Working paper

# How likely are multilateral development banks to need callable capital?

## Implications for risk frameworks and lending capacity

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### Key messages

The probability of any multilateral development bank (MDB) needing to use callable capital is virtually non-existent over a three-year period of sustained stress and a blind lending growth strategy.

While the probability of an MDB experiencing stress is extremely low, investing time and resources in understanding the risks more precisely could unlock significant additional lending.

Enhancing MDB risk appetite frameworks would help both MDBs and shareholders improve their mutual understanding of risk appetite and inform risk-taking decisions by shareholders.

A modest increase in shareholder risk appetite could have a significant impact on potential lending capacity without materially increasing the risk of a call on capital. This paper illustrates variations in shareholder risk appetite that could increase total lending by $42 billion to $114 billion across the MDBs in the analysis.

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All views, errors and omissions in this paper are the sole responsibility of the author and do not represent the views of any MDB.

## About this publication

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# Acronyms

| | |
|---|---|
| ADB | Asian Development Bank |
| AfDB | African Development Bank |
| AIIB | Asian Infrastructure Investment Bank |
| BSM | Black Scholes Merton |
| CAF | Corporación Andina de Fomento |
| EBRD | European Bank for Reconstruction and Development |
| GCI | General capital increase |
| IADB | Inter-American Development Bank |
| IBRD | International Bank for Reconstruction and Development |
| IFC | International Finance Corporation |
| LGD | Loss given default |
| MDB | Multilateral development bank |
| PCT | Preferred Creditor Treatment |
| SGR | Sustainable growth rate |
| VaR | Value at Risk |

# Executive summary

This paper explains the stress testing exercise performed on a selection of multilateral development banks (MDBs) using publicly available data. It forms part of a multi-paper ODI research project on MDB callable capital.

The paper first evaluates the conditions under which an MDB might need to trigger callable capital. The scenario analysis is done through reverse stress tests that simulate conditions to cause financial distress. The analysis confirms that MDBs are very low-risk institutions, and that the probability of a call is negligible over a reasonable time horizon (three years).

The tests are then extended to consider alternative states of financial distress on the grounds that, in practice, the point of non-viability occurs long before capital and reserves have been exhausted. Over a similar three-year time horizon the probability of stress is still negligible. This should not be a surprise and is consistent with the prudent structure and management of MDB balance sheets, low borrower default rates and substantial liquidity buffers.

The key points from this first section are:

- The probabilities of any of the MDBs needing to use callable capital based on equity being totally consumed by losses is virtually non-existent over a three-year period of extreme stress.
- The probabilities of any of the MDBs experiencing a degree of balance sheet stress that might threaten financial viability are also extremely low over a three-year period.
- Management actions could have a significant impact on risk appetite by delaying the need for a capital call, further reducing the probability of that event.

The second half of the paper analyses the same risks, but from a different perspective. Instead of taking the banks as they are today and estimating the risk, it asks the question in reverse. How would lending capacity be affected if shareholders were able to articulate a consistent and clear risk appetite?

The results from the theoretical analysis show the different risk appetites that might exist between the MDBs, and the additional capacity that might be released depending on shareholder priorities. It also shows that modest increases in shareholder risk appetite could have a significant effect on lending capacity across the MDBs.

The paper proposes a risk appetite framework based on three dimensions that MDBs/shareholders could use to supplement existing processes, and that could offer a harmonised framework to set risk appetite for lending:

- Specification of the capital threshold at which stress becomes a concern.
- Setting and accepting a probability of that risk occurring.
- Contextualising the risk by incorporating the risk of increased funding spreads if the credit quality of the MDB begins to deteriorate.

A modest increase in shareholder risk appetite could have a significant impact on potential lending capacity without materially increasing the risk of a call on capital. This paper illustrates variations in shareholder risk appetite that could increase total lending by $42 billion to $114 billion across the MDBs in the analysis.

These findings have three important implications for policy.

First, while the probability of an MDB experiencing stress is extremely low, investing time and resources in understanding the risks more precisely could unlock significant additional lending while maintaining the highest credit ratings.

Second, enhancing MDB risk appetite frameworks will help MDBs and shareholders improve their mutual understanding of risk appetite, and inform risk-taking decisions by shareholders.

Third, as part of risk management and resilience planning, management need a clear mandate for the actions they can take during a crisis to mitigate risk for shareholders.

# 1 Introduction

A key component of the MDB Challenge Fund project on callable capital (Box 1) has been to investigate the scenarios in which callable capital might be required from shareholders in the event of an MDB becoming financially distressed. MDBs and shareholders need to have shared expectations of how they would manage an adverse situation, the tools that they have at their disposal, and the potential financial implications for national budgets.

Scenario modelling can provide better visibility on how these adverse situations might develop. It is possible to estimate the probability of a call taking place, the timeframe over which it might occur, and the potential notional size of a call.

For this project, projecting the financial trajectory of an MDB to stressed state is achieved through the application of 'reverse stress tests'. The purpose of this type of test is to identify the 'scenarios that could potentially lead banks to fail' (BCBS, 2018). If the probability of these extreme events is considered unacceptably high, the bank's management should act to mitigate the risk (S&P Global, 2021). Conversely, if the probability of extreme events is considered to be very remote, this can empower the bank to take more risk.

It is difficult to identify exactly when an MDB might fail in a stress scenario because there are so many factors to consider. However, a key point is that stress is likely to occur before an MDB would have exhausted all of its capital resources. A lack of confidence in the institution could precipitate further problems for the MDB that could compromise its financing model.

The unique nature of MDBs creates some interesting challenges as they are so heavily reliant upon the goodwill of bond markets for wholesale funding. In contrast, private sector banks generally benefit from customer deposits as a source of funding in addition to bond issuance, and are regulated to ensure that they have a sound liquidity position.

MDBs mitigate the risk of losing access to the bond markets in two ways. The first is to manage their balance sheet to ensure that they maintain the highest external credit ratings possible. Maintaining the highest credit rating is an important signal to bondholders of the low risk of the institutions. The second mitigant is to maintain significant liquidity buffers in the form of high-grade investment portfolios on their balance sheets. Liquidity buffers provide some protection against a market dislocation where the MDB is unable to issue new bonds. With a substantial investment portfolio, the MDBs have sufficient funds to pay bondholders for a significant period of time. This is another key criterion in maintaining the highest possible credit ratings.

As policy-based institutions, MDBs face pressures to maintain/increase lending consistently even in a time of crisis, while retaining the highest possible credit ratings and Preferred Creditor Treatment (PCT).[1] To capture these types of effects, the stress tests needed to consider some extremely unlikely cases that would conflict with the core mission of the MDBs.

The modelling described in this paper sets out to answer two fundamental questions. First, what types of scenarios would cause an MDB to become financially stressed and potentially fail? How likely is it that this might happen? Second, how could the risk appetite of shareholders with regard to callable capital affect lending capacity? Would it be possible to expand balance sheets further with a clear understanding of the probability of a call taking place? Each of these questions requires a different modelling approach.

The reverse stress tests use a statistical method using a Monte Carlo engine to simulate a range of credit scenarios that unfold over a 10-year MDB simulation. From the analysis it is possible to draw some conclusions about some fundamental constraints on balance sheet growth. The analysis also highlights a potential conflict between prudential risk management and policy-based growth aspirations.

Creating greater transparency around the risk that shareholders are running with a commitment to callable capital requires a different approach. This question is answered by developing a theoretical model to estimate the probability of a capital call, and to estimate how lending capacity might change with shareholder risk appetite.

Given the technical nature of the analysis, the paper has been structured to cater for different readers. Each section contains a summary of the key points, followed by an explanation of results from the modelling work. More technical aspects such as the model mechanics, data calibration and the derivation of the theoretical model have been put into Appendices.

Section 2 explains the general approach to modelling, defines important terms that are referred to throughout the document and discusses some of the constraints of modelling. Section 3 presents some highlights of the results from the reverse stress tests (Monte Carlo analysis) comparing the relative apparent risk across the group of MDBs in a consistent way.

Section 4 explains the logic behind the theoretical model, compares the apparent risk being taken by different MDBs and discusses the impact of risk appetite on lending capacity. Section 5 concludes the paper with

[1] PCT reflects the market practice that MDBs generally get paid back in the event of restructuring of sovereign bilateral or commercial debts (Cordella & Powell, 2021).

some thoughts on policy implications and suggestions for future research.

### Box 1 Maximising the developmental value of MDB callable capital

This paper is part of a year-long project investigating MDB callable capital, supported by the MDB Challenge Fund and undertaken by a research team based at ODI. The project concludes in spring 2024 and comprises the following papers:

1. Making sense of hybrid capital for multilateral banks.
2. The legal underpinnings of MDB callable capital: implications and policy options.
3. How shareholders account for MDB callable capital in their budgetary frameworks.
4. How likely are multilateral development banks to need callable capital? Implications for risk frameworks and lending capacity
5. Modernising MDB approaches to managing financial stress.
6. Calculating the financial value of MDB callable capital for capital adequacy.

The project is led by Chris Humphrey (ODI senior research associate) and includes Chris McHugh (Senior Advisor, International Association of Credit Portfolio Managers), Eamonn White (Director, Ardhill Advisory) and Bianca Getzel (ODI research officer).

# 2 Modelling approach

The MDBs in scope for this analysis are shown in Table 1 with their respective external ratings.[2] The financing model for these MDBs depends on maintaining high credit ratings and access to wholesale bond markets. This reliance on external ratings as a guide to financial risk-taking has led to operational convergence between the largest MDBs (Humphrey, 2016).

