Beyond Real Estate:
Examining Global Real Asset Allocation Frameworks for Institutional Investors

by

Xiangyu Li
Sichuan University

Submitted to the Program in Real Estate Development in Conjunction with the Center for Real Estate in Partial Fulfillment of the Requirements for the Degree of Master of Science in Real Estate Development

at the

Massachusetts Institute of Technology

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Center for Real Estate
July 30, 2012

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Thesis Supervisor

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Chair, MSRED Committee, Interdepartmental Degree Program in Real Estate Development
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ABSTRACT

Real estate is often considered an asset to provide long term value enhancement and to protect institutional investors against inflation risk. It is a typical real asset due to the physical form and fixed geographic location with a steady return. However, real estate has its limitations. Risks associated with it such as lack of trading flexibility, special property management expertise required, and a growth prospect not always applicable towards the short term favor have impeded certain institutional investors from allocating major investment in real estate.

In management of a dynamic investment portfolio, how institutional investors look at certain real assets is the key issue discussed in this thesis. Infrastructure, for instance, which can refer to roll roads, shipping or railways, is a comparable asset with real estate as it demonstrates a term with physical form and stable income stream. There are other types of real assets such as commodity, regulated utilities, and maritime assets which are also studied.

This thesis delves into the dynamic structure of an institutional investment portfolio and targets to explore the following questions: What do real assets contribute to institutional investors’ traditional stock-and-bond portfolio? What kinds of correlations do real assets have with typical equity and fix-income assets? How do institutional investors strategize their investment plan by allocating real assets in their global portfolio?

The thesis is designed to study the underlying factors for determining the asset allocation framework from both a qualitative and a quantitative perspective. A quantitative analysis including mean-variance optimization, downside risk, correlations, risk parity and Value at Risk will test out how various asset allocation frameworks position real assets in a portfolio. The study also brings in selected real estate indexes to examine how different parings compare with each other and what impact does illiquidity exhibits on portfolio management. An interview-based research is designed to provide understanding of institutional investors’ perspective on how they apply the theoretical framework to the real world practice and how they strategize the management of investment portfolios.

Thesis Advisor: David Geltner
Title: Professor of Real Estate Finance
Acknowledgement

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Last, I would like to dedicate this thesis as a conclusion of my year at MIT to my parents, Shurong Lu, Zhi Li and my family members for supporting me throughout the year.

-Xiangyu Li
TABLE OF CONTENTS

Chapter 1  Introduction........................................................................................................................................... 11
  1.1  Research Motivation ........................................................................................................................................ 11
  1.2  Research Outline .............................................................................................................................................. 12
Chapter 2  An Overview of Real Asset for Institutional Investors ................................................................. 14
  2.1  Definition ......................................................................................................................................................... 14
  2.2  Real Asset Classification .................................................................................................................................. 14
  2.3  Asset Allocation Framework Review ................................................................................................................ 15
  2.4  Literature Review ............................................................................................................................................ 17
Chapter 3  Correlation Analysis ............................................................................................................................. 20
  3.1  Objective ......................................................................................................................................................... 20
  3.2  Data Resource and Methodology ................................................................................................................... 20
  3.3  Methodology ................................................................................................................................................... 21
  3.4  Correlation Analysis ....................................................................................................................................... 21
Chapter 4  Portfolio Analysis .................................................................................................................................. 34
  4.1  Literature Review ............................................................................................................................................ 34
  4.2  Data and Methodology ................................................................................................................................... 35
  4.3  Portfolio Analysis ............................................................................................................................................ 37
  4.4  Conclusions ...................................................................................................................................................... 44
Chapter 5  Value at Risk Analysis ............................................................................................................................ 46
  5.1  Definition ......................................................................................................................................................... 46
  5.2  Data and Methodology ................................................................................................................................... 46
  5.3  Portfolio Simulation .......................................................................................................................................... 49
  5.4  Downside VaR ................................................................................................................................................. 55
  5.5  Traditional Portfolio Model ............................................................................................................................. 56
  5.6  Conclusions ...................................................................................................................................................... 59
Chapter 6  Quantifying Liquidity for Real Asset Transaction in a Mixed Portfolio ........................................... 60
  6.1  Objective ......................................................................................................................................................... 60
  6.2  Data Resource and Methodology ................................................................................................................... 60
  6.3  Rebalancing Analysis .................................................................................................................................... 60
  6.4  Conclusions ...................................................................................................................................................... 68
Chapter 7  Institutional Investors’ Asset Allocation Strategy .............................................................................. 69
  7.1  Objective ......................................................................................................................................................... 69
  7.2  Interviewee Selection ....................................................................................................................................... 69
  7.3  Research Methodology .................................................................................................................................. 69
  7.4  Questionnaire .................................................................................................................................................. 70
7.5 Topics and Discussion ......................................................................................................................... 71

Chapter 8 Final Conclusions .................................................................................................................... 77

BIBLIOGRAPHY ........................................................................................................................................ 85

APPENDIX ................................................................................................................................................ 88

Appendix 1-NPI, REIT-based PureProperty & CPPI Indices (2000-2012) ............................................. 88
Appendix 2-Summary of Sharpe-Markowitz Portfolio .............................................................................. 89
Appendix 3-Value at Risk Test Summary ................................................................................................. 99
Chapter 1  Introduction

1.1  Research Motivation

Investors have always been adapting and adjusting to the changing economic environment. Managing portfolios of assets has been a major challenge for investment managers on both institutional and individual levels. While there are various ways to look at a mixed portfolio, this thesis delves into the institutional level to study the framework of an investment portfolio that derives from the traditionally equity-bond heavy composition and explores the roles of different real assets that provide capital appreciation and stable income stream and different risk outlook as part of a mixed portfolio.

Traditionally, institutional investors have placed little weights on real assets such as real estate, infrastructure, and commodity when managing a large pool of assets. The following diagram shows the typical allocation framework for institutional investors.¹

Figure 1-Institutional Plan Sponsor Asset Allocation Framework

![Allocation by Percentage](image)

Source: 2012 Institutional Real Estate Investor Survey

Traditionally, institutional investors have allocated around 10% to real estate. While traditional equity and fix-income assets still account for the majority of institutional investors’ portfolio, is there a potential to examine real estate and other real assets’ roles in a mixed portfolio from a different perspective? Even

¹ 2012 Institutional Real Estate investor Survey
though real estate was hit hard during the financial crisis and was a catalyst for the derivative market crack down, it has historically been providing stable income that is comparable with bonds as well as a volatility that is much less than stock. Certain infrastructure assets also act on par with real estate. So the question comes down to how a series of real assets such as real estate, infrastructure, and commodity perform in a portfolio that includes traditional stocks and bonds. How do these real assets act in terms of inflation hedging, diversification, and return enhancement roles?

1.2 Research Outline

The author structures the thesis in a framework that synergizes the different quantitative models to test out the compatibility of these models. At the same time, the thesis looks into the associated issues concerning certain asset classes to revisit the model. Then the thesis adds in a qualitative interview-based research to solidify the findings in managing a mixed investment portfolio and intends to explore the explanation of the disparity between model results and actuality.

While chapter 1 introduces of the thesis motivation and questions, chapter 2 studies the traditional allocation framework for institutional investors and looks at the characters of real assets. It also traces back to past industry publications and academic researches which focus on asset allocation and portfolio management. Chapter 3 goes into the detailed portfolio analysis. A correlation analysis looks at the relationship among different assets, including stock, bond, commodity, infrastructure, inflation, oil, and real estate. This part also explores the effect of the financial crisis on these correlations and intends to find implications based on different time frames. Then the thesis focuses on the portfolio analysis using Modern Portfolio Theory to test out roles of selected real assets and compare these models with downside risk models as well. Chapter 4 takes the portfolio analysis further and creates Monte Carlo simulation using the portfolio weights developed in chapter 3 to look at the Value-at-Risk of the portfolio and compares both standard risk model and downside risk model. Then the thesis takes a typical institutional investment portfolio and applies the Value-at-Risk model to it and compares the potential loss factor among the selected portfolios. Chapter 5 intends to study the liquidity issue using the PureProperty index and explores the relationship between rebalancing individual assets within the REIT index and the transaction/management cost effect. Chapter 6 takes a step back and reflects the thesis topic on institutional investors. This chapter is interview based and involves open discussion regarding topics on investment strategy. Chapter 7 concludes the analysis and discussion.
Below is a diagram showing the structure of this thesis:

Figure 2-Thesis Structure

Examining global real asset allocation frameworks for institutional investors

- Traditional Allocation Framework
  - Industry and Academic Study
    - Analysis Review
    - Correlation Analysis
      - Portfolio Analysis
        - Downside Risk Portfolio Analysis
          - Value-at-Risk Analysis
            - Conclusions
        - Allocation Framework
          - Open Discussion
            - Interview-based research
              - Allocation Strategy
                - Diversification Strategy
                  - Investment Criteria
                    - Liquidity Strategy
Chapter 2  An Overview of Real Asset for Institutional Investors

2.1 Definition

Broadly speaking, real asset is defined as “actual, tangible asset (such as valuable antique or art, buildings, coins, commodity, machinery and equipment, stamp collection) as opposed to financial assets (such as bonds, debentures, shares).”\(^2\) Such assets usually have a utility for their owners. They are generally held to protect investors from inflation. Some argue that “real assets ought to be valuable for portfolio diversification because widely diversified portfolios of stocks and bonds are strongly negatively correlated with inflation. Thus real assets are important partly because they might provide a kind of inflation insurance for other assets in the portfolio.”\(^3\)

Real estate is a type of real asset, but not all real estate types are. In a 2011 PREA Quarterly article, panels\(^4\) specifically discussed the category of real assets and stated that core real estate belongs to real asset, but opportunistic properties such as distressed commercial properties don’t provide a long standing hedging effect to their holders. Rather, these properties don’t usually have a correlation to the normal investment portfolios. They provide high alpha liquidity if invested as opportunistic assets, but not beta contribution. Therefore, real estate here refers to core real estate with income generating function. Harvard Business School professor Kenneth A. Froot noted that even though real estate is a real asset, the properties of real estate are not often compared with other real assets such as commodity-linked equities or CPI-linked bonds.

2.2 Real Asset Classification

So what assets can be categorized as real assets? Investors’ understanding of a real asset can be different. Here the term “real” has two distinct financial meanings: real return after adjusting for inflation; real asset that is tangible with intrinsic value.\(^5\) We can see that physically tangible assets such as railroads, toll roads, and real estate properties can be real assets. Commodity, including agricultural products such as corn, sugar, rice, and bean can also be real assets. The futures commodity market has generally been volatile across time. Natural resources are also a major category of real assets. This includes energy

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\(^2\) Definition from “businessdictionary.com”.


\(^4\) Cate Polloey, Bryan Decker, John N. Daly, J. J. Carlson, “Real Assets in an Institutional Portfolio: A Roundtable Discussion”, PREA Quarterly, Fall 2011

resources such as electricity, gas, coal, and oil. There are assets that bear ambiguous definition of real assets as they appear in between real asset and financial assets. REITs, for example, are securitized assets that can gain entry to the physical context of real estate. Infrastructure holding companies are also traded in the stock market but are directly linked to the infrastructure assets such as toll roads and shipping facilities. Therefore, there is a broad definition of real asset and many assets can be within this category. The criterion is more on the character of the asset than on industry associated with it.

2.3 Asset Allocation Framework Review

What are the traditional asset allocation frameworks for institutional investors? Pension Real Estate Association conducted an annual survey to show the real estate investment activities in the context of public and private retirement plans, foundations, and endowments. The surveyed institutions are those who invest in real estate either directly or indirectly.

Asset Allocation by Types

Figure 3 shows the plan sponsor asset allocation framework in 2010. “The real estate holdings (private and public) for the reporting group were $2.36 billion, or 9.8% of the investor total assets.” 6 Traditionally, equity and fix-income have taken up the majority of the investment. Real estate has been in the range between 5% and 10% in the past decade. Stock has been in the 50% range whereas bond is 25%. The allocation framework has been constant in the past decade with minor changes among asset classes.

Figure 3-PREA Surveyed 2010 Plan Sponsor Asset Allocation

Source: PREA Investor Report, July 2011

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6 PREA Investor Report, July 2011
Asset Allocation by Strategies

Figure 4 shows the private real estate investments by strategy for all plans in 2010. Even though core strategy takes half of the total investment volume, it has been decreasing from around 70% since 2004 according to PREA. Opportunistic strategy has been increasing from less than 15% to over 25% in 2010. The figures have been stable from 2008 to 2010, which are all post financial crisis numbers. 25% of institutional investors have more than 10% allocation to real estate.

