Credit Risk Dynamics of Infrastructure Investment

Considerations for Financial Regulators

Andreas A. Jobst
Abstract

Prudential regulation of infrastructure investment plays an important role in creating an enabling environment for mobilizing long-term finance from institutional investors, such as insurance companies, and, thus, gives critical support to sustainable development. Infrastructure projects are asset-intensive and generate predictable and stable cash flows over the long term, with low correlation to other assets; hence they provide a natural match for insurers’ liabilities-driven investment strategies. The historical default experience of infrastructure debt suggests a “hump-shaped” credit risk profile, which converges to investment grade quality within a few years after financial close—supported by a consistently high recovery rate with limited cross-country variation in non-accrual events. However, the resilient credit performance of infrastructure—also in emerging market and developing economies—is not reflected in the standardized approaches for credit risk in most regulatory frameworks. Capital charges would decline significantly for a differentiated regulatory treatment of infrastructure debt as a separate asset class. Supplementary analysis suggests that also banks would benefit from greater differentiation, but only over shorter risk horizons, encouraging a more efficient allocation of capital by shifting the supply of long-term funding to insurers.

This paper is a product of the Office of the Managing Director and Chief Financial Officer of the World Bank Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at ajobst@worldbank.org.
Credit Risk Dynamics of Infrastructure Investment: 
Considerations for Financial Regulators

Andreas A. Jobst¹

_JEL Classification:_ G21, G22, G28

_Keywords:_ project finance, infrastructure, insurance regulation, banking regulation, Solvency II, Insurance Capital Standard, Basel III, solvency regime, credit risk

¹ Andreas (Andy) Jobst is Adviser to the Managing Director and Chief Financial Officer of the World Bank Group, 1818 H Street NW, Washington, DC, 20433, USA; e-mail: ajobst@worldbank.org. The copy-edited report based on this working paper is accessible at http://documents.worldbank.org/curated/en/606411522326750586/Credit-Risk-Dynamics-of-Infrastructure-Investment-Considerations-for-Financial-Regulators. I would like to thank Charles Cohen, Robert Cull, Joaquim Levy, Daniel Mayost, Paul McClure, Alvaro Enrique Pedraza Morales, Jordan Schwartz, Tomas Walter, Chunlan Wang, Peter Windsor, and Ivan Zelenko for their helpful comments and suggestions. The views expressed in this paper are those of the author and do not necessarily represent the views of the World Bank Group, its Executive Board, or management.
I. BACKGROUND

Most emerging market and developing economies (EMDEs) will require more private investment in infrastructure to boost capital expenditure. Investment growth in most EMDEs has fallen below the historical long-term average in recent years. The stock of public capital spending, a proxy for infrastructure, has declined significantly as a share of output over the past three decades. Developing countries would need to invest US$836.0 billion per year, or 6.1 percent of GDP, until 2020 to meet the new infrastructure demand and maintain the service level of existing assets (Ruiz-Núñez and Wei, 2015). Furthermore, the cost of providing infrastructure to support global economic growth and to start closing the gaps in infrastructure investment will be US$94.0 trillion by 2040 according to latest Global Infrastructure Outlook (Oxford Economics, 2017). In many countries, gaps in the quantity of infrastructure per capita are especially glaring. For example, power generation capacity per person is only one-fifth that of advanced economies. However, many countries often lack sufficient fiscal capacity and domestic savings to address the infrastructure gap (Schwartz and others, 2014).

Making infrastructure investment more attractive to long-term institutional investors, such as insurance companies, is a new thinking in development finance, which sees an essential role for private capital. Given the scale of resources needed to address the estimated gap in investment, much of this financing will have to be mobilized by the private sector; however, for infrastructure in EMDEs alone, the demand runs to hundreds of billions of dollars a year and outstrips the capacity for development assistance—the balance sheets of the 10 largest multilateral development banks (MDBs) combined amount to (only) $1.3 trillion. Thus, crowding-in private capital has become a critical paradigm shift in development finance in line with the Addis Ababa Action Agenda of the Third International Conference on Financing for Development (United Nations Department of Economic and Social Affairs, 2015). Engaging more private funding is now a priority for most MDBs, bilateral institutions and donor countries to foster sustained economic growth, social inclusion, and environmental protection in the effort of moving closer to the Sustainable Development Goals (SDGs) until 2030.

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2 This has been accompanied by anemic productivity growth, compounding risks that EMDEs will slow in narrowing their income gap with advanced economies.

3 At the same time, in many advanced economies, the quality of the existing infrastructure stock is deteriorating because of aging and insufficient maintenance.

4 Limited fiscal space due to budgetary constraints and rising debt levels in many countries has led to lower government spending on capital investment (including funding for new infrastructure projects and maintaining existing ones). However, if government borrowing costs are much lower than returns demanded by private investors in infrastructure, private sector performance in building and operating infrastructure would need to be superior to what the public sector can accomplish to at least offset any funding benefits and support a compelling argument for the mobilization of private capital. In other words, the avoidance of public deficits should not result in subsidies given to the private sector all else equal (Summers, 2016).

5 An increasing number of institutional investors, such as insurance companies, recognize the importance of sustainable investment strategies (according to environmental, social and governance (ESG) impact factors) and have begun to provide clear information about the potential benefits and risks, including the effect on prospective
Well-planned infrastructure can permanently raise potential output by boosting demand in the near term and supply in the long term (World Bank Group, 2017; Sutherland and others, 2009). Expanding infrastructure investment in essential services—either relating to physical flows in the real economy (i.e., transport, energy, broadband) or to social goods (i.e., education and healthcare)—is an effective way to (i) promote inclusive growth and (ii) foster local resilience to global shocks, especially in EMDEs. More investment spending increases demand for goods and services, and it creates jobs for both the construction and operation of infrastructure projects. The additional income/wages are then spent elsewhere. Over the longer term, enhanced infrastructure raises productive capacity through the supply effect of better roads, faster trains, bigger ports, more reliable energy generation, cleaner water, and broader coverage of telecommunication services. In particular, investment in sustainable infrastructure helps (i) finance the transition towards a low-carbon, more environmentally friendly economic model, notably in renewable energy and low-emission transport sectors, and (ii) enhances socio-economic resilience, helping countries be better prepared to prevent and/or mitigate the financial impact of natural disasters.

More cross-border capital flows from private long-term investors to infrastructure projects in EMDEs can also help address the imbalance between savings and investments that we see reflected in very low interest rates in advanced economies. According to some theories, interest rates may have remained very low because there is not enough aggregate demand, as aging populations lead to excess savings, and new technologies require less capital (Arezki and others, 2017). Interest rates are consistent with policyholders’ long-term obligations to policyholders. For instance, more than 80 institutions, including insurers representing approximately 15 percent of global premium income and US$9 trillion in assets under management (as of May 2015), have signed up to the Principles for Sustainable Insurance (PSI) under the United Nations Environment Programme’s Finance Initiative since 2012 (as part of the UNEP Inquiry into the Design of a Sustainable Financial System), whose Sustainable Insurance Forum serves as a global framework for the insurance industry to address ESG risks and opportunities. The PSI Initiative proposes a package of options that could help strengthen the alignment between the insurance industry and sustainable development through to 2030 (UNEP, 2015).

6 There are also significant growth benefits from investment in social infrastructure, such as education and healthcare, but these benefits accrue with a delay, and thus, are subject to political myopia and debt aversion. For instance, Atolia and others (2017) find that governments would still limit the fraction of additional public investment in schools to about a half even if they assume a large (15 percent) return differential in favor of schools relative to transport systems, such as roads. Accelerating growth outcomes from education mitigates myopia but at the expense of greater risks to fiscal and debt sustainability. Thus, investment in social infrastructure tied to concessional financing and grants can potentially mitigate the adverse effects of both political myopia and debt aversion.

7 Especially, “climate-smart” infrastructure helps reduce the carbon footprint of progress in EMDEs, which are likely to otherwise become more carbon-intensive as income levels and standards of living (more efficient, affordable services) rise with higher productivity (trade, energy). After all, infrastructure accounts, directly or indirectly, for more than half of all emissions. Thus, climate-smart infrastructure in green technologies reinforces the nationally determined contributions in reducing greenhouse gas emissions according to the 2015 United Nations Climate Change Conference (Levy, 2017a), which entered into force on November 4, 2016. See also Stein and others (2013).

8 Agarwal and others (2018) also demonstrate that infrastructure investment disproportionally benefits the poor and lowers inequality.
Directing excess private savings in advanced economies toward infrastructure in EMDEs that have high potential for productivity gains would not only complement limited domestic resources in these countries, but also create long-term income streams for pensioners in aging societies. By improving the economic outlook, such investment could also boost confidence and increase aggregate demand in investing countries over the near term, even if the direct benefits will emerge only in the future. Especially long-term funding from institutional investors might contribute to higher growth and lower macroeconomic volatility (Aghion, Howitt and Mayer, 2005). Long-term finance is critical for infrastructure projects, which by nature take many years to complete and require lumpy investment (Martinez Peria and Schmukler, 2016).

The prolonged low interest rate environment is particularly precarious for insurance companies (and other institutional investors) with long-term liabilities (see Appendix, Box A1). In a low-for-long scenario, the duration mismatch between assets and liabilities of life insurers widens and gradually erodes economic capital, particularly for firms offering products with long-term guaranteed rates, such as fixed annuities. Life insurers pursue a liability-driven investment strategy of reserves (which are pre-funded by premium payments from policyholders) to minimize the adverse impact of market risk, including future interest rate volatility; this entails finding fixed income products with cash flow characteristics to match cash outflows of liabilities. This match is so significant that most regulators allow insurers that hold assets to maturity to use the coupon interest as a discount rate for the duration-matched liabilities. However, with limited potential of real growth and interest rates to rise over the medium and longer terms, guaranteed rates of return are possible only if they are reset at significantly lower returns to prevent a widening duration gap. Thus, insurers have an incentive to generate returns on assets that exceed returns on liabilities in a sufficient amount to reduce the

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9 This imbalance would not be easily solved by higher public spending, even if countries had enough fiscal space. People would likely just save even more today rather than smoothing out consumption over time, especially if they did not have enough confidence in expected future income (Friedman, 1957).

10 In many EMDEs, structural obstacles, such as regulatory and political uncertainty, often prevent capital mobility from aligning with greater trade openness, which results in underinvestment as domestic capacity remains insufficient to satisfy capital demand.

11 Also sponsors of mature or closed defined-benefit pension plans tend to enter a period of low interest rates with higher funding gaps. However, not all insurers face this transitional challenge. For instance, non-life insurance companies tend to have a very short duration of liabilities, and their main source of income are profits from underwriting (rather than investment).

12 Long-term, guaranteed-payout businesses are especially vulnerable to declining interest rates since the negative duration gap increases the present value of long-term liabilities relative to the present value of assets. The duration gap widens as more investment of premium income and re-investment of maturing assets occur at prevailing low interest rates, which makes it increasingly difficult to find duration-matched risk-free investments that deliver the cash flow required by long-term liabilities. Thus, insurers respond, for example, by repricing or re-designing products to reflect these lower rates. Over time, this will lower the expected return on equity, which will raise the equity risk premium and make it costlier for them to attract capital and less attractive to invest in capital-intensive assets (IAIS, 2017a).
impact of duration mismatches on their long-term, guaranteed payout business. This may call for a shift in investment policies towards portfolio re-balancing with a heavier weight on higher-yielding, alternative asset classes to recover solvency margins.

### Table 1. Taxonomy of Instruments and Vehicles for Infrastructure Finance

| Asset Category | General Instrument | Project-specific | Entity-specific | Capital Pool |
|----------------|--------------------|------------------|----------------|-------------|
| Bonds          |                    |                  |                |             |
| Fixed Income   |                    | Project Bonds (incl. Green/Blue Bonds, Islamic Investment Securities (sukuk)) | Senior Corporate Debt Securities | Bond Indices, Bond Funds, Exchange-traded Funds (ETFs) |
|                | Municipal/Sub-sovereign Bonds |                | Subordinated Bonds |             |
|                | Structured Finance (Securitized Assets/Cash Flows) | Direct/Co-investment Lending to Infrastructure Projects (Project Loans), Syndicated Project Loans | Debt Funds (GPs) |             |
| Loans          |                    | Direct Co-investment Lending to Infrastructure Corporates | Syndicated Loans, Covered Bonds | Loan Indices, Loan Funds |
|                | Hybrid             | Subordinated Loans/Bonds, Mezzanine Finance | Subordinated Bonds, Convertible Bonds, Preferred Stock | Mezzanine Debt Funds (GPs), Hybrid Debt Funds |
| Mixed          |                    |                  |                |             |
| Equity         | Listed             | YieldCos 1/ | Listed Infrastructure and Utilities Stocks, Closed-end Funds, Real Estate Investment Trusts (REITs), Infrastructure Investment Trusts (ITFs), and Master Limited Partnerships (MLPs) | Listed Infrastructure Equity Funds, Indices, Trusts, ETFs |
|                | Unlisted           | Direct/Co-investment Lending to Infrastructure Project Equity, PPP | Direct/Co-investment in Infrastructure Corporate Equity | Unlisted Infrastructure Funds |

Source: OECD (2015a) and author.

Note: 1/ “YieldCos” is a company that is formed to own operating assets producing predictable cash flows, primarily through long-term contracts. Separating volatile activities (e.g., development, R&D, and construction) with uncertain cash flows from activities generating less volatile cash flows of operating assets can lower the overall cost of capital.

**Long-term fixed income instruments with resilient revenue streams fit well with the long-dated liabilities of insurance companies, especially those offering life insurance and annuity products.** Infrastructure projects tend to yield stable and predictable operational cash flows over the long term, with low correlation to other assets and relatively high recovery value in the event of repayment arrears, thereby providing a natural match to life insurers’ long-term liabilities. This match allows insurers to discount liabilities backed by infrastructure-linked instruments using the rates of return of such instruments, which are higher than the market-implied discount.

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13 There are also diversification benefits from infrastructure investment. Although observed correlations are dynamic and change significantly with market conditions and due to exogenous factors, infrastructure investment has relatively low correlation with other assets.

14 The appetite of banks as traditional lenders has fallen in recent years as they become warier of committing to long-term loans (which have become more expensive in capital terms).
rates of liquid assets, such as government bonds, often due to an “illiquidity premium.” Infrastructure finance can also be less risky than traditional asset classes and largely unaffected by economic or market fluctuations, especially when revenue risk is transferred through an offtake contract that mitigates exposure to price and/or demand risks. Such contractual certainty is particularly high in availability-based infrastructure finance, which occurs mostly in the context of public-private partnerships (PPPs). Credit risk is most often mitigated by the relatively high recovery in the event of repayment arrears and provides some protection against a changed market perception of default probabilities, hence resulting in low downgrade risk (see Table 1).

However, the amounts of investment in infrastructure remain relatively limited, considering the large pool of available capital. Saha and others (2018) find that institutional investors have largely avoided infrastructure assets in EMDEs and accounted for just 0.7 percent of private financing for infrastructure projects in low- and middle-income countries from 2011 through the first half of 2017 in 41 infrastructure projects tracked by the World Bank Group’s Private Participation in Infrastructure Database. Direct financing of infrastructure projects remains a small component of insurers’ investment portfolios, which allocate only about 2.5 percent of assets under management to infrastructure investment. This puzzle of under-investment despite capital availability suggests that structural constraints might deter insurers from investing in infrastructure (Blundell-Wignall and Roulet, 2015).

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15 However, in highly regulated (often monopolistic) industry sectors heavy government involvement in infrastructure projects can also lead to uncertainty about revenue streams if governments impose price controls and/or change price guarantees to steer commercial incentives.

16 Many infrastructure projects involve public sector support through fixed-term concession, economic regulation, and de-risking mechanisms (e.g., guarantees).

17 In its recent Investment Behavior Report, EIOPA (2017c) found that European insurers have been increasing their exposures to fixed income securities with lower credit rating quality and more illiquid investments, such as equity from private, non-exchange traded companies, participation in infrastructure projects as well as matching investments in new asset classes, such as infrastructure, mortgages, loans, and real estate.

18 The insurance sector in OECD countries has about $23 trillion of assets under management (about a quarter of global GDP).

19 Similarly, on average, only about one percent of pension funds are invested directly in infrastructure (OECD, 2015c).
Table 2. Challenges for Institutional Investors in Infrastructure Projects

| Government Policy and Enabling Environment—Infrastructure project development capacity and implementation are not aligned with the needs and expectations of investors, causing a lack of “bankable projects.” | Lack of sufficient “bankable” projects | There is a limited supply of well-prepared and well-structured infrastructure projects in EMDEs, especially in the operational phase, which are more attractive to risk adverse institutional investors due to more predictable revenue streams with lower repayment uncertainty. Thus, institutional investors have little incentive to allocate the amount of resources necessary for them to assess possible investment opportunities. Typically project-related risks and returns, even in the same sector, vary differently from country to country (particularly in EMDEs) which often requires specialized and country dedicated teams. Complexity below. The lack of sufficient “bankable” projects also inhibits the extent to which project-related risks can be elevated to a portfolio perspective, as a precondition for infrastructure evolving into a separate asset class. This would facilitate pooling and structuring of projects to reduce transaction costs and could help generate financial instruments with attribution benefits based on specific risk characteristics of infrastructure projects. |
|---|---|---|
| Low risk-adjusted return | Infrastructure assets involve project-specific risks, which are often amplified by political, legal and currency risks in EMDEs. Therefore, investors often require a minimum return to consider taking on such risks. However, investment returns on many infrastructure investments in EMDEs are relatively low, even if the favorable credit performance was considered. Low yields have been driven by several factors, including the limited pipeline of “bankable” projects (which has led to aggressive bidding by investors) and the fact that, in many markets, there is still a large pool of commercial bank funding available for projects on long tenors and low maturities. |
| Negative historical experience | In some cases, the apparent lack of sufficient demand might be partially informed by an idealized view of favorable risk characteristics. The first generation of infrastructure investment products did not cater well to institutional investor needs, and there were cases of investment in projects with poor returns and little economic value (even in advanced economies). Pension funds and other institutional investors suffered losses due to exaggerated demand expectations and financial leverage (e.g., Eurotunnel or the Cross-City Tunnel in Sydney). |
| Complexity—Considerable variation of profit and risk drivers across different infrastructure assets and countries leads to weak investor confidence. | Limited resources and information | Investors may lack the resources for specialized infrastructure teams that will most likely be needed to address the idiosyncratic nature of many risk factors affecting the credit performance of infrastructure and/or only have limited information when committing to infrastructure investments. The amount and accessibility of information about projects also depends on the type of funding and the security design (if applicable); for example, in the case of infrastructure debt, information is easier to provide under loan structures than publicly-listed bond issues. This information hurdle might create investors’ perception of infrastructure being risky due to greater valuation uncertainty, and, thus, deter them from exploring such long-term investment decisions in their strategic asset-allocation decisions—despite high repayment capacity of regulated utilities and projects with availability-based revenues (often in the context of PPPs). A knowledge deficit also perpetuates the prevailing regulatory treatment of infrastructure finance as a form of corporate finance—even though anecdotal evidence suggests that infrastructure investment can be less risky than traditional asset classes, especially over the medium and longer term in light of the generally flattening term structure of marginal default risk and higher recovery rates (see Regulatory Treatment and Risk Appetite below). |
| Challenges due to the inherent nature of infrastructure projects | Infrastructure investments involve a multitude of risks depending on the industry sector and geography of individual projects as well as their funding structure. Institutional investors have a general preference for revenue visibility and certainty. The construction phase of new (pre-operational) infrastructure projects typically does not yield returns (i.e., there are no regular payoffs for three to five years) and/or entails cash flow uncertainty, which is often well beyond the traditional fixed income risk appetite and the mandate of many institutional investors. In contrast, fully operational underlying assets in secondary phase projects provide greater stability of returns and potentially simpler operational management, which is more attractive to risk adverse investors. During the entire project life-cycle, infrastructure investments tend to (i) lack make-whole provisions or early repayment or refinancing by the borrower and (ii) have relatively restrictive/unclear investment exit strategies (e.g., no equity investment during the construction phase plus a few years into operation, unclear/potentially difficult exit via debt refinancing, and no rating of the borrower’s special purpose. |

**Regulatory Treatment and Risk Appetite**—Regulatory and statutory requirements for infrastructure-related exposures (equity, debt, derivatives) can discourage investment.

| Differing mandates and lower risk appetite of institutional investors | Institutional investors (pension plans, sovereign wealth funds, and insurance companies) are very different in terms of governance structures, applicability of financial regulations, return expectations, risk appetite, and portfolio diversification targets. These requirements may not be designed to support infrastructure investments. Furthermore, institutional investors tend to be risk averse and limited in their capacity to manage multiple risks, which creates a natural bias for investments in advanced economies. Unlike banks with local intermediaries, institutional investors would have to bear currency risk, which are generally higher in EMDEs. They also tend to prefer fully operational projects (“brownfield”) with established revenue streams, which helps them avoid carrying costs from operational delays and construction risks of pre-operational projects (“greenfield”); however, EMDEs have less-developed markets for investing in existing assets (many of which are managed by the public sector through state-owned enterprises). |

| Financial regulation and capital requirements | The financial regulation of infrastructure investment is evolving. For instance, insurance regulations (except for the Solvency II Directive for European insurance companies), infrastructure debt is generally treated like any other type of long-term exposure, which results in a relatively high capital charge. This would reduce incentives for insurance companies to invest in infrastructure as an expedient way to achieve asset-liability matching in a low-rate environment. It could also weaken the effectiveness of mobilizing resources from the private sector—as both financiers and implementer for commercially viable infrastructure investments. |

Source: Baha and others (2018) and author.

Note: “Y” with house on projects in emerging market and developing economies (EMDEs).
The generally accepted view of the beneficial risk profile of infrastructure would need to be balanced against structural hurdles that can undermine the successful deployment of funding. There are many reasons for this low participation of infrastructure, including the limited supply of fully operational infrastructure projects issuing debt. Often the risk appetite of institutional investors does not match the realities of the supply of infrastructure opportunities in EMDEs. Revenue visibility and certainty is one of the key considerations for institutional investors; thus, they generally prefer projects that either (i) entail renovating existing infrastructure assets or (ii) have an established performance track record and no construction and operational delay risks. Therefore, it is important to identify and understand potential market failures and regulatory barriers that may be contributing to current under-investment (see Figure 1 and Table 2):

- **Infrastructure investments can be highly complex (and involve a multitude of risks).** The way the project is financed is often the key differentiator as to who performs the ongoing management. Infrastructure investments, with their long-time horizon and an undeveloped secondary market, tend to be illiquid and, therefore, present a different risk profile in comparison with the broader asset classes. Risk varies depending on the industry sector and geography of individual projects, as well as how their financing is structured. Infrastructure projects focusing on the construction phase pose a greater risk

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20 Table 2 summarizes the main challenges of institutional investors, which have been discouraged from funding infrastructure in EMDEs due to the lack of “bankable” projects, challenges due to the inherent nature of infrastructure projects as well as the high risk and low returns associated with investing in developing countries. See also OECD (2014).

21 Institutional investors also show increasing risk-taking in “greenfield,” or new, projects in the energy sector (as opposed to transportation, water, or information and communications technology); this is partly explained by the fact that the construction period, which is typically associated with elevated default risk, tends to be shorter in the energy sector (ranging between 18 to 36 months). Investment in other sectors, such as transport, often occurs after construction, during the “brownfield” phase, where greater certainty of revenue streams and stability of the regulatory environment help avoid the carrying costs arising from a gradual draw-down of the debt portion during the construction period (Saha and others, 2018).

22 The global financial crisis illustrated that some infrastructure investments proved to be quite volatile, with much lower-than-predicted cash flows and higher correlation with asset markets (Bianchi and Drew, 2014).
in terms of cash flow uncertainty and can be difficult to manage.\textsuperscript{23} In contrast, fully operational projects provide greater stability of returns and potentially simpler operational management, which are more attractive to risk adverse investors. Fully operational underlying assets, but their supply is limited.\textsuperscript{24} They also offer greater cash flow certainty and, thus, the potential to satisfy insurers’ matching adjustment criteria.

- **Investors may have only limited information when committing to infrastructure investments.** This informational hurdle might create investors’ perception of infrastructure being risky, despite the long tradition of regulated utilities of yielding low-risk cash flows. The amount and accessibility of information about projects may also depend on the format of the debt—for example, information is easier to provide under loan structures than publicly-listed bond issues. High-quality data about any specific infrastructure project must be readily available, accessible and standardized for an adequate assessment of risks, paired with sufficient expert knowledge—not only of the financial instrument, but also for the underlying project (Gründl and others, 2016).

- **The financial regulation of infrastructure investment is evolving.** The risk characteristics of project finance, which is a crucial source of funding infrastructure, have yet to be reflected comprehensively and consistently in most solvency regimes. In insurance regulations, infrastructure debt is generally treated like any other type of long-term exposure, which results in a relatively high capital charge—even though anecdotal evidence suggests that infrastructure investment can be less risky than traditional asset classes, especially over the medium and longer terms). This would reduce incentives for insurance companies to invest in infrastructure as an expedient way to achieve asset-liability matching in a low-rate environment. It could also weaken the effectiveness of mobilizing resources from the private sector—as both financier and implementer for commercially viable infrastructure investments—in the broader and more systematic way that could have transformational impact on the infrastructure gap in many EMDEs.

**Creating an enabling regulatory environment for infrastructure investment is fundamental to mobilizing long-term finance.** While low investment in infrastructure to date has not primarily been the result of regulatory barriers, differences in aggregate risk characteristics would need to be reflected in the prudential treatment of infrastructure while recognizing the wide range of risk factors determining its credit performance. In addition, regulatory constraints might become more binding (and have greater impact on individual investment decisions) as (i) capital becomes more expensive in response to rising interest rates and (ii) demand for

\textsuperscript{23} However, infrastructure investments should provide an illiquidity premium enhancing its appeal to investors.

\textsuperscript{24} Insurers have traditionally focused on the cash-generating secondary phase (“brownfield”) while private equity firms (or similar investors) would provide financing for the riskier primary phase (“greenfield”). However, limited supply of these secondary phase assets has led insurers to explore more complex and risky primary phase and/or equity-based infrastructure investment with potentially more lucrative returns. While these investments are attractive for participating insurance products or unit-linked funds, they also increase the ambiguity in the timing and/or amount of expected cash flows, and the complexity of borrower options.
infrastructure investment increases, especially if project development capacity limits the availability of “high quality project finance” that is most amenable to regulatory differentiation (see Appendix, Glossary). Insufficient nuance in the calibration of capital charges could inhibit the broadening of participation in infrastructure finance to a wider range of insurance companies that rely on the proportionality of standardized approaches, including smaller insurers, which might lack internal models for assessing the credit risk profile of infrastructure exposures.

Until recently, insurance regulations have not focused on infrastructure investments as a distinct asset class (see Appendix, Box A3). Data constraints have so far limited the scope of possible differentiation of infrastructure debt as distinct asset class in standardized approaches. Risk-based solvency regimes in many countries still require insurance companies to allocate sizeable amounts of capital to cover unexpected losses from credit risk of long-term debt investments, and especially for unrated exposures, such as project loans (see Table 1). Regulatory capital charges reduce the internal rate of return and the profitability of holding these investments. If they are not fully aligned with actual credit performance, for instance, due to insufficient empirical data to motivate closer calibration, expected returns may not compensate for higher capital charges (in comparison to other investments). This may restrict capital-efficient investment to certain asset classes or risk categories within the spectrum of fixed income instruments (Becker and Ivashina, 2015), including alternative investments, such as infrastructure debt, and explain why the search for yield has been moderate in the insurance sector (IMF, 2016). In addition, regulatory reforms in the banking sector have had a significant impact on infrastructure finance, especially in EMDEs, where project finance is a crucial source of funding, and where financial systems are less diversified (see Appendix, Box A2).

In this paper, we explore the possibility of a differentiated regulatory treatment under two important solvency regimes for insurance companies—the European Solvency II Directive and the Insurance Capital Standard (ICS), supplemented with similar analysis for the capital assessment of project finance in the Basel III framework for banks. The analysis of new data on the credit dynamics of infrastructure debt securities and project loans offers an opportunity to differentiate their risk profile from that of corporate exposures underpinning existing standardized approaches in these solvency regimes. Establishing a consistent

25 There might be indirect effects of post-crisis financial regulatory reforms that may have affected infrastructure investment outside its germane credit risk properties, such as the rising cost of hedging due to higher capital requirements for derivatives transactions or the treatment of unsecured lending by banks affecting market competition for project funding.

26 A stringent regulatory treatment and its adverse effect the cost or provision of commercial financing sources and instruments could also limit the ability of development organizations to crowd-in insurance companies as both financier and underwriter for commercially viable infrastructure investments, especially in EMDEs.

27 The differentiation would reflect the divergent risk profiles of corporate and infrastructure debt, which warrant a review of the proportionality of standardized approaches. In this paper, the flexible treatment of downgrade risk and the use of an economic capital model help address the limitations in existing prudential methodologies, which approximate the term structure of credit spreads through a linear positive function of maturity as in traditional credit risk models (“maturity adjustment”).
regulatory treatment could encourage greater demand for infrastructure investment by insurance companies. The asset-heavy capital intensity, low-to-manageable operating risk, and the long-term importance of infrastructure services support a favorable credit performance (despite usually higher leverage in project finance than similarly rated non-financial corporates issuing debt). Based on the implied default and recovery rates, we calculate differentiated capital charges. The calibration approach preserves the integrity of existing prudential methodologies but relies on the actual credit performance that would otherwise be used for the specification of internal capital models to assess the proportionality of existing standardized approaches. We find that the declining downgrade risk of infrastructure debt—together with a high recovery rate (comparable to that of senior secured corporate loans)—would significantly reduce capital charges if infrastructure were recognized as a separate asset class as new empirical evidence becomes available. This could potentially free up capital of institutional investors, mobilizing resources to finance infrastructure, and thus promoting development. However, the capital impact of a differentiated regulatory treatment varies significantly depending on the extent to which current regulatory methodologies can accommodate the distinctive risk profile of infrastructure debt.

Supplementary analysis suggests that greater differentiation for capital charges required by banks would encourage a more efficient allocation of capital by shifting the supply of long-term funding to insurers. While the potential reduction of capital charges for insurers increases with the maturity of investment (up to 65 percent, depending on the risk horizon and credit rating (for infrastructure debt securities)), banks benefit from a more differentiated regulatory treatment but only over shorter risk horizons. The potential capital reduction (of up to about 50 percent) declines with the maturity of investment, partially because the diminishing marginal default risk of infrastructure debt over time cannot be approximated by a linear positive function of amortization in the current specification of internal model-based (IRB) approaches. These findings respond to rising investor demand for a clear infrastructure asset classification being embedded in regulatory frameworks. Prudential assessments can be an important element in developing an efficient market for re-orienting capital towards critical infrastructure. A better understanding of the aggregate credit performance over time helps

28 The marginal default rates improve steadily over time and reach investment grade level less than five years after origination (resulting in 10-year cumulative default rates just below investment grade), with recovery rates of about 75 percent. Thus, there seems to be a non-linear relationship between remaining maturity and credit risk (which results in a “hump-shaped” term structure of the cumulative default probability).

29 We reviewed the aggregate credit performance data of more than 6,000 projects from a consortium of leading sector lenders (Moody’s Analytics Data Alliance Project Finance Consortium), of which more than 1,000 loans financed infrastructure projects in EMDEs, and Moody’s-rated infrastructure debt securities issued by 1,000 corporate infrastructure and project finance entities over a study period between 1983 and 2015. We use these data on the credit performance to improve the estimates of required capital charges using various credit risk models to achieve greater proportionality of standardized approaches.

30 For instance, the capital charge for project loans in the pre-operational phase with a maturity of only one year would decline by more than 60 percent (see Box 2).
elevate the credit risk analysis of infrastructure investment from a project-specific to a portfolio perspective, as a precondition for infrastructure evolving into a separate asset class. This would facilitate pooling and structuring of projects to reduce transaction costs (Golnaraghi, 2017).

The favorable credit performance of infrastructure debt supports the objective of post-crisis regulatory reforms to encourage a long-term investment perspective. The regulatory recognition of the “hump-shaped” credit risk profile of infrastructure projects engenders a complementary “maturity preference” by banks and institutional investors, such as insurance companies, which better aligns with the maturity term of funding. Greater regulatory differentiation of infrastructure finance is likely to shift demand for operational (“brownfield”) projects with revenue visibility away from banks to insurance companies, whose balance sheet structure is more amenable to the stable funding of long-term investments, with a focus on duration-matching rather than maturity and/or liquidity transformation. A differentiated regulatory treatment would encourage a more efficient use of capital for infrastructure finance, with bank lending covering the riskier initial construction phase of infrastructure projects (“greenfield”) while insurers would be ideally suited as financier of projects in the operational phase by re-financing bank loans (or providing continued funding after expiration of short-dated bank loans).

The potential impact of financial regulation on infrastructure finance contributes to the current policy debate on creating an enabling environment for infrastructure investment.31 The focus of the current G20 policy agenda on climate sustainability is squarely placed on mobilizing private resources to reduce the infrastructure gap and develop resilient infrastructure that facilitates adaptation to climate change and extreme weather events.32 Attracting sufficient capital from long-term institutional investors, many of which are regulated entities, requires a close examination of structural barriers to investment, including gaps in existing regulatory frameworks. In addition, the Financial Stability Board (FSB), at its Plenary meeting in October 2017, agreed to examine the trends in infrastructure finance (including, to the extent possible, the effects of regulatory reforms on this financing) as part of its broader framework for post-

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31 Note that establishing infrastructure finance as a separate asset class also requires adequate securities market regulations if debt claims are commoditized. See Carvajal and others (2017) for an overview of key regulatory issues that could affect the issuance of debt instruments for infrastructure financing, with a focus on placement regime, disclosure obligations and control issues in financing structures.

32 In the Overview of Argentina’s G20 Presidency, this is stated in “We will seek to develop infrastructure as an asset class by improving project preparation, addressing data gaps on their financial performance, improving the instruments designed to fund infrastructure projects, and seeking greater homogeneity among them. […] Developing infrastructure as an asset class holds great promise to channel the savings of today into public infrastructure, efficient transportation services, basic sanitation, energy flows and digital connectivity that will make each person of today a global citizen and worker of tomorrow (Macri, 2017).”

33 At the October 2017 Plenary meeting, FSB members approved a second evaluation under the Framework for Post-Implementation Evaluation of the Effects of the G20 Financial Regulatory Reforms. This evaluation will examine the effects of the G20 financial regulatory reforms on financial intermediation, with a specific focus on financing of infrastructure investment during 2018.
implementation evaluation of the G20 financial regulatory reforms. The FSB is due to report its findings at the next G20 Summit, in Buenos Aires in November 2018 (FSB, 2017b).

The paper is organized as follows. Section II explains the methodology, which comprises the extraction of relevant credit risk parameters and the calibration of capital charges under a differentiated regulatory treatment of infrastructure debt. Section III discusses the main findings for important solvency regimes, including a summary of credit risk profile of projects loans in EMDEs together with supplementary results for project lending under Basel IV. Section IV offers conclusions.

II. METHODOLOGY

The analytical framework for deriving a differentiated capital charge for infrastructure investment follows a three-step process. The calibration uses the historical default experience of infrastructure debt securities and project loans to assess whether their actual credit dynamics (which would otherwise be used for the specification of internal capital models) warrant a lower capital charge under standardized approaches of two important solvency regimes for insurance companies—Solvency II Directive for European insurers and the forthcoming Insurance Capital Standard (ICS) for internationally active insurance groups (IAIGs). We only consider the intrinsic risk profile of infrastructure debt vis-à-vis the standard risk assumptions on long-term debt, without adjustments to existing prudential approaches. Between 2013 and 2015, EIOPA (2013a, 2013b, 2015a and 2015b) completed a similar calibration exercise when it provided guidance to the European Commission on a reduced capital charge for infrastructure exposures in the European Economic Area (EEA) and OECD countries (see Appendix, Box A3). We revisit this approach in the context of Solvency II but widen the technical scope to additional credit risk models consistent with the requirements of ICS and an economic capital model for

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34 The focus of the framework is “on post-implementation evaluation; that is, evaluating the effects of G20 financial regulatory reforms for which implementation is well underway or completed. In particular, the core reform areas to which the framework is applied are: (i) making financial institutions more resilient; (ii) ending ‘‘too-big-to-fail’’; (iii) making derivatives markets safer; and (iv) transforming shadow banking into resilient market-based finance. The framework can be applied both to individual reforms, as well as to cross-sectoral and cross-cutting issues stemming from the interaction and combined effects of those reforms, on key aspects relating to the functioning of the global financial system (FSB, 2017a).”

35 See also FSB (2014) regarding the impact on long-term finance.

36 These data were obtained from recent studies published by Moody’s Investors Service (2016b, 2017c, 2017d, 2017e and 2017g).

37 The exercises covered investments in infrastructure project bonds, loans and equity (both directly and via funds), and resulted in a small reduction of the spread risk solvency capital requirement for “qualified infrastructure investment” (see http://europa.eu/rapid/press-release_MEMO-15-5734_en.htm). Infrastructure corporates were excluded due to the lack of comprehensive and publicly available performance data for unlisted infrastructure assets. This represents not only an obstacle for regulators but also for insurers as potential investors in infrastructure.
cross-validation. Our analysis is supplemented with similar analyses for related provisions applicable to project lending under the finalized Basel III framework for banks (BCBS, 2017).

- **First, we determine the credit risk dynamics of project loans, infrastructure debt securities, and related asset classes.** For this purpose, we derive the main credit risk parameters from the historical credit performance of infrastructure debt securities and unrated project loans in both advanced and developing economies. The focus of the paper is on project loans but additional information on infrastructure debt securities was used to cover a wider spectrum of rated infrastructure debt. The data analysis relies largely on the findings from recent studies by Moody’s Investors Service (2017c, 2017e and 2017g) on the historical default experience of infrastructure debt over a study period between 1983 and 2015.39 The empirical risk profile is determined by (i) the number of impaired loans/obligors during a given time period40 and (ii) the extent to which their notional amounts have been recovered through debt enforcement and insolvency proceedings (after emergence from default (see Appendix, Glossary). The change in credit risk dynamics—in terms of marginal default rate and ultimate recovery41—is analyzed over

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38 Given that our approach is closely aligned with the capital assessment of unexpected losses from credit risk under the Basel III framework, we complete a similar albeit less detailed analysis for commercial banks.

39 The scope of EMDEs is defined by country-specific income groups as defined in the World Development Indicators database (World Bank, 2017; see also Appendix, Glossary). The dataset is decomposed into three main sample subsets: (i) advanced economies (i.e., “OECD or EEA”), comprising projects located in high income countries that are members of either EEA or OECD, and (ii) EMDEs that are not categorized as high income (“EMDE-A”). In addition, countries that are members of either OECD and EEA are excluded from the latter sample to form a control sample (“EMDE-B”). We also combine the observations for all three sub-samples (“all sub-samples”). See Box 1 for more details on the dataset and credit risk parameters, which serve as inputs to this calibration exercise.

40 The definition of default underpinning the calculation of default rates used in this paper is based on the Basel II/III framework (BCBS, 2017; see also Appendix, Glossary), which captures a wide range of defaults (beyond the scope of Moody’s definition of default), including circumstances in which the reporting bank considers that the obligor is unlikely to pay its credit obligations in full. For example, debt obligations are considered defaulted if they are put on non-accrued status or the bank makes a charge-off (or account-specific provision) resulting from a significant perceived decline in credit quality. While the default of a single project finance debt facility occurs at the instrument level, the default rates based on the number of projects for which at least one senior secured project finance bank loan has defaulted.

41 The ultimate recovery rate used in this analysis (see Appendix, Glossary) is determined for each senior secured project finance debt facility consistent with the definition in the Basel III framework (BCBS, 2017) and is not based on the assumption that all senior secured project finance debt facilities share the same ultimate recovery rate (which is also used by Moody’s Investors Service). However, there is only a minimal difference between recovery rates at a project level basis and a facility level basis. According to Moody’s Investors Service (2018), the average ultimate recovery rate calculated on a project level basis and a facility level basis was 79.3 and 80.8 percent, respectively, for all project loans registered with the Moody’s Analytics Data Alliance Project Finance Consortium over a study period between 1983 and 2016. Note, however, that there is a significant difference between ultimate recovery rates and the valuation of distressed sales, which is based on 30-day post-default trading prices. In this case, the average ultimate recovery rate calculated on a project level basis and on a facility level basis was 50.5 percent and 58.9 percent, respectively.
time and across different industry sectors and countries/regions, based on two main data samples:

- **For project loans**, the dataset comprises 6,389 projects accounting for approximately 62 percent of all project finance transactions originated globally between 1983 and 2015 (see Figure 2); the data was obtained from a consortium of project finance lenders and investors (see Box 1).\(^{42,43}\) The study also includes results for subsets of projects originated over a curtailed study period between 1995 and 2015, which more closely aligns with the period over which EMDEs have become a distinct market sector of focus for investors, and, thus, forms the main empirical basis for our analysis.\(^{44}\)

- **For infrastructure debt securities**, the analysis uses the relevant portfolio-based credit risk parameters from Moody’s-rated infrastructure\(^{45}\) debt securities issued by 1,000 corporate infrastructure and project finance entities from around the world as well as 1,600 U.S. municipal obligors over the same study period (Moody’s Investors Service, 2016b and 2017e).\(^{46,47}\)

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\(^{42}\) Note that project loans represent 80 percent of funding volume for infrastructure worldwide.

\(^{43}\) Shortening the study period also removes the composition effect of clustered defaults between 1983 and 1994 period attributable to a disproportionately small number of projects (281, or less than 5 percent of total loans).

\(^{44}\) Principal amongst the finance channels for infrastructure are project bonds and sub-sovereign issues in bond markets, loans and direct lending in non-public markets, and direct/co-investments in project equity.

\(^{45}\) In this context, the term “infrastructure” is used in a broad sense and includes securities issued by both public and private issuers (operating companies and projects) that provide large and capital-intensive assets underpinning economic activity.

\(^{46}\) This amounts to a total volume of $2.7 trillion, of which most infrastructure debt securities are concentrated in North America. Issuers in EMDEs accounted for 9 percent of the count of total infrastructure debt securities but 26 percent of issuance by volume. Given that the sample share of infrastructure debt securities in EMDEs (Moody’s Investors Service, 2017d) is smaller than that of project loans, which make up about 20 percent of the sample (Moody’s Investors Service, 2017c and 2017g), the overall findings (which are referenced as “global” sample throughout the paper) for infrastructure debt securities are more applicable to advanced economies than EMDEs.

\(^{47}\) The credit risk analysis of non-infrastructure exposures (corporate loans and non-financial corporate debt) (Moody’s Investors Service, 2016a, 2017b and 2017d) was included in our analysis for cross-validation and performance benchmarking.
Second, we estimate the time-varying distribution of expected losses. The combination of default and recovery rates for infrastructure debt securities and project loans (and all other assets classes) over different risk horizons provides an approximation of expected losses. These expected losses inform the estimated amount of economic capital to cover the tail risk of unexpected losses. We use an empirically-fitted generalized extreme value (GEV) distribution (Jobst, 2007 and 2014) to derive a conditional tail expectation (CTE) of unexpected losses at a desired level of statistical confidence to derive the required capital charge consistent with the existing prudential standards (see Appendix, Technical Description, Section C).

Third, we determine the capital charge under the Solvency II Directive and the forthcoming Insurance Capital Standard (ICS). The capital charges were derived from the historical default experience (i.e., default rates, implied transition probabilities and recovery rates) of infrastructure debt securities and project loans by (i) mapping expected losses to current reduction factors for qualifying (unrated) infrastructure investment for EEA and OECD countries (in the case of Solvency II), and (ii) calibrating the credit risk factors to expected losses by adapting the Vasiček (2002) model and the advanced internal ratings-based (A-IRB) approach of the finalized Basel III framework (BCBS, 2017) (in the case of the ICS). We differentiate the properties of infrastructure debt from those of standard corporate exposures without adjustments to existing regulatory methodologies. For the latter, we acknowledge that the diminishing marginal default risk of project finance implies that the term structure of cumulative default risk cannot be

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48 The CTE is defined as the residual density beyond a pre-specified probabilistic threshold.

