**Equity Diversification from an Allocation to Listed Infrastructure**

by

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# Abstract

There is huge demand for investment in new and existing infrastructure projects, estimated by the OECD to be USD 6.3 trillion, to support global growth through to 2030. The private sector is expected to contribute to the financing of these projects and ensuring potential investors understand the nature of the asset class is critical for encouraging their participation. Investments in unlisted infrastructure projects are widely regarded as a source of diversifying returns that can improve risk-adjusted returns. However, diversification studies into listed infrastructure have reached conflicting views on its equity diversification, with a recent trend towards dismissing it as an inferior, fake infrastructure that offers little portfolio benefits. Consequently, investors are presented with conflicting information, creating a reluctance to invest that reduce a capital availability and increases financing costs making it harder to meet the new investment that is needed.

In this work the authors review previous listed infrastructure studies to identify explanations for the varying conclusions. They have typically focused on a subset of the listed infrastructure sector and short time periods, which has led to inconsistent results. The review of these has guided this study’s comprehensive review into listed infrastructure to determine the correlation of infrastructure over different time periods and equity correlation across subsets of the asset class, including individual stocks, stock sectors, active funds and benchmark indices.

Our findings agree that not all listed infrastructure investments provide equity diversification but within this heterogeneous asset class there are stocks and sectors that do. Surprisingly, this does not result in active funds and benchmark indices with a similar low correlation profile, instead these investment vehicles through which many investors will seek to access listed infrastructure, has much higher correlation. Furthermore, correlations are found to vary over time, particularly in response to extreme market events.

# 1. Introduction

The OECD (2017) estimates that an annual infrastructure investment of USD 6.3 trillion is required to support global growth and development through to 2030. A combination of public and private sector investment is needed to meet the large-scale investment necessary to develop projects that facilitate essential services. The attraction for the private sector is that these unique assets typically have a monopolistic position with high barriers to entry and inelastic user demand. These economic characteristics are believed to results in stable financial returns, inflation-protected cash-flows, low correlation to traditional assets and macroeconomic factors, and high income generation (Sawant, 2010).

In the low growth, low interest rate environment that has persisted since the 2008 Global Financial Crisis (GFC) investing in infrastructure has proven to be increasingly appealing and the result has been huge asset growth of infrastructure investment strategies as investors have increased their portfolio allocations. Consequently, there is no shortage of willing investors looking to finance infrastructure projects, as evidenced by USD the 158 billion of cash in unlisted infrastructure funds that is waiting to be invested (Preqin, 2018). The problem is funding of the projects. Government budgets cannot afford to pay private sector investors the rate of return that is necessary for all of the required projects to be built (OECD, 2017). In the absence of infrastructure budget increases, a solution to this problem is to reduce the cost of funding. In part this may be achieved by increasing competition amongst potential investors by making infrastructure available to a broader set of capital providers.

Currently, the majority of private sector infrastructure investments are financed through private, unlisted funds which are the preserve of institutional investors, such as defined benefit (DB) pension schemes. Listed infrastructure has proven less popular and criticised forhaving lower returns than unlisted infrastructure (Rothballer and Kaserer, 2012). However, when viewed from the taxpayers perspective this makes listed infrastructure a relatively attractive financing choice. Increasing the portion of infrastructure that is funded through listed companies could help improve value for money and the funding of a greater number of projects.

EDHEC’s (2016) survey of 184 investors representing USD 8 trillion of assets under management found that diversification was the most important factor for investing in infrastructure so not maximising returns isn’t an insurmountable obstacle for attracting investment. However, EDHEC’s (2016) survey also found an unwillingness to invest in infrastructure if it cannot be defined as an asset class. These views have prompted numerous studies into whether listed infrastructure can be considered an asset class and, if so, what sort of returns investors should expect. There isn’t a formal set of definitions of what constitutes an asset class but Amenc et al (2012) and Inderst (2009) provide some useful rules of thumb. Amenc et al (2012) states that for a group of assets to be considered an asset class they should have greater covariance within the group of assets than with other asset classes. Inderst (2009) believes assets should to subject to the same laws and regulations and have similar risk-return characteristics. The problem of asset class definition is worsened by “Infrastructure” being an umbrella term applied to a diverse group of projects, companies and sectors that are accessed through a variety of investment vehicles and financing structures.

The consensus amongst academic researchers is that unlisted infrastructure investments are indeed an asset class provide the advertised characteristics of stable returns and diversification (Sawant, 2010). However, there is a disagreement about whether these characteristics are also present in listed infrastructure. Studies by Oyodele (2013) find that listed infrastructure does provide diversification, but other studies dispute these claims and believe listed infrastructure isn’t a distinct asset class or, as Blanc-Brude et al (2016) puts it, is “Fake Infra”.

Previous studies have typically surveyed different, short time periods and often with a focus on a particular region, sub-sector or investment structure within this heterogeneous asset class. These differences in study approach may contribute to the inconsistency of conclusions. To give the private sector more confidence to invest there needs to be a clear understanding the expected return profile, with a focus on diversification due to this being investors main motivation for allocating to infrastructure.

This paper aims to contribute to the existing body of knowledge on listed infrastructure by studying the diversification profile of these structures, over multiple time periods. By exploring whether these characteristics make the case for listed infrastructure as an asset class the study will provide a clearer understanding of the investment opportunity to better inform investors’ decision making process. The intended audience is investors, asset managers and academics.

The first section presents a review of the existing academic literature on this topic, this is followed by a description of the methodology followed in this study. The next section presents the results and accompanying analysis. The final section offers conclusions and recommendations.

# 2. Literature review

It is widely agreed by academic researchers that unlisted infrastructure investments typically generate stable returns with low correlation to equities and bonds which results from owning unique projects with cash flows contractually linked to inflation and disconnected from general economic activity ( Inderst, 2009). Blanc-Brude et al’s (2016) review of UK unlisted infrastructure firms founds that their fundamental performance is consistent with the narrative i.e. revenues and profits are considerably less volatile and are not impacted significantly by the business cycle. Consequently, unlisted infrastructure is regarded as a distinct asset class with diversification potential and other characteristics that are found to improve an investment portfolio’s risk-adjusted returns.

However, in contrast to unlisted studies, the academic research on listed infrastructure does not reach a collective conclusive verdict on the investment merits. Previous studies have covered various different types of listed infrastructure, studied different regions and over different time periods and can generally be split into three groups based on their conclusions. The first make the case that listed infrastructure is an asset class and that it provides portfolio diversification benefits; the second set argues that listed infrastructure does not provide diversification and cannot be considered an asset class; and the third set finds that listed infrastructure is too heterogeneous to be considered an asset class as some parts do provide diversification whereas other parts do not.

A review of these studies proves offers insights into how opinions of listed infrastructure have evolved over time, where the current thinking lies and what can be done to fill the gaps and improve the clarity of conclusions about its role as a diversifier.

## 2.1. Positive asset class and diversification findings

The idea of listed infrastructure as a standalone asset class is fairly new so there aren’t any academic studies prior to the 2000s. Newell and Peng conducted some of the earliest academic studies covering various regions and time periods. They found low equity market correlation and high correlation between the infrastructure sub-sectors indicating that it is indeed an asset class for their studies of both US and Australian listed infrastructure Newell and Peng’s (2007, 2008).However, neither study includes the GFC period so seems incomplete relative to later studies.