A second, self-evident observation is that the MDBs are extremely low-risk institutions. In the spirit of reverse stress testing, it is clear that any shocks applied would have to be very severe to cause financial distress.

**Table 1 Long-term issuer ratings for major MDBs**

| MDB | | S&P | Moody's | Fitch |
|---|---|---|---|---|
| African Development Bank | AfDB | AAA | Aaa | AAA |
| Asian Development Bank | ADB | AAA | Aaa | AAA |
| Asian Infrastructure Investment Bank | AIIB | AAA | Aaa | AAA |
| Corporación Andina de Fomento | CAF | AA | Aa3 | AA- |
| European Bank for Reconstruction and Development | EBRD | AAA | Aaa | AAA |
| Inter-American Development Bank | IADB | AAA | Aaa | AAA |
| International Bank for Reconstruction and Development | IBRD | AAA | Aaa | AAA |
| International Finance Corporation | IFC | AAA | Aaa | NR |

Source: FitchConnect, December 2023

The idea of operational convergence is the justification for some key assumptions in the modelling. It is important to note that AIIB is an exception because it is still in growth mode and the overall shape of the bank is expected to change over time (AIIB, 2020). The AIIB position has been taken account of in the modelling process by assuming that it may ultimately converge to a similar risk profile and capital structure to other MDBs, while noting that the actual trajectory could evolve quite differently.

The key modelling assumptions are:

- **The relative mix of assets and liabilities for a particular MDB is stable**. In practice this means that the ratio of loans to investment

[2] IFC is included as a 'control' as it does not have callable capital.

portfolios is constant, and that the debt funding strategy is proportionate to the loan portfolio.

- **The geographic mix of the loan portfolio is stable over time**. This does not entail that the portfolio riskiness is constant as the modelling process varies the credit quality of individual countries.[3]
- **PCT has a fixed value**. In the modelling, PCT is reflected by a constant loss given default (LGD) of 10% to be consistent with other analyses (Lütkebohmert, Sester, & Shen, 2023; Risk Control, 2022). As the modelling is for a reverse stress test, and to facilitate interpretation of the results, it was decided that there is limited additional value in having variable LGDs. The LGD for non-sovereign lending is fixed at 45% on the assumption that there is no PCT benefit (IMF, 2022).
- **MDBs control risk and lending appetite with reference to an internal capital adequacy framework**. This is modelled by creating a risk-weighted asset measure for the loan portfolio. While it is noted that the IBRD reports a non-risk-weighted equity/loans ratio, a proxy risk-weighted asset measure is nevertheless calculated for the IBRD to create comparability between the MDBs.
- **Future General Capital Increases (GCIs) are excluded**. In order to preserve comparability between MDBs, there are no future GCIs in the model. For example, the figures for IBRD will not include the incremental increases that it expects to receive, and the EBRD calculation does not include the capital increase it received at the end of 2023.

The design of the model for the stress tests is an innovation because it is dynamic. Taking a dynamic approach combines the disciplines of risk management and business planning. The model takes a starting set of MDB financial accounts and projects them forward over a 10-year period while subjecting the MDB to shocks in its loan portfolio. Lending allocations for each year are based on the financial performance and credit defaults that have taken place in the previous year. The simulations output captures a significant amount of data for every year and every scenario: an income statement, a balance sheet, a credit migration history for each borrower, capital adequacy metrics.

## Key modelling principles

The goal of the modelling is **comparability between MDBs**. Although the calibration of the financial performance of each MDB is based on its own public accounts, the credit scenarios for sovereign credit migration are consistent. That is to say, if country X is downgraded in year Y in a

[3] Noting that AIIB would expect to increase diversification over time as it fully deploys its lending capability.

scenario, every bank with that country in its portfolio is affected in proportion to its lending exposure.

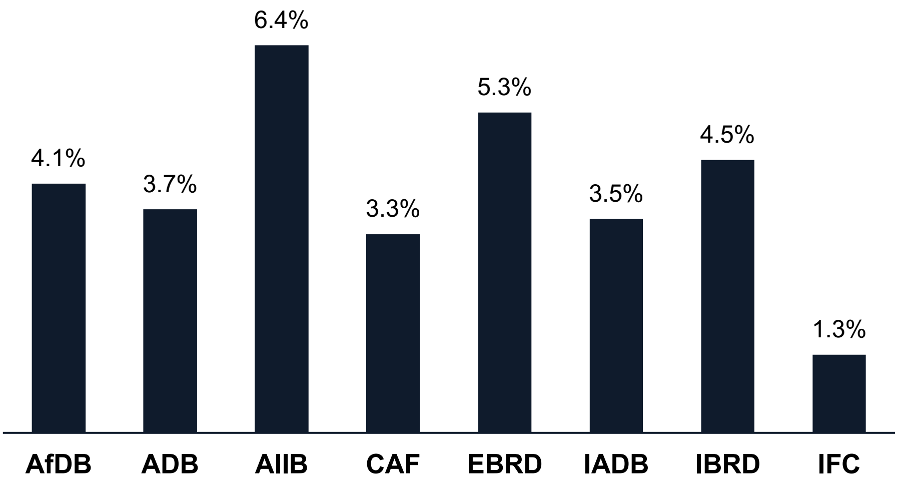
The dynamic approach allows the inclusion (or exclusion) of **management actions** to control the financial condition of the bank. This is extremely important as it can demonstrate the apparent conflict between a policy-based growth strategy and the need for prudential risk management.

The modelling choices lead to a fundamental constraint on growth for an MDB. This will be described as the 'sustainable growth rate' (SGR) of an MDB. The formula for the SGR measure is derived in Appendix 1. It estimates how quickly a bank can grow organically by building capital and reserves when targeting a capital ratio or balance sheet structure.

In the absence of any GCIs, growth is limited. Figure 1 shows the estimate for each MDB based on recent financial accounts using the baseline assumptions for PCT. The SGR for AIIB is somewhat artificial because the MDB is not in steady state yet. If it were to have a capital structure similar to other MDBs, the number would be closer to 4.5%. It should be noted that, if the shareholders of an MDB mandated a significant expansion in lending, it is reasonable for an MDB to expect a GCI to be implemented.

The SGRs in Figure 1 are a useful predictor for the output from the model. If MDBs are forced to grow more quickly without an increase in capital resources, they are likely to show signs of stress.

**Figure 1 MDB Sustainable Growth Rates**




Source: Author's analysis.

## Financial data

The baseline data for the analysis is drawn from the published annual reports for each MDB, supplemented with data from Bloomberg for debt profiles and funding spreads, and from FitchConnect for country ratings and for checking consistency between MDB financial statements.

**Table 2 Reference data**

| MDB | Annual Reports |
|---|---|
| African Development Bank | AfDB (2018-2022) |
| Asian Development Bank | ADB (2018-2022) |
| Asian Infrastructure Investment Bank | AIIB (2018-2022) |
| Corporación Andina de Fomento | CAF (2018-2022) |
| European Bank for Reconstruction and Development | EBRD (2018-2022) |
| Inter-American Development Bank | IADB (2018-2022) |
| International Bank for Reconstruction and Development | IBRD (2019-2023) |
| International Finance Corporation | IFC (2019-2023) |

The financial data is used ‘as is’ with the only adjustments being for derivative exposures where netting has not been applied in the accounts. In these cases, the derivative exposure on the balance sheet is netted off to the liability side of the balance sheet.

## Modelling constraints

Modelling by its nature requires a series of assumptions and simplifications in order to perform analysis. Monte Carlo models produce statistical output and cannot capture every possible outcome. Increased complexity of model inputs could reflect a broader range of outcomes, but at the cost of computational resources and a less specific attribution of risk.

Similarly, the analytical model developed for Section 4 requires simplification of an MDB’s operations to make the analysis tractable and provide a counterbalance to statistical approaches. The analysis is also estimated from publicly available data which could be enhanced by using MDBs’ internal data and resources.

The results presented in this paper are representations of the modelling choices and input assumptions.

# 3 MDB reverse stress tests

This section explains the findings of the reverse stress testing using the 10-year simulation model. The purpose is to determine the types of scenarios that would cause an MDB to become financially stressed and potentially fail. The mechanics of the model are explained in Appendix 1, and the credit simulation methodology in Appendix 2. As highlighted in the previous section, the model was designed to extract a rich data set for each of the scenarios.

## Base case scenarios

The Monte Carlo modelling is performed for each of the MDBs in Table 1 using a bottom-up approach of the country-level loan portfolio and testing for various default and loss scenarios in a similar way to Lütkebohmert et al. (2023), but with a focus on financial statements rather than regulatory measurement.

The model also assumes different fixed LGDs for sovereign (10%) and private sector lending (45%), as described in Section 2. The reason for including a low sovereign LGD of 10% in the model is to capture the effect of PCT. There is a high probability that an MDB will eventually be repaid the full nominal value of a non-accruing loan, but the MDB will experience costs from continuing to fund the lending position. Late payment by a borrower imposes interest rate costs on the MDB. The choice of 10% is based on analyses by other authors (Lütkebohmert et al., 2023; Risk Control, 2023). This approach means it is possible to model for the loss of PCT in extreme cases by adjusting the LGD to 45% for sovereign lending.

The first step was to perform a preliminary set of common scenarios across all eight MDBs. Table 3 shows the range of baseline models. Credit migration volatility is a measure of the adjustment made to the transition matrix (see Appendix 2). The Sovereign LGD reflects the low loss rates expected for MDBs only for sovereign lending. In all cases, the LGDs for private sector operations were set at 45%.

