2 Overview of the infrastructure asset class

Despite the lack of a unique definition of infrastructure assets, its overall asset class principally comprises physical structures and networks that facilitate basic services for the existence, competitiveness and further development of both, an economy and a society.[1] It is often claimed that the ideal infrastructure investment generates predictable, long-term and stable cash flows that show a low correlation with other investments available on the capital market, protects against inflation risk and exhibits some kind of monopolistic market characteristics.[2] These properties, if existing in practice, appear to be the desired salvation for institutional investors like insurance companies, as they mitigate the jeopardy of the prevailing low-interest rate period. In order to capture that potential, the following sections shed some light on the typical characteristics that infrastructure investments tend to have in common and clarify the resulting consequences for their underlying risk-return profiles.

2.1 Current market situation for infrastructure investments

There is some evidence in the literature that in general, increasing infrastructure expenditures exert a positive influence on an economy´s future growth, especially towards the long run.[3] In this sense, the World Economic Forum (2012) estimates that every dollar spent on functional, i.e. value adding, public infrastructure will generate an economic return of five to 25 % in terms of gross domestic product (GDP) growth.[4] Although this interdependence between economic growth and infrastructure expenditures might act to some extent as a driving force for governmental spending in the infrastructure sector, there is still a large unmet capital demand for infrastructure investments around the world, leading to a global infrastructure gap of almost US $ 1 trillion per year.[5] The literature offers a vast variety of different figures on the right capital endowment for the entire infrastructure sector, but altogether, they finally draw the picture of a severe discrepancy between the capital´s provision and demand. The OECD (2007) forecasts that there is a global, cumulative capital need of about US $ 70 trillion until 2030 only for the publically most important sectors transport, communication, energy and water.[6] McKinsey Global Institute (2013) estimates a world-wide capital requirement of about US $ 57 trillion for the same sectors only to keep up with the current expectations of economic growth until 2030.[7] With regard to Europe, the European Commission (2014) estimates a cumulative capital demand for infrastructure investments in the fields of transport, energy and communication of about EUR 1 trillion until 2020.[8] Considering the amount of expected

[1] See Newell/Peng (2008), p. 22; OECD (2007), p. 20; WEF (2012), pp. 2-3.

[2] See, amongst others, Inderst (2010), p. 73.

[3] See Sanchez-Robles (1998), p. 106; Esfahani/Ramirez (2003), pp. 470-471; Canning/Pedroni (2008), pp. 523-524.

[4] See WEF (2012), p. 2.

[5] Measured as the difference between capital need and spending, see WEF (2012), p. 1.

[6] See OECD (2007), p. 97.

[7] See McKinsey Global Institute (2013), p. 1.

[8] See European Commission (2014), p. 2.

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infrastructure spending, PwC (2014) forecasts a global rise of yearly capital expenditures for infrastructure assets from US $ 4 trillion in 2012 to US $ 9 trillion by 2025.[9]

Although all of these figures should be treated as rough estimates depending on many different economic scenarios, they all have the expectation of an enormous capital demand for future infrastructure investments in common. This expectation can be further supported by four long-term trends that seem to exert a major influence on the future deployment of the global infrastructure needs and thus provide valuable investment opportunities for institutional investors like insurance companies.[10]

First, there are fundamentally demographic developments in effect which basically evolve from two distinctions, population growth and population ageing.[11] From the perspective of the infrastructure sector, a growing and ageing population inevitably requires two capital-intensive actions, on the one hand, to intensely increase the existing infrastructure capacities and on the other hand, to build additional ones in order to satisfy the changing needs of the total population. The pressure stemming from these distinctions can be severe, as for instance, it is expected that until 2030 about 16 % of the worldwide population will be aged 60 years or over, while this group accounts for even more than 25 % of total population in Europe.[12] Resulting from a growing proportion of the old-aged people among societies, this trend is likely to emerge as a tightening condition on public budgets, leading through higher social expenses to an accelerating decline in remaining public funds for future infrastructure spending. In 2014, the average proportion of public social expenditures across the OECD countries already reached a historically high level with about 21.6 % of the GDP.[13] Since the public expenditures for pensions and social welfare are commonly expected to grow for most developed countries, it is likely that this trend will retain to shrink public funds available for infrastructure investments and thus, a growing participation of private investors like insurance companies in financing infrastructure assets seems to be inevitable.

Furthermore, as a result of the recent financial and sovereign debt crises, severe financial constraints on public budgets of both, developed and emerging countries, have been imposed in a widely manner. These come into effect, for example, through national debt brakes like they are implemented in Germany or through higher yield spreads of sovereign bonds, in particularly for highly indebted countries like Greece.[14] Therefore, governments around the world are under strong pressure to reduce their public debt levels and to consolidate their budgets.[15] In case of the European Union, the average gross debt level relative to GDP raised from 61.3 % in 2004

[9] See PwC (2014), p. 6-7.

[10] See, amongst others, OECD (2007), p. 21; PwC (2014), pp. 14-19.

[11] See OECD (2007), pp. 155-157.

[12] See United Nations (2015), p. 3.

[13] See OECD (2016a), statistics about social expenditure.

[14] See Bundesbank (2014), p. 26 for the development of bond spreads.

