6. Conclusion

In this paper, we considered the performance of direct investments in three real asset classes: natural resources (namely timberland and farmland), energy infrastructure, and commercial real estate. Using publicly available data for a period starting in 1978 (for real estate) or 1996 (for infrastructure) and ending in 2012, our main result is that investing in these real asset classes would have provided significant diversification benefits relative to a traditional portfolio consisting of only public equities and government bonds, without evidence of deteriorating overall performance. While investments in natural resources had particularly low downside risk, investments in energy infrastructure and commercial real estate showed significant downside risk, comparable to a traditional portfolio of equities and bonds.

Another important caveat is that with the exception of timberland investments (and commercial real estate for 1978-1987), the real asset classes did not provide any inflation hedging benefits over our full 1978-2012 time period. Further, the diversification benefits of direct investments in natural resources were much lower in times when equity markets went down. This could be explained by liquidity shocks being correlated across markets, or more generally that institutions are much less likely to invest in illiquid securities such as direct investments in timberland and farmland during times of sustained negative equity returns. This illustrates the significant challenge of investing in all of these real assets, namely dealing with illiquidity, generally long holding periods, and information uncertainty.

* samples full / same
* White S.E.
* Lag 1, 2, 3
* contemporaneous
* quarterly / annual
vol < vol

regressions
• Longer history benefits
• alphas benefits over traditional
* % improvement in statistical power
R^2 —

* Pacing analysis

AvR
Q reg
* combined

① Liquidity Risk
② Down SP500 Dummy
③

Table 9. Real assets returns and down-side equity betas

	Timberland	Farmland	Property	Property (Transact.)	Alerian
Starting year:	1987	1992	1978	1994	1996
End year:	2011	2011	2011	2011	2011
Alpha	0.0409**	0.0618***	0.0220***	0.0438*	0.00860
	(2.45)	(3.48)	(4.55)	(1.81)	(0.26)
S&P 500	-0.0987	0.119*	-0.00929	0.0823	0.114
	(-1.49)	(1.76)	(-0.26)	(0.50)	(0.41)
1Q Lagged S&P 500	-0.0764	-0.0953	-0.0186	-0.0773	0.124
	(-1.06)	(-1.65)	(-0.53)	(-0.52)	(0.52)
2Q Lagged S&P 500	-0.0633	-0.184*	0.0123	0.0650	0.0902
	(-0.54)	(-1.91)	(0.32)	(0.42)	(0.48)
3Q Lagged S&P 500	-0.0879	-0.201**	0.00724	-0.0269	0.169
	(-1.04)	(-2.48)	(0.17)	(-0.22)	(0.77)
Down S&P 500	0.260*	-0.135	0.0785	-0.0220	0.369
	(1.81)	(-1.01)	(1.01)	(-0.06)	(0.66)
1Q Lagged Down S&P 500	0.225*	0.223*	0.105	0.292	-0.419
	(1.74)	(1.83)	(1.23)	(1.23)	(-0.99)
2Q Lagged Down S&P 500	0.163	0.325*	0.0479	0.0257	-0.250
	(0.91)	(1.95)	(0.68)	(0.07)	(-0.66)
3Q Lagged Down S&P 500	0.177	0.295**	0.0753	0.310	-0.456
	(1.42)	(2.57)	(1.11)	(1.45)	(-1.24)
Bonds (20y)	0.0916	0.0922	0.0176	0.0641	-0.130
	(1.25)	(1.61)	(0.50)	(0.38)	(-0.57)
Bonds (1y)	0.497	-2.007***	-0.332**	-1.089	0.895
	(1.04)	(-3.97)	(-2.34)	(-1.09)	(0.57)
N	104	84	137	76	68
R2	0.157	0.232	0.190	0.138	0.190

The table presents the regression coefficients from quarterly return regressions on an index tracking a particular asset class (Timberland, Farmland, Property, and Alerian infrastructure) on a constant and the quarterly return of the S&P 500, 20-year maturity Treasury bonds, and 1-year maturity Treasury notes, plus the return of the product of the S&P 500 return and a dummy that equals one if this return is negative ("Down x S&P 500"). We further include the one-, two-, and three-quarter lagged returns of the S&P 500 and its interaction (Q1, Q2, and Q3 Lagged, respectively). The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

performance in the various real asset classes on the liquidity innovation in the aggregate stock market and its one-quarter lag, as well as the contemporaneous return of the S&P 500, 20-year government bonds, and 1-year bonds. The results indicate that none of the real asset classes have a positive association with stock market liquidity as measured by our proxy. The performance of direct investments in farmland, property, and energy infrastructure has negative and statistically significant coefficients on the liquidity innovation, suggesting that these investments do (slightly) better when the stock market deteriorates. For example, the coefficient on the liquidity innovation for the Alerian MLP Infrastructure Index equals -0.183 (with a t-statistic of 1.97), such that a decrease in liquidity of 0.10 (i.e., a standard deviation shock) is associated with a quarterly return that is 1.8% higher. We thus find no evidence that the real assets have exposure to systematic stock market liquidity risk.

Finally, we consider the evidence that the diversification benefits of real assets are lower if equity markets go down. While an increased exposure to equity market risk (i.e., a higher equity market beta) in down markets could potentially have different causes, a reasonable candidate explanation for illiquid asset classes is exactly their illiquidity. For example, many large institutions trading across asset classes may become more constrained when equity markets go down, which could affect their investment decisions in other asset classes. They may be particularly likely to avoid buying more into less liquid asset classes at such times, because the ability to move in and out of positions quickly and at low cost may be especially valuable during times when equity markets go down.[21]

We investigate whether the investment performance of the real asset classes had more exposure to equity market risk in down markets by allowing the equity market beta to be different in up versus down markets. Specifically, we construct a "Down" dummy that equals one if the equity market, as proxied by the S&P 500, has a negative excess return in a given quarter, and equals zero otherwise. In our full 1978-2012 time period, this Down dummy has a mean of 37%. Next, we interact the Down dummy with the S&P 500 return, and add this interaction to the specification in Table 5, where we regress quarterly returns of the various real asset classes on a constant plus the quarterly returns on the S&P 500, 20-year and 1-year government bond returns. In order to account for smoothing, we further include 1-quarter, 2-quarter, and 3-quarter lags of the return on both the S&P 500 and its interaction with the Down dummy (adding a fourth lag of both does not change any of the results). The results are presented in Table 9 (next page).

We find strong evidence that investment in natural resources have much stronger exposure to equity market risk during times when equity markets go down. There is no such evidence for commercial real estate or energy infrastructure investments. The downside betas are economically and statistically significant for both timberland and farmland investments. Ignoring the very small positive correlation in the quarterly returns on the S&P 500 (about 6%, insignificant with a p-value of 52%), we sum up the coefficients on the contemporaneous and various lags of the S&P 500 return, and likewise for their interactions with the Down dummy. For the NCREIF Timberland Index, this results in an upward equity market beta of -0.33 that has a 15% p-value and is thus statistically insignificant. However, the sum of the interactions of the S&P 500 return and the Down dummy equals 0.83, with a 3% p-value, and is thus clearly different from zero. The total downside beta thus equals 0.50 (= -0.33 + 0.83), which is again strongly statistically significant with a p-value below 1%. For the NCREIF Farmland Index, the results are quite similar, with an upward market beta of -0.36 (p-value of 11%) and a downside market beta of 0.35 (= -0.36 + 0.71) that is statistically significant with a p-value of 4%.

[21] While the association with equity market liquidity is of course precisely what we considered in Table 8, it is quite possible that our proxy for equity market liquidity is overly noisy, such that using a simpler measure like negative stock market returns in a given quarter is an important robustness check and complementary to the analysis in Table 8.

other assets provide some hedging benefit to lower performance in others markets, these assets can be considered to be safer.

Our proxy for the systematic liquidity of stock markets is the measure introduced by Pastor and Stambaugh (2003).[19] Their measure of liquidity captured temporary price changes due to the volume of trading. If stocks are becoming less liquid, then a similar volume of stock trades will induce greater price changes, which will make the stocks more costly to trade. For example, the same quantity of sell orders is more likely to push the price down. If the decrease in price is purely related to liquidity, the price should only be temporarily lower, and thus over time should revert back up. The result of the lower liquidity is thus greater price reversals due to order flows. The systematic stock market liquidity measure is based on the magnitude, across all stocks trading in the market, of how large these price reversals linked to trading volume are. Specifically, we use expected innovation in their aggregate liquidity index, which is made available through WRDS (the Wharton Research Data Services).[20] The liquidity innovation series is rescaled, and can be interpreted as the second-order autocorrelation of the overall market liquidity, which is quite persistent. However, using the aggregate level itself results in very similar results to those shown. Figure 4 plots the 3-month moving average of innovations in systematic stock market liquidity (using the right-hand-side axis).

As the graph shows, the time period since 1978 is characterized by several episodes in which liquidity in the stock market systematically deteriorated, indicated by large negative innovations. Two of these episodes can be linked to recent financial crises, for example the Asian financial crisis starting in the summer of 1997 and lasting through 1998, and of course the recent financial crisis in the United States starting in 2007. In such episodes, the liquidity innovations can go down by 0.30. The time series standard deviation in the quarterly series is 0.10.

Table 8 presents the results of regressing the quarterly

Table 8. Innovations in aggregate stock market liquidity and real assets returns

	Timberland	Farmland	Property	Property (Transact.)	Alerian
Starting year:	1987	1992	1978	1994	1996
End year:	2011	2011	2011	2011	2011
Liquidity innovation	0.0163	-0.0194	-0.0338**	0.0266	-0.183*
	(0.60)	(-0.79)	(-2.48)	(0.55)	(-1.97)
1Q Lagged Liquidity innov.	0.0161	-0.127*	-0.043***	-0.0782	0.0443
	(0.37)	(-1.89)	(-2.85)	(-1.60)	(0.48)
S&P 500	0.0215	0.0165	0.0179	0.112	0.297*
	(0.54)	(0.46)	(0.56)	(1.40)	(1.68)
Bonds (20y)	0.114	0.277***	-0.0358	0.0247	-0.176
	(1.28)	(2.83)	(-0.66)	(0.11)	(-0.54)
Bonds (1y)	0.322	-2.55***	-0.107	-0.205	-0.619
	(0.50)	(-3.05)	(-0.59)	(-0.19)	(-0.28)
N	100	80	135	72	64
R-sq	0.035	0.262	0.101	0.071	0.184

The table presents the regression coefficients from quarterly return regressions on an index tracking a particular asset class (Timberland, Farmland, Property, and Alerian infrastructure) on a constant, the contemporaneous (and one-quarter lagged) quarterly changes in aggregate stock market liquidity, and the quarterly return of the S&P 500, 20-year maturity Treasury bonds, and 1-year maturity Treasury notes. The coefficient on the constant is not included in the table though included in the regression. The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

[19] See Lubos Pastor and Robert Stambaugh, 2003, "Liquidity Risk and Expected Stock Returns," Journal of Political Economy, 111-3, 642-685.

[20] See https://wrds-web.wharton.upenn.edu/wrds.

5. Equity-downside (liquidity) risk and real assets investment performance

A feature that all real asset classes have in common is that investments therein are illiquid, meaning that they are more difficult or costly to trade. The illiquidity is manifested most obviously in the typically long periods in which the money invested is held in any particular investment. Direct investments in real asset classes are particularly illiquid when compared to investing in traditional asset classes such as large cap public equities (as captured in this paper by the S&P 500) and government bonds (as captured in this paper by 20-year maturity Treasury bonds), both of which are among the most liquid securities traded. In this section, we discuss various aspects in which illiquid asset investments are distinct from liquid securities such as public equities and governments bonds, and specify what consequences these have for investors, including long-term investors such as pension funds. All of these consequences would generally require higher expected rates of return in compensation for the additional projected costs and risks inherent in investing in illiquid securities.