Figure 4-PREA Surveyed 2010 Plan Sponsor Asset Allocation (by strategy)

2010 Plan Sponsor Asset Allocation (by Strategy)

- Core, 74,083, 52%
- Value-Added, 26,985, 19%
- Opportunistic, 41,368, 29%

Source: PREA Investor Report, July 2011

It appears that investors still favor core assets as they provide safe and healthy income despite lower returns. There was a phase when investors increase their investment in opportunistic assets before the financial crisis but have been stabilizing after the crisis. Investors have since been cautious about opportunistic investing because of the risk and the uncertainty.

Figure 5 shows the comparison between investors plan size among the three private real estate investment strategies. Larger plans tend to dominate the opportunistic investment as such investment requires certain risk tolerance and large capital scale. Smaller plans have a lead on the core investment as there is a large diversity in core market.

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7 Excludes debt and investments not readily allocable by strategy.
2.4 Literature Review

In 1995, Harvard Business School professor Kenneth A. Froot examined the hedging properties of real assets for a series of diversified portfolios. The research found out that “long exposures to a number of real assets—gold, the CRB index, commodity-linked equities, and, particularly, broad real estate indexes—provide relatively weak hedges for broadly diversified portfolios.” This finding poses an interesting perspective to the current thesis topic as we target to find out over the past 30 years, what role has real estate performed in a typical investment portfolio. What strategies do institutional investors use to navigate the weights among different real assets?  

Zia Mohiuddin Ansari, Erasmus Univesity Rotterdam, studied the shipping role in portfolio risk management in a research paper conducted in 2006. Categorized as a real asset, shipping is an important class for large institutional investors in managing their portfolio risk. The paper examined the risk and return tradeoffs of shipping stocks by looking at it with regard to a set of portfolio management issues and by studying the industry cycles. The paper concluded that the systematic risk factors of shipping securities are dependent upon company specific factors and other macro and micro economic factors, which is indicative of how investment institutions should strategize the asset allocation to shipping.

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8 Kenneth A. Froot, “Hedging Portfolios with Real Assets—which real assets can help protect financial portfolios?” 1995
9 Zia Mohiuddin Ansari, “Portfolio Risk Management in Shipping Real Assets and Shipping Security Assets”, Erasmus University Rotterdam, 2006
In 2007, Alternative Investment Analytics studied the role of commodities in an institutional portfolio as a real asset by examining the optimal asset allocation for a target return to several selected real assets including TIPS, NCREIF, Bond, and Equity. The research found out that “real assets may contribute substantially to traditional stock and bond portfolios.” And that “certain real assets, such as the BCI commodity index may serve as a hedge against inflation risk.”  

In a 2011 research by Mellon Capital Research, real asset is defined as those that “retain purchasing power when paper currencies lose buying power. That is, real assets increase in nominal price at least as fast as inflation.” The author concluded from the research that the real assets including physical real estate, land, physical commodities, and TIPS have hedging and diversification roles in stock and bond heavy portfolios but managing diversified physical real estate and land requires operational skill, which leads to a liquidity concern in this thesis research that intends to take into account. 

In a 2011 academic research by Technische Universitat Munchen, Rothballer and Kaserer studied the infrastructure’s role in risk management and found out that infrastructure stocks on average exhibit significantly lower market risk than other equities while there is large variation among different infrastructure classes. The study concluded that infrastructure can be characterized as an ‘average volatility, low beta’ business, implying that infrastructure firms have a similar level and an even higher share of idiosyncratic risk compared with other equities. 

In a 2012 research paper published by J.P. Morgan Asset Management, Joseph, Dessner, and Santiago, together with the research team, explored the inflation issue in asset allocation strategy by examining historic performance of different assets with respect to their effectiveness against inflation. The paper also looked at the active and passive strategies in managing inflation risks to study what is a practical way to react to inflation change in both downturn and growth periods. 

More recently in April 2012, J.P. Morgan published a research on asset allocation framework for global real assets that includes real estate, infrastructure, natural resources and transport. By examining such

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factors as growth, inflation, return structure, risk profile, diversification, and the nature of asset classes, the study boldly suggests that in the next decade or so, there is possibility that portfolio allocations to real assets could increase to as much as 25%.\textsuperscript{14}

In June, 2012, McKinsey & Company published a study on alternative investments and explores the growth potential within the asset management community. The research explores the resurgent demand for alternative investments by examining the alternatives allocation in the global institutional market. The study also predicts that asset managers are expected to increase their alternative-like products by 5 percentage points in the next several years.\textsuperscript{15}


\textsuperscript{15} Onur Erzan, Kurt MacAlpine, Nancy Szmolyan, “The mainstreaming of alternative investments-fueling the next wave of growth in asset management”, McKinsey & Company, June 2012
3.1 Objective

This chapter is structured on a set of quantitative models to study the correlations between different asset returns. The models are designed to test the hedging potential of different assets against stock and inflation, the impact of financial crisis on diversification, and the long term co-movement between different assets.

3.2 Data Resource and Methodology

In order to study the asset allocation, the author identifies several asset classes to construct typical investment portfolios comprising stock and bond.

- Real estate index (NCREIF Property Index, 1978 to 2009), to represent US real estate annual index.\(^\text{16}\)
- Infrastructure (A composite index comprised of S&P 500 Railroad, S&P 500 Utility and S&P Healthcare, 1975-2009), a running average of the total returns of the three indexes to represent infrastructure annual index.\(^\text{17}\)
- Commodity (S&P GSCI, 1975-2009), formerly the Goldman Sachs Commodity Index, to represent the overall commodity price index.
- Stock (S&P 500 index, 1975-2009), to represent US stock market annual index.
- Risk-free rate (USA Total Return T-Bill Index, 1975-2009), to represent the average risk-free rate in the portfolio analysis.

Additional data:
In order to compare different asset classes’ co-movement, the study also includes the following additional data sets in the additional analysis:

\(^{16}\) NCREIF Property Index started in 1978
\(^{17}\) Historic index for healthcare only started in 1987. The thesis creates an average of S&P 500 Railroad and S&P 500 Utility represent the index from 1975-1986, average of all three indexes total return to represent the composite index from 1987-2009.
• Oil price (West Texas Intermediate Oil Price, 1975-2009), to represent annual price index of oil.
• CPI index (USA Consumer Price Index, 1975-2009), to represent overall consumer price in the US.
• Farmland (NCREIF Farmland, 1992-2009), to represent farmland annual index as a subcategory of real estate.
• Timberland (NCREIF Timberland, 1987-2009), to represent timberland annual index as a subcategory of real estate.

3.3 Methodology

In this chapter, the author constructs correlation analysis to test out how different asset classes move in relation to others. The models examine how these assets link to stock movement, how they hedge against inflation, and what impact the financial crisis has on these assets. The structure of the models is based on different spans of time period and different pairing possibilities. Stock and bond are set as the base to be compared with, then inflation is tested against several selected assets, and several additional assets are tested as well.

3.4 Correlation Analysis

Figure 6 compares mean and standard deviation of several assets. Real estate and US long term Treasury bond share similar character as they both exhibit low risks. On the other hand, they have relatively low returns as well. Infrastructure has slightly higher mean than stock with a comparable risk as stock. Commodity, in general, has a high volatility. Oil price, as a subcategory of commodity, has an even higher volatility than commodity because of its risk associated with global market uncertainty.
Correlation Analysis

First, we compare stock and bond with commodity, infrastructure and real estate for the period from 1975 to 2009 to include complete economic cycles.¹⁸

Correlation for 1975-2009

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P GSCI</th>
<th>Composite Infra</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500 Stock</td>
<td>0.10</td>
<td>0.76</td>
<td>0.14</td>
</tr>
<tr>
<td>US 10-year</td>
<td>-0.18</td>
<td>0.24</td>
<td>-0.05</td>
</tr>
<tr>
<td>Treasury Bond</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both real estate and commodity have low correlation with stock. Infrastructure has a high correlation with stock. Both real estate and commodity have negative correlations with long term Treasury bond. Infrastructure also has a higher correlation with stock than real estate and commodity do.

Then we add in the data from 2010 to 2011 to see how the past two years affected the correlation.

Correlation for 1975-2011

¹⁸ The selection of time frame is based on the decision to include both the periodic peak and bottom points in the history of stock, bond, commodity, infrastructure and real estate.
The extension of data presents similar results. Both real estate and commodity have low correlation with stock and negative correlations with long term Treasury bond. Infrastructure maintains a high correlation with stock and bond.

Then we take out the data from 2008 to 2011 to look at the historic movement from 1975 to 2007.

**Correlation for 1975-2007**

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P GSCI</th>
<th>Composite Infra</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500 Stock</td>
<td>-0.14</td>
<td>0.72</td>
<td>0.06</td>
</tr>
<tr>
<td>US 10-year</td>
<td>-0.12</td>
<td>0.37</td>
<td>-0.23</td>
</tr>
<tr>
<td>Treasury Bond</td>
<td>-0.19</td>
<td>0.24</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

Now something interesting happens. Commodity goes negatively correlated to stock. NCREIF NPI moves even further less correlated to stock from 1975 to 2007 than from 1975 to 2009/2011, and goes much more negatively correlated to Treasury bond. The impact of financial crisis helps bring real estate and commodity down together with stock.

**COMMODITY VS STOCK**

Figure 7-Stock and Commodity Historic Index (1975-2011)

![Stock and Commodity Historic Index (1975-2011)](image-url)

Source: Global Financial Data
Figure 7 shows how stock index moves with commodity. Notice how stock fluctuates in the past 20 years to several major cycles and how commodity has minor but more frequent fluctuations.

Figure 8 - Stock and Commodity Historic Annual Return (1975-2011)

Co-movement:
From the correlation matrix for 1975-2009, commodity has a correlation of 0.10 with US stock. From the correlation matrix for 1975-2011, commodity has a correlation of 0.11 with US stock. However, if we take out the data during financial crisis from 2008 to 2009, we get a correlation of -0.14 between S&P 500 and S&P GSCI. This result indicates that historically, commodity is negatively correlated with US stock market. But with the financial crisis, both the stock market and commodity price moved down significantly and in the past two years, both asset classes move together.
Figure 9 shows how stock index moves compared with real estate. Real estate has been growing steadily before late 2007. It also took a hit slightly before the financial crisis.

Figure 10-S&P 500 and NCREIF NPI Historic Annual Return (1975-2011)
Co-movement:
From the correlation matrix for 1975-2009, real estate has a correlation of 0.14 with US stock.
From the correlation matrix for 1975-2011, real estate has a correlation of 0.13 with US stock.
If we take out the data during financial crisis from 2008 to 2011, we get a correlation of 0.06 between S&P 500 and real estate. This result indicates that historically, real estate has low correlation with US stock market. But with the financial crisis, both the stock market and real estate moved down in somewhat close ties in the past two years. Different from the movement of commodity, real estate exhibits some kind of lag.

INFRASTRUCTURE VS STOCK

Figure 11-S&P 500 and Composite Infrastructure Historic Index (1975-2011)

Figure 11 shows how infrastructure moves compared with stock. Infrastructure took a smaller hit the late 1990s internet bubble than stock, and also has a smaller drop during the financial crisis and now bounces back further than stock.
Co-movement:
From the correlation matrix for 1975-2009, infrastructure has a correlation of 0.76 with US stock.
From the correlation matrix for 1975-2011, infrastructure has a correlation of 0.75 with US stock.
If we take out the data during financial crisis from 2008 to 2011, we get a correlation of 0.72 between S&P 500 and infrastructure. This indicates that even with the financial crisis starting in 2008, both transportation and stock move very closely. Therefore, infrastructure is highly correlated with the US stock market regardless of the financial crisis impact.

**COMMODITY, REAL ESTATE AND INFRASTRUCTURE VS INFLATION**

Then, we examine how several real assets react to CPI in order to understand their hedging role against inflation. \(^{19}\)

**Correlation for 1975-2011**

<table>
<thead>
<tr>
<th>Inflation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P GSCI</td>
<td>-0.01</td>
</tr>
<tr>
<td>Composite Infra</td>
<td>0.22</td>
</tr>
<tr>
<td>NCREIF NPI</td>
<td>0.40</td>
</tr>
</tbody>
</table>

\(^{19}\) NCREIF data started from 1978
Co-movement:

From the correlation matrix for 1975-2007, 1975-2009, 1975-2011, commodity has a negative correlation of between -0.03 and -0.01 with US Inflation.

Infrastructure and real estate both have a relatively high correlation between 0.22 and 0.42, which indicates that infrastructure and real estate may be good hedges against inflation.