Dechant et al (2010) followed up with a later diversification study on Australian listed infrastructure that did incorporate the GFC and also found similarly low correlation to equities, which they use as the basis for arguing that it is a distinct asset class. However, they note that during the GFC, equity market correlation increased and remained at elevated levels. This finding highlights the important point that correlations may not be constant over time. During the GFC, an increase in equity market correlation was widespread across asset classes and led to many studies challenging modern portfolio theory and the perceived benefit of diversification (Asness, 2011).

Russ et al’s (2010) study of global infrastructure returns from 2000-2010 identified low correlation with US equities, but high correlation with non-US equities, 0.44 and 0.83, respectively. Their finding that listed infrastructure diversification varies across equity regions highlights the influence that regional focus may have on the results found across empirical studies. Heston and Rouwenhorst (1995) explored this from a wider equity market perspective by analysing 12 European countries’ equity markets between 1978 and 1992 and a found stronger diversification effect came from country exposures than sector exposures. Therefore, listed infrastructure’s diversification potential may vary depending on an investor’s existing regional exposure and the similarity it has with the regional exposure inherent in a listed infrastructure allocation.

To overcome the impact of regional biases on results, later studies have taken a broader approach and analysed listed infrastructure from a global perspective. Rothballer and Kaserer (2012) take this approach in their study of listed infrastructure that focuses whether it is a low risk investment relative to other equities. They find that it is not low risk but the risk cannot be explained by market beta as per the Capital Asset Pricing Model, but instead is mostly idiosyncratic risk thus indicating low equity market correlation. Another important finding from this study is significant variation of risk across sectors, for example, the infrastructure utilities stocks had an average beta of 0.50 whereas infrastructure companies in the telecommunications sector had an average beta of 1.09. Rothballer and Kaserer argue that this variation across sectors is evidence that listed infrastructure is not an asset class. However, the logic of this argument is flawed when considering that the same variation between sectors is present across the wider equity market as well, and “equities” are indisputably an asset class.

Bird et al (2014) build on the factor analysis framework to analysing global listed infrastructure returns by performing multi-variate regression with an expanded Fama and French (1993) factor analysis approach. They agree with previous risk analysis studies that listed infrastructure has low market beta and also find that conventional market factors, such as the small cap factor and value factor, lack strong explanatory power which leads them to conclude that listed infrastructure does indeed have high idiosyncratic risk and dispels the idea that the diversification effect is solely being driven by regional differences.

These studies have covered different portfolio characteristics, time periods, regions and methods of analysis but arrived at the same conclusion: that listed infrastructure does provide diversification. It is surprising then, that other studies present a different, contradictory narrative challenges listed infrastructure’s legitimacy as an asset class and its diversification potential.

## 2.2. Negative asset class and diversification findings

Idzorek and Armstrong (2009) study the period 1990-2007, which is achieved by creating a series of backfilled infrastructure indices, an approach that differs to previously mentioned studies that use empirical, stock-level data. They identify moderate correlation between 0.57 and 0.61 with US stocks and higher correlation with non-US stocks 0.63 to 0.70. They conclude that whilst listed infrastructure offers a unique investment opportunity it cannot be considered an asset class due to its overlap with another asset class, equities. However, their approach of using the same data to back-fill the earliest periods for a series of benchmarks that are subsequently treated as independent samples is flawed so the results should be treated with scepticism.

Recent academic research from EDHEC’s Infrastructure Institute has been particularly vocal about the perceived limitations of listed infrastructure. Their high-profile research, which has been covered by the Financial Times (FT, 2017), argued that listed infrastructure is “Fake Infra” and offers no portfolio benefit. They conclude that the asset management industry’s marketing of infrastructure amounted to mis-selling. These views are driven by EDHEC’s Blanc-Brude et al’s (2016) study that analysed active funds as well as infrastructure stocks and indices from 2001 to 2016. These investment vehicles were analysed across a range of metrics to test if the listed approach fits the infrastructure narrative. For their diversification study, they perform a mean-variance optimisation (MVO) and use the models inclusion or exclusion of listed infrastructure in the recommended allocation as evidence that it does or does not provide diversification, respectively. They find that indices, active funds and majority of sectors do not feature in the optimiser’s efficient portfolio recommendation so conclude that listed infrastructure does not provide diversification benefits, however, there are some flaws within their approach. Firstly, a well-understood limitation of MVOs is the tendency for recommendations of un-diversified portfolios with very large weights to just a few assets, which makes the condition of asset class inclusion an inappropriate test for diversification. It is recommended that minimum diversification constraints are imposed on the MVO tool in order for realistic, investible portfolio to be recommended (J. Lin, 2013). Secondly, the authors’ use of a 15 year time period is too long to study active funds as there is only one fund with enough track record, so this sample may be a poor representation of the population with misleading results.

In some cases, the studies that have reached negative conclusions on listed infrastructure have done so using flawed methodologies and data sets that are either small or potentially subject to data-mining in order to reach the conclusions. However, there are other areas within these studies that simply reach different conclusions about the same asset class using similar methods and samples to earlier studies that reached positive conclusions so this inconsistency is problematic for reaching an overall conclusion.

## 2.3. Mixed asset class and diversification findings

Through the previously mentioned studies it can be seen that researchers have reached very different conclusions. This may to be due to the authors’ desire to make strong, conclusive, generalisations where it is not really possible. Panayiotou and Medda (2014) challenge prior research that assumes infrastructure is a homogenous asset class and the generalisations that all sectors have the same characteristics. They analysed the return profile of each infrastructure sector and sub-sector from 2003-2013 and found significant differences. They summarise that infrastructure is an asset class comprised of unique projects with their own return drivers, which is based off similar findings to Rothballer and Kaserer (2012) factor analysis study, but more nuanced in its conclusion.

Oyodele’s (2014) study on UK-listed infrastructure from 2001-2010 found similar dispersion of returns and diversification amongst sectors and argues the differences are consistent with the infrastructure narrative - when listed investments are exposed to core or unique infrastructure they tend to exhibit more stable returns and diversification benefits.

These studies argue that there is a weak case for listed infrastructure being an asset class in the traditional sense, as defined by Amenc et al (2012), but they also highlight strong evidence of diversification, albeit possibly not from the entire range of investments.

## Time periods

In addition to the different approaches, listed infrastructure investments and regions that are present across studies there is also variation in the time periods that have been studied.

The listed infrastructure “asset class” or “investment strategy” is fairly new and rose to prominence following the privatisation of utilities companies in the 1980s. Consequently, there aren’t any infrastructure indices with returns that pre-date 1990, which prevents analysis into the long term behaviour of the asset class.

The shortage of datahas led to previous studies often analysing just a single, short time period (Oyodele 2013, Newell and Peng 2007). This is problematic because whilst over the long-term the stock market is found to be an efficient mechanism for accurately reflecting fundamental information (Fama, 1998) but there are periods, such as market shocks, where share price performance becomes disconnected from fundamentals due to panic-selling.