### Table 3 Scenario variations

| Name | Credit migration volatility | Sovereign LGD |
|---|---|---|
| 100% growth (**GR1**) | 100% | 10% |
| 200% growth (**GR2**) | 100% | 10% |
| PCT strong (**PS**) | 50% | 10% |
| PCT weak (**PW**) | 100% | 10% |
| No PCT (**NP**) | 100% | 45% |
| Volatile No PCT (**VNP**) | 200% | 45% |

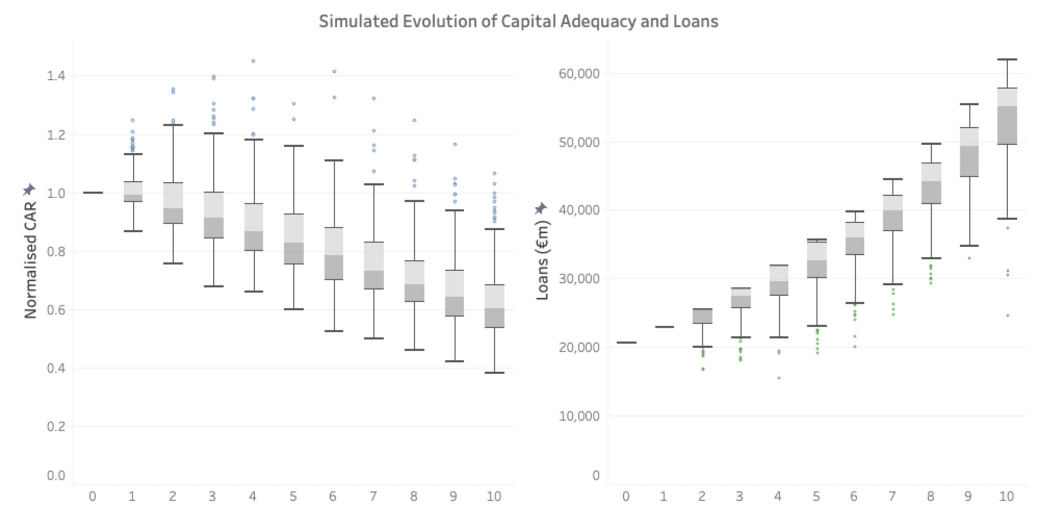
The two growth scenarios (GR1 and GR2) force the MDB to aim to increase its balance sheet by either 100% (doubling) or 200% (tripling). This growth objective is followed blindly in the model with no regard to capital adequacy management. The other four scenarios (PS, PW, NP, VNP) aim for 100% growth as in scenario GR1, but impose capital management on the MDB with a target capital ratio equal to the estimate from the last set of financial accounts available at the time of the analysis.

When the MDB is managing to a capital ratio in the model, the MDB is given the flexibility to reduce lending by a maximum of 5% in a given year to rebalance its finances in stress.

Box 2 illustrates how forcing growth onto an MDB causes the capital position to deteriorate. The graphs show the evolution of the capital adequacy ratio (left hand graph) and the loan book (right hand graph). The bank is essentially unable to grow at that rate. As this scenario allows for PCT the bank does not run into trouble. However, in practice this type of capital deterioration would run the risk of the MDB being downgraded and losing access to capital markets for bond issuance.

## Box 2 Case study: AfDB 200% balance sheet increase

This chart shows the evolution of the capital ratio of the AfDB compared to 2022 over a 10-year simulation, and the corresponding loan book growth if the bank had a strategy of increasing lending by 200% (tripling the balance sheet). PCT is allowed for in this scenario and the LGD is fixed at 10%. Without that assumption the bank would fail and a call on capital would definitely be made.




The low LGD from PCT also explains the scenarios where the capital position improves as the RWA calculation in the model uses a 45% LGD.

**NOTE**: The full set of similar charts for the scenarios is included as an Appendix to this report on the main ODI website.

Source: Author's analysis

The key message here is that, in the example in Box 2, although the model does not technically result in zero equity and a call on capital, the bank would be likely to suffer serious stress and might lose access to funding, which could be terminal.

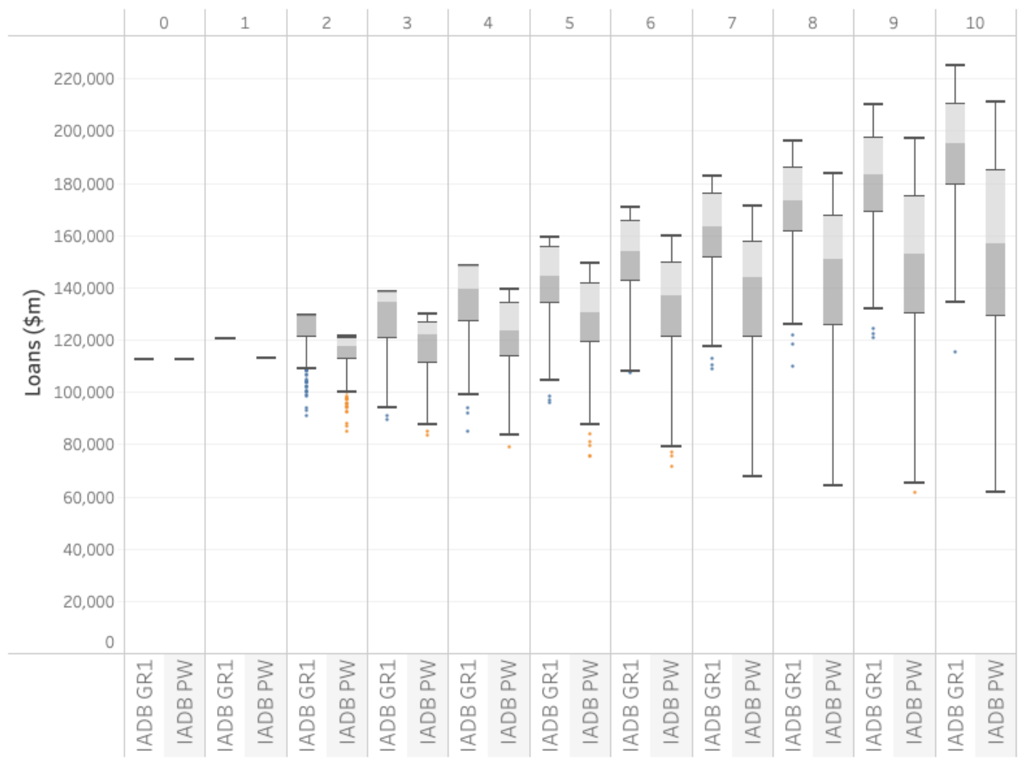
Perhaps this is no surprise – the Sustainable Growth Rates in Table 1 in the previous section predict that forced growth is not possible without accepting a weaker capital position.

Box 3 shows another example of the impact of management actions on the loan portfolio trajectory for IADB. This compares the GR1 scenario (loan growth 100%) to the PW scenario (weak PCT). The credit default rates are the same in both scenarios.

## Box 3 Case study: IADB comparative loan growth

This chart compares loan growth for scenarios GR1 and PW. The left-hand bar in each year shows the forced growth, and the right-hand bar shows the growth managed with the constraint of a capital adequacy framework.

The median growth rate achievable for the managed scenario (PW) is 3.4% per annum, compared to the theoretical SGR of 3.5%.




Source: Author's analysis

This example also highlights the policy dilemma that a shrinking loan book would not be in line with the objectives of the bank. While that possibility is allowed for in the model, it might be politically unacceptable.

Having established some evidence that there is a trade-off between risk and growth, the next step is to significantly increase the applied stress on the MDBs.

## Triggering stress through forced growth

The results above highlighted the conflict between growth objectives and prudential risk management. Indeed, many of the scenarios in which the MDB actively protects its capital base result in loan book shrinkage, which would likely be against the policy objectives of an MDB.

## Box 4 Probability of capital ratio falling to zero

*Variations by Sovereign LGD, Forced Growth Rate, Risk Tenor*
*Credit Scenario: 2 x Moody's average sovereign transition rates*

| | 10 yr Growth | Tenor | AfDB | ADB | AIIB | CAF | EBRD | IADB | IBRD | IFC |
|---|---|---|---|---|---|---|---|---|---|---|
| LGD 10% | 100% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 150% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 200% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 250% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| LGD 30% | 100% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 150% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 200% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 250% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| LGD 45% | 100% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 150% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | 5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 200% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | 5 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 |
| | 250% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | 5 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 |

Source: Author's analysis

As an extension of the base case analyses, the models were re-run using aggressive forced growth scenarios to identify where the stress might lie. Box 4 shows the results for the case where the capital resources of each bank are completely exhausted (capital ratio is zero) and callable capital would be required to pay off bondholders.

There are four growth scenarios which require the MDB to increase lending by 100%, 150%, 200% and 250%. The LGDs for sovereign risk are set at 10%, 30% and 45%.

The good news is that, in the presence of PCT, the probability of callable capital being needed is essentially zero over a long timeframe. It is only when the LGDs are increased that stress starts to appear in four banks after five years of such a stress scenario: AfDB, CAF, IADB and IBRD.