Figure 13-Annual Returns of Selected Assets VS Inflation Movement

Figure 13 shows the annual return of commodity, infrastructure and real estate compared with inflation adjusted for scale of movement. Commodity has been consistently volatile throughout the period. Infrastructure appears less volatile than commodity, but still higher than real estate.

**OIL VS INFLATION, STOCK AND COMMODITY**

What about oil’s correlation with stock and inflation? We construct the same correlation analysis, below is the result.

**Correlation for 1975-2011**

<table>
<thead>
<tr>
<th></th>
<th>WTI Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP500Stk</td>
<td>0.09</td>
</tr>
<tr>
<td>SP GSCI</td>
<td>0.62</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.07</td>
</tr>
</tbody>
</table>

**Correlation for 1975-2009**

<table>
<thead>
<tr>
<th></th>
<th>WTI Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP500Stk</td>
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</table>

**Correlation for 1975-2007**

<table>
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<tr>
<th></th>
<th>WTI Oil</th>
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</thead>
<tbody>
<tr>
<td>SP500Stk</td>
<td>-0.13</td>
</tr>
<tr>
<td>SP GSCI</td>
<td>0.61</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.19</td>
</tr>
</tbody>
</table>

From the correlation matrix for 1975-2007, oil has a correlation of -0.13 with US stock. From the correlation matrix for 1975-2009, oil has a correlation of 0.09 with US stock. From the correlation matrix for 1975-2011, oil has a correlation of 0.09 with US stock. Oil price was impacted by the financial crisis and moved somewhat closer with the stock market, although not enough to indicate any strong co-movement with stock.

From the correlation matrix for 1975-2007, 1975-2009, 1975-2011, oil always has a high correlation with commodity, which indicates that oil, as a type of commodity, exhibits similar characteristic to general commodity in terms of annual index fluctuation.
Interestingly, oil price has relatively lower correlation with inflation than do real estate and infrastructure, indicating that oil may not be as good an inflation hedge as real estate and infrastructure.  

REAL ESTATE, FARMLAND, TIMBERLAND VS STOCK

Then, we take the three sub asset classes within real estate to look at the performance of each individual asset with stock. Quarterly return is used in place of annual return for the period between 1992 and 2012. The correlation matrix is as below:

<table>
<thead>
<tr>
<th></th>
<th>NCREIF NPI</th>
<th>NCREIF Farmland</th>
<th>NCREIF Timberland</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP500Stk</td>
<td>0.19</td>
<td>0.11</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Figure 14-Scatter Plot of Returns and Risks among Selected Assets (1989-2011)

Risk-return analysis (return is expressed as quarterly return)

<table>
<thead>
<tr>
<th></th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>NCREIF NPI</th>
<th>NCREIF Farmland</th>
<th>NCREIF Timberland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.37%</td>
<td>1.79%</td>
<td>2.00%</td>
<td>2.77%</td>
<td>2.51%</td>
</tr>
<tr>
<td>Risk</td>
<td>8.35%</td>
<td>4.38%</td>
<td>2.45%</td>
<td>3.26%</td>
<td>3.93%</td>
</tr>
</tbody>
</table>

20 Kenneth A. Froot, Hedging Portfolios with Real Assets-which real assets can help protect financial portfolios? 1995
From the Mean-variance graph, we can see that traditional real estate index (NCREIF NPI) has lower average quarterly return than stock, and slightly higher average quarterly return than Treasury bond. The quarterly risk is less than half of stock for real estate NPI. Both farmland and timberland have higher returns than stock and less than half the risk of stock. Stock market is much more volatile in terms of quarterly performance than the three real estate indices. Among the three real estate categories, farmland and timberland have shown attractive return-variance prospect.

Figure 15- Quarterly Historic Index (1992-2011)

From the quarterly index, we can see that real estate was more severely affected by the financial crisis than farmland and timberland. Farmland was not as driven down as timberland during the financial crisis. Farmland has been surging throughout the data period. However, no indication of industry background was given at this stage of the thesis.
If the numbers hold and we assume this 20-year period data somehow represents the market in general, then by including real estate, especially farmland and timberland in a stock and bond portfolio will largely reduce the portfolio risk. Farmland and timberland also offer competitive return prospect. However, the data is only based on a period spanning 20 years, which may not cover an economic cycle that is of appropriate scale to ensure the application of the result.

**Conclusion**

The correlation analysis among different assets provides some interesting results to look at the diversification and hedging potential of different assets. Both commodity and real estate have low or negative correlations with stock, but both were hit by the financial crisis in 2008, which increases their correlation with stock. Infrastructure, on the other hand, has a very high correlation with stock and moves alongside the stock during the financial crisis.

Both infrastructure and real estate have a notable correlation with inflation, indicating that these assets can be held to at least partly hedge against inflation. Commodity, however, has a negative correlation with inflation, which is interesting to note. Oil price has little correlation with stock and inflation, and has a high correlation with commodity. As oil is also a type of commodity, it somehow exhibits a similar character as commodity index.
Farmland and Timberland in the NCREIF index, interestingly, show a similar character to NCREIF NPI except that the effect of financial crisis has limitation on these two assets. Both of these two assets have comparable returns as stock, but less volatile than stock. They have great potential for those investors who seek high return and comparable risk level as real estate. The data history for farmland and timberland is relatively short, which may not cover the full spectrum of the market.
Chapter 4  Portfolio Analysis

4.1 Literature Review

Modern Portfolio Theory was development in the 1950s through 1970s. The theory is developed to maximize portfolio expected return for a given amount of portfolio risk by comparing and adjusting the portions of various assets in the portfolio. Modern Portfolio Theory, although has its limitation in the financial industry, has been widely recognized as a common tool in the portfolio management fields. MPT was first introduced by Harry Markowitz in a 1952 article later was included in a book\textsuperscript{21}.

MPT makes the assumption that investors are risk averse. Given different portfolios with the same expected return, investors would always prefer the least risky one. As expected return increases, investors will have to take on additional risk. However, in real world, different investors have different investment strategies. But MPT assumes that a rational investor would always choose a portfolio with high return and low risk. In a portfolio, the combination of assets can be different. There are correlations between any two assets which affects the portfolio variance. Investors can hold a portfolio that can take advantage of diversification by reducing overall portfolio risk. Markowitz and Andrew Brennan have developed such theories along the way.

Groups of compositions including stock and bond are constructed in comparison with a starting case that only includes stock and bond. The comparison is to look at how commodity, infrastructure and real estate impact the overall variance given a certain target return and how bringing different real estate indexes affect the efficient frontiers.

\textsuperscript{21} According to Wikipedia.
4.2 Data and Methodology

The portfolio analysis uses a series of compositions to represent an investment portfolio and intends to compare different roles certain real assets play. The author divides the pairing to two sets: one with the standard volatility analysis, using standard deviation of each asset class as the risk; the second set uses the downside risk in place of standard volatility to test out how downside risk compares with standard risk.

Figure 17-Portfolio Analysis Data List

<table>
<thead>
<tr>
<th>Asset bucket</th>
<th>Data Category</th>
<th>Data Source</th>
<th>Notes</th>
<th>Provider</th>
<th>Start Year</th>
<th>End Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Estate</td>
<td>US NCREIF NPI</td>
<td>Total Return</td>
<td>NCREIF</td>
<td>1978</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>Real Estate</td>
<td>REITs Index</td>
<td>Total Return</td>
<td>FTSE</td>
<td>1975</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>Commodity</td>
<td>S&amp;P GSCI</td>
<td>Total Return</td>
<td>GFD</td>
<td>1975</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>Stocks &amp; Bonds</td>
<td>S&amp;P 500</td>
<td>Total Return</td>
<td>GFD</td>
<td>1975</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>T-Bond</td>
<td>US 10-year Treasury Bond</td>
<td>Total Return</td>
<td>GFD</td>
<td>1975</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>T-Bill</td>
<td>USA Total Return T-Bill Index</td>
<td>Average Return</td>
<td>GFD</td>
<td>1975</td>
<td>2009</td>
<td></td>
</tr>
</tbody>
</table>

Constraints:

1. The sum of all weights among different assets within a portfolio equals 1.

\[ \sum_{i=1}^{n} W_i = 1 \]

Where \( n \) denotes the total number of assets modeled in the analysis

2. All the weights for asset classes are non-negative.

3. Portfolio mean return is expressed as the mean of each asset multiplied by the weight of that asset:

\[ E(r_p) = w_i \ast E(r_i) \]

4. Portfolio variance is expressed as the weight of each asset multiplied by the weight of the comparing asset, multiplied by the covariance between these two assets:

\[ \sigma_{p, i} = w_i \ast w_j \ast \text{Cov}(r_i, r_j) \]

---

22 Here the author uses FTSE NAREIT Equity REIT index to represent PureProperty with haircut modification as noted in the preceding paragraphs.

$$Var_p = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j Cov_{i,j}$$

Where n denotes the number of asset classes within this specific portfolio

$$Cov_{i,j} = \sigma_i \sigma_j Cor_{i,j}$$

Where $Cov_{i,j}$ denotes the covariance between asset i and j, $\sigma_i$ denotes the standard deviation of asset i, and $Cor_{i,j}$ denotes the correlation coefficient between assets i and j’s annual returns.

Figure 18-List of Pairing Tests

<table>
<thead>
<tr>
<th></th>
<th>Standard Volatility</th>
<th>Downside Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stock, Bond</td>
<td>Stock, Bond</td>
</tr>
<tr>
<td>2</td>
<td>Stock, Bond, Real Estate</td>
<td>Stock, Bond, Real Estate</td>
</tr>
<tr>
<td>3</td>
<td>Stock, Bond, Commodity, Infrastructure</td>
<td>Stock, Bond, Commodity, Infrastructure</td>
</tr>
<tr>
<td>4</td>
<td>Stock, Bond, Commodity, Infrastructure, Real Estate</td>
<td>Stock, Bond, Commodity, Infrastructure, Real Estate</td>
</tr>
<tr>
<td>5</td>
<td>Stock, Bond, Commodity, Infrastructure, Real Estate, PureProperty</td>
<td>Stock, Bond, Commodity, Infrastructure, Real Estate, PureProperty</td>
</tr>
</tbody>
</table>
4.3 Portfolio Analysis

Standard Volatility
First, we run the efficient frontier for standard volatility.

Below is the result of portfolio compositions at different mean targets:

Figure 19: Markowitz Portfolio Comparison

According to the efficient frontier diagram, we can see that real estate has a better diversification role than infrastructure and commodity. With the same target return, the stock/bond portfolio with real estate has lower portfolio volatility than that with commodity and infrastructure. The portfolio with stock, bond and real estate will still benefit from including commodity and infrastructure from a diversification perspective, especially when target return is high. This is because real estate has a relative low return but also a low volatility measured by standard deviation. In contrast, infrastructure has a high mean return, which, when added to the portfolio, increases the target return.

---

Figure 20 shows area chart of efficient frontier at different target returns.

Figure 20-Asset Composition of the Efficient Frontier with Stock, Bond, Commodity, Infrastructure and Real Estate

![Efficient Frontier Chart](image)

Source: Global Financial Data, NCREIF

From the above comparison, we can see that with the introduction of real estate, commodity and infrastructure, for a certain mean target, real estate and infrastructure have major roles. Stock is stable throughout the different target return points. Treasury bond has also a stable role until target return increases close to the highest possible for the portfolio. Commodity contributes relatively little to the optimum portfolio composition. Why is it so?

Let’s look back at the mean-volatility matrix for these assets:

<table>
<thead>
<tr>
<th></th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>SP GSCI</th>
<th>Composite Infra</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.132</td>
<td>0.089</td>
<td>0.094</td>
<td>0.139</td>
<td>0.091</td>
</tr>
<tr>
<td>Volatility</td>
<td>0.175</td>
<td>0.108</td>
<td>0.236</td>
<td>0.178</td>
<td>0.083</td>
</tr>
</tbody>
</table>

Commodity has the highest volatility of 0.236 with the lowest average mean among the five assets. To minimize the portfolio variance with a target portfolio return, commodity starts with some weights as the expected return is fixed low from the start, but as the expected return increases, infrastructure starts to take away weights.