Consequently, studying short time periods of performance can lead to conclusions being made that are not representative of the long term experience, particularly if the short time period includes an highly unusual event. Furthermore, a broad equity market study by Ramchand and Susmel (1998) found that correlations are not stable over time and increase at times when stock market volatility is relatively high. This finding suggests that listed infrastructure studies included the 2008 GFC, where correlations increased, will likely reach different conclusions than studies that exclude it. The study of different, short time periods may explain the inconsistent findings made by academics and industry practitioners.

Blanc-Brude et al (2016) overlook the scarcity of the listed infrastructure investments with long track-records and present a study with sample sizes that are too small to draw reliable findings and may lead to results that are not representative of the wider population. The use of small sample sizes may further contribute towards the inconsistency of findings across studies.

The different time periods studies and varying sample sizes may have both contributed towards the contradictory findings and create a confusing picture of the diversification benefits of listed infrastructure.

## Contributing to the body of knowledge

A review of the academic literature makes it clear that studies with different time horizon focuses, different regional focus and different investment sets have led to inconsistent results and conclusions being made about listed infrastructure. Despite this, the consensus of academic thinking currently leans towards the view that listed infrastructure is not a distinct asset class and does not provide diversification. This will likely reduce investor demand and have negative consequences for the funding cost of projects.

Studies that have explored the heterogeneity within the asset class present a more balanced picture. However, the study of just a limited number of time periods and listed infrastructure options and the simple use of headline statistics with little transparency into the diverse performance of this disparate asset class doesn’t convincingly dispel the criticism that has been directed at the sector.

The listed infrastructure body of knowledge would benefit from further studies into the sector not only to investigate the characteristics of this young asset class using a longer period of data but to understand the persistency of correlation over time. Examining active funds over multiple time periods alongside infrastructure stocks and indices will help test the fund management industry’s claims about diversification benefits and identify areas that are relatively attractive or unattractive from a diversification perspective.

# 3. Methodology

The aim of this study is to analyse the correlation of the various types of listed infrastructure with global equities over multiple time periods. This will provide a comprehensive picture of how the asset class behaves as guidance for both investors and asset managers that are motivated by investing in or managing funds where diversification is a priority. The expectation is that there are varying levels of correlation within this heterogeneous asset class and that diversification varies across time.

The research objectives are:

* Determine the correlation of the various types of listed infrastructure with global equities.
* Perform analysis over multiple time periods to determine persistence of correlation.
* Consider the relative attractiveness, from a diversification perspective, of infrastructure stocks, active funds and indices.

The chosen research method is quantitative analysis of time series data as it allows large samples to be measured objectively and the results presented as conventional statistics. This is consistent with the approach taken in previous studies so will generate results that are easily comparable. From a practical perspective, the approach is suited to the study of listed infrastructure as the input data (fund and share prices) is publicly available.

## 3.1. Measuring diversification

To measure of diversification used in this study is the correlation coefficient. It is a widely used and well-understood measure of the relative directional movements between two data sets. In this case, the total returns of listed infrastructure and global equities. All summary statistics have been calculated from monthly total returns, which are comprised of income return and price return (capital growth) components.

To interpret the correlation results, the study will follow the widely accepted rule of thumb presented in table 1 (Hinkle et al, 2003).

The correlation coefficient is calculated for the following sets of samples:

* Infrastructure stocks and global equities
* Infrastructure stock sectors and global equities
* Infrastructure stocks (in MSCI World) and global equities
* Infrastructure stocks (not in MSCI World) and global equities
* Active funds and global equities
* Indices (regional and sector speciality indices included) and global equities
* Indices (globally diversified only) and global equities

In addition to calculating the mean correlation for each sample other metrics are presented to give insights into the distribution of values and potential heterogeneity within the samples. Standard deviation, kurtosis, skewness and minimum and maximum values are included, as well as histograms for a visual representation of the distribution of correlations in each sample.

## 3.2. Measuring the persistence of diversification

As discussed earlier, the youth of the asset class hinders long-term analysis on a large sample. Performing analysis on a 20 year time period from 01/07/1998 - 30/06/2018 yields a sample of 177 stocks but just 5 indices and 0 stocks. The inability to measure each of the three sectors over the same long period presents the choice of analysing a shorter common time period or longer time periods, some of which will be common to the three datasets. The chosen approach is to combine the two and perform the analysis a 10 year time period (01/07/2008 - 30/06/2018), 15 year time period (01/07/2003 - 30/06/2018) and a 20 year time period (01/07/1998 - 30/06/2018). Whilst it is not possible to make the comparison with active funds for the 20 year time period, it is worth including for the insights it provides into the longer-term performance of infrastructure stocks and indices that spans multiple economic and market cycles. To be transparent about the different length track records for each dataset, the sample size in each time period is provided. The inclusion of the GFC, the worst market crash in 75 years, should lead in a conservative estimate of the future diversification benefits. It is widely accepted that during financial crisis correlations across listed investments increase as investor’s engage in a “flight to safety” and sell their investments indiscriminately as they try to de-risk their portfolio and move to cash investments.

In addition to long-term, single-point analysis this study includes rolling correlation to gain insights into the persistence of diversification in different market environments. This represents an enhancement over previous studies that covered just a single or small number of time periods. Rolling correlation is performed over the 20 year time period with each correlation window of 5 years and a 1 year step between each window, which generates 16 individual 5-year data points. The 1 year step leads to an 80% overlap with previous correlation windows so directional trends can be identified.

## Robustness Tests

By calculating the correlations of active funds, infrastructure stocks and indices a comparison can be made on their relative attractive from a diversification perspective. The aim is to test the hypothesis that different listed infrastructure strategies are uniformly correlated with global equities. If this can be rejected then alternative hypothesis that there are significantly different levels of correlation can be accepted, indicating that the asset class’s perceived heterogeneity is reflected in the sample means. This builds on the work of previous studies that have reviewed multiple strategies but not provided statistical testing as part of their comparison. Blanc-Brude et al (2016)

To test the hypothesis, t-tests are performed, specifically the two-tailed t-test for population means with unknown variance. This allows us to test the exploratory hypothesis that that the two samples have equal means (null hypothesis) and if null hypothesis can be rejected then alternative hypothesis, that the means off the two populations are different, can be accepted. Practically, this requires the correlation with global equities to be calculated for each infrastructure investment, which are then aggregated into a sample set from which the mean is calculated. The sample mean is then tested against another sample’s mean to determine if there is a significant difference between them.

The hypothesis and t-test equation are provided in Figure 1:

Figure 1: T-test

Hypothesis:

$$σ\_{X}^{2} \ne σ\_{Y}^{2} $$

$$H\_{o}: μ\_{A}- μ\_{I }=0$$

$$H\_{A}: μ\_{A}- μ\_{I }\ne 0$$

T-test:

$$T=\frac{\left(\overbar{X}- \overbar{Y}\right)-(μ\_{a}-μ\_{i})}{\sqrt{\frac{S\_{X}^{2}}{n}+\frac{S\_{Y}^{2}}{m}}} $$

A requirement for conducting a t-test is that the means are independent with no overlapping between the two sample groups. Whilst the underlying stocks may be present across the active funds, indices and MSCI World they are highly unlikely to be entirely invested in exactly the same stocks with the same size positions so the test remains valid.