## Box 5 Probability of capital ratio falling by 50%

*Variations by Sovereign LGD, Forced Growth Rate, Risk Tenor*
*Credit Scenario: 2 x Moody's average sovereign transition rates*

| | 10 yr Growth | Tenor | AfDB | ADB | AIIB * | CAF | EBRD | IADB | IBRD | IFC |
|---|---|---|---|---|---|---|---|---|---|---|
| LGD 10% | 100% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 150% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | 200% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | - |
| | 250% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.8 | - |
| LGD 30% | 100% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | - |
| | 150% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | - |
| | | 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | - |
| | 200% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | - |
| | | 5 | 0.4 | 0.0 | 0.4 | 0.0 | 0.0 | 0.4 | 12.4 | - |
| | 250% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | - |
| | | 5 | 2.4 | 0.0 | 1.2 | 0.8 | 0.0 | 1.6 | 20.0 | - |
| LGD 45% | 100% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.8 | 0.0 |
| | | 5 | 1.2 | 0.0 | 0.0 | 0.4 | 0.0 | 1.6 | 12.0 | 0.0 |
| | 150% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 1.2 | 0.0 |
| | | 5 | 3.6 | 0.0 | 0.0 | 1.2 | 0.0 | 3.2 | 20.4 | 0.0 |
| | 200% | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 2.0 | 0.0 |
| | | 5 | 7.6 | 0.0 | 0.8 | 4.8 | 0.0 | 7.2 | 32.4 | 1.2 |
| | 250% | 3 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 3.2 | 0.0 |
| | | 5 | 12.0 | 0.0 | 1.6 | 6.8 | 0.0 | 10.0 | 44.4 | 2.8 |

** AIIB is a special case as it is so well capitalised and the modelling process forces extra balance sheet expansion relative to the other MDBs. Although some probabilities in the table are non-zero there is a very high degree of uncertainty around them.*

Source: Author's analysis

The problem, as discussed above, is that stress is likely to appear long before zero capital is reached. It is subjective where that point might be, so for the second analysis (Box 5) this threshold is set at 50%, meaning that when an MDB loses half of its capital it would become significantly stressed. AIIB remains an outlier for this type of test because it is still so well-capitalised compared to its existing portfolio, so while the results are shown for completeness they are greyed out to indicate that they are not a meaningful stress indicator.

Box 5 can be considered an indicator of which MDBs are taking the most risk today. The banks taking the most risk by this measure in order is as follows: IBRD, AfDB, IADB and CAF. The reason that IFC and EBRD do not have the same pressure is that they have significant private sector operations and do not have the same apparent reliance on PCT. ADB seems to be less leveraged than the other MDBs.

## How and when would a call on capital manifest itself?

A central purpose of the modelling is to show how an MDB would arrive at a moment of stress, over what timeframe, and whether this would result in a call on capital.

As highlighted in a previous project paper on the legal underpinnings of callable capital (Humphrey, 2024), there are different scenarios in which a capital call might occur. First, for the EBRD and AIIB, it is when all possible capital resources are exhausted. For the other MDBs a call could come at a moment of significant financial stress in anticipation of funds being needed to repay bondholders. This may severely test the viability of the MDB, but it does not entail that the MDB becomes a ‘gone concern’.

It is useful to conceptualise the routes to a call on capital to appreciate the timespan over which it would play out. There are two credit crisis routes to a call, and one liquidity crisis route. All three would ultimately be in play during a real crisis, but it is worth considering them separately for the purpose of unpacking the sequence of events. Additional losses might occur from unforeseen operational events, although these events are unlikely to be the driving force of a crisis.

## Losses from non-accrual

A crisis would start with an increasing number of borrowers failing to pay loans and the loans being classified as non-accrual. MDBs already experience non-accrual and it can be absorbed into their business models when the rates of non-payment are modest. However, as the volume of loans falling into non-accrual increases, the net income of the MDB shrinks. Loan revenues decrease while funding costs remain stable. In order to erode capital and reserves, the MDB would have to incur outright losses for a very long time.

As a crude illustration based on the IBRD, if the reported interest income for June 2023 is halved (to reflect 50% of the loan book becoming non-accrual), the operating result would swing from a reported profit of $1,114 million to a loss of $3,692 million. This would make a reasonable dent in reported usable equity of $53,105 million, but it would take many years of this type of adverse scenario to drain capital resources.

## Credit defaults

A faster way to a crisis would be through the crystallisation of losses from defaults. If this is caused by a genuine bankruptcy or failure to pay by a borrower, the loan would be marked down to a lower value and the loss, or accounting provision, would have to be put through capital and reserves. In the model, the calculation reflects a loss of either 10% or 45% of loan value depending on whether PCT is being simulated or not. The new valuation should reflect expected losses and so would be more severe than accounting for non-accrual.

The data from the modelling in Boxes 4 & 5 illustrate the timescale over which this might become a problem for MDBs and the associated probability of it occurring. It shows that the probability of exhausting capital and reserves over a three- or five-year period is effectively zero for all MDBs. Even for the AfDB and IBRD in the most extreme cases, the probabilities of eroding the entire capital base are below 1% when the bank is forced to grow at unsustainable rates and when PCT is lost.

### Combined credit and liquidity crisis

The most likely scenario in which a call on capital would occur would be when a credit crisis leads to a liquidity crisis. The justification for the call in this instance would have to be that there is a realistic probability of needing the called capital to repay bondholders. The MDB would have incurred significant losses to erode its capital base to a point where the cost of funding rises, and the ability of the bank to refinance itself in the wholesale markets is compromised.

The point at which this might materialise is of course uncertain – for this modelling exercise the working assumption is 50% of the capital base. This reflects the types of magnitude of loss that would be considered a potential point of non-viability in the private sector.

Box 5 shows the probabilities of the higher threshold for stress. Clearly, the chance of losing 50% of capital is going to be higher. Nevertheless, for the case with the full benefit of PCT the probability of hitting this stress threshold is still effectively zero over a three- and five-year period. In the model, it is only when the MDB is subjected to unrealistic growth rates and removing PCT that there would be a crisis.

## What could the magnitude of a call on capital be?

The probability of a call on capital for any of the MDBs is extremely low over a reasonable time period of three to five years of sustained crisis and forced growth, even in the event of a combined credit and liquidity crisis. However, in the event that there were to be a call, how much would be required?

It is not possible to put a single number on this for any MDB as there are too many possible scenarios to consider. It is possible to perform a naïve calculation by considering a range of outcomes by applying different combinations of default rates and LGD to the loan portfolio and comparing it to the magnitude of existing capital and reserves.

Box 6 compares the MDBs for extreme losses relative to the current stock of callable capital. IFC is excluded as it has no callable capital. The scenarios are extreme beyond what has ever been experienced. In all cases, half of the loans are written off either at an LGD of 45% (similar to the private sector losses on sovereign debt) or 75% (an extreme value).

At the 45% LGD level, only ADB, IADB and IBRD would need to make a capital call, and then for less than 10% of the outstanding stock. At the very extreme 75% level, the range of calls on capital for six of the MDBs would be from 0% to 20.3% of the outstanding stock, the exception being CAF as it has a small base of callable capital to begin with. The figures take no account of shareholders’ future potential ability to fulfil the call on capital.

## Box 6 Estimating the magnitude of a capital call

| | AfDB | ADB | AIIB | CAF | EBRD | IADB | IBRD |
|---|---|---|---|---|---|---|---|
| Loans ($ bn) | 27.6 | 144.3 | 22.2 | 30.4 | 32.0 | 112.7 | 241.0 |
| Equity at CC (50% loss) | 6.6 | 27.1 | 10.2 | 6.9 | 10.4 | 18.9 | 30.2 |
| Current CC ($bn) | 185.0 | 134.5 | 77.6 | 3.0 | 25.3 | 164.9 | 296.0 |
| **Capital Call Magnitude** | | | | | | | |
| 50% default, LGD 45% | 0.0 | 5.4 | 0.0 | 0.0 | 0.0 | 6.4 | 24.0 |
| 50% default, LGD 75% | 3.8 | 27.0 | 0.0 | 4.5 | 1.6 | 23.3 | 60.2 |
| **Capital Call as a percentage of current CC** | | | | | | | |
| 50% default, LGD 45% | 0.0% | 4.0% | 0.0% | 0.0% | 0.0% | 3.9% | 8.1% |
| 50% default, LGD 75% | 2.0% | 20.1% | 0.0% | 100.0% | 6.4% | 14.1% | 20.3% |

Notes:
IBRD using Total Equity rather than ‘Usable Equity’ from the accounts
CAF CC includes callable and capital subscriptions receivable
AIIB/EBRD presented as call at 50% of equity for comparability with other MDBs

Source: Author’s analysis

## Summary of findings

The stress tests highlight the tension between growth aspirations and prudential risk management. The probability of callable capital being required when an MDB has exhausted all reserves seems vanishingly small. This should perhaps be expected given the prudent structure of MDB balance sheets and the value of PCT.

The timeline over which a call on capital might materialise despite the low probability is likely to be measured in years rather than months. A crisis scenario would play out over a period of time and the MDB and shareholders should have time to plan and react. If the worse were to happen and a call on capital is required, a simple calculation shows that the quantities are unlikely to be significant relative to the outstanding stock of callable capital.

Another critical component which merits further discussion, and that is addressed in a companion paper for this project, is the role of management actions and resilience planning (White & McHugh, 2024). It can clearly have an impact on reducing risk and ought to form part of an MDB’s capacity planning.

This leads to an absolutely fundamental question – how can risk appetite be formulated to achieve an increase in SGRs for all MDBs? How can lending be increased such that shareholders have transparency on the risk that is actually being taken? Clearly, not all MDBs have the same risk position.

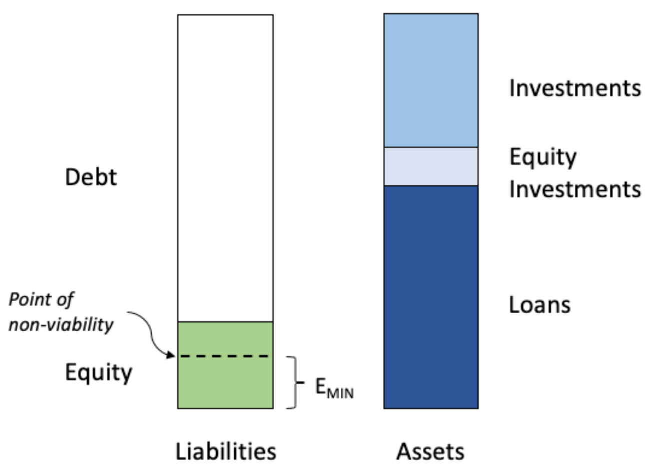
The next section proposes a risk management framework with theoretical underpinnings that could reframe the way MDB lending capacity is defined.

