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1. Introduction

According to earlier estimates done by OECD (2007) the annual infrastructure requirements for electricity transmission and distribution, road and rail transport, telecommunication and water are likely to average 3,5 % of the world GDP per year through 2030, or USD 71 trillion. The investment in infrastructure by governmental bodies has declined the last decades, where total investments in infrastructure in OECD countries fell from 4 % of GDP in 1980 to 3 % in 2005. In addition to the financial crisis that has exacerbated the situation, the funding gap in developing and emerging markets has kept increasing. Especially in Europe and USA the public authorities has privatized a lot of the conservation associated with infrastructure. The infrastructure funding gap may provide attractive investment opportunities for private and institutional investors in the future and also increase demand for private capital. Investment opportunities and characteristic related to infrastructure as an asset class has lead to an increase in popularity among investors.

Investments in infrastructure include a wide spectrum of investment vehicles normally defined as “economic infrastructure” (Transport, Utilities, Communication, Renewable energy, etc.) or “social infrastructure” (Schools, Healthcare, Defence, Prisons, etc.).

Infrastructure as an asset class has been characterised among earlier studies to have many unique characteristics. The economic characteristics are normally related to high entry barriers, economies of scale, inelastic demand for services, low operating cost and high target operating margins, and long duration.

This thesis will be structured in the following way:

The first section portrays the purpose and motivation behind our topic, as well as emphasizes what we are going to analyse and refinements of the paper.

In the second section we will give a broad definition on what characterizes infrastructure as an asset class. This part will emphasize a broader understanding of how the infrastructure market is composed, why investors invest in infrastructure, and why investments in infrastructure has become a more popular asset class the resent years.

In the third section we will present previous studies and relevant literature discussing infrastructure as an asset class

Section four describes the methodology we use to analyse infrastructure as an asset class, and how we conduct our portfolio optimization both with and without infrastructure.

Section five presents the different data we will use in our analysis.

In the sixth section we present our results.

In the final section we summarize our results, and based on our findings, give suggestions to portfolio optimization utilizing infrastructure as a diversification tool.

2. Hypothesis

The main goal of this thesis is to present infrastructure as an asset class, and to analyse the potential diversification benefit of including listed infrastructure in a mixed asset portfolio.

Our hypothesis is:

H_0 : Including listed infrastructure in a mixed asset portfolio will have **no** significant diversification benefit.

H_A : Including listed infrastructure in a mixed asset portfolio will have **a** significant diversification benefit.

3. Literature Review

Compared with traditional optimal portfolio theory, academic literature regarding optimal portfolio theory utilizing infrastructure as a diversification tool are scarce. In part due to lack of performance data (often private company information) but also due to a high degree of heterogeneity across different infrastructure sectors. In this section we will present some of the key studies relevant for our research question. In particular we present research covering infrastructure risks, diversification benefits, comparable studies of listed vs. unlisted, and direct vs. indirect investments.

Joseph B. Oyedele et al. (2014) examine global infrastructure investment performance with other global asset classes such as real estate, bonds, stocks and private equity. They also look at the correlation between infrastructure investments and other asset classes in order to reflect the diversification opportunities of implementing infrastructure in a mixed asset portfolio. Their findings indicate that the effect of infrastructure in a mixed asset portfolio is more related to risk reduction than enhancement of returns. More specifically, they state that a systematic allocation of between 10 and 17.63% of infrastructure into a global investment portfolio can significantly enhance diversification benefits for investors.

When it comes to diversification benefits of infrastructure it is important to highlight the difference between listed and unlisted infrastructure. In order to examine the potential enhancement of portfolio performance when including infrastructure, we are focusing on listed infrastructure in order to obtain data on historical performance of infrastructure. George A. Martin (2010) argues that listed infrastructure stocks might serve as a useful reference point for infrastructure performance, but that they are primarily driven by stock market volatility and that their characteristics are therefore less useful as a proxy for unlisted infrastructure.

De Francesco et al. (2015) compare the unlisted infrastructure index MSCI Global Infrastructure Asset Index (made public in 2009) with the listed MSCI World Infrastructure Index. They find that in the period (2009-2014) the unlisted index

has outperformed the listed index with an annualized return over the last five years of 14.0%, compared with 9.6% for the listed index. They argue however that the difference might be biased due to different sectorial compositions. After creating a listed proxy of the unlisted index by picking listed stocks and making a portfolio matching the sectorial composition of the index, they find that the differences in annualized returns diminish. They are still there, but much smaller than in their original comparison.