The following t-tests have been performed:

* Test 1. infrastructure stocks ≠ active funds
* Test 2. infrastructure stocks ≠ indices (global)
* Test 3. active funds ≠ indices (global)
* Test 4. infrastructure stocks (in MSCI World) ≠ infrastructure stocks (not in MSCI World)

# 4. Data

This section describes the construction of the datasets that represent the different listed infrastructure investment types. Section 4.1. describes the reference index that is used to represent for global equities. Stocks, active funds and indices are covered in sections 4.2., 4.3. and 4.4., respectively.

## 4.1. Reference index

The correlation has been calculated relative to global equities, using the MSCI World Total Return (MSCI World) as a representative index., which is the most widely referenced global equity index as evidenced by 27% of the 5,355 active global equity funds using it as a benchmark. (Morningstar, 2018).

The MSCI World is exposed to stocks from all sectors and industries infrastructure so there is an overlap with the infrastructure stocks in this study. 45 of the MSCI World’s constituents, representing 2.6% of index weight, are also present in the S&P Global Infrastructure index. The seemingly logical step of excluding these stocks from the MSCI World makes the unrealistic assumption that investors allocate to global equity strategies that explicitly exclude infrastructure stocks, which has the consequence of over-stating the diversification benefits relative to what an investor would actually experience. This study has not removed the infrastructure stocks from the MSCI World in order to accurately reflect investors’ global equity exposure and ensure consistency with the approach taken in most other studies.

## 4.2. Infrastructure stocks dataset

The approach of this study is to leverage the stock selection processes of the index providers to create a dataset from the stocks that are constituents of the infrastructure indices. This should lead to a more accurate infrastructure stocks sample as they are motivated to provide effective and precise exposure to the asset class in order to encourage infrastructure active funds and exchange traded funds (ETFs) to choose them as their reference benchmark.

The implementation of this approach required the obtaining the constituent data for the listed infrastructure indices using Morningstar Direct. Duplicate listings were removed as were non-primary share listings. This filtering process returned of 849 stocks with an average track record of 21 years. In addition to analysing the stocks in aggregate, separate subsets have been defined to analyse stocks grouped into their Morningstar sectors, and by their inclusion or absence from the MSCI World.

## 4.3. Active funds dataset

A dataset is created for active funds that specialise in the ownership of infrastructure stocks. These were identified by searching the Morningstar Direct database for open-end, equity mutual funds with a name containing “infra”, or benchmarked to an index with a name containing “infra”. The filtering process returned 117 funds with an average size of USD 199.6 million and average track record of 7 years (Morningstar Direct, 2018). No funds were excluded based on asset size. Firstly, because fund sizes are not static and, secondly, doing so reduces comparability with future studies.

## 4.4. Indices dataset

Listed infrastructure indices are managed by index providers with the objective of tracking the performance of a diversified set of liquid infrastructure shares with constituent weights determined by market-cap. The dataset for indices was compiled by screening the Morningstar Direct database for equity market indices containing “infra’ in their name. This resulted in a sample of 31 indices with an average track record of 12 years.

Most of the 31 indices take a broad approach of being globally diversified across multiple sectors but there are 17 indices that take a specific regional or sector focus. The study has not omitted indices that have a regional or sector focus but presents data for a sub-set of indices that take a global, diversified approach, which may be more representative of the overall investment opportunity.

## 4.5. Data Source

Data for index constituents and returns for stocks, indices and active funds were obtained from Morningstar Direct.

All analysis was performed on a local currency basis to eliminate the effect of currency movements, which is an essential consideration for a study focused on global listed infrastructure and global equities.

# 5. Results

## Descriptive statistics

### Infrastructure stocks

The universe of infrastructure stocks has promising diversification potential. For the 20 year period, there are 177 stocks within the infrastructure stocks dataset with returns history spanning this time period. The average correlation with the MSCI world is low, and close to negligible, at 0.32. The highest correlation in the sample is 0.68 and the lowest is -0.02 indicating that whilst infrastructure stocks do not provide negative correlation, no stocks in the sample had high correlation.

Over the 10 year and 15 year periods the correlation has increased and the upper end of the range sample has risen, but still remains low. The standard deviation remained stable and kurtosis and skewness are negligible across all periods.

Figure 2: 20 year correlation of infrastructure stocks and global equities

Figure 3: 15 year correlation of infrastructure stocks and global equities

Figure 4: 10 year correlation of infrastructure stocks and global equities

As described earlier, listed infrastructure stocks do not have their own sector classifications but are found across a range of sectors. This study explores the differences that are present across infrastructure stocks when they are grouped by their sector to further explore the diversification potential and identify heterogeneity. For transparency, each calculation is accompanied by the count of stocks per sector to highlight cases they are small (Financial Services and Healthcare) as this may reduce the reliability of results.

The count infrastructure stocks in table 3 shows the most densely populated sectors are utilities, industrials, technology and basic materials. Over the 20 year time period, the average correlations of these sectors varied considerably from 0.22 for utilities to 0.44 for industrials.

This indicates that there is heterogeneity across infrastructure stocks when they are grouped into their respective sectors. Every sector, except financial services, has delivered low or negligible correlation over the each of the three time periods.

These results indicate that whilst there is scope for diversification by investing across the universe of infrastructure stocks, this can be improved by focusing on stocks within the utilities sector.

To determine the effect of overlap with the MSCI World, the infrastructure stocks can be split into two cohorts: those that are also owned by the MSCI World and those that are not. In Table 4, the correlations for the sample of infrastructure stocks that are also constituents in the MSCI World. We can see that for each time period there is low correlation with the MSCI World despite being present within the index. However, in Table 5 it is shown that the sample of infrastructure stocks that are not constituents in the MSCI World has an even lower mean correlation and standard deviation in each time period. For both sets, skewness and kurtosis are negligible. The analysis of these two cohorts confirms that infrastructure stocks that are not constituents of the MSCI World had less correlation to global equities than those that are. A t-test of the two sample means is presented in section 5.3.4.

### Active funds

The population of active funds was too young to cover the 15 year and 20 year time periods as there is just one active fund with 15 years of history which is an insufficient sample to draw conclusions from, a fact not disclosed in Blanc-Brude at al’s (2016) study that covered an earlier 15 year time period. However, there are 39 funds with enough data to perform analysis over the 10 year time period and this finds an average correlation of 0.65 with global equities. This is considered moderate correlation, but at the upper of the range approaching high correlation. The range of correlations is from 0.40 to 0.85 indicating that there aren’t any funds that have delivered negligible correlation. This indicates that there is still some benefit to including active funds into a portfolio that already contains global equities, but to a much lesser extent than buying the average infrastructure stock directly.

There is low kurtosis and skewness in the sample distribution. Importantly, the relatively low standard deviation of correlations for the active funds indicates that they are more homogenous than stocks in terms of providing similar levels of moderate correlation. This finding is consistent with the earlier study by Blanc-Brude et al (2016) that covered a smaller set of active funds over different time periods.