A critical aspect of illiquidity is that information on illiquid investments is more difficult and costlier to generate and to evaluate. For example, publicly available information on the past performance of investments in the illiquid security is scarce, to a large extent because transaction prices and cash flows are not easily publicly available. This renders it more costly to familiarize oneself with investing in the asset class, and as a result there will be fewer investors who are willing to bear such costs; fewer investors in turn perpetuates the lack of liquidity.

The lack of information raises further questions that can only be answered by delving deep into the asset class and having actual investment experience over one or more full investment cycles. How comparable is the particular investment being offered to the investments for which generic information is available? How can one evaluate the quality of the team that will manage the investment (which has repercussions on one's confidence in the projected cash flows and risk)? How many direct investments would one need to be reasonably diversified? To what extent is the information available on the particular investment being offered all the information that is relevant to making the investment decision? Next to higher costs, for example to hire experts, the first consequence for investors of the difficulty of gathering information is that it increases the uncertainty and thus the (perceived) risk of investing in the asset class.

A second consequence of illiquidity is that transacting is more difficult and costly. The higher difficulty of transacting means that buying and selling properties may take considerable time, for example to find investors willing to take the other side of the transaction. If an investment is being sold, it may take considerable effort to generate sufficient information about the past, current, and projected future performance of the investment in order to do so. In the extreme, it may mean that at particular points in time, for example when borrowing generally becomes more difficult or costly, there may be no investor at all willing to trade at any price. It further means that any urgency to transact may lead to large adverse price movements.

Given our data, we cannot address most of the questions raised here. The main question we are able to address empirically is whether investments in real asset classes tend to perform worse at times when liquidity in the stock market dries up. If so, this would make it more costly to exit these investments for investors who may want to exit during a crisis period, during which it is typical for systematic stock market liquidity to decrease . Another motivation is that investment performance may be more strongly correlated across markets when aggregate news is bad, recent returns are negative, and aggregate liquidity is low. As a result, some of the diversification benefits may disappear if investors transact during such times of crisis. Another mechanism through which investment performance across markets may become more correlated when stock market trading becomes more difficult is that changes in liquidity are correlated across markets.

Assets whose performance is lower when systematic liquidity in the stock market is lower are more risky, even if this lower performance is not accompanied by lower cash flows in the long run. The increased risk is due to the timing of the lower performance. Times when stock market liquidity is relatively low are generally times when the recent investment performance in the stock market has been low. These are exactly the times when it is most important for the other asset classes to not have similarly low performance. If they do not, i.e. when in inflation (denoted in the table as 1Q / 2Q / 3Q Lagged CPI change), as well as on the one- and two-quarter future changes in inflation (denoted in the table as 1Q / 2Q Future CPI change). We also tried specifications with even more future changes in CPI included, but those were never statistically (or economically) significant and also did not qualitatively affect any conclusions. Likewise, adding additional lagged changes (four or more quarters ago) did not result in significant coefficients or change anything.

The regression results are presented in Table 7. A positive coefficient on future, contemporaneous, or lagged changes in CPI can be interpreted as evidence in favor of inflation hedging, while a negative coefficient means that investor performance tends to deteriorate in times of increasing inflation. The results indicate that natural resources, and especially direct investments in timberland, were able to provide hedging protection against changes in CPI. Using the NCREIF Timberland Index, we find coefficients that are both economically and statistically significant, indicating that the performance of timberland investments is positively related to changes in CPI both in the past (1Q and 3Q lagged are significant) as well as in the future (2Q and 1Q future CPI changes are significant). The coefficient on the contemporaneous change in CPI is positive but economically small and statistically insignificant. The economic magnitude of the coefficients seems meaningful. For example, the coefficient on the 1Q future CPI change equals 1.20, with a t-statistic of 3.72 (which means that the associated p-value for the hypothesis that the coefficient cannot be distinguished from zero is below 0.1%). As a result, a standard deviation shock increase in CPI of 1% in any given quarter (say the first quarter or 1Q of 2000) that is associated with a contemporaneous increase in the investment performance of timberland of only 0.12% (say the first quarter of 2000), can be associated with anticipatory returns of 1.2% and 0.64% in the previous two quarters (say the last two quarters of 1999), and can further be associated with lagged positive returns of 1.4%, 0.34%, and 1% in the following three quarters (say 2Q, 3Q, and 4Q in 2000).

The results for direct investment in farmland are considerably weaker, especially because the coefficient on the contemporaneous change in CPI is negative (equal to -0.768) and statistically significant. There is only weak statistical evidence that the sum of all 6 CPI change coefficients is different from zero, with a p-value of 8.3%. In comparison, the corresponding p-value for timberland investments equals 0.03%. In fact, using the conventional 5% for the critical level of p-values, we cannot reject the hypothesis that the sum of the 6 CPI change coefficients equals zero for any of the asset classes considered in Table 7, with only timberland investments excepted.

For property, the ability to hedge changes in inflation is quite weak if we consider the full 1978-2012 time period, as none of the coefficients are economically or statistically significant in column 3. This holds for both the appraisal-based NCREIF Property Index and the NCREIF Transaction-Based Index; to save space we only report the results for the former. However, if we consider the 1978-1987 (inclusive) time period – which constitutes the only period for which we have data in which there was significant inflation – then we find strong evidence that commercial real estate provided some inflation protection. Obviously, we should interpret these results with significant caution, as they are based on only 10 years of quarterly observations. Nonetheless, the statistical and economic significance of the association between future CPI changes and current appreciations in commercial real estate appraisals is quite strong for this decade for which we have data. For example, the R-squared equals 49% and the sum of all 6 CPI change coefficients is clearly different from zero, with a p-value of 0.004%. The economic significance seems meaningful, as the sum of the CPI change coefficients for one and two quarters ahead is 0.223 + 0.543 = 0.77, such that commercial real estate was able to hedge over three-quarters of the inflation changes in this period.

For the direct investments in energy infrastructure as measured by the Alerian MLP Infrastructure Index, there is no evidence for inflation hedging at all. Lagged CPI changes are strongly negatively associated with investment returns, while there are weak positive correlations with future CPI changes (weak, as these are not individually statistically significant). For both traditional assets as public equities the evidence is statistically weak, though unsurprisingly 20-year maturity bond returns are strongly negatively associated with this and next quarter's change in CPI.

The resulting regression has an R-squared of 11% and a coefficient on this quarter's change in CPI of 0.34. We then estimate the unanticipated change in inflation to be the residual in this regression. The actual change in CPI and the estimate of the unanticipated change in inflation have a correlation of 94%, such that the results using the latter are basically the same as just using actual changes. As a result, in order to save space we will only show the results using the actual changes in CPI.

As the figure shows, the late 1970s and early 1980s were the only period in our sample with relatively high inflation (with a maximum quarterly CPI increase of 4.4% and a largest quarterly decrease of -3.9%). That means that for all real asset classes except commercial real estate, we are unable to estimate the association between investment returns and inflation during periods where inflation hedging is arguably most important. Over the full 1978-2012 period, the average change in the CPI was 1% per quarter, and the standard deviation of the quarterly changes was 1% as well. Over 1978-1987, the average change in the CPI was 1.6% per quarter with a standard deviation of 1.1%.

For each asset class considered in this paper, we estimate the ability to hedge unanticipated changes in inflation using the longest time period available (the results using just the 1996-2012 period common across all real asset classes are similar). Similar to Erb and Harvey (2006), for simplicity we assume that changes in CPI are a reasonable proxy for unexpected inflation or the difference between actual and expected inflation (i.e., news about inflation).[15]

Another issue is that returns in financial markets will respond to news about inflation, which comes out with some delay. Furthermore, financial markets may be able to partly anticipate future news about inflation. In addition, any potential smoothing in the appraisal values on which the real assets performance is based may lead to an additionally delayed response in investment returns to news about inflation. To account for all of these possibilities, we regressed investment returns not only on contemporaneous changes in inflation, but also on the one-, two-, and three-quarter lags of changes

Table 7. Association between investment performance and changes in CPI

	Timberland	Farmland	Property	Property	Alerian	S&P 500	Bonds (20y)
Starting year:	1987	1992	1978	1978	1996	1978	1978
End year:	2012	2012	2012	1988	2012	2012	2012
2Q Future CPI change	0.635**	0.288	0.185	0.543**	-0.353	0.339	0.341
	(1.99)	(0.45)	(0.94)	(2.72)	(-0.33)	(0.46)	(0.68)
1Q Future CPI change	1.199***	1.167**	0.242	0.223	1.080	1.128	-1.516*
	(3.72)	(2.45)	(1.20)	(0.87)	(0.80)	(1.38)	(-1.67)
CPI change	0.122	-0.768**	0.234	-0.040	1.264	-0.355	-2.89***
	(0.29)	(-2.08)	(0.57)	(-0.16)	(0.64)	(-0.28)	(-4.58)
1Q Lagged CPI change	1.413***	1.066	0.241	-0.235	-2.84**	0.362	1.412**
	(3.23)	(1.50)	(0.70)	(-1.17)	(-2.47)	(0.46)	(2.01)
2Q Lagged CPI change	0.355	0.517	-0.0379	0.441*	-1.162	-1.330	0.228
	(1.20)	(1.12)	(-0.09)	(-2.03)	(-0.78)	(-1.32)	(0.31)
3Q Lagged CPI change	1.006***	1.301**	-0.430	-0.410*	-2.087*	-0.977	0.229
	(2.76)	(2.14)	(-1.08)	(-2.03)	(-2.00)	(-1.02)	(0.37)
P-value sum of all CPI change coefficients equal zero	0.030%	8.30%	10.9%	0.004%	40.0%	43.3%	6.50%
N	102	82	135	37	66	135	135
R-sq	0.172	0.337	0.059	0.488	0.170	0.035	0.244

The table presents the regression coefficients from quarterly return regressions on an index tracking a particular asset class (Timberland, Farmland, Property, Alerian infrastructure, S&P 500, and 20-year constant maturity government bonds) on a constant and quarterly changes in the CPI index. The coefficient on the constant is not included in the table though included in the regression. We further include the contemporaneous change in the CPI index; the one-, two-, and three-quarter lagged CPI changes (i.e., 1Q, 2Q, and 3Q Lagged CPI change); and the next quarterly change in the CPI (1Q Future CPI change) as well as the quarterly change in the CPI two quarters in the future (2Q Future CPI change). The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

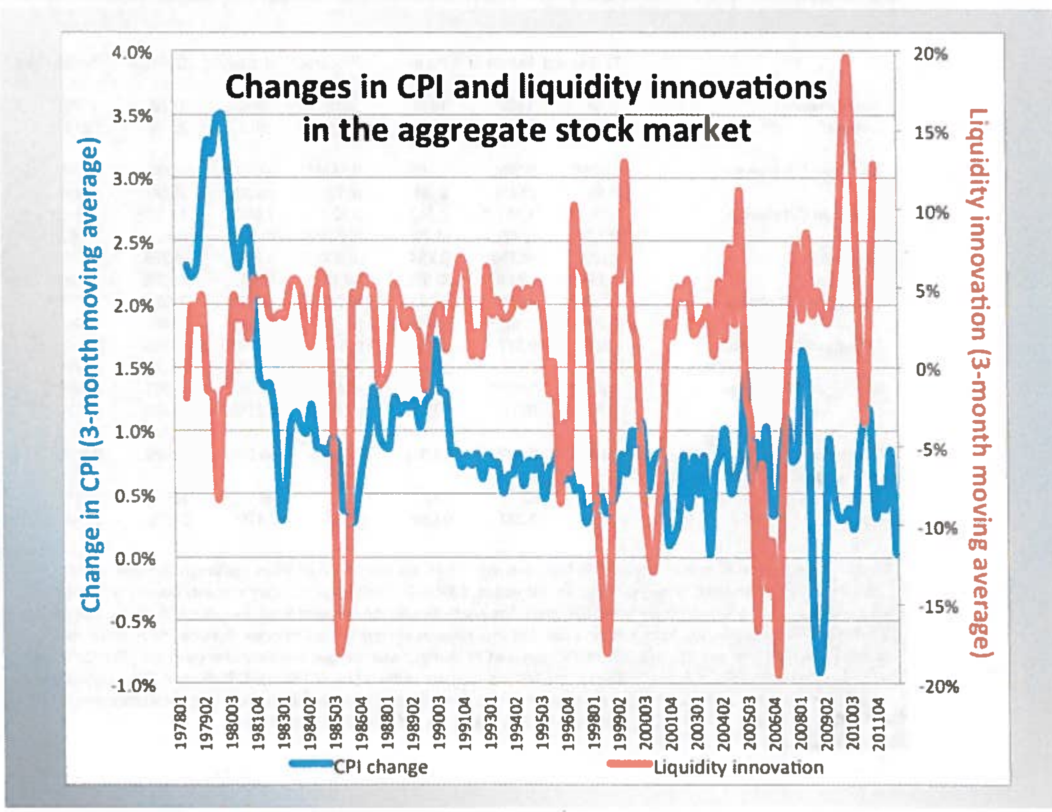
[15] See Claude Erb and Campbell Harvey (2006), "The strategic and tactical value of commodity future," Financial Analyst Journal, 67-2, 69-97. However, quarter-on-quarter changes in CPI have an autocorrelation of 34% over our time period of 1978-2012, such that part of these changes will be anticipated. Therefore, we employ a second method as a robustness check, where we first estimate next quarter's change in CPI using this quarter's change.