# 4 Shareholder risk appetite and MDB lending capacity

How can a shareholder know how much risk they are taking with callable capital, or indeed any degree of financial distress at an MDB? Determining the probability of financial stress for an MDB requires significant assumptions about default rates, the value of Preferred Creditor Status, and the moment at which an MDB becomes non-viable. Statistical simulation (using Monte Carlo) could be used, but there is an alternative approach that is less computationally demanding. The alternative approach relies on analysing the MDB at a macro level and considering the overall shape of the balance sheet, rather than focusing on a bottom-up credit simulation of borrowers.

Figure 2 shows a generic MDB balance sheet. The asset side of the balance sheet comprises a loan book, potentially some equity investments and a high-grade investment portfolio. The liabilities consist of senior debt, and equity in the form of paid-in capital and retained profits.

**Figure 2 Generic MDB balance sheet structure**




Source: Prepared by the author

When the equity of a bank is at zero it is technically bankrupt. However, as previously noted, banks will become significantly stressed long before this point is reached. In the absence of any clear signals from shareholders or management that there is a plan to rescue the situation, the capital markets might no longer be willing to fund the senior debt of the bank and it would enter a liquidity crisis. It is not possible to stipulate a precise level at which this stress threshold might be crossed as it depends on market events. However, the equity would still be positive and in Figure 2 it is represented by $E_{MIN}$.

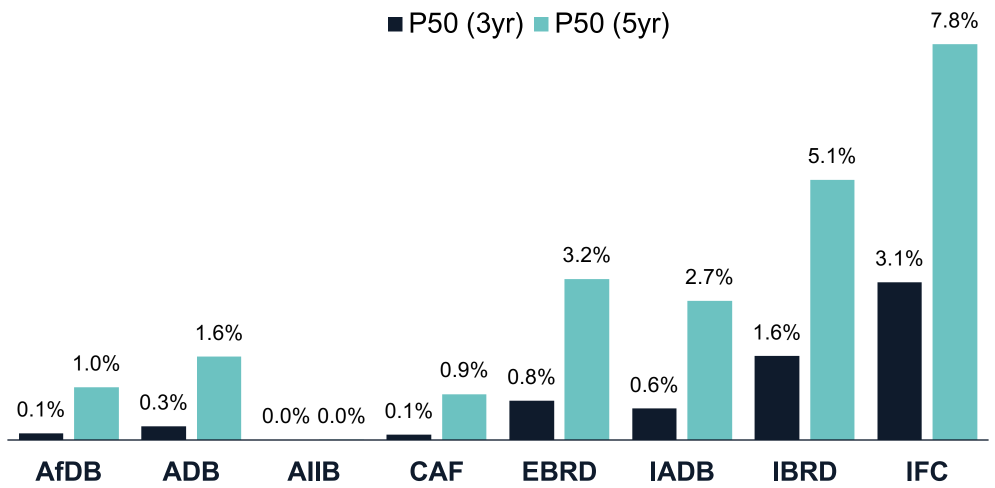
This approach relies on structural modelling, which treats the balance sheet of the MDB as a financial option (Chatterjee, 2015; Merton, 1974). Appendix 3 explains how the model is constructed and how the original Black-Scholes-Merton option framework for default risk needs to be adjusted to cater for MDBs and measuring the impact of loan growth.

For non-technical readers, the essential task is to estimate how volatile the value of the assets is, and then to work out the probability of losing enough equity to cause a problem (i.e. losing enough to hit the $E_{MIN}$ threshold). Calculating the volatility of the assets does require making some assumptions – the approach taken for this analysis is also explained in Appendix 3.

## Baseline stress levels

Using average financial data for the MDBs, and the balance sheet volatility assumptions from Appendix 3, it is possible to estimate the probability of stress of the eight MDBs at the 50% loss level (P50).[4] Figure 3 shows the results for a three- and five-year stress tenor.

**Figure 3 Probability of MDB stress (3 and 5 years)**




Source: Author’s analysis

The results are broadly consistent with the results of the Monte Carlo analysis in the previous section, although ADB and IADB are indicated as taking more risk, and AfDB a bit less. The other key difference is that this measure shows EBRD and IFC taking noticeably more risk. This is because this method is more market-based and has a specific input for the volatility of equity investments.

A critical input to the calculation is the anticipated growth rate of the MDB (based on the applicable SGR). These SGRs will necessarily differ by

[4] This will be referred to from hereon as the ‘P50’ level. P60 would imply a 60% loss of capital.

MDB due to different public/private sector lending models. However, do MDBs take the same risk after adjusting for SGR differences? This a very intriguing question because all the MDBs are so highly rated.

Our model shows that MDBs do not take the same risk after adjusting for business mix, and therefore would have a different growth rate. By changing the expected loan growth rate in the model, it is possible to recalculate the lending that might be achieved as a result.

## Recalibrating MDB lending for risk appetite

The figures below project lending capacity for the eight MDBs in billions of US dollars[5] over a three-year window from the latest financial accounts as detailed in Section 2. It is important to establish a base case because all scenarios need to be relative to where lending 'might' be in the future. Based on where lending is in the latest accounts, the overall increase could be in the region of $81.4 billion without any changes to risk mandates or leverage (Table 4). As previously noted, the figures for AIIB are affected by its high degree of capitalisation. The table is intended to show 'capacity' rather than what is operationally achievable over a three-year period.

**Table 4 Baseline lending change over 3 years ($bn)**

| USD bn | AfDB | ADB | AIIB | CAF | EBRD | IADB | IBRD | IFC | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Loans at t0 | 27.6 | 144.3 | 22.2 | 30.4 | 32.0 | 112.7 | 241.0 | 51.5 | 661.7 |
| Loans at t3 | 31.1 | 160.9 | 26.7 | 33.5 | 37.4 | 125.0 | 275.0 | 53.5 | 743.1 |
| | | | | | | | | | |
| Change | 3.5 | 16.5 | 4.5 | 3.1 | 5.3 | 12.3 | 34.0 | 2.0 | 81.4 |
| % Inc | 12.8% | 11.5% | 20.4% | 10.1% | 16.7% | 11.0% | 14.1% | 3.9% | 12.3% |

Source: Author's analysis

Using the probabilities from Figure 3, the first question to ask is what lending might look like if all MDBs adopted the same risk appetite as IBRD (i.e. all MDBs adopt an approximate 1.6% probability of P50 stress). The reason for choosing IBRD as the benchmark is that it is the largest sovereign lender in the group and is taking the most apparent risk on its balance sheet.

**Table 5 Potential lending uplift using 'IBRD risk' ($bn)**

| USD bn | AfDB | ADB | AIIB | CAF | EBRD | IADB | IBRD | IFC | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | 31.1 | 160.9 | 26.7 | 33.5 | 37.4 | 125.0 | 275.0 | 53.5 | 743.1 |
| 'IBRD risk' | 33.9 | 173.0 | 39.0 | 36.7 | 38.9 | 130.3 | 275.0 | 51.4 | 778.2 |
| | | | | | | | | | |
| Change | 2.8 | 12.2 | 12.3 | 3.2 | 1.5 | 5.3 | 0.0 | (2.1) | 35.1 |
| % Inc | 8.9% | 7.6% | 46.0% | 9.5% | 4.0% | 4.2% | 0.0% | -3.9% | 4.7% |

Source: Author's analysis

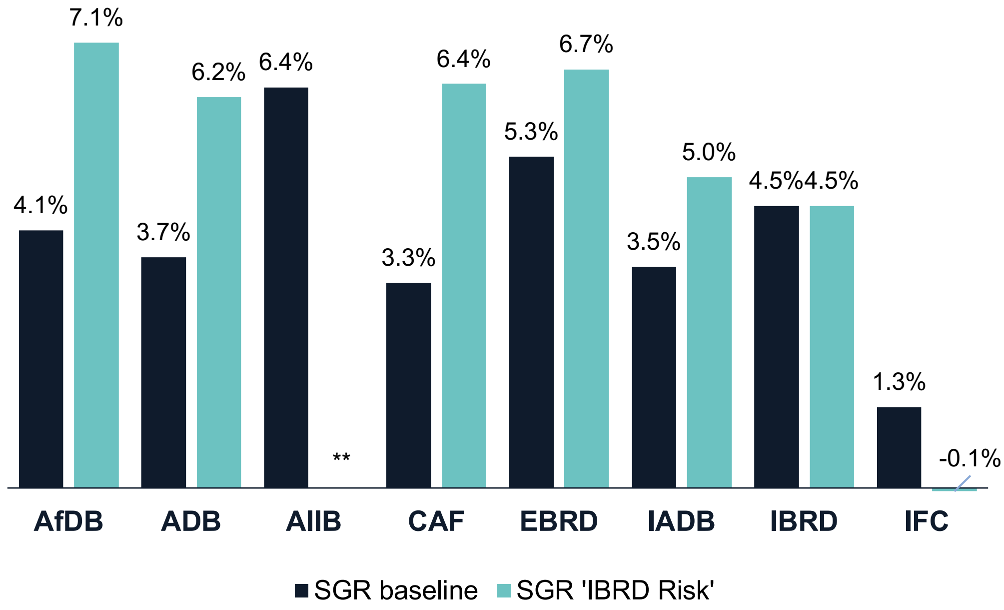
Table 5 shows the marginal increase in lending if all MDBs took the same apparent risk as IBRD. This shows a net potential increase of $35.1

[5] The exchange rates for AfDB (UA/USD) and EBRD (EUR/USD) are February 2024.

billion, or $37.2 billion excluding the reduction for IFC and with the same caveat for AIIB.