### Indices

In-line with active funds, the listed infrastructure indices are also found to have higher correlation than the underlying infrastructure stocks. This sample includes indices with particular regional or sector focus. Over the 20 year period the average correlation is 0.47 and the standard deviation is low at 0.07, however, there are only 5 indices with sufficient history for inclusion in this sample. The shorter time periods that emphasise the more recent past record increased correlation, with the 10 year time period’s mean correlation high at 0.71 with much higher standard deviation, 0.18. Kurtosis and skewness are more important in this study. Heavier tails are identified in the 10 and 20 year time periods, and there is negative skew in the 10 and 15 year period but positive skew over 20 years. This could be due to the fairly small sample sizes and indicates that predictions about listed infrastructure indices may be less reliable than the other studies. The data is presented in Table 7 and Figures 4, 5 and 6.

The correlation for the subset of indices that excludes regional and sector focused indices and just cover those with a globally diversified approach are presented in Table 8 and Figures 7 and 8. There are no global indices with 20 years’ of return history so this time period is not included. The exclusion of indices that have a regional or sector specialism leaves a cohort with much higher correlation to global equities, 0.77 and 0.82 over 15 years and 10 years, respectively. The low standard deviation indicates that there has been little differentiation across the different indices and therefore can be considered to be a fairly homogenous subset.

Figure 5: 20 year correlation of indices (all) and global equities

Figure 6: 15 year correlation of indices (all) and global equities

Figure 7: 10 year correlation of indices (all) and global equities

Figure 8: 15 year correlation of indices (global) and global equities

Figure 9: 10 year correlation of indices (global) and global equities

## 5.2. Rolling correlation

### 5.2.1 Infrastructure stocks

The infrastructure stocks have experienced varying levels of correlation with global equities over the past 20 years. It has risen from negligible levels in the earliest period of this study to 0.47, during the financial crisis, and subsequently has fallen back to negligible levels. These results indicate that over different market environments infrastructure stocks have consistently had negligible or low correlation with global equities.

Figure 10: Rolling correlation of infrastructure stocks and global equities

When the infrastructure stocks are split into their sectors this study finds that in addition to different levels of correlation over the long-term there are differences in the persistency of their correlation. Consumer Services, Consumer Cycles and Technology have quite stable correlations over time as evidenced by the low standard deviation 0.05-0.06, whereas infrastructure stocks in the healthcare sector experienced low correlation to global equities on average (0.32) but this correlation was more volatile with a range of -0.01 to 0.56 and standard deviation of 0.19. The increase in correlation occurred during the GFC indicating a greater sensitivity to economic and market shocks for some sectors than others. Infrastructure stocks in the healthcare sector was relatively more impactedthan those in the consumer cyclical sector.

Figure 11: Rolling correlations of infrastructure stock sectors and global equities

### 5.2.2. Active funds

The correlation for the active funds has changed substantially over time. In the earliest measurement period it was high at 0.83 but has decreased to 0.52 and is approaching low correlation levels.

Figure 12: Rolling correlations of active funds and global equities

### 5.2.3. Indices

The full sample of indices, including those with a regional or sector focus, has experienced substantial changes to its correlation profile over time. It has ranged from having negligible correlation in its earliest period, rising to high correlation during the GFC, and falling to moderate levels in the subsequent period where the global stock market has recovered.

In contrast, the average correlation of the infrastructure indices (global only) has moved in a much higher range from 0.62 to 0.9, which is moderate to high. Again, the correlation increased through the period of the financial crisis where correlations between most assets increased and have subsequently fallen to levels that were lower than prior to the GFC.

Figure 13: Rolling correlations of indices and global equities

Figure 14: Rolling correlations of indices (global) and global equities

## 5.3. T-test results

This section presents the t-test results that were performed using sample correlation means over the 10 year time period.

### 5.3.1. Infrastructure stocks and active funds

A t-test for infrastructure stocks and active funds is unnecessary due to the sample of infrastructure stocks having a mean correlation (0.39) that is lower than the minimum value in the range of active funds’ correlations (0.40). On this basis, it is not possible for the two samples to have the same mean and we can accept the null hypothesis that active funds have different (higher) correlations than infrastructure stocks.

### 5.3.2. Infrastructure stocks and indices (all)

A t-test for infrastructure stocks and indices is also unnecessary due to the infrastructure stocks having a 10 year mean correlation (0.39) that is lower than the minimum value in the range of indices correlations (0.76). The null hypothesis can be rejected and the alternative that indices do not have equal correlations to infrastructure stocks and are significantly higher.

### 5.3.3. Active funds and indices (global)

The samples of active funds and indices have closer mean correlations and ranges that overlap so a t-test is a useful for comparison. At the 0.05 significance level there is a very low p-value (0.00000002) indicating that the null hypothesis can be rejected and the alternative hypothesis that active funds and indices (global) do not have the same correlation but active funds have significantly lower correlation.

### 5.3.4. Infrastructure stocks – MSCI World overlap

This t-test is to determine if being a constituent in the MSCI World impacts a stock’s correlation with global equities. Performing a t-test for the sample means of the subset of infrastructure stocks that are also present in the MSCI World and infrastructure stocks that are not in the MSCI World results in a p-value of 0.002. The null hypothesis can be rejected and the alternative can be accepted, confirming that infrastructure stocks that are present in the MSCI World have significantly higher correlation than the infrastructure stocks that are absent.

# 6. Discussion

## 6.1. Infrastructure stocks

Infrastructure stocks have generated returns that have negligible to low correlation with equities both over the long-term and across many shorter time periods. This finding supports conclusions in previous studies by Oyodele et al (2013) and Newell and Peng (2007) that infrastructure stocks have provided diversification to equities.

Oyodele et al’s (2014) theory appears to fit global listed infrastructure, specifically that there are different levels of diversification across infrastructure sectors and these may be explained by sensitivity to the economic sensitivity, revenue drivers, demand elasticity and regulatory risk. This divergence across sectors undermines the case that listed infrastructure is a single asset class, as per the conditions set by Amenc et al (2012).

By exploring the different correlation characteristics of the infrastructure stocks that form part of this overlap with those that don’t, it has been found that infrastructure stocks in the MSCI word have significantly higher correlation than infrastructure stocks that aren’t. The implication of this intuitive result is that active funds and indices may be able to lower their correlation by excluding stocks from their investment universe that are contained within the MSCI World.

The changes in correlation during different time periods may explain why some studies have found lower diversification benefits and therefore reached contrasting conclusions, particularly if the study included the GFC. Studies of listed infrastructure that include this period, the worst financial crisis in 75 years, may underestimate the diversification benefits enjoyed in normal, less extreme market conditions.

## 6.2. Indices

This study finds that infrastructure indices have significantly higher average equity market correlation than the sample of infrastructure stocks and active funds. It appears that despite an opportunity set of stocks with low correlation to global equities, the process of selecting stocks for constituents and their corresponding weights undermines diversification potential. This outcome is surprising given investors’ demand for infrastructure is driven by the preference for diversification. The difference between the globally-diversified indices and those with a sector or regional speciality suggests that the specialist indices are delivering lower correlation, which further indicates heterogeneity and differing levels of correlation are present across sub-sectors and regions.

