Risk, return and infrastructure investments: which factors matter – and which don't?



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The current situation of low interest rates urges institutional investors to search for alternatives in the investment universe. One of the most promising alternatives is infrastructure which exhibits strategically relevant characteristics from an investor's point of view. Transport, utilities and telecommunication are industries of specific interest for asset managers. Some market participants even argue that infrastructure can solve the low interest rates issue. The aim of the paper[1] is to derive an asset class factor model for infrastructure investments which are driven by their unique characteristics. Though, infrastructure is not entirely new as an investment opportunity, investors of privately financed projects demand a thorough understanding of the key performance drivers and the risk factors affecting the returns of such investments.

Institutional investors and especially insurers will find two implications in this study. First, the asset class factor model identifies significant factors being relevant to correctly determine the cost of equity and, second, several positive characteristics of infrastructure investments are less applicable than often assumed.

Risk factors and model development

The main characteristics of infrastructure investments are low correlations with traditional asset classes (i.e. stocks and bonds), inflation hedge, stable cashflows, low volatility and downside protection. Some of these characteristics are already put into perspective. For example, systematic risk of infrastructure firms is lower than the overall market risk. However, infrastructure shows almost the same total volatility than the market which suggests there is much idiosyncratic risk left. Inflation protection of listed infrastructure firms is not more extensive than a broad stock market index. Furthermore, a downside protection which is frequently mentioned in the context of infrastructure investments has not been observed regarding listed infrastructure indices.[2]

Nonetheless, studies on infrastructure also depend on the respective investment period, the financing instrument (equity or debt), the geographic focus (developed vs. emerging markets) and whether it is a greenfield or brownfield investment which results in different risk profiles.

The authors' study analyses the underlying risks of listed infrastructure firms which can be derived from the infrastructure-specific characteristics. Since the study takes a look at stocks, widely accepted risk factors of stocks are also included in the factor model. That is, the market factor (RM-Rf), size (SMB), and book-to-market ratio (HML) which combined are also known as the Fama / French model. A momentum factor (MOM) can be considered as well, resulting in a 4-factor model, also known as the Carhart model.

In addition to the four stock market factors six infrastructure-specific factors are included.[3] First, a cashflow-volatility factor (CFVOLA) is included given the long-term contracts and inelastic demand of infrastructure services. Hence, investors might expect a higher return if infrastructure firms demonstrate higher cashflow volatility. Furthermore, infrastructure firms tend to be highly leveraged (LEV). The higher the firms leverage the more likely the firm defaults for which investors expect to be compensated. It is also important to keep in mind that a high and constant need for investments (INV) is necessary, especially during the construction phase but al-

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so during the operating phase in terms of maintenance. Moreover, interest rate risks are of major importance – especially for insurers who depend on consistent asset-liability management. Despite this crucial fact for investors, none of the previous studies analyzed the interest rate exposure of infrastructure investments. Here, two effects can be expected. On the one hand the proportion of debt capital results in a high interest rate exposure. On the other hand, the firm's value is significantly affected if the discount factor slightly changes due to interest rate changes and consequently alters the discounted long-term cashflows. Interest rate sensitivity is taken into account in the model through the term structure (TERM) and the default spread (DEF). The last factor in the model refers to the regulatory risk (REG) which might affect the expected rate of return of infrastructure firms.

All factors are described as excess returns and thus represent risk premiums for each factor. This approach (10-factor model) allows a direct calculation of the cost of equity.

A second reduced model that only includes the infrastructure-specific factors and the market factor (7-factor model) is also tested with respect to significance and explanatory power.

Data and descriptive statistics

The authors' dataset refers to U.S. infrastructure stocks and accounts for several necessary prerequisites to analyze such investments in detail. First, through business descriptions, the authors only include companies which own or operate physical infrastructure assets, guaranteeing that such firms are theoretically able to generate stable cashflows. Second, the study spans a time period of more than 30 years (January 1980 to December 2011) and, thus, is one of the few long-term studies in this field of research. Third, the authors differentiate between utility and non-utility firms (i.e. telecommunication and transportation). Furthermore, the dataset can be dissected by size and book-to-market ratio. Based on this data, the authors construct a value-weighted infrastructure index (VWI index) of all selected infrastructure stocks and nine value-weighted infrastructure portfolios sorted by size (small / medium size / big) and book-to-market ratio (low / medium BM / high).

Index and portfolios	Mean excess return (% p.a.)	Standard dev. (% p.a.)	Sharpe ratio (annualized)
VWI index	6.00	13.61	0.44
Small / low	6.84	17.42	0.39
Medium size / low	6.60	16.42	0.40
Big / low	5.16	18.33	0.28
Small / medium BM	9.72	12.19	0.80
Medium size / medium BM	8.04	14.13	0.57
Big / medium BM	7.44	14.93	0.50
Small / high	10.56	15.59	0.68
Medium size / high	10.08	14.69	0.69
Big / high	7.44	15.93	0.47

Fig. 1: Performance of infrastructure index and portfolios

Figure 1 shows the excess returns (over the 1-month T-Bill), the standard deviation, and the annualized Sharpe ratio of the VWI index and the nine portfolios. Apparently, portfolios with smaller stocks generate higher expected returns contradicting the assumption companies with higher market capitalization have monopolistic or oligopolistic power and, thus, higher returns. Moreover, stocks with high book-to-market ratio end up with higher returns being in line with the generally observed performance of value stocks.

