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Insurers' Investment in Infrastructure: Overview and Treatment under Solvency II

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INSURERS' INVESTMENT IN INFRASTRUCTURE: OVERVIEW AND TREATMENT UNDER SOLVENCY II

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ABSTRACT

The financial market environment poses serious challenges for insurance companies to provide stable returns on a long-term basis, as in particular traditional asset classes are currently characterized by generally low interest rates and high volatility. Against this background, the aim of this paper is to study infrastructure investments from an insurer's perspective. In particular, based on a categorization of different types of infrastructure investments, we provide an overview of main characteristics along with risks and chances. In addition, the treatment of different infrastructure investments under Solvency II regulations is studied, which can have a considerable impact on an insurer's asset management decisions. The study shows that the attractiveness of infrastructure investments strongly depends on the type of investment and its treatment under Solvency II and that considerable risks can be involved.

Keywords: Infrastructure, Solvency II, capital requirements, renewable energy, performance

1. INTRODUCTION

Against the background of the current financial market environment with low interest rates and volatile stock markets, infrastructure investments are increasingly discussed in the insurance industry. Allianz, for instance, recently decided to invest in parking meters in Chicago[1] while in January 2013, Munich Re announced an investment in wind parks in France, aiming to diversify their portfolio with sustainable investments with manageable risks and attractive returns.[2] However, benefits and detriments of infrastructure investments strongly depend on the type of investment structure (e.g. (project) bonds, loans, equity, or funds), which may differ tremendously and can thus not be generalized.[3] In addition,

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1 See Allianz SE (2012a): https://www.allianz.com/de/presse/news/finanzen/beteiligungen/news_2012-02-01.html, access 12/06/2012; and Allianz SE (2012b): https://www.allianz.de/ratgeber/vorsorge/aktuell/klarer-kurs-in-schwerer-see.html, access 12/06/2012.

2 See MEAG (2013): http://www.meag.com/reddot/html/de/unternehmen/up_peressemitteilungen_7557.asp, access 02/10/2013.

3 See, e.g., Beeferman (2008); Inderst (2010); Rothballer and Kaserer (2012).

especially for insurers, the attractiveness of infrastructure investments is further impacted by their treatment under Solvency II, the new European risk-based capital regulation for insurers, planned to be introduced sometime after 2016. Hence, the aim of this paper is to provide an overview of different ways of how to invest in infrastructure along with main characteristics and risks, and to study the treatment of these different types from an insurer's perspective under Solvency II.

Infrastructure investments have for a long time been seen as an investment of national economies only. However, with an increasing privatization and deregulation of national property since the 1980s[4] and an increasing investment gap expected by the OECD (2006) until the year 2030, infrastructure investments can be expected to provide important opportunities for private and institutional investors over the next decades.[5] In particular, annual infrastructure investment requirements of approximately 90 billion USD in electricity are needed, 175 billion USD in road infrastructure, 620 billion USD in water infrastructure, and 33 billion USD in rail infrastructure in OECD countries by 2025-2030.[6] The total worldwide infrastructure requirements from 2000 to 2030 are estimated to be 71 trillion USD.[7] Therefore, the discontinuation of federal spending on infrastructure can be expected to establish future growth for private and institutional investors over the next decades.[8] With the financial crisis in 2007/2008, also many regulatory changes in the credit business for infrastructure have been made. Debt ratios have been lowered, and, therefore, existing infrastructure projects, which until now have been mainly financed by debt, now require new capital to assure the projects' funding. This deleveraging process will presumably lead to an increased demand for equity capital and increase the investment volume of infrastructure investments in the future. Finally, due to recent innovations and research on renewable energy, especially the energy infrastructure will require substantial amounts of capital to replace old energy facilities with new solar and wind power energy systems. At the same time, renewable energy will also become a substantial part of future transportation systems, e.g. E-Mobility, thus leading to new investments in several infrastructure sectors at the same time. For insurers seeking new investment alternatives, especially the stability of long-term cash flows plays a major role along with the question of how different infrastructure investment types are treated under Solvency II.

In the literature, Inderst (2010) provides an overview of investment characteristics regarding different infrastructure vehicles, risk-return profiles as well as historical performance,

4 See Beyerle, Voß, and Weber (2011, p. 5).
5 See OECD (2007, pp. 13-14).
6 See OECD (2007, p. 23).
7 See OECD (2006, p. 29).
8 See OECD (2007, p. 29).

emphasizing the heterogeneity of this asset class. A literature review with focus on infrastructure equity investments is provided by Blanc-Brude (2013), while Severinson and Yermo (2012) discuss the impact of changes of accounting standards and Solvency II on an insurer's asset allocation. In addition, Bitsch, Buchner, and Kaserer (2010) illustrate risk, return and cash flow characteristics of infrastructure fund deals based on the private equity CEPRES database. Regarding the very mature Australian infrastructure market, Peng and Newell (2007) analyze listed and unlisted infrastructure funds and equity from 1995 to 2006 and find listed infrastructure funds and equity to show higher returns along with a higher volatility than the stock market (ASX All Ordinaries), thereby also contributing to an improved portfolio diversification due to low correlations, which particularly holds true in the case of unlisted infrastructure investments. Similar results are found in Finkenzeller, Dechant, and Schäfers (2010), who also study infrastructure investments in the Australian infrastructure market for listed indexes (UBS Australia Infrastructure and UBS Australia Utilities Index) as well as unlisted investments (Colonial First State Index – consisting of five Australian infrastructure funds) using an extended dataset from 1994 to 2009. Rothballer and Kaserer (2012) focus on global listed infrastructure stocks (1975 to 2009) and show that these exhibit a lower market risk than non-infrastructure equities, but not a lower total corporate risk. In addition, the authors further show that the utilities sector (followed by transportation and telecommunication) represents the least risky sector of global listed infrastructure investments in terms of total and market risk. Further analysis on e.g. evidence of excess returns and inflation hedging ability of infrastructure for listed stocks (particularly in the utilities sector) in the U.S. and Australian market from 1995 to 2009 has been conducted by Bird, Liem, and Thorp (2012) (only in sectors with strong pricing power) and by Rödel and Rothballer (2012). Besides the analysis of investment characteristics and the general market for infrastructure investments, many empirical and practice-oriented studies such as Beyerle, Voß, and Weber (2011) and Heymann et al. (2008), for instance, discuss the importance of infrastructure investments for institutional investors, which is of high relevance for insurance companies.

Hence, the academic literature so far mainly dealt with empirical questions and thereby often focused on single specific infrastructure investment types (e.g. private equity or infrastructure stocks and funds). In this paper, we aim to focus on an insurer's perspective by first providing a comprehensive overview of different ways to invest in infrastructure along with their main characteristics, performance, and risks, and then studying the treatment under Solvency II. We thereby differentiate between equity, debt, and funds as well as between direct and indirect investments. The heterogeneity of the asset class is further illustrated by means of a case study, comparing investments in onshore and offshore wind parks as well as toll roads.

The remainder of this paper is structured as follows. Section 2 provides a categorization of infrastructure investments along with a discussion of performance and risks. Based on this, Section 3 exhibits the treatment under Solvency II, and Section 4 concludes.

2. Infrastructure Investments: Characteristics and Market Overview

Definition of infrastructure

There is no clear or unique definition of infrastructure in general.[9] "Investable" infrastructure is typically focused on material infrastructure as laid out in Table 1, which refers to economic aspects such as traffic organization and transport, plants and supplies used by a national economy to provide energy supply, disposal facilities and facilities with the aim to protect natural resources as well as telecommunication. The sectors transport, utilities (energy and disposal), communication and renewable energy are mainly classified as economic infrastructure, while social infrastructure includes, e.g., hospitals, schools or police stations.[10]

Table 1: Sectors available as material infrastructure investments[11]

Economic infrastructure	*Sectors and subsectors*
Transport	Ground: Roads, rails, bridges, tunnels, parking Air: Airports Water: Canals, ports
Utilities (energy and disposal)	Energy supply Generation, transmission, distribution: oil and gas, district heating, water Disposal: Waste, sewage water, storage, recycling
(Tele) Communication	Cable networks Transmission Satellites Radio tower
Renewable energy	
Social infrastructure	
Social	Hospitals, diagnostics Retirement homes Schools, nursery schools Culture Sports structures, recreation Administrative buildings, government Police force, prisons

9 See Bitsch, Buchner, and Kaserer (2010, p. 110, 113); Inderst (2009, pp. 6-7); OECD (2011, p. 15).
10 See EIOPA (2013a, p. 33).
11 See, e.g., EIOPA (2013a, p. 33); Inderst (2010, p. 72).

Investing in infrastructure

In general, one needs to distinguish several stages when investing in infrastructure projects: Planning, construction, operation, and winding-up.[12] In particular, during the early years (planning and construction), investors have negative cash flows due to high capital requirements and then expect high payouts during later years.[13] One further differentiation is given by dividing infrastructure investments into "*Brownfield*" and "*Greenfield*".[14] "Brownfield" refers to less risky, often already existing infrastructure projects with stable cash flows, where investors need to modernize and renovate facilities and that are more often located in developed markets.[15] "Greenfield" links to new investments, bearing higher risks but therefore also involving higher return opportunities for the investors, being more characteristic of emerging markets.[16]

When investing in infrastructure, private and institutional investors further have different choices between *direct* and *indirect* infrastructure investments that can be *listed* or *unlisted*,[17] which are associated with different characteristics and risks as shown in Table 2, following the Solvency II asset categorization. Hereby, the simplest way to invest in infrastructure is by purchasing corporate bonds, stocks (corporate equity) or infrastructure funds. *Directly* investing in infrastructure generally comes along with higher capital needs and higher political and regulatory risks, depending on the concrete investment (see also Table 2).[18] Investors can thereby again choose between *listed* investments such as stocks and bonds of, e.g., energy firms, which may show a higher correlation with the general stock market movement, or *unlisted* investments.[19] The latter can comprise project bonds, project loans or Public Private Partnerships (PPP), for instance, where private or institutional investors can contribute capital and cooperate with the government to build public infrastructure, but depending on the PPP financing model are not allowed to determine the usage of the infrastructure, as only the state has sovereign functions.[20] As these kinds of investments are

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12 See, e.g., EIOPA (2013a, p. 35).