The higher average correlation of indices compared to infrastructure stocks may be explained by market-cap weighted approach to index construction that is prevalent across all of the infrastructure indices, which means it is the infrastructure stocks with the largest market-cap that form the largest index constituents. Larger stocks are typically constituents of many indices and widely held by ETF investors. Da and Shive’s (2018) study of ETFs found that stocks that are constituents across many ETFS have higher equity market correlation. Whilst correlation has declined since the GFC, the growth of ETF investing in recent years may mean an increasing number of generalist investors own infrastructure stocks so the relatively higher correlation is likely to persist and could become even more extreme in the next financial crisis.

Amenc et al’s (2012) study of equity benchmarks found that the market cap-weighted approach creates indices that lack diversification and are sub-optimal from a risk-return perspective. . They recommend a weighting scheme designed to deliver the desired outcome, which in the case of infrastructure indices may be to maximise diversification.

## 6.3. Active funds

Over the 10 year time period, active funds are found to have moderate correlation to global equities (0.65), which whilst lower than indices, is significantly higher than the average correlation of the infrastructure stocks. This confirms the earlier finding by Blanc-Brude et al (2016) that active funds do not deliver meaningful diversification, and improves its validity by analysing the samples over many time periods. This finding prompts the question of why active fund managers have not been able to achieve the diversification that they frequently promise despite the performance of the underlying universe of stocks supporting this outcome.

Studies that have analysed active funds in a broader context provide some potential explanations that can be applied to the listed infrastructure context. Chevalier and Ellison (1997) found that asset growth ambitions influences the behaviour of mutual fund managers and that the stated objectives are not always followed. Instead, active fund managers typically try to maximise total returns in order to attract investors from competitors of which in the case of listed infrastructure may undermine the ability satisfy the diversification goal.Another potential explanation is style-drift. Chen et al (2000) studied 180 US equity active funds between 1975 and 1995 found that there was often a blend of stocks within a portfolio, many of which do not fit the stated investment style. Infrastructure suffers from ill-defined definitions so the potential for non-infrastructure stocks to enter portfolios is quite high. If infrastructure active funds are investing part of their portfolio into non-infrastructure stocks this will lead to a divergence in correlation profiles from infrastructure stocks.

The rolling correlation analysis highlights the trend that since the GFC the correlation of active funds has been decreasing. A finding that may suggest that diversification is becoming a more important feature following the lessons of the GFC but this phenomenon is also present amongst infrastructure stocks so does not necessarily reflect a conscious change in management approach.

# 7. Conclusions

Attracting investors to listed infrastructure is crucial for ensuring the vast capital requirement for developing new projects and maintaining existing projects can be supported by the private sector. Investors are mainly attracted to infrastructure for its diversification potential, a characteristic that the asset management industry has been happy to emphasise. An accurate understanding of true nature of listed infrastructure investment is key to avoiding investor disappointment that could ultimately reduce the long-term supply of capital.

Much of the existing research has presented mixed results and contradictory conclusions about listed infrastructure’s diversification. The current lack of consensus may confuse and deter potential investors so this study has sought to address the inconsistencies and shortcomings by undertaking a comprehensive review.

By studying different strategies within the sector over many time periods it has been possible to draw more insightful conclusions about the historic performance of listed infrastructure that may help instruct expectations of future performance and if it can be considered an asset class.

Listed infrastructure cannot be considered an asset class in the traditional sense. It is a heterogeneous, sub-set of the wider equity market and therefore fails on both the asset class tests of homogeneity and uniqueness. This unevenness has been a factor in the contradictory views amongst academics. However, it is misleading to extend this binary conclusion to the diversification characteristic as the picture is far more mixed. It is better to view listed infrastructure investments as a spectrum of diversification potential.

Infrastructure stocks were found to have very attractive diversification characteristics with global equities over both long and short time periods. This diversification was present across a range of sectors and in both benign market environments and in periods of stress. This widespread, persistent diversification indicates investors can construct portfolios of infrastructure stocks in order to achieve diversification. However, there are differences across stocks depending on their sector and presence in mainstream equity indices, which should be considered by investors and fund managers when selecting stock investments to maximise diversification.

Despite this rich opportunity set, the investment industry has not managed active funds or indices in a way that delivers the low correlation potential that is present in the underlying universe of infrastructure stocks. They have failed meet investors demand for diversification. The infrastructure indices that invest globally are found to have high correlation to global equities and should therefore be avoided entirely by investors that prioritise diversification. The industry needs to respond to these shortcomings by developing funds and strategies funds that better emphasise diversification characteristics. There is a large opportunity for active funds and indices that are able to deliver an outcome that truly delivers the potential that is available in the underlying stocks. In the meantime, the implication for investors looking to active funds for diversification is that they should consider the sector composition and presence of stocks in the MSCI world when making their selection and monitoring.

The downside of listed infrastructure, regardless of the method of accessing it, is that the diversification potential of lessens in periods of stress. Unfortunately, this is precisely the time when diversification is most needed And serves as a stark reminder of the limitations of listed infrastructure investments.

The short history of active funds and indices has been partially addressed through the study of multiple time periods but overall the strength of conclusions is still limited by only spanning two decades. The trend of falling bond yields that has persisted for over three decades may have influenced demand for infrastructure given the perception of it being a diversifying asset class with high income and stable returns. At the time of writing, bond yields around the world are far below their long-term average so not only may the tailwind of falling bond yields finished but the trend could reverse as in a rising bond government bond yields their relative attractiveness diminishes significantly when investors can achieve similar returns from risk-free government bonds. Consequently, a study of listed infrastructure that considers the behaviour of these investments in an environment of rising bond yields will be particularly helpful for further enhancing the understanding of the nature of infrastructure investments. It may take the passing of multiple market cycles over a period of decades before investors can be truly sure of the long-term investment characteristics of listed infrastructure.

# Tables

Table 1: Interpreting Correlation

|  |  |
| --- | --- |
| Size of Correlation | Interpretation |
| .90 to 1.00 (−.90 to −1.00) | Very high positive (negative) correlation |
| .70 to .90 (−.70 to −.90) | High positive (negative) correlation |
| .50 to .70 (−.50 to −.70) | Moderate positive (negative) correlation |
| .30 to .50 (−.30 to −.50) | Low positive (negative) correlation |
| .00 to .30 (.00 to −.30) | Negligible correlation |

Table 2: Long term correlation of infrastructure stocks and global equities

|  |  |  |  |
| --- | --- | --- | --- |
| Start Date | 01/07/2008 | 01/07/2003 | 01/07/1998 |
| End Date | 30/06/2018 | 30/06/2018 | 30/06/2018 |
|  |  |  |  |
| Mean | 0.39 | 0.37 | 0.32 |
| Standard Deviation | 0.16 | 0.15 | 0.16 |
| Kurtosis | -0.33 | -0.36 | -0.69 |
| Skewness | -0.04 | 0.07 | 0.35 |
| Minimum | -0.08 | 0.02 | -0.02 |
| Maximum | 0.84 | 0.79 | 0.68 |
| Count | 564 | 429 | 177 |

