8	39	4.39%	4.66%	\$6,424	\$1,331,102.02	\$1,427,852.49
8	40	4.39%	4.66%	\$6,424	\$1,426,337.75	\$1,533,385.00
9	41	4.13%	4.40%	\$6,424	\$1,524,171.95	\$1,642,206.30
9	42	4.13%	4.40%	\$6,424	\$1,628,247.97	\$1,758,264.21
9	43	4.13%	4.40%	\$6,424	\$1,738,964.04	\$1,882,039.98
9	44	4.13%	4.40%	\$6,424	\$1,856,743.80	\$2,014,046.83
9	45	4.13%	4.40%	\$6,424	\$1,982,037.91	\$2,154,832.14

	Standard TDF	TDF including PE
Total TDF value at T	\$1,982,037.91	\$2,154,832.14
Delta \$		\$172,794.23
Delta %		8.72%

**Table 7: Increase in the Amount Saved at Maturity of the 45-year TDF including in Private Equity as Compared to the Standard TDF (with \$6,424 p.a. Pension Contribution).**

Table 7 shows, based on this study, the increase in total savings that a pension plan member would have available in year 45 if Private Equity was added to the TDF. The exposures to Private Equity and the corresponding return assumption we chose mirror the findings of this study: i.e. Private Equity exposures for 7.1%, 6.98%, 6% and 5.28% in rebalancing periods 1-6, 7, 8 and 9, respectively.