Figure 2 presents the factors and their respective mean excess returns and standard deviations. Interestingly, the leverage factor, which equals a long position in stocks with high leverage ratio and a short position in stocks with low leverage ratios, generates an economically significant excess return of 4.32 percent per year. Surprisingly, the leverage factor is able to outperform both the market factor and the value factor during the financial crisis of 2008 / 2009 and the value factor in total. Still, the risk exposure of infrastructure firms regarding leverage and other factors can only be interpreted in detail in the following regression analysis.

Factors	Excess return (% p.a.)	Standard dev. (% p.a.)
RM-Rf	6.60	16.07
SMB	1.80	10.88
HML	3.84	10.84
MOM	7.80	16.35
CFVOLA	1.32	8.35
LEV	4.32	10.77
INV	1.92	7.79
TERM	5.04	12.99
DEF	0.24	7.41
REG	0.24	2.42

Fig. 2: Mean excess returns of the constructed infrastructure factors and stock market factors

Main results

Regressions

The first regression analysis focuses on the VWI index as the dependent variable (Figure 3). Four findings are of major interest. First, the explanatory power (i.e. adjusted R-square) of the two infrastructure factor models is superior to the Carhart model. Especially, the 7-factor model performs better than the Carhart model, although it forgoes the widely accepted SMB and HML factors. Second, while the HML is still significant in the Carhart model it can be seen that the

Variables	1) CAPM	2) Fama / French 3-factor model	3) Carhart 4-factor model	4) Infrastructure 7-factor model	5) Infrastructure 10-factor model
β_M	0.693***	0.747***	0.757***	0.703***	0.725***
β_{SMB}		-0.172***	-0.175***		-0.146***
β_{HML}		0.117**	0.134***		0.0495
β_{MOM}			0.0477		0.0517*
β_{CFVOLA}				-0.203***	-0.138***
β_{LEV}				0.197***	0.168***
β_{INV}				-0.0440	-0.0615
β_{TERM}				0.170***	0.173***
β_{DEF}				0.218***	0.267***
β_{REG}				0.411**	0.328*
α	0.119	0.0767	0.0355	-0.0315	-0.0486
Adj. R^2	66.9 %	69.9 %	70.1 %	73.7 %	75.0 %

Fig. 3: Model comparison with VWI index as dependent variable

This figure shows five models to evaluate infrastructure stocks. The observation starts in January 1980 and ends in December 2011 (384 months). The adjusted R-square values from each time series are reported at the end of the figure. Standard errors are computed using the Newey-West[6] correction for heteroscedasticity and serial correlation. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

		1) Low	2)	3) High
CAPM - alpha	1) Small	0.154	0.561***	0.548***
	2)	0.136	0.416**	0.547***
	3) Big	-0.0444	0.385*	0.338
Fama / French - alpha	1) Small	-0.0542	0.355***	0.263
	2)	0.0400	0.204	0.324**
	3) Big	0.0303	0.179	0.135
7-factor - alpha	1) Small	0.133	0.331***	0.197
	2)	0.118	0.0454	0.180
	3) Big	0.00296	0.0579	0.00543
10-factor - alpha	1) Small	-0.0754	0.153	0.0487
	2)	0.0769	-0.0799	0.0570
	3) Big	0.0245	-0.0520	-0.0724

Fig. 4: Intercept (alpha) for nine infrastructure portfolios based on four different models

This figure illustrates the intercepts (alpha) of each model. Significance is computed using the Newey-West[7] correction for heteroscedasticity and serial correlation. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

significance disappears in the 10-factor model. This suggests that infrastructure stocks are primarily valued on the basis of their debt-to-equity ratio instead of their book-to-market ratio. Third, all factors, except for the HML, INV, MOM and REG factors are significant on the 5 percent level. Also, worth mentioning is that infrastructure stocks bear an economically significant interest rate risk. A one percent increase in the term structure equals an increase in the return of the infrastructure index of 0.17 percent. Fourth, cashflow volatility is compensated with a negative premium which is in contrast to the general assumption of more risky asset receiving a premium. More precisely, firms with stable cashflows generate higher returns than such with volatile cashflows. This anomaly has been documented in previous studies by Ang et al.[4] with regard to idiosyncratic volatility and Huang[5] for cashflow volatility.

One of the most important insights of this study is that the significance of the intercept (alpha) extracted from each model and the nine portfolios that are used as test assets. If a model absorbs the entire return variation in the cross-section, the intercept of the model should be zero. However, if the intercept is significantly different from zero, further performance drivers can be assumed. As reported in Figure 4, the CAPM leaves five out of the nine portfolios with a significant alpha. The Fama / French model still shows two alphas with significant values. In contrast, the 7-factor model merely has one significant alpha and the 10-factor model is able to explain all excess returns and does not contain any significant alpha.