13 See J-curve effect, e.g., Inderst (2009, p. 7).

14 See EIOPA (2013a, p. 35).

15 See Page et al. (2008, p. 105); EIOPA (2013a, pp. 35-36); Credit Suisse (2010, p. 2).

16 See Beyerle, Voß, and Weber (2011, p. 6); Credit Suisse (2010, p. 2).

17 See Bitsch, Buchner, and Kaserer (2010, p. 109); Inderst (2009, p. 8f.). See also Beeferman (2008) for a comprehensive categorization and discussion of differences between infrastructure investment types from the perspective of pension funds.

18 Exemplarily for a risky investment would be the investment in a geothermal energy plant, showing possibly high equity returns with high volatility, but having very low liquidity, low transparency of the investment object and requiring large amounts of capital. As a less risky investment, participation in an office building would provide comparably low equity returns with also high volatility, but high liquidity and transparency and requires a low capital investment (see Beyerle, Voß, and Weber, 2011, p. 31).

19 See Beyerle, Voß, and Weber (2011, p. 8).

20 For more information on PPP models in Germany, see e.g. Federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung (BMVBS), 2010).

negotiated directly between the investor and the infrastructure projectors, PPP investments are often *illiquid*, have a *long time horizon*, and need a *minimum investment amount.*[21] In addition, direct infrastructure investments in real estate are possible. Even though real estate in general does not always qualify as an infrastructure investment object, there are still similarities, including the ones listed above, e.g., indivisibility, site dependence, long lifecycles and investment horizons, and illiquidity risk.[22] Furthermore, real estate investments can also involve several default risk factors such as long construction periods, faulty construction or project planning and technological progress.

Funds as an *indirect* investment, in contrast, can be broadly diversified (across sectors or investment markets) through investing in different infrastructure projects (which can have complex structures and further in turn invest in listed and unlisted infrastructure projects).[23] This generally implies lower political and regulatory risks as compared to (individual) direct investments in case the fund provides sufficient liquidity. However, infrastructure funds can also involve considerable concentration and cluster risks in case they have a regional or sector focus in contrast to globally and cross-sector diversified infrastructure funds, for instance. In addition, investments can already be made with smaller amounts of capital.[24] When comparing listed and unlisted funds, the market for the latter, which are not traded at a stock exchange, is rather illiquid and, hence, the investment duration is generally longer as compared to liquid listed fund investments.

The characteristics of the investment thus strongly depend on the type of investment (e.g. direct versus indirect, listed versus unlisted) and cannot be simply generalized.[25] However, there are several properties that infrastructure investments typically exhibit (or that are at least expected), but which may differ depending on sector, environment, investment phase, way of investment and the individual project. For example, as mentioned above, large infrastructure investments have a *long economic lifetime* and *long capital commitment* of about 60 years on average and even up to 99 years, thus also facing illiquidity risk.[26] Pumped-storage power stations, for instance, show an economic lifetime of about 70 years, whereas the lifetime of wind parks is about 20 years.[27] Such projects often involve *high capital needs*.[28]

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[21] See Bitsch, Buchner, and Kaserer (2010, p. 109); Beyerle, Voß, and Weber (2011, p. 8).

[22] See Finkenzeller, Dechant, and Schäfers (2010, p. 266).

[23] See Beeferman (2008, p. 21), Bitsch, Buchner, and Kaserer (2010, p. 109).

[24] See Bitsch, Buchner, and Kaserer (2010, p. 109); Beyerle, Voß, and Weber (2011, p. 8).

[25] See Bitsch, Buchner, and Kaserer (2010, p. 107); Massing and Pick (2011, p. 622).

[26] In the case of direct unlisted investments such as real estate, see Bitsch, Buchner, and Kaserer (2010, p. 109); Rickards (2008); Beeferman (2008, p. 7).

[27] See Beyerle, Voß, and Weber (2011, p. 31). Further examples include bridges, which have a time horizon of more than 30 years, fiber optic cables with more than 40 years, and real estate of 50 and up to 100 years. However, the individual time horizon can vary, as it depends on many factors (see Federation of the German Construction Industry, 2007, p. 24; Fischer, 2008, p. 2; Swiss National Science Foundation, 2011, p. 70).

[28] See Sawant (2010a); Szymanski (1991).

Table 2: Overview and classification of infrastructure investments following Solvency II (EIOPA) and selected empirical results regarding specific characteristics of infrastructure investments

Asset class	*Specification*	*Author(s)*	*Stable cash flows*	*Inflation hedging ability*	*Correlations / diversification potential*	*Performance and risks*
Direct investment						
Bonds	Corporate, government bonds					
	Debt financed PPPs, project bonds	Sawant (2010c) (60 emerging markets infrastr. project bonds from 15 countries)	- Yes (but only visual inspection: fairly stable)	- No (possibly due to sample bonds having fixed coupons)	- Low with equities and commodities	- Low return, low volatility - Negative Sharpe ratios (returns not sufficient in light of their risk, unattractive)
		Sirtaine et al. (2005) (34 PPP concessions in Latin America, representative of global privatization trends in Latin America (on average in operation for 7 years))	-	-	-	- Financial returns of private infrastructure concessions not considerable, sometimes below cost of capital - Strong variance of returns across concessions and countries (on average telecom and energy concessions better than transport and water) - Variance of returns across concessions partially explained by quality of regulation (the better quality of regulation, the closer the alignment between financial returns and costs of capital) - But: Potential bias due to economic regulation, incentive to dress down profitability so as not to be penalized at periodic tariff reviews
Loans	Corporate loans, project loans, infrastructure loan secritization					
Equity	Listed: corporate equity	(1) Rothballer and Kaserer (2012) (global stocks, 1975-2009) (2) Rödel and Rothballer (2012) (global stocks, 1973-2009)		- (2) Yes, but only for high pricing power (not significant, only slightly superior than non-infrastr. stocks) - (2) In general not better than other equity	-	- (1) Lower market risk (beta) than MSCI World (portfolio diversification effects) - (1) Total corporate risk (volatility of stock returns) not lower - (1) Significant level of idiosyncratic risk (due to high regulatory and construction risk etc. => need for well diversified portfolios of investors) - (1) High degree of heterogeneity among infrastr. sectors: utilities least risky, followed by transport and telecom

	Unlisted: private equity	Bitsch et al. (2010) (363 infrastr. private equity (PE) deals, 311,000 non-infrastr. PE deals)	- No (not more stable than non-infrastr. deals in the sense of predictable)	- Yes (but not stat. significant)	- Not uncorrelated with public equity markets - Uncorrelated with macroeconomic development	- Duration no longer than non-infrastr. PE deals (but: bias due to funds; duration pressure due to J-curve effect) - Initial capital requirements significantly higher than non-infrastr. deals - Lower default rates - Higher performance / returns (explained by higher market / political risk, higher leverage) - "Brownfield" (approx. with PE) have lower default rates and higher return than "Greenfield" deals (approx. with venture capital)
Real estate						
Indirect investment						
Funds	Listed	Listed and unlisted funds (studied jointly, mixed with stocks): (1) Peng and Newell (2007) (Australian *unlisted* funds (5), UBS infrastr. series as proxy for *listed* infrastr. stocks) (2) Finkenzeller et al. (2010) (Australian *unlisted* funds, UBS index for *listed* infrastr. stocks) (3) Bird et al. (2012) (Australian *listed* and *unlisted* stocks / funds and U.S. listed stocks)		- (1) No (but only short time period considered) - (2) Yes, but mainly restricted to (regulated) utilities sector	- (1) Low with stock market - (2) Low/moderate with trad. asset classes - (1) unlisted showed lower corr.with other asset classes than listed infrastr. - (2) significant inter-infrastr.-sector correlations - (3) no serial corr. (despite illiquidity, valuation appraisal-based etc. explained by noise in data)	- (1)/(3) All infrastr. sectors significantly outperform property, stocks, bonds (in terms of total return) - (3) But: Large variation depending on sector; regulated assets (e.g. utilities) outperform unregulated assets - (1)/(2)/(3) Listed infrastr. has higher (highest) risk / volatility and highest return; higher than unlisted funds - (1) Listed composite infrastr. gave third highest return, outperforming unlisted infrastructure - (1)/(2) Unlisted infrastr. has lowest volatility among all considered asset classes - (2) Unlisted infrastr. return similar to equity and bonds, lower than property - (3) Listed infrastr. has higher volatility and higher beta than listed utilities
	Unlisted (private equity, hedge funds, alternatives, commodities)					

In addition, investments in infrastructure projects generally show *large economic external effects*, since improved or newly constructed infrastructure affects society and the attractiveness of a local area, for instance. This may lead to an inflow of labor force leading to increased tax income and further possible investments in local infrastructure. From an economic perspective, infrastructure shows a *low elasticity of demand*, i.e., price increases for usage of infrastructure or increased fees show low or no effects on infrastructure demand. Furthermore, infrastructure assets such as PPPs (e.g. construction of a highway) are often *regulated objects* within *monopolistic or quasi-monopolistic markets* with *high barriers to entry*,[29] which are thus also assumed to induce inflation hedging ability. Investments are also often *not divisible* and have to *fulfill minimum investment sizes*, as public infrastructure cannot operate at its economic optimum, which also implies that supply and demand are less flexible.[30]

Many infrastructure attributes, such as liquidity risk or the amount of capital needs, have not or only partially been empirically studied in the scientific literature. In Table 2, we thus present selected empirical results on further (typically desired or expected) characteristics that have been empirically studied in the literature, focusing on stable cash flows and the inflation hedging ability of infrastructure investments.[31] In addition, correlations with other asset classes as well as risk and return aspects are presented, which are discussed in more detail in the next subsection.