But what about correlation?
Correlation for 1975-2009

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P GSCI</th>
<th>Composite Infra</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500 Stock</td>
<td>0.10</td>
<td>0.76</td>
<td>0.14</td>
</tr>
<tr>
<td>US 10-year Treasury Bond</td>
<td>-0.18</td>
<td>0.24</td>
<td>-0.05</td>
</tr>
</tbody>
</table>

Commodity has a relatively low correlation with stock and a negative correlation with bond. This enables commodity to take at least some weights in the portfolio. But so does real estate. We look at the composition of all five assets in Figure 20, and we can see that real estate overshadows commodity in the optimum portfolio composition from the start. Why? From the correlation matrix, real estate has a similar correlation with stock and bond as commodity does, the average mean is also similar to commodity, but has a much lower volatility than commodity does. Therefore, to minimize the portfolio variance with a target mean, real estate overtakes commodity in that with the same contribution to mean, real estate has a lower volatility to contribute to the portfolio. With the inclusion of infrastructure, the high return and similar volatility as stock provides a very plausible alternative in an investment portfolio.

**PureProperty**

At last, we include PureProperty index in the overall portfolio analysis. Since PureProperty has only around 10 years of data, the author compares it with REITs index as PureProperty is the stock market's valuation of the REITs' properties as indicated by REIT equity share prices.

Figure 21-PureProperty, REIT and NPI Historic Index (1999-2011)

Source: NCREIF, FTSE, NAREIT
We construct the correlation among the three indexes from 1999 to 2009:

<table>
<thead>
<tr>
<th>PureProperty</th>
<th>NPI</th>
<th>REITs</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.88%</td>
<td>99.18%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 22-PureProperty, REIT and NPI Annual Returns (1999-2011)

And the mean-volatility matrix from 1999-2009:

<table>
<thead>
<tr>
<th></th>
<th>PureProperty</th>
<th>NPI</th>
<th>REITs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>9.76%</td>
<td>9.53%</td>
<td>14.24%</td>
</tr>
<tr>
<td>Volatility</td>
<td>11.17%</td>
<td>11.05%</td>
<td>22.42%</td>
</tr>
</tbody>
</table>

As PureProperty has an almost perfect correlation with REITs (as it is derived from original REITs index), the model uses REITs data from 1975-2009 to represent PureProperty and made the following haircut:

Mean: PureProperty has a risk premium at 1/2 the REITs risk premium
Volatility: PureProperty has 1/2 of the volatility of REITs
Correlation: we use the same correlation of REITs to other assets as the correlation of PureProperty to other assets as PureProperty has an almost perfect 100% correlation with REITs.

Below is the area chart of efficient frontier at different target returns including both NCREIF NPI and PureProperty.
Then the mean-return matrix is as follows:

<table>
<thead>
<tr>
<th></th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>SP GSCI</th>
<th>Composite Infra</th>
<th>NCREIF F NPI</th>
<th>PureProperty</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Mean</th>
<th>0.132</th>
<th>0.089</th>
<th>0.094</th>
<th>0.139</th>
<th>0.091</th>
<th>0.117</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatility</td>
<td>0.175</td>
<td>0.108</td>
<td>0.236</td>
<td>0.178</td>
<td>0.083</td>
<td>0.091</td>
</tr>
</tbody>
</table>

We can see from the mean-return matrix, PureProperty has an average return between real estate and infrastructure, while the volatility is on par with real estate and Treasury bond. By including PureProperty in the overall portfolio, it reduces the overall variance while maintaining a healthy return target. That explains why PureProperty dominates the composition chart throughout.

However, because our assumption is based on the high correlation between PureProperty and REITs with limited data history (10 years versus the 34 years the model uses), there is limitation in how much the result can be applicable.

As PureProperty eliminates the leverage effect that REITs usually depend on, the returns on PureProperty appears different than those on REITs. However, REITs returns are still higher than NCREIF NPI index. The financial crisis forced REITs to recapitalize at the downturn of the market as REITs had to issue more diluting stock shares to repay the debt they owe before the financial crisis. This repayment did not affect as much on the properties assets as the REITs themselves, but they did hurt the return on equity.26

**Downside Risk**

In this analysis, downside risk calculation is as follows 27

- Semi-deviation defined by

\[
SD(X) = \left( E[(X - E[X])^2 1_{(X \leq E[X])}] \right)^{1/2}
\]

\[
1_{(X \leq E[X])} = \begin{cases} 
1 & \text{if } X \leq E[X] \\
0 & \text{else} 
\end{cases}
\]

Where \(1_{(X \leq E[X])}\) is an indicator function, i.e.

- Below target semi-deviation for target \(t\) defined by

\[
TSV(X, t) = \left( E[(X - t)^2 1_{(X \leq t)}] \right)^{1/2}
\]

Downside correlations are calculated as:

26 David Geltner, Professor of Real Estate Finance, Center for Real Estate, MIT, 2012
27 Definition from Wikipedia
Corr \((A, B)_{\text{downside}}\), where \(A\) represents the series of difference between annual return that is below overall average return and the average return, while where annual return is above average return, this difference is expressed as zero. The same rule applies to asset \(B\).

First, we run the efficient frontier and market portfolio for downside risk. Below is the result for portfolio compositions at different mean targets with standard risk on the left and downside risk on the right:

Figure 24- Downside Markowitz Portfolio Comparison

![Figure 24- Downside Markowitz Portfolio Comparison](image)

On the downside, the portfolio including commodity and infrastructure perform slightly better than the one including real estate. The inclusion of real estate on top of commodity and infrastructure does not change much of the Markowitz portfolio volatility.

Let’s look back at the mean-semi-volatility matrix for these assets:

<table>
<thead>
<tr>
<th></th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>SP GSCI</th>
<th>Composite Infra</th>
<th>NCREIF F NPI</th>
<th>PureProperty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.132</td>
<td>0.089</td>
<td>0.094</td>
<td>0.139</td>
<td>0.091</td>
<td>0.117</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.175</td>
<td>0.108</td>
<td>0.236</td>
<td>0.178</td>
<td>0.083</td>
<td>0.091</td>
</tr>
<tr>
<td>Semi Deviation</td>
<td>0.200</td>
<td>0.090</td>
<td>0.282</td>
<td>0.178</td>
<td>0.083</td>
<td>0.105</td>
</tr>
</tbody>
</table>
As shown in the semi deviation, Treasury bond has a semi deviation lower than standard deviation, which increases its weights in the portfolio composition for all that includes Treasury bond. As stock has a semi deviation higher than standard deviation, its weights are reduced in all composite portfolios.

4.4 Conclusions

The portfolio analysis results shown in this chapter indicates that in a mixed portfolio, certain real assets outperform others in the efficient frontier, while in the Sharpe-Markowitz portfolio, certain assets lose power against traditional stock and bond.

Diversification

NCREIF NPI index reduces the portfolio volatility when added to the traditional stock and bond portfolio in the efficient frontier while maintaining a healthy portfolio return. When comparing diversification roles, real estate performs better than the combination of commodity and infrastructure in terms of return-over-risk ratio. When real estate is combined with commodity and infrastructure in a stock-and-bond portfolio, the return-over-risk ratio is slightly improved over the portfolio that just includes real estate, stock and bond. However, when comparing a portfolio that includes stock, bond and real estate with a portfolio that includes stock, bond, commodity and infrastructure, the former one has a higher return-over-risk ratio than the latter one. Adding commodity and infrastructure in the Sharpe portfolio has limited diversification effect.

As we increase the number of assets in the portfolio, the weight of stock goes down in the Sharpe portfolio. Bond, on the other hand, has a major role in this portfolio in all the compositions as we increase the number of assets in the portfolio. When introduced to the portfolio mix, PureProperty shows some interesting potential. In the Sharpe portfolio and the Markowitz model, PureProperty has had consistent major roles. The high return and compatible risk with NCREIF NPI enables PureProperty to stay at a prominent portion in the optimization model.

Risk-return Strategy

28 A reduction of around 10% return.
Because infrastructure has high average returns with a comparable risk level with stock, it does provide return potential for investors who are more risk tolerant. When investment managers set up relatively high target returns, infrastructure’s role in a mixed portfolio improves. Commodity, interestingly, has little weight in all the portfolio compositions and all the downside risk portfolio compositions. This is mainly due to the high volatility of commodity and relatively low average return. However, the high volatility of commodity also attracts hedge funds and high-frequency traders who are more risk tolerant than traditional institutional investors who are more long-term players.

**Real Asset Roles**

Both infrastructure and real estate have major roles in the efficient frontier. It depends on the investor’s risk aversion and specialty to decide on the portfolio structure. Real estate index dominates infrastructure in the Sharpe-Markowitz portfolio. Within real estate, PureProperty is slightly more dominant than private real estate in that it offers similar risk and higher return, which explains the high weights in the Sharpe-Markowitz portfolio in the standard, downside risk model, and the ones with haircuts regarding liquidity. When PureProperty and NPI are put together in a portfolio of assets, both of them have notable weights. Commodity has little weight in the efficient frontiers in both standard and downside risk models. The high volatility of commodity attracts short-term investors, but may not take a major role in the long-term investor’s portfolio.
Chapter 5   Value at Risk Analysis

5.1   Definition

What is Value at Risk?

It is a measure of potential loss of a specific value on a defined time period and a given confidence interval. VaR focuses on the potential losses for investors to estimate the probability of a certain percentile confidence level. For example, a 1 million VaR at 5% at one day level means there is a 5% chance that there is more than 1 million of loss and there is a 95% chance there will be 1 million gain in any one day.

Therefore, the factors of a typical Value-at-Risk are:

1. Specified amount of loss value
2. Defined time period over which the risk is assessed
3. A confidence interval

Value at Risk is most often adopted by commercial and investment banks in recent decades to identify the potential loss of their traded portfolios over a specific period. Companies are tested to assess their loss potential in order to evaluate their ability to recover without risking the firm at large.

5.2   Data and Methodology

In order to examine the VaR for our optimization portfolio, the author uses the data from previous chapters that was originally designed to test out the optimization model. Six asset classes are used in here for the composition of an investment portfolio. Risk-free rate is calculated using the average return of T-Bill Index.
Below is a summary of the return and risk-premium of listed assets:

Risk-free rate is the average of government T-Bill annual returns from 1975 to 2009
\[ r_f = 5.71\% \]

Market beta is defined as the difference between asset risk premium divided by the market risk premium.
\[ \beta_m = \frac{E_{Asset[r]} - r_f}{E_{Market[r]} - r_f} \]

Here we assume a market risk premium of 6%, that is \( E_{Market[r]} = 6\% \)

<table>
<thead>
<tr>
<th>Asset E[r]</th>
<th>13.2%</th>
<th>9.4%</th>
<th>13.9%</th>
<th>10.5%</th>
<th>9.1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Risk Premium</td>
<td>7.5%</td>
<td>3.2%</td>
<td>3.7%</td>
<td>8.2%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Market Beta</td>
<td>1.25</td>
<td>0.54</td>
<td>0.62</td>
<td>1.37</td>
<td>0.80</td>
</tr>
</tbody>
</table>

In order to create a simulation of the portfolio return, we take the Sharpe-Markowitz portfolio weights from the portfolio analysis as the expected weights for each asset class within the portfolio. Then we have:

29 Here the author uses FTSE NAREIT Equity REIT index to represent PureProperty with haircut modification as noted in the preceding paragraphs.
30 Historic index for healthcare only started in 1987. The thesis creates an average of S&P 500 Railroad and S&P 500 Utility represent the index from 1975-1986, average of all three indexes total return to represent the composite index from 1987-2009.
\[ E(r_p) = w_i \cdot E(r_t) \]

Now we run another efficient frontier analysis and market portfolio with some haircuts to each asset to net out the transaction cost effect. \(^{31}\) Below are the market portfolio weights

<table>
<thead>
<tr>
<th></th>
<th>SP500Stk</th>
<th>USTBnd</th>
<th>10-yr</th>
<th>SP GSCI</th>
<th>Composite</th>
<th>Infrastructure</th>
<th>PureProp</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9%</td>
<td>27%</td>
<td>3%</td>
<td>0%</td>
<td>37%</td>
<td>24%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In order to create a random history of the aggregate market value, we introduce the following variables:

1. **Risk-free interest rate**
   - The assumption is that the portfolio value will increase at a fixed annual interest rate at 3%.

2. **Market risk premium**
   - The assumption that the market value increases at a fixed risk premium rate on top of the risk-free interest rate at 6%.

3. **Random volatility**
   - This is a normal (Gaussian) distribution. By introducing this random variable, we add in the possibility of increasing or decreasing at a random percentage (between 0% and 100%) of the assigned volatility of 15%. Volatility is realized in each period, so that this risk outcome accumulates in the history of market value levels.

4. **Auto Regression**
   - We also introduce an Auto Regression factor at 0.2 upon previous year’s return to reflect the lagging effect. This in turn, will also affect the annual volatility.

5. **Circles**
   - We introduce another deterministic factor as circles of 10 years to reflect the circular effect of asset performance.