49 The ICS has been developed by the International Association of Insurance Supervisors (IAIS) and is scheduled to come into force after 2019.
approximated by a linear positive function of amortization. However, the non-linear relationship between the remaining maturity and credit risk is not adequately reflected in the linear maturity adjustment of the IRB formula. Therefore, the calibration is completed with a flexible maturity adjustment and endogenizes non-linear adjustment to the capital charge in both the adapted Vasiček (2002) and economic capital models. More specifically, our approach for differentiated regulatory treatment under the two solvency regimes is as follows:

- **Solvency II**—We closely follow the existing calibration of reduced risk factors underlying the amended capital charge for qualifying infrastructure investments in EEA and OECD countries in the *Spread Risk Sub-Module of the Standard Formula* (European Commission, 2017) (see Appendix Figure 22).\(^{50}\) Given the lack of market prices, we adopt the “simplified calculation of the capital requirement for spread risk” (EIOPA, 2014, p. 23) assuming that product of the duration and a risk factor dependent on the credit quality is a prudent approximation for spread risk; thus, we infer the spread risk charge from observable credit risk (EIOPA, 2013a, 2013b and 2015a). We map expected losses of unrated project loans to the general elasticity of the reduced risk factors against the expected losses of non-financial corporate debt over different time horizons (see Appendix, Technical Description, Section A).\(^{51}\) We then cross-validate the current treatment of infrastructure investment under Solvency II with the potential treatment for investments in EMDEs, using the same methodology and empirical specification.

- **Insurance Capital Standard (ICS)**—We replicate the asymptotic single factor model (Vasiček, 2002; see Appendix, Technical Description, Section B.2)\(^{52}\) underlying the current specification of the credit risk factor (see Appendix Figure 23), which includes the risk of credit deterioration separate from default (IAIS, 2017b). Given that the recovery rate is fixed under this approach, it is conceptually consistent with the *foundation internal ratings-based* (F-IRB) approach in the finalized Basel III framework (BCBS, 2017).\(^{53}\)

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\(^{50}\) According to the *Solvency Capital Requirement (SCR) Spread Risk Sub-Module* for fixed income investment as stipulated in EU Regulation 2015/35 (European Commission, 2015) on January 17, 2015, and amended by EU Regulation 2016/467 (European Commission, 2016) on April 2, 2016 (regarding the definition of “qualifying infrastructure investment,” which was refined in EU Regulation 2017/1542 (European Commission, 2017) on September 14, 2017 regarding the calculation of capital requirements for “qualifying infrastructure corporates.”

\(^{51}\) The risk factors for rated infrastructure debt are determined consistent with the difference in risk factors between rated and unrated qualifying infrastructure in EEA and OECD member countries.

\(^{52}\) The IAIS has used this approach for calibrating the credit risk stress factors for corporate exposures as part of the field testing of the “ICS Version 1.0” (IAIS, 2017b), and is based on the parametrization of the IRB approach under Basel III.

\(^{53}\) Most prudential standards of risk-based solvency regimes require (re)insurance companies to hold sufficient capital to cover expected losses at a certain level of statistical confidence over a given time horizon. The SCR under
capital charges at a statistical confidence level of 99.5 percent over a one-year risk horizon (which corresponds to the credit risk sensitivity of both ICS and Solvency II). For comparison, we also determine the capital charge following the A-IRB approach for specialized lending (project finance) under Basel III at statistical confidence levels of 99.5 and 99.9 percent, with and without maturity adjustment and prudential floors applied to both default and recovery rates (see Appendix, Technical Description, Section B.1). This extends our analysis to a potentially differentiated regulatory treatment under the standardized Basel III approach, which currently applies only to “high quality project finance.”

- **Solvency II vs. ICS**—The capital charges for spread risk under Solvency II and credit risk under ICS are not comparable (see Appendix Figures 22 and 23). In former, the prudential risk factors of the standard formula for spread risk are calibrated to the valuation impact of a spread increase consistent with a 1-in-200-years event (i.e., at the 99.5th percentile of the historical distribution of annualized log returns), depending on the rating and duration of investment. Downgrades and default risk are not explicitly covered (EIOPA, 2014). Instead, both risks are addressed implicitly in the calibration of the factors of movements in credit spreads. In contrast, the credit risk stress factor in the ICS (in the current application of the adapted Vasiček (2002) model) is explicit and specified as the combined valuation effect of the one-year default probability (at the 99.5th percentile), after accounting for the recovery rate, and the downgrade risk implied by unexpected losses over the residual maturity of investment.

**The calibration of the capital charge for infrastructure debt is based on a reduced form credit risk approach and does not include a structural model for the various risk components.** The credit performance of infrastructure debt securities and project loans is influenced by a wide range of structural factors, including risk sharing and allocation mechanism governing price/demand risk (including the impact of concessions), counterparty credit or performance risk, currency risk, and legal/political risk depending on the type of infrastructure, the stage of project completion/operation, and contractual features (see Table 2 and Appendix, Box A4). The project structure needs to be transparent on risks that are either managed by

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Solvency II is based on a *Value-at-Risk* (VaR) measure calibrated to a 99.5 percent confidence level over a one-year time horizon (which is equivalent to a CTE of about 98.7 percent).

54 Performing the same estimation – albeit at different levels of statistical confidence – provides the basis for comparing the differences in capital intensity of infrastructure investment by both insurance companies and banks.

55 The factors also implicitly address not only the change in the level of credit spreads, but also the shape of the term structure for the level of spreads.

56 This requires dedicated risk mitigation instruments that reduce political and regulatory risks. Unexpected regulatory changes can result in pricing/tariff changes or repudiation of concessions and agreements, affecting cash flows and resulting in deadweight losses to investors.
contractual provisions or absorbed by investors in return for a commensurate premium, which gets priced into the term structure of credit spreads (Wang and Sundararajan, 2016). Box 1 provides a short overview of the historical credit performance of infrastructure debt together with explanations of the main reasons for default.

Box 1. Summary of Moody’s Report on the Credit Performance of Project Loans in EMDEs

On December 13, 2017, Moody’s Investor Service (2017e) published a detailed analysis of the historical credit performance of project loans drawn from an aggregate data repository supported by a consortium of participants in the project finance market segment (Moody’s Analytics Data Alliance Project Finance Consortium) over a study period of more than 30 years (January 1, 1983—December 31, 2015), comparing projects located in advanced economies with projects located in emerging market and developing economies (EMDEs), across all infrastructure business types (production/transformation, capacity provision, distribution, and services (see Appendix Table 1)). This analysis complemented the annual study of default and recovery rates for unrated project loans, which they published in March 2017 (Moody’s Investor Service, 2017c).

The dataset is decomposed into three main sample subsets based on country-specific income groups as defined by the World Bank Group (World Bank, 2017; see Appendix, Glossary): (i) advanced economies (i.e., “OECD or EEA”), comprising projects located in high-income countries that are members of either EEA or OECD, and (ii) EMDEs that are not categorized as high income (“EMDE-A”). In addition, countries that are members of either OECD and EEA are excluded from the latter sample to form a control sample (“EMDE-B”). The study also presents the results for the credit performance of three other samples: (i) projects located in EEA countries only (“EEA”), (ii) the combination of both “OECD or EEA” and “EMDE-B” samples (“all subsets”), and (iii) all projects collected by the Moody’s Analytics Data Alliance Project Finance Consortium (“total study sample”). The last of these is the most comprehensive, as it adds projects in high-income countries that are not members of either EEA or OECD to the “all subsets” sample.

The dataset is substantially representative of industry-wide project finance activity, comprising 6,389 projects (in 137 countries), which account for 62.0 percent of all project finance transactions originated globally between January 1, 1983, and December 31, 2015. The study also considers the credit performance of similar subsets of projects originated over the period 1995-2015 (with 6,108 projects in 135 countries); this more closely aligns with the period over which EMDEs have evolved into a distinct market sector of focus for investors. Based on the Basel II/III definition of default (BCBS, 2017; Appendix, Glossary), the dataset includes 460 projects for which at least one senior secured project finance bank loan has defaulted. Of these 460 defaulted projects, 237 have subsequently emerged from default. The curtailed study period (1995-2015) includes 407 defaults and 192 recoveries representing 88.5 percent of the total defaults and 81.0 percent of the total recoveries in the total study period (1983-2015). The 1995-2015 period excludes projects that originated before 1995; hence the default count for this curtailed study period can be lower in each year than for the entire dataset.

Defaults of project loans are more concentrated in EMDEs than in advanced economies, with most occurring in the power sector (consistent with the relative incidence of project loans in this sector). There is a high concentration of projects in a few key countries in the “EEA or OECD” sub-sample (with the United States, United Kingdom, Australia, and large euro area economies representing about three-quarters of the sample) and a lower concentration of projects within the EMDE-A and EMDE-B subsets (with Brazil, Mexico, Indonesia, South Africa, China, Thailand, India, Argentina, Russia, the Philippines, and Nigeria accounting for slightly more than half of all projects in the sample) (see Appendix Figures 2
and 3). The concentration remains nearly the same for the defaults by country in each of the principal subsets. It is apparent that there is a high concentration of defaults in a few key countries within the EMDE-A and EMDE-B subsets in Argentina, Brazil, Indonesia, and Thailand (with Colombia and Venezuela gaining greater sample weight).

The study also examines the “composition effect” of sample membership in terms of project, default, and recovery count by means of “Lorenz curves.” Appendix Figure 7 charts the concentration of projects, defaults, and recoveries (on a cumulative basis) in each sample subset as the proportion of countries (ranked in order of project count) included in each subset increases. For the “EEA or OECD” sub-sample, the concentration of projects and of both defaults and recoveries increase in a similar way. In contrast, for the EMDE-A and EMDE-B subsets, defaults and recoveries are more concentrated than projects in key countries, which is consistent with the observed differences in sample composition across subsets.

Additional observations related to the frequency of projects and defaults in each subset:
Projects and defaults are concentrated in the power sector in both advanced and developing countries. Appendix Figures 4 and 5 show the concentration of projects and defaults by principal industry sector within each subset. The infrastructure and power sectors dominate the “EEA or OECD” subset. In contrast, the power and oil and gas sectors dominate the EMDE-A and EMDE-B subsets.3

The absolute number of projects in EMDEs has slightly increased over time but remained broadly stable. Appendix Figure 6 shows the incidence of projects originated and the cumulative number of active projects by subset from 1990 (for the 1983-2015 study period). The number of projects in each of the EMDE-A and EMDE-B subsets is less than one fifth of the number of active projects in the “EEA or OECD” subset.

Overall, the study finds that project loans in EMDEs exhibit resilient credit performance. Predictable, resilient revenue streams over the long term support favorable credit performance, especially where revenue risk is transferred through an offtake contract, which mitigates repayment contingencies from price and demand uncertainty. While most project finance borrowers are highly leveraged, thinly capitalized special purpose vehicles (SPVs) which characterize project finance—with limited financial flexibility, structural features, underwriting discipline, and incentive structures—seem effective in minimizing default risk and achieving high and stable recoveries (see Appendix, Box A4).4

The cumulative default risk of project loans in EMDEs is close to low investment grade credit quality. The average 10-year cumulative default rate ranges between 9.4 and 10.3 percent (for samples EMDE-A and EMDE-B) over the original sample period (1983-2015), broadly consistent with 10-year cumulative default rates for “Ba1/BB+”-rated corporates (10.5 percent), and it improves to 7.7-8.3 percent over a curtailed study period (1995-2015). This compares favorably to the 10-year cumulative default rate of 6.5 percent for the “EEA or OECD” subset, which is close to the default rate of 5.4 percent for corporates of low investment grade credit quality (“Baa3/BBB-”) (see Appendix Figures 9-12). For project loans in the context of PPPs, which serves as proxy for availability-based infrastructure projects supporting a high degree of repayment certainty, the average 10-year cumulative default rate declines to 5.5-6.1 percent (for samples EMDE-A and EMDE-B) and 4.4 percent (for the “EEA or OECD” subset) over a study period between 1995-2015.

The marginal default rate of project loans improves steadily over time, reaching solid investment grade level five years after financial close. Projects face significant incremental risk during the construction phase and/or the commencement and ramp-up of operations. During an initial three-year period following loan origination, marginal annual default rates are consistent with speculative grade credit quality (“Ba2/BB” for projects in advanced economies and “Ba3/BB-” for projects in EMDEs) but fall significantly thereafter, trending towards marginal default rates equivalent to low investment grade credit quality (“Baa3/BBB-”) in the fifth year before settling at a credit quality consistent with “A”-category corporate ratings by year seven from financial close. Interestingly, after five years, the marginal default rate of project loans is lower in EMDEs than in advanced economies (and consistent with that of “AA/Aa”-rated corporates). For project loans in the context of PPPs, the evolution of the marginal default rate of project loans in EMDEs coincides with the credit profile of the aggregate marginal default rate of all project loans in the sample. This suggests that higher contractual certainty in PPPs essentially nullifies the marginally higher default risk of projects in EMDEs relative to those in advanced economies.

Recovery rates are high and nearly the same for projects loans in advanced and developing countries, despite high gearing and long tenors, which are typical for project finance loans but are generally associated with riskier corporate loans. The average ultimate recovery rates5 (as per the
definition in the Basel II/III framework; see Appendix, Glossary) for project loans in EMDEs is 77.9-79.1 percent (for samples EMDE-A and EMDE-B), marginally lower than that for EEA or OECD countries (79.9 percent) and for the total study data set (79.5 percent), and consistent with the recovery rate for secured senior corporate loans (80.4 percent). For the shorter study period (1995-2015), the recovery rates improve slightly to 80.2 percent for projects in EEA or OECD countries and decline to 75.6-77.2 percent in EMDEs. For project loans in PPPs, the recovery rates are around 85 percent.

- **Both default risk and recoveries are stable across countries in each sub-sample.** Appendix Figure 8 charts the stability of the credit risk factors (default and recovery rates, a weighted average) in each sample subset as the proportion of countries (ranked by project count) included in each subset. Both credit risk factors are less sensitive to the sample composition for projects in the “EEA or OECD” sub-sample. However, for projects in both advanced and developing countries, the credit performance improves at the margin (and the credit risk parameters become increasingly stable) as countries with smaller project counts are added to the respective sample subset. Overall, there is no evidence of a “composition effect” due to sample selection distorting the overall result of credit performance.

- **The credit performance varies across sectors, with projects in the oil and gas sector outperforming projects in other sectors of EMDEs.** Curtailing the time horizon for analysis of the broader data set to 1995-2015 shows lower default rates for all advanced economy and EMDE subsets, but has limited impact on recovery rates. For oil and gas (including biofuels), the 10-year cumulative default rate is significantly lower in EMDEs (5.3-5.7 percent vs. 7.9 percent) while the average recovery rate is notably higher (84.7 percent vs. 66.8 percent). Conversely, for the power sector, the 10-year cumulative default rate is higher in EMDEs (10.5-11.5 percent vs. 5.3 percent) and average recoveries are lower than for advanced economies (78.4-79.7 percent vs. 91.8 percent) during 1995-2015. For the (broad) infrastructure sector, the 10-year cumulative default rate is somewhat higher in EMDEs (6.9-9.2 percent vs. 5.6 percent) and average recoveries are marginally lower than for advanced economies (77.8 percent vs. 78.5 percent), where projects with availability-based revenue streams are more prevalent. For transportation projects (included in the broad infrastructure sector), the default
rate is lower in EMDEs (6.6-8.3 percent vs. 10.3 percent), but so are average recoveries (61.1 percent vs. 93.1 percent).

However, the sample composition significantly influences sector-specific credit performance. Defaults in the power and oil and gas sectors represent the largest and second-largest shares of defaults of project loans in EMDEs, whereas the (broad) infrastructure and power sectors dominate defaults in advanced economies, with 79 percent and 70 percent of all defaults, respectively (see Appendix Figure 5).

Defaults of projects in EMDEs are largely caused by political and regulatory risks rather than demand risk. In EMDEs, 40-50 percent of defaults are due to country risk (defaults caused by currency transfer or convertibility constraints, local currency devaluation, expropriation, imposition of discriminatory taxation or regulation), whereas in advanced economies, the most common cause
for defaulted project loans is market risk due to adverse variances in price and volume assumptions. Figure 5 and Appendix Figure 6 also show that the default rate of project loans in EMDEs is resilient to swings in general macro-financial conditions. Despite the scarcity of availability-based revenue projects in EMDEs, the limited impact of market factors on default risk might be due to structural features that enhance project repayment capacity (e.g., cash flow control, robust off-taker arrangements) (see Appendix, Box A4).

Note:
1/ The Moody’s Analytics Data Alliance Project Finance Consortium categorizes projects loans into ten sectoral categories: (i) “chemicals production,” (ii) (broad) “infrastructure” (incl. ports & terminals, public services and administration, transport, and water systems & desalination), (iii) “leisure and recreation,” (iv) “manufacturing” (incl. automotive, building materials, and construction), (v) “media and telecom” (incl. media content, media distribution, and telephone), (vi) “metals and mining” (incl. processing), (vii) “oil & gas” (incl. distribution, exploration & production), refining, liquefied natural gas, and biofuels), (viii) “power” (electricity generation/transmission/distribution), (ix) “transportation” (other than covered in infrastructure, e.g., aircraft/ships), and (x) “other.” The report shows the results for four sectors separately (power, oil&gas, and infrastructure (and its sub-category “transport”)).

2/ Projects located in EEA or OECD countries may also qualify for lower regulatory capital under the Solvency II framework, consistent with the qualifying criteria for lower regulatory capital as defined by the European Commission (2015 and 2017) in the Commission Delegated Regulation (EU) 2017/1542. Moody’s also published summary-level findings for the “EEA or OECD (restricted scope)” subset which comprises infrastructure projects with availability-based revenues that provide predictable cash flows, and which more closely aligns with these criteria. See also the Glossary (Appendix) for a detailed definition of “qualifying infrastructure investment” (and its analogue in the Basel III framework (BCBS, 2017), which applies a similar concept to “high quality project loans”).

3/ The large share of energy projects in the sample of project loans reflect sectoral preferences by banks but is also consistent with the observations in Saha and others (2018) about the participation of institutional investors in projects in low- and middle-income countries (see Appendix, Glossary).

4/ Curtailing the time horizon for our analysis to 1995-2015 from 1983-2015 shows lower default rates for all advanced economy and EMDE subsets, but has limited impact on recovery rates.

5/ The ultimate recovery values exclude any recoveries under political risk insurance arrangements. The number of defaults of facilities backed or insured by Export Credit Agencies is very small and not statistically significant.

6/ Defaults primarily due to market risk include defaults are caused by adverse variances in price and volume assumptions (e.g., lower than expected output commodity prices; higher than expected input commodity prices; or lower than projected traffic volumes/demand/usage/patronage. Defaults primarily due to country risk include defaults caused by currency transfer or convertibility constraints, local currency devaluation, expropriation, imposition of discriminatory taxation or regulation, contract repudiation by a sovereign entity, political force majeure, or war and civil disturbance.
III. MAIN FINDINGS AND DISCUSSION

The historical default experience of infrastructure debt securities and project loans over the study period between 1983 and 2015 suggests a high degree of resilience in both advanced and developing countries (see Table 3). The risk profile of project loans (and infrastructure debt securities) improves over time and exhibits risk characteristics that differ significantly from those of general corporates. This observation of a non-linear relationship between remaining maturity and credit risk is consistent with findings from previous research on the “hump-shaped” term structure of the credit spreads for project finance (Gadanecz and Sorge, 2004). For instance, the marginal default rates of project loans in EMDEs decline steadily over time (as infrastructure projects amortize) and reach investment grade level less than five years after origination (resulting in 10-year cumulative default rates just below investment grade) – as opposed to corporates, whose marginal default rate remains considerable over the longer term. The combination of 10-year cumulative default rates of around 8 percent and an average ultimate recovery rate of close to 80 percent (virtually the same as those for senior secured corporate loans) suggests a credit performance close to that of investment grade corporates.

The diminishing marginal default risk after a few years can be explained by the payment structure of project finance. A project loan represents an unsecured lending arrangement, whose repayment is based solely on cash flows from future operations (Weber and Alfen, 2010; see Appendix Box A4). With their asset-heavy capital intensity, low-to-manageable operating risk, and long-term importance, infrastructure projects can support higher leverage than similarly rated non-financial corporates issuing debt. The amortization schedule deleverages the capital

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57 There are variations in credit performance across the three principal industry sectors in each subset of the analysis (i.e., (broad) infrastructure (which includes transport), power as well as oil & gas), with the transport sector in EMDEs outperforming other sectors during the initial lending period (with default rates below those in advanced economies). Conversely, transport projects included in EEA or OECD countries have the highest 10-year cumulative default rate across principal industry sectors.

58 In project finance, the credit performance depends on (i) the project’s cash flow generated from contractually obligated end user of the project’s output, such as the electricity sold by a power plant, and (ii) the collateral value of the project’s assets. Infrastructure projects often have higher levels of leverage than non-infrastructure investments. However, their capital-intensive nature, generally low-to-manageable operating risk, and the long-term importance of infrastructure services can help support higher levels of leverage than similarly rated non-financial corporates.

59 More specifically, we find that the 10-year cumulative default rate for project loans in EMDEs ranges between 7.7 percent and 10.3 percent, and, thus, is broadly consistent with 10-year cumulative default rates for “Ba1/BB+”-rated corporates (10.5 percent). For PPPs, the cumulative default rate over the first 10 years is virtually the same of those in advanced economies, at less than 6.0 percent (and slightly below the implied default rate of the lowest investment grade-rated corporate exposure).

60 The actual LGD for the global sample of unrated project loans (“all sub-samples”) is 21.1 percent, which is further refined for the specific sub-samples “EEA or OECD”, “EMDE-A”, and “EMDE-B” as 19.8 percent, 22.8 percent, and 24.4 percent, respectively. For the comparator asset classes (infrastructure debt securities, non-financial corporate debt, and general corporate exposures), the LGDs are 44.0 percent, 62.0 percent, and 19.6 percent. For infrastructure debt securities for the specific sub-samples “EEA or OECD”, “EMDE-A”, and “EMDE-B,” the LGDs are 41.2, 47.5, and 50.1 percent, respectively.
structure of the project and may gradually improve its credit status *mutatis mutandis*, especially in the “brownfield” phase, where certainty of revenue streams avoids the “carrying cost” arising from a gradual draw-down of the debt portion during the “greenfield” phase (see Table 2).\(^6^1\)

Thus, the evolving capital structure may lead to a non-linear relationship between remaining maturity and credit risk in project finance, which results in a “hump-shaped” default risk profile, i.e., the term structure of credit spreads cannot be approximated by a linear positive function of maturity (as in traditional credit risk models).\(^6^2\)

The apparent impact of the repayment schedule on credit performance of project finance also underscores the importance of liquidity risk (rather than insolvency risk) as determinant of credit quality, especially given the high recovery rate in project finance.

**The credit risk properties of project loans and infrastructure debt securities are different from those of standard corporate exposures.** Infrastructure projects generate predictable, resilient revenue streams over the long term, especially where revenue risk is transferred through an offtake contract that mitigates repayment uncertainty due to price and/or demand risks. Such contractual certainty is particularly high in availability-based infrastructure finance, which occurs mostly in the context of PPPs. Also, other structural features in project finance, which clearly delineate and allocate risk and control of cash flows, seem to prove effective at limiting defaults and keeping losses to a minimum (see Appendix, Box A4).

**More specifically, the findings for the default and recovery rates are as follows:**

- **Near-investment grade default risk.** Despite higher incremental default risk during the construction phase of projects (“greenfield” stage), the marginal default risk of project loans in EMDEs improves to investment grade level in less than five years after origination. Specifically, the likelihood that a loan performing at the start of a specific year will default within that year exceeds the level for high non-investment grade corporate exposures after the project’s financial closing (consistent with that of “Ba/BB”-rated (speculative grade) corporates); but this likelihood converges with that of investment grade instruments as projects become fully operational and mature (“brownfield” stage). After five years, the marginal default rate of project loans is consistent with that of “AA/Aa”-rated corporates and, in fact, is slightly lower on average in EMDEs than in advanced economies (see Appendix Figure 13). Thus, the cumulative default rates of project loans stabilize after several years, like those of investment grade instruments, whereas default rates for comparable corporate debt continue to rise until maturity (see Figures 4 and 6). The average annual default rate of project loans in

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\(^{6^1}\) A recent study on the role of institutional investors for infrastructure finance also suggests that the risk profile (and corresponding investor preference) tends to vary across industry sectors (Saha and others, 2018). While institutional investors tend to prefer “greenfield” projects in the energy sector, where the construction periods are short, longer construction periods, for instance in transportation, tend to shift investor interest towards “brownfield” projects if there is sufficient certainty of revenue streams and stability of the regulatory environment.

\(^{6^2}\) This aspect will be picked up in the calibration exercise, with includes a non-linear adjustment to the capital charge related to the impact of downgrade risk on the probability of default.
EMDEs remains below 1.0 percent and about one-third higher than for project loans in advanced economies. The difference in default risk between EMDEs and advanced economies narrows in PPPs, which also lower the cross-sectional volatility, especially for broad infrastructure projects, including ports and terminals and water utilities. Over the sample period, the default risk for projects in the oil and gas sector (including biofuels) as well as the transport industries is in fact lower in EMDEs than in advanced economies. The converse applies for investments in project loans in power-generating industries. Overall, default rates for project loans in the context of PPPs are considerably lower than for the infrastructure sector in general (see Appendix Figure 14).

- **High asset recovery rate.** Ultimate recovery rates for project defaults in EMDEs are high and stable, averaging about 80 percent (similar to in advanced economies), and, thus, are like those for senior secured corporate bank loans, even though most project finance borrowers are highly leveraged, thinly capitalized special purpose vehicles with limited financial flexibility (see Figure 7 and Appendix Figure 15). As in advanced economies, the recovery rates vary significantly across the main industry sectors and are lower for projects in power generating industries and transport. Interestingly, project lending in the context of PPPs has a disproportionate impact on raising asset recovery values in EMDEs (even above levels for projects in advanced economies).

- **Expected loss is equivalent to low investment grade–rated non-financial corporates.** The average annual expected loss of project loans in EMDEs (at about 1.5 percent) is slightly higher than in advanced economies (0.9 percent), which is close to that of low investment grade–rated (“Baa/BBB”) non-financial corporate debt securities (1.0 percent) but below that of high non-investment grade–rated (“Ba/BB”) infrastructure debt securities (1.9 percent) (see Figure 8 and Appendix Figure 16). This comparison on aggregate suggests an implicit rating of project loans close to investment grade, which is directionally consistent with the general regulatory treatment of unrated investments.

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63 After ten years, the cumulative default rate implies a level of credit risk similar to that of investment grade-rated corporates.

64 High recovery rates provide some protection against a changed market perception of default probabilities (e.g., due to a severe rating downgrade). Ultimate recovery rates are higher for projects that default later in the life of the loan. Losses on projects that default in the construction phase are higher than those that default in operational phase.

65 Note that under the Solvency II Directive (European Commission, 2017), unrated debt securities and loans receive a risk factor equivalent to that of a rated investment between CQS=3 (“Baa/BBB”) and CQS=4 (“Ba/BB”); for qualifying infrastructure investment (see Appendix, Glossary), the risk factor at CQS=3 (“Baa/BBB”) applies. The ICS applies to project loans the capital charge for unrated corporate exposures (and re-insurance) with a rating between CQS=4 (“Ba/BB”) and CQS=5 (“B”). Under the standardized approach of the finalized Basel III framework, project loans (like other forms of specialized lending in corporate finance) are assigned a risk weight of 100 percent (consistent with rated investments with CQS=4 (“Ba/BB”)), which declines to 80 percent (consistent with rated investments between CQS=3 (“Baa/BBB”) and CQS=4 (“Ba/BB”)) if the project is operational and meets the criteria for “high quality project finance” (BCBS, 2017; see Appendix, Glossary).
Figure 6. Unrated Project Loans (1995-2015)—Probability of Default (PD) (in percent)

Source: Moody’s Investors Service (2017) and author.

Note: * the average and standard deviation of the marginal probability of default is calculated over a 10-year time horizon, the total sample of project loans in the Moody’s Analytics Project Finance Data Consortium dataset comprises ten sectors, of which three sectors—power, oil & gas, and broad infrastructure and its sub-category “transport” are shown separately. For the curtailed study period (1995-2015), the share of the total number of defaults in the selected sectors for samples “EEA or OECD,” “EMDE-4” and “EMDE-6,” respectively, is as follows: power (33/33/32 percent), oil & gas (10/13/14 percent), and infrastructure (63/64/60 percent), of which a sub-sample for “transport” (2/1/2 percent) was created.

Figure 7. Unrated Project Loans (1995-2015)—Recovery Rate (in percent)

Source: Moody’s Investors Service (2017) and author.

Note: the recovery rate represents the “ultimate recovery” (outside the results from distressed debt sale and work-out process) and is based on cohorts of loans with the same origination year; the standard deviation of the recovery rate is calculated as a cross-sectional measure for each sample (i.e., a 10-year time horizon) which is missing for some sub-samples due to lack of robustness. The total sample of project loans in the Moody’s Analytics Project Finance Data Consortium dataset comprises ten sectors, of which three sectors—power, oil & gas, and broad infrastructure and its sub-category “transport” are shown separately.
We can recover the credit risk parameters from the published data to calibrate the capital charges for debt securities and lending under two important solvency regimes for insurance companies—Solvency II and the Insurance Capital Standard (ICS). The objective is to explore whether greater data availability would give rise to a more differentiated regulatory treatment of infrastructure investment.\textsuperscript{66} We apply the data to existing standardized approaches, differentiating the risk properties of infrastructure debt from those of corporate exposures \textit{without} adjustments to current regulatory methodologies. Only the intrinsic risk profile of infrastructure debt vis-à-vis the standard risk assumptions on long-term debt is considered. We also examine the credit performance of rated infrastructure debt securities, which was published by Moody’s in a similar study (Moody’s Investor Service, 2017c and 2017d). And we look at additional asset classes to compare robustness and calibrate a separate economic capital model for cross-validation (Jobst, 2007 and 2014). In addition, we consider the current regulatory treatment of infrastructure exposures for banks under the Basel III framework, which is conceptually very similar to the planned implementation of the credit risk stress factors under ICS.

\textsuperscript{66} This was done by (i) mapping the current reduction factors for qualifying (unrated) infrastructure investment for EEA/OECD countries under the Solvency II SCR Standard Formula — Spread Risk Sub-Module (Art. 180 (11)-(13)) (European Commission, 2015 and 2017) to the expected loss of project loans in EMDEs and (ii) calibrating new credit risk stress factor for ICS (IAIS, 2017b) following the advanced internal ratings-based approach according to the finalized Basel III framework (BCBS, 2017).
Our findings show sufficient scope for reducing the capital charge for investments in infrastructure debt. The historical credit performance of project finance bank loans and infrastructure debt securities support the robust calibration of revised capital charges under existing standardized approaches, with a high degree of credit risk parameter stability over time and across countries. We find that the capital charges would decline significantly under both Solvency II and ICS when the favorable default risk profile and recovery rates of infrastructure debt is taken in account, especially for financial arrangements that imply high contractual certainty about revenue streams (see Table 4).67 Under Solvency II, the capital charge for

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67 Infrastructure projects often involve strong public sector support through fixed-term concession, economic regulation, and de-risking mechanisms. Especially the start-up phase may require interventions along the three phases of the project life-cycle (World Bank, 2015; see Appendix, Box A4). At project level, improving preparation...
The capital impact of a differentiated regulatory treatment varies significantly depending on the extent to which current regulatory methodologies can accommodate the distinctive risk profile of infrastructure debt (see Table 2). Using actual credit performance data under various configurations of modelling credit risk stress in ICS and amending the current risk reduction factor for qualifying infrastructure investment in Solvency II would result in capital charges that are closely aligned with those suggested by an economic capital model using the same credit performance data (see Figures 9 and 10; Appendix Figure 17). However, impact of the declining marginal default rate and high recovery rate of infrastructure debt (i.e., “hump-shaped” credit risk profile) on a differentiated capital charge varies significantly across the risk factors in Solvency II and the implementation of the adapted Vasiček (2002) model and the A-IRB approach under ICS:

- **Solvency II**—We map the expected loss of infrastructure debt to the current risk factors of the spread risk module for corporate exposures and infrastructure investment. A differentiated treatment under Solvency II implies a reduction of existing risk factors, which increase linearly with duration, and, thus, fully reflects the lower default risk over time (albeit in a simplified way as variations of default risk within “duration buckets” (e.g., within the first five years) are not recognized (see Appendix Table 7)). The term structure of capital charges shifts downward and flattens in line with the cumulative effect of the adjusted risk factors.

- **Insurance Capital Standard (ICS)**—The adapted Vasiček (2002) model emphasizes the stressed expected losses (i.e., stressed PD multiplied by LGD) in the first year and assigns a relatively small capital charge to the downgrade risk over the remaining maturity of investment (see Appendix, Technical Description, Section B.2). Thus, the insensitivity of credit risk to the remaining maturity provides little differentiation across variations in the cumulative default probability after the first year. We find that the actual

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68 The implied spread volatility consistent with the credit risk-based reduced capital charge would also need to be reflected in the discount factor of reserves whose cash flows are matched by infrastructure investment that are held to maturity (“maturity adjustment”).
marginal default risk of infrastructure debt is below the implied marginal default risk in the current calibration of ICS (even in the first year, as can be seen in the results for the Vasiček (2002) model with fixed LGD (see Appendix Table 3)); however, the higher recovery rate of infrastructure debt dominates the capital impact of greater differentiation (resulting in a commensurate downward shift of the term structure of capital charges). The declining marginal default risk results in a further flattening of the term structure of capital charges, but the impact is relatively small. This effect would be more pronounced if the A-IRB approach with cumulative default probabilities (see Appendix, Technical Description, Section B.1) had been used for the current capital charge under ICS; however, the maturity adjustment under this approach assumes a linear relationship between remaining maturity and credit risk, which would overstate the default risk of infrastructure debt over the medium and longer terms.

More specifically, we find that:

- **Solvency II**—The historical credit performance of infrastructure debt relative to non-financial corporate debt suggests a further adjustment of risk reduction factors for qualifying infrastructure exposures beyond the current scope of EEA or OECD countries (see Table 4). For investments with a maturity of 10 years, the empirically consistent capital charge for project loans declines from 23.5 percent to 12.9 and 15.0 percent for the global and EMDE samples (down by 45 and 36 percent), respectively (see Figure 9). This reflects the linear adjustment of current risk factors based on lower implied expected losses of infrastructure debt based on our mapping exercise using the reduction factor elasticity established by EIOPA in its original amendment of the standard formula (see Appendix, Technical Description, Section A). The enhanced credit performance of project loans in PPPs would further reduce the capital charge to 9.7 and 11.6 percent for the global and EMDE samples (down by 45 and 36 percent), respectively (see Appendix Table 6). Additional analysis of rated infrastructure debt securities indicates some flexibility to lower capital charges on these instruments. For instance, the charge for “Baa/BBB”- and “Ba/BB”-rated securities would decline from 20.0 and 35.0 percent to 15.7 and 28.5 percent, respectively, for a global sample of infrastructure debt securities (see Appendix Table 7).

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69 See Appendix Tables 19-21 for more detailed results on rated infrastructure debt securities in the global and both EMDE samples, based on the differentiated regulatory treatment under Solvency II and ICS (both the adapted Vasiček (2002) model and A-IRB approach to credit risk).
Figure 9. Summary of Main Findings (Insurance): Actual and Differentiated Capital Charges for Unrated Project Loans, 1995-2015
(In percent of exposure amount)

Sources: BIS (2017), Moody’s Investors Service (2017) and author.

Note: the capital charges for spread risk and credit risk under the Solvency II Directive and the Insurance Capital Standard (ICS) are not comparable. In Solvency II, the risk factors of the standard formula for spread risks are calibrated to the valuation impact of spread increases at the 95th percentile, depending on the rating and duration of investment. Downgrades and default risks are not explicitly covered (BIS, 2014). In contrast, the credit risk stress factor in the ICS is modelled explicitly based on the combined valuation effect of the one-year default probability (at the 90.5th percentile) and the downgrade risk. Reduced capital charge for qualifying infrastructure investment in EEA or OECD countries according to EU Regulation 2017/1542 (European Commission, 2017). 1/ Solvency II Directive: current capital charge for Vario and low-exposure under the original Solvency II JMP Standard Formula Spread Risk Sub-Model (which applies to infrastructure debt investment outside the EU or OECD member countries). For other criteria for qualifying investment are satisfied and differentiated capital charge consistent with the average annual expected losses of unrated project loans in all sample countries corresponding to “all subsamples” and only emerging market and developing economies (corresponding to non-high-income countries in the “EMUI-A” samples) as defined in Moody’s Investors Service (2017). 2/ Insurance Capital Standard (ICS): calibrated credit risk stress factor based on the cumulative default rate of unrated project loans in an adapted Basel (2002) model (ICS: 2017d) with actual and best IGD of 45-percent (consistent with the Moody’s (F4-F8) approach under the final Basel III framework BIS (2017))—the pattern bar chart show the results for the use of the actual recovery rate (which is much lower for unrated project loans).
• **Insurance Capital Standard (ICS)**—The capital charge under the planned treatment of corporate exposures would need to decline significantly to be consistent with the actual credit performance of infrastructure debt. For investments with a maturity of 10 years, the credit performance of project loans\(^{70}\) implies a reduction of the capital charge from 12.7 percent to 4.4 and 5.5 percent for the global and EMDE samples, respectively (see Table 4), if the credit risk stress factor is calibrated based on the adapted Vasiček (2002) model—but only if actual recovery rates were used. With a fixed LGD assumption of 45 percent (consistent with the *foundation internal ratings-based* (F-IRB) approach under the finalized Basel III framework (BCBS, 2017) and the current specification of recovery rate of corporate exposures under ICS), the estimated capital charge drops only by 25 and 13 percent, respectively (4.4 and 5.5 percent) (see Figure 9).\(^{71}\) The modelling of downgrade risk in Vasiček (2002) model gives little weight to the evolution of marginal default rates, and, thus, generating a flattening term structure of capital charges in any case without fully reflecting the “hump-shaped” credit risk profile of infrastructure debt. Thus, the largest impact from a differentiated treatment is due to the actual recovery rate (which is far above the fixed parameter in the current specification in ICS). Under the A-IRB approach, which is closely related to the current calibration of the credit risk factor of ICS, the capital charge decreases to 8.3 and 8.9 percent, respectively (see Appendix Table 3).\(^{72}\) However, the linear maturity adjustment to the capital charge overstates the capital impact of the diminishing marginal default risk of infrastructure debt. Without maturity adjustment, the capital charge would decrease to 4.0 and 4.9 percent for the global and EMDE samples, respectively. Restricting the calibration to project loans for public-private partnerships (PPPs) only—as a proxy for contractual certainty in keeping with the concept of “qualifying infrastructure investment”—would further reduce the capital charge under a differentiated regulatory treatment (by about half). Under the adapted Vasiček (2002) model with a fixed (actual) LGD, the capital charge would be 7.5 (2.3) percent and 8.4 (2.9) percent for the global and EMDE samples, respectively (see Appendix Table 4). As with the calibration for credit risk under Solvency II, rated infrastructure debt securities would also attract a lower capital charge. For instance, the charge for “Baa/BBB”- and “Ba/BB”-rated securities would decline from 5.6 and 9.8 percent to 2.5 and 3.2 percent, respectively, for a global sample of infrastructure debt securities (see Appendix Tables 16-17).

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\(^{70}\) The annual expected loss of a sample of project finance loans (0.9 percent) is half of the expected losses implied by “Ba/BB”-rated corporates.

\(^{71}\) See also Appendix Tables 16-17 for more detailed results on project loans (with and without PPP context) and “comparator” asset classes based on the adapted Vasiček (2002) model (with actual and fixed LGD) at a statistical confidence of 99.5 and 99.9 percent.

\(^{72}\) See also Appendix Tables 8-11 for more detailed results on project loans (with and without PPP context) and rated infrastructure debt securities for different configurations of the A-IRB approach at a statistical confidence of 99.5 percent.
• *Economic capital model*—For the global and EMDE samples of project loans, the economic capital charge at a statistical confidence level consistent with current prudential requirements suggests significantly lower capital charges. The CTE point estimate under the GEV approach indicates a diminishing marginal capital intensity of project loans over time, consistent with lower incremental default risk after the construction phase of projects. This credit performance results in an estimated capital charge of 8.0 percent for the global sample and between 10.5 and 12.5 percent for the EMDE sample over a 10-year risk horizon (see Appendix Table 5). Considering only project loans as part of PPPs would reduce the estimated capital charge to 5.8 percent and between 8.8 and 7.7 percent in EMDEs (see Appendix Table 18).

The calibration of a capital charge for infrastructure debt might also require reviewing the impact of the prevailing regulatory treatment of structured finance arrangements under both solvency regimes. In the current calibration of the credit risk stress factor for securitization under ICS (IAIS, 2017b), the capital charge of an infrastructure investment classified as a securitization exposure with a rating of CQS=4 (“BB/Ba”) or higher would remain unchanged but triples for exposures rated CQS=5 (“B”); any unrated securitization exposure and exposures rated lower than CQS=5 (“B”) require even a capital deduction (irrespective of maturity). Under Solvency II, individual infrastructure project bonds and loans are treated as corporate exposures rather than securitization exposures even if credit risk is “tranching,” i.e., investor claims have different risk exposure to credit performance of the transaction. Given the prevalence of unrated bank project lending for infrastructure finance (and most infrastructure debt securities being rated between “BBB/Baa” and “BB/Ba”), this exemption results in a lower capital requirement for insurers (and for non-investment grade exposures held by banks)—despite the reduced capital charges for *simple, transparent and standardized* (STS) securitization (European Parliament/European Council, 2017).75

73 However, this treatment does not apply to pooled infrastructure exposures, which could be explored as a possible extension to the current regulatory treatment to attract institutional investors to a diversified portfolio of infrastructure projects.

74 This treatment has been adopted from the prudential requirements for credit institutions and investment firms defined in the EU Capital Requirements Regulation (CRR) for banks (“In order to ensure that the risks and risk reductions arising from institutions’ securitization activities and investments are appropriately reflected in the capital requirements of institutions it is necessary to include rules providing for a risk-sensitive and prudentially sound treatment of such activities and investments. To this end, a clear and encompassing definition of securitization is needed that captures any transaction or scheme whereby the credit risk associated with an exposure or pool of exposures is tranched. An exposure that creates a direct payment obligation for a transaction or scheme used to finance or operate physical assets should not be considered an exposure to a securitisation, even if the transaction or scheme has payment obligations of different seniority,” European Parliament/European Council, 2017, recital (50)).