Particularly the duration of the investment and the stability of the cash flows is one aspect of special relevance for insurance companies, which also depends on the concrete type of infrastructure project. For instance, bond-like infrastructure investments with a large capital investment in the beginning and long-term cash flows over decades are sensitive towards changes in interest rates and can thus be used for duration matching purposes. Hence, for insurers, the integration of infrastructure projects in asset liability management decisions can provide the opportunity to match their long-term liability durations.[32] Many infrastructure objects exist over long time horizons and depending on the type of investment, e.g., investments with bond-like payout structures, can provide *stable cash flows*. However, to the best of our knowledge, empirical support for stable cash flows so far only exists for the case of project bonds as shown by Sawant (2010c) (see Table 2), which, however, is based on a visual inspection. In the case of private equity project deals, in contrast, Bitsch, Buchner, and Kaserer (2010) do not find support that private equity infrastructure deals provide more stable

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[29] See Sawant (2010b, p. 1038); German Insurance Association (2013, p. 4).

[30] See Inderst (2009, pp. 6-7); Li and Li (2013, p. 51).

[31] A literature review with focus on infrastructure equity is also given in, e.g., Blanc-Brude (2013).

[32] See Inderst (2010, p. 81); European Commission (2013, p. 9).

cash flows (in the sense of predictable) using a cash flow variability measure that accounts for different durations and time-dependent means of cash flows.

In the case where the investor holds pricing power for the infrastructure object cash flows, the investment performance is assumed to *hedge against inflation* by adjusting prices accordingly. While for project bonds, Sawant (2010c) does not find empirical support for an inflation hedging ability (possibly due to fixed coupons), empirical support has been provided by Rödel and Rothballer (2012) for global listed infrastructure stocks, whereby the inflation hedging ability was mainly restricted to sectors with strong pricing power and, in addition, only slightly superior to the inflation hedging ability of non-infrastructure stocks. Infrastructure equities in general, however, do not hedge inflation better than non-infrastructure equities.[33] The authors explain their findings by 1) restrictions in monopolistic pricing power of infrastructure firms and an increasing competitiveness, 2) the fact that cost-based regulatory regimes dominate incentive-based regimes in most infrastructure sectors, whereby the former does not necessarily provide a hedge against inflation, and 3) an inflation exposure on the cost side, amongst others. Similarly, Bird, Liem, and Thorp (2012) also provide evidence for the inflation-hedging ability of infrastructure investments in the U.S. and Australian market for stocks and fund investments within the (regulated) utility sector only. As their dataset is an updated set of the one used in Peng and Newell (2007), the fact that the latter did not find support for an inflation hedging ability could be explained by the short time period that is considered in their analysis. For the case of private equity project deals, Bitsch, Buchner, and Kaserer (2010) find support for an inflation hedging ability (but not statistically significant).

Thus, as infrastructure investments are very heterogeneous and can differ in many ways, there is also some discussion about whether infrastructure investments can be classified as an own stand-alone asset class at all.[34]

Performance of infrastructure investments

The heterogeneity of infrastructure investments also becomes apparent when considering the selected empirical results regarding performance and risks as exhibited in the right column of Table 2. In general, empirical analyses regarding the financial performance of infrastructure fund investments are often subject to restrictions as data is limited; e.g. in the case of funds, the majority was launched only after 2004.[35] Due to the general lack of data, most studies

[33] See Rödel and Rothballer (2012, p. 117).
[34] See Massing and Pick (2011, p. 622); Bird, Liem, and Thorp (2012, p. 2).
[35] See Preqin (2012, p. 29); Massing and Pick (2011, p. 622).

have been conducted for the case of listed stocks as well as listed and unlisted funds, especially for the mature Australian market (see Table 2), where sufficient data is available and which cannot be simply generalized to other markets, but still provides an important indication of performance and risks.

Regarding *listed corporate equity*, Rothballer and Kaserer (2012) use a large global dataset of infrastructure stocks across 71 countries and find that infrastructure equity has a significantly lower market risk (beta) than comparable equities in the MSCI World index but that total corporate risk (volatility of stock returns) is not lower compared to other public equities, suggesting a significant level of idiosyncratic risk, which the authors explain by the high political and regulatory risks associated with infrastructure investments, amongst others, and which also implies that investors should have a well-diversified portfolio. They also find a high degree of heterogeneity across different sectors, with utilities being the least risky (total and market risk significantly lower than market average), followed by transport (significantly lower market risk) and the telecom subsector (similar market risk).

For the case of *unlisted private equity infrastructure deals*, Bitsch, Buchner, and Kaserer (2010) show based on their unique database that unlisted infrastructure private equity investments (based on private equity and venture capital deals) exhibit higher returns[36] and are uncorrelated to the macroeconomic development (but not uncorrelated to public equity markets). The authors thereby explain higher returns of infrastructure private equity deals by the higher market and political risk as well as higher leverage. At the same time, capital requirements are considerably higher at inception of the project. The authors also show that the duration of infrastructure deals is no longer than the duration of non-infrastructure deals, which may be ascribed to a bias in funds caused by the J-curve effect, i.e., the duration pressure caused by negative cash flows in the first 2-3 years, followed by at least one cycle of 5 years for rapidly increasing cash flows.[37] In addition, infrastructure deals exhibit lower default frequencies as compared to non-infrastructure private equity deals, whereby “Brownfield” investments (approximated with private equity deals) have higher returns and lower default rates than “Greenfield” investments (approximated with venture capital deals).

The lower default rates of infrastructure investments can also be confirmed in the case of *project bonds* as laid out in the study (with restricted sample size) by S&P (2010, p. 4) regarding historical annual default rates, which shows that the general infrastructure project bond default rate for 2003 to 2009, for instance, lies between 0.5% and 2%, whereas the

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36 Using a sample of 7,453 investments made in 81 countries by 254 PE firms (1971-2005), Lopez-de-Silanes, Phalippou, and Gottschalg (2011) find a median IRR of 21% gross of fees. In addition, the authors find that one in ten investments goes bankrupt and that one fourth has an IRR of above 50%.

37 See also Page et al. (2008) with reference to Probitas Partners (2007).

default rate for corporate bonds for the identical time period is between 1% and 5.5%.[38] According to Weber and Alfen (2009, p. 50), these considerably lower default rates could be explained by the more thorough assessment and examination of infrastructure projects. Regarding *project loans*, a study by Moody's (2013) shows that 10-year cumulative default rates of infrastructure investments (excluding the telecom and power sectors) are low-investment grade / high-speculative credit grade, being speculative grade during the construction phase in the first two project years and less risky in later years of the operation phase.[39] In addition, ultimate recovery rates are higher the later the default occurs, averaging approximately 80% and even 100% in two thirds of the cases. Overall, the infrastructure sector still proved to be the least risky, but without including the (more risky) media & telecom and power sectors.

In this context, the empirical study by Sawant (2010c) based on 60 emerging markets *project bonds* from 15 countries shows that the considered infrastructure project bonds exhibit a generally unattractive risk return profile, having a negative Sharpe ratio with low risk but also low returns.[40] Similar results have been found for PPP (private infrastructure) concessions by Estache and Pinglo (2004) and Sirtaine et al. (2005) in the case of Latin America, where returns were sometimes even below the cost of equity, whereby on average telecom and energy concessions were better than transport and water as found by Sirtaine et al. (2005). The authors also found highly volatile returns across concessions, sectors, and countries, whereby the variance of returns could partly be explained by the quality of regulation. In particular, for higher regulatory quality, financial returns were closer to cost of capital, thus emphasizing the need for a high quality of regulation.

Regarding *listed and unlisted infrastructure funds*, in contrast, different studies (mainly using Australian unlisted funds and listed equity, partly also including stocks in their analysis) show that all infrastructure sectors outperform property, stocks, and bonds in terms of total return for instance.[41] However, large variations were found depending on the respective sector. Bird, Liem, and Thorp (2012), for instance, show that the regulated utilities sector generally outperformed other unregulated assets. In addition, listed infrastructure was shown to have a higher (or highest) risk (in terms of volatility) and the highest return, also outperforming unlisted infrastructure.[42] Furthermore, unlisted infrastructure had the lowest volatility among all considered asset classes and especially also lower than listed infrastructure.[43] The returns

38 See S&P (2010, p. 4).
39 See EIOPA (2013a, p. 43).
40 See Sawant (2010c, p. 82).
41 See Peng and Newell (2007); Bird, Liem, and Thorp (2012).
42 See Peng and Newell (2007); Bird, Liem, and Thorp (2012); Finkenzeller, Dechant, and Schäfers (2010).
43 See Peng and Newell (2007); Finkenzeller, Dechant, and Schäfers (2010).

of unlisted infrastructure were thereby similar to bonds, but lower than property. For the listed Australian infrastructure and utilities sector, the authors further find (by visual inspection when accounting for certain factors, see Bird, Liem, and Thorp, 2012, p. 19) a declining trend in the three-year rolling excess returns, which the authors explain by increasing rents of managers, which undermines net returns.

One further major aspect is the diversification potential of infrastructure assets, i.e. the correlation with other asset classes. Here, Sawant (2010c), for instance, showed that the correlation of infrastructure project bonds is low with equities and commodities, thus providing diversification potential. In the case of unlisted private equity deals, as described above, Bitsch, Buchner, and Kaserer (2010) do not find support that cash flows are uncorrelated with public equity markets, but uncorrelated with the macroeconomic development. In regard to listed and unlisted infrastructure funds and stocks, a generally low correlation with the stock market and other traditional asset classes was found (see Table 2).[44] In addition, unlisted infrastructure funds showed a lower correlation with other asset classes than listed infrastructure (stock), thus representing better opportunities for diversifying a portfolio. Finally, significant inter-infrastructure-correlations were found by Finkenzeller, Dechant, and Schäfers (2010).