4. Inflation and the investment performance in real assets

One potentially attractive feature of real assets is that they may provide a hedge against increases in inflation. This is particularly relevant for pension funds providing defined benefit (henceforth DB) plans with inflation protection. The majority of large public pension funds providing a DB plan do, according to Andonov, Bauer, and Cremers (2013).[17] Their database consists of detailed annual information for over 800 public and private public funds providing a DB plan over 1990-2010 from the US, Canada, and Europe. Public funds are much more likely to promise inflation protection. For example, in 2010 about 60% of the public funds included in their sample offered an explicit promise of inflation protection for their DB plan, while only 22% of the private pension funds did so. Geographically, public pension fund DB plans seem have similar propensities to offer inflation protection, with 56% of public funds in the U.S. doing so, 71% in Canada, and 60% in Europe (all data for 2010, the sample for Europe is quite small, see their paper for details). Even for DB plans that do not promise explicitly to provide inflation protection, hedging for inflation remains a concern. Their liabilities, i.e. the promised pension benefits, will increase due to future wage growth, which by itself tends to be positively correlated with inflation over longer periods of time.

In this section, we measure by the Consumer Price Index (CPI). Figure 4 below shows the 3-month moving average in the change in the CPI since 1978.

Figure 4. Changes in the Consumer Price Index (CPI) and innovations in aggregate stock market liquidity, 1978-2012



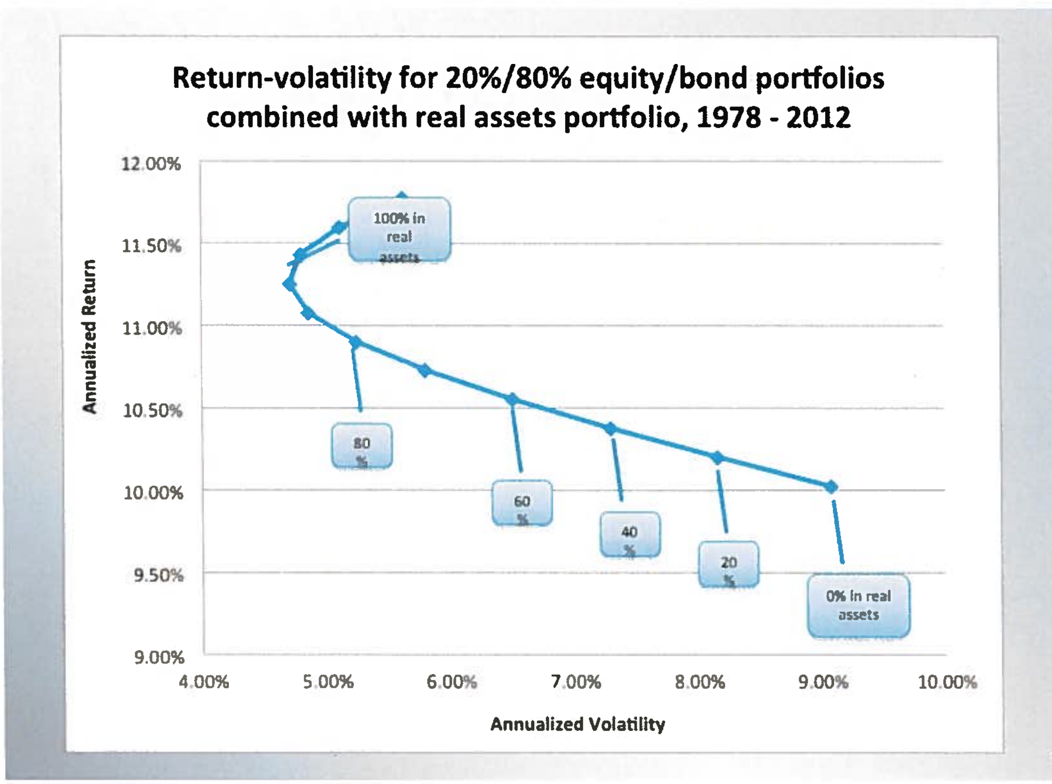
[17] See e.g. Aleksandar Andonov, Rob Bauer, and Martijn Cremers (2013), "Pension Fund Asset Allocation and Liability Discount Rates: Camouflage and Reckless Risk Taking by U.S. Public Plans?" working paper, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2070054.

Sharpe ratio over these two periods of 2.0 and 1.6, respectively. At the same time, an important caveat is that the NCREIF indices used in this paper are not directly investable. Even if we assume that they are representative of the relevant investment universe, any actual portfolio will be considerably less well-diversified than the NCREIF index, which consists of many more separate properties than individuals investors will be able to participate in. In that sense, the volatility estimates using the NCREIF indices will significantly understate the actual volatility perceived in their relevant markets by individual participants.

That brings us to the question of why real asset classes would have persistently higher Sharpe ratios than traditional asset classes such as equities and bonds. The main reason seems to us that direct investments in real assets are typically large and locked up for extensive periods of time, giving rise to potentially severe agency costs and illiquidity. These will be discussed in Section 5. First, in Section 4, we will discuss another potential advantage of real assets investments, namely their ability to hedge for changes in inflation.

Timberland Index from 1987-1991, of equal weights in timberland, farmland, and commercial real estate from 1992-1995, and from 1996 onwards the returns are identical to before. Over 1978-2012, the real asset portfolio had an average annual return of 11.8% and an annual volatility of 5.6%, while the 60/40 equity/bond portfolio had a mean return of 11.3% per year and annual volatility of 10.9%, and the 20/80 equity/bond portfolio had a mean return of 10.0% per year and annual volatility of 9.1%. Over this longer period, the difference in average returns between these portfolios was thus quite minor, while the real asset portfolio had substantially lower volatility. As a result and as Figures 3A (using the 60/40 equity/bond portfolio) and 3B (using the 20/80 equity/bond portfolio) illustrate, increasing allocations to real assets would have changed the average return little but would have resulted in lower volatility. Of course, these are only illustrations using past returns, whereas projections of future returns in the different real asset classes are subject to very large uncertainty (see more discussion later). In particular, it seems to us to be quite uncertain whether future average expected returns in the real asset classes are significantly higher than in public equities. However, across the two periods considered (1996-2012 and 1978-2012), two results overlap that we are more confident about (relative to predictions of future average returns of real assets versus equity and government bonds). Over both periods, the correlations between real assets performance and equity/bond performance were relatively low (especially using the smoothed quarterly real asset returns), and the volatility of the real assets performance was lower than that of public equities. For example, the 60/40 equity/bond portfolio had an annual Sharpe ratio of 1.04 over 1978-2012 and of 0.79 over 1996-2012, while the equally weighted portfolio had an annual

Figure 3B. Average returns and volatility for portfolios combining a traditional 20%-equity/80%-bonds asset allocation with an equally weighted portfolio in real assets, 1978-2012

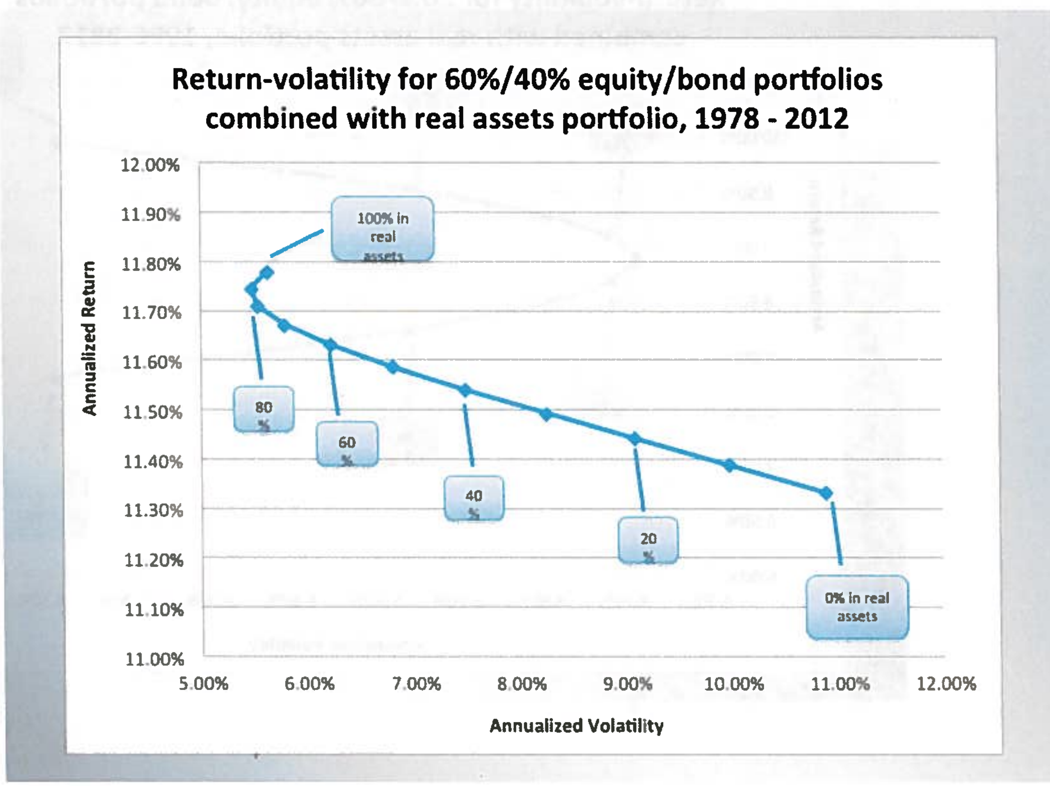


return and a lower volatility. As a result, allocating increasingly larger weights towards real assets would have improved the average return with a lower volatility, as illustrated by the figure. For example, a portfolio with 60% invested in the equity/bond portfolio and 40% in the equally weighted real asset portfolio had an average return of 9.0% per year and an annual volatility of 7.8% over 1996-2012.

Over the same 1996-2002 period, the more conservative portfolio investing 20% in public equities and 80% in government bonds had an average return of 7.8% per year and a standard deviation of 6.1%, while the equally weighted portfolio tracking the performance of direct investment in real assets had an average return of 9.9% per year and a standard deviation of 6.1%. Using annual returns, the more conservative real asset portfolio has a return correlation of only 18% with the equity/bond portfolio, and again a higher average return and basically identical volatility. As a result, allocating increasingly larger weights towards real assets would have improved the average return with a lower volatility, as illustrated by the figure. For example, a portfolio with 60% invested in the 20/80 equity/bond portfolio and 40% in the equally weighted real asset portfolio had an average return of 9.1% per year and an annual volatility of 4.7% over 1996-2012.