[15] A good example is Greece and its long-term struggle against the debt burden.

up to 85.2 % in 2015,[16] leading to average interest payments of about 2.3 % of the GDP.[17] In this regard, Checherita-Westphal and Rother (2012) show that the influence of high public debt levels on both, the long-term economic growth as well as the governmental investment behavior, is negative and non-linear.[18] Although there is currently some debt relief through the low interest rate environment for some countries like Germany, the generally increasing public debt levels in conjunction with a higher social spending are rather likely to negatively affect the available public expenditures for infrastructure investments in future and can be seen as the second major trend for a stronger involvement of private investors.

With regard to the long-term economic growth, for which a well-funded infrastructure sector is clearly a precondition, PwC (2015) estimates a significant change in the global economic order in terms of national GDP values from the current G7 (USA, Japan, Germany, United Kingdom, France, Italy, Canada) to a new group of emerging economies, called E7 (China, India, Brazil, Russia, Indonesia, Mexico, Turkey) in 2050.[19] Measured at purchasing power parity, the cumulative GDP of the E7 is expected to be twice that of the G7, whereof based on its national contributions, China and India are on first and second rank, followed by the USA.[20] This forecast can be underpinned by academic literature, for example, Jorgenson and Vu (2013), who point out a similar change in the global economic order until 2020.[21] Therefore, the emerging economies are expected to account for about half of global infrastructure expenditures over the next decades and hence generate an enormous capital demand for financing infrastructure assets.[22] In combination with constrained public budgets even in these countries, the covering of this capital need is likely to offer a wide variety of valuable investment opportunities for insurance companies and builds the third trend.

The last major trend can be found in a growing public sensitivity to the environmental status. For the infrastructure sector, this sensitivity implies a need for action not only limited to a reduction of environmental pollution caused by the infrastructure systems, but also for increasing the resilience of existing infrastructure assets to adverse natural outcomes and disasters.[23] Hence, it is likely that the current shift in the investment focus of several major institutional investors towards environmental issues will continue in future and tie their investments more strongly to an environmental context.[24] This expectation can be supported, for instance, by the growing effort of Scandinavian funds for divestment in polluting infrastructure assets or by data provided by Preqin (2016a), showing that the majority of global

[16] See Eurostat (2016a), statistics about general government gross debt.

[17] See Eurostat (2016b), statistics about general government gross debt w.r.t. interest payable.

[18] See Checherita-Westphal/Rother (2012), p. 1403.

[19] See PwC (2015), pp. 8-10.

[20] See PwC (2015), p 3.

[21] See Jorgenson/Vu (2013), pp. 398-399.

[22] See McKinsey Global Institute (2013), p. 23.

[23] See McKinsey Global Institute (2013), p. 17.

[24] See OECD (2007), pp. 162-167.

infrastructure deals over the last few years has already been completed in the field of renewable energy.[25]

These four superior trends are commonly expected to strongly challenge the future evolvement of infrastructure investments.[26] Since a government´s ability of financing infrastructure investments through taxation is limited, it is inevitable for governments in future to increase the privatization among public infrastructure assets, liberalize the structures of the infrastructure market and to incentivize private investors to meet these four long-term challenges under governmental supervision. As stated by the OECD (2007) and by Kikeri and Nellis (2004), governments basically need to change their future role from an exclusive investor in infrastructure towards a prudent supervisor who sets up attractive financing conditions for private investors and only stipulates the major aims under which private investors fund infrastructure assets.[27]

In this regard, there is already an increasing political effort to incentivize capital markets for financing infrastructure investments, for instance, through the introduction of the Europe 2020 Project Bond Initiative starting in 2012 by the European Union that aims to foster infrastructure debt investments.[28] Despite these first public programs, the current market for infrastructure assets cannot be seen as established, since private investors willing to fund infrastructure investments lack a standardized access to the various types of infrastructure investments. In order to overcome this obstacle, there are first efforts for a generalization of single market segments emerging in the literature. The extensive review of this literature stream has pointed out that there are three different main approaches commonly used to categorize the currently extremely heterogeneous infrastructure asset class into several major asset sub-classes. Every approach emphasizes different characteristics and risks of the underlying infra-structure asset, but if considered together, as intended in this thesis, these approaches are expected to provide a comprehensive overview of the infrastructure market´s current fragmentation.

The first approach categorizes infrastructure investments by the field of their operating business sector (sector approach). This perspective distinguishes between economic infrastructure assets, meaning physical systems that enable the basic functioning of the economy and society, and social infrastructure assets, which refer to systems and institutions that provide services essential for the continuity of a society (see Table 1). The field of economic infrastructure mainly includes the sectors transport, utilities and communication, whereas social infrastructure comprises the sectors health, education, security, culture, administration and retirement. Potential investors need to consider at first the suitability of the preferred business sector for their investment purposes, since all sectors can differentiate heavily in terms of, for example, risk sources, market competition or geopolitical factors that ultimately affect the investment´s expected return. Thus, it is difficult to draw a general conclusion about the eligibility of individual sectors, but, because investments in social infrastructure are usually subject to severe constraints, for example, in terms of a regulatory return cap or a compulsion for regularly capital

[25] See The Guardian (2016) and Preqin (2016a), p. 1.

[26] See e.g. OECD (2007), p. 14.

[27] See OECD (2007), pp. 30-31 and Kikeri/Nellis (2004), pp. 113-114.

[28] See European Union (2012), Regulation No 670/2012.

injections by the investor, infrastructure assets among this sector might be rather inappropriate for insurance companies.