Apart from the empirical findings in the scientific literature, information about performance and risks are also provided in studies from the industry. Table 3, for instance, reflects expected risk-return profiles according to a categorization of Credit Suisse (2010, p. 2). When investing in infrastructure, one generally expects comparably high returns with lower volatility, while at the same time accepting a low level of liquidity.[45] However, risk-return profiles strongly depend on the respective sectors (see also Table 1 and 2), the project's maturity as well as its geographical location. For instance, a "Greenfield" investment in a new wind park provides a different risk-return profile than a "Brownfield" investment in, e.g., the renovation of an already existing toll road. According to Credit Suisse (2010, p. 2), the risk-return profile of "Brownfield" investments can thereby be classified between fixed income and equity investments, whereby "Greenfield" infrastructure investments exhibit considerably larger risk-return variations than investments in classical equity, for instance. Furthermore, according to findings in the U.S. and Australian infrastructure markets, infrastructure investments generally exhibit low correlations with traditional asset classes,[46] which should particularly hold for unlisted investments.

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[44] See Peng and Newell (2007); Bird, Liem, and Thorp (2012); Finkenzeller, Dechant, and Schäfers (2010).

[45] See Bitsch, Buchner, and Kaserer (2010, p. 106); Massing and Pick (2011, p. 621).

[46] Quarterly measured between 1994 and 2009; indirect infrastructure measured via the UBS Australia Infrastructure Index, indirect utilities measured via the UBS Australia Utilities Index, and direct

Table 3: Expected risk and return level for different types of infrastructure investments according to Credit Suisse (2010, p. 3)

Expected risk and return level	Low	Medium	High	Very high
Types of infrastructure investments (examples)	Seasoned toll roads Social infrastructure	Electricity generation Gas processing Ports	Airports Desalination Rail infrastructure	"Greenfield" project development[47] New toll roads Merchant power plants[48]
Category / status	"Brownfield"		"Greenfield"	

Although financial performance information on infrastructure funds cannot generally reflect the asset class performance as a whole (as each infrastructure investment type is different and the performance may not easily be quantifiable as laid out previously and in Table 2), in the following performance data is exemplarily laid out as presented in the Preqin Global Infrastructure Report 2012, which includes 108 unlisted infrastructure funds and provides vintage[49] information on funds from 1993 to 2008 along with their net internal return rates (IRR). The report shows that funds established from 1993 to 1999 have a median net IRR of 9% in the overall period (up to 2012), whereas younger funds from 2000 to 2005 exhibit a median of 21.1%.[50] Funds established in 2006 and later show lower median net internal return rates, since these funds still hold capital reserves ("dry powder") for future investments, which prevents an adequate performance analysis. The general target IRR of unlisted infrastructure funds according to Preqin (2012, p. 29) is shown in Table 4. These findings are approximately in line with the figures listed in in Page et al. (2008, p. 105) with reference to Probitas Partners (2007), where "Brownfield" investments exhibit an expected IRR of 10% to 12% and "Greenfield" investments have an expected IRR of 15% and more. According to

infrastructure via a constructed index by Colonial First State (see Beyerle, Voß, and Weber, 2011, p. 7; Finkenzeller, Dechant, and Schäfers, 2010, p. 267).

47 This refers to the research and development of a new infrastructure technology such as, e.g., the Next Generation Mobile Networks "4G".

48 Merchant power plants are generally funded by investors and sell electricity on the free energy market. They do not serve retail customers, and therefore have to compete in the market to sell their produced power (see Meel, 2013, www.eefi.org/plugins/p2_news/printarticle.php?p2_articleid=431, access 01/13/2013; North Pacific Training and Performance Inc., (2013): Glossary of Electric Utility Terms. http://www.north-pacific.ca/Glossary/merchant_power_plant.html, access 01/13/2013).

49 According to Preqin, the "vintage year represents the year in which the fund made its first investment" (see Preqin, 2010, p. 6); vintage is thus classified as the year of the first investment made by the fund vehicle, while the performance figures will be the overall performance of the fund over its life up to when the report is published.

50 See Preqin (2012, p. 29).

Inderst (2010, p. 80), however, pension funds as investors, for instance, typically assume lower figures, using an expected return of 9% to 10% and a volatility of 7% to 8%.

Table 4: Target net internal return rate of unlisted infrastructure funds according to Preqin (2012)[51]

Target Net IRR	≤ 10%	10.1-15%	15.1-20%	20.1-25%	≥ 25%
Proportion of Funds	15%	52%	23%	1%	9%
Category / status	"Brownfield"		"Greenfield"		

Further aspects that should be taken into account in a performance and risk assessment is that as infrastructure is closely connected to public sovereignty, the financial success of infrastructure projects strongly depends on the regulatory environment. Federal politics can lead to improved project financing, but can also have a negative impact on projects, even making them unprofitable. From an investor's perspective, these risk and regulatory changes are not fully predictable or calculable.[52]

In addition, material infrastructure projects influence regions or societies and, hence, further risks and chances can rise due to the interaction of external effects of infrastructure projects. As such external effects can be both positive and negative, investors have to analyze each investment not only quantitatively, but also based on a qualitative risk assessment approach.[53] However, as large investment projects have long building and maintenance periods, an accurate forecast regarding external effects as well as internal project cash flows are highly challenging. In this context, Blanc-Brude (2013) (with focus on "public" infrastructure) points out the relevance of contractual features regarding risk and return, which may be even more important than the specific type of investment. In addition, for fund investments, concentration or cluster risks of infrastructure projects can emerge from similar infrastructure investments within the investment portfolio of the fund.[54] Such cluster risks could evolve from e.g. a fund specialized on regional investments such as roads in a certain regional area that could at the same time be affected by natural catastrophes. Finally, infrastructure projects are often long-term projects, which imply the risk of innovation. If the technology within the specific infrastructure project becomes out-of-date or unprofitable, investors might suffer

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51 See Preqin (2012, p. 29); in addition Weber and Alfen (2009, pp. 47-50) provide information on risk-return profiles, for several infrastructure investment objectives. In case high risk is classified as "Greenfield" and low risk as "Brownfield" investments, their statements on IRRs are in line with the findings of Preqin (2012): "Brownfield" (PPPs: 9-14%, toll road: 8-12%), "Greenfield" (power generation: 12-25%, railway: 14-18%).

52 See the BaFin (German Federal Financial Supervisory Authority) (2012).

53 See Inderst (2010, pp. 80-81).

54 See Inderst (2010, pp. 80-81).

huge losses as projects might be declared as total failures[55], aspects that should be taken into account in the context of a performance and risk assessment of infrastructure investments.

In summary, a performance measurement of infrastructure investments including concrete risk-return profiles can indeed be obtained in the case of listed investments. However, even in these cases, one needs to study the composition of the considered index or fund to identify possible concentration effects regarding individual stocks or a geographic focus (Blanc-Brude, 2013, p. 41). For other investments forms, particularly for unlisted or illiquid investment, a quantitative risk assessment is not easily possible due to illiquidity risk, regulatory and political risks, valuation risk, as well as innovation and technological risks, which cannot be simply quantified using classical performance measures and individually influence the performance of each single infrastructure investments. In these cases, investors need to conduct an adequate qualitative risk assessment.

Infrastructure market development

Information about the infrastructure market development is only partially available and typically limited to listed investments or listed and unlisted funds in general. Table 5 shows that the infrastructure market by the end of 2010 comprised about 160 billion USD assets under management according to industry data provided by Preqin (2012), of which about 68 billion USD represents "dry powder", i.e. capital (cash reserves) committed to be invested, but still available in the fund.[56] Table 5 also shows that the market size increased from 9 billion USD in 2003 to 160 billion USD in 2010, which emphasizes the strong growth potential of the infrastructure investment market. Furthermore, the average worldwide unlisted infrastructure fund deal size in 2011, for instance, was 400 million USD.[57]

Table 5: Infrastructure assets under management 2003 to 2010[58]

	2003	2004	2005	2006	2007	2008	2009	2010
Unrealized value ($bn)	5	6	9	16	33	49	60	92
Dry powder ($bn)	4	11	15	37	61	63	64	68

The infrastructure investor's landscape is broadly distributed, but the main global investors in infrastructure funds are public pension funds (19%), private sector pension funds (17%), banks (10%), and insurance companies (8%). Their geographical location ranges from the

55 See BaFin (2012).
56 See Preqin (2012, p. 13).
57 See Preqin (2012, p. 24).
58 See Preqin (2012, p. 13); measured annually in December.

U.S. (25%), U.K. (13%), Australia (7%), Canada (5%), Switzerland (5%) and Germany (4%).[59]

Table 6: Infrastructure market maturity and characteristics[60]

Status	Emerging	Maturing	Mature
Market maturity			
Ranking low to high	Latin America China Mexico CE4 Other Asia	Japan Germany BeNeLux France U.S. Canada ….	U.K. Australia
Characteristics			
Property rights	Weak	Strong	Strong
Legal setting for private ownership of infrastructure	Low	Medium	High
Number / value of deals	Low	Moderate	Significant

Notes: Focus is laid on countries ranked by maturity based on country risk and the value of completed infrastructure deals in the last 24 months as a percentage of the GDP. Country risk is mainly measured as legal, regulatory, political, economic and financial risk. "CE4" refers to Poland, Hungary, Czech Republic as well as the Slovak Republic (see OECD (2007, p. 32 with reference to Löwik and Hobbs, 2006, p. 10)).

These observations are also in line with the global market maturity statuses laid out in Table 6, which shows that besides the already mature markets Australia and the U.K., especially the Central European countries are maturing, thus offering new investment opportunities.