Another way to look at changing risk appetite is to consider the impact on growth rates that would be achievable. Figure 4 shows how the SGRs for the MDBs would change (relative to the original SGRs in Figure 1) if the MDBs adopted ‘IBRD risk’. The alternative SGR for AIIB is not shown (marked as **) because the bank is not in steady state – it is clear from the financial reports that it has a lot of growth capacity. However, for the other MDBs invested in sovereign lending, the change in potential growth rate can be material (e.g. in the case of CAF nearly doubling).

**Figure 4 The effect of risk appetite on potential sustainable growth rates**




Source: Author’s analysis

What if the shareholders and MDBs accepted even higher risk tolerances for a given level of borrower risk? This could be done in two different dimensions – either by changing the stress threshold, or by changing the risk probability of reaching this threshold. There are clearly many possible combinations, but to illustrate, the examples in Box 7 focus on two different thresholds ‘P50’ and ‘P60’ – that is to lose either 50% or 60% of capital – and to change the probability limit to either 2% or 4%. The measure of ‘value’ that is unlocked is again presented as a potential increase in lending capacity in billions of US dollars.

At this point it is worth returning to the original question of the probability of a capital call. If an MDB were to reach a stress level of losing 50–60% of its capital, concepts such as PCT would be sorely tested as would funding risk. This is where the existence of bank resilience plans and management actions become critical for controlling viability risk.

## Box 7 Lending capacity for different risk tolerances

The table shows the calculated loan book three years ahead relative to different combinations of risk threshold and the probability of reaching that threshold. The total potential changes for the different combinations are highlighted in dark shading for ease of reference.

In the strongest risk appetite example (P60, 4%) the potential lending uplift is $114.3 billion, an increase of 15.4% over the baseline case.

| USD bn | AfDB | ADB | AIIB | CAF | EBRD | IADB | IBRD | IFC | Total |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | 31.1 | 160.9 | 26.7 | 33.5 | 37.4 | 125.0 | 275.0 | 53.5 | 743.1 |
| Loans (P50) 2% | 34.2 | 174.3 | 39.4 | 36.9 | 39.3 | 131.5 | 277.3 | 51.9 | 784.9 |
| Loans (P50) 4% | 35.2 | 180.2 | 40.5 | 38.1 | 41.0 | 136.1 | 286.3 | 54.5 | 811.9 |
| Increase (P50) 2% | 3.0 | 13.4 | 12.6 | 3.5 | 1.9 | 6.5 | 2.3 | (1.6) | 41.7 |
| Increase (P50) 4% | 4.1 | 19.4 | 13.8 | 4.6 | 3.6 | 11.1 | 11.3 | 1.0 | 68.8 |
| Loans (P60) 2% | 36.1 | 184.8 | 45.5 | 39.2 | 41.6 | 138.6 | 286.9 | 55.4 | 828.2 |
| Loans (P60) 4% | 37.2 | 191.3 | 46.9 | 40.4 | 43.4 | 143.6 | 296.3 | 58.3 | 857.5 |
| Increase (P60) 2% | 4.9 | 24.0 | 18.7 | 5.7 | 4.3 | 13.6 | 11.9 | 1.9 | 85.1 |
| Increase (P60) 4% | 6.1 | 30.4 | 20.2 | 6.9 | 6.1 | 18.6 | 21.3 | 4.8 | 114.3 |

Source: Author’s analysis

## The impact of wholesale funding risk

Another potential consequence is the risk to the MDB wholesale funding model. Notwithstanding the liquidity management plans of MDBs, it is instructive to see what the effect of widening spreads would be on the projected lending uplift in Box 8.

## Box 8 The impact of funding spreads widening

The table recalculates the P50 lending uplift cases from Box 6 by imposing a wholesale funding spread increase on the MDBs. This compresses net lending margins depending on the proportion of equity to debt on the balance sheet.

The changes in the darker boxes are the quantity of potential lending relative to the comparable case with no funding adjustment (e.g. P50 4% with and without the funding adjustment).

| USD bn | AfDB | ADB | AIIB | CAF | EBRD | IADB | IBRD | IFC | Total | Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Baseline | 31.1 | 160.9 | 26.7 | 33.5 | 37.4 | 125.0 | 275.0 | 53.5 | 743.1 | |
| Loans (P50) 2% | 34.2 | 174.3 | 39.4 | 36.9 | 39.3 | 131.5 | 277.3 | 51.9 | 784.9 | |
| Loans (P50) 4% | 35.2 | 180.2 | 40.5 | 38.1 | 41.0 | 136.1 | 286.3 | 54.5 | 811.9 | |
| **Funding + 25 bps** | | | | | | | | | | |
| Baseline | 29.9 | 156.7 | 25.9 | 32.4 | 35.7 | 121.6 | 263.0 | 51.7 | 717.0 | (26.1) |
| Loans (P50) 2% | 32.1 | 167.0 | 37.2 | 35.1 | 36.4 | 125.8 | 258.4 | 49.1 | 741.0 | (43.8) |
| Loans (P50) 4% | 33.0 | 172.7 | 38.3 | 36.1 | 38.0 | 130.2 | 266.7 | 51.5 | 766.5 | (45.4) |

Source: Author’s analysis

The figures in Box 8 repeat the calculations for lending uplift for the P50 threshold and risk probabilities of 2% and 4%, and superimpose a funding increase of 25 basis points in wholesale borrowing. This is not intended as a stress test of funding, but rather to illustrate the relative negative impact on lending capacity.

The funding spread increase is converted to a margin compression figure on a net basis so that it enables comparability between institutions that are free to change lending margins and those that are constrained. An ability to adjust lending margins for funding risk is a significant risk mitigant.

Introducing funding as a third dimension does start to complicate the analysis, but it is a fair reflection of the complexity that MDBs face in designing a risk framework. An increase in funding does diminish potential lending capacity. Comparing the cases on a like-for-like basis, it is clear that the impact of funding is higher when balance sheets are more leveraged, which is a logical outcome. The change in lending capacity per basis point of funding spread adjustment is also reasonably linear for a given balance sheet structure.

Finally, and crucially, MDBs need to retain access to capital markets to ensure funding to fulfil their countercyclical lending role. Increased lending risk would need to be carefully balanced against maintaining the highest possible ratings and low and stable funding spreads.

## Summary

The theoretical approach to modelling MDB balance sheets requires some assumptions about the structure of their balance sheets. Using public financial information, and the concept of ‘operational convergence’ to justify using common parameters, it is possible to construct a 3-dimensional risk-based framework to estimate lending capacity (i.e. the dimensions being the capital threshold at which stress could occur, the probability of stress, and the impact of funding spreads).

This section highlights some indicative results to give an order of magnitude for what might be possible with different risk appetites from shareholders regarding the stress threshold, and the probability of stress. It later introduces a third dimension of the impact of funding stress which increases the richness of the output.

Any model will be constrained by how it is calibrated, although this approach has the value of enabling comparability across MDBs. The framework has the power to pose some useful questions about the magnitude of risk that an MDB and its shareholders are willing to take. Shareholders need to decide what is appropriate for them and express that in a form that MDBs can react to. It is hoped that the framework outlined in this section is a stimulus for that discussion.

# 5 Conclusions and policy considerations

The purpose of the modelling component of this MDB Challenge Fund project was to explore the probability of a capital call by subjecting the selected group of MDBs to reverse stress tests, essentially finding the scenarios in which failure would happen and callable capital would be required.

Using publicly available financial data has a disadvantage in that there will be more refined detailed information inside the MDBs. However, it comes with the significant advantage of being able to create a truly comparable analysis by ensuring that the stress tests use exactly the same scenarios for each MDB.

Another useful property of reverse stress tests is that there is no constraint on what is statistically possible. It is more of an exercise to imagine very bad situations. That being said, the scenarios have to be relatable and make some commercial sense even if they are extreme. In the case of MDBs, credit migration over long periods of time is a natural process to use. Similarly, it is important to include PCT and see what the impact is of removing it. While it would be possible to add more complexity to the modelling (e.g. adding stochastic LGDs), that can sometimes detract from the usefulness of the output by making it harder to interpret.

The headline conclusion of the stress testing using Monte Carlo is that a call on capital is a negligible risk to shareholders over a reasonable time frame (of say three to five years). This should come as no surprise given the well-capitalised structure of MDBs and their pursuit of the highest possible credit ratings.

In practice, a crisis would manifest itself long before capital were truly exhausted (e.g. capital ratio of zero). The most likely path would be a gradual deterioration in the loan book leading to non-accrual and defaults, a reduction in the capital base, potential for credit downgrades and pressure on funding spreads. At some point, the MDB business model would become non-viable and this theme is explored in other papers in the project. We do not know where this level would be, although it is highly likely to be a function of the belief in shareholder support and the chance of recapitalisation, which would avoid the risk (and need) for callable capital.

Exploring the probability of stress in the modelling starts to show cases which would be very bad for the MDBs. However, these cases are predicated on the pursuit of unfettered growth targets in volatile markets with no regard for capital management. This is clearly not realistic – risk management frameworks and management action plans would serve to mitigate these risks. In that sense, statistical analysis might overstate the probability of a crisis.