Table 1: Infrastructure categorization using the sector approach

Economic infrastructure			Social infrastructure		
Transport	Utilities	Communication	Health	Education	Security
- Ground: Roads, Rails, Bridges, Public transport - Water: Ports, Water routes - Air: Airports	- Energy, Water, Heat supply: Oil, Gas, Coal, Renewable energy sources - Energy distribution: Power grids, Energy storage - Waste management	- Cable networks - Satellites - Radio stations	- Hospitals	- Schools, Universities	- Prisons, Police
			Culture	Administration	Retirement
			- Parks - Sports buildings	- Administrative buildings - Courts	- Retirement homes

Source: Own table, based on Gatzert/Kosub (2014), p. 353 and Kleine/Krautbauer/Schulz (2015), p. 81.

The second approach separates infrastructure investments according to their maturity (investment stage approach). Infrastructure investments at an early stage are commonly considered as greenfield assets, whereas investments at a later stage as brownfield assets.[29] This separation can be seen as a first risk-sensitive classification of infrastructure investments, because it differentiates the asset´s risk exposure depending on its stage on the lifecycle, which can be usually divided into four separate phases. At first, a design and planning phase builds the technical foundation for every infrastructure asset, which is followed by a capital-intensive construction phase in order to enable the investor with the ability to realize cash flows during the operating phase. The end of this lifecycle is usually represented by a decommissioning phase, during which the asset usually loses heavily in value due to fewer remaining operating periods and higher maintenance costs.[30]

Comparing greenfield to brownfield assets, the former type of asset does either not exist or only stands at an early project stage, so that it still needs to be constructed, which typically adds a plenty of additional risk sources to those mandatory for the operating phase.[31] Brownfield assets usually refer to assets that are already established and generate cash flows, hence they do not include any design and planning or construction risks and can provide more information for potential investors in terms of, for example, demand patterns about the asset´s underlying business model, insights about the market dynamics or its regulation.[32] Therefore, the asset´s

[29] See Oyedele/Adair/McGreal (2014), pp. 3-4.

[30] See Gatzert/Kosub (2014), p. 353; Ehlers (2014), p. 5.

[31] See Oyedele/Adair/McGreal (2014), pp. 3-4.

[32] See Bitsch/Buchner/Kaserer (2010), p. 112.

lifecycle status as a distinctive feature highlights brownfield assets as less risky than greenfield assets, but in turn, they also realize lower returns for the investor.[33] From the perspective of an insurance company as a risk-averse investor, brownfield assets seem to be a rather suitable investment choice, since the recent history provides good examples for the financial jeopardy of the greenfield assets´ construction phase (e.g. the Berlin airport).

The third categorization approach of infrastructure investments is based on the final investment vehicle that is used for the investor´s acquisition process (Table 2, investment vehicle approach).[34] Considering the scattered insights among the literature, it seems to be useful to subsume these by a three-step approach in order to illustrate the complexity of the investor´s current decision process for financing an infrastructure asset. At first, there is the investor´s basic distinction between an equity or debt investment in the preferred infrastructure sector (capital type), for example, the investment in stocks or bonds, which is followed by the choice of a preferred degree of the investor´s own influence on the asset (investment type), for instance, a direct or indirect investment through funds, and as the final step, there is the selection of the preferred degree of standardization underlying the acquisition process, for example, buying the targeted combination of capital and investment type as a listed or unlisted asset (investment vehicle).

Due to the extreme complexity of this three-step approach, it is not possible to conclude a general eligibility of any combination over the others for insurance companies (Table 2). All of them exhibit different characteristics, especially in terms of their risk and return contribution to the investor´s portfolio or the underlying market depth, leading to the intense heterogeneity of the infrastructure asset class at an aggregated level. But it clarifies the current challenges an investor is subject to when deciding on financing infrastructure, which, altogether, require a deep understanding of the infrastructure market and its complex dynamics. Therefore, the following section explains each investment vehicle in greater detail in order to comprehend and assess some of these issues.

[33] See Oyedele/Adair/McGreal (2014), pp. 3-4 and Bitsch/Buchner/Kaserer (2010), p. 123.

[34] See, for example, Gatzert/Kosub (2014), pp. 354-358.

Table 2: Infrastructure categorization using the investment vehicle approach (Part I)

Capital Type	Vehicle / Type	Listed Asset	Unlisted Asset
Equity	Direct	Stocks: • Market depth: Deep capital markets available • Liquidity: High • Know-how requirement: Capital market know-how • Diversification potential: Low, usually high correlation with other equity assets in the market	Unlisted equities / PPPs: • Market depth: Limited opportunities • Liquidity: Low, usually less exit options • Know-how requirement: High, specific project and business model know-how • Diversification potential: Rather high due to stable cash flows
	Indirect	Listed equity funds: • Market depth: Limited market • Liquidity: Medium • Know-how requirement: Capital market know-how • Diversification potential: Low, usually high correlation of the fund´s portfolio with other equity assets	Unlisted equity funds: • Market depth: Limited market • Liquidity: Low to medium • Know-how requirement: High, specific sector and business model know-how • Diversification potential: Basically, rather high level, but depending on assets´ sectors and regions

Table 2: Infrastructure categorization using the investment vehicle approach (Part II)

Capital Type	Type \ Vehicle	Listed Asset	Unlisted Asset
Debt	Direct	Corporate Bonds: • Market depth: Limited capital market • Liquidity: High • Know-how requirement: Fixed-Income and business model know-how • Diversification potential: Rather low, usually high correlation with other bonds in the market	Project Loans / Project Bonds: • Market depth: High supply, but mainly dominated by banks • Liquidity: Low, no secondary market yet • Know-how requirement: Credit market and business know-how • Diversification potential: Rather high due to direct link to stable infrastructure business models
	Indirect	Bond funds / Loan funds: For this segment, there are only few market offers available (around 40 funds in 2012) which do not provide sufficient track records and data for proper performance assessment according to the literature.	