3. INFRASTRUCTURE INVESTMENTS UNDER SOLVENCY II

Based on the general overview and categorization of infrastructure investments, we now specifically focus on the insurer's perspective. Against the background of highly volatile capital markets and low interest rates, infrastructure investments have been increasingly in the focus of insurance companies as an alternative to traditional asset classes. In 2011, the asset volume of private insurers in the German market comprised approximately 1.3 trillion Euros.[61] One often mentioned argument in favor of infrastructure investments from an insurer's perspective is the high duration (of special relevance for life insurers with their high durations on the liability side), which – as shown in the previous section – however depends

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[59] See Preqin (2012, p. 31).

[60] See OECD (2007, p. 32).

[61] See German Insurance Association (Gesamtverband der Deutschen Versicherungswirtschaft e.V.) (2012, p. 22).

on the concrete type of investment, i.e. whether it is bond-like or not, for instance (see Table 2). The same holds true for the associated risks.

The global infrastructure project investment volume in 2011 amounted to 405 billion USD with the majority in *loans* (328 billion USD = 81%), followed by *equity* (62 billion USD = 15%), and infrastructure *bonds* (16 billion USD = 4%).[62] Regarding loans, for instance, according to, e.g., EIOPA (2013a, p. 36), insurers increasingly provide direct long-term lending as banks are reducing their activities partly due to Basel III or may even buy portfolios of infrastructure loans from banks in the future. In particular, apart from direct issuance of loans, insurers can also hold loans via transfer of credit claims from banks to insurers by means of loan securitization, for instance. With respect to equity, EIOPA (2013a, p. 37) points out that this amounts to less than 5% in Europe, but with a growing trend in regard to unlisted infrastructure funds, which provide less volatile returns (see Table 2). Finally, even though infrastructure project bonds make up only a minor part of the total infrastructure investment volume, EIOPA (2013a) sees chances by way of the Europe 2020 Project Bond Initiative, for instance, [63] which is intended to provide credit enhancement by means of guarantees. Hence, for insurers, the question generally arises which type of infrastructure investment is attractive against the background of their business model and the regulatory environment.

Solvency capital requirements for infrastructure investments under Solvency II

In this context, particularly Solvency II, the new European regulatory framework for insurance companies, planned to be in force sometime after 2016, is one major key driver for or against investments in infrastructure assets due to the risk-based capital requirements imposed by the new system. The higher the capital requirement, the less attractive is the investment in general. Solvency II requires an adequate assessment of risks associated with asset investments and, hence, in case of infrastructure investments, the amount of capital requirements will strongly depend on the respective investment type as shown in the previous section (see Table 2). The quantitative capital requirements are thereby regulated in Solvency II's Pillar 1 and can be derived either using the standard model provided by the regulatory authorities, or an internal model that more adequately reflects the company's individual risk situation.

In case of the Solvency II standard model, different risk categories need to be aggregated in order to calculate the overall solvency capital requirement (SCR). The relevant risk measure

[62] See EIOPA (2013a, pp. 36-37).
[63] See European Commission (2013, p. 12).

is the value at risk for a 99.5% confidence level. In the following, we focus on the market risk module[64], which contains seven submodules that need to be aggregated in order to derive the total solvency capital requirement for the market risk module: interest rate risk, equity risk, real estate risk, credit spread risk, concentration risk, illiquidity risk and exchange rate risk. [65] Of main relevance in the context of infrastructure investments (bonds, stocks, real estate, and funds) are thereby the equity risk, interest rate risk, spread risk and property risk sub modules. The solvency capital requirement for each submodule is given by the change in the net asset value (NAV) arising from a shock or stress (e.g. a decrease or increase in interest rates), whereby the *NAV* is defined as the difference between assets *A* and liabilities *L*:

$$\Delta NAV = \max\left(NAV - \left(NAV \mid shock\right), 0\right) = \max\left(\left(A - L\right) - \left(\left(A - L\right) \mid shock\right), 0\right).$$

In the case of *equity* investments, for instance, a shock of 39% for “type 1” equity, i.e., companies listed in the EEA or OECD is required (without symmetric adjustment against pro-cyclical effects according to QIS 5; 30% with adjustment), which corresponds to a solvency capital requirement of 39%. Investments in “type 2” equity, i.e. companies outside of the EEA or OECD, have higher capital requirements of 49% (40% with adjustments). Strategic participations are charged with 22% and investments in *real estate* generally have a risk capital of 25%.

When calculating the solvency capital requirements for *bonds* (loans in principle are to be treated similarly, see EIOPA (2013a)), the market risk submodules for interest rate risk and spread risk have to be taken into account. Hence, in the following, the SCR calculations are illustrated for the case of bonds, focusing only on the asset side for simplicity, i.e. the *NAV* only refers to the value of assets. The SCR for spread risk *sp* for one bond *i* is thus given by

$$Mkt_{sp}^{bonds} = \max\left(\Delta NAV \mid spread\ shock; 0\right) = \max\left(MV_i \cdot duration_i \cdot F^{up}\left(rating_i\right); 0\right),$$

where MV_i denotes the market value of bond *i*, $duration_i$ refers to the modified Macaulay duration of the bond, and F^{up} denotes the shock depending on the bond’s rating (see Table 7; CEIOPS, 2010, pp. 121-123).[66]

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[64] See CEIOPS (2010, p. 90); Gatzert and Martin (2012, pp. 4-5).

[65] See Directive 2009/138/EC (2009, p. 125).

[66] See CEIOPS (2010, p. 121).

Table 7: Spread risk shock factor F^{up} (see CEIOPS, 2010, p. 123)

	F^{up}	*Duration Floor*	*Duration Cap*
AAA	0.9 %	-	-
AA	1.1 %	-	-
A	1.4 %	1	29
BBB	2.5 %	1	23
BB	4.5 %	1	13
B or lower	7.5 %	1	10
Unrated	3.0 %	1	12

The SCR for interest rate risk *int* refers to all assets sensitive to changes in the term structure and is derived by

$$Mkt_{\text{int}} = \max\left(Mkt_{\text{int}}^{up}, Mkt_{\text{int}}^{down}\right) ,$$

where $Mkt_{\text{int}}^{up} = PV_{\text{int}} - PV_{\text{int}}^{up}$, i.e. the difference between the present value $\left(PV_{\text{int}}\right)$ of the bond without stress and with upward shock $\left(PV_{\text{int}}^{up}\right)$[67] given by

$$PV_{\text{int}}^{up} = \sum_{t=1}^{T} \frac{CF(t)}{\left(1+r_f(t)\cdot\left(1+s^{up}(t)\right)\right)^t},\; T = \max\left(t \mid CF(t) \neq 0\right),$$

where $CF(t)$ denotes the cash flow in period *t*, r_f refers to the risk-free rate given by the regulator, and s^{up} the upward adjustment of the term structure (see Table 8; CEIOPS, 2010, p. 111).

Table 8: Interest rate s^{up} factors (see CEIOPS, 2010, p. 111)

Maturity *t* (years)	Relative change $s^{up}(t)$
1	70%
2	70%
…	…
25	26%
>25	25%

The aggregation of the modules is done using the so-called square-root formula,

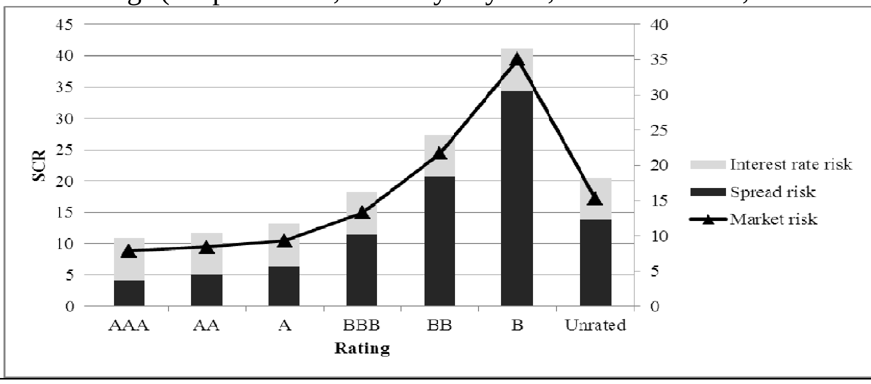
$$SCR_{mkt}^{SII} = \sqrt{\sum_{\text{int},sp} CorrMkt_{\text{int},sp} \cdot Mkt_{\text{int}} \cdot Mkt_{sp}} .$$

[67] As we focus on the asset side, the shock scenario is just referring to the upside movement of the interest rate curve, whereby the term structure is altered to higher interest rates (discounted values increase, reducing the PV_{int} of the bond).

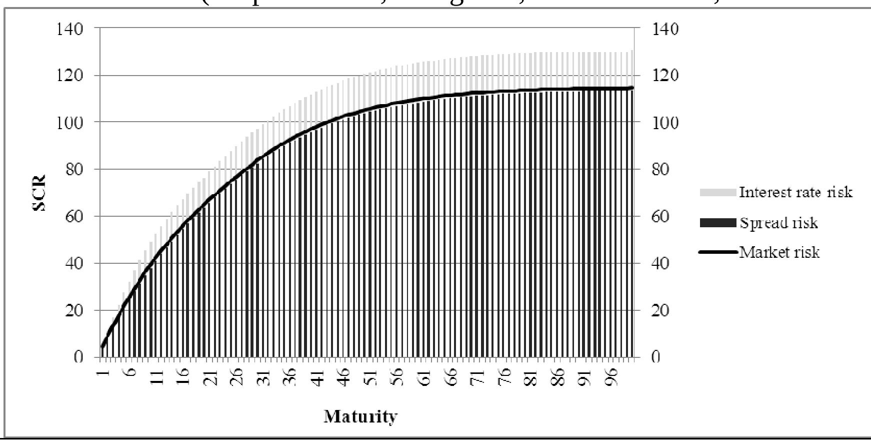
Figure 1 illustrates the solvency capital requirements for interest rate risk and spread risk due to changes of bond's rating and different maturities (all other factors remain fixed), using a correlation $CorrMkt_{int,sp} = 0$ (due to using the up-shock scenario).