Table 3: Long term correlation of infrastructure stock sectors and global equities

|  |  |  |  |
| --- | --- | --- | --- |
| Start date | 01/07/2008 | 01/07/2003 | 01/07/1998 |
| End date | 30/06/2018 | 30/06/2018 | 30/06/2018 |
|   | Correlation | Count | Correlation | Count | Correlation | Count |
| Basic Materials | 42.0% | 57 | 39.2% | 41 | 37.1% | 9 |
| Communication Services | 35.4% | 37 | 35.7% | 31 | 39.5% | 15 |
| Consumer Cyclical | 37.0% | 14 | 38.5% | 13 | 43.4% | 6 |
| Energy | 38.0% | 41 | 36.0% | 31 | 26.1% | 10 |
| Financial Services | 44.9% | 4 | 59.1% | 2 | - | 0 |
| Healthcare | 47.0% | 6 | 38.6% | 6 | 26.1% | 4 |
| Industrials | 45.0% | 178 | 42.1% | 125 | 36.3% | 42 |
| Real Estate | 48.7% | 14 | 43.5% | 8 | 48.4% | 3 |
| Technology | 48.7% | 43 | 45.1% | 35 | 44.1% | 21 |
| Utilities | 29.9% | 170 | 29.9% | 137 | 22.5% | 67 |

Table 4: Long term correlation of infrastructure stocks in MSCI World and global equities

|  |  |
| --- | --- |
|   | Overlap with MSCI World |
| Start date | 01/07/2008 | 01/07/2003 | 01/07/1998 |
| End date | 30/06/2018 | 30/06/2018 | 30/06/2018 |
| Mean | 0.43 | 0.41 | 0.34 |
| Standard Deviation | 0.19 | 0.17 | 0.18 |
| Kurtosis | -0.85 | -0.78 | -1.02 |
| Skewness | -0.15 | -0.08 | 0.10 |
| Minimum | -0.01 | 0.04 | -0.02 |
| Maximum | 0.84 | 0.79 | 0.65 |
| Count | 154 | 139 | 81 |

Table 5: Long term correlation of infrastructure stocks not in MSCI World and global equities

|  |  |
| --- | --- |
|   | Not present in MSCI World |
| Start date | 01/07/2008 | 01/07/2003 | 01/07/1998 |
| End date | 30/06/2018 | 30/06/2018 | 30/06/2018 |
| Mean | 0.38 | 0.35 | 0.30 |
| Standard Deviation | 0.15 | 0.13 | 0.15 |
| Kurtosis | -0.10 | -0.19 | -0.15 |
| Skewness | -0.14 | -0.03 | 0.57 |
| Minimum | -0.08 | 0.02 | 0.01 |
| Maximum | 0.78 | 0.74 | 0.68 |
| Count | 409 | 290 | 96 |

Table 6: Long term correlation of active funds and global equities

|  |  |
| --- | --- |
| Start date | 01/07/2008 |
| End date | 30/06/2018 |
| Mean | 0.65 |
| Standard Deviation | 0.12 |
| Kurtosis | -0.83 |
| Skewness | 0.19 |
| Minimum | 0.40 |
| Maximum | 0.85 |
| Count | 39 |

Table 7: Long term correlation of infrastructure indices (all) and global equities

|  |  |  |  |
| --- | --- | --- | --- |
|  Start Date | 01/07/2008 | 01/07/2003 | 01/07/1998 |
|  End Date | 30/06/2018 | 30/06/2018 | 30/06/2018 |
|  |  |  |  |
| Mean | 0.71 | 0.64 | 0.47 |
| Standard Deviation | 0.18 | 0.18 | 0.07 |
| Kurtosis | 2.74 | 0.42 | 2.36 |
| Skewness | -1.72 | -1.14 | 1.16 |
| Minimum | 0.21 | 0.24 | 0.38 |
| Maximum | 0.89 | 0.83 | 0.59 |
| Count | 28 | 20 | 5 |

Table 8: Long term correlation of infrastructure indices (global) and global equities

|  |  |  |
| --- | --- | --- |
| Start Date | 01/07/2008 | 01/07/2003 |
| End Date | 30/06/2018 | 30/06/2018 |
|  |  |  |
| Mean | 0.82 | 0.77 |
| Standard Deviation | 0.04 | 0.03 |
| Kurtosis | -0.92 | 0.74 |
| Skewness | 0.54 | -0.18 |
| Minimum | 0.76 | 0.72 |
| Maximum | 0.89 | 0.81 |
| Count | 11 | 6 |

Table 9: Rolling correlation of infrastructure stocks and global equities

|  |  |  |  |
| --- | --- | --- | --- |
| Start date | End date | Correlation | Count |
| 01/07/1998 | 30/06/2003 | 0.23 | 177 |
| 01/07/1999 | 30/06/2004 | 0.24 | 196 |
| 01/07/2000 | 30/06/2005 | 0.28 | 338 |
| 01/07/2001 | 30/06/2006 | 0.32 | 387 |
| 01/07/2002 | 30/06/2007 | 0.31 | 407 |
| 01/07/2003 | 30/06/2008 | 0.35 | 429 |
| 01/07/2004 | 30/06/2009 | 0.43 | 448 |
| 01/07/2005 | 30/06/2010 | 0.45 | 471 |
| 01/07/2006 | 30/06/2011 | 0.45 | 510 |
| 01/07/2007 | 30/06/2012 | 0.47 | 535 |
| 01/07/2008 | 30/06/2013 | 0.45 | 564 |
| 01/07/2009 | 30/06/2014 | 0.38 | 571 |
| 01/07/2010 | 30/06/2015 | 0.33 | 595 |
| 01/07/2011 | 30/06/2016 | 0.35 | 621 |
| 01/07/2012 | 30/06/2017 | 0.29 | 638 |
| 01/07/2013 | 30/06/2018 | 0.27 | 681 |

 Table 10: Rolling correlation of infrastructure stock sectors and global equities