## Endnotes

1. Median participant income in the United States of America in 2015 was approximately \$73,000. At an 8.8% pension contribution rate of median income, this amounts to approximately \$6,424 of annual pension savings. These results are based on the assumption that the TDF's allocation to Private Equity is 7.1% in rebalancing period 1-6, 6.98% in rebalancing period 7, 6% in rebalancing period 8 and 5.28% in rebalancing period 9. Please see Table 7 in the Appendix for the detailed calculations. See also [https://pressroom.vanguard.com/nonindexed/HAS2016\\_Final.pdf](https://pressroom.vanguard.com/nonindexed/HAS2016_Final.pdf). Past performance is no guarantee of future performance.
2. <https://am.jpmorgan.com/gi/getdoc/1383271688187>. Link accessed on 11/11/2016. For the purpose of this study, J.P. Morgan Asset Management's 2016 Long-term Capital Markets Assumptions were selected as reference data. Our aim was to base our analysis on a widely-used, well-established (this particular publication is in its 20th edition), and highly transparent dataset published by a reputable third-party. On the same basis we selected the Fidelity data we used for our glide path modelling.
3. Note that J.P. Morgan sources its Private Equity data from the Burgiss Manager Universe, which contains the full transactional history between LPs and their fund investments; as such, J.P. Morgan's return assumptions are net of manager fees. Due to the change in the asset allocation across asset classes, the TDF may be subject to a different fee profile that may impact net returns. This study has not taken such potential fee changes impact on net returns into account. In addition, the performance of the indices reflects reinvestment of dividend and, where applicable, capital gains distributions. Future exchange rate fluctuations may significantly impact gross and net returns.
4. <http://fundresearch.fidelity.com/mutual-funds/category-performance-annual-total-returns/FREE>. Link accessed on 8/19/2015. The Fidelity data is being used for educational purposes only and not for commercial reasons.
5. <https://www.fidelity.com/mutual-funds/fidelity-fund-portfolios/freedom-funds-manage>. Link accessed on 8/19/2015.
6. We used a mean-variance optimization framework in this study. Please see Cochrane (2001) for further reference.
7. [https://pressroom.vanguard.com/nonindexed/HAS2016\\_Final.pdf](https://pressroom.vanguard.com/nonindexed/HAS2016_Final.pdf). Link accessed on 11/11/2016.
8. We calculated the total dollars saved over a 45-year period if a pension plan member had made equal annual dollar contributions investing in a TDF with an allocation to Private Equity of 7.1% in rebalancing period 1-6, 6.98% in rebalancing period 7, 6% in rebalancing period 8 and 5.28% in rebalancing period 9. We then repeated this calculation for a TDF that does not include Private Equity. The difference in the amount saved (at maturity) between the two TDFs is equal to the additional savings that would have accrued had the retiree chosen the TDF including an allocation to Private Equity over a standard TDF. For exact details of the calculations and the assumptions made, please see Table 7 in the Appendix.
9. We chose to include the specific allocation to Private Equity of 9.4% as the PEGCC Public Pension Fund Analysis (2014) found that U.S. pension funds invest 9.4% of their portfolio in Private Equity on a dollar-weighted basis (<http://www.investmentcouncil.org/app/uploads/2014-pension-fund-analysis2.pdf>). Link accessed on 11/11/2016.
10. Swensen (2000)
11. <https://www.blackrock.com/investing/literature/brochure/investment-trends-brochure.pdf>. Link accessed on 11/11/2016.
12. For further reference regarding the construction of retirement investment products using Modern Portfolio Theory please see <https://corporate.morningstar.com/us/documents/Indexes/AssetAllocationIndexRulebook.pdf>. Link accessed on 11/11/2016.
13. We used a mean-variance optimization framework in this study. Please see Cochrane (2001) for further reference.
14. <https://am.jpmorgan.com/gi/getdoc/1383271688187>. Link accessed on 11/11/2016.
15. <http://fundresearch.fidelity.com/mutual-funds/category-performance-annual-total-returns/FREE>. Link accessed on 8/19/2015.
16. Note that the results in this study are expressed in terms of expected excess returns. For the sake of brevity, we omit the term "excess" and instead refer to expected excess returns as expected returns, or simply returns. Expected excess returns are obtained if one subtracts the risk-free rate from expected returns.
17. <https://web.stanford.edu/~wfscharpe/art/sr/sr.htm>. Link accessed on 11/11/2016.
18. Fixing the risk of the TDF is synonymous to imposing a constraint on the optimization. We imposed restrictions in order to test whether we can improve investors' welfare relative to the TDF excluding Private Equity irrespective of investors' preferences.
19. We used data from Fidelity to derive the appropriate glide path (<http://fundresearch.fidelity.com/mutual-funds/category-performance-annual-total-returns/FREE>). Link accessed on 8/19/2015.
20. Note that Private Equity was constrained to a maximum weight of 10% in any rebalancing period. All other asset classes were constrained to a +/-5% allocation change as measured against the standard TDF's allocation. Further, we constrained all weights to obtain a minimum value of 0% as we did not consider short-selling a viable investment strategy in the TDF setting.
21. Further, various studies in the academic literature discuss the impact of return intervals on beta estimates; these studies point out that if the chosen time horizon is shorter than the true one, beta estimates may be biased (e.g. Levhari and Levy (1977)).
22. Often portfolio optimization exercises face the problem of producing corner solutions, especially when restricting weights to be strictly positive (no short-selling restriction). Corner solutions emerge when the optimization algorithm generates highly concentrated weights in few asset classes, which results in an insufficiently diversified portfolio. Corner solutions do not indicate that Modern Portfolio Theory (hereafter, MPT) is flawed, but rather underline the idea that MPT is sensitive to the accuracy of its inputs. To obtain sensible allocation ranges we restrict the exposure of the optimized TDF to Private Equity to be between



0% and 10%. To remedy this issue further we restrict the weights of all other asset classes to be within +/- 5% of the standard TDF (for reference see Fabozzi, Focardi and Kolm (2006)).

23. Where appropriate, we reported numbers rounded to one decimal place in the main body of the document.

24. We calculated the total dollars saved over a 45-year period if a pension plan member had made equal annual dollar contributions investing in a TDF with an allocation to Private Equity of 7.1% in rebalancing period 1-6, 6.98% in rebalancing period 7, 6% in rebalancing period 8 and 5.28% in rebalancing period 9. We then repeated this calculation for an allocation that does not include Private Equity (standard TDF). The difference in the amount saved (at maturity) between the two TDFs is equal to the additional savings that would have accrued had the retiree chosen the TDF including an allocation to Private Equity over a standard TDF. For exact details of the calculations and the assumptions made.