The exploration of extreme scenarios raises the question of shareholder risk appetite. How could this be articulated in a framework that would facilitate discussion between MDBs and shareholders in a consistent way? Section 4 proposes a modified BSM model which can be used to explore different outcomes dependent on risk appetite. The results suggest that a 3-dimensional risk framework could be a useful way to supplement existing risk reporting as an alternative measure of risk and reward, using lending capacity as the common risk measure (consistent with Recommendation 1A from the G20 CAF Panel (2022)). Ultimately, risk appetite can only be accepted by shareholders based on the risk reports that they are presented with.

Based on these findings and conclusions, the following policy options should be considered:

- Shareholder and MDBs should develop a richer risk appetite framework to explain the risks that are being taken, and the potential rewards (an uplift in lending).
- This paper proposes a 3-dimensional framework for consideration which would be defined with risk sensitivities using increased lending over a three-year period as a common metric. The risk metrics would include the capital threshold at which stress could occur, the probability of stress and the impact of funding spreads.
- In the absence of a regulator, shareholders should insist on a harmonised risk reporting framework to enable comparability between MDBs for their investments.
- Shareholders could potentially extend the risk framework to other non-regulated investments or exposures without callable capital, such as regional/national development banks.
- In addition to a richer risk framework, shareholders and MDBs need to revisit management action frameworks as an additional risk mitigant (explored in more detail in White and McHugh (2024)).

# References


ADB (2018-2022) *Annual Reports*. Retrieved from https://www.adb.org/documents/series/adb-annual-reports

AfDB (2018-2022) *Financial Reports*. Retrieved from https://www.afdb.org/en/documents-publications/annual-report

AIIB (2018-2022) *Financial Statements*. Retrieved from https://www.aiib.org/en/aboutaiib/financial-statements/index.html

AIIB (2020) *Corporate Strategy: Financing Infrastructure for Tomorrow*. Retrieved from https://www.aiib.org/en/policies-strategies/strategies/.content/index/_download/AIIB-Corporate-Strategy.pdf

BCBS (2018) *Stress testing principles*. Retrieved from https://www.bis.org/bcbs/publ/d450.pdf

CAF (2018-2022) *Financial Statements*. Retrieved from https://www.caf.com/en/investors/financial-statements/

Chatterjee, S. (2015) *Modelling Credit Risk*. Retrieved from Centre for Central Banking Studies, Bank of England: https://www.bankofengland.co.uk/-/media/boe/files/ccbs/resources/modelling-credit-risk

Cordella, T., and Powell, A. (2021) Preferred and Non-preferred Creditors. *Journal of International Economics, 132*. doi:10.1016/j.jinteco.2021.103491

EBRD (2018-2022) *Financial Reports*. Retrieved from https://www.ebrd.com/financial-report-2022

G20 CAF Panel (2022) *Boosting MDBs' Investing Capacity: An Independent Review of Multilateral Development Banks' Capital Adequacy Frameworks*. Retrieved from https://cdn.gihub.org/umbraco/media/5094/caf-review-report.pdf

Hull, J. C. (2018) *Options, Futures and Other Derivatives* (9th ed.). Global Edition: Pearson.

Humphrey, C. (2016) The Invisible Hand: Financial Pressures and Organisational Convergence in Multilateral Development Banks. *Journal of Development Studies, 52*(1), 92-112. doi:10.1080/00220388.2015.1075978

Humphrey, C. (2024) *The legal underpinnings of MDB callable capital: implications and policy options*. Retrieved from ODI: https://odi.org/en/publications/the-legal-underpinnings-of-mdb-callable-capital-implications-and-policy-options/

IADB (2018-2022) *Financial Statements*. Retrieved from https://publications.iadb.org/en/publications?keys=financial+statements

IBRD (2019-2023) *Management's Discussion and Analysis and Financial Statements*. Retrieved from https://financesapp.worldbank.org/summaryinfo/financialresults/

IFC (2019-2023) *Management's Discussion and Analysis and Consolidated Financial Statements*. Retrieved from https://www.ifc.org/en/about/investor-relations/financial-statements

IMF (2022) *Sovereign Debt*. Retrieved from https://www.imf.org/en/Publications/WP/Issues/2022/06/17/Sovereign-Debt-519809

Lütkebohmert, E., Sester, J., and Shen, H. (2023) *On the Relevance and Appropriateness of Name Concentration Risk Adjustments for Portfolios of Multilateral Development Banks*. Retrieved from SSRN: https://dx.doi.org/10.2139/ssrn.4642039

Merton, R. C. (1974) On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *Papers and Proceedings of the Thirty-Second Annual Meeting of the American Finance Association, 29*(2), 449-470.

Moody's (2023) *Sovereign default and recovery rates, 1983-2022*. Retrieved from https://www.moodys.com/research/Sovereigns-Global-Sovereign-default-and-recovery-rates-1983-2022-Sector-In-Depth--PBC_1358913

Risk Control (2022) *MDB Sovereign Loan Credit Performance and PCT: Public Data Analysis*. Retrieved from https://www.riskcontrollimited.com/insights/mdb-sovereign-loan-credit-performance-and-pct/

Risk Control (2023) *Ratings and Capital Constraints on IBRD and IDA*. Retrieved from https://www.riskcontrollimited.com/wp-content/uploads/2023/10/Ratings-and-Capital-Constraints-on-IBRD-and-IDA-23-57a-1-9-23-v70.pdf

S&P Global (2021) Reverse Stress Testing: A critical assessment tool for risk managers and regulators. Retrieved from https://www.spglobal.com/marketintelligence/en/mi/research-analysis/reverse-stress-testing-assessment-tool-risk-managers-regulators.html

White, E. and McHugh, C. A. (2024) *Enhancing MDB resilience increases lending capacity: callable capital, recovery planning and improving loss absorbing capacity*. Retrieved from ODI: https://odi.org/en/publications/xxxxxxxxxxx

World Bank (2024) IFC Investment Services Projects. Retrieved from https://finances.worldbank.org/Projects/IFC-Investment-Services-Projects/efin-cagm/about_data

# Appendix 1 Model mechanics

This section explains the mechanics underlying the model used for the Monte Carlo analysis in Section 3, and some of the results can also be used in Section 4 to build the theoretical, top-down model.

The model is designed to represent an ongoing annual lending strategy for a development bank. A core assumption is that the bank targets a specific lending ratio 'κ' which could be either an accounting-based Equity/Loans ratio (as in the case of IBRD), or more generally a capital ratio that reflects Basel-aligned risk-weighted assets (i.e. Equity/RWAs).

In either case, where the bank is targeting a Basel capital ratio or an E/L, the expected average credit risk for non-defaulting loans in the portfolio is assumed to be constant over time even though the actual average credit risk in the Monte Carlo model is allowed to migrate. This has the effect of fixing the expected Loans/RWA ratio for performing assets (and therefore κ) as the probability of default (PD) is constant.

The Basel regulatory formula for RWAs shows that, with a fixed PD, the resulting RWAs are linear with the expected loss given default (LGD).

## Model definition: loan growth and equity

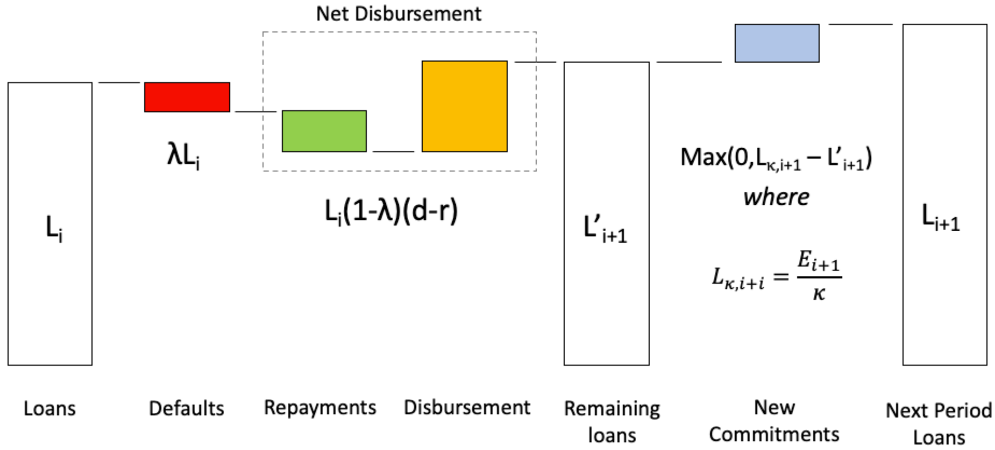
The mechanics of the model are shown in Figure 5 and Figure 6 below. The bank starts a period at time 'i' with a loan book with notional $L_i$ and equity of $E_i$ in the ratio $\kappa$.

$$\kappa = \frac{E_i}{L_i} \qquad \ldots(1)$$

In Figure 5 during the period 'i', the loan book experiences defaults on a fraction of the loan book (λ). A fraction of performing loans (r) are repaid, and additional disbursements are made that have previously been committed to (d). At the end of the period, the loan book has a net notional of $L'_{i+1}$.

The bank then extends new loans such that it achieves its target lending ratio $\kappa$ and a loan notional for the next period of $L_{i+1}$. However, if the available equity $E_{i+1}$ is insufficient to support the existing loan book then new incremental lending can be restricted without changing the target lending ratio $\kappa$. A further increase in new loans to $L_{i+1}$ depends upon whether the target loan notional based on the target loan ratio ($L_{\kappa,i+1}$) is higher or lower than the remaining loans. An alternative model variation can switch this off and force growth to the loan book, overriding the optionality inherent in the model.