Source: Own table, based on Gatzert/Kosub (2014), pp. 354-358; Kleine/Krautbauer/Schulz (2012), pp. 27-28, pp. 58-60; Bitsch/Buchner/Kaserer (2010), pp. 109-110.

For the field of direct equity investments, the investor can basically choose between an investment in a listed equity stake of a company whose business model is related to the infrastructure sector or an investment in an unlisted and hence private equity stake of an infrastructure company or physical asset. The former type of asset relates to publically traded stocks which are usually relatively liquid, require only profound capital market knowledge and their performance is usually correlated to a certain degree with the overall market performance.[35] Therefore, the properties of this asset sub-class are relatively similar to those of other listed equities. The latter one comprises direct capital investments in physical assets such as, for instance, toll roads, power plants or power grids, which can be acquired and managed by investors on their own behalf or in share with a government in case of a more specific investment structure like a public private partnership (PPP).

PPPs are characterized by a certain form of cooperation between a private investor (often bearing the design, planning and construction risk) and the government (often bearing the demand, pricing and inflation risk) which is contractually arranged for a certain length of time.[36]

[35] See Bitsch/Buchner/Kaserer (2010), p. 109.

[36] See OECD (2007), p 32; for a comprehensive overview see Grimsey/Lewis (2002).

A well-negotiated PPP can be advantageous for both parties, the private investor who mitigates some specific risk factors to the public partner, and the government which can reduce its public expenditures for infrastructure. However, it is not possible to generalize the economic performance of PPP structures, because it highly depends on the exact risk allocation and tariff structure between both parties underlying each deal.[37]

In general, direct investments in unlisted infrastructure equity as an individual sub asset-class are usually characterized by the requirement of large capital commitments as well as a profound knowledge about the assets´ underlying business models and its sectors.[38] In addition, the commitments usually underlie long time horizons accompanied by only a few possible exit options for investors, which characterizes the investment as rather illiquid and to be more risky compared to their listed or indirect counterparts within the infrastructure market.[39] However, due to their direct relation to infrastructure business models, which is shown by Bitsch (2012) to generally provide more stable cash flows than non-infrastructure business models, these investments can be considered as rather eligible for portfolio diversification purposes.[40]

Indirect equity investments through the investor´s participation in a public or private fund investing in either listed or unlisted infrastructure equity stakes, represent an alternative approach for even smaller investors to engage in the field of infrastructure. The main motives for investors to select this type of investment are, for instance, to participate in the relatively stable infrastructure business models while providing an usually lower capital commitment than for direct investments, a lower degree of own asset management duties as investors often act as limited fund partners and finally, to be endowed with several, standardized exit options depending on the fund´s legal framework (e.g. regulated withdrawal of money, sale of partnership to a secondary investor etc.).[41] The diversification potential of this type of asset for institutional investors like insurance companies depends highly on the regionally and sector-specifically clustering of infrastructure investments within the fund´s portfolio, but can be considered as relatively advantageous in contrast to other types of investments on the capital market.[42]

In case of debt investments, the market currently offers only direct investments to a sufficient extent.[43] These can be split between either listed debt assets, for example, listed bonds of companies associated with the infrastructure business, or unlisted debt assets, for instance, direct loans or bonds for certain infrastructure projects. It is reported that listed corporate infrastructure bonds behave rather similar to bonds from non-infrastructure companies in terms

[37] For typical PPP contracts in practice, see for example Blanc-Brude (2013), pp. 19-20 and Zhang (2005), p. 657.

[38] See, e.g. Bitsch/Buchner/Kaserer (2010), p. 109.

[39] See Gatzert/Kosub (2014), p. 354; Finkenzeller/Dechant/Schäfers (2010), p. 266.

[40] See Bitsch (2012), p. 209; Kleine/Krautbauer/Schulz (2012), p. 59.

[41] See Bitsch/Buchner/Kaserer (2010), p. 109.

[42] See Gatzert/Kosub (2014), p. 354.

[43] See Kleine/Krautbauer/Schulz (2012), p. 55.

of risk-return when having the same credit rating and maturity, thus offering a low exploitation of the potential benefits of the infrastructure business.[44]

Infrastructure loans in contrast, provide a direct access to infrastructure business models. Regarding the average cumulative default rates of infrastructure project loans, which measure the probability of a cohort´s default up to distinct time intervals, these seem not to entirely reflect the stylized potential of infrastructure assets in terms of cash flows´ stability and riskiness. Based on recent data and rating categories from Moody´s, such infrastructure loans are classified in a range between low to speculative investment grade (Moody´s Baa/Ba rating).[45] In contrast, considering the marginal annual default rates, which measure the probability that a member of a cohort which has survived up to a specific date will default by the end of that time interval, infrastructure loans seem to reflect the stylized potential of infrastructure assets only after a certain period of time. Starting with the high levels of non-investment grade´s marginal annual default rates, the rates for infrastructure loans fall three years after their closing towards those consistent with upper investment grade loans (Moody´s A rating).[46] The relatively high marginal default rates at the beginning of the infrastructure loan´s settlement compared to their later values are likely to result from the general high riskiness of the infrastructure asset´s underlying construction phase, for which the history provides several examples (e.g. the Berlin airport).[47]