75 Under the standard formula of Solvency II, capital charges for investment in securitization remain consistently higher than for those for corporate bonds and loans. Corporate exposures receive a capital charge of 9.4 percent (CQS=3 (“BBB/Baa”)) and 15.0 percent (unrated) over a risk horizon of five years (European Commission, 2014b); for qualifying infrastructure investment (European Commission, 2015, 2016 and 2017), the capital charge (under the categorization of corporate exposure) declines to 9.4 percent and 12.5 percent, respectively (see Appendix Table 7).
In contrast, securitization exposures over a risk horizon of five years receive a capital charge of 19.7 percent (CQS=3 (“BBB/Baa”)) and 100.0 percent (unrated); for STS-qualifying (“Type 1”) securitization (European Commission, 2014a), the capital charge declines to 15.0 percent for “BBB/Baa”-rated exposures while the capital charge for unrated exposures would remain unchanged (Aiyar and others, 2015). Similar stringency applies to the regulatory treatment for securitization for banks under the standardized approach in the Basel III framework (BCBS, 2017). Corporate exposures (which includes project finance as a form of specialized lending) receive a risk weight of 75 percent (CQS=3 (“BBB/Baa”)) and 100 percent (unrated); for unrated “high quality project finance,” the risk weight declines to 80 percent while the risk weight for rated project finance remains unchanged (see Box 2). In contrast, securitization exposures over a risk horizon of five years receive a risk weight of 105 percent (CQS=3 (“BBB/Baa”)) and 180 percent (unrated); for STS-qualifying securitization (European Commission, 2014a), the risk weight declines to 65 percent and 155 percent, respectively. The risk weights decline further for shorter investment periods (e.g., 120 percent for any securitization exposure over a one-year risk horizon and 70 percent for STS-qualifying securitization, both rated CQS=3 (“BBB/Baa”)). Thus, from a regulatory perspective, banks would prefer the classification of an investment as a securitization exposure only if it were investment grade-rated.
| Data Subset (Project Loans) | Avg. Expected Loss* | Current 1/ | Differentiated | Planned 2/ | BASEL III - A-IRB 4/ | Economic 5/ |
|---------------------------|---------------------|-----------|---------------|-----------|------------------|-----------|
| All sub-samples           | 0.9                 | 23.5      | 12.9          | 12.7      | 9.5              | 4.4       |
| EEA or OECD e/            | 0.9                 | 20.0      | 9.8           | 12.7      | 9.1              | 3.9       |
| EMDE-A                    | 1.4                 | 23.5      | 15.0          | 12.7      | 11.1             | 5.5       |
| EMDE-B                    | 1.7                 | 23.5      | 16.0          | 12.7      | 11.5             | 6.1       |
| of which PPP only**       | 0.2                 | 23.5      | 9.7           | 12.7      | 7.5              | 2.3       |
| All sub-samples           | 0.2                 | 20.0      | 9.7           | 12.7      | 7.5              | 2.3       |
| EEA or OECD e/            | 0.2                 | 20.0      | 9.7           | 12.7      | 7.5              | 2.5       |
| EMDE-A                    | 0.7                 | 23.5      | 11.6          | 12.7      | 8.4              | 2.9       |
| EMDE-B                    | 0.7                 | 23.5      | 11.8          | 12.7      | 8.3              | 2.9       |
| **Memo Items/1**          |                     |           |               |           |                  |           |
| Infrastructure debt securities |                   |           |               |           |                  |           |
| "Baa"-rated, global       | 0.3                 | 23.5 (14.0)** | 15.7          | 5.6       | 3.2              | 3.1       |
| "Ba"-rated, global        | 1.9                 | 35.0      | 28.5          | 9.0       | 7.3              | 7.2       |
| Non-financial corporate debt securities |               |           |               |           |                  |           |
| "Baa"-rated, global       | 1.0                 | 20.0      | 20.0          | 5.6       | 4.7              | 6.6       |
| "Ba"-rated, global        | 3.2                 | 35.0      | 35.0          | 9.8       | 10.6             | 15.3      |
| Corporate                 | "Baa"-rated, global | 0.4       | 20.0          | 5.6       | 5.3              | 2.2       |
| "Ba"-rated, global        | 1.6                 | 35.0      | 35.0          | 9.8       | 10.3             | 4.2       |

Memo: The sub-samples refer to (i) all EEA and OECD member countries ("EEA or OECD"), (ii) all non-high-income countries ("EMDE-A"), and (iii) all non-high-income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Montenegro, Romania, and Turkey ("EMDE-B"). According to the sample selection in Moody’s Investors Service (2017b) for a study period between 1995 and 2015, capital charges were derived from (i) mapping the risk factors for qualifying infrastructure investment for EEA/OEC countries under the Solvency II/IFRS Standard Formula (spread risk sub-model) to the average annual expected losses (over a 10-year horizon) of unsecured project loans (which act as “anchor” for the rating-based capital charge for infrastructure debt securities (global) and (ii) calibrating credit risk stress factors for the Insurance Capital Standard (ICS) by using either the cumulative default rate of unsecured project loans in an adapted Vastiek (2002) model or the advanced internal ratings-based (A-IRB) approach for unsecured loans from credit risk of specialized lending (project finance) under the Basel III framework (2017b), with and without application of the maturity adjustment and floors for marginal VRs (E.U. percent) and LGD (25 percent). 7 Calculated as the product of the average annual default rate based on the 10-year cumulative default probability and the constant low-given-default (LGD) – for the memo items infrastructure debt securities, non-financial corporate debt, and general corporate exposures, the recovery rate for unsecured senior bonds (E.U.3/0.80/0.4 percent) is chosen otherwise (E.U.4/0.15/0.15 percent, respectively, for senior secured bonds). 8/ project loans for private-public partnerships only; **/ The risk factors are identical to those used in the Risk-Adjusted Capital (RAC) or the RAC capital requirement as applied. / The risk factors are identical to those used in the Risk-Adjusted Capital (RAC) or the RAC capital requirement as applied. |
Box 2. Estimation Results for Projects Loans and Infrastructure Debt Securities under the Basel III

We also explore whether the finalized Basel III framework (BCBS, 2017) for banks would benefit from greater nuance regarding the capital assessment of infrastructure investment under standardized approaches. The credit risk factor in ICS and the IRB approach for credit risk in Basel III share the same conceptual basis (i.e., asymptotic single risk factor model). Thus, we can apply the credit risk parameters of project loans and infrastructure debt securities (as well as comparator asset classes) to the specification of the IRB approach (with and without maturity adjustment and prudential floors) (see Appendix, Technical Description, Section B.1). In addition, we implement the Vasiček (2002) and GEV-based economic capital models for cross-validation (see Appendix, Technical Description, Section B.2 and Section C).

The Basel III framework preserves all options for determining credit risk weights for unexpected losses of project finance as specialized corporate lending. These include the standardized approach as well as both internal ratings-based (IRB) approaches (foundation and advanced) for corporate exposures, including the slotting criteria approach for specialized lending under the foundation IRB approach.

- **Standardized approach.** Under the standardized approach, project lending (like general corporate exposures) is subject to a risk weight of between 20 percent (for CQS=0 (“Aaa/AAA”) and CQS=1 (“Aa/AA”)) and 150 percent (CQS=5 (“B”) and lower) depending on the credit quality (see Appendix Table 2 for the matching of credit ratings and credit quality steps (CQS)). If external ratings do not exist or are not allowed, the risk-weighting is 130 percent during the pre-operational phase and 100 percent during the operational phase, which lowers to 80 percent if the exposure meets the criteria for “high quality project finance” (see Appendix, Glossary).

- **Foundation IRB approach.** This approach is permissible if banks can estimate the probability of default (PD) (with other credit risk parameters such as loss-given-default (LGD), exposure-at-default (EAD) and effective maturity predetermined). If banks do not meet the requirements for estimating the PD, they are required to map their internal risk grades to five supervisory categories, each of which is associated with a specific risk weight (the “slotting criteria approach”). These supervisory categories (from “strong” to “weak” and “default”) represent qualitative proxies of credit grades. The risk weights associated with each supervisory category range from 70 percent (for CQS=3 (“Baa/BBB”) and better) to 250 percent (for CQS=6 (“Caa/CCC”) and worse).

**Current capital charges.** Given the standard conversion factor of 12.5 between risk weights and required capital (which implies a minimum capital adequacy ratio (CAR) of 8 percent of risk-weighted assets (RWAs)), the imputed capital charge under the standardized and slotting criteria approaches for project loans would range from 5.6 to 20.0 percent (even if a risk horizon of multiple years is ignored). However, given that banks need to satisfy a higher CARs after accounting for additional capital buffer requirements (and tend to hold a managerial capital buffer above the prudential minimum), the CAR would easily double, raising the lowest possible capital charge to more than 11 percent, which is higher than most estimates under internal models above, using actual credit performance data of project loans.

**Estimated capital charges—project loans.** Internal models based on actual credit risk parameters would result in capital charges that are significantly below those implied by current standardized approaches. We find that the empirically-consistent capital charge under the A-IRB for project loans with a maturity of 10 years ranges from 5.4 to 11.1 percent and 6.4 to 11.8 percent for the global and EMDE samples, respectively, depending on the extent to which the maturity adjustment and the prudential floors are considered (see Table 5 below and Appendix Tables 12-15). If the risk horizon is reduced to one year (to allow for a maturity-consistent comparison with the capital intensity of project loans under the
standardized approach), the capital charge ranges from 3.2 to 3.8 percent and 4.0 to 4.4 percent for the global and EMDE samples, respectively. The significant reduction of the capital charge over shorter risk horizons indicates that the linear maturity adjustment in the A-IRB approach cannot accommodate the non-linear relationship between remaining maturity and credit risk of project finance as the amortization schedule deleverages the capital structure over time. For the adapted Vasiček (2002) model, which can partially address the “hump-shaped” credit risk profile of infrastructure debt through a downgrade risk component, the capital charge would decline further to between 5.8 and 7.1 percent (using actual recovery rates) as well as 12.5 and 14.2 percent (based on a fixed recovery rate assumption of 55 percent (i.e., LGD=45 percent, consistent with the foundation IRB approach) for the global and EMDE samples, respectively. If the risk horizon is reduced to one year (but maintaining the downgrade risk component), the capital charge ranges from 3.5 to 7.5 percent and 4.5 to 8.8 percent for the global and EMDE samples, respectively. The empirically fitted economic capital model generates an estimated capital charge of between 9.0 and 11.7 percent for the global and EMDE samples, respectively, which is very similar to results obtained from the A-IRB approach with maturity adjustment and prudential floors. The capital charge declines to 2.1 and 3.2 percent for the global and EMDE sample if the risk horizon is reduced to one year.

| Table 5. Summary of Main Findings (Banking): Estimated Capital Charges for Unrated Project Loans, 1996-2015 |
|---------------------------------------------------------------|
| **Basel III Framework**                                      |
| **Standardized Approach**                                    |
| **Operational**                                              |
| **Pre-operational**                                         |
| **General**                                                 |
| **High-quality**                                            |
| **Internal Ratings-Based (IRB) Approach**                   |
| **Foundation**                                              |
| **Sloting criteria 3/4**                                     |
| **Vasiček model 5/6**                                       |
| **w/ LGD floor 4/5**                                        |
| **w/ mat. adj. and w/o floors**                             |
| **Economic 7/8**                                            |
| **Data Subset (Project Loans)**                             |
| **Avg. Expected Loss**                                      |
| **All sub-samples**                                         |
| **EEA or OECD**                                              |
| **EMDE-A**                                                  |
| **EMDE-B**                                                  |
| **of which (PPP only):**                                    |
| **All sub-samples**                                         |
| **EEA or OECD**                                              |
| **EMDE-A**                                                  |
| **EMDE-B**                                                  |

Considering the capital estimates under the A-IRB (and supplementary models) above, banks would generally prefer to use internal models to assess the credit risk of project loans. In Figure 11, the marginal trade-off between the capital charges using the A-IRB approach (which is invariant to CAR in this stylized representation) and the capital charges using standardized/slotting criteria approaches shows that the former clearly dominates the latter at common levels of CAR—even if we considered a more
favorable treatment for “high quality project finance” (under the standardized approach). Thus, the standardized and slotting criteria approaches would need to be more differentiated to establish greater proportionality with actual credit performance (as indicated by the results from the economic capital model); otherwise, well-capitalized banks—if they have no access to empirical data to satisfy prudential requirements for internal models—would have no economic incentive to hold unrated infrastructure (project) debt after accounting for the average opportunity cost of regulatory capital.

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**Figure 11. Basel III Framework (Banking): Regulatory Treatment of Unrated Project Loans—Analysis of Marginal Impact (in percent)**

*Sources: BGS (2017), Moody’s Investors Service (2017a) and author.*

*Note: 1/ Specialized lending for which a rating is not available but is deemed to be “high quality” the credit risk weight is 80 percent (above 100 percent); 2/ If banks do not meet the requirements for the estimation of the PD under the *foundation internal ratings-based (F-IRB)* approach, they are required to map their internal risk grades to the supervisory categories, each of which is associated with a specific risk weight (slotting criteria approach)—for illustration, unrated project loans were assumed to be consistent with a “good” classification (i.e., AQS = 4), which would result in a risk weight of 90 percent; 3/ Capital charge under the advanced internal ratings-based (A-IRB) approach (but without prudential floors to PD and LGD) with actual credit risk parameters of unrated project loans in all non-high income countries ("EMDE-A sample") over a risk horizon of 1 year and 10 years, respectively.*

**Estimated capital charges—infrastructure debt securities.** Analogous to the calibration for the capital charge for unexpected credit risk from project loans, we also derive the capital requirement for rated infrastructure debt securities under the A-IRB approach of the Basel III framework (and supplementary models, such as the Vasiček (2002) and GEV-based models). Under the standardized approach, the risk weight of rated infrastructure debt securities (like general corporate exposures) would be between 20 percent (for CQS=0 and 1) and 150 percent (CQS=5 and lower) depending on the credit quality (as stated above in the context of project loans). This translates into an implied capital charge of between 1.6 percent (for CQS=0 and 1) and 12.0 percent (CQS=5 and lower) for infrastructure debt securities at the minimum capital requirement of 8.0 percent. Using the actual credit dynamics of rated infrastructure debt securities (with a focus on the common rating classes), the capital charge under the A-IRB approach with maturity adjustment (and prudential floors) ranges from 11.4 percent (for CQS=2) to 24.7 percent (CQS=5 and lower) for the global sample and 12.6 percent (for CQS=2) to 26.0 percent (CQS=5 and lower) for infrastructure debt securities in EMDEs. The capital charge is between 3.6 percent (for CQS=2) and 17.8 percent (CQS=5 and lower) for the global sample and between 4.6 percent (for CQS=2) and 18.4 percent (CQS=5 and lower) in EMDEs if the maturity adjustment is removed (but prudential floors remain in place). These results are consistent with the estimated capital charge under different economic models (Vasiček (2002) and GEV), which suggest a capital charge of between about 2 percent (for CQS=2) and about 20 percent (CQS=5 and lower) for infrastructure debt securities at large.
The standardized approach (and the slotting criteria approach under the foundation IRB approach) deter well-capitalized banks (or banks with relatively high risk-weighted credit risk overall) from holding infrastructure debt. Our results suggest that a more differentiated regulatory treatment might be warranted for banks that are limited to the standardized approach if they have no access to empirical data to satisfy the prudential requirements for internal models (especially those that do not meet the requirements for the estimation of the PD under the foundation IRB). In fact, banks using the standardized approach cannot efficiently invest in pre-operational project loans above the minimum capital requirement—even if the risk horizon of investment is ignored (see Figure 11).

**Note:**

1/ The estimated capital charge ranges from 9.4 to 9.9 percent and 3.1 to 3.8 percent if only project loans for PPPs are considered.
2/ The estimated capital charge ranges from 1.4 to 2.5 percent and 1.7 to 2.7 percent if only project loans for PPPs are considered.
3/ The estimated capital charge ranges from 3.1 to 3.9 percent (using actual recovery rates) and 10.2 to 11.7 percent (with a fixed recovery rate) if only project loans for PPPs are considered.
4/ The estimated capital charge ranges from 1.7 to 5.5 percent (using actual recovery rates) and 2.2 to 6.3 percent (with a fixed recovery rate) if only project loans for PPPs are considered.
5/ The estimated capital charge decline to 6.6 and 8.6 percent if only project loans for PPPs are considered.
6/ The estimated capital charge decline to 1.5 and 2.2 percent if only project loans for PPPs are considered.
7/ This marginal trade-off assumes that the investment in project loans does not affect overall capital adequacy (i.e., the capital intensity is either the same as the prevailing capital intensity of the bank’s balance sheet or the bank increases the potentially higher capital consumption by means of additional capital.

Even modest reductions in capital charges have a significant impact on capital efficiency, resulting in a higher return on equity (RoE) of infrastructure investments under a differentiated regulatory treatment. The investment in infrastructure is only attractive if the costs associated with investing in debt securities or originating and servicing project loans are not overly onerous for the insurer and generate returns that are commensurate to (and potentially exceed) the cost of capital required to satisfy minimum prudential requirements. A balance is required between the economic benefits of the asset class (and its associated unexpected losses from credit risk) and the difficulty of implementing the actual investment, including the capital intensity, which may erode any potential gains.

We examine the potential returns from infrastructure investment as a function of capital charges to illustrate the trade-off insurers would need to make if they are faced with a choice of investing in infrastructure project loans and infrastructure debt securities. We find that infrastructure exposures can provide competitive expected returns to investors (after controlling for regulatory capital requirements), especially after considering a differentiated regulatory treatment under standardized approaches:
Solvency II—For a differentiated regulatory treatment, at an annualized yield of 4.6 percent, the decline of the capital charge from 23.5 percent for project loans in EMDEs over a 10-year risk horizon (according to the standard formula for spread risk of corporate exposures; see Figure 12, purple line) to about 15 percent raises the RoE to about 16 percent. This is more than 50 percent above the median RoE of European insurers in 2016 (EIOPA, 2017a). Similarly, recalibrating the risk factors to a lower capital charge for rated infrastructure exposures in EMDEs, consistent with the actual credit performance of “Baa/BBB”-rated infrastructure debt securities, would increase RoE to about 16.5 percent (Appendix Figure 19). Higher expected returns would also encourage portfolio re-balancing of insurers away from conventional investments, such as government bonds, which generate almost the same RoE after controlling for lower capital intensity.

Insurance Capital Standard (ICS)—We illustrate the same trade-off between the current and differentiated regulatory treatment of infrastructure investment in the context of the ICS. We find that reduction of the current capital charge of 12.7 percent for project loans in EMDEs over a 10-year risk horizon (according to the planned credit risk stress factor for corporate exposures using the adapted Vasiček (2002) model with actual recovery rates (IAIS, 2017b) to about 6 percent (based on a differentiated capital charge of project loans in EMDEs) raises the RoE to 43 percent (Appendix Figure 20); there would still be a substantial increase of RoE even if the recovery rate assumption were restricted to a fixed LGD of 45 percent in line with the foundation IRB approach under Basel III). Similarly, recalibrating the risk factors for rated infrastructure exposures in EMDEs based on the actual credit performance of “Baa/BBB”-rated infrastructure debt securities would increase the RoE by 21 percent to about 60 percent (see Appendix Figure 21).

Of course, this is a highly stylized illustration of regulatory capital efficiency since many insurers would apply internal models for their calibration of capital charges. However, this analysis provides an important comparative perspective on the proportionality of standardized approaches for smaller insurers, which might lack internal models for assessing the credit risk profile of infrastructure exposures, and can guide the cross-validation of internal models by supervisors. Our findings also facilitate the capital assessment of infrastructure investment by other long-term institutional investors, such as pension funds.

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76 Under the current risk reduction factor of qualifying infrastructure investment in EEA or OECD member countries, the capital charge would be 20.0 percent over a 10-year risk horizon (see Table 4).

77 See also Appendix Figure 18.
These empirical findings offer a nuanced perspective on the credit risk dynamics of infrastructure investment against the background of an evolving regulatory environment for insurance companies. The consideration of a more differentiated regulatory treatment of project loans and infrastructure debt securities represents a timely contribution to the current development of both Solvency II and ICS:

- **Solvency II**—EIOPA has started the public consultation on a draft technical advice for the second phase of the Review of the Solvency Capital Requirement (SCR) Standard Formula under Solvency II in November 2017 (“second set of advice”). The review process solicits comments and suggestions on (i) potential simplifications and proportionate application of the SCR requirements; (ii) the removal of technical

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76 The review aims to (i) ensure a proportionate and technically consistent supervisory regime for (re)insurance undertakings and (ii) consider possible simplifications in the SCR standard formula and to ensure the proportionate application of the requirements. See also [https://eiopa.europa.eu/regulation-supervision/insurance/scr-standard-formula-review](https://eiopa.europa.eu/regulation-supervision/insurance/scr-standard-formula-review).

79 This follows the publication of the “First Set of Advice to the European Commission on Specific Items in the Solvency II Delegated Regulation” (EIOPA, 2017a) in October 2017.

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inconsistencies, i.e., recalibration of certain risks and other technical issues; and (iii) the removal of unjustified constraints to financing. Our analysis of the credit performance of project loans, and its implications for consistent regulatory treatment of infrastructure finance, is closely related to the review of the current prudential requirements for unrated debt as well as unlisted equity under the standard formula of Solvency II. 

- **Insurance Capital Standard (ICS)**—The IAIS is about to complete the calibration of the credit risk stress factors for the next version of the ICS (“ICS Version 2.0”), which will establish the group-wide, consolidated solvency assessment for internationally active insurance groups (IAIGs) and global systemically important insurers (G-SIIs) after 2019. The **Capital, Solvency and Field Testing Working Group (CSFWG)** of the IAIS will start the field testing exercise of ICS Version 2.0 by mid-2018, which could consider revised risk factors for infrastructure exposures.

Our findings suggest that a more differentiated regulatory treatment of both rated and unrated infrastructure debt under both Solvency II and ICS might be warranted.

- **Solvency II**—Greater regulatory nuance in the treatment of infrastructure finance beyond the current restriction to “qualifying investments” in EEA or OECD member countries would entail (i) changes in the standard parameters in the **Spread Risk Sub-Module of the Standard Formula** and (ii) widening the geographical scope of risk reduction in the capital assessment to EMDEs. In addition, EIOPA could consider amending the current requirement of contractually guaranteed revenues for “qualifying infrastructure investment” in line with the definition of “high quality project finance” in the finalized Basel III framework (BCBS, 2017); this would bring within the scope of “qualifying infrastructure investment” also projects that have a high degree of contractual certainty but lack availability-based revenue streams (or do not benefit from explicit government support)—a situation that is more common for infrastructure projects in EMDEs. Projects could meet agreed performance levels through alternative contractual

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80 The second set includes the following items arising from the calls for technical advice: risk margin, simplifying the look-through approach, policy options on loss-absorbing capacity of deferred taxes, premium and reserve risks, catastrophe risks, mortality and longevity risks, counterparty default risk, currency risk at group level, interest rate risk, own funds, unrated bonds and loans, unlisted equity and strategic participations.

81 Only a small portion of project loans in EMDEs are availability-based; however, especially in the power generation sector, government guarantees and feed-in tariffs help reduce the contingencies of volume-based revenues. This is reflected in the superior credit performance of project loans PPP projects. While availability-based projects eliminate the impact of demand risk from project loans, and, thus, have a better credit performance, it might also create incentives for operators to neglect maintenance and upkeep, which might in some cases also lead to higher default risk and/or lower recovery rates. In addition, if payments are based on availability rather than demand, charges may be linked fully or partially to inflation.
arrangements that mitigate demand and/or price risk, which would provide a high degree of contractual certainty about repayment from future revenues.\textsuperscript{82}

- **Insurance Capital Standard (ICS)**—The differentiated treatment of infrastructure debt could be included in the calibration of the credit risk factor for corporate exposures under ICS—possibly in combination with further data collection\textsuperscript{83} and technical consultations prior to the final calibration of ICS before the end of 2019. The data collection would help assess the impact of the credit risk factors proposed in this paper (and the feasibility of additional differentiation by industry sector, geography and/or other characteristics). Given the high degree of recovery in infrastructure projects (albeit at high cross-sectional variability), the calibration of the capital charge should reflect actual recovery rates of infrastructure debt in lieu of the standard recovery assumption for corporate exposures in the current calibration of ICS.\textsuperscript{84} In addition, the IAIS could introduce a separate treatment for “qualifying infrastructure investment” consistent with the definition of “high quality project finance” in Basel III (BCBS, 2017; see Appendix, Glossary), which would result in a further reduction of capital charge for unrated exposures. While a geographical distinction (such as in Solvency II) might not necessarily be required, a potentially lower capital charge for “high quality project finance” could distinguish projects in advanced economies from those in EMDEs.

\section*{IV. CONCLUSION}

Infrastructure projects generate predictable and resilient revenue streams over the long term, especially where contractual arrangements mitigate price and/or demand risks. Thus, infrastructure investment is a very good match for the long-dated liabilities of insurance companies, especially for those offering life insurance and annuity products. Creating an

\textsuperscript{82}This would include contracts that are either (i) predominantly availability based but contain some use based component or (ii) offer guaranteed returns on equity, including guaranteed electricity prices for alternative energy generation (i.e., “feed-in tariffs”).

\textsuperscript{83}The data collection should be sufficiently granular to support a cohort-based analysis of credit performance (i.e., marginal default risk and recovery rate) of a geographically diverse sample of infrastructure debt and project loans in both advanced and developing countries and include controls for sample selection bias (e.g., composition effects due to country selection and the endogeneity of maturity choice). For the full specification of an economic capital model, the data should also cover the cross-sectional variation of credit risk measures to estimate expected losses at different levels of statistical confidence.

\textsuperscript{84}Note that the current LGD assumption of 45 percent represents the through-the-cycle (TTC) recovery rate of unsecured corporate exposures used in the Basel III framework (BCBS, 2017), which is conceptually consistent with the ultimate recovery rate published by Moody’s Investors Service (2017g) used in our analysis (based on the determination of LGD after emergence from default (see Appendix, Glossary)). However, the ultimate recovery rates do not account for lower recovery in distressed sales (reflecting a market-consistent approach for the valuation of credit-sensitive assets under stress); further analysis and data collection might be required to ensure conceptual consistency of recovery assumptions in the existing calibration approach for credit risk in ICS.

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enabling regulatory environment for infrastructure investment can help mobilize long-term finance from insurance companies, and, thus, gives critical support to sustainable development, especially in EMDEs, where gaps in infrastructure investment are particularly large. However, so far, the lack of sufficient data on the credit performance of project finance has hindered a more differentiated regulatory treatment of infrastructure as a separate asset class in most solvency regimes.

In this paper, we used new data on the historical default experience of infrastructure debt securities and project loans. Infrastructure debt in both advanced and developing economies exhibited distinctly positive credit risk characteristics. Losses in infrastructure projects during the construction phase ("greenfield") resulted in default rates of project finance that were higher than those for corporate debt investment; but they tended not to be substantial enough to make them less attractive than corporate exposures. The marginal default rates improved steadily over time and reached investment grade level in less than five years after financial close, which implied a non-linear relationship between the remaining maturity and credit risk. However, the “hump-shaped” default risk profile of infrastructure debt also indicated that getting projects to (and through) the start-up phase may require interventions during the three phases of the project life-cycle, including an active role for development banks and governments in (i) helping to build a pipeline of bankable projects that satisfy well-identified demand and (ii) de-risking projects through revenue guarantees to reduce counterparty risk (World Bank, 2015, pp. 85f).

Our findings suggest a significant reduction in the capital charges for insurance companies if infrastructure debt were treated separately from general corporate debt exposures in standardized approaches. Based on the implied default and recovery rates, we calculated a differentiated capital charge based on existing prudential methodologies under two solvency regimes (ICS and Solvency II), differentiating the properties of infrastructure debt from those of corporate exposures, whose credit performance underpins the current specification of standardized approaches. The declining downgrade risk of infrastructure debt—together with a high recovery rate (comparable to that of senior secured corporate loans)—would significantly reduce capital charges if standardized approaches recognized infrastructure as a separate asset class.

The potential reduction of capital charges might entail important general equilibrium effects. If a differentiated regulatory treatment of infrastructure debt releases capital, greater demand might push investors towards riskier projects at the margin. Given the limited supply of bankable infrastructure projects, this could raise the average credit risk of infrastructure debt above the expected losses from the historical default experience used for the calibration of capital charges in this paper. While the aggregate effect from a supply shock is difficult to estimate and outside the scope of the analysis, it underscores that adjustments to minimum capital requirements require regular supervisory review to ensure that prudential standards are consistent with actual credit risk and changing risk-taking behavior of regulated entities.

Our findings offer an important perspective on the credit risk dynamics of infrastructure investment against the background of an evolving regulatory environment. Any reduction of
the capital charge under standardized approaches is arguably more relevant for small investors that do not have the capacity to develop internal models; however, it also informs the prudential review of internal models developed by larger insurers, encouraging enhanced data collection and risk analysis. The IAIS is in the process of field testing the current calibration of the credit risk factors for rated and unrated debt exposures in the next version of ICS in 2018 before completing the specification of ICS in 2019 (after a final round of field testing). Similarly, the EIOPA is completing the public consultation on the second phase of the Review of the Solvency Capital Requirement (SCR) Standard Formula under Solvency II, which also includes an assessment of unrated investment exposures. In both areas, our results could support considerations aimed at establishing infrastructure as a separate asset class with a differentiated capital assessment. This would also have a signaling effect for other institutional investors, such as pension funds, for which the predictable revenue streams from infrastructure finance provides a natural match for their long-term liabilities.

Although regulatory disincentives may be just one of several impediments to efficient infrastructure finance, they are interwoven with many structural challenges impacting prudential standards. Prudential regulation and its impact on access to private capital is not a binding constraint in most countries but changes in monetary conditions and greater demand for capital are likely to change this situation. In addition, high quality infrastructure projects, as a potential requirement for a differentiated capital treatment (such as in the case of Solvency II), depend on the resolution of key bottlenecks, such as (i) uncertainty in industry regulation and political environment as well as (ii) insufficient project development capacity for sustainable infrastructure. In many EMDEs, there is limited institutional capacity to identify high quality

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85 Extensions of our work could include similar analysis of other solvency regimes, such as the risk-based capital (RBC) framework in the United States (which is featured in Appendix, Box A3 and Appendix Table 7; see also http://www.naic.org/cipr_topics/topic_risk_based_capital.htm) as well as the solvency margin ratio framework for Japanese insurers (see https://www.fsa.go.jp/en/refer/ins/capital.html). In addition, the empirical basis of our calibration effort, which is based on the historical credit performance of project loans drawn from Moody’s Analytics Data Alliance Project Finance Consortium, could be supplemented with similar information from the S&P Global Market Intelligence’s Project Finance Consortium (Gevero and Baker, 2016). The database warehouses project credit performance data dating back to 1980 and included 7,959 projects—624 defaulted and 377 resolved originated globally as of end-2014. Similarly, data from project lending by international financial institutions (IFIs) would help assessing any difference in credit performance due to the preferred creditor status (PCS) of public lenders. The Global Emerging Markets (“GEMs”) Risk Database Consortium is the world’s largest default and loss database for the IFIs’ business in EMDEs. GEMs was established in 2009 as a joint effort between the European Investment Bank (EIB) and the International Finance Corporation (IFC) of the World Bank Group to pool credit performance data of project lending into a comprehensive credit risk database. The GEMs database combines almost 30 years of investment experience with sovereign, public and private counterparts across different loan types. As of the end of 2016, the GEMs database comprised about 8,300 borrowers, 1,700 default events and 1,900 resolved contracts, making it the world’s largest default and loss database on project lending by IFIs in EMDEs. This represents a real alternative to the statistics published by rating agencies and conforms with the regulatory framework for banks and insurance companies. See http://www.gems-riskdatabase.org/about-gems/index.htm.

86 Political, legal and regulatory uncertainty affecting, for instance, the enforcement of claims, often prevents capital flows from aligning with increasing trade openness in EMDEs if infrastructure is funded by cross-border investors.
infrastructure projects and making them financially viable by designing and adopting sound business models.  

The evolution of these regulations in line with actual credit performance can be an important step forward in re-orienting capital towards more sustainable investments.

By increasing the rate of return of holding infrastructure-linked instruments, a differentiated regulatory treatment may help insurers (and other institutional investors) rebalance their asset portfolios over time towards infrastructure projects. Greater differentiation of infrastructure finance could also help shift demand for long-dated infrastructure investment away from banks to insurance companies. The complementary funding structure and risk appetite of banks and long-term investors, such as insurance companies, suggests blending different sources of finance to support an efficient use of capital and risk sharing. The balance sheet structure of long-term investors is more amenable to the stable funding of operational projects that provide tangible collateral and generate stable revenues; banks would retain incentives to lend during the riskier, initial (construction) phase of infrastructure projects—and throughout the life of the project as liquidity back-stop, for instance, to mitigate the nominal impact of currency shocks to foreign currency-denominated funding.

In addition to providing stable and long-term revenue, infrastructure is inherently beneficial to the insurance model, especially as an effective way to address risks brought by climate change. Climate-related risk will increasingly exert pressure on infrastructure and capital project integrity (Jackson, 2018), which will also require regulatory requirements being closely aligned with the actual credit performance when committing public resources and investment capital. Much as insurers often address the risk of their health liabilities by investing in health providers, insurers’ exposure to climate change may be mitigated by investing in climate-friendly infrastructure (which might also benefit from their underwriting experience in infrastructure projects). Decisions about climate-smart infrastructure investment in energy and transportation in EMDEs will have a strong impact on global warming in the next decades and influence the impact of transition risks on the valuation of investments across many industry sectors. Reducing this impact will help mitigate the risk of sudden depreciation of many existing assets that support insurers’ current liabilities (“stranded assets”), which strengthens institutional resilience and increases the potential attractiveness of investing in these assets.

Going forward, the insurance industry will be critical to mobilizing private capital for development if regulations governing their investment activities evolve to acknowledge the diversification benefits infrastructure finance can bring to larger portfolios. This would also elevate the credit risk analysis of infrastructure investment from a project-specific to a portfolio

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87 In the context of upgrading project development capacity at the national and local levels, the High-Level Expert Group on Sustainable Finance (European Commission, 2018) recommends the use of standardized PPP contract to lower transaction costs and ensure more predictability in project deals – from the construction phase through service delivery to termination of contracts.
perspective as a precondition for the recognition of infrastructure as a separate asset class, reflecting the complementarity of banks and long-term investors in blending sources of finance.\textsuperscript{88}

\textsuperscript{88} To broaden access to long-term funding for infrastructure beyond a limited number of sponsoring and arranging banks and insurance companies, EMDEs should further develop their domestic markets by addressing market failures and policy shortcomings. Market development benefits from a sound macroeconomic environment, institutional stability and legal certainty, and a diversified financial sector that efficiently channels savings to investments.
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Cumulative default rates are calculated from the weighted average marginal default rates (hazard rates) for all cohorts, based on the methodology described in Section 7.1 (Cohort Analysis: 1990-2015) in Moody’s Investors Service (2017c).

Defaults are identified based on the definition of default in paragraphs 220 and 221 of the recently finalized Basel III framework (BCBS, 2017, p. 93):

“...
220. A default is considered to have occurred with regard to a particular obligor when either or both of the two following events have taken place:
• The bank considers that the obligor is unlikely to pay its credit obligations to the banking group in full, without recourse by the bank to actions such as realizing security (if held).
• The obligor is past due more than 90 days on any material credit obligation to the banking group. [In the case of retail and PSE obligations, for the 90-days figure, a supervisor may substitute a figure up to 180 days for different products, as it considers appropriate to local conditions.] Overdrafts will be considered as being past due once the customer has breached an advised limit or been advised of a limit smaller than current outstandings.

221. The elements to be taken as indications of unlikeliness to pay include:
• The bank puts the credit obligation on non-accrued status.
• The bank makes a charge-off or account-specific provision resulting from a significant perceived decline in credit quality subsequent to the bank taking on the exposure.
• The bank sells the credit obligation at a material credit-related economic loss.
• The bank consents to a distressed restructuring of the credit obligation where this is likely to result in a diminished financial obligation caused by the material forgiveness, or postponement, of principal, interest or (where relevant) fees.
• The bank has filed for the obligor’s bankruptcy or a similar order in respect of the obligor’s credit obligation to the banking group.
• The obligor has sought or has been placed in bankruptcy or similar protection where this would avoid or delay repayment of the credit obligation to the banking group.
...”

For a defaulted loan, emergence from default is deemed to occur following any of the following events: (i) repayment of overdue interest, (ii) restructuring with no subsequent default, (iii) restructuring with lender being taken out of the deal – for example, by repayment of the defaulted loan with no participation in a restructured debt facility, (iv) material restructuring, and (v) liquidation.

The European Economic Area (EEA) is the area in which the agreement on the EEA provides for the free movement of persons, goods, services and capital within the European Single Market. The EEA includes the 28 member countries of the European Union and Norway, Iceland and Liechtenstein. For additional information and a list of all EU Member States, see http://www.efta.int/eea and https://europa.eu/european-union/about-eu/countries_en.

The marginal default rate (hazard rate) is the ratio of the number of project defaults in a specific time period divided by the number of projects exposed to the risk of default at the beginning of that time period. For the purposes of this Study, marginal default rates have been calculated on a monthly basis.

89 The definition has remained unchanged relative to the one in the Basel II framework (BCBS, 2006).
OECD
The Organization for Economic Co-operation and Development (OECD) currently has 35 member countries: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

Project Finance
In the Basel III framework, project finance is defined as (BCBS, 2017, pp. 14 and 54f):

“44. A corporate exposure will be treated as a special[zed] lending exposure if such lending possesses some or all of the following characteristics, either in legal form or economic substance:

• The exposure is not related to real estate and is within the definitions of object finance, project finance or commodities finance under paragraph 45. If the activity is related to real estate, the treatment would be determined in accordance with paragraphs 59 to 75;

• The exposure is typically to an entity (often a special purpose vehicle (SPV)) that was created specifically to finance and/or operate physical assets;

• The borrowing entity has few or no other material assets or activities, and therefore little or no independent capacity to repay the obligation, apart from the income that it receives from the asset(s) being financed. The primary source of repayment of the obligation is the income generated by the asset(s), rather than the independent capacity of the borrowing entity; and

• The terms of the obligation give the lender a substantial degree of control over the asset(s) and the income that it generates.

45. Exposures described in paragraph 44 will be classified in one of the following three subcategories of special[zed] lending:

(i) Project finance refers to the method of funding in which the lender looks primarily to the revenues generated by a single project, both as the source of repayment and as security for the loan. This type of financing is usually for large, complex and expensive installations such as power plants, chemical processing plants, mines, transportation infrastructure, environment, media, and telecoms. Project finance may take the form of financing the construction of a new capital installation, or refinancing of an existing installation, with or without improvements.

(ii) Object finance refers to the method of funding the acquisition of equipment (e.g., ships, aircraft, satellites, railcars, and fleets) where the repayment of the loan is dependent on the cash flows generated by the specific assets that have been financed and pledged or assigned to the lender.

(iii) Commodities finance refers to short-term lending to finance reserves, inventories, or receivables of exchange-traded commodities (e.g., crude oil, metals, or crops), where the loan will be repaid from the proceeds of the sale of the commodity and the borrower has no independent capacity to repay the loan.”

[...]

“10. The five sub-classes of special[zed] lending (SL) are project finance, object finance, commodities finance, income-producing real estate, and high-volatility commercial real estate. Each of these sub-classes is defined below.

Project finance
11. Project finance (PF) is a method of funding in which the lender looks primarily to the revenues generated by a single project, both as the source of repayment and as security for the exposure. This type of financing is usually for large, complex and expensive installations that might include, for example, power plants, chemical processing plants, mines, transportation infrastructure, environment, and telecommunications infrastructure. Project finance may take the form of financing of the construction of a new capital installation, or refinancing of an existing installation, with or without improvements.

12. In such transactions, the lender is usually paid solely or almost exclusively out of the money generated by the contracts for the facility’s output, such as the electricity sold by a power plant. The borrower is usually an SPE that is not permitted to perform any function other than developing, owning, and operating the installation. The consequence is that repayment depends primarily on the project’s cash flow and on the collateral value of the project’s assets. In contrast, if repayment of the exposure depends primarily on a well-established, diversified, credit-worthy, contractually obligated end user for repayment, it is considered a secured exposure to that end-user.

**High Quality Project Finance (Basel III Framework)**

In the Basel III framework, “high quality project finance” is defined as (BCBS, 2017, p. 14):

“A high quality project finance exposure refers to an exposure to a project finance entity that is able to meet its financial commitments in a timely manner and its ability to do so is assessed to be robust against adverse changes in the economic cycle and business conditions. The following conditions must also be met:

- The project finance entity is restricted from acting to the detriment of the creditors (e.g., by not being able to issue additional debt without the consent of existing creditors);
- The project finance entity has sufficient reserve funds or other financial arrangements to cover the contingency funding and working capital requirements of the project;
- The revenues are availability-based or subject to a rate-of-return regulation or take-or-pay contract;
- The project finance entity’s revenue depends on one main counterparty and this main counterparty shall be a central government, PSE or a corporate entity with a risk weight of 80% or lower;
- The contractual provisions governing the exposure to the project finance entity provide for a high degree of protection for creditors in case of a default of the project finance entity;
- The main counterparty or other counterparties which similarly comply with the eligibility criteria for the main counterparty will protect the creditors from the losses resulting from a termination of the project;
- All assets and contracts necessary to operate the project have been pledged to the creditors to the extent permitted by applicable law; and
- Creditors may assume control of the project finance entity in case of its default.”

**Qualifying Infrastructure Investment (Solvency II Directive)**

According to EU Regulation 2016/467 (European Commission, 2016) of April 2, 2016, which was amended by EU Regulation 2017/1542 (European Commission, 2017) (in the context of separate provisions for the regulatory treatment of infrastructure corporates) and became effective on September 14, 2017, “qualifying infrastructure investment” is defined as follows:
“Qualifying infrastructure investment shall include investment in an infrastructure project entity [i.e., an entity or corporate group which, during the most recent financial year of that entity or group for which figures are available or in a financing proposal, derives the substantial majority of its revenues from owning, financing, developing or operating infrastructure assets] that meets the following criteria:

(a) the cash flows generated by the infrastructure assets [i.e., physical assets, structures or facilities, systems and networks that provide or support essential public services] allow for all financial obligations to be met under sustained stresses that are relevant for the risks of the project;

(b) the cash flows that the infrastructure entity generates for debt providers and equity investors are predictable;

(c) the infrastructure assets and infrastructure entity are governed by a regulatory or contractual framework that provides debt providers and equity investors with a high degree of protection including the following:

   (a) the contractual framework shall include provisions that effectively protect debt providers and equity investors against losses resulting from the termination of the project by the party which agrees to purchase the goods or services provided by the infrastructure project, unless one of the following conditions is met:

      a. the revenues of the infrastructure entity are funded by payments from a large number of users; or

      b. the revenues are subject to a rate-of-return regulation;

   (b) the infrastructure entity has sufficient reserve funds or other financial arrangements to cover the contingency funding and working capital requirements of the project;

Where investments are in bonds or loans, this contractual framework shall also include the following:

(i) debt providers have security or the benefit of security to the extent permitted by applicable law in all assets and contracts that are critical to the operation of the project;

(ii) the use of net operating cash flows after mandatory payments from the project for purposes other than servicing debt obligations is restricted;

(iii) restrictions on activities that may be detrimental to debt providers, including that new debt cannot be issued without the consent of existing debt providers in the form agreed with them, unless such new debt issuance is permitted under the documentation for the existing debt;

Notwithstanding point (i) of the second subparagraph, for investments in bonds or loans, where undertakings can demonstrate that security in all assets and contracts is not essential for debt providers to effectively protect or recover the vast majority of their investment, other security mechanisms may be used. In that case, the other security mechanisms shall comprise at least one of the following:
pledge of shares;
(ii)  step-in rights;
(iii) lien over bank accounts;
(iv)  control over cash flows;
(v)  provisions for assignment of contracts;

(d) where investments are in bonds or loans, the insurance or reinsurance undertaking can demonstrate to the supervisor that it is able to hold the investment to maturity;

(e) where investments are in bonds or loans for which a credit assessment by a nominated ECAI is not available, the investment instrument and other pari passu instruments are senior to all other claims other than statutory claims and claims from liquidity facility providers, trustees and derivatives counterparties;

(f) where investments are in equities, or bonds or loans for which a credit assessment by a nominated ECAI is not available, the following criteria are met:

(i)  the infrastructure assets and infrastructure entity are located in the EEA or in the OECD; 14.9.2017 L 236/16 Official Journal of the European Union EN

(ii)  where the infrastructure project is in the construction phase the following criteria shall be fulfilled by the equity investor, or where there is more than one equity investor, the following criteria shall be fulfilled by a group of equity investors as a whole:

— the equity investors have a history of successfully overseeing infrastructure projects and the relevant expertise,

— the equity investors have a low risk of default, or there is a low risk of material losses for the infrastructure entity as a result of their [the, sic.] default,

— the equity investors are incentive[ed] to protect the interests of investors;

(iv)  where there are construction risks, safeguards to ensure completion of the project according to the agreed specification, budget or completion date;

(v)  where operating risks are material, they are properly managed;

(vi)  the infrastructure entity uses tested technology and design;

(vii) the capital structure of the infrastructure entity allows it to service its debt;

(viii) the refinancing risk for the infrastructure entity is low;

(ix)  the infrastructure entity uses derivatives only for risk-mitigation purposes.”

| Public-Private Partnership (PPP) | A public sector procurement structured as a Public-Private Partnership. There is no standard definition of what constitutes a PPP. A PPP is often defined as a long-term contractual agreement between a public sector governmental entity and a private developer to design, build, finance, operate and/or maintain an infrastructure asset |
for a specific period. These partnerships allow a government entity to grant a
concession or right to a private consortium to design, develop, build, operate and
maintain an infrastructure asset. The classification of a project as a PPP project is
based on its classification by the Moodys Analytics Data Alliance Project Finance
Consortium and involves some subjectivity.

| Ultimate Recovery | A default for which a recovery has been realized following the emergence from
default (which has been specifically defined by the Moodys Analytics Data Alliance
Project Finance Consortium; see above). This is deemed to occur following any of
the following events: (i) repayment of overdue interest; (ii) restructuring with no
subsequent default; (iii) restructuring with lender being taken out of the deal – for
example, by repayment of the defaulted loan with no participation in a restructured
debt facility; and (iv) material restructuring; and (v) liquidation. This definition of
recovery contrasts with that of recoveries for distressed sales, which is based on the
30-day post-default trading prices (Moodys Investors Service, 2009). The use of
post-default trading prices to measure recovery is common practice in the credit
default swap market and are most relevant for bond investors who liquidate their
holdings shortly after default, as often required by their portfolio governance rules,
and their own investment objectives (Moodys Investors Service, 2018).

| World Bank Group Country Classification | In the World Development Indicators database (and most other time series
datasets), all 189 World Bank member countries, plus 28 other economies with
populations of more than 30,000, are classified so that data users can aggregate,
group, and compare statistical data of interest, and for the presentation of key
statistics. The main classifications provided are by geographic region, by income
group, and by the operational lending categories of the World Bank Group.
Economies are currently divided into four income groupings: low, lower-middle,
upper-middle, and high. Income is measured using gross national income (GNI)
per capita, in U.S. dollars, converted from local currency using the World Bank
Atlas method. Countries are immediately reassigned on July 1 each year, based on
the estimate of their GNI per capita for the previous calendar year. Income
groupings remain fixed for the entire fiscal year (i.e., until July 1 of the following
year), even if GNI per capita estimates are revised in the meantime. The term
country, used interchangeably with economy, does not imply political
independence but refers to any territory for which authorities report separate social
or economic statistics.