As one of the key incentives of infrastructure investments are related to the differences in risk profile compared to more traditional equity, Christoph Rothballer and Christoph Kaserer (2012) test the market risk and total risk of more than 1400 listed stocks across infrastructure sectors including telecommunication, utilities and transport. Their findings suggest that infrastructure has significantly lower market risk than comparable equities in the MSCI All Country World Index, confirming its portfolio diversification benefits. They also argue that their findings indicate that total risk is not lower for infrastructure due to high levels of idiosyncratic risk. This unsystematic risk can be explained by construction risk, operating leverage, the exposure to regulatory changes and the lack of product diversification.

Publications prior to Rothballer and Kaserer such as Beeferman (2008), Rickards (2008) and Inderst (2009) all associate infrastructure with low market correlation. The reasons lie in the nature of infrastructure and the demand it faces. Demand for services such as energy, communication and transportation has a low correlation to disposable income or economic cycles as they are required to satisfy basic human need and are essential input to any economic activity (Rothballer and Kaserer, 2012).

It is claimed that infrastructure firms have stable and predicible income streams due to low competitive pressure in infrastructure industries. Bitsch et al. (2010) analyse the risk, return and cash flow characteristics of infrastructure investments using a dataset of global infrastructure and non-infrastructure investments done by unlisted funds. They argue that infrastructure deals have a higher performance than non-infrastructure deals despite having lower default frequency. They also

find that infrastructure deals have low correlation with GDP. Despite this, they find no significant difference between infrastructure and non-infrastructure investments in terms of their cash flow characteristics.

Florian Bitsch (2012) on the other hand confirms the common hypothesis that infrastructure investments have more stable cash flows than non-infrastructure investments. He examines a global sample of 120 listed infrastructure investment companies and funds, and compare their performance to a global sample of listed private equity used in Lahr and Herschke (2009). Despite finding evidence of higher cash flow stability for infrastructure investments, he does not find that investors positively value the cash flow stability. Instead, more volatile cash flows are valued at a premium. Additionally, he finds evidence that sector specific and regulatory risk play a significant role for the valuation of infrastructure investments companies and funds.

For our research it is also important to emphasise the difference in direct and indirect investment in infrastructure, and the difference in performance characteristics on those investments. Finkenzeller and Fleischmann (2012) investigate the long-run relationship and short-term dynamics between direct and securitized (indirect) infrastructure returns and the relationship of infrastructure investments to real estate indices. Their research results suggest an existence of a long-run relationship between direct and securitized infrastructure driven by a common underlying infrastructure business factor. This implies that investors are not able to realize long-term portfolio diversification benefits by allocating funds to both direct and securitized infrastructure. In the short run however, they find that indirect infrastructure is driven by the general stock market. Lastly, they find no evidence of a long-term interrelationship between infrastructure and real estate, concluding that a portfolio with a long-term investment horizon should include both types of assets.

When analysing diversification benefits of infrastructure it might be useful look at previous studies trying to estimate the value of the world market portfolio and how much infrastructure accounts for the overall portfolio.

Depending on how broadly infrastructure is defined, RARE (2016) estimates infrastructure assets to lie in the 20 to 50 trillion dollars range globally. Approximately 25% of these assets are privately owned, of which listed infrastructure accounts for 50% (or 2.5% of the world market portfolio)

4.0 Methodology

In this paper we will analyse and check whether investment in infrastructure can improve the risk-return relationship in a portfolio consisting of asset class such as stocks, bonds, and real estate. Given our research question it is natural to use modern portfolio theory and portfolio optimisation techniques.

4.1. Limitations

Basically we analyse the risk and return characteristics related to investments in infrastructure, and therefore exclude other “gains” as inflation hedge and tax benefits. The thesis goal is to give comprehensive picture of infrastructure as an asset class and look at the risk-return relationship, and not focus on specific infrastructure investments, such as utilities only. In our analyses we will also exclude psychological factors that can affect financial markets.

4.2. Descriptive Statistics

Before the analysing part is presented, a description of the dataset used will be presented through descriptive statistics. It will be presented how the different indices have performed over the sample period such as return, standard, skewness and kurtosis.

We will distinguish between geometric and arithmetic return. Arithmetic average return gives an estimate on expected return. When arithmetic average is calculated we treat each observation as an equally likely “scenario” based on historical data.

$$\mu_a = \frac{1}{n} \sum_{j=1}^n R_{i,j}$$

Geometric average return, or time-weighted return, is used to find a target of the *actual* return on a portfolio over a given sample period. The geometric mean return is calculated as follows:

$$\mu_g = \left(\prod_{j=1}^n (1 + R_{l,j}) \right)^{1/n} - 1$$

Where

$R_{i,j}$ = Return on asset i , in period j .

$R_{l,j}$ = Return on asset l , in period j (geometric).

n = number of observations

The standard deviation will be used to measure the risk of the different indices. Standard deviation is given by:

$$\sigma = \sqrt{\frac{1}{n} \sum_{t=1}^n (R_t - R_i)^2}$$

Where

R_i = Arithmetic mean return.