6. **Black-swan effect**

\(^{31}\) This composition is slightly different from the Sharpe-Markowitz weights derived from the previous chapter as certain haircuts are applied to each asset to net out the transaction cost. 100 bps for real estate, 50 bps for PureProperty, 20 bps for stock, bond, infrastructure, and commodity.
Lastly, a Black-swan effect is added to factor in the fat-tail of certain asset performance. This is also a random generation for the assigned period for the purpose of simulation.

Then we run a 50-year simulation of the single asset factoring in the different combinations of the above variables. The starting value of the asset is fixed at 1 $. Below is the result.

Figure 26-One Random History ("Drawing") of the Aggregate Market Value History

As we can see from the simulation that both riskless asset and market trend assets increase at a fixed trend whereas random factors impact the asset performance by either lagging, creating circles or creating inertias. Since this is only a random generation, no specific historic data is yet applied to the model. In the next part, the thesis will explore the actual assets performance under the Monte Carlo simulation.

5.3 Portfolio Simulation

Now we factor in the assets we selected as previously introduced. There are six assets to composite the portfolio. First, we take a look at the individual asset’s performance using the Monte Carlo simulation.
Below is a list of factors we take into account:

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>LTBond</th>
<th>Composite</th>
<th>Infra</th>
<th>Commodity</th>
<th>PureProperty</th>
<th>NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential Trend</td>
<td>1.51%</td>
<td>-2.79%</td>
<td>-2.30%</td>
<td>2.19%</td>
<td>-1.18%</td>
<td>-2.61%</td>
<td></td>
</tr>
<tr>
<td>Idiosyncratic Volatility</td>
<td>10.00%</td>
<td>5.00%</td>
<td>15.00%</td>
<td>10.00%</td>
<td>10.00%</td>
<td>10.00%</td>
<td></td>
</tr>
<tr>
<td>Beta with Market</td>
<td>1.25</td>
<td>0.54</td>
<td>0.62</td>
<td>1.37</td>
<td>0.80</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>AR Parameter</td>
<td>0.30</td>
<td>0.00</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

Differential Trend is a deterministic trend component apart from the "Market" trend determined on the preceding sheet. Normally in equilibrium per the CAPM this would equal the Beta of the asset class with respect to the market minus 1.

We make the assumption of the idiosyncratic volatility for stock, commodity, PureProperty and NCREIF NPI 10%, infrastructure’s idiosyncratic volatility at 15% and T-bond’s idiosyncratic volatility at 5%.

Market beta of each asset is calculated as

$$\beta_m = \frac{E_{Asset}[r] - r_f}{E_{Market}[r] - r_f}$$

We also assign the Auto Regression factor of 0.3 to stock, 0 to T-bond, and 0.2 to infrastructure, commodity, PureProperty and NPI. This will inject auto regression into the asset class returns. The auto regression will induce a lag or smoothing in the asset class.

Then, we create a Monte Carlo simulation of 50 years’ price index for each asset and the market. The indexes all start at 1.
The 50-year simulation shows that since we factor in the market beta using CAPM, there is certain degree of co-movement with the market. The individual assets also somehow drift away from the riskless asset. Economic cycles are factored in to reflect the ups and downs of certain period within an assumed cycle.

Below is the scatter plot for the returns of four asset classes versus market returns:

Figure 28-Selected Asset Simulation Run Scatterplot
At last, we construct 5000 simulations of portfolio returns and indexes using the following assumption:

Riskless rate from T-bond average return: $r_f = 5.71\%$

Market beta is calculated as: $\beta_m = \frac{E_{Asset[r]} - r_f}{E_{Market[r]} - r_f}$

Here we assume a market risk premium of 6%, that is $E_{Market[r]} = 6\%$

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>LTBond</th>
<th>Infra</th>
<th>Commodity</th>
<th>PureProperty</th>
<th>NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset $E[r]$</td>
<td>13.2%</td>
<td>8.9%</td>
<td>9.4%</td>
<td>13.9%</td>
<td>10.5%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Asset Risk Premium</td>
<td>7.5%</td>
<td>3.2%</td>
<td>3.7%</td>
<td>8.2%</td>
<td>4.8%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Market Beta $\beta_m$</td>
<td>1.25</td>
<td>0.54</td>
<td>0.62</td>
<td>1.37</td>
<td>0.80</td>
<td>0.56</td>
</tr>
</tbody>
</table>
We take the Sharpe-Markowitz portfolio weights from the portfolio analysis as the expected weights for each asset class within the portfolio. Then we have:

\[ E \left( r_p \right) = w_i \cdot E(r_i) \]

Where \( w_i \) is listed below:

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>9%</th>
<th>27%</th>
<th>3%</th>
<th>0%</th>
<th>37%</th>
<th>24%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP500Stk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USTBnd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-yr SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PureProp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCREIF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Now we set the maximum loss of the portfolio to the minimum return in all the 50-year simulations. Portfolio value is calculated as \( V_t = V_{t-1} \cdot (1 + r_t) \) where \( V_t \) is the portfolio value in year \( t \), \( V_{t-1} \) is the portfolio value in year \( t-1 \), \( r_t \) is the annual return in year \( t \). Here we assume \( r_a,b \) is the year \( a \) return on year \( b \). Therefore, year 5 gain is expressed as \( r_{5,1} = \frac{V_{5,1}}{V_{1,1}} - 1 \).

Next, we run 5000 simulations of the maximum loss, year 5 gain, portfolio mean, and volatility. Below is a histogram summary of one-year maximum loss.

Figure 29-Histogram of Simulated Maximum Loss within Any One Year

<table>
<thead>
<tr>
<th>Frequency (out of 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
</tr>
<tr>
<td>250</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Source: Global Financial Data, FTSE, NCREIF
Below is a histogram summary of portfolio gain in year five.

Figure 30-Histogram of Simulated 5-year Gain

The average maximum 1-year loss is at 21% of total portfolio value. A 5% Value at Risk in any one year is around 32% of total portfolio value. That is there is 5% probability that the portfolio will lose more than 32% of total value in one year.
A 5% Value at Risk in 5-year gain is 2% loss of total portfolio value. That is there is 5% probability that the portfolio will lose 2% in year five.

5.4 Downside VaR

Now we replace the asset weights with the minimum-variance Downside portfolio weights. The weights are the results from Chapter 3, Portfolio Analysis. These are the haircut for downside models.

<table>
<thead>
<tr>
<th>SP500Stk</th>
<th>USTBnd</th>
<th>10-yr</th>
<th>SP GSCI</th>
<th>Composite Infrastructure</th>
<th>PureProp</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0%</td>
<td>45.6%</td>
<td>0.79%</td>
<td>4.65%</td>
<td>29.4%</td>
<td>8.51%</td>
<td></td>
</tr>
</tbody>
</table>

Then we apply the weights to the Monte Carlo Simulation model and below are the results:

Histogram summary of one-year maximum loss:

Figure 32-Histogram of Simulated Maximum Loss within Any One Year (Downside Risk)

Histogram summary of portfolio gain in year five.

Figure 33-Histogram of Simulated 5-year Gain
Below is the cumulative distribution graph
Figure 34-Cumulative Distribution Graph (Downside Risk)

5.5 Traditional Portfolio Model

Now we replace the asset weights with the traditional portfolio model weights from PREA’s survey. Here we keep real estate a total of 10% with PureProperty at 6% and NCREIF NPI at 4%. We assign another %
to other real assets including 4% to commodity and 4% to infrastructure. Then we assign 25% to bond as is shown in the sponsor survey by PREA and the rest 57% to stock. Now we run the Monte Carlo simulation again with the following weights:

<table>
<thead>
<tr>
<th></th>
<th>USTBnd</th>
<th>SP500Stk</th>
<th>10-yr SP</th>
<th>GSCI</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>PureProp</td>
<td>6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NCREIF NPI</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Below are the results:

Histogram summary of one-year maximum loss

Figure 35-Histogram of Simulated Maximum Loss within Any One Year (Traditional Portfolio)

Histogram Simulated Max Loss Any 1 yr

Source: Global Financial Data, FTSE, NCREIF

Histogram summary of portfolio gain in year five.

Figure 36-Histogram of Simulated 5-year Gain (Traditional Portfolio)

32 Here commodity and infrastructure are set at the same percentage for simplicity.
Cumulative distribution graph

Figure 37-Cumulative Distribution Graph (Traditional Portfolio)
Based on the Monte Carlo simulation, the 5% Value-at-Risk for the Markowitz optimization portfolio is around 31% of loss, the 5% Value-at-Risk for the downside optimization portfolio is around 30% of loss, and the 5% Value-at-Risk for the traditional portfolio is around 45% of loss.

The Markowitz optimization portfolio has a much less magnitude of loss at the 5% percentile than the traditional portfolio within one year.\(^33\) The average mean of loss for Markowitz is around 21% within any one year, the average mean of loss for downside portfolio within any one year is around 20%, and the average mean of loss for traditional portfolio is at around 30%.

The decrease in stock and bond with the increase in real estate within a portfolio according to optimization portfolio reduces the magnitude of potential loss within the any one-year period according to the Value-at-Risk model. This might indicate the potential of increasing real estate in a mixed portfolio to protect against losses.

### 5.6 Conclusions

Based on the VaR model, the Sharper-Markowitz portfolio shows less risk at a target loss within one year than the traditional portfolio with heavy weights on stock and bond, low weights on real estate. The magnitude of the 5-year gain for traditional portfolio structure at 5% percentile probability is comparable with that in the Sharpe-Markowitz portfolio. The average 5-year gain at 5% percentile probability for traditional portfolio structure is also comparable with the Sharpe-Markowitz portfolio.

It’s important to notice that there is limitation in Value at Risk. VaR makes assumptions about return distributions and we are assuming the historical return distribution can represent the distribution of returns looking forward. This could be an assumption that has limitation in its applicability. The effect in the correlation error is magnified in the Monte Carlo simulations, which proves another potential error in the VaR model.\(^34\) The simplicity of VaR model is also another risk because the model makes assumptions that may not represent the actual performance of the assets. There is a narrow focus when creating the VaR model.\(^35\)

---

\(^{33}\) Assumptions for traditional portfolio are made for the purpose of simplicity.


\(^{35}\) Adam Odar, “Value at Risk (VAR)”, NYU Stern School of Management
Chapter 6  Quantifying Liquidity for Real Asset Transaction in a Mixed Portfolio

6.1 Objective

Certain real assets appear to be less liquid than traditional assets such as stock and bond because of their nature. The link to physical plant or properties, as well as the production/construction risk prevents these assets to be traded at a frequent and instant manner. This chapter takes PureProperty as a sample index to explore the rebalancing turnover as a measure of illiquidity and intends to take the transaction/management cost as a risk premium associated with PureProperty. This is also an attempt to bring real estate investment through a more liquid channel into the asset management process.

6.2 Data Resource and Methodology

In order to examine how rebalancing affects PureProperty trading, the author uses data from FTSE for PureProperty index. There are two sets of data. One is annual price index of all individual REITs and annual price index of FTSE NAREIT REITs. The other is PureProperty individual REIT price index and individual weights. Here we use the data of 109 individual REITs’ one-day prices and weights. The data is from April, 2nd to represent a typical rebalancing day. Then we compare the two data sets to see what impact rebalancing has on the different methodologies and see if there is a middle ground to quantify the rebalancing cost.

6.3 Rebalancing Analysis

Risk Analysis

First, we take a look at the individual REITs’ performance throughout the time starting from 2000 as compared with Equity REIT index. We use the data for the 10-year period from 2000 to 2010. The starting indexes are adjusted to 1.

[36] Rebalancing happens every month on the second Friday according to FTSE.
Figure 37 show the scatter plot of monthly mean-volatility for individual REITs and REIT Index

Scatter Plot of Monthly Mean-Volatility of Individual REITs and REIT Index

<table>
<thead>
<tr>
<th>Monthly Return</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.00%</td>
<td>-1.00%</td>
</tr>
<tr>
<td>-2.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>-1.00%</td>
<td>1.00%</td>
</tr>
<tr>
<td>0.00%</td>
<td>2.00%</td>
</tr>
<tr>
<td>1.00%</td>
<td>3.00%</td>
</tr>
<tr>
<td>2.00%</td>
<td>4.00%</td>
</tr>
<tr>
<td>3.00%</td>
<td>5.00%</td>
</tr>
<tr>
<td>4.00%</td>
<td>6.00%</td>
</tr>
</tbody>
</table>

Source: FTSE, MIT CRE

Figure 38 shows both composite Equity REIT index (as shown in dark bold line) and individual REITs indexes.