In Figures 3A and 3B, we use the full time period of 1978-2012, at each point equally weighting those real asset returns that are available. This means that the real asset portfolio consists of only the NCREIF Property Index from 1978-1986, of equal weights in the NCREIF Property Index and the NCREIF

Figure 3A. Average returns and volatility for portfolios combining a traditional 60%-equity/40%-bonds asset allocation with an equally weighted portfolio in real assets, 1978-2012

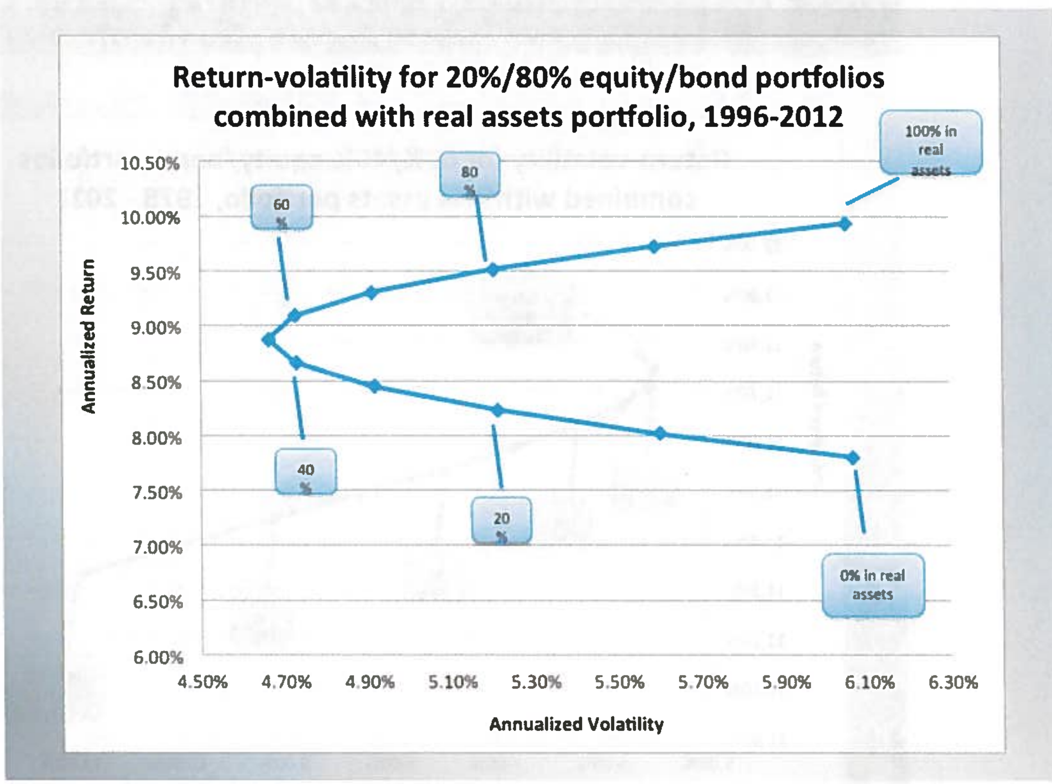


the Alerian MLP Infrastructure Index. Both portfolios are reconstituted at the beginning of each quarter to keep those weights constant.

For each of the two starting portfolios (i.e., the 60/40 and 20/80 equity/bond portfolios), we then form nine additional portfolios, assigning weights of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90%, respectively, to the equally weighted real assets portfolio, and the remainder to the equity/bond portfolio. For each of the resulting portfolios, we calculate the 17 annual (calendar year) returns from 1996 to 2012, and based on those the average and the standard deviation of the annual return. We use annual returns to account for possible smoothing in the real asset indices. The resulting average returns and standard deviations are plotted in Figure 2A (for the 60/40 equity/bond portfolio) and Figure 2B (for the 20/80 equity/bond portfolio).

Over 1996-2012, the traditional portfolio investing 60% in public equities and 40% in government bonds had an average return of 8.3% per year and a standard deviation of 10.5%, while the equally weighted portfolio tracking the performance of direct investment in real assets had an average return of 9.9% per year and a standard deviation of 6.1%. Using annual returns, the real asset portfolio has a return correlation of 51% with the 60/40 equity/bond portfolio, with a higher average

Figure 2B. Average returns and volatility for portfolios combining a traditional 20%-equity/80%-bonds asset allocation with an equally weighted portfolio in real assets, 1996-2012



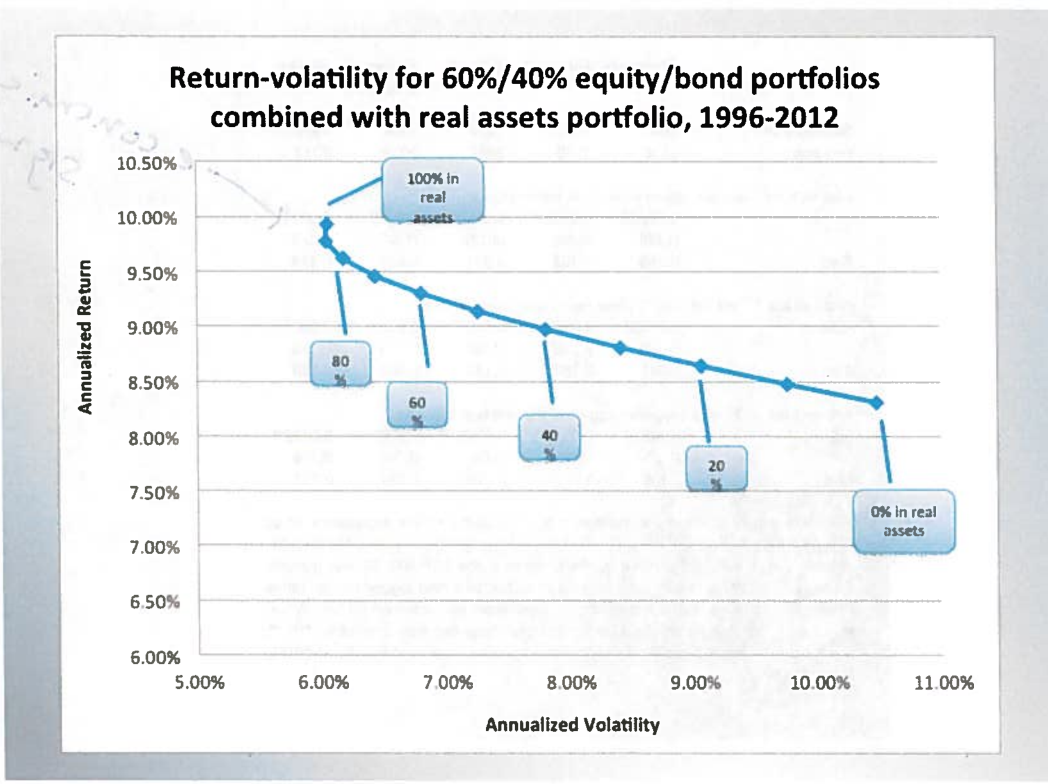
3.3 Diversification benefits of adding real assets to an equity/bond portfolio

The relatively low correlations between the investment performance of real assets and traditional assets like public equities and government bonds (see Table 2) combined with the positive abnormal returns of the real assets relative to these traditional assets (see Tables 3 to 6) suggests considerable diversification benefits to adding direct investments in real assets to an equity/bond portfolio. In this section we try to illustrate the extent of these benefits using a quite basic and thus simplified example.

We start with two equity/bond portfolios. The first or 60/40 portfolio invests 60% in public equities (i.e., S&P 500) and 40% in government bonds (i.e., 30% in 20-year maturity government bonds and 10% in 1-year maturity bonds). This starting portfolio is meant to mimic the basic asset allocation typical of large pension funds in the US, Canada, the Netherlands, and the UK.[16] The second or 20/80 portfolio is more conservative and invests 20% in public equities and 80% in government bonds (i.e., 65% in 20-year maturity government bonds and 15% in 1-year maturity bonds).

Next, we form an equally weighted portfolio mimicking the investment performance of the four main real asset indices for which we have data available: timberland, farmland, commercial real estate, and energy infrastructure. Specifically, the returns of the fictional real assets portfolio are calculated by assigning a 25% weight each to the NCREIF Timberland Index, the NCREIF Farmland Index, the NCREIF Property Index, and

Figure 2A. Average returns and volatility for portfolios combining a traditional 60%-equity/40%-bonds asset allocation with an equally weighted portfolio in real assets, 1996-2012



[16] See e.g. Aleksandar Andonov, Rob Bauer and Martijn Cremers (2012), "Can Large Pension Funds Beat the Market?" working paper, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1885536

assets would have produced positive alpha relative to portfolios consisting of public equities and government bonds. The statistical evidence becomes weaker once we also control for lagged returns of public equities and bonds. These lagged returns are meant to account for any smoothing in the appraisal-based valuations of the real assets. Any smoothing would reduce the estimated volatility, which indeed tends to go up a bit after controlling for lagged returns in public equities and government bonds. However, using the full time period available (rather than only using the 1996-2012 period over which we have data across all real asset classes) generally lowers the estimated volatility while keeping the alpha estimates similar, thereby strengthening the evidence that in particular direct investments in commercial real estate have had positive abnormal returns relative to equities and bonds. The Alerian MLP infrastructure index, which captures the investment performance of publicly traded energy MLPs, is thereby strongly related to the investment performance of publicly traded energy stocks. Controlling for such exposure reduces the abnormal returns of the Alerian index and renders them statistically insignificant, even if they remain economically large. In the end, we find that the evidence that investors would have improved their overall performance by adding direct investments in real assets such as farmland, commercial real estate, and energy infrastructure to a portfolio consisting of public equities and government bonds is strong, and lacks statistical power only for direct investments in timberland and energy infrastructure. This lack of statistical power may very well be due to the relatively short period for which we have quarterly returns available, e.g. only 17 years or 68 quarterly observations for the Alerian energy infrastructure index.

Table 6. Alpha estimates for longest time period available also controlling for lagged equity and bond returns

	Timberland	Farmland	Property	Property (Transact.)	Alerian
Starting year:	1987	1992	1978	1994	1996
End year:	2012	2012	2012	2012	2012
Also include 1-quarter lagged equity and bond returns:					
Alpha	0.00954*	0.0339***	0.0154***	0.0215	0.0331
	(1.68)	(4.44)	(4.18)	(1.44)	(1.54)
R-sq	0.058	0.102	0.091	0.027	0.178
Also include 1- and 2-quarter lagged equity and bond returns:					
Alpha	0.00636	0.0367***	0.0157***	0.0187	0.0401*
	(1.04)	(4.85)	(4.03)	(1.27)	(1.84)
R-sq	0.086	0.183	0.137	0.060	0.188
Also include 1-, 2-, and 3-quarter lagged equity and bond returns:					
Alpha	0.00880	0.0394***	0.0159***	0.0207	0.0472**
	(1.30)	(4.38)	(4.06)	(1.36)	(2.08)
R-sq	0.109	0.201	0.218	0.130	0.234

economically significant

The table presents the alpha estimates from quarterly return regressions of an index tracking a real asset class (Timberland, Farmland, Property, and Alerian infrastructure) on a constant and the quarterly return of the S&P 500, 20-year maturity Treasury bonds, and 1-year maturity Treasury notes, plus their lagged returns (up to three quarters lagged). The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

the coefficients on the contemporaneous or any of the lagged equity and government bond returns. For example, the alpha estimates at the bottom of the table result from a regression with 13 independent variables – the constant, the contemporaneous returns (equity, long-maturity and short-maturity bonds), and three lags each for the three return series.

The results indicate that controlling for up to three lagged quarterly returns weakens the evidence in favor of positive alphas for real asset classes, but primarily statistically rather than economically. All the alpha coefficients in Table 4 generally remain positive and of quite similar magnitude as in Table 3, though their statistical significance declines for property and Timberland, such that only Farmland and energy infrastructure (as captured by the Alerian index) continue to have positive alphas that are statistically significant at 1%. However, we saw earlier that the statistical significance of the alpha for Alerian energy index declines after controlling for exposure to the natural gas and petroleum (or "oil") sector. This continues to be the case after adding lagged quarterly returns, including the lagged quarterly returns of the oil sector.