For the fiscal year 2017, the World Bank Group defines low-income economies as
those with a gross national income (GNI) per capita of $1,025 or less in 2015;
lower-middle-income economies as those with GNI per capita between $1,026 and
$4,035; upper-middle-income economies are those with a GNI per capita between
$4,036 and $12,475; high-income economies are those with a GNI per capita of
$12,476 or more (World Bank Group, 2017b).
VII. BOXES

Box A1. The Impact of Low Interest Rates on Insurance Activities (from Jobst and others, 2014)

Unlike banks, which benefit from lower funding costs due to declining short-term interest rates and the likely widening of term spreads, the opposite is true for insurance companies, which do not engage in term and liquidity transformation but invest reserves that are pre-funded by premium payments from policyholders. In most cases (except for most non-life insurance business lines), the duration of liabilities exceeds that of available investment assets (i.e., negative duration gap). Thus, insurers face rising re-investment risk if returns from liability-matched investments decline.

The adverse impact of low interest rates varies by the balance sheet structure and the type of business. Interest rate risk of existing policies (i.e., the legacy book) in life insurance can be significant as future premiums cannot be changed to reflect lower investment returns and the higher value of interest-dependent assets can usually not compensate for the higher present value of liabilities due to the “short-long mismatch.” If the duration of liabilities exceeds that of assets, and interest rates decline, lower investment income increases the insurer’s dependence on underwriting performance and/or could encourage greater risk-taking (once gains from higher yielding assets have been realized).\(^1\) Low interest rates would require insurers to either increase premiums for the same expected future claims payments or lower guarantees to policyholders lest they risk reducing future earnings. While there are usually no tight substitutes for insurance, and setting higher premium rates should be theoretically possible, in practice, insurers would be reluctant to change their pricing conditional on investment returns.

Both life and non-life insurers would need to take lower investment returns into account in the pricing of new underwriting. However, low interest rates are unlikely to have a serious solvency impact on non-life business (in particular for protection-oriented product lines) in absence of negative demand effects and lower expenses due to low inflation expectations. Similarly, some life insurance products (mortality, disability, and long-term care) have more protection features than saving features and do hardly have substitutes. These protection-oriented features would allow insurers to compensate lower investment returns with higher risk charges. However, demand for those less vulnerable businesses (protection-oriented life products, property and casualty) is still inherently susceptible to economic conditions and is likely to decline during recessions (which tend to trigger a relaxation of monetary conditions (and lower interest rates)).

Insurance supervisors have identified the current environment of low interest rates as a major risk for the life insurance industry (EIOPA, 2013a). Despite these concerns, a quantification of the risk is not easily available even for those markets where long-term guarantees are a predominant feature of life insurance contracts.

Note:

\(^1\) This situation is potentially aggravated by a higher substitutability of some life insurance products and negative demand effects impacting premium income from life insurance due to lapse risk.
Box A2. Impact of Banking Regulation on Infrastructure Finance

In the wake of the global financial crisis, comprehensive financial regulatory reforms have been introduced by G20 countries with a view to making the global financial system safer and more resilient to better serve the real economy.\(^1\) While the global benefits of these reforms are expected to outweigh the costs significantly, their adoption may have unintended consequences at the country level—the topic of this event. Hence, it becomes increasingly important to monitor any cross-border spillover effects, especially EMDEs that are not required to implement these reforms but may be affected nonetheless.

Given the bank dominance in most financial systems in EMDEs, higher capital and liquidity requirements for specialized bank lending (such as project finance),\(^2\) financial regulatory reforms in the banking sector have a significant impact on infrastructure finance—and also illustrate how unintended effects might arise from otherwise conceptually plausible reforms. Basel III reforms penalize long-term project finance as a non-recourse financing technique for investment projects based on projected cash flows (in the standardized approach for solvency and in the calibration of cash flow/funding stability factors of standard liquidity risk measures).\(^3\)

In addition, the move towards a more “one-size-fits-all” approach may adversely affect infrastructure finance by not accounting for inherent risk mitigating factors of projects, such as its ring-fenced structure or the lender’s access to the project’s cash flows or assets. The reliance on external credit ratings to calculate risk weights may also affect entities in EMDEs, which are less likely to be rated or have insufficient history to calculate reliable default probabilities. Finally, current regulatory reforms (including the collateral requirements for OTC derivatives and higher capital intensity of trading assets) may increase hedging costs that may pose an additional impediment to effective longer-term finance.

Thus, a more stringent regulatory treatment of infrastructure – directly or indirectly – could limit the ability of development organizations to crowd-in the private sector as both financier and implementer for commercially viable infrastructure investments.\(^4\)

Note:

1/ These reforms comprise (i) more stringent capital and liquidity requirements for banks (including revisions to the securitization framework, the treatment of market risk, and resolution), (ii) measures to deal with financial institutions that are systemically important, and \textit{over-the-counter} (OTC) derivatives.
2/ Additional aspects of reforms are relevance: (i) constraints on trade finance for SMEs, and (ii) the lack of credit ratings for (smaller) corporates in EMDEs raising banks’ capital charges for lending to them.
3/ More specifically, these include three elements of the Basel III framework (BCBS, 2017). First, the liquidity coverage ratio (LCR), which will be more stringent with contractual “committed facilities” granted to project finance than for other types of financing. The second one is the \textit{net stable funding ratio} (NSFR), which restricts the maturity mismatch for lending in tenors above one year. Under this provision, banks with limited access to medium/long-term funding would face strong restrictions to participate in project finance requiring long tenors. The third risk indicator relates to tighter limits for large exposures, which may limit the participation of relatively small banks in project finance, as projects are generally large (Garcia-Kilroy and Rudolph, 2017). The approach relies inter alia on adopting new financial solutions, such as guarantees, which help de-risk private sector exposures.
So far, the lack of sufficient data on the credit performance of project finance has hindered a more nuanced regulation of infrastructure investment in most insurance solvency regimes. Data limitations have not only constrained the economic risk assessment but have also held back efforts to develop a more nuanced regulatory treatment. Data constraints are particularly acute for infrastructure projects in emerging market and developing economies (EMDEs), where aggregate statistics of the historical credit dynamics are scarce. Thus, it is unlikely that the regulatory treatment of infrastructure investment will change without a comprehensive risk analysis of reliable credit performance data and an associated calibration exercise.

In 2015, European regulators were first to formally acknowledge the importance of infrastructure finance as long-term investment for insurers and introduced a reduced capital charge for infrastructure investments outside the general capital requirements for bonds and loans (European Commission, 2015). Following the advice of the European Insurance and Occupational Pension Authority (EIOPA, 2013), which performed a comprehensive analysis of historical data of the credit risk of infrastructure investments, in September 2016, the European Commission revised down the standard formula capital charges for “qualifying infrastructure investments” (debt and equity) in the Solvency II Directive. For infrastructure debt, the re-calibration resulted in a significant capital relief relative to equivalent corporate bonds and loans under the spread risk sub-module. However, this favorable regulatory treatment for infrastructure on both the asset and liabilities side of the balance sheet remains restricted to investments in countries that are members of either the European Economic Area (EEA) or the Organization for Economic Co-operation and Development (OECD). So, infrastructure projects in many EMDEs do not benefit.

Outside Europe, the regulatory treatment of infrastructure investments is less advanced. In the United States, the regulatory capital treatment of credit risk under the risk-based capital (RBC) framework is based on standard NAIC ratings (and associated risk factors), which do not recognize infrastructure debt as separate asset class. Moreover, the application of similar regulatory capital treatment does not capture lower return volatility (especially in private markets) of infrastructure projects.

Recently, as a first step towards specifying a comprehensive analytical approach to assessing capital requirements for infrastructure investments, the Valuation of Securities Task Force and the Securities Valuation Office (SVO) of the NAIC (2017), in cooperation with the insurance industry, have started developing methodologies to evaluate power-generating infrastructure projects (“Power Generation/Renewable Power Projects Methodology”) with a view to amending the Purposes and Procedures Manual of the NAIC Investment Analysis Office. It also provides a framework against which insurers can evaluate the regulatory impact should such transactions occur (Karapiperis, 2017).

At the international level, a consensus on the regulatory treatment of infrastructure investments has yet to emerge. The insurance capital standard (ICS), which has been developed by the International Association of Insurance Supervisors (IAIS, 2017b) and establishes as a group-wide, consolidated capital requirement for the solvency assessment of international active insurance groups (IAIGs) to be adopted after the end of 2019. Under the current calibration of the ICS, the treatment of market and credit risk of infrastructure debt would be equivalent to that of any other type of long-term exposure.

Note:
1/ Moreover, the current calibration of capital charges recognizes sovereign guarantees but does not recognize guarantees at the sub-national level, which are quite important in some countries.

2/ The amendment covers all criteria that insurers’ investments must meet, whether equity or debt, to be considered “qualifying infrastructure investment.” Equities classified as infrastructure investments (“infrastructure equities”) carry a lower capital charge (30 percent) than equities listed in EEA or OECD countries (“Type 1 equities”), for which 39 percent is required. Moreover, within the market risk module of Solvency II, the correlation of the SCR for infrastructure equities to the SCR for Type 1 equities (see Appendix Figure 22) is set to 75 percent, which has a diversifying impact on the overall capital charge for investments.

3/ The differentiated regulatory treatment is stipulated in EU Regulation 2015/35 (European Commission, 2015) on January 17, 2015, and amended by EU Regulation 2016/467 (European Commission, 2016) on April 2, 2016 (regarding the definition of “qualifying infrastructure”), which was subsequently refined in EU Regulation 2017/1542 (European Commission, 2017) on September 14, 2017 in the context of the revised capital requirement for “qualifying infrastructure corporates.” The reduction of capital charges is subject to several qualifying criteria, such as investment grade credit quality, predictability of cash flows, and a robust contractual framework, including strong termination clauses (see Appendix, Glossary).

4/ The amendment also benefits the fair valuation of reserves supported by long-term, predictable cash flows from infrastructure projects. The “matching adjustment” allows insurers to discount their liabilities by the rate of return of infrastructure-linked instruments, which tends to be higher than the market-implied discount rates (due to the illiquidity premium), thus reducing the present value of these liabilities and the business cost for insurers.
Box A4. Risk Mitigation in Infrastructure Project Finance: Structural Features and World Bank Group Initiatives

Project finance represents the most important funding source of infrastructure in EMDEs, which tends to involve unsecured lending arrangements for a standalone, clearly identified economic unit (Weber and Alfen, 2010), i.e., the repayment in lending arrangements is based solely on the cash flow generation of the project. Liability is limited to the contributed equity capital, and lenders often have limited recourse to the project sponsors, which requires strong contractual provisions. However, the asset-heavy capital intensity, low-to-manageable operating risk and the long-term importance of infrastructure services tend to support higher levels of leverage in project finance than similarly rated non-financial corporates issuing debt. The scope of information provision and monitoring oversight is typically greater than for traditional corporate borrowers.

Current regulator definitions of “qualifying infrastructure investment” (European Commission, 2017) and “high quality project finance” in the finalized Basel III framework (BCBS, 2017) have established a taxonomy for greater contractual certainty in project finance. However, this does not necessarily entail availability-based payments upon completion of projects (and/or explicit government support if this occurs in the context of PPPs), which are frequently not available in EMDEs. Projects could meet agreed performance levels also though alternative contractual arrangements that provide a high degree of contractual certainty about repayment from future revenues by mitigating demand and/or price risk through offtake contracts.

The World Bank Group and other multilateral development organizations have developed programs that help mitigate market failures that can hinder the successful deployment of funding to infrastructure projects:

- **Infrastructure investments can be highly complex to manage.** Infrastructure projects focusing on the construction or project phase (“greenfield”) pose a greater risk in terms of cash flow uncertainty. Fully operational underlying assets (“brownfield”) provide greater stability of returns and potentially simpler operational management, but their supply is somewhat limited. The World Bank Group address the contractual uncertainty during the project phase by bringing to the market bankable infrastructure projects and helping countries develop an enabling regulatory and legal environment. In this context, the World Bank-initiated Global Infrastructure Facility (GIF) is focused on helping client countries in project preparation. Recent initiatives aimed at greater mobilization of private capital for infrastructure finance also include ways for countries to recycle their existing assets, for example, by leasing them to private operators. The money raised from private investors in these “brownfield” assets can then be used by governments to finance new projects.

- **Investors might face information constraints and lack instruments to bring opportunities to risk levels that they can absorb.** Risk varies depending on the sector and geography of individual projects, as well as in the way their finance is structured. Many investors do not have confidence they can understand the details of the opportunities they face and whether the risk is appropriate to the profile of their portfolio. The World Bank Group is working with many partners to (i) expand data platforms, (ii) rate PPP procurement rules and (iii) make the guarantee products to de-risk infrastructure projects more understood by a broader audience. The private sector arm of the World Bank Group—the International Finance Corporation (IFC)—also developed co-investment vehicles that allow institutional investors to co-participate in the origination of project loans in EMDEs.
Several contractual features ensure that project finance loans are structured (i) to be both highly robust to a wide range of potentially severe risks and (ii) to maximize any post-default asset recovery (Moody’s Investors Service, 2017c and 2017g):

- **Default risk**—Construction risk is substantially transferred to a construction contractor through a turnkey construction contract, which specifies the delivery of a functional asset at an agreed time and within budget in accordance with required performance parameters. Appropriate economic incentives help mitigate performance risk, including provisions for liquidated damages as well as financial support instruments, such as a bank letter of credit or other performance support instruments. Offtake contracts mitigating price and demand risk that can undermine predictable and resilient revenue streams over the long term. Liquidity risks can be avoided through protective forward-looking covenants, reserving mechanisms, cash traps and other structural features; this also includes project finance transactions, which raise all necessary funding at financial close. Detailed appraisals by lenders of all aspects of the project help ensure that key risks are identified, allocated and mitigated such that residual risk is within acceptable parameters. The preparation of a detailed financial model (including whole life operating & maintenance costs, and periodic capital maintenance expenditures) and evaluation of the impact of stress scenarios help assess the project’s resilience. Covenants ensure that projects cannot evolve beyond the agreed scope, underpinning a predictable trajectory for the business. Finally, procedures for routine monitoring by agents, representatives and/or advisors and triggers for enhanced reporting and monitoring controls to allow for early intervention can mitigate the risk of non-accruals and contractual failure.

- **Asset recovery**—The high asset intensity of infrastructure places a premium on creditor rights and economic incentives for the various stakeholders to mitigate economic loss following a default. Senior secured lenders benefit from first ranking security interests over all material assets, which would need to be legal, valid, binding and enforceable (i.e., perfected) on or before financial close. A step-in regime (i.e., step-in, cure, and step-out rights) provides senior secured lenders with appropriate rights and sufficient time to remedy a default. Pre-agreed inter-creditor arrangements, including decision-making and voting procedures, remove uncertainty about senior lender control upon default (or upon triggering threshold covenants before senior lenders incur any economic loss); this would also require structural risk mitigation features that prevent other creditor claimants might emerge during a bankruptcy or administration process to challenge pre-agreed inter-creditor rights and security interests. Finally, the strategic or essential nature of a profitable project creates collective interest by all stakeholders in averting default.

**Note:**

1/ The *Global Infrastructure Facility* (GIF) is a partnership among governments, multilateral development banks, private sector investors, and financiers. It is designed to provide a new way to collaborate on preparing, structuring, and implementing complex infrastructure projects that no single institution could handle on its own. The comprehensive project support provided by the GIF draws on the combined expertise of its technical and advisory partners. This group, which includes commercial banks and institutional investors, ensures that well-structured and bankable infrastructure projects are brought to market in a way that can sustainably meet the needs of governments and service users. Since 2015, the GIF has built up a portfolio of 36 infrastructure projects, which is expected to mobilize over $30 billion in total investment. See [http://www.globalinfrastructure.org/](http://www.globalinfrastructure.org/) and [https://hubs.worldbank.org/news/Pages/Making-Infrastructure-Work-The-GIF-Comes-of-Age-12022018-100101.aspx](https://hubs.worldbank.org/news/Pages/Making-Infrastructure-Work-The-GIF-Comes-of-Age-12022018-100101.aspx).
VIII. TECHNICAL DESCRIPTION

A. Solvency II (Spread Risk Sub-Module)

The Solvency II framework represents a risk-based regulatory framework for insurance companies in the European Union, which aims at facilitating the development of a single market for insurance activities by harmonizing solvency regulation of insurance companies that conduct business in EU Member States. The capital assessment under the Solvency II Directive 2009/138/EC (European Parliament/European Council, 2009) comprises a bottom-up calculation of different risks affecting the value of the economic balance sheet of insurers. Based on the European Level 2 implementation measures, the Solvency II framework establishes total balance sheet economic capital approach, which stipulates a Standard Formula (standardized approach) but also allows insurers to determine their own statutory capital needs using internal models, subject to supervisory approval, or prescribed approaches for various risks based a standard formula (European Commission, 2008). The minimum capital adequacy (i.e., the solvency capital requirement, or SCR) is calibrated to satisfy 99.5 percent VaR-based change in economic capital and surplus over one-year time horizon.90

The standardized approach under Solvency II is divided into six risk modules (life underwriting risk, non-life underwriting risk, health risk, market risk, counterparty default risk, and operational risk), which themselves are further divided into component sub-risks (e.g., premium/reserve risk and catastrophe risk in the non-life underwriting risk module) (see Appendix Figure 22). As part of the bottom-up calculation of the SCR, the standardized approach applies a combination of stress tests, scenarios and factor-based capital charges to determine capital charges for each risk (i.e., risk modules and sub-risk components) and incorporates a diversification benefit from correlation across risk modules (and reduction for reinsurance and capital market hedging programs). Thus, the generic definition of the SCR for a particular risk (based on net impact of a given change in the risk factor on the economic balance sheet after hedging) is defined as

\[
SCR_{p,q} = \sqrt{\sum_p \sum_q \rho(p,q) \times SCR_p \times SCR_q} \quad (A1.1)
\]

where \(SCR_p\) and \(SCR_q\) denote the capital requirements for sub-risk components \(p\) and \(q\) (“sub-risk modules”), respectively, with correlation \(\rho(p,q)\) between them, which is applied to the sum of the individual risk exposures of each risk category (see Appendix Figure 22).

In the overall SCR calculation, the capital charge for credit risk from investments is captured by spread risk, which forms part of the market risk SCR, subject to the diversification effect from combining spread risk with interest rate risk, equity risk, property risk, currency risk, concentration risk, and counter-cyclical premium risk. More specifically, the capital requirement for market risk referred to in Art. 105(5) of Directive 2009/138/EC is equal to the sum of all

90 For instance, most notably, the estimation of the discount factor for assets and liabilities over long time horizon has focused on actuarial methods of determining the interest rate term structure for valuation purposes.
possible \((p, q)\)-combinations of sub-modules of the market risk module after accounting for correlation \(\rho(p, q)\) according to

\[
\begin{bmatrix}
\text{interest rate}
\mid 1 & A & A & 0 & 0.25 \\
\text{equity}
\mid A & 1 & 0.75 & 0.75 & 0.25 \\
\text{property}
\mid A & 0.75 & 1 & 0.5 & 0.25 \\
\text{spread}
\mid A & 0.75 & 0.5 & 1 & 0.25 \\
\text{concentration}
\mid 0 & 0 & 0 & 1 & 0 \\
\text{currency}
\mid 0.25 & 0.25 & 0.25 & 0.25 & 0.1
\end{bmatrix}, \quad (A1.2)
\]

where parameter \(A\) shall be equal to 0 where the capital requirement for interest rate risk set out in Art. 165 refers to an increase in the term structure of interest rates. In all other cases, the parameter \(A\) is equal to 0.5.

The spread risk capital charge on bonds and loans is assessed through a factor-based calculation (starting from the market value of the instrument and taking into account its credit quality step and duration), assuming that spreads on all instruments increase, leading to an instantaneous reduction in the value of bonds (EIOPA, 2014). According to Art. 180 (11)-(13) of the Solvency II Directive, the spread risk sub-module for corporate and loan exposures is defined as

\[
SCR_{\text{Spread Risk}} = \begin{cases}
D \times b_{i,j,k=1} & \text{if } D \leq 5 \text{ years} \\
\sum_{i,j,k\in[2,5]} a_{i,j,k} + (D - 5 \times (k - 1)) \times b_{i,j,k\in[2,5]} & \text{if } D > 5 \text{ years}
\end{cases} \quad (A1.3)
\]

where \(a\) and \(b\) are the risk factors for a specific asset class \(i\) with credit quality step (CQS) \(j \in \{1, \ldots, 6\}\) in each “duration bucket” \(k\{1-5\} \in \{D \leq 5; 5 > D \leq 10; 10 > D \leq 15; 15 > D \leq 20; D > 20\} \ (in \ years)\) for an investment with duration \(D\).

Since 2015, the Solvency II Directive has become more precise regarding the regulatory treatment of infrastructure investment. In February 2015, the European Commission requested technical advice from the EIOPA on the viability and calibration of infrastructure investment of insurance companies to be recognized under Solvency II. EIOPA proposed the creation of a new asset class of qualifying infrastructure investments (with preferable risk characteristics) under the standard formula for market risk with reduced capital charges for infrastructure exposures in both debt and equity. In the same year, the EC adopted EIOPA’s recommendations as part of the measures introduced under the Capital Markets Union by issuing Delegated Regulation (EU) 2016/467, which became effective in April 2016 (European Commission, 2016). Under this amendment to Solvency II, own funds that insurers need to hold against qualifying investments are lower than for comparable non-qualifying infrastructure investment or other similar investments.

In 2016, the European Commission requested and received further advice from EIOPA regarding the criteria and calibration of infrastructure corporates as a new asset class (in keeping with the
previous consideration of infrastructure investment). The Commission decided to include separate risk calibrations for debt investment in qualifying infrastructure corporates following EIOPA’s technical advice as well as complementary evidence confirmed that qualifying infrastructure corporate investments can be safer than non-infrastructure investments. In September 2017, it published the Delegated Regulation (EU) 2017/1542 (European Commission, 2017), which amends the Delegated Regulation (EU) 2015/35 (European Commission, 2015) concerning the calculation of regulatory capital requirements for certain categories of assets held by insurance and reinsurance undertakings with a focus on infrastructure corporates. Delegated Regulation (EU) 2015/35 also revises certain elements of the previous Delegated Regulation (EU) 2016/467 affecting the regulatory treatment of qualifying infrastructure (European Commission, 2016).  

For this paper, we focus on the current capital charge for rated and unrated infrastructure debt. According to Art. 180 (11)-(13) of the Solvency II Directive as amended by Commission Delegated Regulation (EU) 2016/467, specific shocks apply to infrastructure debt (Art. 180 (14)-(16)). The spread risk charge for infrastructure investment is reduced if the underlying infrastructure project satisfies certain requirements (“qualifying infrastructure”). The adjusted capital charge is calculated by lowering the risk factors in equation (A1.3) above, conditional on the rating of the issuer (or an assumed minimum rating of “Baa/BBB” if the exposure is unrated) and the duration of the debt, so that

\[ S_{\text{SCR}}^{\text{Spread Risk}_{\text{Infra}}} = S_{\text{SCR}}^{\text{Spread Risk}} - \varphi_{\text{qualifying}} \]  

or more specifically,

\[
S_{\text{SCR}}^{\text{Spread Risk}_{\text{Infra}}} = \begin{cases} 
D \times (b_{i,j} \in [0,3; \text{unrated}], k=1 - \varphi_{j,k=1,\text{qualifying}}) & D \leq 5 \text{ years} \\
\alpha_{i,j} \in [0,3; \text{unrated}], k \in [2,5] + (D - 5 \times (k - 1)) & D > 5 \text{ years} \\
\times (b_{i,j} \in [0,3; \text{unrated}], k \in [2,5] - \varphi_{j \in [0,3], k \in [2,5], \text{qualifying}}) & 
\end{cases}
\]  

where \( \varphi_{j,k,\text{qualifying}} \) is the reduction factor\(^92\) for \( j \)-rated exposures with duration \( D \) in duration bucket \( k \).\(^{93}\) Note that the reduced risk factors only apply to exposures rated CQS=3 (“Baa/BBB”) or higher (and unrated exposures).

\(^{91}\) Following the introduction of a new qualifying infrastructure corporate asset class, other provisions of Solvency II were aligned, such as the formula for the solvency capital requirement and the due diligence requirements.

\(^{92}\) For instance, the risk factor stress applied to a “Baa/BBB”-rated infrastructure project with a duration of three years declines by about 30 percent compared to the shock applicable to corporate debt.

\(^{93}\) Also note that if qualifying infrastructure investments are held in a matching portfolio (e.g., to cover annuities), the impact on own funds should be the lower of the matching adjustment stress and the qualifying infrastructure stress risk factor under the spread risk sub-module.
Appendix Table 7 shows the evolution of the SCR for bonds and loans as a function of the spread duration (in years) and for the various CQS, represented by their equivalent rating class. These shocks are applied to the market value of bonds and loans that represent qualifying infrastructure investments. For these exposures, the risk factors have been reduced by about 30 percent, with unrated exposures being assigned a risk factor stress matched to the risk factor of conventional bonds and loans with CQS=3 based on the duration of the exposure.

The spread risk charge is normally derived from the credit risk premium estimated as the 99.5 percent Value-at-Risk (VaR) of daily rate returns over a 12-month time horizon set out in Art. 101(3) of the Solvency II Directive. However, given the scarcity of listed infrastructure investments, it is difficult to observe the market-implied credit risk premium. Thus, for the assessment of a differentiated regulatory treatment of unrated and/or unlisted infrastructure debt, we follow the logic of the indirect estimation approach taken by EIOPA (2013a, 2013b and 2015a) by inferring the spread risk charge from observable credit risk according to the “simplified calculation of the capital requirement for spread risk on bonds and loans.” This approach assumes that differences in the absolute level and volatility of credit risk between infrastructure debt and corporate debt corresponds to similar differences in spread behavior (if idiosyncratic and systemic components of credit risk are broadly comparable). In other words, the “asset portfolio is materially less diversified in terms of credit quality and duration compared to the portfolio used in the calibration of the standard formula. Therefore, the product of the duration and a risk factor dependent on the credit quality is assumed to be a prudent approximation for spread risk,” according to EIOPA’s guidance on the standard formula calculation for the Solvency Capital Requirement (EIOPA, 2014, p. 23).

We apply a differentiated approach by augmenting the existing adjustment of the capital charge for the spread risk of infrastructure debt. According to the amendment for long-term investments of insurance companies, “qualifying infrastructure investments” in EEA or OECD countries

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94 Among several conditions, the infrastructure project and related debt instruments (bonds or loans) must meet the following criteria set forth in Art. 164: (i) infrastructure project is located in the European Economic Area (EEA) or the Organization for Economic Co-operation and Development (OECD), (ii) creditors are protected by a certain number of covenants concerning the use of the cash flows generated by the infrastructure project, and the project must generate an availability-based revenue (as opposed to volume-based revenue), and, if no rating is available, (iii) the exposure ranks senior to all other claims. Unrated infrastructure loans or bonds that meet these specific criteria are treated as if they were rated CQS=3 (“Baa/BBB”).

95 Note that outside the directional conjecture of higher credit risk resulting in higher spread risk, also the difference in the absolute levels of credit risk per se is instructive. For instance, if the credit risk component in the spread for infrastructure debt was for example 50 percent of the value for corporate debt, this would not necessarily mean that the fluctuations are lower; but to produce the same absolute change, the percentage changes for infrastructure would have to be double what can be observed for corporate debt (EIOPA, 2013a).

96 Projects located in countries that are within the EEA and/or OECD members may qualify for lower regulatory capital under Solvency II. The “EEA or OECD (restricted scope)” subset in Moody’s Investors Services (2017c and 2017g) comprises infrastructure projects within the EEA or OECD regions with availability-based revenues that provide predictable cash flows. The finalized Basel III framework (BCBS, 2017) also adopted the concept in the
benefit from a reduced capital charge (“reduction factor”) of about 25 percent for rated exposures. Unrated exposures are set equal to CQS=3 of rated (general) bonds and loans (which implies decrease of the capital charge of between 12 and 17 percent for unrated exposures depending on the duration).

In our approach, we derive revised capital charges for infrastructure exposures on published results of the historical credit dynamics of unrated project loans and infrastructure debt securities (Moody’s Investors Service, 2016b, 2016c, 2017a, 2017c, 2017e and 2017g):97

• *Unrated project loans.* We determine the risk factors for unrated project loans by mapping their expected losses to the general elasticity of the reduced risk factors for qualifying infrastructure in EEA or OECD countries to the expected losses of corporate debt implied by Moody’s credit rating for the first two “duration buckets,” \( k = \{1; 2\} \), corresponding to \( D \leq 5 \) years and \( 5 \) years < \( D \leq 10 \) years, respectively; the risk factors for unrated project loans at higher “duration buckets” are scaled to the rate of change of reduced risk factors for qualifying infrastructure in EEA or OECD countries.

• *Rated infrastructure debt securities.* The risk factors for rated infrastructure debt securities are determined on a global basis based on observable expected loss for each rating grade, consistent with the difference in risk factors between rated and unrated qualifying infrastructure in EEA and OECD member countries—in terms of both level difference and sensitivity to a change in credit quality.

We first determine the risk factors for unrated project loans in EEA and OECD countries (corresponding to sample “EEA/OECD”). They are derived from mapping the average annual expected loss \( \mathbb{E}(L_j^{EEA/OECD}) \) to the assigned risk factors for unrated (qualifying) infrastructure debt within the scope of the current reduction factor under the amended spread risk sub-module, specification of “high quality project finance,” which also includes a definition of availability-based revenues, which refers to the entitlement of a project finance entity to receive payments from its contractual counterparties (e.g., the government) once construction is completed as long as contract conditions are fulfilled. “Availability payments are sized to cover operating and maintenance costs, debt service costs and equity returns as the project finance entity operates the project. Availability payments are not subject to swings in demand, such as traffic levels, and are adjusted typically only for lack of performance or lack of availability of the asset to the public (BCBS, 2017, p. 15).” Such projects closely align with qualifying criteria for lower regulatory capital under the Solvency II Delegated Regulation (European Commission, 2015 and 2017). The European Commission Delegated Regulation (EU) 2017/1542 of 8 June 2017 amended the Delegated Regulation (EU) 2015/35 concerning the calculation of regulatory capital requirements for certain categories of assets held by insurance and reinsurance undertakings. For calibration exercise, we use the broader sample “EEA or OECD,” which also includes volume-based revenue project loans (outside the strict interpretation of “qualifying infrastructure investment”) since most infrastructure projects outside the EEA or OECD regions have volume-based revenues.

97 In principle, this analysis could be extended to the credit risk for many different compositions of the debt portfolio of insurance companies in terms of granularity, maturity and credit ratings, but it would be difficult to choose the most relevant cases.
Since unrated (qualifying) infrastructure debt is treated like corporate exposures (debt or loans) with credit quality $j = 3$, we specify the updated capital charge for unrated project loans in EEA or OECD countries as

$$SCR_{Spread \text{ Risk}_{\text{Infra}}}^{\text{EEA/OECD}} = SCR_{Spread \text{ Risk}_{\text{Infra}}} - \gamma_{j=\text{unrated}}$$ (A1.6)

or more specifically as

$$SCR_{Spread \text{ Risk}_{\text{Infra unrat}}}^{\text{EEA/OECD}} =
\begin{cases}
D \times \left( b_{l,j=\text{unrated},k=1} - \gamma_{j=\text{unrated},k=1}^{\text{EEA/OECD}} \right) & D \leq 5 \text{ years} \\
\left( a_{l,j=\text{unrated},k=2} + \left( D - 5 \times (k - 1) \right) \right) \times \left( b_{l,j=\text{unrated},k=2} - \gamma_{j=\text{unrated},k=2}^{\text{EEA/OECD}} \right) & 5 \text{ years} < D \leq 10 \text{ years}
\end{cases}$$ (A1.7)

based on the elasticity $d\varphi_{j,k,\text{qualifying}}/dE(L_{j,k}^{\text{corp}})$ of the current reduced risk factor for rated infrastructure debt to the implied expected loss of non-financial corporate debt issuers at rating grades $j \in \{0; 1; 2; 3; 4\}$ (according to the historical credit performance published by Moody’s Investors Service (2017b)), assuming that

$$\frac{d\varphi_{j,k,\text{qualifying}}}{dE(L_{j,k}^{\text{corp}})} \approx \frac{d\gamma_{j=\text{unrated},k\in[1,2]}^{\text{EEA/OECD}}}{dE(L_{j=\text{unrated},k\in[1,2]}^{\text{EEA/OECD}})}$$ (A1.8)

subject to the constraint that the reduced risk factors $b_{l,j=\text{unrated},k=1} = 2.5$ and $b_{l,j=\text{unrated},k=2} = 1.5$ for unrated qualifying infrastructure debt investments in EEA or OECD countries (European Commission, 2017) with durations of less than 5 years and above 5 years (but below 10 years), respectively, remain consistent with the average expected loss of unrated project loans in EEA or OECD countries, $E \left( L_{j=\text{unrated},k\in[1,2]}^{\text{EEA/OECD}} \right)$. The rate of change risk factors for unrated project loans at higher “duration buckets” $k = \{3; 4; 5\}$ is scaled to the rate of change

98 Note that his reduction is based on all project loans in sample “EEA or OECD” (Moody’s Investors Service, 2017g) which also includes some projects with volume-based revenues, which fall outside the original scope of “qualifying infrastructure investment” (European Commission, 2017).

99 The scaling to the reduction factor (i.e., the difference between the original risk factor $b_{l,j,k}$ and the reduced risk factor $b_{l,j,k} - \gamma_{j,k}^{\text{EEA/OECD}}$) is based on the following linear sensitivity of the risk factor $b_{l,j,k}$ of the capital charge to expected loss (EL) over a 5-year and 10-year risk horizon, respectively:

$$15.481 \times E(L_{j,k=1}^{\text{corp}}) + 1.1356 \text{ and } 2.1344 \times E(L_{j,k=2}^{\text{corp}}) + 0.6558.$$
of risk factors for qualifying, unrated infrastructure exposure in EEA or OECD countries,
\[ db_{i,j=\text{unrated}, k\in[3,5]}^\text{EEA/OECD} / dk, \] so that \(^{100}\)
\[
b_{i,j=\text{unrated}, k\in[3,5]} - \gamma_{j=\text{unrated}, k\in[3,5]}^{\text{EEA/OECD}} \times \frac{b_{i,j=\text{unrated}, k\in[2,4]} - \varphi_{j,k\in[2,4]}^{\text{qualifying}}}{b_{i,j=\text{unrated}, k\in[2,4]} - \varphi_{j,k\in[2,4]}^{\text{qualifying}}}.
\]

Based on the mapping of risk factors to project loans in EEA or OECD countries, we derive the general expression of a revised capital charge for the total sample (“all sub-samples”) and the EMDE samples of project loans as

\[
SCR_{\text{Spread Risk in fra un rated}} ^{\text{Infra un rated}} =
\begin{cases}
D \times \left( b_{i,j,k=1} - \gamma_{j=\text{unrated}, k=1}^{\text{EEA/OECD}} \right) \times \frac{\mathbb{E}\left( L_{\text{any subset}}^{\text{unrated},k=1} \right)}{\mathbb{E}\left( L_{j=\text{unrated}, k=1}^{\text{EEA/OECD}} \right)} & D \leq 5 \text{ years} \\
\left( D - 5 \times (k - 1) \right) \times \frac{\mathbb{E}\left( L_{\text{any subset}}^{\text{unrated},k=2,5} \right)}{\mathbb{E}\left( L_{j=\text{unrated}, k=2,5}^{\text{EEA/OECD}} \right)} & D > 5 \text{ years}
\end{cases}
(A1.9)
\]

where \(\mathbb{E}\left( L_{i,j=\text{unrated}, k}^{\text{any subset}} \right)\) is the average annual expected loss of unrated project loans issued in any other sub-sample, such as project loans in EMDEs (“EMDE-A” and “EMDE-B”), \(\mathbb{E}\left( L_{i,j=\text{unrated}, k}^{\text{EMDE-A}} \right)\) and \(\mathbb{E}\left( L_{i,j=\text{unrated}, k}^{\text{EMDE-B}} \right)\).\(^{101}\)

Since we can observe the difference in the absolute level of credit risk between infrastructure debt securities at different rating grades (Moody’s Investors Service, 2016b and 2017e) and unrated project loans (Moody’s Investors Service, 2017c and 2017g), we can also determine the capital charge for infrastructure debt securities based on the relation between the expected losses of unrated project bonds in all sub-samples (reflecting a global scope) and unrated project loans in EEA or OECD countries using a narrow definition of qualifying infrastructure (“EEA or OECD (restricted scope)”). Thus, the risk factors are calibrated consistent with those for unrated project loans after controlling for differences in credit risk (while preserving the elasticity of risk factors to the credit rating implied by the adjusted risk factors for global infrastructure debt securities) so that

\(^{100}\) The risk factors for the other “duration buckets” \(k_{[3-5]} \in \{10 > D \leq 15; 15 > D \leq 20; D > 20\} \) (in years) are extrapolated based on the ratio between the reduced risk factors and the risk factors under a more differentiated approach.

\(^{101}\) The results for the “EEA or OECD” sample in Appendix Tables 5 and 7 (and related exhibits), show the risk factors for a narrow definition of infrastructure projects in EEA or OECD countries (“EEA or OECD (restricted scope)”), which includes only availability-based revenue projects, consistent with the European Commission’s (2017) definition of “qualifying infrastructure investment.”
Finally, we combine both $\text{SCR}_{\text{infra} \text{unrated}}$ and $\text{SCR}^{\text{EEA/OECD}}_{\text{infra} \text{rated}}$ in equations (A1.9) and (A1.12) above to solve for a general capital charge for rated infrastructure debt securities, outside the current scope of the reduced capital charge for qualifying infrastructure in EEA or OECD countries, consistent with the risk factor sensitivity to expected losses, so that
\[ \text{SCR}_{\text{Spread RiskInfrarated}} = \text{SCR}_{\text{Spread RiskInfrarated}}^{\text{EEA/OECD}} \times \frac{\mathbb{E} \left( L_{j \in [0,5]} \big| \text{infra debt} \right)}{\mathbb{E} \left( L_{j \in [0,5]} \right)} \]  

(A1.13)

with

\[ \mathbb{E} \left( L_{j \in [0,5]} \right) = \frac{\mathbb{E} \left( L_{j \in \text{any subset}} \big| \text{infra debt} \right)}{\mathbb{E} \left( L_{j \in \text{all subsets}} \big| \text{infra debt} \right)} \times \mathbb{E} \left( L_{j \in [0,5]} \right), \quad (A1.14) \]

where \( \mathbb{E} \left( L_{j \in \text{any subset}} \right) \) denotes the expected loss of any sub-set of project loans in the study sample, including \( \mathbb{E} \left( L_{j \in \text{unrated, } k} \right) \) and \( \mathbb{E} \left( L_{j \in \text{EMDE-A}} \right) \) and \( \mathbb{E} \left( L_{j \in \text{EMDE-B}} \right) \).
B. Insurance Capital Standard (Credit Risk Stress Factor)

The insurance capital standard (ICS) establishes a group-wide, consolidated solvency assessment for internationally active insurance groups (IAIGs) and global systemically important insurers (G-SIIs). It represents a minimum standard members of the International Association of Insurance Supervisors (IAIS) will implement (or propose to implement) considering specific market circumstances in their respective jurisdictions after the end of 2019.102 The ICS aims at establishing comparability of capital assessments across jurisdictions to (i) enhance confidence in cross-border analysis of IAIGs among group-wide and host supervisors and (ii) enable investors to assess and compare the solvency of insurance firms competing internationally, enhancing market discipline and reducing regulatory arbitrage.103 The ICS is part of the Common Framework (ComFrame), which should be used by group-wide supervisors to assess the financial condition of IAIGs.104 On July 21, 2017, the IAIS published the initial version of the ICS ("Version 1.0") for extended field testing, which is conducted by the Capital, Solvency and Field Testing Working Group (CSFWG). The final version of the ICS ("Version 2.0") is due to be completed by the end of 2019 for adoption by the IAIS along with the remainder of ComFrame.105

The current specification of the credit risk stress factor has been field tested based on a calibration that closely follows the model underlying the internal ratings-based (IRB) approach for credit risk in the Basel III framework with some insurance-specific adjustments (BCBS, 2017). Under the planned implementation of the ICS, the credit (stress) risk factors are calibrated based on the historical credit dynamics of sovereign and corporate debt securities and loans as well as reinsurance receivables. The suggested calibration approach follows an asymptotic single risk factor model consistent with the IRB approach in the Basel III framework for banks but the statistical confidence is set to 99.5 percent instead of 99.9 percent over an assumed stress period of a one-year risk horizon. As opposed to the European insurance regulation, the current version of ICS does not distinguish infrastructure investments from other types of exposures in the

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102 The ICS also serves as a minimum standard for a prescribed capital requirement (PCR) of insurance groups.