This comprehensive overview shows that the market for infrastructure investments offers a plenty of different opportunities for investors to engage in the field of infrastructure. Recent data highlights that among institutional investors, insurance companies are currently the fourth largest investor in infrastructure.[48] However, regarding their average target aim for their portfolios´ allocation to infrastructure assets (3.9 %), it deviates significantly from their current portfolio´s exposure (2.9 %).[49] One rationale behind this mismatch can be found in the still unclear evidence on the empirical performance and riskiness of infrastructure investments, thus, resulting in a challenging valuation processes, which is stated to be one of the major problematic market issues institutional investors are concerned about.[50] This is not surprising, since there is a common complaint among practitioners as well as researchers about the prevailing lack of sufficient market data for infrastructure investments in order to properly assess their true risk-return profiles.[51]

This thesis will focus on direct investments in unlisted infrastructure equity stakes (hereafter named as direct infrastructure assets) from the perspective of an insurance company, because

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[44] See Kleine/Krautbauer/Schulz (2012), p. 49.

[45] See Moody´s (2013), p. 16 and Moody´s (2011), p. 33.

[46] See Moody´s (2013), p. 18.

[47] See Moody´s (2013), p. 18.

[48] See Preqin (2016b), p. 35.

[49] See Preqin (2016b), p. 36.

[50] See Preqin (2016b), p. 38.

[51] See e.g. Bahceci/Weisdorf (2014), p. 1.

this type of investment offers the strongest potential to participate in the special properties that tend to be unique for infrastructure assets. Therefore, this asset class is expected to represent the currently most valuable investment opportunity for insurance companies in the field of infrastructure assets. The following section provides scientific results in order to quantify their market potential as well as their risk-return profiles and hence builds the foundation for an own valuation model of an infrastructure asset developed in chapter 4.

2.2 The risk-return profile of direct infrastructure assets

It can be generally advantageous for institutional investors like insurance companies to directly invest in unlisted infrastructure equity and hence own this position in their balance sheets. According to the literature, direct infrastructure assets, at least in a stylized manner, are perceived to exhibit features like, for instance, high hurdles for a competitor´s market entry in terms of capital and business knowledge requirements, a generally long business model duration, a low correlation of the assets´ returns with other asset classes, an inelastic market demand pattern for the assets´ underlying business models which provides the ability for a sound inflation hedge and finally, relatively low default rates.[52] Furthermore, it is also frequently claimed that such infrastructure investments depict some kind of a hybrid asset, because one the one hand, they tend to combine equity-like returns with bond-like risks and on the other hand, they show some similarity to real estate investments.[53]

Although there are infrastructure investments that seem to satisfy some of these stylized features quite well, for instance the renewable energy sector in Germany with its feed-in tariff, a generalization of these features to hold for the entire infrastructure asset class is currently either not possible or at least challenging due to the prevailing lack of independent market data and the scarcity of empirical literature regarding the performance of infrastructure investments.[54] Nevertheless, academic research has identified several diverse risk sources that tend to be typically apparent for direct infrastructure assets and thus, build a suitable starting point for the assessment of its general risk-return profile.[55] However, the impact of these risk sources on an asset´s total performance can be highly diverse and differs strongly from investment to investment, since Tables 1 and 2 indicate the high heterogeneity of the whole infrastructure asset class. In order to comprehend the main risk channels underlying all direct infrastructure assets, Table 3 aims to aggregate the common risk sources found in literature to the typical lifecycle stages of such an infrastructure investment.[56] By connecting the risk sources to the different time-variant stages, it is possible to draw a first conclusion about the general distribution of risks among the total lifetime of such an asset and hence to provide the theoretical foundation for modelling the infrastructure asset in chapter 4.

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[52] See Inderst (2010), p. 73; Peng/Newell (2007), p. 424; See Moody´s (2013), p. 18.

[53] See Inderst (2010), p. 78; Newell/Peng (2008), p. 25.

[54] Private databases mostly used are provided by Preqin, Mercer Investment Consulting or CEPRES.

[55] For a comprehensive overview of risks, see, e.g. Inderst (2010), pp. 80-81; Loosemore (2007), p. 71; Bing et al. (2005), p. 28.

[56] Typical lifecycles mentioned by, e.g., Ehlers (2014), p. 5.

During the design and planning phase, which typically marks the first phase in the lifespan of an infrastructure asset, especially site and technical risks seem to appear. Common sources of risk can be found in challenges with land use and ground condition (e.g. in terms of suitability for the infrastructure project, its consistence, ground pollution, animal and plant protection, etc.) or design failures (e.g. in terms of inefficient technical solutions to specific problems emerging in subsequent stages).[57] In order to avoid a significant delay of the remaining lifecycle phases, high effort should be allocated by investors to the analysis of the risks involved at this project stage. Significant failures are even more dangerous to the asset´s total realization, since infrastructure investments are usually subject to a J-curve effect of cash flows, which means that the asset is not able to generate cash flows to cover any unexpected incoming expenditures.[58] The case of the Berlin airport and its problems with the smoke extraction system is a good example for the magnitude and tediousness of failures during this stage on the asset´s overall evolvement and the scope of necessary capital injections made by investors.