For all series (except the Alerian MLP infrastructure Index) we have data available before 1996. For example, the return series for Timberland starts in 1987, for Farmland in 1992, and for Property in 1978. Table 5 shows the abnormal return estimates for the longest time period available for the respective real asset classes, in a specification that only controls for contemporaneous equity and bond returns. The alpha estimates in Table 5 are similar to the results in Table 3.

In Table 6, we show the alpha estimates again using the longest time period available but now adding lagged equity and bond returns as well, similar to Table 4. We again find that adding lags does not change the coefficients very much, but reduces the statistical significance for Timberland and the transaction-based property index. On the other hand, using the full history since 1978 the appraisal-based property index has an annualized alpha of about 6.5% per year with a t-statistic of 4.06 (i.e., a p-value below 1%), whereas the annualized alpha of about 4.4% per year over 1996-2012 was not significant at 10%. This illustrates the benefit of having a longer history that reduces the standard error on the alpha estimate.

In conclusion, the available (though limited) data on the investment performance of real assets suggests that these

Table 5. Alpha estimates for longest time period available using only contemporaneous equity and bond returns

	Timberland	Farmland	Property	Property (Transact.)	Alerian
Starting year:	1987	1992	1978	1994	1996
End year:	2012	2012	2012	2012	2012
Alpha	0.0132**	0.0320***	0.0142***	0.0230**	0.0428***
	(2.01)	(5.39)	(4.32)	(2.01)	(2.86)
S&P 500	0.0160	0.0364	0.0216	0.0736	0.282*
	(0.45)	(1.09)	(0.70)	(0.93)	(1.74)
Bonds (20y)	0.0562	0.0750	0.00815	0.0583	-0.175
	(0.94)	(1.33)	(0.19)	(0.34)	(-0.88)
Bonds (1y)	0.685	-1.344***	-0.332**	-0.576	-0.0959
	(1.52)	(-3.48)	(-2.35)	(-0.64)	(-0.06)
N	104	84	140	76	68
R-sq	0.033	0.087	0.052	0.017	0.141

The table presents results from quarterly return regressions of an index tracking a real asset class (Timberland, Farmland, Property, and Alerian infrastructure) on a constant and the quarterly return of the S&P 500, 20-year maturity Treasury bonds, and 1-year maturity Treasury notes. The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

relative to a benchmark consisting of public equities and government bonds. Timberland has the smallest alpha of 3.6% per year (= 4 x 0.009). The largest alphas are for Farmland (13.4% per year) and the Alerian infrastructure index (17.1% per year). As the t-statistics in parentheses indicate, all of these abnormal returns are statistically significant at 1% or 5%, i.e. we can reject that these alphas are equal to zero with a high degree of confidence. Only a small percentage of the quarterly returns on the real asset classes are spanned by a linear combination of the traditional asset classes, with the largest R-squared for the Alerian MLP infrastructure index of 14%. One reason that this R-squared is the highest may that this latter Alerian index is based on publicly traded infrastructure MLPs, while all the other indexes track the investment performance of assets that are not publicly traded.

In addition, the Alerian MLP infrastructure index captures only energy infrastructure investments, particularly the transport and storage of natural gas and petroleum. As such, it has significant exposure to the investment performance of the publicly traded stocks in the energy sector. Our proxy for this performance is the value-weighted return of a portfolio of all publicly traded U.S. stocks in the energy sector (i.e. with 4-digit Standard Industrial Classification (SIC) codes 1300-1389, 2900-2912, and 2990-2999).[15] If we add the quarterly stock return of the energy sector to the specification for the Alerian infrastructure index in Table 3, its energy beta is 0.36 (t-statistic of 2.47) and the R-squared goes up to 23%. The resulting alpha goes down to a still economically large 12.1% per year, though in this specification it is no longer statistically significant with a t-statistic of 1.58 (results are not reported to save space, and are available upon request).

As we have seen, one concern is that the quarterly returns on the real asset classes are based on appraisal values that are smoothed. An important robustness check is therefore to also include the one-quarter, two-quarter, and three-quarter lags of the equity and bond returns. The resulting regressions thus feature 7, 10, and 13 independent variables adding the 1-quarter, 2-quarter, and 3-quarter lagged returns, respectively. The alpha estimates are summarized in Table 4 below. To save space, we only report the alpha estimates and do not report

Table 4. Alpha estimates for 1996-2012 also controlling for lagged equity and bond returns

	Timberland	Farmland	Property	Property (Transact.)	Alerian
Also include 1-quarter lagged equity and bond returns:					
Alpha	0.00828	0.0356***	0.0127*	0.0131	0.0331
	(1.33)	(3.70)	(1.88)	(0.87)	(1.54)
R-sq	0.027	0.094	0.135	0.097	0.178
Also include 1- and 2-quarter lagged equity and bond returns:					
Alpha	0.00761	0.0395***	0.0100	0.00950	0.0401*
	(0.96)	(4.06)	(1.35)	(0.66)	(1.84)
R-sq	0.065	0.178	0.230	0.126	0.188
Also include 1-, 2-, and 3-quarter lagged equity and bond returns:					
Alpha	0.0127	0.0445***	0.0110	0.0143	0.0472**
	(1.44)	(3.79)	(1.54)	(0.99)	(2.08)
R-sq	0.155	0.214	0.386	0.197	0.234

The table presents the alpha estimates from quarterly return regressions of an index tracking a real asset class (Timberland, Farmland, Property, and Alerian infrastructure) on a constant and the quarterly return of the S&P 500, 20-year maturity Treasury bonds, and 1-year maturity Treasury notes, plus their lagged returns (up to three quarters lagged). The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

[15] We thank Kenneth French for making this data available on his website, where we use the "oil" group, one of 49 industry groups in http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/ftp/49_Industry_Portfolios.zip

to add real assets to the portfolio. Would such an investor conclude that the investment performance of real assets had any "alpha" (i.e. unexplained return, positive or negative) during 1996-2012, relative to the performance of public equities and government bonds?

We estimate alphas by regressing the quarterly excess returns in the respective real asset classes on the quarterly excess returns of public equities and government bonds. Excess returns are calculated by subtracting the total return on the 30-day Treasury bill. In effect, we are comparing the real asset returns to the returns on a benchmark consisting of the linear combination of public equities, long-maturity and short-maturity government bonds that is most correlated with the real asset returns. The alpha is the regression coefficient on the regression constant. A positive alpha means that the relevant real asset class has outperformed relative to the most correlated portfolio of public equities and government bonds. As a result, a positive alpha would suggest that an investor would have been able to improve performance by adding the real asset class to a portfolio consisting of only public equities and government bonds.

Everywhere in this paper, the regression results use standard errors that are robust (White), i.e. that are adjusted for heteroskedasticity and autocorrelation. The adjustment for heteroskedasticity accounts for the possibility that the volatility of returns (or regression errors) changes over time. The adjustment for autocorrelation would account for returns that are correlated across time, e.g. due to smoothing the appraisal-based valuations used to calculate the real asset investment returns.

Table 3 presents the regression results using only contemporaneous equity and bond returns. We find that all natural resource asset classes have a positive alpha or abnormal return

Table 3. Alpha estimates for 1996-2012 using only contemporaneous equity and bond returns

	Timberland	Farmland	Property	Property (Transact.)	Alerian
Alpha	0.00901**	0.0335***	0.0148**	0.0232**	0.0428***
	(2.10)	(5.00)	(2.34)	(2.30)	(2.86)
S&P 500	0.0267	0.0338	0.0693	0.0853	0.282*
	(0.87)	(0.92)	(1.24)	(1.19)	(1.74)
Bonds (20y)	0.0733*	0.0668	0.0482	0.113	-0.175
	(1.70)	(1.04)	(0.51)	(0.65)	(-0.88)
Bonds (1y)	0.156	-1.317***	-0.0001	-0.840	-0.0959
	(0.38)	(-3.04)	(-0.00)	(-1.04)	(-0.06)
N	68	68	68	68	68
R-sq	0.021	0.076	0.053	0.036	0.141

The table presents results from quarterly return regressions of an index tracking a real asset class (Timberland, Farmland, Property, and Alerian infrastructure) on a constant and the quarterly return of the S&P 500, 20-year maturity Treasury bonds, and 1-year maturity Treasury notes. The t-statistics in parentheses are based on robust (White) standard errors that are adjusted for heteroskedasticity and autocorrelation. ***, **, and * indicate that the coefficient's associated p-value is below 1%, 5%, and 10%, respectively.

since 1996, especially the significant losses experienced in 2007-2009. In particular, the last row of Table 1 gives the maximum cumulative loss of an investment made during 1996-2012 using quarterly returns, and calculated as the largest percentage lost from a peak to a trough in the cumulative investment performance presented in Figure 1. The maximum losses are largest for public equities and infrastructure, with losses of -45% and -43%, respectively. Commercial real estate (Property) also sustained significant losses, with a maximum cumulative loss of -24% for the NCREIF Property Index from the end of the second quarter of 2008 to the last quarter of 2009. During 1996-2012, downside losses for natural resources were very limited.

Table 2A reports the correlations of the quarterly returns for 1996-2012. All real asset classes have low correlations with equities, except the Alerian MLP Infrastructure index, which has a correlation with the S&P 500 of 36%. Likewise, correlations with long-maturity bonds are generally low, with the highest correlation (in absolute terms) for the Alerian index with a correlation of -27%. The two natural resource indices, Timberland and Farmland, have a 62% correlation. However, natural resources, property, and infrastructure have relatively low quarterly return correlations. The largest correlation across real asset classes is for Timberland and Property with a correlation of 33%.

However, the smoothing in appraisal-based valuations could distort not only the volatility of these series, but their correlations as well. We again simplistically address this issue by considering correlations based upon annual returns in Table 2B, with a caveat that these are based on only 17 annual observations in each series. The correlations change most for the two property indices, both the appraisal-based NCREIF Property Index and the NCREIF Transaction-Based Property Index, indicating large positive correlations with equities and large negative correlations with bonds.

3.2 Alphas of real assets relative to public equities and government bonds

In this section, we take the perspective of an investor in public equities and government bonds, who is considering whether

Table 2A. Correlations of quarterly returns, 1996-2012

	Timberland	Farmland	Property	Property (Transact.)	Alerian	S&P 500	Bonds (20y)
Farmland	62%						
Property	33%	18%					
Property (Transact.)	22%	6%	55%				
Alerian	-23%	-18%	1%	3%			
S&P 500	1%	10%	21%	13%	36%		
Bonds (20y)	12%	-2%	0%	3%	-27%	-51%	
Bonds (1y)	19%	-15%	11%	-5%	-8%	-25%	30%