Figure 38-Individual REITs indexes vs Composite REIT index

Source: FTSE, MIT CRE
The graph shows the movement of all individual REITs indexes within the 10-year period. Certain REITs have outperformed other REITs because of the idiosyncratic nature of these specific REITs. But we can see that the REITs market started to slow down starting in late 2006 and took a bigger hit from the financial crisis in 2008. Some REITs recovered faster than others, and the majority of the REITs have been recovering more mildly. After the financial crisis, there are several REITs which diverged further away, causing a “black swan event” with a “fat tail”, adding additional noise to the REITs index.

Then, we look at the REITs index from two risk perspective:
1. The volatilities of the composite REIT index
2. The idiosyncratic risks of individual REITs away from the composite index

Here as the second risk is the idiosyncratic risk away from the composite index volatility, we assume that the volatilities of the composite REITs are independent of the idiosyncratic risk away from the composite index. The relationship is expressed as below:

\[
\text{Var} (X + Y) = \text{Var} (X) + \text{Var} (Y)
\]

If X and Y are uncorrelated, that is \( \text{Corr} (X,Y) = 0 \)

In other words, let’s use \( r_{i,t} \) to represent the return of REIT i at time t, and \( \varepsilon_{i,t} \) to represent the excess return of this REIT i at time t on top of the composite index return expressed as \( r_{\text{avg},t} \), then the correlation of the average return and the excess return at time t is zero.

\[
\text{corr} (r_{i,t}, \varepsilon_{i,t}) = 0
\]

And \( r_{i,t} = r_{\text{avg},t} + \varepsilon_{i,t} \)

Then,

\[
\text{Var} (r_{i,t}) = \text{Var} (r_{\text{avg},t}) + \text{Var} (\varepsilon_{i,t})
\]

Here \( \text{Var} (r_{i,t}) \) denotes the average variance of all individual REITs, \( \text{Var} (r_{\text{index},t}) \) denotes the variance of the composite REIT index, and \( \text{Var} (\varepsilon_{i,t}) \) denotes the variance of the excess returns of all individual REITs.

Figure 398- Equity REIT Monthly Index (2000-2010)
Index volatility is showed in the diagram below:

Figure 40- Equity REIT Index Monthly Return

Figure 41- Equity REIT Annual Return
Average monthly return of the composite REIT index is 0.67%.
Monthly volatility of the composite REIT index is 7.19%.
Average monthly volatility of all individual REITs is 9.99%.

Annual volatility of the composite REIT index is denoted as:

\[ \text{Vol}_{\text{annual}} = \sqrt{12} \times \text{Vol}_{\text{monthly}} \]

Therefore, annual volatility of the composite index is
\[ \text{Vol}_{\text{annual, index}} = \sqrt{12} \times 7.19\% = 24.9\% \]

And annual variance of the composite index is
\[ \text{Var} (r_{i,t}) = \text{Vol}_{\text{annual, index}}^2 = 6.2\% \]

Annual volatility of individual REITs is
\[ \text{Vol}_{\text{annual, indiv}} = \sqrt{12} \times 9.99\% = 34.6\% \]

And annual variance of the individual REITs is
\[ \text{Var} (r_{i,t}) = \text{Vol}_{\text{annual, index}}^2 = 12.0\% \]

According to the variance equation
\[ \text{Var} (r_{i,t}) = \text{Var} (r_{avg,t}) + \text{Var} (\epsilon_{i,t}) \]

We get
\[ \text{Var} (\epsilon_{i,t}) = \text{Var} (r_{i,t}) - \text{Var} (r_{avg,t}) = 12.0\% - 6.2\% = 5.8\% \]

Therefore, annualized idiosyncratic volatility is
\[ \text{Vol}_{\text{annual}} = \sqrt{\text{Var} (\epsilon_{i,t})} = 24.1\% \]
Monthly idiosyncratic volatility is $\text{Vol}_{\text{monthly}} = \frac{\text{Vol}_{\text{annual}}}{\sqrt{12}} = \frac{24.1\%}{\sqrt{12}} = 6.9\%$

What does this imply?
The drift of individual REITs away from the composite index has an annual volatility of 24.1%, or a monthly volatility of 6.9%, no matter how the composite index moves.
The idea of rebalancing is to recalculate each individual REIT’s new weight from regression for trading, and these new weights are new levels of indexes for individual REITs which need to either sell or buy to rebalance to these new levels. The following part will delve into the rebalancing process to reexamine the risk analysis in this part.

Then we switch from standard deviation (volatility) to average absolute deviation by multiplying approximately 0.8 times the standard deviation.

$AD_{\text{monthly}} = SD \times 0.8 = 6.9\% \times 0.8 = 5.52\%$

This is the average absolute monthly drift for the average REIT index.

**Monthly Turnover Analysis**

PureProperty index has a review process for weights of all individual REITs each month. Below is the basic process of rebalancing according to FTSE:

1. Monthly review
For the total of more than one hundred individual REITs, FTSE reports daily weights based on trading. Every month the new weights are applied to each individual REIT of the PureProperty Index Series.

2. Rebalance once a month
The weights for individual REITs are recalculated on the second Friday of each month following the algorithm regression models using data available as of the close of business on the previous day.

3. Weights change
Weight changes resulting from the monthly review will be implemented at the close of business on the third Friday of each month.

To illustrate the data:
The author uses PureProperty price index and weights. Here we use data of 109 individual REITs’ one-day prices and weights. The data is April, 2\textsuperscript{nd} to represent a typical rebalancing day.\textsuperscript{37} The following graph demonstrates one individual REIT’s rebalance movement.

Figure 42-Illustrative Rebalancing Graph

This diagram is a demonstration of daily weight movement compared to target monthly weight movement. As weights drift away from target level, the weights will be readjusted to the target level each month, causing either short or long position. For all REITs included in the FTSE NAREIT PureProperty index, there are 109 (the total number of listed REITs) such pairs of weight movement lines throughout time. The weights are percentage numbers. Then, we sum up all the absolute differences in weights to get daily turnover percentage of individual constituents.

\textbf{Results:}

The following table shows the turnover of all 22 constituents on a typical day of April 2\textsuperscript{nd}, 2012.\textsuperscript{38}

\textsuperscript{37} According to FTSE, rebalancing happens every month on the second Friday according to FTSE, trading happens after the third Friday every month.

\textsuperscript{38} Here we use single-day data to represent a typical day of rebalancing.
The average turnover rate of all constituents is 11.68%. As rebalancing happens once a month, we multiply the monthly turnover rate by 12 to get the annual turnover rate, 140%.

Now let’s look back at the idiosyncratic drift from the previous analysis.

The average monthly absolute deviation is about 0.8 times the standard deviation. 
\[ AD_{\text{monthly}} = SD \times 0.8 = 6.9\% \times 0.8 = 5.52\% \]

For simplicity, we use 6% here.

The average normal weight of trading individual REITs is 2.4% across all 22 constituents based on the analysis of the data of April 2nd 2012 and the average normal weight of trading individual REITs for all eight tradable REITs is 1.75%. Therefore, we apply the “tradable” rate to the all 109 individual REITs with the monthly drift rate of 6%, then we get the monthly rebalancing turnover of 
\[ 6\% \times 1.75\% \times 109 = 11.45\% \]
Multiply the monthly turnover of 11.45% by 12, we get the annual turnover rate, 137%.

---

39 The top eight constituents are considered “tradable” here in the analysis according.
Comparing the two methodologies, we get comparable annual turnover rates. Assume a typical trading cost for rebalancing is 25 basis points.\textsuperscript{40} Now for around 137\% or 140\% of rebalancing, we get around 35 basis points. Factoring in other risks associated with real estate trading, a 50 basis points risk premium for PureProperty seems reasonable.

Brad Case from FTSE noted that “One thing to keep in mind is that the short positions arise only in the property type, region, or type/region combination indices—not in the “headline” all-property, all-region index. Another issue, aside from the treatment of dividends on short holdings, is the de-levering piece. Essentially, the ETF manager is trying to hold a (long) fixed-income position that replicates the (short) fixed-income position of the REITs. The index is based on REIT-level data on the book value of total debt, plus an assumed industry-wide average cost of debt that we estimate from Federal Reserve H15 data on commercial paper and Moody’s Baa corporate bond rates. So you’re trying to hold a fixed-income position that generates the same income (return) as that assumed average cost of debt times the aggregate book value of total debt across all REITs.”

6.4 Conclusions

Although there is no clear indication of the direct drive for the weight fluctuation, the REIT price drift has somehow impacted the portfolio weights change. The new target weights are regressed by calculation, and this requires each individual REIT to rebalance to the new target weight each month. This applies to any portfolio that attempts to track an index with fixed weights differing from simple market-cap-based weights. However, there could also be some kind of Brownian drift term that affects the weights drift.

The result shows that a risk premium of around 50 basis points may be deducted from the historic returns of the PureProperty index regarding rebalancing cost. This factors in the additional management cost of the real estate index. As REITs appears more tradable than physical real estate assets, this is an attempt to treat certain real assets through a more liquid way and in turn, certain risk premiums are considered.

\textsuperscript{40} According to FTSE.
Chapter 7  Institutional Investors’ Asset Allocation Strategy

7.1 Objective

This chapter further looks into the real world practice of investment management on asset allocation strategies. This is an interview-based research intended to gain understanding from institutional investors’ perspective. This chapter includes open-ended conversations with investment professionals from different global markets. The framework of the discussion is flexible in terms of discussion topics with a general focus on portfolio structure and investment strategy in order to understand disparity among different investors and common goals as well.

7.2 Interviewee Selection

The selection of interviewee is based on the diversity of industry and geographic exposure. This group includes international institutional investors with heavy international exposure and strong placement on real estate and other real assets. Interviewee list includes top asset management company in the United States by AUM (asset under management), top sovereign wealth fund located in Asia (ex China), top investment management firm located in the US, top asset management firm in China by AUM (asset under management), one of the largest asset management firms in the world by AUM and leading financial indices company in Europe. Other interviewees participate partially or informally in the interview. All interviewees are protected of their identities in this thesis.

7.3 Research Methodology

The interviews were conducted either in person, over the phone or emails.

The interviews were conducted from May, 2012 to July, 2012.

Typical interviews took 30-60 minutes.

Interviews include open discussion on recent investment management trends and strategies, specific discussion on asset allocation to real estate and other real assets, and open discussion on globalization of investment.
7.4 Questionnaire

The questionnaire was provided to the interviewee as a base for discussion, and some of the questions were not directly targeted during the interview. Therefore, this chapter does not depend on the collection of interviewees’ responses as any representative of quantitative data. Rather, the organization of the interview is intended to engage asset managers in an open discussion of the general portfolio strategy and align such strategies in the understanding of the applicability of our analysis.

Sample questions

1. Asset allocation criterion and strategy

- What do you think is the typical asset allocation framework to real estate for a global institutional investor? What about to commodity and infrastructure?

- When deciding on the investment portfolio, is there a base model for investors to compare with? What are the limitations/issues in selecting real asset classes such as real estate, infrastructure and commodity?

2. Liquidity for real estate and other real asset classes

- When including real estate and other real asset classes in an investment portfolio, how do you see liquidity issue as you make allocation decisions?

- Have industry professionals quantified liquidity cost when comparing weights? If so, which asset classes do you think require the most in cost management? If not, how do they deal with illiquidity risk?

- Do you see real estate as a separate asset class from other real assets such as infrastructure and shipping, or do you see it as an alternative investment for an institutional investor?

3. Global diversification

- When investing real estate in a global context, what criteria do you see is most important in going into a foreign market?

- Do you see investing in real estate as a diversification hedge or a major investment in a portfolio mix?

- How do investors decide whether to directly or indirectly invest in real assets such as real estate, infrastructure, and shipping?

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41 These questions are open-ended, not all questions are answered. The sample questions provided interviewees a background of the research topic.
7.5  Topics and Discussion

Selection of Portfolio Assets

While there is a large pool of assets institutional investors could look at and there are numerous ways to test out portfolio performance, certain institutional investors tend to have specific targets and base models to compare with. Usually, investment committees make the initial investment decision as to which industries to go in based on the company’s specific preference and experience. After the decisions have been made, fund / investment managers will conduct the research and execute the investment strategy.

For instance, a typical base model could be 75% equity and 25% fix-income. Research department at the front office are assigned to conduct analysis of different portfolio compositions and compare the return/risk with the 75/25 stock-bond portfolio. While there are various results, investors usually set up their target number of assets to invest in and are carefully targeting the expected return.

The diagram below demonstrates how a typical investment group works:
Figure 44-Investment Management Group Structure Sample

![Diagram](image)

Different investors may have different internal team structures. For instance, the decision making body may comprise of both senior executives and fund managers in some regions while in some other areas fund managers have less priority in the decision making process.