The probably most dangerous risk sources seem to appear during the asset´s construction phase, since any cost overruns during this stage cannot be compensated by operating cash flows and the termination of the entire construction project is mostly rather capital-intensive. Typical risk sources according to the literature include site risks, financial risks, regulatory or political risks, cost overruns and delays in the completion of the construction. All of these aggregated sources emerge in a plenty of different and individual risk factors which vary in their impact on the construction phase´s risk contribution to the asset´s total performance. Resulting from the strong relation between the construction risk and the default risk of infrastructure loans as data provided by Moody´s (2013) highlight, the construction phase can be regarded as a significant influence factor for the overall success of the infrastructure asset and thus should be considered carefully by potential investors and emphasized when modeling infrastructure assets.[59]

Considering the operation phase, the infrastructure asset during this stage typically generates first cash flows that are able to compensate the major risk sources appearing at this stage, like financial risks, regulatory or political risks, business risks and environmental risks. During this phase, regulatory and political risks might have the most disruptive potential to the asset´s business model depending on its underlying degree of regulation.[60] Recent history points out how dangerous this threat can be to the total performance of entire infrastructure sectors that were formerly perceived to be stable and profitable, for instance, the changes in the renewable energy market in Spain in 2014 or Germany´s nuclear power market due to its phase-out of nuclear power plants after the incidents in Fukushima in 2011.[61] It is obviously that the magnitude of negative consequences caused by regulatory changes increases with a higher degree of the business model´s regulatory level. Even if this risk type is difficult to mitigate, investors should be aware of its disruptive potential and try to reduce its magnitude as most as

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[57] The sources for the arguments regarding the lifecycle stages are mainly provided under Table 3 for the sake of comprehensiveness.

[58] See Gatzert/Kosub (2014), p. 353.

[59] See Moody´s (2013), p. 18; The sources for the arguments regarding the lifecycle stages are mainly provided under Table 3.

[60] Preqin (2016b) highlights on p. 38 the field of regulation as one of the major issues for the infrastructure market.

[61] For a comprehensive overview of the Spanish renewable energy market see Rojas/Tubio (2015).

possible, for instance, by negotiating suitably contractual frameworks in case of public private partnerships.

Table 3: Major risk factors for direct infrastructure assets (Part I)

Phase	Type of risk	Source of risk	Impact
Design and Planning	Site risks	Land use, ground condition issues like suitability, pollution, animal and plant protection, etc.	This risk can reach a high level and even lead to project termination in case of, e.g. unsolved environment protection conflicts, etc.
	Technical risks	Design failure, etc.	Inefficient technical solutions to issues of the subsequent stages can have extreme financial consequences, e.g. new Berlin airport.
Construction	Site risks	See above, but unexperienced in the design and planning phase.	See above.
	Financial risks	Interest rate shift, inflation rate changes, exchange rate shift, leverage risks, etc.	Financial risks during the construction phase can affect solvency of both, the investor as well as the construction contractor.
	Cost overruns	Design failures, approval delays, material price changes, etc.	A correction of fundamental design failures can be effort-extensive and expensive. A delay of required approvals at this stage can delay the completion of the whole construction phase.
	Regulatory/ Political Risks	Approval delays, changes in law affecting the conditions of the construction or the operating phases, etc.	It can require new design elements and delay the whole construction phase. Further, it can even make the intended business model inefficient.
	Delay in completion	Approval delays, inefficient work management, etc.	This risk can lead to high opportunity costs in terms of unmet demand.

Table 3: Major risk factors for direct infrastructure assets (Part II)

Phase	Type of risk	Source of risk	Impact
Operating	Financial risks	See above.	These risks can lead to severe financial distress during operation phase.
	Regulatory/ Political risks	See above, plus risk of tariff changes, market liberalization, etc.	Tariff changes can endanger the total business model, e.g. renewable energy market in Spain in 2014.
	Business risks	Operating cost overruns, revenue risk (demand, pricing risk), tax changes, agency conflicts between investor and government, etc.	These factors can significantly affect the total performance of the business model. Especially demand risk can be severe, e.g. the phase-out of nuclear energy in Germany in 2011.
	Environmental risks	Natural disaster, pollution, waste, etc.	Environmental risk can be caused by infrastructure projects or these can be physically affected by natural disasters.
Decommissioning	Illiquidity risks	Less exit options.	There is no secondary market for infrastructure projects, hence it is difficult to find a subsequent investor.
	Pricing/ Valuation risks	Difficulties with valuation of salvage value due to uncertainty in future political/regulatory environment.	It can be very problematic to value a project if there is uncertainty regarding the political/regulatory environment.

Source: Own table, based on EY (2015), pp. 18-20; Inderst (2010), pp. 80-81; Loosemore (2007), p. 71; Bing et al. (2005), p. 28.

The decommissioning phase usually refers to risk types such as illiquidity and valuation risks that on the one hand, also arise during the whole lifespan of an infrastructure investment, but remain as a more adverse characteristic at the asset´s final lifecycle´s phase when its market value usually shrinks caused by fewer operating periods. Due to the absence of a secondary market for direct infrastructure assets, there are only few feasible exit options for investors resulting in a high illiquidity risk.[62] This in turn, contributes to the lack of market data of comparable assets and transactions, which further complicates the valuation process of infrastructure assets, especially if there is uncertainty about major risk factors like political or

[62] See, e.g. Finkenzeller/Dechant/Schäfers (2010), p. 266 or Inderst (2010), p. 80; The sources for the arguments regarding the lifecycle stages are mainly provided under Table 3.

regulatory risk in future. This might work as an additional pressure for investors to hold such illiquid assets until maturity. However, on the other hand, especially the illiquidity risk can be in turn a valuable aspect for long-term investors like insurance companies, which are able to skim an underlying illiquidity premium compared to rather short-term investors.