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Start date | End date | Bas. Mat. | Com. Serv. | Cons. Cyc. | En. | Fin Serv. | Health. | Ind. | Re. Est. | Tech. | Util. |
| 01/07/1998 | 30/06/2003 | 0.27 | 0.44 | 0.43 | 0.09 |   | 0.07 | 0.26 | 0.42 | 0.44 | 0.11 |
| 01/07/1999 | 30/06/2004 | 0.30 | 0.42 | 0.40 | 0.03 |  | 0.01 | 0.25 | 0.45 | 0.42 | 0.14 |
| 01/07/2000 | 30/06/2005 | 0.25 | 0.45 | 0.39 | 0.21 | 0.34 | -0.01 | 0.28 | 0.39 | 0.44 | 0.21 |
| 01/07/2001 | 30/06/2006 | 0.29 | 0.42 | 0.40 | 0.21 | 0.49 | 0.10 | 0.34 | 0.37 | 0.45 | 0.28 |
| 01/07/2002 | 30/06/2007 | 0.30 | 0.39 | 0.38 | 0.21 | 0.50 | 0.15 | 0.31 | 0.37 | 0.42 | 0.26 |
| 01/07/2003 | 30/06/2008 | 0.35 | 0.41 | 0.40 | 0.29 | 0.51 | 0.28 | 0.37 | 0.34 | 0.40 | 0.32 |
| 01/07/2004 | 30/06/2009 | 0.48 | 0.41 | 0.44 | 0.40 | 0.67 | 0.47 | 0.48 | 0.54 | 0.50 | 0.37 |
| 01/07/2005 | 30/06/2010 | 0.51 | 0.42 | 0.45 | 0.41 | 0.68 | 0.49 | 0.49 | 0.57 | 0.51 | 0.39 |
| 01/07/2006 | 30/06/2011 | 0.50 | 0.44 | 0.43 | 0.43 | 0.66 | 0.54 | 0.49 | 0.57 | 0.52 | 0.38 |
| 01/07/2007 | 30/06/2012 | 0.53 | 0.43 | 0.46 | 0.45 | 0.68 | 0.56 | 0.51 | 0.56 | 0.55 | 0.39 |
| 01/07/2008 | 30/06/2013 | 0.54 | 0.39 | 0.44 | 0.44 | 0.47 | 0.55 | 0.50 | 0.56 | 0.54 | 0.36 |
| 01/07/2009 | 30/06/2014 | 0.43 | 0.32 | 0.38 | 0.37 | 0.51 | 0.49 | 0.42 | 0.42 | 0.48 | 0.32 |
| 01/07/2010 | 30/06/2015 | 0.36 | 0.28 | 0.35 | 0.36 | 0.38 | 0.38 | 0.38 | 0.34 | 0.45 | 0.25 |
| 01/07/2011 | 30/06/2016 | 0.32 | 0.33 | 0.38 | 0.37 | 0.48 | 0.41 | 0.41 | 0.38 | 0.46 | 0.26 |
| 01/07/2012 | 30/06/2017 | 0.22 | 0.30 | 0.30 | 0.32 | 0.37 | 0.31 | 0.32 | 0.27 | 0.35 | 0.24 |
| 01/07/2013 | 30/06/2018 | 0.23 | 0.30 | 0.31 | 0.34 | 0.39 | 0.23 | 0.32 | 0.16 | 0.36 | 0.21 |
|   |   |   |   |   |   |   |   |   |   |   |   |
| Mean | 0.37 | 0.38 | 0.40 | 0.31 | 0.51 | 0.31 | 0.38 | 0.42 | 0.46 | 0.28 |
| Standard Deviation | 0.11 | 0.06 | 0.05 | 0.12 | 0.12 | 0.19 | 0.09 | 0.11 | 0.06 | 0.08 |

Table 11: Rolling correlation of active funds and global equities

|  |  |  |  |
| --- | --- | --- | --- |
| Start date | End date | Correlation | Count |
| 01/07/1998 | 30/06/2003 |  |  |
| 01/07/1999 | 30/06/2004 |  |  |
| 01/07/2000 | 30/06/2005 |  |  |
| 01/07/2001 | 30/06/2006 |  |  |
| 01/07/2002 | 30/06/2007 | 0.83 | 1 |
| 01/07/2003 | 30/06/2008 | 0.84 | 1 |
| 01/07/2004 | 30/06/2009 | 0.75 | 3 |
| 01/07/2005 | 30/06/2010 | 0.76 | 5 |
| 01/07/2006 | 30/06/2011 | 0.73 | 13 |
| 01/07/2007 | 30/06/2012 | 0.74 | 19 |
| 01/07/2008 | 30/06/2013 | 0.72 | 37 |
| 01/07/2009 | 30/06/2014 | 0.61 | 40 |
| 01/07/2010 | 30/06/2015 | 0.55 | 46 |
| 01/07/2011 | 30/06/2016 | 0.60 | 54 |
| 01/07/2012 | 30/06/2017 | 0.53 | 61 |
| 01/07/2013 | 30/06/2018 | 0.52 | 68 |

Table 12: Rolling correlation of indices (all) and global equities

|  |  |  |  |
| --- | --- | --- | --- |
| Start date | End date | Correlation | Count |
| 01/07/1998 | 30/06/2003 | 0.29 | 3 |
| 01/07/1999 | 30/06/2004 | 0.53 | 7 |
| 01/07/2000 | 30/06/2005 | 0.57 | 7 |
| 01/07/2001 | 30/06/2006 | 0.61 | 9 |
| 01/07/2002 | 30/06/2007 | 0.59 | 11 |
| 01/07/2003 | 30/06/2008 | 0.59 | 21 |
| 01/07/2004 | 30/06/2009 | 0.75 | 24 |
| 01/07/2005 | 30/06/2010 | 0.77 | 25 |
| 01/07/2006 | 30/06/2011 | 0.79 | 27 |
| 01/07/2007 | 30/06/2012 | 0.80 | 28 |
| 01/07/2008 | 30/06/2013 | 0.78 | 29 |
| 01/07/2009 | 30/06/2014 | 0.71 | 30 |
| 01/07/2010 | 30/06/2015 | 0.66 | 31 |
| 01/07/2011 | 30/06/2016 | 0.65 | 31 |
| 01/07/2012 | 30/06/2017 | 0.55 | 32 |
| 01/07/2013 | 30/06/2018 | 0.53 | 33 |

Table 13: Rolling correlation of indices (global) and global equities

|  |  |  |  |
| --- | --- | --- | --- |
| Start date | End date | Correlation | Count |
| 01/07/1998 | 30/06/2003 |  |  |
| 01/07/1999 | 30/06/2004 | 0.78 | 4 |
| 01/07/2000 | 30/06/2005 | 0.77 | 4 |
| 01/07/2001 | 30/06/2006 | 0.77 | 4 |
| 01/07/2002 | 30/06/2007 | 0.72 | 6 |
| 01/07/2003 | 30/06/2008 | 0.70 | 9 |
| 01/07/2004 | 30/06/2009 | 0.86 | 11 |
| 01/07/2005 | 30/06/2010 | 0.88 | 11 |
| 01/07/2006 | 30/06/2011 | 0.90 | 13 |
| 01/07/2007 | 30/06/2012 | 0.90 | 14 |
| 01/07/2008 | 30/06/2013 | 0.88 | 14 |
| 01/07/2009 | 30/06/2014 | 0.83 | 14 |
| 01/07/2010 | 30/06/2015 | 0.77 | 15 |
| 01/07/2011 | 30/06/2016 | 0.75 | 15 |
| 01/07/2012 | 30/06/2017 | 0.62 | 16 |
| 01/07/2013 | 30/06/2018 | 0.62 | 16 |

Table 14: T-test statistics for active funds and indices (global)

|  |  |  |
| --- | --- | --- |
|   | Active funds | Indices (Global) |
| Mean | 0.65 | 0.82 |
| Variance | 0.02 | 0.00 |
| Observations | 37 | 11 |
| df | 45 |  |
| t Stat | -6.88 |  |
| P(T<=t) two-tail | 0.00000002 |  |
| t Critical two-tail | 2.01 |  |

Table 15: T-test statistics for infrastructure stocks present and absent from MSCI World

|  |  |  |
| --- | --- | --- |
|   | Infrastructure Stocks (MSCI World overlap) | Infrastructure Stocks (MSCI World no overlap) |
| Mean | 0.38 | 0.43 |
| Variance | 0.02 | 0.04 |
| Observations | 409 | 154 |
| df | 229 |  |
| t Stat | -3.17 |  |
| P(T<=t) two-tail | 0.002 |  |
| t Critical two-tail | 1.97 |  |

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