103 The ICS is not intended as a legal entity requirement. Supervisors will be free to adopt additional arrangements that set higher standards or higher levels of minimum capital. Moreover, they can implement supplementary measures of capital adequacy for the IAIGs in their jurisdiction.

104 “The IAIS’ ultimate goal, by a date yet to be determined, is a single ICS that includes a common methodology by which one ICS achieves comparable, i.e., substantially the same, outcomes across jurisdictions. Ongoing work is intended to lead to improved convergence over time on the key elements of the ICS. Not prejudging the substance, the key elements include valuation, capital resources and capital requirements (IAIS, 2017b, p. 3).” The goal for ICS Version 2.0 is the delivery of an ICS that will achieve an improved level of comparability compared to ICS Version 1.0 (but possibly not the level of comparability envisaged by the ultimate goal).

105 The goal of the field testing of the ICS Version 1.0 was the development of a standard method for calculating the ICS capital requirement based on identified two (initially identified) valuation approaches. The consultation on the ICS Version 2.0 (for adoption within ComFrame), which is fit for implementation by supervisors, is scheduled to begin May/June 2018, and will consider other methods of calculation of the ICS capital requirement including the use of internal models (partial or full), external models, and variations of the standard method.
calculation of the credit risk stress factor (and its variation by the type of counterparty, rating grade, and maturity term). The IAIS (2017b) published the planned risk factors for corporate exposures under ICS Version 1.0, which would also apply to investments in infrastructure debt securities and project loans, and, thus, establish our baseline for further analysis.

For the illustration of a differentiated regulatory treatment of infrastructure investment in the context of ICS, we adopt two approaches to calibrate the credit risk stress factors by using the credit performance of infrastructure debt securities and project loans (as well as other asset classes for comparison)—(i) directly applying the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) as a sub-class of the corporate asset class according to the finalized Basel III framework (BCBS, 2017) (with and without maturity adjustment and prudential floors for PD and LGD), and (ii) adapting the Vasiček (2002) model, consistent with the foundation IRB (F-IRB) approach of the Basel III framework (BCBS, 2017) (with LGD fixed at 45 percent). For both approaches, we generate the estimated capital charge at a statistical confidence level of 99.5 percent (which corresponds to prudential requirements for insurance companies in Solvency II and ICS) as well as 99.9 percent (which corresponds to the prudential requirement for banks in the Basel III framework) (see Box 2). We acknowledge that the diminishing marginal default risk of project finance cannot be approximated by a linear positive function of maturity as in traditional credit risk models (and reflected in the linear maturity adjustment of the IRB formula); however, it is, to some extent, reflected in the

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106 Infrastructure equity-type investment (regardless of country) is assigned a very high risk factor of 49 percent (which is equivalent to the “other equity” category comprising equities that are not listed, hedge funds, limited partnerships, commodities, infrastructure and other alternative investments). The risk factor represents an instantaneous relative decrease of the market price. Other equity risk categories (in order of stress factor) are (i) listed equity in developed markets (35 percent), (ii) listed equity in emerging markets (48 percent), and (iii) hybrid debt / preference shares (49 percent). The equity risk charge is calculated after management actions. Note that this contrasts with the capital requirement for equity in the Solvency II framework, which classifies equities as “Type 1” and “Type 2 (Other equities)” in the standard equity risk sub-module according to Art. 168 (European Commission, 2009 and 2015). The former refers to equities listed in regulated markets in countries that are members of either the EEA or OECD, whereas the latter defines equities listed only in emerging markets, non-listed equity, hedge funds, and any other investments not included elsewhere in the market risk module for the computation of the capital requirement under Solvency II. The capital requirement is set equal to the loss in the basic own funds that would result from the instantaneous decrease equal to (i) 39 percent and 49 percent in the value of Type 1 and Type 2 equity investments (and the symmetric adjustment as referred to in Art. 172), respectively, and (ii) 22 percent of equity investments in related undertakings within the meaning of Art. 212(1)(b) and 212(2) of Directive 2009/138/EC. Under the amendment of Solvency II through Commission Delegated Regulation (EU) 2016/467 of 30 September 2015 (European Commission, 2016) the capital charge for equity investments was reduced to 30 percent (which is lower than the 39-percent reduction specified for listed equities).

107 Thus, our results also illustrate the impact of a more nuanced assessment of infrastructure risk for the calibration of bank capital charges.

108 The common “hump-shaped” term structure of credit spreads of project finance suggests a non-linear relationship between the remaining maturity and credit risk. The diminishing marginal default risk after a few years can be explained by the payment structure of project finance, which normally has a relatively higher leverage ratio at the early stage. A project loan represents an unsecured lending arrangement, whose repayment is based solely on the cash flow generation of a standalone, clearly identified economic unit (Weber and Alfen, 2010; see Appendix Box A4). The repayment is made through an amortization schedule, which deleverages the capital structure, and, thus, gradually improves the credit status of the project.
downgrade risk on expected losses in the adapted Vasiček (2002) model. For the implementation of the IRB formula, we generate results with and without the linear maturity adjustment to show the range of possible estimates to accommodate the varying impact of the non-linear relationship between remaining maturity and credit risk in infrastructure projects.

1. Advanced Internal Ratings-Based (IRB) Approach

The advanced IRB approach for credit risk is permissible for project finance as one of the five sub-categories of specialized corporate lending under the Basel framework (BCBS, 2017; see Box 2). This approach assumes that insurers meet the bank requirements for estimating the one-year probability of default (PD) and loss-given-default (LGD), and the exposure-at-default (EAD) (where relevant) of (infrastructure) project finance (and infrastructure debt).

Thus, the capital requirement ($K$)—based on the underlying specification of an asymptotic single risk factor model—is defined as:

$$K = \left( \frac{LGD \times \Phi^{-1}(PD) + \frac{R}{\sqrt{1-R}} \times \Phi^{-1}(a)}{\sqrt{1-R}} \right) \times PD \times LGD \times \frac{1+(M-2.5)b}{1-1.5b} \text{ full maturity adjustment}$$

(A2.1)

where PD is the default rate over one year associated with the internal borrower grade to which that exposure is assigned, with statistical confidence (single-sided) $a = 0.999$ (i.e., 99.9 percent) assuming standard normal cumulative distribution function $\Phi(\cdot)$, effective maturity $M = \sum_t t \times CF_t / \sum_t CF_t$, where $CF_t$ denotes the cash flows (principal, interest payments, and

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109 See description of the adapted Vasiček (2002) model in the next section for the technical specification of the asymptotic single risk factor model.

110 See also BCBS (2005).

111 With application of the floor requirements, the PD and LGD for each exposure that is used as input into the calculation of expected loss must not be less than 0.05 percent and 25 percent, respectively. Note that under the foundation IRB approach, the LGD would be restricted further. Senior claims on banks, securities firms and other financial institutions (including insurance companies and any financial institutions in the corporate asset class) that are not secured by recognized collateral will be assigned a LGD of 45 percent. Senior claims on other corporates that are not secured by recognized collateral will be assigned a LGD of 40 percent. For banks, $K$ then serves as input to the determination of the risk-weighted amount (after considering the implied leverage of 12.5 due to the minimum capital requirement and EAD).

112 This calculation of effective maturity applies if any element of the advanced IRB approach is used. If the effective maturity cannot be calculated according to the specification above, a more conservative measure of $M$ may be chosen, so that $M$ equals the maximum remaining time (in years). However, national supervisors may allow the
fees) contractually payable by the borrower in period $t$, maturity adjustment $b = (0.11852 - 0.05478 \times \ln(PD))^2$, and correlation factor

$$R = 0.12 \times \frac{1-\exp(1-50PD)}{1-\exp(-50)} + 0.24 \times \left(1 - \frac{1-\exp(-50PD)}{1-\exp(-50)}\right). \quad (A2.2)$$

For the planned risk factors for credit risk, we use the credit risk stress factors for corporate and reinsurance exposures in the 2017 Field Testing Technical Specifications, which the IAIS (2017b) published in its Instructions for the May 2017 Quantitative Data Collection Exercise for the ICS. For unrated exposures, the suggested risk factors are broadly aligned with the guidance provided under the Basel III framework.\(^{113}\)

More specifically, we obtain detailed information on the credit dynamics of marginal PDs and recovery rates\(^{114}\) for project loans (for all sample configurations) and rated infrastructure debt securities from Moody’s (2017a, 2017d and 2017g).\(^{115}\) The recovery rates are converted to LGDs and kept constant for the calculation of the capital charge at different maturities. Thus, we can derive a conservative estimate of a differentiated capital requirement ($K_{\text{infra}}$) for infrastructure investment, with and without floor requirements for PD and LGD (BCBS, 2017), at different maturities $m \in M$:

$$K_{\text{infra}_{i,j,M}} = \sum_{m} \left( \frac{\mathbb{E}(LGD_{i,j,m}^{mar}) \times \Phi \left( \frac{\Phi^{-1}(\mathbb{E}(PD_{i,j,m}^{mar})) - \sqrt{1-R} \Phi^{-1}(a)}{\sqrt{1-R}} \right)}{\Phi^{-1}(\mathbb{E}(PD_{i,j,m}^{mar})) \times \Phi^{-1}(\mathbb{E}(LGD_{i,j,m}^{mar}))} \right) \times \frac{1+(M-2.5)b}{1-1.5b} \quad (A2.3)$$

effective maturity to be fixed at 2.5 years (i.e., “fixed maturity treatment”) for facilities to certain smaller domestic corporate borrowers.

\(^{113}\) Unrated exposures are treated like unrated corporate exposures (consistent with the provisions in the Basel III framework under which banks incorporated in jurisdictions that allow the use of external ratings for regulatory purposes assign a “base” risk weight of 100 percent (which is equivalent to the treatment of exposures with a credit quality step (CQS) of 4 (“Ba”)).

\(^{114}\) For unrated project loans, this refers to ultimate recovery rates under the Basel III definition (BCBS, 2017). The recovery rates are as follows: (senior unsecured) non-financial corporate debt securities – global (38.0 percent), (senior unsecured) corporate bank loans – global (80.4 percent), infrastructure debt securities – “global”/“OECD or EEA”/“EMDE-A”/“EMDE-B” (56.0/56.4/55.7/54.9 percent), bank project loans – “global”/“OECD or EEA”/“EMDE-A”/“EMDE-B” (78.9/80.2/77.2/75.6 percent). See Box 1 for the definition of the samples.

\(^{115}\) The credit risk parameters for infrastructure debt securities for regions consistent with the samples of the project loans (“All Sub-samples”, “EEA, “EEA or OECD”, “EMDE-A” and EMDE-B”), we apply the inferred expected loss from the calibration exercise in the context of the analysis of the spread risk sub-module under Solvency II.
with average marginal default probability $\mathbb{E}(PD_{i,j,m}^{\text{mar}})$ and average marginal loss-given-default $\mathbb{E}(LGD_{i,j}^{\text{mar}})$. Given that the capital adequacy is determined at 99.5 percent over a risk horizon of one year under ICS (like Solvency II), we set $\alpha = 0.995$ (in addition to $\alpha = 0.995$ in order to assess the capital charge under the statistical confidence that would otherwise be required if banks were to apply the A-IRB for project loans under the Basel III framework).

Since we have information on the entire default term structure over a ten-year horizon, we adjust equation (A2.3) above to account for the impact of the potential decrease in the deterioration of the obligor’s creditworthiness over time (similar to the application of the Vasiček (2002) model below) by substituting the cumulative default probability $PD_{i,j,m}^{\text{cumul}}$ for the marginal default probability $PD_{i,j,m}$, keep the recovery rate constant, and retain the maturity adjustment as an optional element, so that

$$K_{\text{infra}_{i,j,M}} = \left( \text{LGD}_{i,j} \Phi \left( \frac{\Phi^{-1}(\mathbb{E}(PD_{i,j,m}^{\text{cumul}})) - \sqrt{R} \Phi^{-1}(\alpha)}{\sqrt{1-R}} \right) \right) - \mathbb{E}(PD_{i,j,m}^{\text{cumul}}) \times \text{LGD}_{i,j}. \quad (A2.4)$$

2. Adapted Vasiček (2002) Model/Quasi-Foundation IRB Approach

The current credit risk calibration for the “ICS Version 1.0” (IAIS, 2017b) follows the asymptotic single risk factor model underlying the internal ratings-based (IRB) approach for credit risk in the Basel III framework but also accounts for the potential decrease in value of an asset due to deterioration of the obligor’s creditworthiness impacting the default rate over time through a diminished recovery value.\textsuperscript{116} The capital requirement combines (i) the expected loss based on the stressed expected marginal default rate $\mathbb{E}(PD_{i,j,m}^{\text{mar}})$ and the loss-given-default (LGD) over a risk horizon of one year ($t = 1$) (like the IRB approach) and (ii) the downgrade risk over the residual maturity $T - t$ of the exposure\textsuperscript{117} so that

$$K = \text{LGD} \times PD_{t,\text{stress}}^{\text{mar}} + \text{downgrade risk}$$

\textsuperscript{116} The IRB approach is primarily focused on calculating default rate under stress over a given time horizon at any given confidence level without this consideration. The downgrade risk is approximated through the maturity adjustment in the IRB approach.

\textsuperscript{117} Note that this specification of the capital charge (similar to the A-IRB approach) includes expected loss, which should be covered by provisions (and is excluded in equation (A2.1)). The IAIS has yet to decide whether this amount is included or excluded from the capital requirement ICS once the treatment of credit loss provisions under the various valuation approaches is finalized. The estimated capital charge for infrastructure investment under the IRB approach in Basel III without maturity adjustment and floors for PD and LGD illustrates potential impact of excluding expected losses (since other elements of the model specification in equations (A2.1) and (A2.5) are largely the same).
\[
LGD \times \Phi \left( \frac{\Phi^{-1}(E(PD_{t}^{mar})) - \sqrt{R} \Phi^{-1}(a)}{\sqrt{1-R}} \right) + \exp(-rt) \frac{E(B_t) - B_{tstress}}{B_t}, \quad (A2.5)
\]

where \( PD_{tstress}^{mar} \) is the stressed marginal default rate, \( LGD \) is the loss-given-default, \( r \) is the annualized bond yield,

\[
B_t = \exp(-rT) \left( 1 - LGD \times PD_T^{cumul} \right), \quad (A2.6)
\]
is the current bond price at time \( t \),

\[
E(B_t) = \exp(-r(T-t)) \left( 1 - LGD \times PD_{T-t}^{cumul} \right), \quad (A2.7)
\]
is the expected bond price at time \( t \) after accounting for the (conditional) cumulative default rate

\[
PD_{T-t}^{cumul} = \frac{E(PD_T^{cumul}) - E(PD_T^{mar})}{1 - E(PD_T^{mar})}, \quad (A2.8)
\]

and

\[
B_{tstress} = \exp(-r(T-t)) \left( 1 - LGD \times PD_{T-tstress}^{cumul} \right) \quad (A2.9)
\]
is the stressed bond price at time \( t \).

Considering the risk premium (“market price of risk”) associated with credit risk, which is reflected in the bond price, the “physical” default rates in equations (2.6)-(2.9) above, are converted into risk-neutral PDs via the general relation

\[
\overline{PD} = \Phi \left( \Phi^{-1}(PD) + \lambda R \sqrt{T-t} \right), \quad (A2.10)
\]

with the market price of risk, \(^{118}\) \( \lambda \), so that we have \( \overline{PD}_T^{cumul}, \overline{PD}_{T-t}^{cumul}, \) and \( \overline{PD}_{T-tstress}^{cumul} \). Thus, we can re-write equation (A2.5) above to

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\(^{118}\) The market price of risk is specified as \( \lambda = (0.40625 \times (T-t)^{0.0093}) \) and reflects the long-run estimate using global financial market data. However, the risk premium varies over time and across countries and industries, which would warrant possible re-calibration depending on the type of asset and prudential scope of economic activity affecting the capital assessment of an insurance company.

\(^{119}\) Note that the adapted model should also include the conversion of the stressed default rate, \( \overline{PD}_t^{mar} = \Phi \left( \Phi^{-1}(PD_t^{mar}) + \lambda R \sqrt{T-t} \right) \) for completeness. The adjustment is not material in this context.
\[ K = LGD \times \Phi \left( \frac{\Phi^{-1}(E(PD_{t}^{mar}) - \sqrt{R}\Phi^{-1}(a))}{\sqrt{1-R}} \right) + \exp(-rt) \times LGD \frac{PD_{t-stress}^{cumul} - PD_{t}^{cumul}}{1 - LGD \times PD_{t}^{cumul}}, \quad (A2.11) \]

with all elements being observable, except for \( PD_{t-stress}^{cumul} \), which will be defined further below. Since the current calibration of the credit risk stress factors is aligned with the F-IRB approach corporate credit risk, and LGD is set to 45 percent, equation (A2.11) becomes\(^\text{120}\)

\[ K = 0.45 \times \left( \Phi \left( \frac{\Phi^{-1}(E(PD_{t}^{mar}) - \sqrt{R}\Phi^{-1}(a))}{\sqrt{1-R}} \right) + \exp(-rt) \frac{PD_{t-stress}^{cumul} - PD_{t}^{cumul}}{1 - 0.45 \times PD_{t}^{cumul}} \right), \quad (A2.12) \]

which is referred to as “planned” capital charge in Table 4 (and other exhibits that present the results of this approach). However, in the differentiated treatment of project loans (as well as infrastructure debt securities and other asset classes), the actual LGD values were used consistent with the specification in equation (A2.11) above.\(^\text{121}\)

The two components of the capital requirement—the stressed default rate and the downgrade risk in equation (A2.11) above—are derived from adapting the single factor credit risk model underpinning the Vasiček (2002) bond pricing formula. The model draws on the basic specification of default risk in the Merton (1973 and 1974) model, which assumes that an obligor has issued a zero-coupon bond \( D \) (with repayment at par value \( B \)) and defaults if the value of its assets drop below the value required to be repaid at the bond’s maturity date (“distress barrier”). In this case, creditors recover only the value of the obligor’s assets – which is lower than the contractually due repayment. If the obligor’s asset value follows a lognormal distribution, we can write

\[ dA = \mu A \, dt + \sigma A \, dx \quad \text{(A2.13)} \]

where \( x \) is a random stochastic process (“white noise”), so that at any time \( t \) in the future

\(^{120}\) For the current calibration of the credit risk stress factors in the “ICS Version 1.0,” the marginal and cumulative default probabilities, \( PD_{t}^{mar} \) and \( PD_{t}^{cumul} \), have been obtained from the 2013 version of the Standard and Poor’s 2013 Annual Global Corporate Default Study and Rating Transitions (Vazza and Kraemer, 2014). The value used for \( R \) varies by credit rating, and is given by \( R = 0.12 \frac{1-\exp(-50 \, PD_{t}^{mar})}{1-\exp(-50)} + 0.24 \left(1 - \frac{1-\exp(-50 \, PD_{t}^{mar})}{1-\exp(-50)} \right) \). The bond interest rate \( r \) is assumed to be 5 percent annually. Although this is very different from current bond rates, the effect of the interest rate assumption on the credit risk factors is not material.

\(^{121}\) The actual LGD for the global sample of unrated project loans (“all sub-samples”) is 21.1 percent, which is further refined for the specific sub-samples “EEA or OECD,” “EMDE-A,” and “EMDE-B” as 19.8 percent, 22.8 percent, and 24.4 percent, respectively. For the comparator asset classes (infrastructure debt securities, non-financial corporate debt, and general corporate exposures), the LGDs are 44.0 percent, 62.0 percent, and 19.6 percent, respectively. For infrastructure debt securities for the sub-samples “EEA or OECD,” “EMDE-A,” and “EMDE-B,” the LGDs are 41.2 percent, 47.5 percent, and 50.1 percent, respectively.
\[
\ln A(t) = \ln A(0) + \mu t - \frac{\sigma^2}{2} t + \sigma \sqrt{t} X(t), \quad (A2.14)
\]

where \(X \sim \Phi(0,1)\) is a standard normal random variable. Under the single risk factor model, it is assumed that

\[
X(t) = \sqrt{R} Y(t) + \sqrt{1-R} Z(t) \quad (A2.15)
\]

where \(Y\) is a single, global risk factor, \(Z\) is an obligor-specific, idiosyncratic risk factor, and \(R\) is the correlation of the obligor to the global risk factor, where \(Y, Z \sim \Phi(0,1)\) are independent of each other.

For the ICS, the capital requirement is defined over a one-year time horizon \(t = 1\), and \(T\) is the maturity time of debt, assuming \(T \geq t\). Thus, the expected (marginal) probability of default is defined as

\[
\mathbb{E}(PD_t^{\text{mar}}) = Pr(\ln A(t) < \ln B(t))
\]

\[
= Pr \left( \ln A(t) + \mu t - \frac{\sigma^2}{2} t + \sigma \sqrt{t} X(t) < B(t) \right)
\]

\[
= Pr \left( X(t) < \frac{\ln B(t) - \ln A(t) - \mu t + \frac{\sigma^2}{2} t}{\sigma \sqrt{t}} \right) = \Phi \left( \frac{\ln A(t)}{\sigma \sqrt{t}} + \frac{\mu - \frac{\sigma^2}{2} t}{\sigma \sqrt{t}} \right). \quad (A2.16)
\]

Losses \((L_t)\) occur when the obligor defaults and can be expressed as a European put option, whose underlying asset and strike price at time \(t\) are the assets, \(A(t)\) and the contractual due repayment, \(D(t)\), so that

\[
\mathbb{E}(L(t)) = \Phi(-d_\pm)D(t)e^{-rt} - \Phi(-d_\pm)A(t) \quad (A2.17)
\]

with \(d_\pm = \frac{1}{\sigma \sqrt{t}} \left[ \ln \frac{A(t)}{B(t)} + \left( \mu \pm \frac{\sigma^2}{2} \right) t \right]\) and default barrier

\[
\ln B(t) = \Phi^{-1}\left( \mathbb{E}(PD_t^{\text{mar}}) \right) \sigma \sqrt{t} + \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) t. \quad (A2.18)
\]

**Stressed Default Rate**

In order to determine \(PD_t^{\text{mar}}\) under stress, \(PD_t^{\text{mar}_{\text{stress}}}\), at a given level of statistical confidence according to equation (A2.5) above, we define the general credit shock based on the global factor \(Y(t) = \Phi^{-1}(\alpha)\) with \(\alpha = 0.995\), so that

\[
\mathbb{E}(PD_t^{\text{mar}_{\text{stress}}}) = Pr(\ln A(t) < \ln B(t) | Y(t) = \Phi^{-1}(\alpha)) \quad (A2.19)
\]
which can be re-written by replacing $\ln A(t)$ and $\ln B(t)$ above with equations (A2.14) and (A2.18) above so that

$$
\mathbb{E}(PD_{t\text{stress}}^{mar}) = Pr \left( \ln A(0) + \mu t + \frac{\sigma^2}{2} t + \sigma \sqrt{t} X(t) < \Phi^{-1}(\mathbb{E}(PD_{t\text{stress}}^{mar})) \sigma \sqrt{t} + \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) t \bigg| Y(t) = \Phi^{-1}(a) \right)
$$

$$
= Pr \left( X(t) < \Phi^{-1}(\mathbb{E}(PD_{t\text{stress}}^{mar})) \bigg| Y(t) = \Phi^{-1}(a) \right)
$$

$$
= Pr \left( \sqrt{R} Y(t) + \sqrt{1 - R} Z(t) < \Phi^{-1}(\mathbb{E}(PD_{t\text{stress}}^{mar})) \bigg| Y(t) = \Phi^{-1}(a) \right)
$$

$$
= Pr \left( Z(t) < \frac{\Phi^{-1}(\mathbb{E}(PD_{t\text{stress}}^{mar})) - \sqrt{R} \Phi^{-1}(a)}{\sqrt{1 - R}} \right)
$$

$$
= \Phi \left( \frac{\Phi^{-1}(\mathbb{E}(PD_{t\text{stress}}^{mar})) - \sqrt{R} \Phi^{-1}(a)}{\sqrt{1 - R}} \right), \quad (A2.20)
$$

which is equivalent to the stress PD in the IRB formula of the Basel III framework in equation (A2.1), with the asset process in equation (A2.13) above re-written as

$$
\ln A(T) = \ln A(0) + \mu T + \frac{\sigma^2}{2} T + \sigma \sqrt{T} \left( \sqrt{R} \Phi^{-1}(a) + \sqrt{1 - R} Z(t) \right). \quad (A2.21)
$$

**Downgrade Risk**

In order to account for the downgrade risk until maturity $T$, i.e., the risk of credit deterioration separate from default, we derive the stressed bond price with $PD_{T-t\text{stress}}^{cumul}$ for equation (A2.20) above. We carry forward equation (A2.21) above so that

$$
\ln A(T) = \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) T + \sigma \sqrt{T} \sqrt{R} \Phi^{-1}(a) + \sigma \sqrt{T} \sqrt{1 - R} Z(t) + \sigma \sqrt{T - t} W(t), \quad (A2.22)
$$

with $W \sim \Phi(0,1)$. Thus, we can write

$$
PD_{T-t\text{stress}}^{cumul} = Pr \left( \ln A(T) < \ln B(T) \big| Y(T) = \Phi^{-1}(a) \right)
$$

$$
= Pr \left( \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) T + \sigma \sqrt{T} \sqrt{R} \Phi^{-1}(a) + \sigma \sqrt{T} \sqrt{1 - R} Z(t) + \sigma \sqrt{T - t} W(t) < \Phi^{-1}(\mathbb{E}(PD_{t\text{stress}}^{cumul})) \sigma \sqrt{T} + \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) T \right)
$$
\[ P(t) < \Phi^{-1} \left( \frac{\kappa(t)}{\sqrt{T}} \right) \Phi^{-1} \left( \frac{\kappa(t)}{\sqrt{T}} \right) \]

with default threshold in equation (A2.18) also carried forward so that

\[ \ln B(T) = \Phi^{-1} \left( \frac{\kappa(t)}{\sqrt{T}} \right) \sigma \sqrt{T} + \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) T. \]  

(A2.24)

Under the risk-neutral measure, including the market price of risk (as specified in equation (A2.10)) in the expression above yields

\[ \hat{P}D \sim T - ut \sim us = \Phi \left( \frac{\kappa(t)}{\sqrt{T}} \right) \sigma \sqrt{T} + \ln A(0) + \left( \mu - \frac{\sigma^2}{2} \right) T. \]  

(A2.25)

Thus, consistent with the nomenclature in the previous section of the advanced IRB approach, we apply the empirical credit risk parameters so that

\[ K_{infra,i,T} = 0.45 \times \left( \Phi \left( \frac{\kappa(t)}{\sqrt{T}} \right) \right) + \exp(-t) \frac{\hat{P}D \sim T - tstress}{1 - 0.45 \times \hat{P}D \sim T}. \]  

(A2.26)

C. Economic Capital Model (Generalized Extreme Value (GEV))

For the specification of economic capital required to cover unexpected loss from infrastructure investment, we apply extreme value theory (EVT) as a general statistical concept to model the historical credit risk dynamics; this approach takes into account even large (non-linear) fluctuations in credit risk affecting the valuation of infrastructure exposures over a one-year risk horizon. More specifically, the historical distribution of the marginal expected loss at a given point in time

\[ L_{i,j}^{mar} = PD_{i,j}^{mar} \times LGD_{i,j}^{mar} \]  

(A3.1)

is assumed to fall within the domain of attraction of the generalized extreme value (GEV) distribution as a closed form solution to estimating their limiting (or asymptotic tail) behavior, i.e., the probability of large positive increases in both the level and volatility of both PDs and LGDs. Based on the parametric fit of the GEV to the historical credit dynamics, we can determine the economic capital for unexpected loss based on the density forecast at a high percentile level, such as the conditional tail expectation (CTE), as coherent risk measure (Artzner and others, 1999).
We first motivate the application of EVT for modeling the credit risk shock. For each sample, we specify the individual asymptotic tail behavior of a historical series of expected losses, $L_{i,j}^{mar}$, through parametrically fitting a sequence of normalized extremes (maxima or minima) drawn from a sample of i.i.d. random variables to a limit distribution that identifies the asymptotic tail behavior (i.e., the likelihood of even larger extremes as the level of statistical confidence approaches certainty). The Fisher-Tippett-Gnedenko theorem (Fisher and Tippett, 1928; Gnedenko, 1943) defines the attribution of a given distribution of normalized maxima (or minima) to be of extremal type.

Let the matrix $X_{i,j}^{mar}$ denote a vector-valued i.i.d. random series of $L_{i,j}^{mar}$ with maturity $D$ for asset class $i$ and rating grade $j$. $Y_{i,j}^{mar} = \max(L_{i,j,1}^{mar}, ..., L_{i,j,n}^{mar})$ defines the sample maximum over an estimation period of $n$-number of observations. The distribution of normalized extremes satisfies the conditions of GEV if there exists a choice of normalizing constants $\alpha_{i,j} > 0$ and $\beta_{i,j} > 0$, such that the probability of each ordered $n$-sequence of normalized sample maxima $(y_{i,j}^{mar} - \alpha_{i,j})/\beta_{i,j} > 0$ converges to the non-degenerate limit distribution $G_{\beta_{i,j}}(\cdot)$ as $n \to \infty$ and $\beta_{i,j} \in \mathbb{R}$, 122 so that $\lim_{n \to \infty} P \left( \frac{(y_{i,j}^{mar} - \alpha_{i,j})}{\beta_{i,j}} \leq y \right) \to G_{i,j}^{mar}(\cdot)$. In this case, their distribution conforms to one of three distinct types of extremal behavior as limiting distributions (which are expressed below in their general form without specific notation): 123

$$EV0: G_0(x) = \exp(-\exp(-x)) \quad \text{if } x \geq 0, \xi = 0$$

$$EV1: G_1(x) = \exp(-x^{-1/\xi}) \quad \text{if } x \in [\mu - \sigma/\xi, \infty[, \xi > 0$$

$$EV2: G_2(x) = \exp(-(-x)^{-1/\xi}) \quad \text{if } x \in (-\infty, \mu - \sigma/\xi[, \xi < 0$$

If $\xi > 0$, GEV falls within the class of Fréchet (EV1) distributions, which feature regularly varying tails, including fat-tailed distributions, such as Stable Paretian distributions. $\xi < 0$ indicates (negative) Weibull (EV2)-type distributions, i.e., distributions without a tail but a finite end-point (e.g., uniform or beta distributions). In the case of $\xi \to \infty$, GEV approaches a Gumbel (EV0) distribution, which encapsulates thin-tailed distributions, 124 for which all moments exist.

122 The upper tails of most (conventional) limit distributions (weakly) converge to this parametric specification of asymptotic behavior, irrespective of the original distribution of observed maxima (unlike parametric VaR models).

123 See Embrechts and others (1997), Coles (2001), and Vandewalle and others (2004), as well as Théron and Ribereau (2012) for additional information on the definition of EVT.

124 For instance, normal, log-normal, gamma and exponential distributions.
The cumulative distribution functions (cdf) above are combined into a unified parametric specification of the general GEV cdf, which for \( X_{L_i}^{mar} \) is defined as

\[
G_{L_i,j}^{mar}(x) = \begin{cases} 
\exp \left( - (1 + \frac{\xi_{L_i,j}(x - \mu_{L_i,j})}{\sigma_{L_i,j}})^{-1} / \xi_{L_i,j} \right) & \text{if } 1 + \frac{\xi_{L_i,j}(x - \mu_{L_i,j})}{\sigma_{L_i,j}} \geq 0 \\
\exp \left( - \exp \left( - \frac{x - \mu_{L_i,j}}{\sigma_{L_i,j}} \right) \right) & \text{if } x \in \mathbb{R}, \xi_{L_i,j} = 0 
\end{cases} .
\] (A3.2)

Differencing equation (A3.2) above as \( G'_{L_i,j}^{mar}(x) = \frac{d}{dx} G_{L_i,j}^{mar}(x) \) yields the probability density function

\[
g_{L_i,j}^{mar}(x) = \frac{1}{\sigma_{L_i,j}} \left( 1 + \frac{\xi_{L_i,j}(x - \mu_{L_i,j})}{\sigma_{L_i,j}} \right)^{-1 / \xi_{L_i,j} - 1} \exp \left( - \left( 1 + \frac{\xi_{L_i,j}(x - \mu_{L_i,j})}{\sigma_{L_i,j}} \right)^{-1} \right), \] (A3.3)

where the scale, location, and shape parameters are estimated as \( \hat{\mu}_{L_i,j} > 0, \hat{\sigma}_{L_i,j} > 0, \hat{\xi}_{L_i,j} \), respectively. The shape parameter is determined by the type of sub-model (EV0, EV1 or EV2).

The moments are calculated from the observable marginal credit risk dynamics as

\[
\mu_{L_i,j}^{mar} = \mathbb{E}(PD_{L_i,j}^{mar}) \mathbb{E}(LGD_{L_i,j}^{mar}) + \rho(PD_{L_i,j}^{mar}, LGD_{L_i,j}^{mar}) \sigma_{PD_{L_i,j}^{mar}} \sigma_{LGD_{L_i,j}^{mar}}
\]

\[
= \mu_{PD_{L_i,j}^{mar}} \mu_{LGD_{L_i,j}^{mar}} + \rho(PD_{L_i,j}^{mar}, LGD_{L_i,j}^{mar}) \sigma_{PD_{L_i,j}^{mar}} \sigma_{LGD_{L_i,j}^{mar}} \] (A3.4)

\[
\sigma_{L_i,j}^{mar} = \sqrt{\frac{\pi^2}{6} \left( \mu_{PD_{L_i,j}^{mar}}^2 \sigma_{LGD_{L_i,j}^{mar}}^2 + \mu_{LGD_{L_i,j}^{mar}}^2 \sigma_{PD_{L_i,j}^{mar}}^2 + \sigma_{PD_{L_i,j}^{mar}}^2 \sigma_{LGD_{L_i,j}^{mar}}^2 \right)} \text{ (if } \xi = 0) \] (A3.5)

125 The upper tails of most (conventional) limit distributions (weakly) converge to this parametric specification of asymptotic behavior, irrespective of the original distribution of observed maxima (unlike parametric VaR models). The higher the absolute value of shape parameter, the larger the weight of the tail and the slower the speed at which the tail approaches its limit. The shape parameter also indicates the number of moments of the distribution, e.g., if \( \xi = 1/2 \), the first moment (mean) and the second moment (variance) exist, but higher moments have an infinite value. The moments of order \( n \geq 1/\xi \) are unbounded, i.e., \( 1/\xi \) indicates the highest bounded moment for the distribution. This is of practical importance since many results for asset pricing in finance rely on the existence of several moments.

126 Given that stability of the recovery rate over the risk horizon, the average ultimate recovery rate was used.
with average (expected) marginal default probability, $\mathbb{E}(PD_{i,j}^{\text{mar}})$, average (expected) marginal loss-given-default (LGD), $\mathbb{E}(LGD_{i,j}^{\text{mar}})$, which is derived from $\mu_{LGD_{i,j}^{\text{mar}}} = (1 - \mu_{\text{Recovery}_{i,j}^{\text{mar}}})$, and their correlation, $\rho$. The volatility of the default probability,

$$\sigma_{PD_{i,j}^{\text{mar}}} = \left(\frac{\pi^2}{6} \sigma_{\text{Loss Ratio}_{i,j}}^2 \mu_{\text{Loss Ratio}_{i,j}} \right) \times \mu_{PD_{i,j}^{\text{cumul}}} \times \mu_{PD_{i,j}^{\text{mar}}}, \quad (A3.6)$$

and the volatility of the LGD,

$$\sigma_{LGD_{i,j}^{\text{mar}}} = \sigma_{\text{Recovery}_{i,j}^{\text{mar}}} \times \left(\frac{\pi^2}{6} \sigma_{\text{Loss Ratio}_{i,j}}^2 \sigma_{\text{Loss Ratio}_{i,j}} \right) \times \left(\frac{\mu_{\text{LGD}_{i,j}^{\text{mar}}}}{1 - \mu_{\text{LGD}_{i,j}^{\text{mar}}}}\right), \quad (A3.7)$$

are derived from the cross-sectional distribution

$$f_{\text{Loss Ratio}_{i,j}}(\cdot) = \left(\mu_{\text{Loss Ratio}_{i,j}}', \sigma_{\text{Loss Ratio}_{i,j}}\right) \quad (A3.8)$$

of country-based (aggregate) loss ratios (or default rates),\(^{127}\) with average loss ratio $\mu_{\text{Loss Ratio}_{i,j}}$ and standard deviation $\sigma_{\text{Loss Ratio}_{i,j}}$ (over the curtailed study period, i.e., between 1995 and 2015, for project loans (Moody’s Investors Service (2017g)) and the average $\mu_{PD_{i,j}^{\text{cumul}}}$ over a ten-year time period.\(^{128}\) The specification of the two volatility measures extracts a measure of uncertainty about the default and recovery rates from the cross-sectional dispersion of the empirical loss ratio of project loans. The same scaling is applied to infrastructure debt securities and other comparator asset classes.

The tail shape parameter $\xi_{i,j}$ is estimated from the empirical quantile function of the loss ratio (which is assumed to exhibit asymptotic limiting behavior consistent with GEV given the persistence of LGD in $G_{i,j}^{\text{mar}}(\cdot)$), so that

\(^{127}\) Note that the standard deviation needs to be adjusted to ensure that the second moment is consistent with the overall calibration of the loss function to the GEV distribution. For $\xi = 0$, we can write $\sigma^2 \pi^2 / 6$ (Jobst, 2007 and 2014).

\(^{128}\) Note that the loss (or default) ratio and the cumulative default probability are highly correlated; however, there is a cyclical and structural gap between the two measures since the latter is a conditional measure (based on a cohort of project loans), whereas the former refers to the ratio between the total number of defaults and the total number of projects (without controlling for the annual variation of project loans and default probability).
\[ F_{\text{Loss Ratio}_{ij}}^{-1}(a_1) = G_{\text{Loss Ratio}_{ij}}^{-1}(a_2) = \mu_{\text{Loss Ratio}_{ij}} + \sqrt{\frac{\pi^2 \sigma_{\text{Loss Ratio}_{ij}}^2}{\xi_{ij}}} \left( -\ln(a_2) \right)^{-1\xi_{ij}} - 1 \]  
(A3.9)

holds for each specific asset class \( i \) with \( j \in \{1, \ldots, 6\} \), where \( F_{\text{Loss Ratio}_{ij}}^{-1}(\cdot) \) represents the observed loss ratio at statistical confidence levels of 99.5 and 99.9 percent, \( a_1 \in \{0.999; 0.995\} \), which corresponds to statistical confidence levels of 98.7 and 99.5 percent, \( a_2 \in \{0.987; 0.995\} \) under GEV.\(^{129}\) The marginal default rate \( \mu_{PD_{ij}^{\text{mar}}} \) (and its volatility as well as the tail shape) changes each period over the risk horizon (which is not indicated in this specification for simplicity), whereas the recovery rate \( \mu_{LGD_{ij}^{\text{mar}}} \) rate is assumed to remain constant over time.

Given the general expectation

\[
\int_0^\infty x \left( 1 + \frac{\xi_{ij} (x - \mu_{ij}^{\text{mar}})}{\sigma_{ij}^{\text{mar}}} \right)^{-1/\xi_{ij}} \exp \left( -\left( 1 + \frac{\xi_{ij} (x - \mu_{ij}^{\text{mar}})}{\sigma_{ij}^{\text{mar}}} \right)^{-1/\xi_{ij}} \right) \, dx = \\
\left( \mu_{ij}^{\text{mar}} + \frac{\sigma_{ij}^{\text{mar}}}{1 - \xi_{ij}} \right) \left( 1 + \frac{\xi_{ij} (x - \mu_{ij}^{\text{mar}})}{\sigma_{ij}^{\text{mar}}} \right)^{-1/\xi_{ij}} \right) \quad \text{(A3.10)}
\]

based on the c.d.f. in equation (A3.2) above, we obtain the CTE (or \textit{conditional VaR}) as probability-weighted residual density beyond a pre-specified statistical confidence level \( \alpha \) ("severity threshold"):

\[
\text{CTE}_{a,L_i^{ij} \text{mar}} = \mathbb{E} \left( \frac{x - \alpha_{ij}}{\beta_{ij}} \bigg| \frac{x - \alpha_{ij}}{\beta_{ij}} \geq G_{L_i^{ij} \text{mar}}^{-1}(a) = \text{VaR}_{a,L_i^{ij} \text{mar}} \right) \quad \text{(A3.11)}
\]

with quantile function

\[
G_{L_i^{ij} \text{mar}}^{-1}(a) = G_{L_i^{ij} \text{mar}}^{-1}(\cdot) = \inf \left( \frac{x - \alpha_{ij}}{\beta_{ij}} \bigg| G_{L_i^{ij} \text{mar}}^{-1}(\cdot) \geq a \right) = \mu_{ij}^{\text{mar}} + \frac{\sigma_{ij}^{\text{mar}}}{\xi_{ij}} \left( -\ln(a) \right)^{-1\xi_{ij}} - 1
\]

A3.12

and

\[
\text{VaR}_{a,L_i^{ij} \text{mar}} = \sup \left( G_{L_i^{ij} \text{mar}}^{-1}(\cdot) \bigg| \Pr \left( \frac{x - \alpha_{ij}}{\beta_{ij}} > G_{L_i^{ij} \text{mar}}^{-1}(\cdot) \right) \geq a \right). \quad \text{(A3.13)}
\]

\(^{129}\) Note that the quantile value at the 99.5\(^{th}\) and 99.9\(^{th}\) percentile is comparable to the 98.7\(^{th}\) and 99.5\(^{th}\) percentile of the GEV distribution, which generates a \textit{conditional tail expectation} (CTE) (CEA, 2006). The choice of the 99.9\(^{th}\) percentile is needed to illustrate the results of the economic capital.
Thus, in the context of deriving an economic capital charge at different maturities $m \in M$, equation (A3.11) above is extended to determine the capital requirement as

$$K = \sum_{m=1}^{M} CTE_{a,m,L_{ij}^{mar}} = \sum_{m=1}^{M} \mathbb{E} \left( \frac{x-\alpha_{i,j}}{\beta_{i,j}} \right)^{\frac{x-\alpha_{i,j}}{\beta_{i,j}}} \geq G_{i,j,m}^{-1}(\alpha) = Var_{a,m,L_{ij}^{mar}}$$ (A3.14)

where $M$ denotes the total effective maturity of the exposure. The statistical confidence level $\alpha$ is chosen consistent with the common risk sensitivity of solvency regimes of insurance companies and banks, which is $Var_{0.995,m,L_{ij}^{mar}}$ and $Var_{0.999,m,L_{ij}^{mar}}$ for insurance companies and banks, and roughly corresponds to $CTE_{0.987,m,L_{ij}^{mar}}$ and $CTE_{0.995,m,L_{ij}^{mar}}$. 
IX. ADDITIONAL FIGURES AND TABLES

[see next pages]
Appendix Figure 1. Sample Overview: Number of Projects and Countries (1983-2015)

Sources: Moody’s Investors Service (2017g) and author.
Appendix Figure 2. Unrated Project Loans (1983-2015)—Sample Composition (Projects by Country)

Source: Moody’s Investors Service (2017g).

Note: For the shorter sample time period (1995-2015), the number of countries/projects for each sample declines to: 135/6,108 (for “Total Study”), 114/5,792 (for “All Sub-samples”), 26/2,602 (for “EEA”), 37/4,785 (for “EEA or OECD”), 78/1,148 (for “EMDE-A”), and 73/984 (for “EMDE-B”).
Appendix Figure 3. Unrated Project Loans (1983-2015)—Sample Composition (Defaults by Country)

Source: Moody’s Investors Service (2017g).

Note: for the shorter sample time period (1995-2015), the number of countries/defaults for each sample declines to: 135/407 (for “Total Study”), 114/401 (for “All Sub-samples”), 26/154 (for “EEA”), 37/297 (for “EEA or OECD”), 78/111 (for “EMDE-A”), and 73/102 (for “EMDE-B”).
Appendix Figure 4. Unrated Project Loans (1983-2015)—Sample Composition (Projects by Principal Industry Sector)

Source: Moody’s Investors Service (2017g).