Although every infrastructure investment is faced with most of these risks, their occurrence and their precise influence on the asset´s overall performance can highly differ from asset to asset depending on many diverse aspects like, for example, the business sector or geopolitical factors. This makes it impossible to aggregate and quantify a general impact of the mentioned risks applicable to every infrastructure investment during their stages. However, clarifying the time-variant interdependence between the asset´s lifecycle phases and the underlying risk sources mentioned by the literature, helps potential investors to thoroughly evaluate the risk distribution of a potential infrastructure asset in the course of an adequate due diligence process. It can be concluded that investors should be aware of the severe differences in the magnitude and scope of the major risk sources emerging during the different lifecycle phases, assess them on an aggregated stage level and mitigate those risk types using suitable hedging, insurance and contractual measures.[63]

The potential to assess a performance pattern of direct infrastructure assets subject to these vast stream of risk sources is currently limited due to the lack of sufficient market data, but remains extremely important for evaluating the expected role of such assets within an institutional portfolio. In order to overcome this obstacle, recent academic literature, however, focuses on empirically identifying the historical risk-return profile of direct infrastructure investments which makes it possible to draw several conclusions about the general performance pattern that most direct infrastructure assets are likely to incorporate.

Thereby, the analyzed performance series in academic research are mainly derived from investments made by unlisted infrastructure funds and thus typically comprise appraisal-based data series focusing on rather mature infrastructure markets like in Australia, Canada or the United Kingdom. Table 4 gives a comprehensive overview of the most relevant empirical findings so far, which is limited to academic research, since the objectivity of insights available from several major infrastructure funds and investment banks cannot be guaranteed. In case that there is no annualized data given, the respective values for return and volatility are annualized by using standard calculus. Furthermore, it is worth noting that so far, only six academic studies investigated the performance of direct infrastructure assets in a thoroughly manner, meaning that the conclusions drawn by these results are still limited, but suitable to reveal some of the asset´s common risk-return features.

The empirical results show that direct infrastructure assets are generally outperformed by their listed counterparts in terms of annualized returns, but this superiority is also accompanied by a higher risk exposure in terms of volatility. However, compared to the other major investment classes, direct infrastructure assets demonstrate a historically superior risk-return profile. With regard to the claim whether they show equity-like returns with bond-like risks, it seems that the

[63] See, for example, Schaufelberger/Wipadapisut (2003), p. 212, for financial mitigation strategies.

risk-return profile of its asset class shows rather some similarity to direct property investments than to equity or bond investments in terms of the provided return and volatility data.

Considering the time period of the global financial crisis (2007-2009), Newell, Peng and De Francesco (2011) disclose a strongly protective character of direct infrastructure assets during the general market downturn. While the returns of listed assets like infrastructure stocks and general equities become negative and more volatile compared to their pre-crisis level, the asset class of direct infrastructure assets, in contrast, shows a sharp decline in its return, but it still remains positive and is accompanied by only a small raise in volatility (6.3 % up to 6.7 % versus 13.9 % up to 21.5 % for equities in general). A possible explanation for this behavior besides the relatively stable business model for infrastructure services seems to be the underlying valuation process. Since there is no standardized market for trading equity stakes of unlisted infrastructure assets, this type of asset, similar to direct property assets, is typically valued on an appraisal-base, so that general economic downturns, especially in the short-term, have not the same effect on the asset´s value as for listed investments which are valued in a more frequent manner.[64]

Two empirical studies analyze the cash flow behavior of unlisted direct infrastructure investments so far. Bitsch (2012) shows by analyzing the data of listed funds which are primarily investing in direct infrastructure assets that these assets generally provide less volatile, hence more stable cash flows than non-infrastructure assets. In terms of growth rate and volatility, the results indicate values of 6 % and 7 %, respectively, for the time period 2000-2010.[65] Bahceci and Weisdorf (2014) come to a similar conclusion, highlighting that infrastructure assets in general (unlisted and listed equity) have the lowest cash flow volatility and show a relatively low correlation with the other assets in their sample. With regard to the growth rates of the cash flows underlying their analysis, infrastructure investments rank between property assets and listed equities (S&P 500) in the sample.[66]

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64 See Newell/Peng/De Francesco (2011), p. 72 or Humphreys/Maclean/Rogers (2016), p. 8.

65 See Bitsch (2012), p. 210.

66 See Bahceci/Weisdorf (2014), p. 34.

Table 4: Comparison of returns and volatilities (p.a.) of major asset classes in percent

Study	Period	Unlisted direct infrastructure	Listed infrastructure	Equities	Bonds	Unlisted direct property
Peng/Newell (2007)	1995-2006	14.1 / 5.8	22.4 / 16.0	12.9 / 11.0	7.2 / 4.3	10.9 / 1.5
Newell/Peng/ De Francesco (2011)	1995-2009	14.1 / 6.3	16.7 / 24.6	9.1 / 13.9	7.0 / 4.6	10.6 / 3.0
	2007-2009	8.2 / 6.7	-23.9 / 23.0	-13.2 / 21.5	7.1 / 6.9	3.3 / 5.8
Finkenzeller/ Dechant/Schäfers (2010)	1994-2009	8.0 / 3.8	14.8 / 16.6	7.7 / 15.0	8.1 / 4.9	9.4 / 4.9
Hartigan/Prasad/ De Francesco (2011)	1998-2008	12.7 / 6.5	13.8 / 13.6			12.5 / 3.2
Bird/Liem/Thorp (2014)	1995-2009	12.1 / 6.1	16.2 / 15.2			
Oyedele/Adair/ McGreal (2014)	2001-2010		6.0 / 14.3	4.7 / 19.0	3.5 / 3.8	
	2007-2009		-3.5 / 21.2	-19.2 / 32.6	-4.8/ 5.7	