Inflation hedge and downside protection

Inflation hedge through infrastructure investments is often assumed but not guaranteed and must be evaluated for each company / project separately. The authors' data differentiates between industry, size, and book-to-market ratio allowing a more detailed view at the inflation hedge abilities of infrastructure. In order to analyze inflation, the returns of the «Treasury Inflation Protected Securities» (TIPS) index minus the risk-free rate were introduced to the 10-factor model. Results are presented in Figure 5 and show that rather small to medium size stocks with low book-to-market ratio are able to offer some inflation protection. Furthermore, utilities rather than non-utility stocks hedge against inflation.

However, the results also show that, aside from the low significance, a one percent change in the TIPS index does not generate a one percent increase in the infrastructure portfolio returns. Hence, a perfect inflation hedge is not offered. Figure 5 presents the empirical results where Panel A contains the coefficients of the TIPS index for the nine

Panel A		1) Low	2)	3) High
β_{INFL}	1) Small	0.593**	-0.0136	0.0225
	2)	0.421**	0.222	0.169
	3) Big	0.0650	0.159	0.315

Panel B	1) Fama / French 3-factor model	2) Carhart 4-factor model	3) Infrastructure 7-factor model	4) Infrastructure 10-factor model
			Utilities	
β_{INFL}	0.311*	0.311*	0.311*	0.311*
			Non-Utilities	
β_{INFL}	-0.0601	-0.0601	-0.0601	-0.0601

Fig. 5: Inflation protection distinguished by portfolio and industry

infrastructure portfolios. Panel B provides coefficients distinguished by utilities and non-utilities for each regression model.

In addition to the inflation protection the downside protection of infrastructure investments has been analyzed, assuming that certain portfolios of infrastructure firms are more resistant against economic downturns. For that purpose, the authors use the squared market factor (similar to Treynor und Mazuy)[8] in order to replicate the non-linear relationship between economic downturns and the returns of the infrastructure portfolios. Except for one of the nine portfolios, the authors could show that specific infrastructure portfolios sorted by size and book-to-market ratio do not have the ability to hedge against potential downside risks.

Conclusion

This study identifies the common risk factors that are priced in infrastructure companies and constructs an asset class factor model. Established pricing models are tested, i.e., the single-factor CAPM, the Fama / French 3-factor model, and the Carhart 4-factor model. The authors create a 7-factor model and a 10-factor model, both of which are superior in explaining the return variation of infrastructure returns compared to the Fama / French 3-factor model or the Carhart 4-factor model. The 7-factor model consists of the market excess return and six additional factors: cash flow volatility, leverage, an investment factor, a term premium, a default premium, and a regulatory risk premium. The 10-factor model augments the Carhart 4-factor model with the aforementioned six additional factors.

Because of the frequently mentioned (positive) characteristics of infrastructure investments the motivation of this study is to identify the specific risk premiums of such investments. It can be concluded that infrastructure investments exhibit a significant interest rate and leverage exposure. Furthermore, the authors show that downside protection and inflation hedge is very limited to non-existent. The authors also confirm that infrastructure investments are very heterogeneous and must be evaluated case by case.

Given the regulatory challenges insurers are facing and the current low interest rates, innovations for infrastructure investments will be crucial to exploit their full potential. Convertible bonds can be of great use for that purpose because of lower capital requirements than equity under Solvency II. On the one hand it allows investors to receive more secure payments during the construction phase of an infrastructure project. On the other hand, investors can be exposed to equity when the project passes into the operating phase. Here, the authors' risk factors can help to determine the risk profile of an investment at an early stage.

Notes

1 Ben Ammar, S. und Eling, M. (2013): Common risk factors of infrastructure firms, Working Paper, University of St. Gallen, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2242383.

2 Rothballer, C. and Kaserer, C. (2012): The risk profile of infrastructure investments: Challenging conventional wisdom, Journal of Structured Finance, Vol. 18, 2012, pp. 95–109; Rödel, M. and Rothballer, C. (2012): Infrastructure as hedge against inflation – Fact or fantasy?, Journal of Alternative Investments, Vol. 15, 2012, pp. 110–123; and Bird, R., Liem H. and Thorp, S. (2012): Infrastructure: Real assets and real returns', European Financial Management, 2012, doi: 10.1111/j.1468-036X.2012.00650.x.

3 See Ben Ammar und Eling (2013) for a detailed description of the factor construction.

4 Ang, A., Hodrick R. J., Xing Y. and Zhang X. (2006): The cross-section of volatility and expected returns, Journal of Finance, Vol. 61, 2006, pp. 259–299.

5 Huang, A. G. (2009): The cross section of cash flow volatility and expected stock returns, Journal of Empirical Finance, Vol. 16, 2009, pp. 409–429.

6 See Newey, W. K. and West, K. D. (1987): A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, Econometrica, Vol. 55, 1987, pp. 703–708.

7 See ebd.

8 Treynor, J. and Mazuy, K. (1966): Can mutual funds outguess the market, Harvard Business Review, Vol. 44, 1966, pp. 131–136.