Note: the Moody’s Analytics Project Finance Data Consortium dataset comprises ten sectoral categories, of which three sectors (power, oil & gas, and (broad) infrastructure (and its sub-category “transport”)) are shown separately.
Appendix Figure 5. Unrated Project Loans (1983–2015)—Sample Composition (Defaults by Principal Industry Sector)

Source: Moody’s Investors Service (2017g).

Note: the Moody’s Analytics Project Finance Data Consortium dataset comprises ten sectoral categories, of which three sectors (power, oil & gas, and (broad) infrastructure (and its sub-category "transport") are shown separately.
Appendix Figure 6. Unrated Project Loans (1983-2015): Sample Evolution

Sources: Moody’s Investors Service (2017g).

Note: the loss ratio (or default rate) represents the relationship between the annual number of defaults and the net cumulative number of projects in each sample (starting in 1983).
Appendix Figure 7. Lorenz Curves (Composition Effect): Sample Concentration of Projects, Defaults and Recoveries (in percent)

Sources: Moody’s Investors Service (2017g).

Note: the charts show the change in the concentration of projects, defaults, and recoveries (on a cumulative basis) in each sample subset as the proportion of countries (ranked in order of project count) included in each subset increases (i.e., countries are ordered based on the descending number of projects in the sample).
Appendix Figure 8. Credit Risk Factor Stability (Composition Effect): Cross-Sectional Changes in Default and Recovery Rates (In percent)

Sources: Moody’s Investors Service (2017g) and author.

Note: the charts show the stability of the simple average loss ratio (or default rate) and weighted average recovery rate after controlling for differences in the count of defaults and recoveries, with the former being about twice as frequent.
Appendix Figure 9. Unrated Project Loans (1983-2015) vs. Moody’s Corporate Credit Ratings—Cumulative Annual Probability of Default (In percent)

Sources: Moody’s Investors Service (2017b, 2017c and 2017g) and author.

Note: an overview of the implied default probabilities for each credit rating grade (and the corresponding credit quality step (CQS)) can be found in Appendix Table 2; the sub-samples refer to (i) all EEA and OECD member countries “EEA/OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B” according to the sample selection in Moody’s Investors Service (2017) over a study time period between 1983 and 2015; */ default risk of corporate exposures (global) according to Moody’s Investors Service (2017g).
Appendix Figure 10. Unrated Project Loans (1983-2015) vs. Standard & Poor’s Corporate Credit Ratings—Cumulative Annual Probability of Default (In percent)

Sources: Moody’s Investors Service (2017c and 2017g), Vazza and Kraemer (2017) and author.

Note: an overview of the implied default probabilities for each credit rating grade (and the corresponding credit quality step (CQS)) can be found in Appendix Table 2; the sub-samples refer to (i) all EEA and OECD member countries “EEA or OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B” according to the sample selection in Moody’s Investors Service (2017b) over a study time period between 1983 and 2015; * default risk of corporate exposures (global) according to Moody’s Investors Service (2017g).
Appendix Figure 11. Unrated Project Loans (1995-2015) vs. Moody’s Corporate Credit Ratings—Cumulative Annual Probability of Default (In percent)

Sources: Moody’s Investors Service (2017b, 2017c and 2017g) and author.

Note: an overview of the implied default probabilities for each credit rating grade (and the corresponding credit quality step (CQS)) can be found in Appendix Table 2; the sub-samples refer to (i) all EEA and OECD member countries (“EEA/OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B” according to the sample selection in Moody’s Investors Service (2017b) over a study time period between 1995 and 2015; “*” default risk of corporate exposures (global) according to Moody’s Investors Service (2017g).
Appendix Figure 12. Unrated Project Loans (1995-2015) vs. Standard & Poor’s Corporate Credit Ratings—Cumulative Annual Probability of Default (In percent)

Sources: Moody’s Investors Service (2017c and 2017g), Vazza and Kraemer (2017) and author.

Note: an overview of the implied default probabilities for each credit rating grade (and the corresponding credit quality step (CQS)) can be found in Appendix Table 2; the sub-samples refer to (i) all EEA and OECD member countries “EEA/OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B” according to the sample selection in Moody’s Investors Service (2017b) over a study time period between 1995 and 2015; */ default risk of corporate exposures (global) according to Moody’s Investors Service (2017g).
Appendix Figure 13. Unrated Project Loans (1983-2015) vs. Corporate Loans, Infrastructure Debt Securities and Non-financial Corporate Debt—Cumulative Annual Probability of Default (In percent)

Sources: Moody’s Investors Service (2017b, 2017c and 2017g) and author.

Note: time horizon consistent with study period between 1983 and 2015 (with the exception (*), for which the study period 1995-2015 applies); the sub-sample “EMDE-B” refers to all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) according to the sample selection in Moody’s Investors Service; **/ default risk of corporate exposures (global) according to Moody’s Investors Service.
Appendix Figure 14. Unrated Project Loans (1983-2015)—Probability of Default (PD) (In percent)

Sources: Moody’s Investors Service (2017g) and author.

Note: the average and standard deviation of the marginal probability of default is calculated over a 10-year time horizon; the total sample of project loans in the Moody’s Analytics Project Finance Data Consortium dataset comprises ten sectoral categories, of which three sectors (power, oil & gas, and broad infrastructure (and its sub-category “transport”)) are shown separately. For the original study period (1983-2015), the share of the total number of defaults in the selected sectors for samples “EEA or OECD,” “EMDE-A,” and “EMDE-B,” respectively, is as follows: power (40/16/32 percent), oil & gas (10/33/17 percent), and infrastructure (30/9/9 percent), of which a sub-sample for “transport” (23/2/2 percent) was created.
Appendix Figure 15. Unrated Project Loans (1983-2015)—Recovery Rate (in percent)

Sources: Moody's Investors Service (2017g) and author.

Note: the recovery rate represents the "ultimate recovery" (outside the results from distressed debt sale and work-out process) and is based on cohorts of loans with the same origination year; the standard deviation of the recovery rate is calculated as a cross-sectional measure for each sample over a 10-year time horizon (which is missing for some sub-samples due to lack of robustness); the total sample of project loans in the Moody's Analytics Project Finance Data Consortium dataset comprises ten sectoral categories, of which three sectors (power, oil & gas, and (broad) infrastructure (and its sub-category "transport")) are shown separately.
Appendix Figure 16. Annual Expected Loss: Debt Securities and Project Loans, 1983-2015 (In percent)

**Sources:** Moody’s Investors Service (2017c, 2017d, 2017e, 2017f and 2017g) and author.

**Note:** expected losses are calculated as the product of the average annual cumulative default probability over a 10-year horizon and a constant (ultime) recovery rate, which is estimated based on annual cohorts of originated bonds or loans, over the original study period (1983-2015), which is consistent with the study period underlying the published credit risk parameters of both non-financial corporate bonds and infrastructure debt securities used for comparison; */ refers to geographical scope of subset “all sub-samples,” which comprises all EEA and OECD member countries (“EEA or OECD”) and all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”) in Moody’s Investors Service (2017g); the credit risk parameters for rated infrastructure bonds in subsets “EEA/OECD,” “EMDE-A” and “EMDE-B” were extrapolated from the credit characteristics of infrastructure debt securities on a global basis, conditional on the credit performance of unrated project loans in countries that are included in the different subsets; 1/ based on Moody’s credit rating grades, with PDs and recovery rates of non-financial corporate debt and infrastructure debt securities obtained from Moody’s Investors Service (2016b, 2017b and 2017e); 2/ based on credit performance data of unrated project loans (and the sub-set of projects loans for public-private partnerships (PPP)) in Moody’s Investors Service (2017c and 2017g).
Appendix Figure 17. Unrated Project Loans—Capital Charge under Differentiated Regulatory Treatment (In percent)

Sources: BCBS (2017), EIOPA (2013a, 2013b, 2015a and 2015b), European Commission (2015, 2016 and 2017), IAIS (2017b), Moody’s Investors Service (2017g) and author.

Note: “stdev.” = cross-sectional standard deviation; the sub-samples refer to (i) all EEA and OECD member countries (“EEA/OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”) according to the sample selection in Moody’s Investors Service (2017g) over a study time period between 1995 and 2015; */ Insurance Capital Standard (ICS): calibrated credit risk stress factor by using the cumulative default rate of unrated project loans in either (i) an asymptotic single risk factor model (Vasiček, 2002), parameterized consistent with the internal ratings-based (IRB) approach (with and without application of fixed LGD of 45 percent) or (ii) the direct application of the advanced IRB approach for specialized lending (project finance) according to the finalized Basel III framework (BCBS, 2017), with and without application of the maturity adjustment and floors for marginal PDs (0.05 percent) and LGD (25 percent); /** Solvency II Directive current capital charge for bond and loan exposures under the original Solvency II SCR Standard Formula Spread Risk Sub-Module (which also applies to infrastructure debt investment outside EEA or OECD member countries along with other criteria for qualifying investment according to EU Regulation 2017/1542 (European Commission, 2017) were satisfied) and reduced capital charge for qualifying infrastructure investment in EEA or OECD countries; *** economic capital charge based on empirically fitted generalized extreme value (GEV) distribution using the marginal default and recovery rates (and their corresponding cross-sectional volatilities for the different sub-samples), which generates the conditional tail expectation (CTE) as point estimate at 98.7 and 99.7 percent statistical confidence (single-sided), which corresponds to a Value-at-Risk (VaR) measure at about 99.5 and 99.9 percent, respectively (ECA, 2006).
Appendix Figure 18. Solvency II (Europe): Return on Equity from Project Loan Investment as Function of Regulatory Capital Charges
(In percent)

Sources: Bloomberg L.P., European Commission (2015), Moody’s Investors Service (2017g) and author.

Note: calculation based on the annual yield (less the risk-free rate of 1.0 percent) after tax (35 percent); median return on equity (RoE) of European insurers as of mid-2016 was 9.1 percent (EIOPA, 2017a); 1/ average infrastructure loan rate in the U.K. (4.3 percent) according to Institute and Faculty of Actuaries (2015) at end-2014, which is applied to “global” project loans, and scaled to project loans in EMDE (4.6 percent) consistent with the differential yield of infrastructure debt securities in advanced and developing economies; 2/ using the Solvency II Spread Risk Sub-Module based on empirical credit risk factors for project loans in samples “all sub-samples” and “EMDE-A” as specified in Moody’s Investors Service (2017g) — assuming that the unrated exposure has a duration of 10 years (which is the average tenor of infrastructure project loans according to Ehlers (2014) and OECD (2015a)) and cannot be classified as “qualifying investment,” it is subject to a capital charge consistent with conventional corporate exposures (loans/bonds) of credit quality score (CQS) of between 3 (“Baa”) and 4 (“Ba”).
Appendix Figure 19. Solvency II (Europe): Return on Equity from Investment in Infrastructure Debt Securities as Function of Regulatory Capital Charges (In percent)

Sources: Bloomberg L.P., Moody’s Investors Service (2017g), Morningstar and author.
Note: calculation based on the annual yield (less the risk-free rate of 1.0 percent) after tax (35 percent); median return on equity (RoE) of European insurers as of mid-2016 was 9.1 percent (EIOPA, 2017a); 1/ Morningstar Global Infrastructure Bond Index, estimated based on daily returns between July 1, 2015 and Sept. 30, 2017 (5.0 percent); 2/ Morningstar Emerging Market Infrastructure Bond Index, estimated based on daily returns between July 1, 2015 and Sept. 30, 2017 (5.4 percent); 3/ assumed maturity of 10 years and credit quality score (CQS) of 3 (“Baa”) based on current Solvency II Spread Risk Sub-Module (European Commission, 2015 and 2017); 4/ assumed maturity of 10 years and CQS=3 (“Baa”).
Appendix Figure 20. Insurance Capital Standard (ICS): Return on Equity from Project Loan Investment as Function of Regulatory Capital Charges (In percent)

Sources: Bloomberg L.P., IAIS (2017b), Moody’s Investors Service (2017g) and author.

Note: calculation based on the annual yield (less the risk-free rate of 1.0 percent) after tax (35 percent); average return on equity (RoE) of global insurers as of mid-2016 was 8.8 percent (IAIS, 2017a); 1/ average infrastructure loan rate in the U.K. (4.3 percent) according to Institute and Faculty of Actuaries (2015) at end-2014, which is applied to “global” project loans, and scaled to project loans in EMDE (4.6 percent) consistent with the differential yield of infrastructure debt securities in advanced and developing economies; 2/ credit risk factor under the current calibration of credit risk (corporate and re-securitization) of the ICS for internationally active insurance groups (IAIGs) based on asymptotic single factor credit risk model (by adapting the Vasiček (2002) model), with actual LGD, assuming a maturity of 10 years (which is the average tenor of infrastructure project loans according to Ehlers (2014) and OECD (2015a)) – without differentiation, unrated exposures are treated like corporate exposure (loans/bonds) of credit quality score (CQS) of between 4 (“Ba”) and 5 (“B”).
Appendix Figure 21. Insurance Capital Standard (ICS): Return on Equity from Investment in Infrastructure Debt Securities as Function of Regulatory Capital Charges (in percent)

Sources: Bloomberg L.P., Moody’s Investors Service (2017g), Morningstar and author.

Note: calculation based on the annual yield (less the risk-free rate of 1.0 percent) after tax (35 percent); average return on equity (RoE) of global insurers as of mid-2016 was 8.8 percent (IAIS, 2017a); 1/ Morningstar Global Infrastructure Bond Index, estimated based on daily returns between July 1, 2015 and Sept. 30, 2017 (5.0 percent); 2/ Morningstar Emerging Market Infrastructure Bond Index, estimated based on daily returns between July 1, 2015 and Sept. 30, 2017 (5.4 percent); 3/ assumed maturity of 10 years and corporate issuer rating of credit quality score (CQS) of 3 (“Baa”) based on planned credit risk stress factor in ICS (IAIS, 2017b); 4/ credit risk factor under the current calibration of credit risk (corporate and re-securitization) of the ICS for internationally active insurance groups (IAIGs) based on asymptotic single factor credit risk model (by adapting the Vasištek (2002) model), with actual LGD; 5/ assumed maturity of 10 years and credit quality score (CQS) of 3 (“Baa”).
= Included in the adjustment for the loss-absorbing capacity of technical provisions under the modular approach

Source: EIOPA.
Appendix Figure 23. International Capital Standard (ICS)

ICS Capital Requirement

- Life
  - Mortality
  - Longevity
  - Lapse
  - Expense
- Health
  - Underwriting
  - Lapse
- Non-Life
  - Premium
  - Reserve
- Catastrophe
  - Interest Rate
  - Equity
  - Real Estate
  - Currency
  - Asset Conc
- Operational
- Market
- Credit

Source: IAIS.
### Appendix Table 1. Principal Infrastructure Sectors and Mapping to Main Industry Sectors of Project Loans

| Infrastructure Business Types | Production/Transformation | Capacity Provider | Distributor/Service Provider | Service Hub |
|------------------------------|--------------------------|-------------------|------------------------------|-------------|
| **Examples**                 |                          |                   |                              |             |
| • Power plant                |                          | Pipeline owners   | Water supply and processing   | Airports    |
| • Oil and gas exploration   |                          | Rail network operators | Gas/electricity processing    | Sea ports & terminals |
| and processing               |                          | Electricity grid  |                               |             |
| • Oil & gas (incl. exploration & production, refining, liquefied natural gas, and biofuels) | • Telecom and communications network owners | • Telecom and telecommunications network owners |                       |             |
| • Power (electricity generation) |                          |                   |                              |             |

**Moody’s Analytics Project Finance Data Consortium (categories)**

|                          | Media and telecom (incl. media content, media distribution, and telephone) | (Broad) infrastructure (incl. transport, and water systems & desalination) | (Broad) infrastructure (ports & terminals) |
| • Chemicals production  |                          | (Broad) infrastructure (incl. transport, and water systems & desalination) | (Broad) infrastructure (ports & terminals) |
| • Manufacturing (incl. automotive, building materials, and construction) |                          | (Broad) infrastructure (incl. transport, and water systems & desalination) | (Broad) infrastructure (ports & terminals) |
| • Metals and mining (incl. processing) |                          | (Broad) infrastructure (incl. transport, and water systems & desalination) | (Broad) infrastructure (ports & terminals) |
| • Oil & gas (incl. exploration & production, refining, liquefied natural gas, and biofuels) | • Power (electricity transmission) | (Broad) infrastructure (incl. transport, and water systems & desalination) | (Broad) infrastructure (ports & terminals) |
| • Power (electricity generation) |                          | (Broad) infrastructure (incl. transport, and water systems & desalination) | (Broad) infrastructure (ports & terminals) |

**Coverage of sectors in study**

| Power | Oil & gas | Transport | Oil & gas | (Broad) infrastructure |
|-------|-----------|-----------|-----------|------------------------|
|        | Capacity to reduce price/volume volatility; low cost producer position | Optimized use of fixed network, subject to revenue maximization over the longer term; high reliability market position; leveraging back office functions and other synergies in portfolio companies | Meet contractual expectations (customer satisfaction); enhanced efficiency and cost; minimized leakage of revenues | Understand carriers’ strategic requirements and offer competitive rates; maximize revenue from customer services; managing costs and capital expenditure |

**Profit/risk drivers**

- Source: Moody’s Analytics Data Alliance Project Finance Consortium and author.

**Note:** Based on the three sectors (and one sub-sector) analyzed in greater detail based on ten sectoral categories of the Moody’s Analytics Project Finance Data Consortium: (i) “chemicals production,” (ii) (broad) “infrastructure” (incl. ports & terminals, public services and administration, transport, and water systems & desalination), (iii) “leisure and recreation,” (iv) “manufacturing” (incl. automotive, building materials, and construction), (v) “media and telecom” (incl. media content, media distribution, and telephone), (vi) “metals and mining” (incl. processing), (vii) “oil & gas” (incl. distribution, exploration & production, refining, liquefied natural gas, and biofuels), (viii) “power” (electricity generation/transmission/distribution), (ix) “transportation” (other than covered in infrastructure, e.g., aircraft/ships), and (x) “other.” The report shows the results for four sectors separately (power, oil & gas, infrastructure (and its sub-category “transport”).
### Appendix Table 2. Overview of Implied Default Probabilities for Corporate Exposures and Mapping of Rating Classifications

| Credit Quality Step (CQS) | Moody's A | Moody's Baa | Moody's Ba | Moody's B |
|---------------------------|-----------|-------------|------------|-----------|
|                           | Moody's A | Moody's Baa | Moody's Ba | Moody's B |
|                           | S&P A     | S&P BBB     | S&P BB     | S&P B     |
|                           | cumulative | marginal    | cumulative | marginal |
| Year 1 Year 2 Year 3 Year 4 Year 5 Year 6 Year 7 Year 8 Year 9 Year 10 | cumulative | marginal    | cumulative | marginal |
|---------------------------|-----------|-------------|------------|-----------|
| 2                         | 0.06%     | 0.16%       | 0.17%      | 0.58%     |
|                           | 0.06%     | 0.10%       | 0.17%      | 0.58%     |
| 3                         | 0.39%     | 0.25%       | 0.44%      | 1.79%     |
|                           | 0.39%     | 0.09%       | 0.27%      | 1.21%     |
| 4                         | 0.61%     | 0.37%       | 0.69%      | 3.57%     |
|                           | 0.61%     | 0.12%       | 0.25%      | 1.78%     |
| 5                         | 0.87%     | 0.71%       | 1.08%      | 5.22%     |
|                           | 0.87%     | 0.14%       | 0.39%      | 1.65%     |
| 6                         | 1.16%     | 0.90%       | 1.47%      | 6.87%     |
|                           | 1.16%     | 0.19%       | 0.39%      | 1.65%     |
| 7                         | 1.46%     | 1.08%       | 1.87%      | 8.19%     |
|                           | 1.46%     | 0.18%       | 0.40%      | 1.32%     |
| 8                         | 1.77%     | 1.29%       | 2.23%      | 9.39%     |
|                           | 1.77%     | 0.21%       | 0.37%      | 1.20%     |
| 9                         | 2.10%     | 1.53%       | 2.60%      | 10.38%    |
|                           | 2.10%     | 0.24%       | 0.39%      | 0.99%     |
| 10                        | 2.41%     | 1.39%       | 2.99%      | 11.31%    |
|                           | 2.41%     |            | 3.39%      | 0.81%     |

Sources: Moody’s Investors Service (2017b and 2017g), Vazza and Kraemer (2017), and author.
### Appendix Table 3. Estimated Capital Charges (Actual and Differentiated): Unrated Project Loans—Insurance Capital Standard (ICS) and Economic Capital Model [99.5%]

(In percent)

#### Sample Selection

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|-----------|------------------------|------------------------|
| 1                | 2.1 1.8 2.7 3.0 | 6.3       | -3.6  -57              | -3.3  -52              |
| 2                | 3.2 2.8 4.0 4.4 | 10.7      | -6.7  -63              | -6.3  -59              |
| 3                | 3.9 3.5 4.9 5.4 | 11.8      | -6.9  -59              | -6.4  -54              |
| 4                | 4.5 4.1 5.5 6.2 | 12.3      | -6.8  -55              | -6.1  -50              |
| 5                | 5.0 4.6 6.1 6.8 | 12.5      | -6.4  -51              | -5.7  -46              |
| 6                | 5.5 5.0 6.6 7.3 | 12.6      | -6.0  -48              | -5.3  -42              |
| 7                | 5.9 5.4 7.0 7.7 | 12.7      | -5.7  -45              | -5.0  -39              |
| 8                | 6.3 5.7 7.4 8.1 | 12.7      | -5.3  -42              | -4.6  -36              |
| 9                | 6.6 6.1 7.7 8.5 | 12.7      | -5.0  -39              | -4.2  -33              |
| 10               | 7.0 6.4 8.1 8.9 | 12.7      | -4.6  -36              | -3.8  -30              |

#### IAIS: ICS (Credit Risk) [A-IRB with maturity adjustment, without floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|-----------|------------------------|------------------------|
| 1                | 2.5 2.3 3.0 3.1 | 6.3       | -3.3  -53              | -3.2  -51              |
| 2                | 3.7 3.6 4.4 4.5 | 10.7      | -6.3  -59              | -6.2  -58              |
| 3                | 4.6 4.4 5.3 5.5 | 11.8      | -6.5  -55              | -6.3  -53              |
| 4                | 5.3 5.1 6.1 6.3 | 12.3      | -6.2  -50              | -6.0  -49              |
| 5                | 6.0 5.8 6.7 7.0 | 12.5      | -5.8  -46              | -5.5  -44              |
| 6                | 6.5 6.3 7.2 7.5 | 12.6      | -5.4  -43              | -5.1  -41              |
| 7                | 7.0 6.8 7.7 7.9 | 12.7      | -5.0  -40              | -4.8  -38              |
| 8                | 7.4 7.2 8.1 8.3 | 12.7      | -4.6  -36              | -4.4  -35              |
| 9                | 7.8 7.7 8.5 8.7 | 12.7      | -4.2  -33              | -4.0  -31              |
| 10               | 8.3 8.1 8.9 9.1 | 12.7      | -3.8  -30              | -3.6  -28              |

#### IAIS: ICS (Credit Risk) [A-IRB with maturity adjustment and floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|-----------|------------------------|------------------------|
| 1                | 2.1 1.8 2.7 3.0 | 6.3       | -3.6  -57              | -3.3  -52              |
| 2                | 2.8 2.5 3.6 4.0 | 10.7      | -7.1  -66              | -6.7  -62              |
| 3                | 3.2 2.9 4.1 4.7 | 11.8      | -7.7  -65              | -7.1  -61              |
| 4                | 3.5 3.1 4.5 5.0 | 12.3      | -7.8  -64              | -7.3  -59              |
| 5                | 3.7 3.3 4.7 5.3 | 12.5      | -7.8  -62              | -7.2  -58              |
| 6                | 3.8 3.4 4.8 5.4 | 12.6      | -7.8  -62              | -7.2  -57              |
| 7                | 3.9 3.5 4.8 5.4 | 12.7      | -7.9  -62              | -7.3  -58              |
| 8                | 4.0 3.6 4.9 5.4 | 12.7      | -7.8  -62              | -7.3  -57              |
| 9                | 4.0 3.6 4.9 5.4 | 12.7      | -7.8  -62              | -7.3  -57              |
| 10               | 4.0 3.6 4.9 5.4 | 12.7      | -7.8  -62              | -7.3  -57              |

#### IAIS: ICS (Credit Risk) [A-IRB without maturity adjustment and floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|-----------|------------------------|------------------------|
| 1                | 2.1 1.8 2.7 3.0 | 6.3       | -3.6  -57              | -3.3  -52              |
| 2                | 2.8 2.5 3.6 4.0 | 10.7      | -6.7  -63              | -6.6  -61              |
| 3                | 3.2 2.9 4.1 4.7 | 11.8      | -7.2  -61              | -7.0  -60              |
| 4                | 3.5 3.1 4.5 5.0 | 12.3      | -7.4  -60              | -7.2  -58              |
| 5                | 3.7 3.3 4.7 5.3 | 12.5      | -7.3  -59              | -7.1  -57              |
| 6                | 3.8 3.4 4.8 5.4 | 12.6      | -7.3  -58              | -7.1  -56              |
| 7                | 3.9 3.5 4.8 5.4 | 12.7      | -7.4  -58              | -7.2  -57              |
| 8                | 4.0 3.6 4.9 5.4 | 12.7      | -7.4  -58              | -7.2  -56              |
| 9                | 4.0 3.6 4.9 5.4 | 12.7      | -7.4  -58              | -7.2  -56              |
| 10               | 4.0 3.6 4.9 5.4 | 12.7      | -7.4  -58              | -7.2  -56              |
## Appendix Table 3. Estimated Capital Charges (Actual and Differentiated): Unrated Project Loans—Insurance Capital Standard (ICS) and Economic Capital Model [99.5%] (continued)

(In percent)

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|------------------------|
| 1                | 2.4            | 2.1        | 3.2                     | 3.6                    | 6.3                     | -3.1                   | -49            | -2.7           | -43            |
| 2                | 3.9            | 3.5        | 5.1                     | 5.7                    | 10.7                    | -5.6                   | -52            | -5.0           | -46            |
| 3                | 4.2            | 3.7        | 5.4                     | 6.1                    | 11.8                    | -6.4                   | -54            | -5.7           | -49            |
| 4                | 4.3            | 3.8        | 5.5                     | 6.2                    | 12.3                    | -6.8                   | -55            | -6.1           | -50            |
| 5                | 4.4            | 3.9        | 5.6                     | 6.2                    | 12.5                    | -6.9                   | -56            | -6.3           | -50            |
| 6                | 4.4            | 3.9        | 5.6                     | 6.2                    | 12.6                    | -7.0                   | -56            | -6.4           | -51            |
| 7                | 4.4            | 3.9        | 5.5                     | 6.2                    | 12.7                    | -7.2                   | -56            | -6.5           | -51            |
| 8                | 4.4            | 3.9        | 5.5                     | 6.2                    | 12.7                    | -7.2                   | -57            | -6.5           | -51            |
| 9                | 4.4            | 3.9        | 5.5                     | 6.2                    | 12.7                    | -7.2                   | -57            | -6.5           | -51            |
| 10               | 4.4            | 3.9       | 5.5                     | 6.1                    | 12.7                    | -7.2                   | -57            | -6.6           | -52            |

### IAIS: ICS (Credit Risk) [adapted Vasiček (2002) model with fixed LGD, 99.5%]

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|------------------------|
| 1                | 5.1            | 4.8        | 6.3                     | 6.6                    | 6.3                     | 0.0                   | 0              | 0.3            | 5              |
| 2                | 8.4            | 7.9        | 10.2                    | 10.6                   | 10.7                    | -0.5                   | -5             | -0.1           | -1             |
| 3                | 9.1            | 8.5        | 10.8                    | 11.3                   | 11.8                    | -1.0                   | -8             | -0.5           | -4             |
| 4                | 9.3            | 8.8        | 11.1                    | 11.5                   | 12.3                    | -1.2                   | -10            | -0.8           | -6             |
| 5                | 9.5            | 9.0        | 11.2                    | 11.6                   | 12.5                    | -1.3                   | -11            | -0.9           | -7             |
| 6                | 9.5            | 9.1        | 11.2                    | 11.6                   | 12.6                    | -1.4                   | -11            | -1.0           | -8             |
| 7                | 9.5            | 9.1        | 11.1                    | 11.6                   | 12.7                    | -1.6                   | -12            | -1.1           | -9             |
| 8                | 9.5            | 9.1        | 11.1                    | 11.5                   | 12.7                    | -1.6                   | -13            | -1.2           | -9             |
| 9                | 9.5            | 9.1        | 11.1                    | 11.5                   | 12.7                    | -1.6                   | -13            | -1.2           | -9             |
| 10               | 9.5            | 9.1       | 11.1                    | 11.5                   | 12.7                    | -1.6                   | -13            | -1.2           | -9             |

### Economic Capital [GEV-CTE, 98.7%]

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|------------------------|
| 1                | 1.9            | 1.6        | 2.9                     | 3.4                    | 8.3                     | -3.4                   | -54            | -2.9           | -45            |
| 2                | 3.7            | 3.1        | 5.6                     | 6.7                    | 10.7                    | -5.1                   | -48            | -4.0           | -37            |
| 3                | 5.1            | 4.3        | 7.6                     | 9.1                    | 11.8                    | -4.2                   | -36            | -2.7           | -23            |
| 4                | 6.1            | 5.3        | 8.9                     | 10.6                   | 12.3                    | -3.4                   | -28            | -1.7           | -14            |
| 5                | 6.9            | 6.0        | 9.8                     | 11.8                   | 12.5                    | -2.7                   | -22            | -0.9           | -7             |
| 6                | 7.3            | 6.5        | 10.2                    | 12.1                   | 12.6                    | -2.4                   | -19            | -0.5           | -4             |
| 7                | 7.6            | 6.8        | 10.4                    | 12.2                   | 12.7                    | -2.3                   | -18            | -0.5           | -4             |
| 8                | 7.8            | 7.0        | 10.4                    | 12.3                   | 12.7                    | -2.3                   | -18            | -0.4           | -3             |
| 9                | 7.9            | 7.1        | 10.5                    | 12.4                   | 12.7                    | -2.2                   | -17            | -0.3           | -2             |
| 10               | 8.0            | 7.2       | 10.5                    | 12.5                   | 12.7                    | -2.2                   | -17            | -0.2           | -2             |

Sources: IAIS, Moody’s Investors Service (2016c, 2017a, 2017c and 2017g), and author.

Note: the sub-samples refer to (i) all EEA and OECD member countries (“EEA or OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey (“EMDE-B”)); the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; 1/ capital charges were derived from calibrating credit risk stress factors for the Insurance Capital Standard (ICS) by using the cumulative default rate of unrated project loans in an adapted Vasiček (2002) model or the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) according to the finalized Basel III framework (BCBS, 2017) at a statistical confidence level of 99.5 percent, with and without application of the maturity adjustment and floors for marginal PDs (0.05 percent) and LGD (25 percent); 2/ credit risk factor for corporate exposure under the planned ICS for internationally active insurance groups (IAIGs) based on asymptotic single factor credit risk model (by adapting the Vasiček (2002) model), consistent with the IRB approach under the Basel III framework (BCBS, 2017), with actual and fixed LGD (with the latter replicating the foundation internal ratings-based (F-IRB) approach) — credit risk parameters derived from S&P’s corporate default rate estimates for 2013 (Vazza and Kraemer, 2014) and published in IAIS (2017b) — the capital charge falls between CQS=4 and CQS=5 of rated exposures (and, thus, is broadly consistent with the treatment of unrated corporate exposures of banks incorporated in jurisdictions that allow the use of external ratings for regulatory purposes under the Basel III framework, which assigns a “base” risk weight of 100 percent (which is equivalent to the treatment of exposures with a CQS=4 (“Ba”)); 3/ adapted Vasiček (2002) model is applied to the credit risk parameters of unrated project loans published by Moody’s Investors Service (2017g) to determine the capital requirement for the risk of credit deterioration separate from default — based on the parametrization of the IRB approach under Basel III, with the exception of the cumulative default probabilities after one year (T and maturity T, which are used for calculation of the correlation factor, p, the market price of risk λ=0.012625×(T^-0.0093))×σp, and the bond interest rate of 5 percent per year; 4/ based on the conditional tail expectation (CTE) of the generalized extreme value (GEV) distribution, parametrized using the credit risk data of unrated project loans published by Moody’s Investors Service, following Jobst (2007 and 2014) — CTE at 98.7 percent is roughly equivalent to Value-at-Risk (VaR) at 99.5 percent (CEA, 2006).
Appendix Table 4. Estimated Capital Charges (Actual and Differentiated): Unrated Project Loans (PPP only)*—Insurance Capital Standard (ICS) and Economic Capital Model [99.5%]

(In percent)

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|-------------------------|
| 1                | 0.9            | 1.0        | 1.1                     | 1.1                     |
| 2                | 1.4            | 1.5        | 1.7                     | 1.8                     |
| 3                | 1.8            | 2.0        | 2.4                     | 2.5                     |
| 4                | 2.2            | 2.4        | 2.9                     | 3.1                     |
| 5                | 2.6            | 2.8        | 3.4                     | 3.5                     |
| 6                | 2.9            | 3.1        | 3.8                     | 4.0                     |
| 7                | 3.1            | 3.5        | 4.0                     | 4.2                     |
| 8                | 3.4            | 3.8        | 4.2                     | 4.4                     |
| 9                | 3.7            | 4.0        | 4.4                     | 4.6                     |
| 10               | 3.9            | 4.3        | 4.6                     | 4.8                     |

IAIS: ICS (Credit Risk) [A-IRB with maturity adjustment, without floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|-------------------------|
| 1                | 1.6            | 1.6        | 1.7                     | 1.8                     |
| 2                | 2.4            | 2.5        | 2.7                     | 2.9                     |
| 3                | 3.2            | 3.2        | 3.8                     | 4.0                     |
| 4                | 3.9            | 4.0        | 4.6                     | 4.8                     |
| 5                | 4.5            | 4.6        | 5.4                     | 5.5                     |
| 6                | 5.0            | 5.1        | 6.1                     | 6.3                     |
| 7                | 5.5            | 5.6        | 6.4                     | 6.6                     |
| 8                | 6.0            | 6.1        | 6.7                     | 7.0                     |
| 9                | 6.4            | 6.5        | 7.0                     | 7.3                     |
| 10               | 6.8            | 6.9        | 7.3                     | 7.6                     |

IAIS: ICS (Credit Risk) [A-IRB with maturity adjustment and floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|-------------------------|
| 1                | 0.9            | 1.0        | 1.1                     | 1.1                     |
| 2                | 1.2            | 1.4        | 1.6                     | 1.7                     |
| 3                | 1.5            | 1.6        | 2.0                     | 2.1                     |
| 4                | 1.7            | 1.9        | 2.4                     | 2.5                     |
| 5                | 1.9            | 2.1        | 2.6                     | 2.7                     |
| 6                | 2.0            | 2.2        | 2.8                     | 2.9                     |
| 7                | 2.1            | 2.3        | 2.8                     | 2.9                     |
| 8                | 2.2            | 2.3        | 2.8                     | 2.9                     |
| 9                | 2.2            | 2.4        | 2.8                     | 2.9                     |
| 10               | 2.2            | 2.4        | 2.8                     | 2.9                     |

IAIS: ICS (Credit Risk) [A-IRB without maturity adjustment and floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|-------------------------|
| 1                | 1.6            | 1.6        | 1.7                     | 1.8                     |
| 2                | 2.2            | 2.2        | 2.5                     | 2.6                     |
| 3                | 2.6            | 2.7        | 3.2                     | 3.4                     |
| 4                | 3.1            | 3.1        | 3.7                     | 3.9                     |
| 5                | 3.3            | 3.4        | 4.1                     | 4.3                     |
| 6                | 3.5            | 3.5        | 4.4                     | 4.6                     |
| 7                | 3.7            | 3.7        | 4.4                     | 4.6                     |
| 8                | 3.8            | 3.8        | 4.4                     | 4.6                     |
| 9                | 3.9            | 3.9        | 4.4                     | 4.6                     |
| 10               | 3.9            | 3.9        | 4.4                     | 4.6                     |

IAIS: ICS (Credit Risk) [A-IRB without maturity adjustment, with floors, 99.5%] 1/

| Maturity (Years) | Differentiated | Planned 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|------------------|----------------|------------|-------------------------|-------------------------|
| 1                | 1.6            | 1.6        | 1.7                     | 1.8                     |
| 2                | 2.2            | 2.2        | 2.5                     | 2.6                     |
| 3                | 2.6            | 2.7        | 3.2                     | 3.4                     |
| 4                | 3.1            | 3.1        | 3.7                     | 3.9                     |
| 5                | 3.3            | 3.4        | 4.1                     | 4.3                     |
| 6                | 3.5            | 3.5        | 4.4                     | 4.6                     |
| 7                | 3.7            | 3.7        | 4.4                     | 4.6                     |
| 8                | 3.8            | 3.8        | 4.4                     | 4.6                     |
| 9                | 3.9            | 3.9        | 4.4                     | 4.6                     |
| 10               | 3.9            | 3.9        | 4.4                     | 4.6                     |
### Appendix Table 4. Estimated Capital Charges (Actual and Differentiated): Unrated Project Loans (PPP only)*—Insurance Capital Standard (ICS) and Economic Capital Model (99.5%) (continued)

(In percent)

| Maturity (Years) | Sample Selection | IAIS: ICS (Credit Risk) [adapted Vasiček (2002) model, 99.5%] | IAIS: ICS (Credit Risk) [adapted Vasiček (2002) model with fixed LGD, 99.5%] | Economic Capital [GEV-CTE, 98.7%] |
|------------------|------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------------------|
|                  | All Sub-samples  | Planned 2/ Difference (for EMDE-A) | Difference (for EMDE-B) | Planned 2/ Difference (for EMDE-A) | Difference (for EMDE-B) | Planned 2/ Difference (for EMDE-A) | Difference (for EMDE-B) | Planned 2/ Difference (for EMDE-A) | Difference (for EMDE-B) |
| 1                | 1.1              | 1.2 | 1.4 | 1.5 | 6.3 | -4.9 | -77 | -4.8 | -76 | 1.3 | 1.2 | 2.0 | 2.3 | 6.3 | -4.3 | -69 | -4.0 | -64 |
| 2                | 1.9              | 2.0 | 2.5 | 2.6 | 10.7 | -8.2 | -77 | -8.1 | -76 | 2.5 | 2.4 | 3.9 | 4.5 | 10.7 | -6.8 | -64 | -6.2 | -58 |
| 3                | 2.1              | 2.2 | 2.7 | 2.9 | 11.8 | -9.1 | -77 | -8.9 | -76 | 4.3 | 4.1 | 6.4 | 7.3 | 12.3 | -5.9 | -48 | -5.0 | -41 |
| 4                | 2.2              | 2.4 | 2.9 | 3.0 | 12.3 | -9.4 | -77 | -9.3 | -76 | 5.2 | 5.1 | 7.5 | 8.6 | 12.7 | -5.1 | -40 | -4.0 | -32 |
| 5                | 2.2              | 2.4 | 2.9 | 3.1 | 12.5 | -9.6 | -76 | -9.4 | -76 | 5.4 | 5.3 | 7.6 | 8.7 | 12.7 | -5.1 | -40 | -3.9 | -31 |
| 6                | 2.3              | 2.5 | 3.0 | 3.1 | 12.6 | -9.8 | -76 | -9.5 | -75 | 5.6 | 5.5 | 7.7 | 8.8 | 12.7 | -5.0 | -39 | -3.9 | -31 |
| 7                | 2.3              | 2.5 | 2.9 | 3.0 | 12.7 | -9.8 | -77 | -9.7 | -76 | 5.7 | 5.6 | 7.7 | 8.8 | 12.7 | -5.0 | -39 | -3.9 | -31 |
| 8                | 2.3              | 2.5 | 2.9 | 3.0 | 12.7 | -9.8 | -77 | -9.7 | -76 | 5.8 | 5.7 | 7.7 | 8.8 | 12.7 | -5.0 | -39 | -3.9 | -31 |

**Notes:**
- Sample selection: (i) all EEA and OECD member countries (“EEA or OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”); the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; * project loans for public-private partnerships only; 1/ capital charges were derived from calibrating credit risk stress factors for the Insurance Capital Standard (ICS) by using the cumulative default rate of unrated project loans in an adapted Vasiček (2002) model or the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) according to the finalized Basel III framework (BCBS, 2017) at a statistical confidence level of 99.5 percent, with and without application of the maturity adjustment and floors for marginal PDs (0.05 percent) and LGD (25 percent); 2/ credit risk factor for corporate exposure under the planned ICS for internationally active insurance groups (IAIGs) based on asymptotic single factor credit risk model (by adapting the Vasiček (2002) model), consistent with the A-IRB approach under the Basel III framework (BCBS, 2017) – credit risk parameters derived from S&P’s corporate default rate estimates for 2013 (Vazza and Kraemer, 2014) and published in IAIS (2017b), with actual and fixed LGD (with the latter replicating the foundation IRB approach) — the capital charge falls between CQS=4 and CQS=5 of rated exposures (and, thus, is broadly consistent with the treatment of unrated corporate exposures of banks incorporated in jurisdictions that allow the use of external ratings for regulatory purposes under the Basel III framework, which assigns a “base” risk weight of 100 percent (which is equivalent to the treatment of exposures with a CQS=4 (“Ba”)); 3/ adapted Vasiček (2002) model is applied to the credit risk parameters of unrated project loans published by Moody’s Investors Service, following Jobst (2007 and 2014) – CTE at 98.7 percent is roughly equivalent to Value-at-Risk (VaR) at 99.5 percent (S2A, 2006).
### Appendix Table 5. Estimated Capital Charges (Actual and Differentiated): Unrated Project Loans—Solvency II and Economic Capital Model [99.5%]

#### Sample Selection

| Maturity* (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|-------------------|--------------------------|----------|--------|--------|
|                   | Differentiated           | *qualifying* | *non-qualifying* | *qualifying* | *non-qualifying* |
| 1                 | 1.7                      | 2.0       | 2.2    |
| 2                 | 3.4                      | 4.1       | 4.4    |
| 3                 | 5.2                      | 6.1       | 6.6    |
| 4                 | 6.9                      | 8.2       | 8.8    |
| 5                 | 8.6                      | 10.2      | 11.0   |
| 6                 | 9.5                      | 11.2      | 12.0   |
| 7                 | 10.3                     | 12.1      | 13.0   |
| 8                 | 11.2                     | 13.1      | 14.0   |
| 9                 | 12.0                     | 14.1      | 15.0   |
| 10                | 12.9                     | 15.0      | 16.0   |

#### EIOPA: Solvency II (Spread Risk) 1/

| Maturity* (Years) | Current 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|-------------------|------------|-------------------------|-------------------------|
|                   | *qualifying* | *non-qualifying* | abs. rel. | abs. rel. | abs. rel. |
| 1                 | 2.5         | 3.0                     | -1.0       | -32       | -0.8       |
| 2                 | 5.0         | 6.0                     | -1.9       | -32       | -1.6       |
| 3                 | 7.5         | 9.0                     | -2.9       | -32       | -2.4       |
| 4                 | 10.0        | 12.0                    | -3.8       | -32       | -3.2       |
| 5                 | 12.5        | 15.0                    | -4.8       | -32       | -4.0       |
| 6                 | 14.0        | 16.7                    | -5.5       | -33       | -4.7       |
| 7                 | 15.5        | 18.4                    | -6.3       | -34       | -5.4       |
| 8                 | 17.0        | 20.1                    | -7.0       | -35       | -6.1       |
| 9                 | 18.5        | 21.8                    | -7.7       | -36       | -6.8       |
| 10                | 20.0        | 23.5                    | -8.5       | -36       | -7.5       |

#### Economic Capital [GEV-CTE, 98.7%] 3/

| Maturity* (Years) | Current 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|-------------------|------------|-------------------------|-------------------------|
|                   | *qualifying* | *non-qualifying* | abs. rel. | abs. rel. | abs. rel. | Benchmark 4/ |
| 1                 | 2.5         | 3.0                     | -0.1       | -4        | 0.4        | 0.3 |
| 2                 | 5.0         | 6.0                     | -0.4       | -6        | 0.7        | 0.7 |
| 3                 | 7.5         | 9.0                     | -1.4       | -16       | 0.1        | 1.2 |
| 4                 | 10.0        | 12.0                    | -3.1       | -26       | 1.4        | 1.9 |
| 5                 | 12.5        | 15.0                    | -5.2       | -35       | 2.5        | 10.1 |
| 6                 | 14.0        | 16.7                    | -6.5       | -39       | 3.1        | 15.5 |
| 7                 | 15.5        | 18.4                    | -8.0       | -44       | 3.7        | 17.8 |
| 8                 | 17.0        | 20.1                    | -9.7       | -48       | 4.3        | 20.0 |
| 9                 | 18.5        | 21.8                    | -11.3      | -52       | 4.9        | 22.0 |
| 10                | 20.0        | 23.5                    | -13.0      | -55       | 5.6        | 24.1 |

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**Sources:** EIOPA, Moody’s Investors Service (2016c, 2017ba, 2017c and 2017g) and author.