Figure 1: Exemplary derivation of the SCR for market risk (aggregated based on spread and interest rate risk submodules using the square-root formula) for a bond with different ratings and maturities under the Solvency II standard model (asset side only)

a) SCR for different ratings (coupon: 3.0%; maturity: 5 years; face value: 100; market value: 100)



b) SCR for different maturities (coupon: 3.0 %; rating: BB; face value: 100; market value: 100)



However, when deriving the SCR and when making investment decisions, insurers need to take both assets and liabilities into account. For instance, especially for life insurers, both assets and liabilities are sensitive towards changes in interest rates (bond investments on the asset side, discounting life insurance cash flows on the liability side), such that a duration mismatch results in a non-simultaneous increase of assets and liabilities due to interest rate stress. This may increase capital requirements, as assets generally have a shorter duration than life insurance liabilities and the latter react stronger towards interest rate shocks. Hence, by means of long-term infrastructure investments with long durations, the duration mismatch can be considerably reduced. Particularly important hereby are direct project finance (by means of bonds, loans, and equity), infrastructure investment funds (listed and unlisted) as well as infrastructure loan securitization vehicles.[68]

[68] See EIOPA (2013a, p. 35).

Table 9: Infrastructure investments (see also Table 2) under the Solvency II standard model[69]

Asset class	*Specification*	*Example*	*Solvency II classification*	*Main risks*	*Solvency Capital Requirements*
Bonds	Corporate bonds	Bond of E.ON SE	Corporate bonds	Interest rate risk, spread risk	Dependent on rating and maturity
	Government bonds	Transportation infrastructure bonds	EEA-government bonds	Interest rate risk, spread risk	0%
		-	Non-EEA-government bonds	Interest rate risk, spread risk	Dependent on rating and maturity
	Debt financed PPPs, project bonds	New South Wales (Australia) Waratah annuity bond	Bonds	Interest rate risk, spread risk	Dependent on rating and maturity
Loans	Corporate loans, project loans, infrastructure loan securitization	-	Loan capital	Interest rate risk, spread risk	Dependent on rating and maturity
Equity	Listed: equity	Shares of E.ON SE	Type 1 equity (EEA/OECD)	Equity risk	39%
		Shares of Reliance Ind. Ltd.	Type 2 equity (non-EEA/OECD)	Equity risk	49%
		-	Banks and financial services providers	Equity risk	0% / 100%[70]
	Unlisted: private equity/ project equity	Investment in wind park as project equity	Type 2 equity	Equity risk	49%
	Strategic participation	Listed and unlisted private, project or corporate equity	Strategic participation	Equity risk	22%
Real estate	Real estate	Investment in local school building	Real estate	Property risk	25%
Funds[71]	Listed	-	"Look through approach"	"Look through approach"	Depends on investment, see categories above
	Unlisted (private equity, hedge funds, alternatives, commodities)	-	"Look through approach"	"Look through approach"	Depends on investment, see categories above

Thus, depending on the type of infrastructure investment (see Table 2 for a categorization), solvency capital requirements can strongly differ and Table 9 summarizes the treatment of different infrastructure investment categories under the Solvency II standard model as

[69] See Quantitative Impact Study (QIS) 5 (2011); Directive 2009/138/EC (2009); EIOPA (2013a, p. 41).

[70] Participations in banks and financial service providers require no risk capital for market risk, but are directly excluded from own funds, which thus reduces the amount of available capital by 100% of the participation's value (see CEIOPS, 2010, p. 282; Gatzert and Martin, 2012, p. 8).

[71] If listed or unlisted funds do not provide sufficient information on the investments of the fund itself, thus not allowing the application of the "look through approach", funds are classified as "type 2" (49%).

specified in the fifth Quantitative Impact Study (QIS 5) along with the Solvency II asset classification and the main risks relevant for the solvency capital requirements. In particular, as reflected in Table 9, EIOPA (2013a) sees corporate infrastructure debt (corporate bonds, project bonds and loans) and listed stocks to behave similar to other non-infrastructure corporate debt and equity and thus not to introduce separate risk classes[72], even though there may be considerable differences depending on the sector for the different types of investments (see Table 2), which may be taken into account when using a partial internal model.

As laid out in Table 9, *bond* investments are mainly affected by interest risk and spread risks within the market risk module (see also Figure 1). While corporate bonds, non-EEA government bonds or debt financed (project) bonds differ in their solvency capital requirements according to their bond rating and maturity, EEA-government bonds require 0% capital according to the standard model.[73] One example of a bond-equivalent financial instrument are "transportation/traffic infrastructure project bonds", which should classify as infrastructure EEA-government bonds.[74] Such a bond emitted by the state of Bavaria was discussed by German politicians for infrastructure project financing. In case of unrated corporate and non-EEA government bonds, the spread shock to be taken into account in the calculation of the SCR amounts to 3% with a duration cap of 12 years, thus implying higher capital requirements (see Figure 1a). Note in this context that one general problem specifically associated with infrastructure project bonds is the proper calibration at the 99.5% confidence level (value at risk) due to the lack of large historical data (see also Table 2).[75]

An example for an alternative debt financed investment could be the Australian "annuity-style inflation protected debt instrument" emitted by the New South Wales government, which was "established to fund critical economic and social infrastructure projects across New South Wales".[76] In addition, as long-term infrastructure project bonds can provide unattractive risk-return profiles (see Table 2), the EU initiated the EU2020 bond initiative, whereby the European Investment Bank (EIB) provides junior debt or a similar guarantee of up to 20% of

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[72] See EIOPA (2013a, p. 35).

[73] For a detailed analysis of the quantification of credit risk and market risk, see Gatzert and Martin (2012). Note that in case an internal model is applied, credit spread risk should be taken into account.

[74] See CSU (2012): „Private Finanzierung öffentlicher Infrastruktur". www.csu.de/kommission/wirtschaft/aktuelles/144511247.htm, access 01/18/2013 (in German „Verkehrsinfrastrukturanleihen").

[75] See EIOPA (2013a, p. 41).

[76] See New South Wales Government (NSW) (2012): https://www.waratahbonds. nsw.gov.au, access 02/13/2013. Note that New South Wales has a AAA-rating by the three major credit rating agencies (http://www.treasury.nsw.gov.au/NSW).

the senior debt amount to assure at least an A rating of the project bond and thus increase the attractiveness of infrastructure project bonds.[77]

Unlisted debt investments such as loan capital can be emitted either by direct loans, project loans, or loan securitization through special purpose vehicles.[78] As discussed before, project loans constitute the majority of the infrastructure investments with an expected increasing involvement of insurers as long-term lenders.[79] The treatment is planned to be analogously to bonds by using the spread risk submodule, which depends on duration and the external rating of the instrument. Note that as discussed in Section 2, a study by Moody's (2013) showed that the 10 year cumulative default rates were low-investment grade / high-speculative credit grade, with higher risk in the construction phase and lower risk in the operation phase.[80] Note that as discussed in Section 2, the infrastructure sector still proved to be the least risky, but without including the (generally more risky) telecom and power sectors.

In general, solvency capital requirements for bonds *ceteris paribus* increase with higher durations (but with decreasing marginal increase ("kinked approach", see Figure 1 b))[81], but the SCR can be lowered by a reduced duration mismatch. However, insurers may prefer EEA-government bonds for duration matching as these do not involve capital charges as opposed to alternative long-term investments with relatively high charges. In this case, as discussed before, the SCR arising from the interest rate risk submodule is reduced if investing in infrastructure allows a reduction of the duration mismatch between assets and liabilities, thus implying a reduced sensitivity of the net asset value towards changes in interest rates, which is especially relevant in case of life insurance companies. In particular, long-term bonds with contract terms of more than, e.g., 30 years, are rather difficult to obtain and interest rates are currently low. In this context, Page et al. (2008) specify the average investment period for "Brownfield" investments to be 15 to 30 years, whereas "Greenfield" investments are shorter and range between four to five years.[82]

Of further relevance in this context is the so called "matching adjustment"[83], which allows a reduction of the required capital for long-term liabilities that are duration- and cash flow-

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77 See EIOPA (2013a, p. 42); Sawant (2010c, p. 82); Sawant (2010c) for the case of emerging markets infrastructure project bonds.

78 See EIOPA (2013a, pp. 34; 42).

79 See EIOPA (2013a, p. 42).

80 See EIOPA (2013a, p. 43).

81 See also EIOPA (2013a, p. 42).

82 See Page et al. (2008, p. 105).

83 The matching adjustment or premium is the spread between the risk free rate and the yield of the assets in the portfolio, deducting the expected loss due to default or downgrade of the assets. The matching premium has to be higher than 75% of the long term average of the spread over the risk-free rate of assets of the same

matched by assets and which is still questionable for certain infrastructure investments.[84] As this procedure requires strict criteria to be fulfilled, such as, e.g., holding assets until maturity, managing them separately, and assets being of high quality, i.e., BB rated bonds or above, this might put unrated or low rated infrastructure bond investments in an unfavorable position.