25. We imposed a short-selling restrictions to avoid negative weights and proportionally redistributed all possible negative weight allocations to non-Private Equity asset classes that retained positive weights after the reallocation process.

26. We chose to include the specific allocation to Private Equity of 9.4% as the PEGCC Public Pension Fund Analysis (2014) found that U.S. pension funds invest 9.4% of their portfolio in Private Equity on a dollar-weighted basis (<http://www.investmentcouncil.org/app/uploads/2014-pension-fund-analysis2.pdf>). Link accessed on 11/11/2016. As a further robustness and sensitivity tests, we analyzed the performance of the TDF with allocations to the next integer below and above the 9.4% Private Equity allocation – hence, the 8% and 10% allocation choices.

27. <http://fundresearch.fidelity.com/mutual-funds/category-performance-annual-total-returns/FREE>. Link accessed on 8/19/2015.

28. <https://am.jpmorgan.com/gi/getdoc/1383271688187>. Link accessed on 11/11/2016.

29. Note that risk is measured as the annualized standard deviation of returns.

30. <https://am.jpmorgan.com/gi/getdoc/1383271688187>. Link accessed on 11/11/2016.

31. <https://am.jpmorgan.com/gi/getdoc/1383271688187>. Link accessed on 11/11/2016.

32. Based on Pantheon's reclassification of the original Fidelity TDF asset classes

*This publication has been prepared solely for illustration, educational and or discussion purposes. It does not constitute independent research and under no circumstances should this publication or the information contained in it be used or considered as an offer, inducement, invitation, solicitation or recommendation to buy or sell any security or financial instrument or service or to pursue any investment product or strategy or otherwise engage in any investment activity or as an expression of an opinion as to the present or future value or price of any security or financial instrument. Nothing contained in this publication is intended to constitute legal, tax, securities or investment advice.*

*This publication may include "forward-looking statements". All projections, forecasts or related statements or expressions of opinion are forward-looking statements. Although Pantheon believes that the expectations reflected in such forward-looking statements are reasonable, it can give no assurance that such expectations will prove to be correct, and such forward-looking statements should not be regarded as a guarantee, prediction or definitive statement of fact or probability.*

*Pantheon has taken reasonable care to ensure that the information contained in this document is accurate at the date of publication. However, no warranty or guarantee (express or implied) is given by Pantheon as to the accuracy of the information in this document, and to the extent permitted by applicable law, Pantheon specifically disclaims any liability for errors, inaccuracies or omissions in this document and for any loss or damage resulting from its use. Unless stated otherwise, any opinions expressed herein are current as of the date hereof and are subject to change at any time. Unless stated otherwise all views expressed herein represent Pantheon's opinion.*

*This document is distributed by Pantheon which is comprised of operating entities principally based in San Francisco, New York, London and Hong Kong. Pantheon Ventures Inc. and Pantheon Ventures (US) LP are registered as investment advisors with the U.S. Securities and Exchange Commission. Pantheon Ventures (UK) LLP is authorised and regulated by the Financial Conduct Authority (FCA) in the United Kingdom. Pantheon Ventures (HK) LLP is regulated by the Securities and Futures Commission in Hong Kong.*

*All materials published on the Site are protected by copyright, and are owned or controlled by Pantheon as the provider of the materials. If you download any information or software from this Site, you agree that you will not copy it without the prior written consent of Pantheon or remove or obscure any copyright or other notices or legends contained in any such information.*

---

*\*All views presented in this article are of the author's, and should not be considered an endorsement by the CAIA Association.*

#### **Author Bio**



**Andres Reibel, PhD**  
Pantheon

Andres focuses on high value quantitative economic/financial research for Pantheon. He holds a PhD in Finance at Imperial College London and worked as a consultant in the private equity industry for the Centre for Hedge Fund Research at Imperial College. Previous to this he gained an MSc from Imperial in Finance and also holds a BA in business studies from BW State University Mannheim in Germany. Andres is based in London.