There is an increasing focus on commodity as inflation is going strong in the recent years, which pushes some commodity prices to go up. For example, energy prices have gone up due to inflation movement.
Real Estate’s Role in Investment Portfolio

While real estate can provide inflation hedges, it is usually not a major investment for institutional investors. The typical allocation to real estate is less than 20% and many institutional investors allocate less than 10% to real estate.

The key role real estate plays in a mixed investment portfolio is the foremost physical form of asset with a long-term hold strategy. Real estate is usually considered a channel to store values and is good for inflation hedging. However, real estate is a very illiquid asset which requires specific expertise to run. This is a character that many investors consider risky which puts up a hurdle for them to cross.

Real Estate Investment Strategy

Real estate investment is a specialized investment in many ways. Many institutional investment companies set up real estate investment divisions to directly invest in properties. Some set up funds and issue bonds while others allocate their own equity in real estate. No specific criteria were given as to who tend to invest directly with their own equity and who tend to manage outside funds to invest in real estate. However, some traditional banks tend to lean on management of outside sources of funds that invest in real estate while some sovereign wealth funds prefer equity investment. Because investing in real estate requires real estate expertise, only certain numbers of institutional investors see real estate as a major investment or key business. There are many real estate investment management companies who just specialize in this industry.

When investing in real estate, institutional investors tend to look at several factors:
- Nature of the property
- Location
- Inflation
- Growth factor
- Management cost
- Property depreciation
- Local debt market

When investing in a local market, investors have addressed the importance of local knowledge, which includes local partners with past working experience and connection in the local market.
Global Market

Real estate is often considered a local business. When institutional investors look at foreign markets, they tend to be very careful about the selection of properties. Institutional investors look at the big market indicators such as GDP growth, maturity of the real estate market, and local debt market. Developed countries provide stable income stream when investors hold core assets whereas developing countries provide lucrative growth potential. Another key factor is government control and lending policy. This is specifically important in some Asian markets such as China and Vietnam.

While the real estate market in China is getting more mature, investors also seek growth potential in high growth markets. For instance, institutional investors mainly focused on the residential sector in the past decade. With residential market cooling down and stabilizing, investors are beginning to look outside the residential market. Service centers started to provide growth potential for investors as demand is growing in both first-tier cities and secondary cities. Such service centers include office and shopping centers, which are still growing in countries like China. In markets like India where there is strict government control, investors also look into the IT industry, such as high-tech campus properties where there is large demand and growth.

Further, investors look at the sustainability of the market, the growth of the middle class demographic, and the urbanization movement.

Transparency in developing countries is also a concern that global investors expressed. In some regions of the world, deals takes longer time to invest in these countries because of the intermediate process associated with permitting.

Illiquidity

Liquidity is one major issue for real estate investors. However, for institutional investors who manage a portfolio of assets that sees real estate as one of their investment channels, liquidity is more of a concern on investment of the physical properties than a decisive hurdle. Certain institutional investors tend to act as long-term holders of real estate portfolios and some don’t usually seek opportunistic assets as these assets tend to act as short term investments. Macro-level knowledge of the economic trend and geographic character is more predominant in decision making than individual liquidity.
While some institutional investors expressed the concern with illiquidity in real estate investment, they have not largely quantified the illiquidity. Some investors strategically add certain risk premium, but the strategy is more tactic than quantitative, which readdresses the riskiness of real estate investment. As for liquidity in infrastructure, institutional investors also mentioned that the associated risk premium is higher than other assets because it is less frequently traded than equity and bonds due to its nature.

**Investment Strategy**

There are several key strategies in the real estate investment. While core assets never go down due to their stable performance and key geographic and demographic feature, there are core-plus assets, which are emerging into a new market because of their growth potential with a character that is close to core asset. Opportunistic assets provide the highest potential return, but it requires the ability to finance as typical Loan-to-value ratio is usually as high as 60%-80%.

**Market Trend**

Some institutional investors stated that real estate has been traditionally outperformed the equity market and provides certain degree of diversification thanks to the relatively low correlation with stock. For instance, real estate has a different cycle from stock before the financial crisis in 2008, which allows investors to strategize their investment portfolio accordingly. Further, there is a lag in real estate because of transaction process. Residential real estate was hit hard during the financial crisis. However, commercial real estate has been recovering and has come back relatively strong in the recent period, especially those high quality assets which provide stable healthy income.

**Infrastructure Investment**

Infrastructure is a broad term and could include a large scope of assets. While airline and automobile companies can be categorized as infrastructure assets, what institutional investors focus on lately are more tangible assets. Both open-ended and closed-ended funds are used for infrastructure investment as certain assets tend to have different life spans for investment purpose.

Below are the four typical infrastructure assets institutional investors focus on:
Regulated Utilities refer to companies that own utilities that are regulated. Electric power plant is one regulated utility. Here utility has municipal finance and tax exemption, which provides cheap cost to capital that private equity cannot compete with. Utilities also own a lot of private plants.

Communication Assets refer to materials designed to communicate messages to certain audience, either hardcopy or electronic. “Asset types can range from raw materials (imagery, copy blocks, logos, legal text and the like) to a more finished product that combines raw materials to create corporate brochures, sales collateral, annual reports, press releases, contracts/agreements, technical documentation, education & training materials, employee or customer newsletters and more.” 42

Social Infrastructures refer to social facilities such as healthcare facilities including hospitals, healthcare financing, educational system including schools and universities, military facilities and prison. 43

Transportation here refers to railroads, toll roads, and shipping assets.44

There is no perfect infrastructure index that can represent such a broad scope. However, generally speaking, infrastructure here refers to hard assets with long-term income stream and mostly geographically fixed capital.

Therefore, investing in infrastructure has the advantage of stable income stream, relative low risk, and stable growth. However, a lot of the infrastructure assets have limited accessibility, and are highly regulated by governmental departments. If privatization or partial opening to private investment are encouraged or expanded, there is great potential in investing in infrastructure.

Some institutional investors expressed the shift from investing in infrastructure before the financial crisis to shying away from infrastructure due to the following reasons:

44 Airports and highways are rarely privatized for trading. Here transportation doesn’t typically refer to the physical assets for airports and highways in the US.
- In some key markets, infrastructure was not deal flow because of the magnitude of the asset and the holding strategy some investors have.
- Vague definition of infrastructure has prevented investors from strategizing a sustainable investment within certain time period.

Infrastructure that includes toll roads and railways is usually capital intensive with long-term holding period, which puts up a hurdle for some private equities. Some institutional investors don’t do direct investment in infrastructure because of illiquidity and entry hurdle.

**Commodity Investment**

Commodity usually includes natural resources such as electricity, water, oil, raw metal and agricultural products. Institutional investors have expressed their concern with investing in commodity as it is a tricky asset due to its high volatility. Take oil for example, the oil price fluctuates much more dramatically than stock, which shows that commodity exhibits instability and uncertainty for long-term investors. There are commodity ETFs\(^ {45} \) daily priced that are linked to the price of crude. If such commodity indexes are linked to miners or plants, then investing in such commodity indexes induce risks due to the equipment associated with them.

Hedge funds and high-frequency traders, however, have shown interest in investing in commodity as it provides both short and long opportunities within a relatively short period. As an alternative investment in a mixed portfolio, commodity has not been a major diversifier according to some institutional investors.

\(^ {45} \text{Exchange-Traded-Funds. Here refers to ETFs that hold commodity.}\)
Chapter 8    Final Conclusions

The broad scope of real assets has span over various industries and markets. Certain real assets provide investors both growth potential and uncertainty in the investment community. This thesis intends to explore the roles of several selected real assets in a traditional stock-and-bond portfolio, and the findings have indicated the challenges as well as potential in the dynamic management of investment portfolio.

Real estate and infrastructure exhibit certain inflation hedging potential thanks to their high correlations with inflation. Commodity and real estate may also contribute to the diversification of an investment portfolio due to their low correlation with stock. The high correlation of infrastructure with stock and a comparable return has somehow prevented infrastructure from dominating in a Sharpe-Markowitz portfolio. However, infrastructure may appeal to those investors who are less risk averse as it provides a more attractive return compared with other real assets.

In a stock and bond portfolio, fix-income asset such as long-term government bond has a stable role in all the possible pairing tests and all the Sharpe portfolios. This is in consistence with industry practice. When real estate and infrastructure are included in the portfolio, both assets have major roles. These two real assets may have potential in a diversification role. Within real estate, PureProperty, as a separate index, acts slightly more dominant than the private real estate represented by NCREIF NPI. Infrastructure provides attractive return for investors as target return increases in the portfolio structure. However, infrastructure may not perform well in the Sharpe portfolio according to the portfolio analysis. The reason can be attributed to the high volatility of infrastructure and its high correlation with stock.

Commodity, on the other hand, has little weight in all of the portfolio pairings and has relatively small contribution in the portfolio despite good diversification effect. The low return and high volatility of commodity may have hampered commodity in the Sharpe efficient portfolio. The high risk of the production process associated with commodity also concerns certain long term investors. And just because of this, commodity provides potential in the derivatives market as hedge fund and other high frequency traders seek out hedging opportunities in the high volatile markets, which is not suitable for those long-only institutional investors. Therefore, commodity should have some specific roles in other kinds of portfolio structures linked to both long and short investors and may not appeal to traditional institutional investors. Another challenge for selecting assets is that historic returns of some assets may be

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46 According to the 2012 PREA Investor Report’s plan sponsor asset allocation framework from 1996 to 2010, bonds take up around 25%-30% of the total portfolio.
either too high or too low compared with recent figures. Some investors expect that the short-term returns of these assets won’t go back to historic average. The data to include in the selection process will slightly differ per investors’ preference and this will impact the portfolio choice. There are criteria more complicated than purely looking at historic numbers as several recent data reveal changing trends in some industries. This reflects back to the thesis analysis in that the models have their limitations, as the analysis is mostly based on historic data and not on expected targets. However, the analysis looks at portfolios from a long term perspective and examines the diversification for a longer history than what some investors are looking at. A theoretic methodology can definitely adjust to specific investor preference at some point.

Using the three different portfolio structures as described in the previous chapters to test out the Value at Risk results, the traditional portfolio with around half the weight to stock, a quarter of weight to long term government bond and the rest distributed to the several real assets47, exhibits a larger loss quantity at 5% percentile of probability within any one year period than the Sharpe portfolios including both standard risk and downside risk. The latter two portfolios have substantial weights on real estate (including NPI and PureProperty), much smaller weight on stock, and a comparable weight on bond with the traditional portfolio.

As the Value-at-Risk metrics here are left-hand tail measure, they lean towards the type of risk measures that is similar to downside portfolio optimization analysis. The Downside-risk optimization portfolio weights show slightly better results according to VaR than the Markowitz optimization portfolio. The traditional portfolio created in the VaR is only based on the survey which allocation targets set by real world investors, which are not directly derived through the optimization process based on data used in this thesis. Therefore, it is reasonable to see the result that the traditional portfolio used here does not perform as well as the two optimization models in the Value-at-Risk test.

The thesis also intends to quantify the transaction/management cost effect for PureProperty as a way to take in real estate illiquidity in a dynamic investment world. The analysis results in certain haircut to the risk premium associated to real estate and other assets to net out the operating cost. It is an attempt to bring these real assets through more liquid channels in the understanding of the more interactive management of investment portfolios.

47 Using the traditional portfolio model weights from PREA’s survey. 25% to bond as is shown in the sponsor survey by PREA, 55% to stock, and 5% to real estate, PureProperty, commodity and infrastructure for simplicity.
It is important to note that with the short time period and limited access to data, there are not yet perfect indexes to represent certain assets such as infrastructure and commodity, which shows the limitation of the research conducted through this thesis. The real world practitioners have more measures to take when managing their investment portfolios. However, the author attempts to take steps further to explore the potential portfolio management strategies and is in hope of contributing some valuable addition to the asset management research field in the days to come!

Figure 45 shows how weights change as expected return increases according to different pairings of assets in a stock-and-bond portfolio. It also shows the Sharpe-Markowitz portfolio structure for each pairing.  

Figure 45-Summary of Portfolio Analysis

48 The histogram on the right of the composition diagram demonstrates the Sharpe-Markowitz portfolio weights for the corresponding pairing.