In the case of *equity investments*, as described above, Solvency II implies different solvency capital requirements depending on the investment type. *Listed equity* investments in "global" equity (EEA or OECD) such as shares of E.ON SE, require a shock scenario (and thus a risk capital) of 39%, while investments in "other" equity (non-EEA/OECD) have 49%.[85] Strategic participations induce 22%, whereas shares or participations in banks and financial services providers are directly excluded (100%) from eligible own funds.[86]

Unlisted equity investments or private and project equity such as, e.g., investments in wind parks, are classified as "type 2" equity within the Solvency II framework and thus require a risk capital of 49% without adjustments. EIOPA (2013a) defines project equity as an investment that does not give right to fixed payments, but returns rather consist of dividend payments or sales proceeds at the expiration date.[87] Similar to project bonds, direct project equity (and infrastructure loans) may suffer from insufficient data to calibrate the solvency capital requirements, especially due to missing market values and the problems associated with reported Net Asset Values. Furthermore an approximation by means of other indices is highly difficult due to the high degree of heterogeneity of the asset class and the dependence on the respective sector (see Tables 1 and 2).[88]

Real estate investments induce a capital requirement of 25% and *investment funds* are evaluated via the "look through" approach, whereby the economic substance of each fund is examined by assessing the underlying assets the fund is invested in.[89] As such fund investments often cannot be "looked through", the solvency capital requirements are set to 49%. However, even with a classification as "type 1" equity, the risk of infrastructure

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duration and the held assets have to be at least BBB rated (see EIOPA (2013b); e.g., Risk.net (2013a): www.risk.net/insurance-risk/news/2125493/details-matching-premium-treatment-epifp-emerge-commission-paper, access 04/04/2013).

84 See e.g. Risk.net (2013b): www.risk.net/insurance-risk/news/2204971/german-insurers-warn-of-solvency-ii-threat-to-infrastructure-investment, access 06/05/2013.

85 Reliance Industries Limited is an Indian company with businesses in the energy sector (see Reliance Industries Limited (2013): Reliance Group. http://www.ril.com/html/aboutus/reliance_glance.html, access 02/13/2013).

86 See CEIOPS (2010, p. 282).

87 See EIOPA (2013a, p. 37).

88 See EIOPA (2013a, pp. 49-50).

89 See CEIOPS (2010, p. 109).

investments may not be reflected entirely correct, as according to industry reports, the actual investment performance may often be categorized similar to “property” products.[90] In addition, as shown in Table 2, unlisted funds in mature infrastructure markets such as Australia may generally imply a lower risk as compared to other asset classes and also listed funds.

As can be seen, the treatment of infrastructure investments under Solvency II differs considerably depending on the type of infrastructure investment, which will directly impact an insurer’s asset portfolio decisions. In particular, especially insurers with low capital buffers may shift their assets from unlisted and illiquid investments towards investments with lower solvency capital requirements such as, e.g., EEA-government bonds.[91] In addition, exploiting diversification effects between asset classes will become increasingly important. Especially in case of infrastructure projects, the consideration of diversification should also include the different stages of the investment (e.g. construction and operation) as well as the contract design (impacting cash-flows) and potential regulatory and political risks associated with the investment.[92] Hence, as the current version of the Solvency II standard model does not distinguish between different infrastructure sectors and investment types, a partial internal model may be beneficial in order to better reflect the true risk situation and more adequately capture diversification effects associated with infrastructure investments. However, one problem regarding partial internal models (and the standard model)is the potential lack of data, which may prevent a proper calibration at the 99.5% level.

Still, there is some (yet not much) empirical literature as laid out in Section 2, which indicates certain desirable characteristics for specific infrastructure investment types, which can be taken into account in a partial internal model. This may include the outperformance of infrastructure funds and private equity investments as compared to traditional asset classes, which, however, also depends on the respective sector and the maturity of the infrastructure market as well as whether the investment is “Brownfield” or “Greenfield”, for instance. Especially in case of unlisted infrastructure funds, potentially lower risks (in terms of volatility) should be taken into account as well as diversification effects due to low correlations with other asset classes (listed and unlisted funds, project bonds) and a lower beta (stocks) as shown in Table 2. Lower risks and diversification benefits can thereby imply a reduction in total solvency capital requirements from the market risk module. To reduce the risk exposures of such infrastructure investments through diversification and risk spreading

[90] See Page et al. (2008, p. 105).
[91] Severinson and Yermo (2012, pp. 31-33).
[92] See, e.g., Blanc-Brude (2013, p. 62).

among institutional investors, the European Commission (2013, p. 10) also suggests pooling of financial resources, e.g., by means of long-term investment funds (LTIF).

In addition, a possible reduction of a duration mismatch by means of long-term investments with stable cash flows and low default rates as in case of project bonds and loans should be studied carefully, as this can substantially decrease total solvency capital requirements arising from the interest rate submodule due to different durations of assets and liabilities. Yet, as long as Solvency II favors EEA-government bonds, insurers may potentially avoid unattractive long-term infrastructure investments.[93]

However, risks of infrastructure investments such as political and regulatory risks can as well be considerable and hardly quantifiable. In addition, liquidity risk may arise. A qualitative risk assessment and a thorough risk management thus appear vital when investing in infrastructure, especially in case of direct investments. Furthermore, a careful contract design is crucial, which along with regulatory and political risks underlying the respective infrastructure project play a major role in regard to risk-return profiles.[94] With PPPs, for instance, lower risks may be involved in case of state involvement or guarantees, which should be studied in detail.

One conclusion is that the standard model is not able (partly due to the lack of available data and generally probably not intended) to provide a fully adequate picture of individual infrastructure investments, which is why more research is necessary for specific types of investments in certain sectors, such as wind parks, for instance.

Example: Investing in wind parks and toll roads - qualitative risk assessment and treatment under Solvency II

To illustrate the various ways of investing in infrastructure and to emphasize potential risks and chances associated with infrastructure investments, in the following we present and discuss three concrete examples of investing in infrastructure from an insurer’s perspective along with a qualitative risk assessment and the consequences arising under Solvency II. We thereby compare onshore and offshore wind parks as well as a toll road.[95] As with many infrastructure projects, many project risks, particularly construction risks (e.g. technological / capital risks) can be lowered by efficient contracts design of the infrastructure project.[96] The

[93] See, e.g., Severinson and Yermo (2012, pp. 4-5, 32).

[94] See, e.g., EIOPA (2013a, p. 39); Blanc-Brude (2013, p. 60).

[95] For a detailed discussion of possible risk exposures, see Inderst (2010, pp. 80-81).

[96] See EIOPA (2013a, p. 39).

corresponding characteristics are illustrated in Table 10, where focus is laid on the situation in Germany.

Both types of investment objects (wind parks and toll road) classify as infrastructure in the wider sense, but although they share many similarities, they still have considerably different properties as shown in Table 10. Both projects provide stable cash flows, as toll road users have to pay fees and wind parks in general continuously feed energy into the electrical grid. As onshore and offshore wind parks are rather new facilities, investments will mostly be "Greenfield" for offshore wind parks and possibly also "Brownfield" for onshore wind parks. Toll roads are mainly "Brownfield" investments, as more roads need to be maintained than newly built, whereby in the latter case, toll roads can also classify as "Greenfield" investment (depending also on the country where it is built). Wind parks and toll roads (if "Greenfield" investments) generally require larger capital investments. In addition, such "Greenfield" projects often contain a failure risk during the investment and building period, whereas the reconstruction ("Brownfield" investment) of an existing toll road can be done with less capital and less risk exposure. Hence, even if the toll road is just partly reconstructed, it still provides cash flows, e.g. with just one open toll lane, thus reducing investment and project risks.

In addition to the general arguments discussed above, wind park risk exposures have to be analyzed for onshore or offshore projects separately. Onshore wind parks are based on an established and field-tested technology with many projects already built, implying that risks can be overall well assessed and measured. Offshore wind park risk exposures, in contrast, are still not fully analyzed due to the limited existing experience.[97] Risks can generally arise due to difficulties connecting the wind park to the electrical grid or due to natural weather conditions affecting the wind park efficiency or even causing damages through severe weather.[98] This is even aggravated by the fact that possible damages can in general only be fixed during settled weather conditions, i.e. from April to September when ships can reach the wind park. Furthermore, accumulation risks arise from the fact that offshore wind parks are mainly built in a concentrated way within a small area; additionally, power cables that connect such offshore wind parks with the mainland will be bundled to preserve natural resources e.g. the Northern German mudflat. In addition, accumulation risks also arise whenever a party is simultaneously involved in the risk transfer and the investment in a wind park or generally an infrastructure project, i.e. leading to accumulated risks on the party's asset and liability side.[99]

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[97] See German Insurance Association (2013, p. 4).

[98] See Stillert (2012, p. 625); Müller (2012, p. 938).

[99] See Müller (2012, p. 940).

Table 10: Exemplary risk assessment for infrastructure project characteristics for wind parks and toll roads in the case of Germany[100]

Characteristics	*Onshore Wind Park*	*Offshore Wind Park*	*Toll Road*
Business model	Power generation	Power generation	Toll / fees
Investment type	Unlisted direct and unlisted / listed indirect investment	Unlisted direct and unlisted / listed indirect investment	(Mainly) unlisted and direct investment (PPP)
Project status	"Greenfield" / "Brownfield"	"Greenfield"	Often "Brownfield"
Capital needs	Low[101]	Medium to high[102]	Low to high (~ depends on project size[103])
Durations	Yes (dependent on investment type)	Yes (dependent on investment type)	Yes
Economic lifetime	~ 20 years	~15-20 years	~ 20-30 years
Liquidity	Medium	Medium	-
Entry barriers	Low	High (complicated technology)	High (monopolistic market)
Divisibility	Partly dividable (# of wind turbines)	Partly dividable (# of wind turbines)	Dividable (broadness, length)
External effects on local economy and society (e.g. on local housing area)	Negative effects (e.g. noise)	Neutral effects (less effects on nature, e.g. birds)	Positive effects (improved access)
Political and regulatory risks	Medium (changes of EEG apportionment)	Medium (changes of EEG apportionment)	Low[104]
Technological / innovation risks	Low to medium	Medium to High	Low
Inflation hedge	No	No	Yes

Furthermore, as already mentioned in the previous section, both objects cause external effects on society. Whereas a toll road can provide fast access to rural areas or connect large cities,

[100] The characteristics presented in Table 10 mainly refer to direct and unlisted investments in material infrastructure, see Balz and Niewöhner (2012); Fraunhofer Institute for Wind Energy and Energy System Technology (2011, p. 30); Beyerle, Voß, and Weber (2011, p. 31).