R_t = Return in period t .

n = Number of observations.

After the descriptive statistics are presented we need to estimate the relationship between the different assets. There will be created a correlation matrix between all the assets to see how they behave towards each other.

$$\rho_{x_i y_j} = \frac{Cov(R_i, R_j)}{\sigma_i \sigma_j}$$

Where

$Cov(R_i, R_j)$ = Covariance between the return of asset i and j .

$\sigma_i \sigma_j$ = Standard deviation asset i and asset j .

4.3. Portfolio optimisation

The portfolios will be optimised without any risk free alternatives. The model we will use is Markowitz optimisation model, which is a popular model within the modern portfolio theory. In this paper we will also experiment with portfolio weights used by other institutional investors such as The Canadian Pension fund. The Markowitz equation for estimating the efficient frontier is given by minimizing:

$$W^T \Sigma W - q * R^T * W$$

Where,

W = Vector of portfolios weights.

Σ = Covariance matrix returns.

R = Vector of expected returns.

$W^T \Sigma W$ = Variance of portfolio return.

$R^T W$ = The expected return.

This equation will help us calculate the optimal weight with the lowest variance.

4.4. Performance measures

To measure whether infrastructure as an asset class can improve the portfolios return and the risk-return relationship we will use following risk-adjusted measures for our portfolios.

Sharpe ratio measures the reward to total volatility trade-off.

$$S_i = \frac{R_i - R_f}{\sigma_i}$$

Treynor ratio also measures the volatility trade-off, but it uses systematic risk instead of total risk.

$$T_i = \frac{R_i - R_f}{\beta_i}$$

This means that we need to estimate the beta coefficient for each portfolio. We will use capital pricing model (CAPM) to estimate the beta coefficient.

Jensen's Alpha will be estimated to check if the portfolios have outperformed or underperformed the market portfolio.

$$\alpha_i = R_i - [R_f + \beta_{im} * (R_m - R_f)]$$

Where,

α_i = Jensen's Alfa

R_i = Portfolio i's return

β_{im} = Portfolio i's beta

R_m = Market return

5. Data

Using Bloomberg we are able to collect weekly returns from the last 10 years of major indices representing real estate, equity, bonds and infrastructure. The decision to include other indices or exclude some of the indices presented below will depend on our research and to what extent these indices are sufficient for our analysis. Furthermore, as we are focusing on the potential diversification benefits of listed infrastructure specifically, not infrastructure generally, we are able to overcome the problem of using listed infrastructure as a proxy of unlisted infrastructure. Unlisted infrastructure will not be relevant for our portfolio optimisation problem.

Real Estate

The Dow Jones Global Select REIT

The index is designed to measure the performance of publicly traded Real Estate Investment Trusts (REIT) and REIT-like securities and is a sub-index of the Dow Jones Global Select Real Estate Securities Index (RESI), which seeks to measure equity real estate investment trusts (REITs) and real estate operating companies (REOCs) traded globally. The index is designed to serve as a proxy for direct real estate investment, in part by excluding companies whose performance may be driven by factors other than the value of real estate.

S&P Global Property

The index defines and measures the investable universe of publicly traded property companies. The index is used for benchmarking active funds and setting the foundation for passive funds. It is divided into two sub-indices: S&P Developed Property and S&P Emerging property.

Infrastructure

S&P Global Infrastructure index

The index is designed to track 75 companies from around the world chosen to represent the listed infrastructure industry while maintaining liquidity and tradability. To create diversified exposure, the index includes energy, industrials,

and utilities with weight 20.6%, 39.5% and 39.9% respectively.

Dow Jones Global Infrastructure index

The index includes companies domiciled globally that qualify as pure-play infrastructure companies. Pure-play infrastructure meaning companies whose primary business is the ownership and operation of infrastructure assets. To be qualified for this index companies are required to have more than 70% of cash flows derived from infrastructure lines of business. The index intends to measure all sectors of the infrastructure market, including airports, toll roads, ports, communications, electricity transmission and distribution, oil and gas storage and transportation, and Water.

Bonds

Bloomberg Barclays Global aggregated total return index value unhedged

The Index is a measure of global investment grade debt from 24 local currency markets. This multi-currency benchmark includes treasury, government-related, corporate and securitized fixed-rate bonds from both developed and emerging markets issuers.

Equity

S&P Global 1200 index

This equity index captures approximately 70% of the world's market capitalization, suitable as a proxy for the global listed equity market. It is a composite of seven headline regional indices: S&P 500, S&P Europe 350, S&P TOPIX 150, S&P/TSX 60, S&P/ASX All Australian 50, S&P Asia 50 and S&P Latin America 40.

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