**Note:** The sub-samples refer to (i) all EEA and OECD member countries (“EEA or OECD”), (ii) all non-high income countries (“EMDE-A”), and (iii) all non-high income countries without EEA or OECD countries (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”); the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; */ for illustrative purposes and easier comparison, maturities (rather than duration) are used to show the risk factors for the determination of the capital charges under Solvency II; 1/ capital charges were derived from mapping the risk factors for qualifying infrastructure investment for EEA/OECD countries under the Solvency II SCR Standard Formula Spread Risk Sub-Module to the average annual expected losses (over a 10-year horizon) of unrated project loans; 2/ fixed risk factors for fixed income (debt securities and lending) investment under the Standard Formula of Solvency II (European Commission, 2015), as amended by EU Regulation 2016/467 (European Commission, 2016) and EU Regulation 2017/1542 (European Commission, 2017) — the reduced capital charge (e.g., 20.0 percent in lieu of 23.5 percent over 10 years) applies for qualifying infrastructure investment in an EEA or OECD country (but only if the exposure is rated “Baa/BBB” (CQS=3) or higher — for unrated qualifying infrastructure investment, the risk factor for “Baa/BBB”-rated corporate exposures applies); 3/ based on the conditional tail expectation (CTE) of the generalized extreme value (GEV) distribution, parametrized using the credit risk data of unrated project loans published by Moody’s Investors Service, following Jobst (2007 and 2014) — CTE at 98.7 percent is roughly equivalent to Value-at-Risk (VaR) at 99.5 percent (CEA, 2006); 4/ Corporate loans (global, “Baa” and “Ba”-rated by Moody’s).
## Appendix Table 6. Estimated Capital Charges (Actual and Differentiated): Unrated Project Loans (PPP only)—Solvency II and Economic Capital Model [99.5%]

### Sample Selection

| Maturity** (Years) | Differentiated | Current 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) |
|-------------------|----------------|------------|------------------------|------------------------|
|                   | "qualifying" | abs. rel.  |                        |                        |
|                   | "non-qualifying" | abs. rel. |                        |                        |
| 1                 | 1.2           | 2.5        | -1.5                   | -1.5                   |
|                   | 1.2           | 3.0        | -3.0                   | -2.9                   |
| 2                 | 3.7           | 5.0        | -4.5                   | -4.4                   |
|                   | 4.5           | 6.0        |                        |                        |
| 3                 | 4.9           | 7.5        | -5.9                   | -5.8                   |
|                   | 6.1           | 12.0       |                        |                        |
| 4                 | 6.2           | 10.0       | -7.4                   | -7.3                   |
|                   | 7.6           | 14.0       | -8.3                   | -8.1                   |
| 5                 | 6.9           | 15.5       | -9.2                   | -9.0                   |
|                   | 8.4           | 20.1       |                        |                        |
| 6                 | 7.6           | 17.0       | -10.1                  | -9.9                   |
|                   | 9.2           | 20.1       |                        |                        |
| 7                 | 8.3           | 18.5       | -11.0                  | -10.8                  |
|                   | 10.0          | 21.8       |                        |                        |
| 8                 | 9.0           | 20.0       | -11.9                  | -11.7                  |
|                   | 10.8          | 23.5       |                        |                        |
| 9                 | 9.7           | 11.6       |                        |                        |
|                   | 11.8          |            |                        |                        |
| 10                | 9.7           | 11.7       |                        |                        |

### Economic Capital [GEV-CTE, 98.7%]

| Maturity** (Years) | Differentiated | Current 2/ | Difference (for EMDE-A) | Difference (for EMDE-B) | Benchmark 4/ |
|-------------------|----------------|------------|------------------------|------------------------|-------------|
|                   | "qualifying" | abs. rel.  |                        |                        |             |
|                   | "non-qualifying" | abs. rel. |                        |                        |             |
| 1                 | 1.3           | 2.5        | -1.0                   | -0.7                   | 0.3         |
|                   | 1.2           | 3.0        | -2.1                   | -1.5                   | 0.7         |
| 2                 | 2.5           | 5.0        | -3.7                   | -2.8                   | 1.2         |
|                   | 2.4           | 6.0        | -4.7                   | -3.9                   | 1.9         |
| 3                 | 3.5           | 7.5        | -5.6                   | -4.7                   | 1.9         |
|                   | 3.3           | 9.0        | -7.9                   | -6.9                   | 2.5         |
| 4                 | 4.3           | 10.0       | -7.9                   | -6.9                   | 2.5         |
|                   | 4.1           | 12.0       | -10.8                  | -8.1                   | 3.1         |
| 5                 | 4.8           | 12.5       | -10.8                  | -8.1                   | 3.1         |
|                   | 4.7           | 15.0       | -12.4                  | -11.3                  | 4.3         |
| 6                 | 5.2           | 14.0       | -12.4                  | -11.3                  | 4.3         |
|                   | 5.1           | 16.7       | -13.0                  | -11.3                  | 4.3         |
| 7                 | 5.4           | 15.5       | -14.1                  | -13.0                  | 4.9         |
|                   | 5.3           | 18.4       | -15.8                  | -14.7                  | 5.6         |
| 8                 | 5.6           | 17.0       |                        |                        |             |
|                   | 5.5           | 20.1       |                        |                        |             |
| 9                 | 5.7           | 18.5       |                        |                        |             |
|                   | 5.6           | 21.8       |                        |                        |             |
| 10                | 5.8           | 20.0       | -15.8                  | -14.7                  | 5.6         |

Sources: EIOPA, Moody's Investors Service (2016c, 2017ba, 2017c and 2017g) and author.

Note: the sub-samples refer to (i) all EEA and OECD member countries ("EEA or OECD"); (ii) all non-high income countries ("EMDE-A"); and (iii) all non-high income countries without EEA or OECD countries (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) ("EMDE-B"); the reference to "maturity (years)" indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; */ project loans for public-private partnerships only; **/ for illustrative purposes and easier comparison, maturities (rather than duration) are used to show the risk factors for the determination of the capital charges under Solvency II; 1/ capital charges were derived from mapping the risk factors for qualifying infrastructure investment for EEA/OECD countries under the Solvency II SCR Standard Formula Spread Risk Sub-Module to the average annual expected losses (over a 10-year horizon) of unrated project loans; 2/ fixed risk factors for fixed income (debt securities and lending) investment under the Standard Formula of Solvency II (European Commission, 2015), as amended by EU Regulation 2016/467 (European Commission, 2016) and EU Regulation 2017/1542 (European Commission, 2017) — the reduced capital charge (e.g., 20.0 percent in lieu of 23.5 percent over 10 years) applies for qualifying infrastructure investment in an EEA or OECD country (but only if the exposure is rated “Baa/BBB” (CQS=3) or higher – for unrated qualifying infrastructure investment, the risk factor for “Baa/BBB” rated corporate exposures applies); 3/ based on the conditional tail expectation (CTE) of the generalized extreme value (GEV) distribution, parametrized using the credit risk data of unrated project loans published by Moody’s Investors Service, following Jobst (2007 and 2014) — CTE at 98.7 percent is roughly equivalent to Value-at-Risk (VaR) at 99.5 percent (CEA, 2006); 4/ Corporate loans (global, “Baa” and “B” rated by Moody’s).
## Appendix Table 7. Estimated Capital Charges (Solvency II, Standard Formula): Unrated Project Loans and Infrastructure Debt Securities

(In percent)

### Adjusted Risk Factors for Infrastructure Investment ('Solvency II Amendment') [EEA or OECD] 1/

| Duration (Years) | up to 5 | 5 to 10 | 10 to 15 | 15 to 20 | 20 and more |
|------------------|---------|---------|----------|----------|------------|
|                  | 0.7     | 0.8     | 1.1      | 1.9      |            |
| 5 to 10          | 3.4     | 4.1     | 5.3      | 9.4      | 11.9       |
| 10 to 15         | 5.3     | 6.4     | 7.9      | 15.0     | 21.8       |
| 15 to 20         | 7.1     | 8.3     | 9.8      | 18.8     | 23.5       |
| 20 and more      | 9.0     | 10.1    | 11.6     | 22.5     | 30.0       |

### Differentiated Regulatory Treatment 2/

#### Infrastructure Investment (Global) 3/

| Duration (Years) | up to 5 | 5 to 10 | 10 to 15 | 15 to 20 | 20 and more |
|------------------|---------|---------|----------|----------|------------|
|                  | 0.6     | 0.7     | 0.9      | 1.1      | 2.0        |
| 5 to 10          | 3.0     | 3.7     | 4.7      | 7.6      | 13.7       |
| 10 to 15         | 4.8     | 5.8     | 7.2      | 12.5     | 21.8       |
| 15 to 20         | 6.6     | 7.6     | 9.0      | 15.8     | 27.7       |
| 20 and more      | 8.5     | 9.4     | 10.8     | 19.0     | 29.3       |

#### Infrastructure Investment in EEA or OECD ("Qualifying Infrastructure") 4/

| Duration (Years) | up to 5 | 5 to 10 | 10 to 15 | 15 to 20 | 20 and more |
|------------------|---------|---------|----------|----------|------------|
|                  | 0.8     | 1.0     | 1.2      | 2.2      | 4.0        |
| 5 to 10          | 3.9     | 4.8     | 6.0      | 10.8     | 19.9       |
| 10 to 15         | 6.0     | 7.3     | 9.0      | 17.2     | 30.8       |
| 15 to 20         | 8.2     | 9.5     | 11.2     | 21.5     | 38.6       |
| 20 and more      | 10.3    | 11.6    | 13.3     | 25.7     | 40.7       |

#### Infrastructure Investment in EMDEs 5/

| Duration (Years) | up to 5 | 5 to 10 | 10 to 15 | 15 to 20 | 20 and more |
|------------------|---------|---------|----------|----------|------------|
|                  | 0.8     | 1.0     | 1.2      | 2.2      | 4.1        |
| 5 to 10          | 4.0     | 4.9     | 6.2      | 11.0     | 20.3       |
| 10 to 15         | 6.2     | 7.5     | 9.2      | 17.6     | 31.4       |
| 15 to 20         | 8.4     | 9.7     | 11.4     | 22.0     | 39.3       |
| 20 and more      | 10.6    | 11.9    | 13.6     | 26.3     | 41.5       |

#### Memo Item

| U.S. NAIC RBC Factor 6/ | 0.4 | 0.4 | 0.4 | 1.3 | 4.6 | 10.0 | 19.5 | 19.5 |

**Sources:** EIOPA, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: The reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; “/” project loans for public-private partnerships (PPP) only; “/” risk factors remain unchanged within each “duration bucket,” and rated exposures refer to infrastructure debt securities — Credit Quality Step (CQS): 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”; 1/ risk factors for fixed income (debt securities and lending) investment under the Solvency II SCR Standard Formula of the Spread Risk Sub-Module (European Commission, 2015), as amended by EU Regulation 2016/467 (European Commission, 2016) and EU Regulation 2017/1542 (European Commission, 2017) — the reduced capital charge (e.g., 20.0 percent in lieu of 23.5 percent over 10 years) applies for qualifying infrastructure investment in EEA and OECD countries ("EEA or OECD") (but only if the exposure is rated “Baa/BBB” (CQS=3) or higher – for unrated qualifying infrastructure investment, the original risk factors for “Baa/BBB” rated corporate exposures apply) — for the calibration of the reduction factors, the credit performance of PPP projects in EEA and OECD countries was used (EIOPA, 2013 and 2015); 2/ capital charges were derived from mapping the risk factors for qualifying infrastructure investment for EEA/OECD countries to the average annual expected losses (over a 10-year horizon) of unrated project loans; 3/ based on sample “All Sub-samples” as defined in Moody’s Investors Service (2017g), which comprises all countries except for high-income countries that are not members of either EEA or OECD; 4/ limited to projects in all EEA and OECD member countries ("EEA or OECD") with availability-based revenues consistent with the definition of “qualifying infrastructure investment” (European Commission, 2017); 5/ all non-high income countries ("EMDE-A"); 6/ all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) ("EMDE-B"); 7/ risk-based capital (RBC) charges for C1 investment risk (NAIC, 2015), estimated over a 10-year risk horizon, with unrated exposures treated as exposures rated “Caa and lower.”
## Appendix Table 8. Estimated Capital Charges (Insurance Capital Standard): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework with maturity adjustment and floors* (99.5%)

(In percent)

| Maturity (Years) | Credit Quality Step (CQS) 1/ | Unrated** | Unrated (PPP only) | Credit Quality Step (CQS) 1/ | Unrated** | Unrated (PPP only) |
|------------------|-----------------------------|-----------|--------------------|-----------------------------|-----------|--------------------|
| 0                |                             |           |                    |                             |           |                    |
| 1                | 0.4                         | 0.4       | 0.7                | 2.1                         | 5.6       | 2.5                |
| 2                | 0.6                         | 0.6       | 1.6                | 4.8                         | 8.5       | 3.7                |
| 3                | 0.8                         | 0.8       | 3.0                | 6.7                         | 11.3      | 4.6                |
| 4                | 1.0                         | 1.0       | 1.6                | 4.0                         | 8.5       | 5.3                |
| 5                | 1.2                         | 1.2       | 2.8                | 5.3                         | 10.0      | 6.0                |
| 6                | 1.4                         | 1.4       | 3.2                | 6.2                         | 11.3      | 6.5                |
| 7                | 1.7                         | 1.7       | 4.4                | 7.3                         | 12.3      | 7.0                |
| 8                | 1.9                         | 1.9       | 4.8                | 8.2                         | 13.2      | 7.4                |
| 9                | 2.1                         | 2.1       | 5.3                | 9.3                         | 14.2      | 7.8                |
| 10               | 2.3                         | 2.3       | 6.5                | 10.1                        | 15.2      | 8.3                |

### Differentiated Regulatory Treatment 2/

| Infrastructure Investment (Global) 3/ | Infrastructure Investment in EMDEs 5/ |
|--------------------------------------|--------------------------------------|
| 0.4                                  | 0.4                                  |
| 0.4                                  | 0.4                                  |
| 0.4                                  | 1.2                                  |
| 1.2                                  | 5.6                                  |
| 5.6                                  | 2.5                                  |
| 2.5                                  | 1.6                                  |
| 1.6                                  | 8.2                                  |
| 8.2                                  | 3.0                                  |
| 3.0                                  | 1.7                                  |

### Infrastructure Investment in EEA or OECD 4/ | Infrastructure Investment in EMDEs 6/ |
|---------------------------------------------|--------------------------------------|
| 0.4                                         | 0.4                                  |
| 0.4                                         | 0.4                                  |
| 0.4                                         | 1.1                                  |
| 1.1                                         | 2.9                                  |
| 2.9                                         | 7.1                                  |
| 7.1                                         | 3.1                                  |
| 3.1                                         | 1.8                                  |

**Sources:** IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; “floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); */ project loans for public-private partnerships only; */ Credit Quality Step (CQS): 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody's Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high income countries (“EMDE-A”); 6/ all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
## Appendix Table 9. Estimated Capital Charges (Insurance Capital Standard): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework without maturity adjustment and floors* [99.5%]

(In percent)

| Maturity (Years) | Credit Quality Step (CQS) 1/ | Unrated Unrated** (PPP only) | Credit Quality Step (CQS) | Unrated Unrated** (PPP only) |
|------------------|-----------------------------|-------------------------------|-----------------------------|-------------------------------|
|                  | 0 | 1 | 2 | 3 | 4 | 5 |                | 0 | 1 | 2 | 3 | 4 | 5 |                |
| 1                | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.9 |
| 2                | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 | 1.2 |
| 3                | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 3.2 | 1.5 |
| 4                | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 3.5 | 1.7 |
| 5                | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 3.7 | 1.9 |
| 6                | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 3.2 | 0.0 | 0.0 | 0.0 | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 | 3.8 | 2.0 |
| 7                | 0.0 | 0.0 | 0.0 | 1.7 | 0.0 | 3.6 | 0.0 | 0.0 | 0.0 | 3.6 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 2.1 |
| 8                | 0.0 | 0.0 | 0.0 | 1.7 | 0.0 | 3.8 | 0.0 | 0.0 | 0.0 | 3.8 | 0.0 | 0.0 | 0.0 | 0.0 | 4.0 | 2.2 |
| 9                | 0.0 | 0.0 | 0.0 | 1.7 | 0.0 | 4.1 | 0.0 | 0.0 | 0.0 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 4.0 | 2.2 |
| 10               | 0.0 | 0.0 | 0.0 | 2.1 | 0.0 | 4.3 | 0.0 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 4.0 | 2.2 |

### Differentiated Regulatory Treatment 2/

| Infrastructure Investment (Global) 3/ | Unrated Unrated** (PPP only) | Infrastructure Investment in EMDEs 5/ | Unrated Unrated** (PPP only) |
|--------------------------------------|-------------------------------|-------------------------------------|-------------------------------|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.1 | 0.9 |
| 2 | 0 | 0 | 0 | 0 | 0 | 1.3 | 0 | 0 | 0 | 1.3 | 0 | 0 | 0 | 0 | 2.8 | 1.2 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0.7 | 0 | 0 | 0 | 0.7 | 0 | 0 | 0 | 0 | 3.2 | 1.5 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0.7 | 0 | 0 | 0 | 0.7 | 0 | 0 | 0 | 0 | 3.5 | 1.7 |
| 5 | 0 | 0 | 0 | 1.3 | 0 | 2.9 | 0 | 0 | 0 | 2.9 | 0 | 0 | 0 | 0 | 3.7 | 1.9 |
| 6 | 0 | 0 | 0 | 1.3 | 0 | 3.2 | 0 | 0 | 0 | 3.2 | 0 | 0 | 0 | 0 | 3.8 | 2.0 |
| 7 | 0 | 0 | 0 | 1.7 | 0 | 3.6 | 0 | 0 | 0 | 3.6 | 0 | 0 | 0 | 0 | 3.9 | 2.1 |
| 8 | 0 | 0 | 0 | 1.7 | 0 | 3.8 | 0 | 0 | 0 | 3.8 | 0 | 0 | 0 | 0 | 4.0 | 2.2 |
| 9 | 0 | 0 | 0 | 1.7 | 0 | 4.1 | 0 | 0 | 0 | 4.1 | 0 | 0 | 0 | 0 | 4.0 | 2.2 |
| 10 | 0 | 0 | 0 | 2.1 | 0 | 4.3 | 0 | 0 | 0 | 4.3 | 0 | 0 | 0 | 0 | 4.0 | 2.2 |

### Infrastructure Investment in EEA or OECD 4/

| Unrated Unrated** (PPP only) | Infrastructure Investment in EMDEs 6/ |
|-----------------------------|-------------------------------------|
| 1 | 0 | 0 | 0 | 0 | 0 | 1.3 | 0 | 0 | 0 | 1.3 | 0 | 0 | 0 | 0 | 2.1 | 0.9 |
| 2 | 0 | 0 | 0 | 0 | 0 | 2.2 | 0 | 0 | 0 | 2.2 | 0 | 0 | 0 | 0 | 2.8 | 1.2 |
| 3 | 0 | 0 | 0 | 0 | 0 | 3.6 | 0 | 0 | 0 | 3.6 | 0 | 0 | 0 | 0 | 3.2 | 1.5 |
| 4 | 0 | 0 | 0 | 0 | 0 | 6.8 | 0 | 0 | 0 | 6.8 | 0 | 0 | 0 | 0 | 3.5 | 1.7 |
| 5 | 0 | 0 | 0 | 1.0 | 0 | 7.8 | 0 | 0 | 0 | 7.8 | 0 | 0 | 0 | 0 | 3.7 | 1.9 |
| 6 | 0 | 0 | 0 | 1.0 | 0 | 8.2 | 0 | 0 | 0 | 8.2 | 0 | 0 | 0 | 0 | 3.8 | 2.0 |
| 7 | 0 | 0 | 0 | 1.4 | 0 | 8.5 | 0 | 0 | 0 | 8.5 | 0 | 0 | 0 | 0 | 3.9 | 2.1 |
| 8 | 0 | 0 | 0 | 1.4 | 0 | 9.8 | 0 | 0 | 0 | 9.8 | 0 | 0 | 0 | 0 | 4.0 | 2.2 |
| 9 | 0 | 0 | 0 | 1.4 | 0 | 11.3 | 0 | 0 | 0 | 11.3 | 0 | 0 | 0 | 0 | 4.0 | 2.2 |
| 10 | 0 | 0 | 0 | 1.7 | 0 | 12.3 | 0 | 0 | 0 | 12.3 | 0 | 0 | 0 | 0 | 4.0 | 2.2 |

Sources: IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; */“floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); **/ project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high-income countries (“EMDE-A”); 6/ all non-high-income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
### Appendix Table 10. Estimated Capital Charges (Insurance Capital Standard): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework with maturity adjustment but without floors* [99.5%]

| Maturity (Years) | Credit Quality Step (CQS) 1/ | Unrated** | Credit Quality Step (CQS) | Unrated** |
|------------------|-----------------------------|-----------|---------------------------|-----------|
|                  | 012345                      |           |                           | 012345    |
| 1                |                             |           |                           |           |
| 2                |                             |           |                           |           |
| 3                |                             |           |                           |           |
| 4                |                             |           |                           |           |
| 5                |                             |           |                           |           |
| 6                |                             |           |                           |           |
| 7                |                             |           |                           |           |
| 8                |                             |           |                           |           |
| 9                |                             |           |                           |           |
| 10               |                             |           |                           |           |

### Differentiated Regulatory Treatment 2/

| Infrastructure Investment (Global) 3/ | Infrastructure Investment in EMDEs 5/ |
|--------------------------------------|--------------------------------------|
| 0.0 0.0 0.0 0.7 2.1 3.9 2.1 0.9      | 0.1 0.1 0.0 1.3 3.8 8.8 2.7 1.1      |
| 0.1 0.1 0.1 1.6 4.8 8.5 3.2 1.4      | 0.2 0.2 0.1 2.7 7.3 13.5 4.0 1.7      |
| 0.1 0.1 1.3 3.0 6.7 11.3 3.9 1.8     | 0.3 0.3 1.7 4.7 9.9 16.8 4.9 2.4      |
| 0.1 0.1 1.6 4.0 8.5 13.4 4.5 2.2     | 0.4 0.4 2.1 5.8 12.6 18.4 5.5 2.9      |
| 0.2 0.2 2.8 5.3 10.0 15.1 5.0 2.6    | 0.4 0.4 3.6 7.4 15.0 19.1 6.1 3.4      |
| 0.2 0.2 3.2 6.2 11.3 16.3 5.5 2.9    | 0.5 0.5 4.0 8.4 16.6 19.5 6.6 3.8      |
| 0.3 0.3 4.4 7.3 12.3 17.5 5.9 3.1    | 0.6 0.6 5.5 9.7 17.8 20.9 7.0 4.0      |
| 0.3 0.3 4.8 8.2 13.2 18.5 6.3 3.4    | 0.7 0.7 6.0 10.7 18.8 22.0 7.4 4.2      |
| 0.4 0.4 5.3 9.3 14.2 19.4 6.6 3.7    | 0.8 0.8 6.6 11.9 19.8 23.3 7.7 4.4      |
| 0.4 0.4 6.5 10.1 15.2 20.2 7.0 3.9   | 0.9 0.9 8.0 12.8 20.9 24.5 8.1 4.6      |

| Infrastructure Investment in EEA or OECD 4/ | Infrastructure Investment in EMDEs 6/ |
|--------------------------------------------|--------------------------------------|
| 0.0 0.0 0.0 0.6 1.7 4.9 1.8 1.0           | 0.0 0.0 0.0 1.3 3.4 8.2 3.0 1.1      |
| 0.1 0.1 0.1 1.4 4.1 7.4 2.8 1.5           | 0.1 0.1 0.1 2.7 7.0 12.7 4.4 1.8      |
| 0.1 0.1 1.1 2.6 5.9 9.8 3.5 2.0           | 0.1 0.1 2.2 4.8 9.5 16.4 5.4 2.5      |
| 0.1 0.1 1.3 3.4 7.5 11.7 4.1 2.4           | 0.2 0.2 2.6 6.0 12.0 18.7 6.2 3.1      |
| 0.2 0.2 2.4 4.6 8.9 13.3 4.6 2.8           | 0.2 0.2 4.4 7.6 14.4 20.1 6.8 3.5      |
| 0.2 0.2 2.7 5.4 10.0 14.6 5.0 3.1           | 0.3 0.3 4.9 8.7 16.1 21.1 7.3 4.0      |
| 0.3 0.3 3.8 6.5 11.0 15.7 5.4 3.5           | 0.4 0.4 6.6 10.1 17.4 21.8 7.7 4.2      |
| 0.3 0.3 4.2 7.3 11.8 16.7 5.7 3.8           | 0.4 0.4 7.2 11.2 18.5 22.4 8.1 4.4      |
| 0.3 0.3 4.6 8.3 12.6 17.6 6.1 4.0           | 0.5 0.5 7.8 12.4 19.7 22.7 8.5 4.6      |
| 0.4 0.4 5.7 9.1 13.6 18.5 6.4 4.3           | 0.5 0.5 9.5 13.4 20.9 22.9 8.9 4.8      |

Sources: IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; */“floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); **/project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0=Aaa, 1=Aa, 2=A, 3=Baa, 4=BB, and 5=B; 2/calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/all EEA and OECD member countries (“EEA or OECD”); 5/all non-high-income countries (“EMDE-A”); 6/all non-high-income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
# Appendix Table 11. Estimated Capital Charges (Insurance Capital Standard): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework without maturity adjustment but with floors* (99.5%)

| Maturity (Years) | Credit Quality Step (CQS) | 0 | 1 | 2 | 3 | 4 | 5 | Unrated** | (PPP only) | Credit Quality Step (CQS) | 0 | 1 | 2 | 3 | 4 | 5 | Unrated** | (PPP only) |
|------------------|---------------------------|---|---|---|---|---|---|----------|-------------|---------------------------|---|---|---|---|---|---|----------|-------------|
| 1                | Infrastructure Investment (Global) | 0.4 | 0.4 | 0.4 | 0.7 | 2.1 | 5.6 | 2.5 | 1.6 | 0.4 | 0.4 | 0.4 | 1.2 | 3.5 | 8.2 | 3.0 | 1.7 |
| 2                |                          | 0.4 | 0.4 | 0.4 | 1.3 | 4.1 | 7.8 | 3.3 | 2.2 | 0.4 | 0.4 | 0.4 | 2.0 | 6.1 | 11.9 | 4.0 | 2.5 |
| 3                |                          | 0.4 | 0.4 | 0.7 | 2.1 | 5.4 | 9.9 | 3.8 | 2.6 | 0.4 | 0.4 | 0.9 | 3.1 | 7.8 | 14.3 | 4.6 | 3.2 |
| 4                |                          | 0.4 | 0.4 | 0.7 | 2.4 | 6.4 | 11.3 | 4.2 | 3.1 | 0.4 | 0.4 | 0.9 | 3.6 | 9.6 | 15.3 | 4.9 | 3.7 |
| 5                |                          | 0.4 | 0.4 | 1.3 | 2.9 | 7.3 | 12.3 | 4.4 | 3.3 | 0.4 | 0.4 | 1.6 | 4.2 | 11.1 | 15.6 | 5.2 | 4.1 |
| 6                |                          | 0.4 | 0.4 | 1.3 | 3.2 | 7.9 | 13.0 | 4.5 | 3.5 | 0.4 | 0.4 | 1.6 | 4.5 | 12.0 | 16.8 | 5.3 | 4.4 |
| 7                |                          | 0.4 | 0.4 | 1.7 | 3.6 | 8.2 | 13.5 | 4.6 | 3.7 | 0.4 | 0.4 | 2.1 | 5.0 | 12.4 | 17.5 | 5.3 | 4.4 |
| 8                |                          | 0.4 | 0.4 | 1.7 | 3.8 | 8.4 | 13.9 | 4.7 | 3.8 | 0.4 | 0.4 | 2.1 | 5.2 | 12.7 | 17.8 | 5.3 | 4.4 |
| 9                |                          | 0.4 | 0.4 | 1.7 | 4.1 | 8.7 | 14.3 | 4.7 | 3.9 | 0.4 | 0.4 | 2.1 | 5.6 | 13.0 | 18.3 | 5.3 | 4.4 |
| 10               |                          | 0.4 | 0.4 | 2.1 | 4.3 | 9.0 | 14.6 | 4.7 | 3.9 | 0.4 | 0.4 | 2.5 | 5.8 | 13.4 | 18.8 | 5.4 | 4.4 |

| Maturity (Years) | Infrastructure Investment in EEA or OECD | 0 | 0.4 | 0.4 | 0.4 | 0.6 | 1.8 | 5.2 | 2.3 | 1.6 | 0.4 | 0.4 | 0.4 | 1.1 | 2.9 | 7.1 | 3.1 | 1.8 |
|------------------|------------------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2                |                                          | 0.4 | 0.4 | 0.4 | 1.1 | 3.8 | 7.2 | 3.2 | 2.2 | 0.4 | 0.4 | 0.4 | 1.9 | 5.3 | 10.3 | 4.1 | 2.6 |
| 3                |                                          | 0.4 | 0.4 | 0.6 | 1.8 | 5.0 | 9.1 | 3.6 | 2.7 | 0.4 | 0.4 | 1.1 | 2.9 | 6.8 | 12.8 | 4.8 | 3.4 |
| 4                |                                          | 0.4 | 0.4 | 0.6 | 2.1 | 6.0 | 10.5 | 4.0 | 3.1 | 0.4 | 0.4 | 1.1 | 3.3 | 8.3 | 14.2 | 5.1 | 3.9 |
| 5                |                                          | 0.4 | 0.4 | 1.1 | 2.7 | 6.8 | 11.5 | 4.2 | 3.4 | 0.4 | 0.4 | 1.9 | 4.0 | 9.6 | 15.0 | 5.4 | 4.3 |
| 6                |                                          | 0.4 | 0.4 | 1.1 | 2.9 | 7.3 | 12.1 | 4.4 | 3.5 | 0.4 | 0.4 | 1.9 | 4.3 | 10.4 | 15.3 | 5.5 | 4.6 |
| 7                |                                          | 0.4 | 0.4 | 1.5 | 3.3 | 7.6 | 12.7 | 4.5 | 3.7 | 0.4 | 0.4 | 2.5 | 4.8 | 10.8 | 15.6 | 5.5 | 4.6 |
| 8                |                                          | 0.4 | 0.4 | 1.5 | 3.5 | 7.8 | 13.1 | 4.5 | 3.8 | 0.4 | 0.4 | 2.5 | 5.0 | 11.1 | 15.6 | 5.5 | 4.6 |
| 9                |                                          | 0.4 | 0.4 | 1.5 | 3.8 | 8.0 | 13.5 | 4.6 | 3.9 | 0.4 | 0.4 | 2.5 | 5.3 | 11.4 | 15.6 | 5.6 | 4.6 |
| 10               |                                          | 0.4 | 0.4 | 1.8 | 3.9 | 8.3 | 13.9 | 4.6 | 3.9 | 0.4 | 0.4 | 2.9 | 5.5 | 11.8 | 15.6 | 5.6 | 4.6 |

Sources: IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; /floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); */ project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0="Aaa", 1="Aa", 2="A", 3="Baa", 4="Ba", and 5="B"; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high-income countries (“EMDE-A”); 6/ all non-high-income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
Appendix Table 12. Estimated Capital Charges (Banking): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework with maturity adjustment and floors* [99.9%]

| Maturity (Years) | Differentiated Regulatory Treatment 2/ | Unrated** (PPP only) |
|------------------|----------------------------------------|----------------------|
|                  | Infrastructure Investment (Global) 3/ | Credit Quality Step (CQS) 1/ |
|                  | Unrated** (PPP only)                  | Credit Quality Step (CQS) 1/ |
|                  |                                        | Unrated** (PPP only) |
| 0                |                                        | Unrated** (PPP only) |
| 1                | 0.9 0.9 0.9 1.5 3.6 8.1 3.8 2.5        | 0.9 0.9 0.9 2.3 5.6 11.0 4.4 2.7 |
| 2                | 1.3 1.3 1.3 3.1 7.4 11.6 5.4 3.6        | 1.3 1.3 1.3 4.4 9.6 16.0 6.0 4.0 |
| 3                | 1.8 1.8 2.6 5.3 9.8 14.8 6.4 4.6        | 1.8 1.8 3.1 7.1 12.5 19.1 7.2 5.3 |
| 4                | 2.2 2.2 3.2 6.8 11.9 17.2 7.3 5.6        | 2.2 2.2 3.7 8.7 15.4 20.5 8.2 6.4 |
| 5                | 2.6 2.6 5.2 8.7 13.8 19.1 8.1 6.4        | 2.6 2.6 6.0 10.6 17.9 20.9 9.0 7.4 |
| 6                | 3.1 3.1 6.0 10.1 15.4 20.5 8.8 7.0        | 3.1 3.1 6.8 11.9 19.6 21.1 9.6 8.2 |
| 7                | 3.5 3.5 7.9 11.7 16.7 21.8 9.4 7.7        | 3.5 3.5 8.9 13.4 20.9 22.5 10.2 8.6 |
| 8                | 4.0 4.0 8.7 13.0 17.8 22.9 10.0 8.3       | 4.0 4.0 9.8 14.6 22.0 23.6 10.7 9.0 |
| 9                | 4.4 4.4 9.5 14.4 19.0 23.9 10.6 8.9       | 4.4 4.4 10.7 16.0 23.1 24.8 11.2 9.5 |
| 10               | 4.8 4.8 11.4 15.6 20.3 24.7 11.1 9.4     | 4.8 4.8 12.6 17.1 24.2 26.0 11.8 9.9 |

| Maturity (Years) | Differentiated Regulatory Treatment 2/ | Unrated** (PPP only) |
|------------------|----------------------------------------|----------------------|
|                  | Infrastructure Investment in EMDEs 5/  | Credit Quality Step (CQS) 1/ |
|                  | Unrated** (PPP only)                  | Credit Quality Step (CQS) 1/ |
| 0                |                                        | Unrated** (PPP only) |
| 1                | 0.9 0.9 0.9 1.3 3.3 7.7 3.6 2.6        | 0.9 0.9 0.9 2.2 4.9 9.8 4.5 2.8 |
| 2                | 1.3 1.3 1.3 2.8 7.0 10.9 5.2 3.7        | 1.3 1.3 1.3 4.2 8.8 14.4 6.2 4.2 |
| 3                | 1.8 1.8 2.4 5.0 9.4 14.0 6.2 4.7        | 1.8 1.8 3.5 6.8 11.4 17.9 7.5 5.5 |
| 4                | 2.2 2.2 2.9 6.4 11.5 16.3 7.1 5.7       | 2.2 2.2 4.2 8.4 14.0 19.9 8.4 6.7 |
| 5                | 2.6 2.6 4.9 8.2 13.3 18.3 7.9 6.5       | 2.6 2.6 6.7 10.3 16.3 21.1 9.2 7.5 |
| 6                | 3.1 3.1 5.6 9.6 14.8 19.8 8.6 7.1       | 3.1 3.1 7.6 11.6 18.1 21.9 9.8 8.5 |
| 7                | 3.5 3.5 7.4 11.2 16.0 21.2 9.2 7.8       | 3.5 3.5 9.7 13.2 19.5 22.4 10.4 8.9 |
| 8                | 4.0 4.0 8.2 12.5 17.1 22.4 9.8 8.5       | 4.0 4.0 10.6 14.4 20.6 22.8 10.9 9.4 |
| 9                | 4.4 4.4 9.0 14.0 18.3 23.5 10.4 9.0     | 4.4 4.4 11.5 15.7 21.8 22.9 11.5 9.8 |
| 10               | 4.8 4.8 10.8 15.2 19.5 24.5 11.0 9.6    | 4.8 4.8 13.5 16.9 23.0 23.0 12.0 10.2 |

Sources: IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; */ “floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); ** project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5= “B”; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high income countries (“EMDE-A”); 6/ all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
## Appendix Table 13. Estimated Capital Charges (Banking): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework without maturity adjustment and floors* [99.9%]

(In percent)

| Maturity (Years) | Credit Quality Step (CQS) 1/ | Differentiated Regulatory Treatment 2/ | Credit Quality Step (CQS) | Differentiated Regulatory Treatment 2/ |
|-----------------|-------------------------------|-----------------------------------|--------------------------|-----------------------------------|
|                 | Unrated Unrated** (PPP only) | **Infrastructure Investment (Global) 3/ | Unrated Unrated** (PPP only) | **Infrastructure Investment in EMDEs 5/ |
|                 |                               | 0 1 2 3 4 5 |                               | 0 1 2 3 4 5 |
| 1               |                               | 0.0 0.0 0.0 1.5 3.6 8.1 | 0.0 0.0 0.0 2.0 6.0 11.9 | 0.2 0.2 0.0 2.5 6.0 11.9 |
| 2               |                               | 0.0 0.0 0.0 2.3 6.4 10.6 | 0.0 0.0 0.0 2.0 6.0 11.9 | 0.2 0.2 0.0 3.8 9.3 16.3 |
| 3               |                               | 0.0 0.0 1.5 3.6 7.9 13.0 | 0.2 0.2 2.0 5.5 11.5 18.9 | 0.2 0.2 2.0 6.1 13.7 19.8 |
| 4               |                               | 0.0 0.0 1.5 4.1 9.1 14.5 | 0.2 0.2 2.0 5.5 11.5 18.9 | 0.2 0.2 2.0 6.1 13.7 19.8 |
| 5               |                               | 0.0 0.0 2.3 4.9 10.1 15.6 | 0.2 0.2 3.1 7.0 15.5 19.9 | 0.2 0.2 3.1 7.0 15.5 19.9 |
| 6               |                               | 0.0 0.0 2.3 5.2 10.7 16.3 | 0.2 0.2 3.1 7.4 16.4 21.1 | 0.2 0.2 3.1 7.4 16.4 21.1 |
| 7               |                               | 0.0 0.0 3.0 5.7 11.1 16.8 | 0.2 0.2 3.9 8.0 17.0 21.8 | 0.2 0.2 3.9 8.0 17.0 21.8 |
| 8               |                               | 0.0 0.0 3.0 6.0 11.3 17.2 | 0.2 0.2 3.9 8.3 17.3 22.2 | 0.2 0.2 3.9 8.3 17.3 22.2 |
| 9               |                               | 0.0 0.0 3.0 6.4 11.6 17.6 | 0.2 0.2 3.9 8.8 17.6 22.6 | 0.2 0.2 3.9 8.8 17.6 22.6 |
| 10              |                               | 0.0 0.0 3.6 6.6 12.0 17.8 | 0.2 0.2 4.6 9.0 18.0 23.1 | 0.2 0.2 4.6 9.0 18.0 23.1 |

### Sources
IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

### Notes
The reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books. */ floors refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); /** project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0="Aaa", 1="Aa", 2="A", 3="Baa", 4="Ba", and 5="B"; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high income countries (“EMDE-A”); 6/ all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
Appendix Table 14. Estimated Capital Charges (Banking): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework with maturity adjustment but without floors* [99.9%] (In percent)

| Maturity (Years) | Credit Quality Step (CQS) 1/ | Unrated | Unrated** (PPP only) | Credit Quality Step (CQS) | Unrated | Unrated** (PPP only) |
|------------------|-------------------------------|---------|----------------------|---------------------------|---------|----------------------|
|                  | 012345                        | Unrated** |                     | 012345                    | Unrated** |                     |
| 0                | 0.0 0.0 0.0 1.5 3.6 5.8 3.2 1.4 |         |                     | 0.2 0.2 0.0 2.5 6.0 11.9 4.0 1.7 |         |                     |
| 1                | 0.2 0.2 0.2 3.1 7.4 11.6 4.5 2.1 |         |                     | 0.4 0.4 0.2 4.8 10.4 17.3 5.5 2.5 |         |                     |
| 2                | 0.3 0.3 2.6 5.3 9.8 14.8 5.4 2.6 |         |                     | 0.7 0.7 3.3 7.6 13.5 20.6 6.6 3.3 |         |                     |
| 3                | 0.4 0.4 3.2 6.8 11.9 17.2 6.2 3.2 |         |                     | 0.9 0.9 4.0 9.3 16.6 22.1 7.4 4.0 |         |                     |
| 4                | 0.5 0.5 5.2 8.7 13.8 19.1 6.9 3.6 |         |                     | 1.1 1.1 6.5 11.4 19.3 22.6 8.2 4.7 |         |                     |
| 5                | 0.7 0.7 6.0 10.1 15.4 20.5 7.4 4.0 |         |                     | 1.3 1.3 7.4 12.8 21.2 22.7 8.7 5.2 |         |                     |
| 6                | 0.8 0.8 7.9 11.7 16.7 21.8 8.0 4.4 |         |                     | 1.5 1.5 9.6 14.5 22.6 24.2 9.3 5.4 |         |                     |
| 7                | 0.9 0.9 8.7 13.0 17.8 22.9 8.5 4.7 |         |                     | 1.8 1.8 10.5 15.8 23.7 25.7 9.7 5.7 |         |                     |
| 8                | 1.0 1.0 9.5 14.4 19.0 23.9 8.9 5.0 |         |                     | 2.0 2.0 11.5 17.2 24.9 26.7 10.2 6.0 |         |                     |
| 9                | 1.1 1.1 11.4 15.6 20.3 24.7 9.4 5.3 |         |                     | 2.2 2.2 13.6 18.5 26.1 28.0 10.7 6.2 |         |                     |
| 10               | 0.0 0.0 0.0 1.2 3.1 7.2 2.9 1.6 |         |                     | 0.1 0.1 0.1 2.5 6.0 11.4 4.4 1.8 |         |                     |
| 1                | 0.1 0.1 0.2 2.6 6.5 10.2 4.1 2.3 |         |                     | 0.2 0.2 0.2 4.8 10.2 16.6 6.1 2.6 |         |                     |
| 2                | 0.3 0.3 2.2 4.6 8.8 13.1 4.9 2.9 |         |                     | 0.4 0.4 4.1 7.9 13.2 20.7 7.3 3.5 |         |                     |
| 3                | 0.4 0.4 2.7 6.0 10.8 15.3 5.6 3.5 |         |                     | 0.5 0.5 4.9 9.7 16.2 23.0 8.2 4.2 |         |                     |
| 4                | 0.5 0.5 4.6 7.7 12.4 17.1 6.3 4.0 |         |                     | 0.7 0.7 7.8 11.9 18.9 24.4 9.0 4.8 |         |                     |
| 5                | 0.6 0.6 5.2 9.0 13.8 18.5 6.8 4.4 |         |                     | 0.8 0.8 8.8 13.4 20.9 25.3 9.6 5.4 |         |                     |
| 6                | 0.7 0.7 6.9 10.5 15.0 19.8 7.3 4.8 |         |                     | 1.0 1.0 11.2 15.2 22.5 25.9 10.2 5.6 |         |                     |
| 7                | 0.9 0.9 7.7 11.7 16.0 20.9 7.8 5.2 |         |                     | 1.1 1.1 12.3 16.7 23.9 26.4 10.7 5.9 |         |                     |
| 8                | 1.0 1.0 8.4 13.1 17.1 22.0 8.2 5.6 |         |                     | 1.3 1.3 13.4 18.2 25.3 26.6 11.2 6.2 |         |                     |
| 9                | 1.1 1.1 10.1 14.2 18.3 22.9 8.7 5.9 |         |                     | 1.4 1.4 15.6 19.6 26.7 26.6 11.7 6.4 |         |                     |