Source: Own table, values correspond to annualized return/volatility in percent. Table based on Peng/Newell (2007), p. 438; Newell/Peng/De Francesco (2011), p. 66, p. 71; Finkenzeller/Dechant/Schäfers (2010), p. 265; Hartigan/Prasad/De Francesco (2011), p. 39; Bird/Liem/Thorp (2014), p. 808; Oyedele/Adair/McGreal (2014), p.8, p. 10.

Altogether, the empirical findings point out that direct infrastructure assets seem to rely on business models exhibiting relatively low risk levels while providing relatively high returns and stable cash flows. This tendency can also be supported when considering the interdependence between an asset´s expected return and systematic risk as provided by the capital asset pricing model (CAPM). Thereby, the asset beta as the unleveraged equity beta can be interpreted as a measure for the systematic operating risk of a company and thus should be similar for all companies with the same underlying business model irrespective of its status as listed or not. Taking a look at the asset beta´s value of listed infrastructure companies as an approximation for unlisted infrastructure assets, Rothballer and Kaserer (2012) find that the average infrastructure asset beta is 0.37 and thus considerably lower than the average value for non-infrastructure assets of 0.69.[67] Therefore, it can be concluded that infrastructure assets and their

[67] See Rothballer/Kaserer (2012), p. 99.

underlying business models are in terms of their systematic risk on average generally significantly less risky than non-infrastructure assets.

Analyzing the diversification potential of infrastructure assets, there are several studies indicating a relatively low correlation of direct infrastructure assets´ returns with those of other asset classes (see Table 5). The consistently highest correlation coefficients can be found with listed infrastructure investments (0.22 to 0.37). This tie is not surprising, since both types of assets rely on similar infrastructure business models which are subject to the same risk factors (see Table 3) that exert the same impact on the assets´ performance regardless of their status as listed or unlisted. Another relatively tight connection exists between direct infrastructure assets and unlisted direct property investments (0.20 to 0.51). Although some physical characteristics as well as risk factors are common to both assets, for instance, the indivisibility, a usually long-term investment horizon or the capital-intensive commitment, there are also certain differences between them, for example, the current market standardization, the feasibility of exit options or regulatory requirements.[68] In conjunction with the empirical results provided by Table 4 regarding the assets´ risk-return behavior, the current separation of property and infrastructure assets under the standard formula of Solvency II can be clearly underpinned.

Table 5: Correlation coefficients of direct infrastructure assets with other asset classes

Study	Period	Listed infrastructure	Equities	Bonds	Unlisted direct property
Peng/Newell (2007)	1995-2006	0.31	0.06	0.17	0.26
Newell/Peng/De Francesco (2011)	1995-2009	0.37	0.15	0.06	0.30
Finkenzeller/Dechant/Schäfers (2010)	1994-2009	0.29	0.27	-0.02	0.20
Hartigan/Prasad/De Francesco (2011)	1998-2008	0.22			0.51

Source: Own table, based on Peng/Newell (2007), p. 445; Newell/Peng/De Francesco (2011), p. 66; Finkenzeller/Dechant/Schäfers (2010), p. 267; Hartigan/Prasad/De Francesco (2011), p. 39.

In summary, based on the empirical findings, it can be confirmed that direct infrastructure assets have at least historically performed relatively well compared to other major asset classes. In general, they tend to provide stable and long-term cash flows, while they are also able to realize relatively high returns in combination with low volatilities and low correlation coefficients with other asset classes. In addition, the business models of infrastructure assets in general exhibit a relatively low level of systematic operating market risk as well as low marginal default rates. Furthermore, resulting from their long-term commitment, the generated cash flows offer the opportunity for narrowing the typical duration gap of insurance companies´ balance sheets,

[68] See Finkenzeller/Dechant/Schäfers (2010), p. 266.

which is generally preferred by the design of Solvency II. However, there are severe caveats considering the risk profiles of such assets. Due to the lack of data, the impact of the vast variety of risk sources cannot be generalized to hold for every kind of infrastructure asset in the same manner. The allocation of the several risk types found in the literature to the typical lifecycle stages of such assets shows that there is a time-variant risk profile which finally causes a different risk exposure for an investor according to the current point in time of the assets´ lifespan. The total riskiness of a direct infrastructure asset, therefore, must be properly assessed by insurance companies for each infrastructure asset among every lifecycle stage. Altogether, it can be confirmed that direct infrastructure assets tend to show several properties that are unique for this sub asset-class and that according to these characteristics, they seem to be an appropriate investment opportunity for long-term investors like insurance companies, especially in the context of the prevailing low interest rate period. Thus, the following chapter 3, and in particular the section 3.2, will shed some light on the question whether and to what extent the regulatory treatment under Solvency II reflects these special characteristics in a prudentially manner. For a thorough comprehension and assessment of the complex requirements currently imposed by Solvency II, the subsequent section provides the theoretical foundation of the European insurance industry´s regulation regime and its main properties.

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