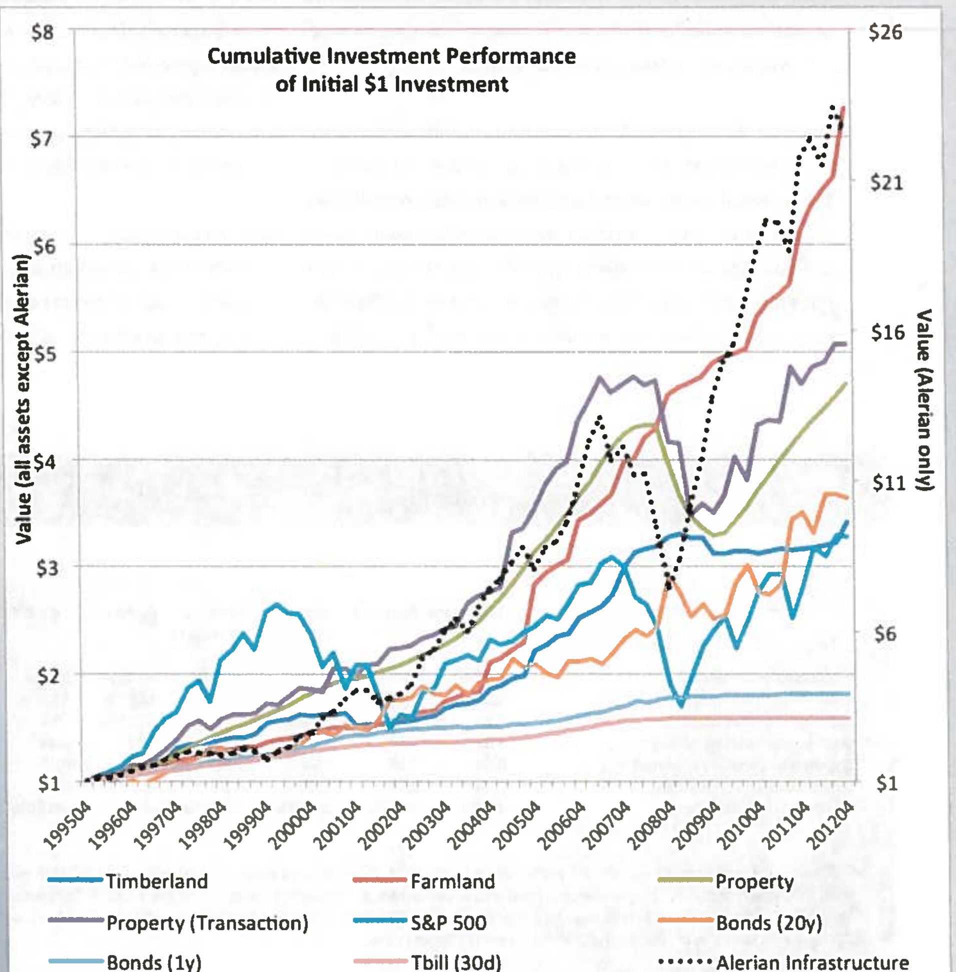
Table 2B. Correlations of annual returns, 1996-2012

	Timberland	Farmland	Property (Transact.)	Property	Alerian	S&P 500	Bonds (20y)
Farmland	61%						
Property	40%	28%					
Property (Transact.)	35%	9%	79%				
Alerian	-24%	-1%	32%	13%			
S&P 500	-15%	-19%	57%	58%	9%		
Bonds (20y)	28%	8%	-53%	-58%	-31%	-79%	
Bonds (1y)	19%	-25%	-16%	-13%	-23%	-48%	67%

While energy infrastructure significantly outperformed all other asset classes during 1996-2012, the Sharpe ratio for energy infrastructure equals 0.70 and is thus the lowest among the real asset classes, due to its relatively high volatility. Farmland and property (using either the appraisal or transaction-based indices) both have a Sharpe ratio of close to 1. Further, natural resources and bonds have slightly positive skewness, while property, energy infrastructure, and public equities are negatively skewed.

Figure 1 presents the cumulative investment performance of an initial $1 investment at the beginning of 1996 through the end of 2012. The values at the end of 2012 range from $1.59 for the 30-day Treasury bills to $22.64 for the Alerian index. The ending values of the $1 investment were $3.42 for direct investments in timberland, $7.27 for farmland, and $4.70 for property (commercial real estate) as compared to $3.28 for the S&P 500 and $3.64 for 20-year Treasury bonds. The figure also illustrates the downside risk in the various asset classes

Figure 1. Cumulative investment performance of an initial $1 investment at the beginning of 1996 through the end of 2012



Note that there are two different axes in the figure. The right-side axis is for the investment performance for the Alerian MLP (energy) infrastructure index, and the left-side axis is for the investment-performance of all other series. See Table 1 for a description of the indices.

3. Investment Performance

3.1 Average returns, volatility, Sharpe ratio, and maximum cumulative loss

In this section, we describe the investment performance of the various asset classes. Table 1 presents some basic descriptive statistics of the investment performance for 1996-2012.

Over this 17-year period, the annualized mean return across asset classes varies from 3.51% per year for 1-year Treasury notes to 20.19% per year for energy infrastructure investments captured by the Alerian energy MLP index. Using quarterly returns, the most volatile asset class was public equity with an annualized volatility of 17.88%, followed by energy infrastructure with an annualized volatility of 16.95%.

We also calculate the volatility of the investment performance using annual data to lessen the impact of any smoothing in the appraisal values, which particularly impacts the real asset classes. In general, smoothing appraisal values could lower the volatility of performance considerably, though should not significantly impact the average return over a sufficiently long period. Indeed, the annualized estimate of volatility is significantly higher using annual returns than using quarterly returns, for all real asset classes except the transaction-based commercial real estate index (though the difference is very minor for farmland). This indicates that the appraisal-based total return indices are likely based on smoothed appraisal values. Interestingly, the estimated annualized volatility for the Alerian energy infrastructure index goes up significantly as well if calculated using annual returns rather than quarterly returns (annualized volatility of 29.01% versus 16.95%, respectively), even though it is based on the prices of publicly traded MLPs. As a result, using annual returns the most volatile asset class is energy infrastructure, which also obtained the highest average return. Of course, using annual returns rather than quarterly constitutes a naïve way to deal with smoothing of the returns. For a discussion on sophisticated treatments of unsmoothing, see Ang (2013).[14]

Next, we calculate the annual Sharpe ratio, i.e. the ratio of the annualized average return divided by the annualized volatility. Using annual returns to calculate volatility, the Sharpe ratio ranges from 0.45 for the S&P 500 index to 1.55 for farmland.

Table 1. Investment performance, 1996-2012

Asset Class:	Timberland	Farmland	Property	Property (Transact.)	Alerian	S&P 500	Bonds (20y)	Bonds (1y)
Annualized mean return	7.45%	12.07%	9.33%	10.20%	20.19%	8.64%	8.28%	3.51%
Volatility of quarterly returns (ann.)	5.63%	7.21%	4.99%	10.52%	16.95%	17.88%	11.46%	1.44%
Volatility of annual returns	7.57%	7.81%	9.01%	11.13%	29.01%	19.41%	11.04%	2.58%
Sharpe ratio (volatility of quart. ret.)	1.32	1.67	1.87	0.97	1.19	0.48	0.72	2.45
Sharpe ratio (volatility of annual ret.)	0.98	1.55	1.04	0.92	0.70	0.45	0.75	1.36
Skewness based on quarterly returns	0.95	3.39	-2.63	-0.32	-0.71	-0.41	0.93	0.25
Maximum cumulative loss	-5.91%	-0.01%	-23.88%	-26.81%	-43.04%	-44.90%	-13.99%	0.00%

"Timberland" represents the investment performance of the NCREIF Timberland Index, "Farmland" of the NCREIF Farmland Index, "Property" of the NCREIF Property Index tracking commercial real estate performance, "Property (Transact.)" of the NCREIF Transaction-Based Index, "Alerian" of the Alerian MLP (Master Limited Partnership) Infrastructure Index, "S&P 500" of the Standard & Poors 500 stock market index, "Bonds (20y)" of the 20-year US Treasury security, and "Bonds (1yr)" of the 1-year US Treasury bill.

[14] Andrew Ang, 2013, "Illiquid Asset Investing," working paper. This is a chapter from the book being written by Andrew Ang titled "Asset Management." Drafts of the various chapters of his book are available on his website at http://www.columbia.edu/~aa610/, and the "Illiquid Assets" chapter specifically is publicly available here: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2200161.

components) has been about 3.8% of global GDP per year, on average.[13] China has been the largest investor in infrastructure over this period, about 8.5% of its GDP, followed by Japan (about 5% of its GDP) and India (about 4.7%). The European Union and the United States have spent about 2.6% of their GDP on infrastructure investments. The report further estimates that for the period 2013-2030, on average about $3.4 trillion will be spent on global infrastructure per year. Most of this will be financed by governments, especially in countries other than the US and the UK. If institutional investors doubled their current allocations to infrastructure investments, from about 3% of their assets (based on data from Preqin) to 6%, the McKinsey report estimates that this doubling would result in an additional $2.5 trillion in infrastructure investments through 2030, which is significant but also less than 5% of the total estimate of $57 trillion needed globally during this time.

2.4 Public equities, government bonds and inflation

Data for the traditional asset classes (public equities and government bonds) as well as for inflation are obtained from the Center for Research in Security Prices (CRSP) at the University of Chicago. Our proxy capturing the investment performance of U.S. public equities is the Standard and Poor's 500 benchmark, the most common large cap US equity index, for which we use the total return index (i.e., with dividends reinvested). For the performance of government bonds, we separately consider long-maturity and short-maturity government debt from the CRSP US Treasury Fixed Term Index Series. The series capturing long-maturity US government debt performance is the 20-year constant maturity series based on Treasury bonds. The series capturing short-maturity US government debt performance is the 1-year constant maturity series based on representative Treasury bonds or notes. For both series, each month the issue is chosen that has a maturity closest to the target (i.e., 20 years versus 1 year, respectively), measured from the end of the previous month. Our proxy for the short-term risk-free rate to calculate excess returns is the total return on the 30-day Treasury bill, again obtained from the CRSP US Treasury Fixed Term Index Series. Finally, the US inflation series used is based on the Consumer Price Index (CPI) level from the CRSP US Government Consumer Price Index file.

[13] See the report "Infrastructure productivity: How to save $1 trillion a year," which is available at http://www.mckinsey.com/insights/mgi/research/urbanization/infrastructure_productivity. The results are based on annual infrastructure spending for the period of 1992 to 2011, for 84 countries (though with parts of the data missing for many of these) accounting for over 90% of global GDP. Data sources include the International Transport Forum (ITF) for spending on roads, rail, ports, and airports, HIS Global Insight for spending on energy and telecommunications infrastructure, and Global Water Intelligence for water and sanitation spending.

properties included in the NCREIF Property Index will sell in any given quarter, the NCREIF Transaction-Based Index is thus less representative of the performance of the overall commercial real estate market. Furthermore, as the transaction return still depends on the lagged appraisal value, the NCREIF Transaction-Based Index is thus not a pure transaction-based index (as would be an index based only on repeat sales using transactions prices exclusively).

According to Real Capital Analytics (see www.rcanalytics.com), which collects information on commercial real estate transactions from investors with at least $2.5 million portfolios, the last six months ending in February 2013 saw 13,231 properties sold with an average price of $14.9 million dollars for a total volume of about $200 billion. For comparison, across all international markets included in the Real Capital Analytics data, the total volume over this period was about $570 billion. For the United States, apartments make up the most important property type, with a transaction volume in that period of about $60 billion. The corresponding transactions for the other properties are about $22 billion for industrial properties, about $51 billion for office buildings, about $30 billion for retail, and about $16 billion for hotels (the remaining property types included in the Real Capital Analytics data are development sites and senior care properties, both of which are not included in the NCREIF index).

2.3 Infrastructure

Our proxy for the investment performance of direct investments in infrastructure is the Alerian MLP (Master Limited Partnership) Infrastructure Index, which is not directly investable but reflects the performance of constituents that are publicly traded. The index consists of 25 energy infrastructure MLPs, and data on its performance is available at http://www.alerian.com/indices/amzi-index/. We use the total return index with ticker AMZIX (New York Stock Exchange). The return series starts with the first quarter of 1996 and ends with the fourth quarter of 2012, and uses capped, float-adjusted, capitalization weighting.

The energy infrastructure MLPs included are engaged in transporting (about 68% of the MLPs, with about 40% in natural gas and the other 28% in petroleum) and in storing/processing of energy commodities (about 32% of the MLPs included). As of the end of 2012, the market capitalization of the MLPs included was about $214 billion, with the largest of the 25 MLPs having a market capitalization of about $45 billion (though its weight in the index was only 9.5%, which is the maintained cap for the largest weight), the smallest of about $2 billion, and a medium of about $5 billion. The top 10 holdings had an aggregate index weight of 64.4%.