48
1. **Stock, Bond**

- Sharpe-Markowitz Volatility: 10.42%
- Sharpe Ratio: 0.51

2. **Stock, Bond, Real Estate**

- Sharpe-Markowitz Volatility: 6.8%
- Sharpe Ratio: 0.63

3. **Stock, Bond, Commodity, Infrastructure**

- Sharpe-Markowitz Volatility: 9.7%
- Sharpe Ratio: 0.54

4. **Stock, Bond, Commodity, Infrastructure, Real Estate**

- Sharpe-Markowitz Volatility: 6.8%
- Sharpe Ratio: 0.64

---

**Downside Risk**

- VS: 8.14%
- Downside Risk: 0.56%
<table>
<thead>
<tr>
<th>Standard Risk</th>
<th>VS</th>
<th>Downside Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sharpe-Markowitz Volatility</strong></td>
<td>10.42%</td>
<td>8.14%</td>
</tr>
<tr>
<td><strong>Sharpe Ratio</strong></td>
<td>0.51</td>
<td>0.56</td>
</tr>
<tr>
<td><strong>1. Stock, Bond, Real Estate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sharpe-Markowitz Volatility</strong></td>
<td>6.8%</td>
<td>7.2%</td>
</tr>
<tr>
<td><strong>Sharpe Ratio</strong></td>
<td>0.63</td>
<td>0.59</td>
</tr>
<tr>
<td><strong>2. Stock, Bond, Commodity, Infrastructure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sharpe-Markowitz Volatility</strong></td>
<td>9.7%</td>
<td>8.0%</td>
</tr>
<tr>
<td><strong>Sharpe Ratio</strong></td>
<td>0.54</td>
<td>0.58</td>
</tr>
<tr>
<td><strong>5. Stock, Bond, Commodity, Infrastructure, PureProperty</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sharpe-Markowitz Volatility</strong></td>
<td>6.9%</td>
<td>6.9%</td>
</tr>
<tr>
<td><strong>Sharpe Ratio</strong></td>
<td>0.66</td>
<td>0.64</td>
</tr>
</tbody>
</table>
1. Stock, Bond, Real Estate

Sharpe-Markowitz Volatility: 6.8%
Sharpe Ratio: 0.63

2. Stock, Bond, Commodity, Infrastructure

Sharpe-Markowitz Volatility: 9.7%
Sharpe Ratio: 0.54

6. Stock, Bond, Commodity, Infrastructure, PureProperty, Real Estate

Sharpe-Markowitz Volatility: 5.6%
Sharpe Ratio: 0.74
3. Stock, Bond, Commodity, Infrastructure, Real Estate

<table>
<thead>
<tr>
<th>Sharpe-Markowitz Volatility</th>
<th>Sharpe Ratio</th>
<th>Downside Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.8%</td>
<td>0.64</td>
<td>7.3%</td>
</tr>
</tbody>
</table>

5. Stock, Bond, Commodity, Infrastructure, PureProperty

<table>
<thead>
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<th>Sharpe-Markowitz Volatility</th>
<th>Sharpe Ratio</th>
<th>Downside Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.9%</td>
<td>0.66</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

6. Stock, Bond, Commodity, Infrastructure, PureProperty, Real Estate

<table>
<thead>
<tr>
<th>Sharpe-Markowitz Volatility</th>
<th>Sharpe Ratio</th>
<th>Downside Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.6%</td>
<td>0.74</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

Figure 46 shows how Value at Risk models perform among standard Sharpe-Markowitz portfolio, downside risk Sharpe-Markowitz portfolio\(^49\), and the traditional portfolio.

\(^49\)Using the Sharpe portfolio weights from the composition of Stock, Bond, Commodity, Infrastructure, PureProperty, Real Estate
Figure 46-Value at Risk Analysis Summary

Standard Risk VS Downside Risk

<table>
<thead>
<tr>
<th>Metric</th>
<th>Standard Risk</th>
<th>Downside Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharpe-Markowitz Volatility</td>
<td>5.9%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Sharpe Ratio</td>
<td>0.64</td>
<td>0.60</td>
</tr>
<tr>
<td>5% VaR max 1-year loss</td>
<td>-32%&lt;sup&gt;50&lt;/sup&gt;</td>
<td>-30%</td>
</tr>
<tr>
<td>5% VaR 5-year gain</td>
<td>-1.7%&lt;sup&gt;51&lt;/sup&gt;</td>
<td>-1.7%</td>
</tr>
</tbody>
</table>

**Traditional Portfolio<sup>52</sup>**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Traditional Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% VaR max 1-year loss</td>
<td>-44.6%</td>
</tr>
<tr>
<td>5% VaR 5-year gain</td>
<td>-5.0%</td>
</tr>
</tbody>
</table>

<sup>50</sup> Negative number denotes absolute loss.

<sup>51</sup> Negative number denotes absolute loss.

<sup>52</sup> Using the traditional portfolio model weights from PREA’s survey. 25% to bond as is shown in the sponsor survey by PREA, 55% to stock, and 5% to real estate, PureProperty, commodity and infrastructure.
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NAREIM – 2010 Annual Symposium Foreign Investor Perspective: Who Is Ready to Invest in The U.S.?


APPENDIX

Appendix 1-NPI, REIT-based PureProperty & CPPI Indices (2000-2012)

Composite Capital Value Indices 2000-2012
REIT-based PureProperty & Private Market-based Transactions Price Indices

Source: FTSE, MIT CRE
Appendix 2-Summary of Sharpe-Markowitz Portfolio

Stock+Bond+Real Estate

<table>
<thead>
<tr>
<th>Rm</th>
<th>Std</th>
<th>SHARPE</th>
<th>SP500Stk</th>
<th>USTBnd</th>
<th>NCREIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0%</td>
<td>6.8%</td>
<td>0.63</td>
<td>22%</td>
<td>29%</td>
<td>49%</td>
</tr>
<tr>
<td>Sharpe</td>
<td></td>
<td>0.43</td>
<td>0.30</td>
<td></td>
<td>0.41</td>
</tr>
</tbody>
</table>

Stock+Bond+Real Estate (haircut)

<table>
<thead>
<tr>
<th>Rm</th>
<th>Std</th>
<th>SHARPE</th>
<th>SP500Stk</th>
<th>USTBnd</th>
<th>NCREIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.7%</td>
<td>7.21%</td>
<td>0.54718</td>
<td>27%</td>
<td>33%</td>
<td>40%</td>
</tr>
<tr>
<td>Sharpe</td>
<td></td>
<td>0.42</td>
<td>0.28</td>
<td></td>
<td>0.29</td>
</tr>
</tbody>
</table>
**Stock+Bond+Real Estate (downside)**

<table>
<thead>
<tr>
<th>Rm</th>
<th>Std</th>
<th>Sharpe</th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>NCREIF NPI</th>
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</thead>
<tbody>
<tr>
<td>10.0%</td>
<td>7.23%</td>
<td>0.59354</td>
<td>24%</td>
<td>53%</td>
<td>23%</td>
</tr>
<tr>
<td>Sharpe</td>
<td></td>
<td></td>
<td></td>
<td>0.38</td>
<td>0.36</td>
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</table>

**Stock+Bond+Real Estate (downside haircut)**

<table>
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<tr>
<th>Rm</th>
<th>Std</th>
<th>Sharpe</th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>NCREIF NPI</th>
</tr>
</thead>
<tbody>
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<td>9.9%</td>
<td>7.58%</td>
<td>0.54649</td>
<td>28%</td>
<td>59%</td>
<td>13%</td>
</tr>
<tr>
<td>Sharpe</td>
<td></td>
<td></td>
<td></td>
<td>0.37</td>
<td>0.33</td>
</tr>
</tbody>
</table>
Stock+Bond+Commodity+Infrastructure

<table>
<thead>
<tr>
<th>Rm</th>
<th>Std</th>
<th>SHARPE</th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>SP GSCI</th>
<th>Composite Infra</th>
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</thead>
<tbody>
<tr>
<td>11.0%</td>
<td>9.71%</td>
<td>0.54362</td>
<td>28%</td>
<td>44%</td>
<td>12%</td>
<td>16%</td>
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<tr>
<td>Sharpe</td>
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<td>0.16</td>
<td>0.46</td>
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</table>

Stock+Bond+Commodity+Infrastructure (haircut)

<table>
<thead>
<tr>
<th>Rm</th>
<th>Std</th>
<th>SHARPE</th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>SP GSCI</th>
<th>Composite Infra</th>
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<tbody>
<tr>
<td>10.8%</td>
<td>9.71%</td>
<td>0.52302</td>
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<td>44%</td>
<td>12%</td>
<td>16%</td>
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<tr>
<td>Sharpe</td>
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<td>0.28</td>
<td>0.15</td>
<td>0.45</td>
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</table>
### Stock+Bond+Commodity+Infrastructure (downside)

<table>
<thead>
<tr>
<th></th>
<th>Rm</th>
<th>Std</th>
<th>SHARPE</th>
<th>SP500Stk</th>
<th>USTBnd 10-yr</th>
<th>SP GSCI</th>
<th>Composite Infra</th>
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<tbody>
<tr>
<td></td>
<td>10.3%</td>
<td>7.98%</td>
<td>0.57790</td>
<td>21%</td>
<td>64%</td>
<td>5%</td>
<td>9%</td>
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<tr>
<td>Sharpe</td>
<td>0.38</td>
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<td>0.13</td>
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### Stock+Bond+Commodity+Infrastructure (downside haircut)

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### Stock+Bond+Commodity+Infrastructure+Real Estate

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![Graph](image1.png)

### Stock+Bond+Commodity+Infrastructure+Real Estate (haircut)

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![Graph](image2.png)

93
Stock+Bond+Commodity+Infrastructure+Real Estate (downside)

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Sharpe 0.38 0.36 0.13 0.46 0.33

Stock+Bond+Commodity+Infrastructure+Real Estate (downside haircut)

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Sharpe 0.37 0.33 0.12 0.45 0.24
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<th>10-yr</th>
<th>SPGSCI</th>
<th>Composite</th>
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### Table 1: Risk and Return Analysis

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<td><strong>PureProperty</strong></td>
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### Stock+Bond+Commodity+Infrastructure+PureProperty (downside)

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<th>SP</th>
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### Stock+Bond+Commodity+Infrastructure+PureProperty (downside haircut)

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<tr>
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<td>0.37</td>
<td>0.33</td>
<td>0.12</td>
<td>0.45</td>
<td>0.41</td>
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96
### Stock+Bond+Commodity+Infrastructure+PureProperty+Real Estate

<table>
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<th>SP500Stk</th>
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<th>GSCI</th>
<th>Infra</th>
<th>PureProp</th>
<th>NCREIF</th>
<th>NPI</th>
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<td>0.41</td>
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### Stock+Bond+Commodity+Infrastructure+PureProperty+Real Estate (haircut)

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<th>GSCI</th>
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<th>PureProp</th>
<th>NCREIF</th>
<th>NPI</th>
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</thead>
<tbody>
<tr>
<td>Stock+Bond+Commodity+Infrastructure+PureProperty+Real Estate (haircut)</td>
<td>9.5%</td>
<td>5.85%</td>
<td>0.64249</td>
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<td>27%</td>
<td>3%</td>
<td>0%</td>
<td>37%</td>
<td>24%</td>
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<tr>
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<td>0.28</td>
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Stock+Bond+Commodity+Infrastructure+PureProperty+Real Estate (downside)

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<th>USTBnd</th>
<th>SP</th>
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Stock+Bond+Commodity+Infrastructure+PureProperty+Real Estate (downside haircut)

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### Appendix 3-Value at Risk Test Summary

**Sharpe-Markowitz Portfolio**

Simulation Results Statistic:

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<tr>
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<th>MaxLossAny1yr</th>
<th>Yr5Gain/Yr</th>
<th>Mean</th>
<th>Volatility</th>
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<td>Mean</td>
<td>-20.9%</td>
<td>10.1%</td>
<td>11.3%</td>
<td>15.3%</td>
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<tr>
<td>Maximum</td>
<td>-3.3%</td>
<td>37.5%</td>
<td>20.8%</td>
<td>21.6%</td>
</tr>
<tr>
<td>95%ile</td>
<td>-11.3%</td>
<td>21.9%</td>
<td>15.5%</td>
<td>18.4%</td>
</tr>
<tr>
<td>5%ile</td>
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<td>7.4%</td>
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**Downside risk Portfolio**

Simulation Results Statistics:

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<th>Yr5Gain/Yr</th>
<th>Mean</th>
<th>Volatility</th>
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<td>18.7%</td>
<td>20.7%</td>
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<td>95%ile</td>
<td>-10.7%</td>
<td>21.1%</td>
<td>14.4%</td>
<td>17.2%</td>
</tr>
<tr>
<td>5%ile</td>
<td>-30.0%</td>
<td>-1.7%</td>
<td>6.6%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Minimum</td>
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<td>8.6%</td>
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<td>Std.Dev</td>
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**Traditional Portfolio**

Simulation Results Statistics:

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