[101] For onshore wind energy, the costs per installed Megawatt (MW) are about 1.15 million Euro. Single wind turbines in Europe currently have turbine sizes between 2 and 6 MW (see Skiba and Reimers, 2012, pp. 32-33).

[102] For offshore wind energy, the costs per installed Megawatt amount to about 3.3 to 3.6 million Euro (see Skiba and Reimers, 2012, p. 32).

[103] The BMVBS PPP-database currently contains projects between 3.5 million Euro to 650 million Euro (see BMVBS, 2013).

[104] The individual risk assessment is based upon the country the investment will be placed. Hence, risk assessment requires a comprehensive approach, e.g., taking into account the country's political and regulatory stability regarding renewable energy decisions (see EIOPA, 2013a, p. 40).

thus improving the traffic infrastructure and leading to an increased counter-urbanization, onshore wind parks mainly downgrade the surrounding landscape. A further significant difference between both projects is the divisibility of the individual infrastructure project. Toll roads can easily be shortened and extended, enlarged and narrowed, affecting the total infrastructure projects' cash flow and costs. A wind park project is typically not divisible, as cash flows are not existent if the wind park is not fully built and connected to the electrical grid.

One major risk factor that strongly affects the risk-return profiles is the regulatory and legal risk, which is particularly associated with the renewable energy sector in Germany.[105] The German energy market was heavily influenced by market intervention by politics, mainly due to the German Renewable Energy Sources Act ("Gesetz für den Vorrang Erneuerbarer Energien" (EEG)) in the year 2000, which ensures a fixed feed-in compensation for energy production over a predefined time span (20 years) (see §21 (2) EEG) and thus provides planning stability for investors. Currently, politics is discussing an adjustment of the EEG, which may have considerable consequences for investors. In addition, the guidelines in 2009/72/EG and 2009/73/EG by the European Union regulate and strictly divide between investment into energy transportation and power generation, thus generating a conflict of interest for financial investors whether to make infrastructure investments in energy transportation or power generation.[106] Such regulations may further negatively affect the possible diversification benefits of investments in the energy sector. Even though politics can also have an impact on toll road investments, the setting of a monopolistic market and the fact that changes are less likely provide more stability for investors.

Regarding the inflation hedge, a risk assessment in practice according to experts of Allianz Capital Partners, for instance, first examines whether the regulatory scheme includes a compensation for inflation (e.g. not for wind parks in Germany, but in the case of French wind parks), second, whether a compensation for inflation could be arranged with the regulatory or public authorities in the context of the infrastructure concession (e.g. in case of transportation or energy infrastructure), and, third, whether the firm can enforce inflation adjustment due to its market position.

Technological and innovations risks involve the risks of new technologies affecting old ones and making them less valuable. In the case of renewable energies, for instance, the improvement of oil production processes regarding unconventional oil sources by oil firms and scientists may have a significant impact on the global energy supply and thus also on the

[105] See German Insurance Association (2013, p. 5).
[106] See German Insurance Association (2013, p. 8).

significance of renewable energy. In particular, oil firms aim to increase oil extraction from so-called bituminous sands with lower operational costs. According to Maugeri (2012, pp. 1, 35), for instance, the so called “Oil Peak”, i.e. the global oil production peak, will move from the supposed peak in 2006 to a peak in 2030, thus slowing down the energy turnaround. Another aspect of relevance in regard to technological risks concerns the complexity of new technologies. Whereas risks of onshore wind parks and toll roads are well researched, offshore wind energy still provides many technological problems that are not yet investigated, including natural influences such as lightning, salty water conditions or the connections of the wind park to the mainland.[107]

As laid out in Table 9, one can choose from different investment types when investing in onshore or offshore wind parks. As an unlisted and direct private equity investment, the investor can buy a participation of, e.g., Leonidas VIII fund,[108] a participation investing in wind parks in the Normandy, France. Such an investment would in principle be classified as a private equity investment involving a capital requirement of 49% and in contrast to a direct and listed investment would involve many characteristics as presented in Table 10. If the investment takes place as a project finance initiative (i.e. a loan contract) in terms of a direct bond-like investment, such as, e.g., the Global Tech I offshore wind park[109] in the German North Sea, the SCR would depend on the rating and maturity. In the case of investing in a listed or unlisted fund with e.g. bond-like payout structures, the solvency capital requirements as well as the classification under Solvency II would result from the “look through approach” and the relevant characteristics such as rating and maturity of the underlying investment. If this information cannot be stated, the investment project needs an individual assessment, as it might otherwise be classified as “other” equity under Solvency II, requiring a solvency capital of 49% (see Table 9).

The investment in a toll road in contrast would mainly be structured as a PPP investment, as the state has a monopoly on roads in Germany. As previously laid out in Table 9, PPP investments may categorize as bond-like payout structures, therefore mainly being affected by the risk categories interest and spread risk submodules of Solvency II. Hence, the solvency

[107] See Allianz SE (2013): A day in the Life: A Windy Project of Grand Dimensions. http://www.agcs.allianz.com/assets/PDFs/GRD/GRD%20individual%20articles/GRD-2008-02-OffshoreWindBARD.pdf, access 02/14/2013.

[108] For more information, see Leonidas Associates (2013): http://www.leonid-as.com/attachments/article/223/Leonidas%20VIII%20Datenblatt.pdf, access 02/15/2013.

[109] For more information, see Global Tech One (2013): http://www.globaltechone.de/windpark/, access 02/15/2013.

capital calculation would be mainly based on the rating and the maturity of the PPP-project (e.g. "Autovia del Camino S.A." rated as "Ba1" by Moody's[110]).

Hence, the attractiveness of investing in infrastructure depends on the type and individual risks, which should be assessed thoroughly before deciding to invest. In particular, the performance and risk-return profiles may not be derived quantitatively for various reasons as discussed in Section 2, which thus requires a qualitative risk assessment.

4. SUMMARY

The aim of this paper is to show the treatment of different infrastructure investment types under Solvency II and to present main characteristics of this heterogeneous asset class, including illiquidity risk, political and regulatory risk, capital needs, time horizon and the existence of duration from an insurer's viewpoint based on a review of empirical literature, whereby the latter focused on stable cash flows, inflation hedging ability, correlations and performance and risks.

Our study emphasizes that the determination of solvency capital requirements depends on the Solvency II categorization of the respective infrastructure investment, which does not further distinguish between, e.g., different sectors or the specific investment type (e.g. PPP or project bond), even though these investments may not have the same risk. Investing in unlisted equity-like infrastructure or listed "type 2" equity, which includes, e.g., wind parks as well as shares in non-EEA stocks, are currently generally associated with capital requirements of up to 49%. Bond-like structures or real estate investments generally exhibit lower solvency capital requirements (but still 25% in the case of real estate, for instance) and can be used for duration matching purposes in an insurer's portfolio, thus having the potential to reduce overall solvency capital requirements. Overall, our analysis shows that a partial internal model may be beneficial to better account for actual risks and specific characteristics of certain infrastructure investments. This may include diversification effects (due to low correlations between listed and unlisted infrastructure funds or stocks with other asset classes) and lower market risk in terms of beta (in case of infrastructure stocks). For instance, especially unlisted infrastructure funds in the mature Australian market showed considerably lower risks as other asset classes including listed infrastructure funds.

[110] "Autovia del Camino is a company that will build, operate and maintain a 70 km shadow toll road linking the cities of Pamplona and Logrono in northern Spain under a long-term concession agreement granted by the Spanish Regional Government of Navarra until 2032." (see Moody's (2013): Moody's Credit Ratings. Rating Action: Moody's Assigns Aaa Rating to Debt Raised by Autovia del Camino (Spain). http://www.moodys.com/pages/default_de.aspx, access 02/15/2013).

As a concrete example, we further illustrated the heterogeneity of infrastructure investments and the necessity of a qualitative risk assessment (if data is not sufficient and risks cannot be simply quantified) by discussing the case of onshore wind parks, offshore wind parks and toll roads. Besides fundamental differences in the underlying risks (technology risks, innovation risks, political and regulatory risks), we further point out different ways of investing in each of the three project types, highlighting that each investment has to be assessed individually and monitored carefully. However, as infrastructure investments are often investment projects in regulated and monopolistic markets, political and regulatory frameworks have to be taken into account in an accurate way when making investment decisions. In particular, insurers need to gather detailed risk-return information about their preferred (infrastructure) investments. However, since risk and return may not be easily quantifiable due to insufficient data or non-quantifiable risks such as political, regulatory, innovation and technological risks, infrastructure investments need to be assessed individually, using a comprehensive qualitative risk assessment approach in addition to a quantitative risk study. Classical performance measurement cannot be conducted in all cases and challenges arise in terms of valuation and the risk assessment of such often (highly) illiquid investments, which also concerns the adequate derivation of solvency capital requirements and the calibration at the 99.5%. Hence, investors seeking stable and long cash flows should be advised to analyze and monitor their investments carefully.

Finally, the decision to invest in infrastructure will also strongly depend on whether solvency capital requirements adequately reflect the risks inherent in the respective investment. Otherwise, European insurers may be forced to withdraw capital from any inadequately or unclassified infrastructure investments. Presumably this would not only negatively affect insurer’s investments, but also national infrastructure construction and maintenance in general. However, associated risks of infrastructure investments may be considerable and more research is necessary to determine adequate solvency capital requirements and to study risk-return profiles, gathering more data, thereby clearly distinguishing between the various types of investment possibilities and infrastructure sectors as well as their exposure to regulatory and political risk.

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