All index constituents are publicly traded partnerships or limited liability companies that are trading on the New York Stock Exchange or NASDAQ, representing the primary limited partner interest (for the partnerships) or the operating company (for the LLCs). Constituents can leave or be added to the index dependent on various criteria such as market capitalization, quarterly distributions, trading volume, float-adjusted market capitalization, and closing price.[12] The index is rebalanced at the end of each quarter, though it can also be rebalanced between quarters due to mergers, delisting, or bankruptcies.

Energy is only one component of various infrastructure investments, which also include roads, rail, ports, airports, water, and telecom. However, we are not aware of indices tracking the performance in direct investments in these other components that are publicly available for a comparable period of time. According to the January 2013 report by the McKinsey Global Institute on Infrastructure Productivity, about 25% of total global infrastructure spending is estimated to be on energy, about 25% on roads, and the remainder on rail, ports, airports, water, and telecom.

While publicly traded partnerships are very important, another limitation of the data using the Alerian index is that many opportunities for direct investments in infrastructure exist through unlisted infrastructure funds. According to Preqin (see http://www.preqin.com/listResearch.aspx) using global data, in 2012 unlisted infrastructure funds obtained over $23 billion in final closes and at least $15.5 billion in interim closes, with similar amounts raised in 2011.

Historical spending in 1992-2011 on infrastructure (across all

[12] See http://www.alerian.com/wp-content/uploads/AMZImethod.pdf for details.

land and about 2% is permanent cropland.[7] Internationally, the United States is in the top three of the amount of arable and permanent cropland (the other two countries in the top three are Brazil and Russia). The estimated value of arable farmland in the United States in 2012 is about $1.6 trillion dollars, the largest estimated value for a given country. For comparison, the estimated value of arable farmland in 2012 for Brazil is about $333 billion (second largest), for Argentina about $217 billion (third largest), and for Australia about $217 billion (fourth largest).

The United States is an international outlier in terms of the percentage of agricultural land that is owned by institutional investors who are not themselves farmers. According to the United States Department of Agriculture (USDA, www.usda.gov), institutional investor ownership amounted to about 30% of farmland in 2007, and about 38% of the agricultural land in the Corn Belt.[8] Less than 1% of this is foreign (i.e., non-US) investor ownership. In contrast, in most other countries institutional ownership is much lower and thus more fragmented. The Global AgInvesting Research & Insight publication estimates that institutional ownership in countries such as Australia, Argentina, Brazil, and Canada is less than 10%, and that for many countries it is below 2%.

The quarterly returns in the NCREIF Farmland Index consist of two components, namely the income return and the appreciation return. The total return is the sum of the two components, and is the return used throughout this paper. The first component, the income return, is calculated by dividing the net operating income by the average investment in the quarter, incorporating capital improvements and any partial sales that happened in that quarter.[9] The second component, the appreciation return, reflects the change in quarterly appreciations, again adjusted for capital improvements and any partial sales.[10] For both components, the return formulas assume that that the earnings, capital expenditures, and partial sales or purchases all occur in the middle of the quarter. As a result, the denominator in both components is the estimated average investment in each quarter.

2.2 Commercial Real Estate

In order to capture the investment performance of direct ownership in commercial real estate, we use both an appraisal-based index that is available over a relatively long period, and a transaction-based index starting more recently. The appraisal-based index is the NCREIF Property Index, a quarterly series starting in the first quarter of 1978 that is made available on the NCREIF website (http://www.ncreif.org/property-index-returns.aspx). It reflects the performance of a large number of different individual commercial real estate properties that have been acquired for investment purposes and are held in a fiduciary environment by NCREIF members (i.e., the property must be owned or controlled by a qualified tax-exempt institutional investor that is a data contributing member of NCREIF), mostly pension funds. All properties included in the index are operated (i.e., not under development).[11] Properties fall into the following types only: apartments, hotels, industrial properties, office buildings, and retail.

The alternative index is the NCREIF Transaction-Based Index, which is based on properties that were previously included in the NCREIF Property Index, but were sold that quarter. The transaction-based index level is calculated by multiplying the average transaction return times the National Property Index (NPI) two-quarter lagged price level. Specifically, the transaction return in each quarter is the average ratio of the transaction sales price divided by that property's two-quarter lagged appraised value, averaged across all properties sold in that quarter. The NCREIF Transaction-Based Index is thus an equally weighted index, while the NCREIF Property Index is value or market capitalization weighted. Another difference is that hotel properties are not included in the NCREIF Transaction-Based Index. The lagged appraisal values used are the same appraisal values used for the calculation of the NCREIF Property Index. However, as only a small proportion of the

[7] These figures and those following are from the December 2012 report "Farmland: an untapped asset class?" from Global AgInvesting, made available at http://www.globalaginvesting.com/downloads/files/Farmland-an-Untapped-Asset-Class.pdf.
[8] See "Trends in US Farm Values and Ownership," 2012, USDA.
[9] The net operating income (NOI) used is measured by gross income less operating expenses, which include taxes, property management, insurance, costs of growing crops if the farmland is operated by the investment manager, etc. The income return formula is NOI / (Beginning Market Value + ½ [Capital Improvements - Partial Sales + Partial Purchases – NOI]).
[10] The appreciation return is calculated as (Ending Market Value - Beginning Market Value + Partial Sales - Capital Improvements - Partial Purchases) / (Beginning Market Value + ½ [Capital Improvements - Partial Sales + Partial Purchases – NOI]).
[11] Properties that are newly developed or that have been recently purchased for redevelopment need at least 60% occupancy to be operating. Existing properties that are neither newly developed nor recently purchased for redevelopment are defined as operating, irrespective of their actual occupancy.

timberland and farmland. For both we use appraisal-based data from NCREIF (National Council of Real Estate Investment Fiduciaries).[3]

Timberland

The index capturing the investment performance of direct ownership in timber properties is the NCREIF Timberland Index, a quarterly series starting in the first quarter of 1987 that is made available on the NCREIF website (http://www.ncreif.org/timberland-returns.aspx). It reflects the performance of a large number of different timber properties that have been acquired for investment purposes and are held in a fiduciary environment by NCREIF members. Most of these investors are pension funds. Only timberland properties that are at least 80% directly owned (i.e., no more than 20% leased) are included.

While the United States, where all properties included in the index are located, has only about 7% of the total forested areas worldwide, it produces about 20% of the world's output of industrial roundwood (i.e., sawlogs).[4] About 504 million acres of United States forestland are employed for commercial timberland production, which amounts to about two-thirds of the total area of forestland. Private individuals own about 290 million acres, much of which was bought in recent years from forest products companies (which currently own about 70 million acres). The remainder is owned by federal and state governments (about 144 million acres).

The sawlogs output is used for the production of paper and wood products. According to the American Forest & Paper Association (AF&PA, www.afandpa.org), the industry generates about 4.5% of the total manufacturing GDP and employs almost 900,000 people with annual payroll income of about $50 billion in 2012. The total value of wood manufacturing in the United States is about $67 billion, and of paper manufacturing about $170 billion (both in 2012).

The quarterly returns in the NCREIF Timberland Index consist of two components: the income return and the appreciation return. The total return is the sum of the two components, and is the return used throughout this paper. The first component, the income return, is calculated by dividing the earnings by the average investment in the quarter, incorporating capital improvements and any partial sales that happened in that quarter.[5] The second component, the appreciation return, reflects the change in quarterly appreciations, again adjusted for capital improvements and any partial sales.[6] For both components, the return formulas assume that that the earnings, capital expenditures, and partial sales or purchases all occur in the middle of the quarter. As a result, the denominator in both components is the estimated average investment in each quarter.

Farmland

The index capturing the investment performance of direct ownership in agricultural properties is the NCREIF Farmland Index, a quarterly series starting in the first quarter in 1992 that is made available on the NCREIF website (http://www.ncreif.org/farmland-returns.aspx). It reflects the performance of a large number of different agricultural properties that have been acquired for investment purposes and are held in a fiduciary environment by NCREIF members, mostly pension funds. The agricultural properties include permanent, row, and vegetable croplands. Permanent croplands are lands cultivated with trees or vines, i.e. with long-term plants that last for several years (such as coffee and cocoa), trees or shrubs producing flowers (such as roses), or nurseries (not including forest trees). Row and vegetables croplands are called arable land, where the crops are temporary and multiple crops can be utilized over time on the same piece of land. Croplands generally produce the highest value, mostly for grains (such as corn, wheat, and barley), seeds (such as soybean), and fiber (such as cotton).

According to the Food and Agriculture Organization (FAO) of the United States (www.fao.org), the United States has about 707 million acres of land, out of which about 23% is arable

[3] See www.ncreif.org.
[4] See https://www.campbellgroup.com/timberland/faqs.aspx. According to the American Forest & Paper Association (AF&PA), the numbers for 2012 are similar; see http://www.afandpa.org.
[5] The earnings figures used are EBITDDA (earnings before interest, taxes, depreciation, depletion, and amortization). The income return formula is EBITDDA / (Beginning Market Value + ½ [Capital Improvements - Partial Sales + Partial Purchases – EBITDDA]).
[6] The appreciation return is calculated as (Ending Market Value - Beginning Market Value + Partial Sales - Capital Improvements - Partial Purchases) / (Beginning Market Value + ½ [Capital Improvements - Partial Sales + Partial Purchases – EBITDDA]).

2. Data and Basic Characteristics

In this section, we give brief descriptions of our data sources for the investment performance and overall market of each of the three real assets under consideration (direct investments in natural resources, infrastructure, and commercial real estate), as well as for the two main traditional assets (public equities and government bonds). For each investment, the goal was to use performance data that broadly reflect the average, aggregate performance in that asset class, using an index that is well accepted as a benchmark by market participants and that has as long a history as possible.

Our data series start at different times depending on when the particular index first becomes publicly available, while all series end at the close of 2012. The longest common time period across all series is the 17-year period from the first quarter of 1996 to the last quarter of 2012. Therefore, in order to compare performance across these real assets, we use 1996-2012 as the time period for our main analysis, though we also show results for individual real asset indices for the full time period available for that real asset.

Our data for the performance of direct investments in natural resources and commercial real estate come from the National Council of Real Estate Investment Fiduciaries (NCREIF), which is a not-for-profit trade association of institutional real estate professionals. NCREIF produces several quarterly indices based on data submitted by their members, which are generally institutional investors and most of which are pension funds. All indices based on NCREIF data share some common characteristics. The return series are quarterly and reflect both income and appreciation returns. The latter are based on the change in quarterly appraisal values, and at least once every three years the appraisal is done by an independent and external appraiser.

The investments included in the NCREIF indices change over time as reflected by what is owned by NCREIF members that contribute data at a particular point in time and thus may not be representative of the market as a whole. We also do not know the number, length of time, or size of the investments represented by these indices. Another significant limitation is that the NCREIF data for timberland and farmland are exclusively based on appraisals, which may not correspond to the prices that the investments would obtain in actual market transactions. However, to our knowledge, no indices that are more representative or based on market price transactions are available for a comparable length of time.

Investments are included after the quarter in which they are acquired by NCREIF members, and can leave the index for various reasons. For example, they may leave the index if (i) they are owned by NCREIF members that leave and thus stop contributing data; (ii) they are sold by NCREIF members that continue to contribute data; or (iii) they are no longer appraised every quarter using fair market value accounting, or these appraisals are not at least once every three years done by an independent and external appraiser. However, the full history of the investment remains in the index. All indices exclusively involve investments made within the United States. The indices are value-weighted, such that each investment included in an index in a particular quarter is weighted by its total market value. While some of the investments may be partly financed by debt, the returns are calculated as if there is no leverage.

The returns are calculated net of investment-level management fees, but are not net of portfolio-level investment management fees. In particular, the institutions that are NCREIF members and report data to NCREIF have deducted the fees they have paid to the managers of the individual investments, but they have not deducted their own costs in managing their portfolio of real asset investments.