Sources: IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; “floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); **/ project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0=”Aaa”, 1=”Aa”, 2=”A”, 3=”Baa”, 4=”Ba”, and 5=”B”; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high income countries (“EMDE-A”); 6/ all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
Appendix Table 15. Estimated Capital Charges (Banking): Unrated Project Loans and Infrastructure Debt Securities—A-IRB under Basel III framework without maturity adjustment but with floors* [99.9%]

| Maturity (Years) | Credit Quality Step (CQS) 1/ | Unrated | Unrated (PPP only) |
|------------------|-------------------------------|---------|--------------------|
|                  | 0                             | 1       | 2                  | 3         | 4       | 5       | 0                   | 1       | 2       | 3         | 4       | 5       | 6       |
| 1                | 0.9                           | 0.9     | 0.9               | 1.5       | 3.6     | 8.1     | 3.8     | 2.5                |
| 2                | 0.9                           | 0.9     | 1.5               | 2.3       | 6.4     | 10.6    | 4.8     | 3.3                |
| 3                | 0.9                           | 0.9     | 1.5               | 2.3       | 6.4     | 10.6    | 4.8     | 3.3                |
| 4                | 0.9                           | 1.5     | 4.1               | 9.1       | 14.5    | 5.7     | 4.3     |                   |
| 5                | 0.9                           | 2.3     | 4.9               | 10.1      | 15.6    | 6.0     | 4.7     |                   |
| 6                | 0.9                           | 2.3     | 5.2               | 10.7      | 16.3    | 6.2     | 4.9     |                   |
| 7                | 0.9                           | 3.0     | 5.7               | 11.1      | 16.8    | 6.3     | 5.1     |                   |
| 8                | 0.9                           | 3.0     | 6.0               | 11.3      | 17.2    | 6.3     | 5.3     |                   |
| 9                | 0.9                           | 3.0     | 6.4               | 11.6      | 17.6    | 6.4     | 5.3     |                   |
| 10               | 0.9                           | 3.6     | 6.6               | 12.0      | 17.8    | 6.4     | 5.4     |                   |

Differentiated Regulatory Treatment 2/

| Infrastructure Investment (Global) 3/ | Infrastructure Investment in EMDEs 5/ |
|-------------------------------------|------------------------------------|
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |
| 0.9                                 | 0.9                                |

| Infrastructure Investment in EEA or OECD 4/ | Infrastructure Investment in EMDEs 6/ |
|---------------------------------------------|------------------------------------|
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |
| 0.9                                         | 0.9                                |

Sources: IAIS, Moody’s Investors Service (2016b, 2017c, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan/debt security appeared on the books; */ “floors” refer to the mandatory floors for marginal PDs (0.05 percent) and LGD (25 percent) in the advanced internal ratings-based (A-IRB) approach under the finalized Basel III framework (BCBS, 2017); **/ project loans for public-private partnerships only; 1/Credit Quality Step (CQS): 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”; 2/ calculated based on the actual specification of the A-IRB approach under the Basel III framework (BCBS, 2017), assuming unrated project loans treated as specialized lending (project finance); 3/ based on sample “all sub-samples,” which comprises all countries except for high-income countries that are not members of either EEA or OECD as specified in Moody’s Investors Service (2017g); 4/ all EEA and OECD member countries (“EEA or OECD”); 5/ all non-high income countries (“EMDE-A”); 6/ all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”).
## Appendix Table 16. Estimated Capital Charges (Adapted Vasiček (2002) Model): Unrated Project Loans and Comparators

### at statistical confidence of 99.5 percent and actual loss-given-default (LGD)

| Maturity (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|----------|-------|-------|
| 1                | 2.4                      | 2.1      | 3.2   | 3.6   |
| 2                | 3.9                      | 3.5      | 5.1   | 5.7   |
| 3                | 4.2                      | 3.7      | 5.4   | 6.1   |
| 4                | 4.3                      | 3.8      | 5.5   | 6.2   |
| 5                | 4.4                      | 3.9      | 5.6   | 6.2   |
| 6                | 4.4                      | 3.9      | 5.6   | 6.2   |
| 7                | 4.4                      | 3.9      | 5.5   | 6.2   |
| 8                | 4.4                      | 3.9      | 5.5   | 6.2   |
| 9                | 4.4                      | 3.9      | 5.5   | 6.2   |
| 10               | 4.4                      | 3.9      | 5.5   | 6.1   |

| Maturity (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|----------|-------|-------|
| 1                | 1.1                      | 1.2      | 1.4   | 1.5   |
| 2                | 1.9                      | 2.0      | 2.5   | 2.6   |
| 3                | 2.1                      | 2.2      | 2.7   | 2.9   |
| 4                | 2.2                      | 2.4      | 2.9   | 3.0   |
| 5                | 2.2                      | 2.4      | 2.9   | 3.1   |
| 6                | 2.3                      | 2.5      | 3.0   | 3.1   |
| 7                | 2.3                      | 2.5      | 2.9   | 3.1   |
| 8                | 2.3                      | 2.5      | 2.9   | 3.0   |
| 9                | 2.3                      | 2.5      | 2.9   | 3.0   |
| 10               | 2.3                      | 2.5      | 2.9   | 3.0   |

### at statistical confidence of 99.9 percent and actual loss-given-default (LGD)

| Maturity (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|----------|-------|-------|
| 1                | 3.5                      | 3.1      | 4.5   | 5.0   |
| 2                | 5.4                      | 4.8      | 6.8   | 7.6   |
| 3                | 5.7                      | 5.1      | 7.1   | 7.9   |
| 4                | 5.8                      | 5.2      | 7.2   | 8.0   |
| 5                | 5.8                      | 5.2      | 7.2   | 8.0   |
| 6                | 5.8                      | 5.2      | 7.2   | 8.0   |
| 7                | 5.8                      | 5.2      | 7.1   | 7.9   |
| 8                | 5.8                      | 5.2      | 7.1   | 7.9   |
| 9                | 5.8                      | 5.2      | 7.1   | 7.9   |
| 10               | 5.8                      | 5.2      | 7.1   | 7.9   |

| Maturity (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|----------|-------|-------|
| 1                | 1.7                      | 1.9      | 2.2   | 2.3   |
| 2                | 2.7                      | 3.0      | 3.5   | 3.7   |
| 3                | 2.9                      | 3.2      | 3.8   | 4.0   |
| 4                | 3.1                      | 3.3      | 3.9   | 4.1   |
| 5                | 3.1                      | 3.4      | 4.0   | 4.1   |
| 6                | 3.1                      | 3.4      | 4.0   | 4.2   |
| 7                | 3.1                      | 3.4      | 4.0   | 4.1   |
| 8                | 3.2                      | 3.4      | 3.9   | 4.1   |
| 9                | 3.1                      | 3.4      | 3.9   | 4.0   |
| 10               | 3.1                      | 3.4      | 3.9   | 4.0   |

### Sources

Moody’s Investors Service (2017b, 2017d, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; */ project loans for public-private partnerships only; 1/ adapted Vasiček (2002) model is applied to the credit risk parameters of unrated project loans (and relevant comparators - infrastructure debt securities, non-financial corporate debt, and general corporate exposures) consistent with the asymptotic single risk factor credit risk model of the internal ratings-based approach (IRB) of the Basel III framework (BCBS, 2017) to determine the capital requirement for the risk of credit deterioration separate from default at 99.5 percent statistical confidence (and 99.9 percent statistical confidence for application to banks) — the parametrization is aligned with the advanced IRB approach, with actual LGD and cumulative default probabilities after one year ($t=1$) and at maturity $T$, which are used for calculation of the correlation factor, $\rho$, the market price of risk, $\lambda=(0.40625\times(7^{-0.0093})/\sqrt{p}$, and the bond interest rate of 5 percent per year; 2/ credit risk parameters for corporate loans derived from Moody’s Investors Service (2017b and 2017g); 3/ credit risk parameters for non-financial corporate debt issuers derived from Moody’s Investors Service (2017d); 4/ credit risk parameters for infrastructure debt securities derived from Moody’s Investors Service (2017b and 2017g).
Appendix Table 17. Estimated Capital Charges (Adapted Vasiček (2002) Model): Unrated Project Loans and Comparators (with fixed recovery rate)

### at statistical confidence of 99.5 percent and fixed loss-given-default (LGD) of 45 percent

| Maturity (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|----------|--------|--------|
| 1                | 5.1                      | 4.8      | 6.3    | 6.6    |
| 2                | 8.4                      | 7.9      | 10.2   | 10.6   |
| 3                | 9.1                      | 8.5      | 10.8   | 11.3   |
| 4                | 9.3                      | 8.8      | 11.1   | 11.5   |
| 5                | 9.5                      | 9.0      | 11.2   | 11.6   |
| 6                | 9.5                      | 9.1      | 11.2   | 11.6   |
| 7                | 9.5                      | 9.1      | 11.1   | 11.6   |
| 8                | 9.5                      | 9.1      | 11.1   | 11.5   |
| 9                | 9.5                      | 9.1      | 11.1   | 11.5   |
| 10               | 9.5                      | 9.1      | 11.1   | 11.5   |

### at statistical confidence of 99.9 percent and fixed loss-given-default (LGD) of 45 percent

| Maturity (Years) | All Sub-samples (Global) | EEA/OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|----------|--------|--------|
| 1                | 7.5                      | 7.1      | 8.8    | 9.2    |
| 2                | 11.6                     | 11.0     | 13.5   | 14.0   |
| 3                | 12.2                     | 11.6     | 14.2   | 14.7   |
| 4                | 12.5                     | 11.9     | 14.4   | 14.9   |
| 5                | 12.6                     | 12.1     | 14.4   | 14.9   |
| 6                | 12.6                     | 12.1     | 14.4   | 14.9   |
| 7                | 12.6                     | 12.1     | 14.3   | 14.8   |
| 8                | 12.6                     | 12.1     | 14.3   | 14.8   |
| 9                | 12.6                     | 12.1     | 14.3   | 14.7   |
| 10               | 12.5                     | 12.0     | 14.2   | 14.7   |

Sources: Moody’s Investors Service (2017b, 2017d, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; * project loans for public-private partnerships only; 1/ adapted Vasiček (2002) model is applied to the credit risk parameters of unrated project loans (and relevant comparators - infrastructure debt securities, non-financial corporate debt, and general corporate exposures) consistent with the asymptotic single risk factor credit risk model of the internal ratings-based approach (IRB) of the Basel III framework (BCBS, 2017) to determine the capital requirement for the risk of credit deterioration separate from default at 99.5 percent statistical confidence (and 99.9 percent statistical confidence for application to banks) — the parameterization is aligned with the foundation IRB approach, with fixed LGD of 45 percent and cumulative default probabilities after one year (t=1) and at maturity T, which are used for calculation of the correlation factor, ρ, the market price of risk, α = 0.40625×(T−t)^0.0093)/νp, and the bond interest rate of 5 percent per year; 2/ credit risk parameters for corporate loans derived from Moody’s Investors Service (2017b and 2017g); 3/ credit risk parameters for non-financial corporate debt issuers derived from Moody’s Investors Service (2017d); 4/ credit risk parameters for infrastructure debt securities derived from Moody’s Investors Service (2016b and 2017g).
## Appendix Table 18. Estimated Capital Charges (Economic Capital Model - GEV): Unrated Project Loans and Comparators

### Conditional Tail Expectation (CTE) of 98.7 Percent

| Maturity (Years) | All Sub-samples (Global) | EEA/ OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|-----------|--------|--------|
| 1                | 1.9                      | 1.6       | 2.9    | 3.4    |
| 2                | 3.7                      | 3.1       | 5.6    | 6.7    |
| 3                | 5.1                      | 4.3       | 7.6    | 9.1    |
| 4                | 6.1                      | 5.3       | 8.9    | 10.6   |
| 5                | 6.9                      | 6.0       | 9.8    | 11.6   |
| 6                | 7.3                      | 6.5       | 10.2   | 12.1   |
| 7                | 7.6                      | 6.8       | 10.4   | 12.2   |
| 8                | 7.8                      | 7.0       | 10.4   | 12.3   |
| 9                | 7.9                      | 7.1       | 10.5   | 12.4   |
| 10               | 8.0                      | 7.2       | 10.5   | 12.5   |

### Conditional Tail Expectation (CTE) of 99.7 Percent

| Maturity (Years) | All Sub-samples (Global) | EEA/ OECD | EMDE-A | EMDE-B |
|------------------|--------------------------|-----------|--------|--------|
| 1                | 1.5                      | 1.4       | 2.2    | 2.5    |
| 2                | 2.9                      | 2.7       | 4.3    | 5.0    |
| 3                | 4.0                      | 3.8       | 5.9    | 6.9    |
| 4                | 4.9                      | 4.6       | 7.1    | 8.1    |
| 5                | 5.5                      | 5.3       | 7.9    | 9.0    |
| 6                | 5.9                      | 5.7       | 8.4    | 9.5    |
| 7                | 6.2                      | 6.0       | 8.5    | 9.7    |
| 8                | 6.4                      | 6.2       | 8.5    | 9.7    |
| 9                | 6.5                      | 6.3       | 8.6    | 9.8    |
| 10               | 6.6                      | 6.4       | 8.6    | 9.8    |

### Sources:
Moody’s Investors Service (2017b, 2017d, 2017e and 2017g) and author.

Note: the reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the loan appeared on the books; */ project loans for public-private partnerships only; 1/ economic capital charge as conditional tail expectation (CTE) as point estimate based on generalized extreme value (GEV) distribution, which was empirically fitted to credit risk parameters of unrated project loans (and relevant comparators - infrastructure debt securities, non-financial corporate debt, and general corporate exposures) following Jobst (2007 and 2014) – CTE at 98.7 and 99.7 percent statistical confidence is roughly equivalent to Value-at-Risk (VaR) of 99.5 and 99.9 percent, respectively (CEA, 2006); 2/ credit risk parameters for corporate loans derived from Moody’s Investors Service (2017b and 2017g); 3/ credit risk parameters for non-financial corporate debt issuers derived from Moody’s Investors Service (2017b); 4/ credit risk parameters for infrastructure debt securities derived from Moody’s Investors Service (2016b and 2017a).
### Appendix Table 19. Estimated Capital Charges (Actual and Differentiated): Infrastructure Debt Securities (Global)—Solvency II and Insurance Capital Standard (ICS) [99.5%]

| Maturity** (Years) | Credit Quality Step (CQS) | EIOPA: Solvency II (Spread Risk) | Difference absolute relative | Difference absolute relative | Difference absolute relative |
|-------------------|---------------------------|----------------------------------|-----------------------------|-----------------------------|-----------------------------|
|                   | Differentiated           | Planned                          |                             |                             |                             |
| 1                 | 0.7                       | 1.1                             | 2.0                         | 3.7                         | 7.1                         |
| 2                 | 1.4                       | 1.7                             | 2.2                         | 4.0                         | 7.4                         |
| 3                 | 2.1                       | 2.6                             | 3.3                         | 5.9                         | 11.1                        |
| 4                 | 2.9                       | 3.5                             | 4.4                         | 7.9                         | 14.8                        |
| 5                 | 3.6                       | 4.4                             | 5.5                         | 9.9                         | 18.5                        |
| 6                 | 4.0                       | 4.8                             | 6.1                         | 11.0                        | 20.5                        |
| 7                 | 4.4                       | 5.3                             | 6.2                         | 12.3                        | 25.3                        |
| 8                 | 4.7                       | 5.8                             | 7.2                         | 13.4                        | 24.8                        |
| 9                 | 5.1                       | 6.2                             | 7.7                         | 14.5                        | 26.5                        |
| 10                | 5.5                       | 6.7                             | 8.3                         | 15.7                        | 28.5                        |

| Maturity** (Years) | Credit Quality Step (CQS) | IAIS: ICS (Credit Risk) [A-IRB without floors, 99.9%] | Difference absolute relative | Difference absolute relative | Difference absolute relative |
|-------------------|---------------------------|--------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|
|                   | Differentiated           | Planned                          |                             |                             |                             |
| 1                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 2                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 3                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 4                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 5                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 6                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 7                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 8                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 9                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 10                | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |

| Maturity** (Years) | Credit Quality Step (CQS) | IAIS: ICS (Credit Risk) [A-IRB with floors, 99.9%] | Difference absolute relative | Difference absolute relative | Difference absolute relative |
|-------------------|---------------------------|--------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|
|                   | Differentiated           | Planned                          |                             |                             |                             |
| 1                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 2                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 3                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 4                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 5                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 6                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 7                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 8                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 9                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 10                | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |

| Maturity** (Years) | Credit Quality Step (CQS) | IAIS: ICS (Credit Risk) [adapted Vasiček (2002) model with fixed USD, 99.9%] | Difference absolute relative | Difference absolute relative | Difference absolute relative |
|-------------------|---------------------------|--------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|
|                   | Differentiated           | Planned                          |                             |                             |                             |
| 1                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 2                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 3                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 4                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 5                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 6                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 7                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 8                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 9                 | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| 10                | 0.0                       | 0.0                             | 0.0                         | 0.7                         | 2.3                         |
| Credit Quality Step (CQS) 1/ | (In percent) |
|-----------------------------|--------------|
| Maturity** (Years) | Differentiated | Planned 5/ | Absolute | Relative | Difference |
| 1 | 0.0 | 0.0 | 0.0 | 0.8 | 2.2 | 67 | -0.2 | -0.2 | -0.6 | -0.6 | -1.4 | -2.2 | -92 | -92 | -98 | -98 | -45 | -38 | -25 |
| 2 | 0.0 | 0.0 | 1.4 | 1.5 | 4.7 | 10.9 | 0.7 | 0.7 | 1.3 | 3.0 | 7.1 | 14.4 | -0.7 | -0.7 | 0.1 | -1.5 | -2.4 | -3.5 | -98 | -98 | 9 | -49 | -33 | -24 |
| 3 | 0.0 | 0.0 | 1.8 | 2.0 | 5.7 | 12.1 | 0.9 | 0.9 | 1.6 | 3.6 | 8.3 | 15.3 | -0.9 | -0.9 | 0.2 | -1.6 | -2.6 | -3.2 | -98 | -98 | 14 | -45 | -32 | -21 |
| 4 | 0.0 | 0.0 | 1.8 | 2.1 | 6.4 | 12.5 | 1.2 | 1.2 | 1.8 | 4.1 | 9.0 | 15.6 | -1.2 | -1.2 | 0.0 | -2.0 | -2.6 | -3.1 | -99 | -99 | 0 | -49 | -29 | -20 |
| 5 | 0.0 | 0.0 | 2.1 | 2.4 | 6.9 | 12.7 | 1.4 | 1.4 | 2.1 | 4.5 | 9.4 | 15.6 | -1.4 | -1.4 | 0.0 | -2.1 | -2.5 | -2.9 | -99 | -99 | 2 | -47 | -27 | -18 |
| 6 | 0.0 | 0.0 | 2.0 | 2.5 | 7.1 | 12.8 | 1.6 | 1.6 | 2.3 | 4.9 | 9.7 | 15.6 | -1.6 | -1.6 | -0.3 | -2.4 | -2.6 | -2.8 | -99 | -99 | 11 | -49 | -27 | -18 |
| 7 | 0.0 | 0.0 | 2.3 | 2.7 | 7.1 | 12.8 | 1.7 | 1.7 | 2.6 | 5.1 | 9.8 | 15.6 | -1.7 | -1.7 | -0.3 | -2.4 | -2.7 | -2.8 | -99 | -99 | 13 | -47 | -27 | -18 |
| 8 | 0.0 | 0.0 | 2.3 | 2.8 | 7.1 | 12.7 | 1.9 | 1.9 | 2.8 | 5.3 | 9.8 | 15.6 | -1.9 | -1.9 | -0.5 | -2.5 | -2.7 | -2.9 | -99 | -99 | 19 | -47 | -28 | -19 |
| 9 | 0.0 | 0.0 | 2.3 | 3.0 | 7.1 | 12.6 | 2.0 | 2.0 | 3.0 | 5.4 | 9.8 | 15.6 | -2.0 | -2.0 | -0.7 | -2.4 | -2.7 | -3.0 | -99 | -99 | 25 | -44 | -28 | -19 |
| 10 | 0.0 | 0.0 | 2.5 | 3.1 | 7.2 | 12.5 | 2.1 | 2.1 | 3.2 | 5.6 | 9.8 | 15.6 | -2.1 | -2.1 | -0.7 | -2.5 | -2.6 | -3.1 | -99 | -99 | 23 | -46 | -27 | -20 |

Sources: EOPA, IAS, Moody’s Investors Service (2017b, 2017d, 2017e and 2017g) and author.

Note: The reference to “maturity (years)” indicates the capital charge for infrastructure debt assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the debtsecurity appeared on the books. 1/ “Global” refers to the credit risk parameter of infrastructure debt securities published in Moody’s Investors Service (2017b), which – in terms of geographical coverage – is consistent with the “all sub-samples” coverage of unrated project loans in Moody’s Investors Service (2017d). 2/ For illustrative purposes and easier comparison, maturities (rather than duration) are used to show the risk factors for the determination of the capital charges under Solvency II; 3/ Credit Quality Step (CQS) 1=“Aaa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”; 2/ Capital charges were derived from mapping the risk factors for bonds and loans under the Solvency II SCR Standard Formula to the average annual expected losses (over a 10-year horizon) of rated infrastructure debt securities consistent with the calibration of unrated project loans; 3/ Credit risk factor is modeled based on the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) with a floor for PD and LGD at 99.5 percent statistical confidence (without application of the maturity adjustment); 4/ the credit risk factor is modeled based on Moody’s Investors Service (2017g); 5/ “adapted Vasiček (2002) model” is applied to the credit risk parameters of infrastructure debt securities as published by Moody’s Investors Service (2017g) at 99.5 percent statistical confidence.
## Appendix Table 20. Estimated Capital Charges (Actual and Differentiated) for Infrastructure Debt Securities (EMDE–NA)—Solvency II and Insurance Capital Standard (ICS) [99.5%]

| Credit Quality Step (CQS) | Differentiated | Differentiated Planned |
|--------------------------|----------------|-----------------------|
| 012345 012345 012345 012345 | 0.8 1.0 1.9 2.4 4.3 8.0 14.5 | 0.9 2.1 2.1 2.1 2.1 2.1 2.1 2.1 |
| EIOPA: Solvency II (Spread Risk) | -0.2 -0.4 -0.7 -1.0 -1.5 -2.0 -2.5 -3.0 | -0.2 -0.4 -0.7 -1.0 -1.5 -2.0 -2.5 -3.0 |
| Maturity** (Years) | | | |
| Difference | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
| IAIS: ICS (Credit Risk) | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
| IAIS: ICS (Credit Risk) | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
| IAIS: ICS (Credit Risk) | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
| IAIS: ICS (Credit Risk) | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
| IAIS: ICS (Credit Risk) | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
| IAIS: ICS (Credit Risk) | | | |
| Differentiated absolute relative | | | |
| Planned absolute relative | | | |
### Appendix Table 20. Estimated Capital Charges (Actual and Differentiated): Infrastructure Debt Securities (EMDE-A)*—Solvency II and Insurance Capital Standard (ICS) [99.5%] (continued)

| Maturity (Years) | Credit Quality Step (CQS) | Differentiated | Planned | Difference |
|------------------|--------------------------|----------------|---------|------------|
|                  |                          | 0% | 1% | 2% | 3% | 4% | 5% | 0% | 1% | 2% | 3% | 4% | 5% | 0% | 1% | 2% | 3% | 4% | 5% |
| 1                |                          | 0 0 | 0.0 | 0.6 | 1.3 | 3.8 | 10.4 | -0.2 | -0.2 | -0.6 | -0.1 | 0.2 | 1.5 | -92 | -92 | -97 | -9 | 4 | 16 |
| 2                |                          | 0 0 | 1.3 | 2.4 | 7.5 | 16.2 | 0.7 | 0.7 | 1.3 | 3.0 | 7.1 | 14.4 | -0.7 | -0.7 | -0.6 | 0.4 | 1.8 | -98 | -98 | -90 | 21 | 5 | 12 |
| 3                |                          | 0 0 | 1.7 | 3.0 | 8.7 | 17.2 | 0.9 | 0.9 | 1.6 | 3.6 | 8.3 | 15.3 | -0.9 | -0.9 | 0.1 | -0.6 | 0.4 | 1.9 | -98 | -98 | -95 | 16 | -14 | 13 |
| 4                |                          | 0 0 | 1.6 | 3.2 | 9.5 | 17.4 | 1.2 | 1.2 | 1.8 | 4.1 | 9.0 | 15.6 | -1.2 | -1.2 | -0.2 | -0.9 | 0.5 | 1.8 | -99 | -99 | -99 | 22 | 5 | 11 |
| 5                |                          | 0 0 | 2.0 | 3.6 | 10.0 | 17.2 | 1.4 | 1.4 | 2.1 | 4.5 | 9.4 | 15.6 | -1.4 | -1.4 | -0.1 | -0.9 | 0.6 | 1.6 | -99 | -99 | -99 | -21 | 6 | 10 |
| 6                |                          | 0 0 | 1.9 | 3.7 | 10.1 | 16.9 | 1.6 | 1.6 | 2.3 | 4.9 | 9.7 | 15.6 | -1.6 | -1.6 | -0.4 | -1.2 | 0.4 | 1.3 | -99 | -99 | -99 | -24 | 4 | 8 |
| 7                |                          | 0 0 | 2.2 | 4.0 | 10.0 | 16.5 | 1.7 | 1.7 | 2.6 | 5.1 | 9.8 | 15.6 | -1.7 | -1.7 | -0.4 | -1.1 | 0.2 | 0.9 | -99 | -99 | -99 | -22 | 2 | 6 |
| 8                |                          | 0 0 | 2.2 | 4.1 | 9.8 | 16.1 | 1.9 | 1.9 | 2.8 | 5.3 | 9.8 | 15.6 | -1.9 | -1.9 | -0.6 | -1.2 | 0.0 | 0.5 | -99 | -99 | -99 | -23 | 0 | 3 |
| 9                |                          | 0 0 | 2.2 | 4.3 | 9.8 | 15.7 | 2.0 | 2.0 | 3.0 | 5.4 | 9.8 | 15.6 | -2.0 | -2.0 | -0.8 | -1.1 | 0.0 | 0.1 | -99 | -99 | -99 | -20 | 0 | 0 |
| 10               |                          | 0 0 | 2.4 | 4.4 | 9.7 | 15.2 | 2.1 | 2.1 | 3.2 | 5.6 | 9.8 | 15.6 | -2.1 | -2.1 | -0.8 | -1.2 | -0.1 | -0.4 | -99 | -99 | -99 | -21 | -2 | -2 |

Sources: EIOPA, IAIS, Moody’s Investors Service (2017b, 2017d, 2017e and 2017g) and author.

Note: The reference to “maturity” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the debt security appeared on the books. “EMDE-A” refers to the credit risk parameters of infrastructure debt securities all non-high income countries, consistent with the geographical coverage for unrated project loans in Moody’s Investors Service (2017a). ** Maturities (rather than duration) are used to show the risk factors for the determination of the capital charges under Solvency II. 1/ Credit Quality Step (CQS): 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”; 2/ capital charges were derived from mapping the risk factors for bonds and loans under the Solvency II SCR Standard Formula Spread Risk Sub-Module to the average annual expected losses (over a 10-year horizon) of rated infrastructure debt securities consistent with the calibration of unrated project loans in Moody’s Investors Service (2017a); 3/ for illustrative purposes and easier comparison, maturities (rather than duration) are used to show the risk factors for the determination of the capital charges under Solvency II. 4/ credit risk factor is modeled based on the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) with/without a floor for PD and LGD at 99.5 percent statistical confidence. 5/ credit risk factor for corporate exposure under the planned Insurance Capital Standard (ICS) for internationally active insurance groups (IAIGs) based on asymptotic single factor credit risk model (by adapting the Vasicek (2002) model), consistent with the IRB approach for unexpected losses from credit risk under the Basel III framework (BCBS, 2017), with actual and fixed LGD (with the latter replicating the foundation IRB approach — credit risk parameters derived from S&P’s corporate default rate estimates for 2013 (Gacci and Kraemer, 2014) and published in IIS (2017b); 6/ adapted Vasicek (2002) model is applied to the credit risk parameters of infrastructure debt securities as published by Moody’s Investors Service (2017g) at 99.5 percent statistical confidence.
| Credit Quality Step (CQS) | EIOPA: Solvency II (Spread Risk) | IAIS: ICS (Credit Risk) [A-IRB without floors, 99.5%] | IAIS: ICS (Credit Risk) [A-IRB with floors, 99.5%] | IAIS: ICS (Credit Risk) [adapted Vasiček (2002) model with fixed LGD, 99.5%] |
|--------------------------|----------------------------------|----------------------------------------------------|-----------------------------------------------------|--------------------------------------------------|
| 1                        | 0.8                              | 0.2                                                | 0.2                                                 | 0.2                                               |
| 2                        | 1.0                              | 0.4                                                | 0.4                                                 | 0.4                                               |
| 3                        | 1.2                              | 0.6                                                | 0.6                                                 | 0.6                                               |
| 4                        | 1.4                              | 0.8                                                | 0.8                                                 | 0.8                                               |
| 5                        | 1.6                              | 1.0                                                | 1.0                                                 | 1.0                                               |
| 6                        | 1.8                              | 1.2                                                | 1.2                                                 | 1.2                                               |
| 7                        | 2.0                              | 1.4                                                | 1.4                                                 | 1.4                                               |
| 8                        | 2.2                              | 1.6                                                | 1.6                                                 | 1.6                                               |
| 9                        | 2.4                              | 1.8                                                | 1.8                                                 | 1.8                                               |
| 10                       | 2.6                              | 2.0                                                | 2.0                                                 | 2.0                                               |

Note: The table continues with more data points.
### Appendix Table 21. Estimated Capital Charges (Actual and Differentiated): Infrastructure Debt Securities (EMDE-B)—Solvency II and Insurance Capital Standard (ICS) [99.5%] (continued)

| Credit Quality Step (CQS) 1/ | IAS: ICS (Credit Risk) | Planned | Difference |
|-------------------------------|-------------------------|---------|------------|
|                               | absolute | relative | absolute | relative |
| Maturity** (Years)            |          |          |          |          |
| 1                             | 0.0 0.0 0.0 1.2 3.1 8.7 | 0.0 0.2 0.6 1.4 3.6 8.9 | -0.2 -0.2 -0.6 -0.2 -0.5 -0.2 | -92 -92 -97 -17 -13 -2 |
| 2                             | 0.0 0.0 1.3 2.2 6.4 13.8 | 0.0 0.2 1.3 4.1 9.0 15.6 | -0.7 -0.7 0.0 -0.7 -0.6 | -98 -98 -27 -10 -4 |
| 3                             | 0.0 0.0 1.6 2.8 7.5 14.9 | 0.0 0.2 1.6 4.1 9.0 15.6 | -0.9 -0.9 0.0 -0.8 -0.4 | -98 -98 1 -22 -10 -2 |
| 4                             | 0.0 0.0 1.6 3.0 8.3 15.3 | 0.0 0.2 1.8 4.1 9.0 15.6 | -1.2 -1.2 -0.2 -1.1 -0.7 0.3 | -99 -99 12 27 8 -2 |
| 5                             | 0.0 0.0 1.9 3.3 8.8 15.3 | 0.0 0.2 2.1 4.1 9.0 15.6 | -1.4 -1.4 -0.2 -1.2 -0.6 0.3 | -99 -99 12 27 8 -2 |
| 6                             | 0.0 0.0 1.9 3.5 8.9 15.1 | 0.0 0.2 2.3 4.1 9.0 15.6 | -1.6 -1.6 -0.6 -1.4 -0.8 0.5 | -99 -99 16 29 8 -3 |
| 7                             | 0.0 0.0 2.2 3.7 8.9 14.9 | 0.0 0.2 2.6 4.1 9.0 15.6 | -1.7 -1.7 -0.6 -1.4 -0.9 -0.7 | -99 -99 15 27 9 -4 |
| 8                             | 0.0 0.0 2.2 3.8 8.8 14.7 | 0.0 0.2 2.8 4.1 9.0 15.6 | -1.9 -1.9 -0.8 -1.6 -1.5 -1.0 | -99 -99 21 28 10 -6 |
| 9                             | 0.0 0.0 2.2 4.0 8.7 14.4 | 0.0 0.2 3.0 4.1 9.0 15.6 | -2.0 -2.0 -0.8 -1.4 -1.1 -1.2 | -99 -99 27 25 11 -7 |
| 10                            | 0.0 0.0 2.4 4.1 8.7 14.2 | 0.0 0.2 3.2 4.1 9.0 15.6 | -2.1 -2.1 -0.8 -1.5 -1.1 -1.4 | -99 -99 24 26 11 -9 |

Sources: EIOPA, IAS, Moody’s Investors Service (2017b, 2017d, 2017e and 2017g) and author.

Note: The reference to “maturity (years)” indicates the capital charge for infrastructure debt, assuming that investment occurs after financial close, i.e., investors fully participate in the term structure of default risk over the given risk horizon (up to 10 years) after the debt security appeared on the books. 1/ “EMDE-B” refers to the credit risk parameters of infrastructure debt for non-high income countries without EU or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey), consistent with the geographical coverage for unrated project loans in Moody’s Investors Service (2017g). 2/ For illustrative purposes and easier comparison, maturities (rather than duration) are used to show the risk factors for the determination of the capital charges under Solvency II; 1/ Credit Quality Step (CQS) 0=“Aaa”, 1=“Aa”, 2=“A”, 3=“Baa”, 4=“Ba”, and 5=“B”. 2/ Capital charges were derived from mapping the risk factors for bonds and loans under the Solvency II SCR Standard Formula Spread Risk Sub-Module to the average annual expected losses (over a 10-year horizon) of rated infrastructure debt securities consistent with the calibration of unrated project loans; 3/ Credit risk factors for fixed income (debt securities and lending) investment under the Standard Formula (European Commission, 2015); 4/ Credit risk factor is modeled based on the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) with/without a floor for PD and LGD at 99.5 percent statistical confidence (without application of the maturity adjustment given that the marginal default probability for infrastructure debt securities converges to zero shortly after 2.5 years (which anchors the maturity adjustment)); 5/ Credit risk factor for corporate exposure under the planned Insurance Capital Standard (ICS) for internationally active insurance groups (IAIGs) based on asymptotic single factor credit risk model (by adapting the Vasiček (2002) model), consistent with the IRB approach for unexpected losses from credit risk under the Basel III framework (BCBS, 2017), with actual and fixed LGD (with the latter replacing the foundation IRB approach); 5/ Credit risk parameters derived from S&P’s corporate default rate estimates for 2013 (Biswas and Kraemer, 2014) and published in IAS (2017b); 6/ Adapted Vasiček (2002) model is applied to the credit risk parameters of infrastructure debt securities as published by Moody’s Investors Service (2017g) at 99.5 percent statistical confidence.
Appendix Table 22. Estimated Capital Charges (Banking): Project Loans and Infrastructure Debt Securities—Basel III Internal Ratings-based (IRB) Approach and Economic Model

(Continued)

| Maturity (Years) | Global | EMDE-A 1/ | EMDE-B 1/ |
|------------------|--------|----------|----------|
|                  | Credit Quality Step (CQS) 4/ | Unrated* (PPP only)** | Credit Quality Step (CQS) 4/ | Unrated* (PPP only)** | Credit Quality Step (CQS) 4/ | Unrated* (PPP only)** |
| 1                | 0.0    | 1.5      | 3.6      | 5.8      | 3.2    | 1.4      |
| 2                | 0.2    | 3.1      | 7.4      | 11.6     | 4.5    | 2.1      |
| 3                | 2.6    | 5.3      | 9.8      | 14.8     | 5.4    | 2.6      |
| 4                | 3.2    | 6.8      | 11.9     | 17.2     | 6.2    | 3.2      |
| 5                | 5.2    | 8.7      | 13.8     | 19.1     | 6.9    | 3.6      |
| 6                | 6.0    | 10.1     | 15.4     | 20.5     | 7.4    | 4.0      |
| 7                | 7.9    | 11.7     | 16.7     | 21.8     | 8.0    | 4.4      |
| 8                | 8.7    | 13.0     | 17.8     | 22.9     | 8.5    | 4.7      |
| 9                | 9.5    | 14.0     | 19.0     | 23.9     | 8.9    | 5.5      |
| 10               | 11.4   | 15.6     | 20.3     | 24.7     | 9.4    | 5.5      |

| Maturity (Years) | Basel III—Advanced Internal Ratings-based Approach (A-IRB) with maturity adjustment, without floors 5/ | Basel III—Advanced Internal Ratings-based Approach (A-IRB) with maturity adjustment and floors 5/ | Basel III—Advanced Internal Ratings-based Approach (A-IRB) without maturity adjustment, with floors 5/ |
|------------------|-------------------------------------------------|---------------------------------------------|-------------------------------------------------|
| 1                | 0.0    | 1.5    | 3.6    | 11.0    | 4.4    | 2.7      |
| 2                | 1.3    | 3.1    | 7.4    | 11.6    | 5.4    | 3.6      |
| 3                | 2.6    | 5.3    | 9.8    | 14.8    | 6.4    | 4.6      |
| 4                | 3.2    | 6.8    | 11.9   | 17.2    | 4.1    | 2.5      |
| 5                | 5.2    | 8.7    | 13.8   | 19.1    | 8.1    | 6.4      |
| 6                | 6.0    | 10.1   | 15.4   | 20.5    | 8.8    | 7.0      |
| 7                | 7.9    | 11.7   | 16.7   | 21.8    | 9.4    | 7.7      |
| 8                | 8.7    | 13.0   | 17.8   | 22.9    | 10.0   | 8.3      |
| 9                | 9.5    | 14.0   | 19.0   | 23.9    | 10.6   | 8.9      |
| 10               | 11.4   | 15.6   | 20.3   | 24.7    | 11.8   | 9.8      |

| Maturity (Years) | without maturity adjustment and floors 5/ | without maturity adjustment, with floors 5/ |
|------------------|---------------------------------------------|---------------------------------------------|
| 1                | 0.0    | 1.5    | 3.6    | 11.0    | 4.4    | 2.7      |
| 2                | 1.3    | 3.1    | 7.4    | 11.6    | 5.4    | 3.6      |
| 3                | 2.6    | 5.3    | 9.8    | 14.8    | 6.4    | 4.6      |
| 4                | 3.2    | 6.8    | 11.9   | 17.2    | 4.1    | 2.5      |
| 5                | 5.2    | 8.7    | 13.8   | 19.1    | 8.1    | 6.4      |
| 6                | 6.0    | 10.1   | 15.4   | 20.5    | 8.8    | 7.0      |
| 7                | 7.9    | 11.7   | 16.7   | 21.8    | 9.4    | 7.7      |
| 8                | 8.7    | 13.0   | 17.8   | 22.9    | 10.0   | 8.3      |
| 9                | 9.5    | 14.0   | 19.0   | 23.9    | 10.6   | 8.9      |
| 10               | 11.4   | 15.6   | 20.3   | 24.7    | 11.8   | 9.8      |
Appendix Table 22. Estimated Capital Charges (Banking): Project Loans and Infrastructure Debt Securities—Basel III Internal Ratings-based (IRB) Approach and Economic Model

| Credit Quality Step (CQS) | Basel III—Foundation Internal Ratings-based Approach (F-IRB) | Actual F-IRB with fixed LGD of 45 percent | Note | Actual GEV-CTE, 99.7% |
|--------------------------|-------------------------------------------------------------|-----------------------------------------|------|----------------------|
| 1/ Unrated*              | 0.0 1.1 1.5 3.8 9.2                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 0.1 0.3 1.4 5.0 |
| 2/ Unrated*              | 0.0 1.2 1.6 3.2 8.3                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.2 1.5 3.8 9.2 |
| 3/ Unrated*              | 0.0 1.7 2.1 3.8 9.2                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.7 2.1 3.8 9.2 |
| 4/ Unrated*              | 0.0 1.4 2.5 3.9 9.2                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.4 2.5 3.9 9.2 |
| 5/ Unrated*              | 0.0 1.5 2.6 3.9 9.2                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.5 2.6 3.9 9.2 |
| 6/ Unrated*              | 0.0 1.6 2.6 3.9 9.2                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.6 2.6 3.9 9.2 |
| 7/ Unrated*              | 0.0 1.8 2.9 4.1 9.6                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.8 2.9 4.1 9.6 |
| 8/ Unrated*              | 0.0 1.9 3.2 4.3 9.6                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 1.9 3.2 4.3 9.6 |
| 9/ Unrated*              | 0.0 2.0 3.4 4.5 9.6                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 2.0 3.4 4.5 9.6 |
| 10/ Unrated*             | 0.0 2.1 3.6 4.7 9.6                                       | 0.0 1.1 1.5 3.8 9.2                         |      | 0.0 2.1 3.6 4.7 9.6 |

Note: After the reference to Moody's Investors Service (2016, 2017, 2017a, 2017c to 2017g) and author. Calculated according to: Moody’s Investors Service (2016, 2017, 2017a, 2017c to 2017g), which comprises all EEA and OECD member countries (“EEA or OECD”) and all non-high income countries without EEA or OECD members (i.e., Bulgaria, Croatia, Mexico, Romania, and Turkey) (“EMDE-B”); 2/ all non-high income countries... in Moody’s Investors Service (2017a, 2017d and 2017e) between 1983 and 2015, consistent with original study period of unrated project loans in Moody's Investors Service (2017c and 2017g); 3/... capital charge (A-IRB) approach for specialized lending (project finance) at a statistical confidence level of 99.9 percent, with and without application of the maturity adjustment and floors for marginal PDs (0.05 percent) and LGD (25 percent) according to the finalized Basel III framework (BCBS, 2017); 4/ capital charge... advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) at a statistical confidence level of 99.9 percent, with and without application of the maturity adjustment and floors for marginal PDs (0.05 percent) and LGD (25 percent) according to the finalized Basel III framework (BCBS, 2017); 5/ capital charge based on the cumulative default rate of up to 10 years under the advanced internal ratings-based (A-IRB) approach for specialized lending (project finance) at a statistical confidence level of 99.9 percent, with and without application of the maturity adjustment and floors for marginal PDs (0.05 percent) and LGD (25 percent) according to the finalized Basel III framework (BCBS, 2017); 6/ capital charge based on the set of credit risk parameters for infrastructure debt securities are based on past studies by Moody’s Investors Service (2017a, 2017d and 2017e) between 1983 and 2015, consistent with original study period of unrated project loans in Moody's Investors Service (2017c and 2017g); 7/ capital charge based on exact specification of F-IRB approach with fixed LGD of 45 percent and actual PDs; 8/ capital charge based on exact specification of F-IRB approach with fixed LGD of 45 percent and actual PDs; 9/ capital charge based on the set of credit risk parameters for infrastructure debt securities are based on past studies by Moody’s Investors Service (2017a, 2017d and 2017e) between 1983 and 2015, consistent with original study period of unrated project loans in Moody's Investors Service (2017c and 2017g); 10/ capital charge based on exact specification of F-IRB approach with fixed LGD of 45 percent and actual PDs.