Using appraisal-based valuations has inherent limitations, such that the returns should be interpreted with caution and as a proxy for the actual changes in valuations. One particular limitation is that appraisal values may be smoothed across time, which we will try to adjust for in our empirical analysis. To the extent that actual valuations (i.e., actual net asset values or NAVs) differ from the appraised valuations, such discounts and premiums to NAVs may wash out over long periods. Accordingly, results using appraised valuations may be more reflective of the actual investment performance when using longer time periods.

2.1 Natural Resources

We consider two types of investments in natural resources:

first decade (1978-1987), a period characterized by significant inflation and for which we have data only for commercial real estate. Over this period, we find strong evidence that commercial real estate provided hedging benefits.

Finally, we provide a brief discussion of a critical aspect that is common across direct investments in each of the three real assets considered (i.e., natural resources, infrastructure, and commercial real estate), namely the lack of liquidity. The illiquidity is manifested in generally long holding periods and higher costs of trading. These trading costs include higher costs of gathering and interpreting information on the investments, the time and effort required in finding a party to trade with, and any adverse price impact of trades that are relatively large or done at inopportune times. This illiquidity renders investments in these asset classes more risky, especially for investors with shorter investment horizons or for investors who have substantial uncertainty about when they would be required to sell any investments due to financing constraints. As a result, such investors would presumably demand a positive liquidity premium, i.e. a higher expected return on illiquid investments as a compensation for this greater risk.

It is empirically challenging to estimate any liquidity premium without having access to more detailed transactions data. Likewise, it is hard to measure exposure to systematic liquidity risk in these real asset markets. Instead, the main question we address empirically is whether direct investments in real assets perform worse when stock market liquidity goes down, or when stock market returns are negative. We find no evidence for the first, but strong evidence for the second for direct investment in timberland and farmland. Specifically, the investment performances of both the NCREIF Timberland and Farmland Indices have much stronger exposure to equity market returns when these are negative. The relatively large downside equity betas reflect increased risk for investors, as it means that the considerable diversification benefits discussed above are (albeit temporarily) significantly lower during times when equities go down. However, we find no evidence for increased exposure to equity market risk in down markets for property or energy infrastructure investments.

The remainder of this paper is organized as follows. In Section 2, we describe our data sources in detail and give an overview of the basic characteristics of the real asset markets. Section 3 presents an analysis of investment performance, including average annual returns, volatility, Sharpe ratios, the maximum cumulative loss, correlations across real asset classes and with equity and government bonds, abnormal returns relative to equities and government bonds, as well as the diversification benefits of adding real assets to an equity/bond portfolio. In Section 4, we consider the extent to which investment in real asset classes has provided any inflation hedging benefit. Section 5 discusses liquidity risk and any increased exposure to equity market risk in down markets. Finally, we conclude in Section 6.

thus distinct from our data on the other real asset classes, for which we use investment performance data of non-publicly traded securities. The publicly traded infrastructure MLPs are generally quite illiquid, such that the volatility of the investment returns includes both the volatility of the underlying net asset values as well as the volatility due to trading in illiquid markets.

We investigate the following aspects of the performance of direct investments in natural resources, infrastructure, and commercial real estate: (i) the risk-return trade-off, (ii) their downside risk, (iii) the correlation with public equities, government bonds, and the other real asset classes, (iv) the diversification benefits from adding real assets to a portfolio consisting of equities and bonds, (v) their ability to hedge exposure to inflation, and (vi) their exposure to systematic shocks to liquidity in the stock market.

We compare the risk-return trade-off across asset classes by calculating the annual Sharpe ratio, i.e. the ratio of the annualized average return divided by the volatility of the annual returns (rather than quarterly returns to minimize effects from smoothing). During the common time period 1996-2012, the annual Sharpe ratio ranges from 0.45 for the S&P 500 index to 1.55 for farmland investments. While energy infrastructure investments significantly outperformed all other asset classes, their annual Sharpe ratio equals 0.70 and is thus the lowest among the real asset classes, due to their relatively high volatility. Farmland and property both have a Sharpe ratio of close to 1.

The downside risk in each asset class is assessed using the maximum cumulative loss of any investments made during the period, i.e. the lowest peak-to-trough return over the available sample. The maximum losses are largest for public equities and infrastructure, with losses of -45% and -43%, respectively, both of which were sustained in the recent financial crisis. Commercial real estate (Property) also suffered significant losses, with a maximum cumulative loss of -24% for the NCREIF Property Index from the end of the second quarter of 2008 to the last quarter of 2009. Downside losses for investments in both natural resource types, timberland and farmland, were very limited.

The quarterly returns of all real asset classes have low correlations with equities, except the Alerian MLP Infrastructure index, which has a 36% correlation with the S&P 500. The real assets have generally low correlations with long-maturity bonds as well. Correlations across real asset classes are also limited. The 62% correlation of the two natural resource indices (Timberland and Farmland) excepted, the largest correlation across real asset classes is for Timberland and Property with a correlation of 33%. These correlations are generally similar using quarterly and annual returns, with the exception being the two property indices. Using annual returns, for which smoothing issues in appraisal values seem less important, both the appraisal-based NCREIF Property Index and the NCREIF Transactions-Based Property Index have large positive correlations with equities and large negative correlations with bonds (about 60% with the S&P 500 and -58% with 20-year bonds).

Next, we illustrate what diversification benefits could have been obtained by combining a portfolio consisting of equity and bonds (e.g. 60% in the S&P 500, 30% in 20-year bonds, and 10% in 1-year bonds) with a real asset portfolio (specifically, an equally-weighted portfolio across the four main real asset indices considered, if available). Based on the longest time period considered of 1978-2012, adding real assets to the equity/bond portfolios would have resulted in significantly lower volatility but would have left the average returns largely identical. The diversification benefits seem most pronounced for direct investments in farmland and infrastructure.

Measuring inflation by changes in the Consumer Price Index (CPI), real assets have provided almost no inflation hedging benefit over the full 1978-2012 time period considered, except for direct investments in timberland. The performance of the NCREIF Timberland Index indicates that the performance of timberland investments is positively related, in an economically meaningful way, to changes in CPI both in the past as well as in the future. None of the other real asset classes show clear evidence for a positive association between investment returns and changes in inflation over 1978-2012. One potential explanation may be that inflation changes were quite limited during most of this time period, which may make it harder to estimate any hedging benefits. The main exception is the

1. Introduction

Direct investments in real assets are quite distinct from traditional asset classes such as public equities and government bonds, e.g. due to a lack of active trading on exchanges and typically long holding periods. In this white paper, we provide some introductory description of three different real asset classes: natural resources (timberland and farmland), infrastructure (specifically investments in energy infrastructure), and commercial real estate. Of these three, only the latter has been an asset class in which large institutional investors such as pension funds have long held major investments, while natural resources and infrastructure have only recently become more prevalent in institutional portfolios.

Using an international sample of over 800 defined benefit pension funds for 1990-2010, Andonov, Bauer, and Cremers (2012) document that about 80% of the generally large funds in their sample hold direct real estate investments in their portfolio in both 1990 and 2010.[1] In contrast, it is only in the last 10 years that these institutions have become significant investors in natural resources and infrastructure. For example, less than 1% of these large pension funds held any investments in natural resources or infrastructure in 2000. However, at the end of their sample in 2010, 32% of pension fund portfolios included investments in natural resources and 28% in infrastructure.[2] There are some regional differences. Specifically, U.S. funds are more likely to hold natural resources (35% of funds in 2010) rather than infrastructure investments (18% of funds in 2010), while the reverse holds in Canada (6% of funds in 2010 invested in natural resources, while 39% invested in infrastructure). European funds are particularly likely to invest in natural resources (52% of funds in 2010, versus 39% with infrastructure investments).

At the same time, the percentage of assets devoted to these alternative asset classes remains minor, at least in the portfolios of the large pension funds included in the Andonov, Bauer, and Cremers (2012) study. Among funds investing in real estate, on average 5.75% of the portfolio was allocated to this asset class in 2010. For natural resources and infrastructure, the portfolio weights among funds investing in these asset classes were on average below 1% in 2010.

For each asset class, in this paper we discuss some basic features of its overall market and of the performance of an index tracking the performance of direct investments therein. We employ publicly available data throughout. Due to data availability limits, we exclusively focus on U.S. data. The length of time for which we have available data on the quarterly investment performance differs across asset classes and is completely driven by the starting points for the available series. In general, we only use publicly available data that seem broadly representative for the asset class and are available for a reasonably long period of time. For direct investment in commercial real estate, the data go back to 1978, the longest sample. For direct investments in energy infrastructure, the data go back to 1996 only, constituting the shortest sample. For direct investments in timberland and farmland, investment performance data go back to 1987 and 1992, respectively. Our data set ends in December 2012.

The data on natural resources and commercial real estate investments come from the National Council of Real Estate Investment Fiduciaries (NCREIF), a not-for-profit trade association of institutional real estate professionals, and are based on data submitted by their members (generally institutional investors, mostly pension funds). The NCREIF indices reflect both income and appreciation returns, the latter of which are based on changes in quarterly appraisal values. The data on infrastructure are based on the Alerian MLP (Master Limited Partnership) Infrastructure Index, which is not directly investable but reflects the performance of constituents (25 energy infrastructure MLPs) that are publicly traded. As such, the infrastructure investments data we use are quite distinct from the NCREIF data. We discuss the various ways in which the data used are limited (such that the results summarized below should be interpreted with caution) in some detail in Section 2. For example, the appraisal-based quarterly data seem smoothed, which if taken at face value would underestimate their volatility, and the NCREIF investment data do not include the costs of managing the institutional portfolios. On the other hand, the investments data of Alerian MLP Infrastructure Index are based on traded prices of the constituent MLPs engaging in energy transport and storage. These data are

[1]See Aleksandar Andonov, Rob Bauer, and Martijn Cremers (2012), "Can Large Pension Funds Beat the Market?" working paper, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1885536.

[2]An important caveat is that the investments in natural resources include commodities, which are not considered in this paper. The pension fund holdings data used by Andonov, Bauer, and Cremers (2012) do not distinguish commodity investments versus direct investments in timberland and farmland.

The Performance of Direct Investments in Real Assets: Natural Resources, Infrastructure, and Commercial Real Estate

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Abstract

This paper considers the performance of direct investments in three real asset classes: natural resources (namely timberland and farmland), energy infrastructure, and commercial real estate. Using publicly available data for a period starting in 1978 (for real estate) or 1996 (for infrastructure) and ending in 2012, we document that investing in these real asset classes would have provided significant diversification benefits relative to a traditional portfolio consisting of only public equities and government bonds, without evidence of deteriorating overall performance. However, with the exception of timberland investments, the real asset classes did not provide any inflation hedging benefits over our time period. Further, the diversification benefits of direct investments in natural resources are lower in times that equity markets go down. Significant challenges of investing in real assets include illiquidity, generally long holding periods, and information uncertainty.

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Introduction to Global Financial Institute

Global Financial Institute was launched in November 2011. It is a new-concept think tank that seeks to foster a unique category of thought leadership for professional and individual investors by effectively and tastefully combining the perspectives of two worlds: the world of investing and the world of academia. While primarily targeting an audience within the international fund investor community, Global Financial Institute's publications are nonetheless highly relevant to anyone who is interested in independent, educated, long-term views on the economic, political, financial, and social issues facing the world. To accomplish this mission, Global Financial Institute's publications combine the views of Deutsche Asset & Wealth Management's investment experts with those of leading academic institutions in Europe, the United States, and Asia. Many of these academic institutions are hundreds of years old, the perfect place to go to for long-term insight into the global economy. Furthermore, in order to present a well-balanced perspective, the publications span a wide variety of academic fields from macroeconomics and finance to sociology. Deutsche Asset & Wealth Management invites you to check the Global Financial Institute website regularly for white papers, interviews, videos, podcasts, and more from Deutsche Asset & Wealth Management's Co-Chief Investment Officer of Asset Management Dr. Asoka Wöhrmann, CIO Office Chief Economist Johannes Müller, and distinguished professors from institutions like the University of Cambridge, the University of California Berkeley, the University of Zurich and many more, all made relevant and reader-friendly for investment professionals like you.

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