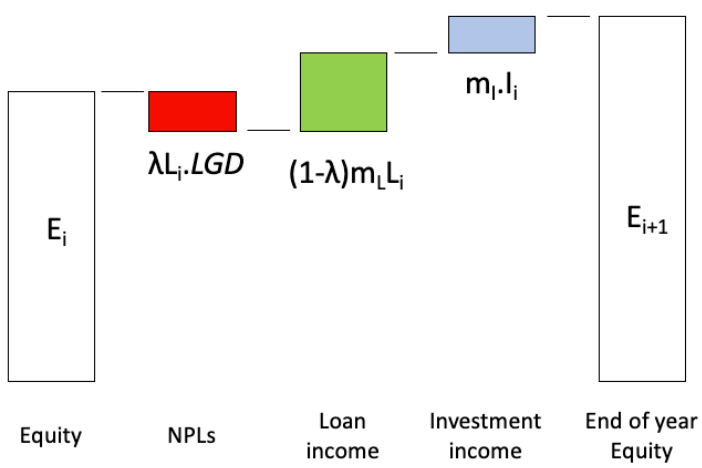
**Figure 5 Changes in loans over a single period**




Source: Prepared by the author

Figure 6 presents the change in equity during the period 'i' based on what happens to the loan book. The bank starts the period with equity $E_i$. The defaulting loans are written off with a loss given default (LGD) which is a proxy for expected losses that might be incurred either from an asset sale or interest losses on delayed repayments. The bank receives a net interest margin '$m_L$' on the performing loans in the portfolio, and a net margin '$m_I$' on the investment portfolio, leaving the bank with equity $E_{i+1}$.

**Figure 6 Changes in equity over a single period**




Source: Prepared by the author

The changes in equity in period *i* are shown in Equation 2.

$$E_{i+1} = E_i - \lambda.L_i.LGD + (1-\lambda).m_L.L_i + m_I.I_i \qquad \text{…(2)}$$

Assuming that the ratio of loans to total assets ($w_L$) is constant (i.e. the balance sheet structure is stable over time), and using the relationship from Equation 1, this gives

$$E_{i+1} = L_i\left(\kappa - \lambda.LGD + (1-\lambda).m_L + \frac{(1-w_L)}{w_L}.m_I\right) \qquad \text{…(3)}$$

$$L_{i+1} = L_i\frac{\left(\kappa - \lambda.LGD + (1-\lambda).m_L + \frac{(1-w_L)}{w_L}.m_I\right)}{\kappa} \qquad \text{…(4)}$$

Substituting for $E_i$ using Equation 1 gives the future equity in terms of the initial loan portfolio (Equation 3), and dividing by κ gives the target loan notional based on the available equity at the end of the period (Equation 4) assuming that capital is being managed to a particular capital ratio.

## Calculating the sustainable growth rate of the MDB

The modelling process needs to assume that there is an annual capital cycle, although it is clear that MDB lending and capital management would be more active and frequent in practice.

Equation 4 can be rearranged to show the sustainable growth rate (SGR) of the MDB loan book 'g' in Equation 5. This should reflect a steady state growth, with a stable capital ratio, based on a set of LGD and default assumptions. Any forced growth of the loan book above this level is essentially pushing the MDB into a potentially unstable capital position over time. This result will be used for the theoretical modelling in Section 4.

$$g = \frac{L_{i+1}}{L_i} - 1 = \frac{(1-\lambda).m_L + \frac{(1-w_L)}{w_L}.m_I - \lambda.LGD}{\kappa} \qquad \text{…(5)}$$

# Appendix 2 Monte Carlo parameters

In order to provide comparability across the eight MDBs in the analysis, the modelling needed to be done at a 'global' level to generate common scenarios for each country. The approach entailed modelling the credit migration of the entire universe of MDB borrowers, and then separating out the specific groups of countries that are relevant to each of the MDBs into sub-scenarios.

## Credit ratings

There were 136 separate sovereign borrowers identified across the MDBs using the annual reports, or in the case of IFC cross-referenced against the list of reported investments (World Bank, 2024). Of the list of 136 borrowers, 113 were formally rated by one of S&P, Moody's or Fitch as of January 2024. Ratings for the remaining 23 were estimated using a combination of the World Bank income group classification and region. These unrated countries are generally smaller borrowers and so any mis-estimation of ratings would not be significant for the analysis.

The baseline transition matrix for sovereign credit transition was taken from Moody's Investors Service and normalised to 100%, as shown in Figure 7 (Moody's, 2023). Variations in the matrix for different scenarios to account for PCT and stress entailed increasing or decreasing the transition probabilities and adjusting the 'no transition' probability.

**Figure 7 Normalised base case credit transition matrix**

| From/to | AAA | AA | A | BBB | BB | B | CCC/C |
|---|---|---|---|---|---|---|---|
| AAA | 97.08% | 2.81% | 0.03% | 0.08% | 0.00% | 0.00% | 0.00% |
| AA | 2.64% | 94.20% | 2.47% | 0.60% | 0.09% | 0.00% | 0.00% |
| A | 0.00% | 3.46% | 92.34% | 3.21% | 0.94% | 0.05% | 0.00% |
| BBB | 0.00% | 0.00% | 5.24% | 89.27% | 4.93% | 0.37% | 0.03% |
| BB | 0.00% | 0.00% | 0.00% | 6.71% | 86.09% | 6.50% | 0.28% |
| B | 0.00% | 0.00% | 0.00% | 0.00% | 4.05% | 88.52% | 4.99% |
| CCC/C | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 12.77% | 74.62% |

Source: Adapted from Moody's (2023)

## Country credit correlations

The approach for country correlations required the key country risks across the MDBs to be individually prioritised. Taking the top 10 country borrowers for each MDB (15 in the case of IBRD) and collapsing the list gave a unique list of 41 key borrowers, of which 38 had sufficient data using Bloomberg to perform correlation analysis (see Table 6 for country list).

The correlation analysis used the natural logarithms of the returns on spreads to benchmark hard currency government curves over a three-year period from January 2021, and also a rolling one-year curve to establish a minimum, maximum and median correlation. This was repeated using z-spread curves and the results were similar (Pearson test showing 92.1% similarity). The median correlations were used for scenario generation on a regional basis.

The correlation grid for the 38 primary borrowers was converted into a triangular matrix using a Choleksy decomposition and combined with the transition matrix to produce a time series of credit transition for each country as a Markov chain. Other borrowers are assigned a vector based on geography and rating to align them to one of the primary 38 borrowers and may be upgraded or downgrade accordingly. For modelling, a country that defaulted to 'D' was deemed permanent and did not recover. This would potentially bias the results towards a more pessimistic outcome. However, exposures to the lowest-rate countries tended to be smaller so the effect is mitigated.

**Table 6 Combined list of key borrowers**

The key list of 41 borrowers of which 38 had sufficient data for correlation analysis using Bloomberg.

| Country | Area |
| --- | --- |
| China | East Asia & Pacific |
| Indonesia | East Asia & Pacific |
| Philippines | East Asia & Pacific |
| Vietnam † | East Asia & Pacific |
| Georgia | Europe & Central Asia |
| Greece | Europe & Central Asia |
| Kazakhstan | Europe & Central Asia |
| Poland | Europe & Central Asia |
| Romania | Europe & Central Asia |
| Serbia | Europe & Central Asia |
| Türkiye | Europe & Central Asia |
| Ukraine | Europe & Central Asia |
| Uzbekistan | Europe & Central Asia |
| Argentina | Latin America & Caribbean |
| Bolivia | Latin America & Caribbean |
| Brazil | Latin America & Caribbean |

| | |
|---|---|
| Colombia | Latin America & Caribbean |
| Dominican Republic | Latin America & Caribbean |
| Ecuador | Latin America & Caribbean |
| Mexico | Latin America & Caribbean |
| Panama | Latin America & Caribbean |
| Paraguay | Latin America & Caribbean |
| Peru | Latin America & Caribbean |
| Trinidad and Tobago | Latin America & Caribbean |
| Uruguay | Latin America & Caribbean |
| Venezuela | Latin America & Caribbean |
| Egypt | Middle East & North Africa |
| Morocco | Middle East & North Africa |
| Tunisia | Middle East & North Africa |
| Bangladesh † | South Asia |
| India | South Asia |
| Nepal † | South Asia |
| Pakistan | South Asia |
| Sri Lanka | South Asia |
| Angola | Sub-Saharan Africa |
| Cameroon | Sub-Saharan Africa |
| Côte d’Ivoire | Sub-Saharan Africa |
| Kenya | Sub-Saharan Africa |
| Nigeria | Sub-Saharan Africa |
| Senegal | Sub-Saharan Africa |
| South Africa | Sub-Saharan Africa |

† Insufficient data for correlation analysis

# Appendix 3 Modified BSM model

## Estimating the probability of MDB stress

It is possible to use a structural model following Black-Scholes-Merton to estimate the probability of a capital call (Chatterjee, 2015). The typical approach models the possible default of an entity by estimating the point at which equity goes to zero. However, as explained above, the point of non-viability for an MDB would be at a significantly higher level of equity ($E_{MIN}$).

A complication with applying this model to an MDB is that the balance sheet will grow over time in line with increases in capital in and this would not be captured by using the risk-free rate of interest as the forward. Instead, the forward value of the balance sheet is projected which removes the need to consider interest rates in the standard formula.

Using the Merton approach, we can therefore approximate the following:

$$Stress\ probability = N(-\mathrm{d}_2) \qquad \ldots(6)$$

Where,

$$\mathrm{d}_2 = \frac{\ln(F_t/K_t) - \sigma^2 \mathrm{t}/2}{\sigma\sqrt{\mathrm{t}}} \qquad \ldots(7)$$

And,

- ‘N’ is the cumulative normal distribution function
- ‘$F_t$’ is the forward potential value of the balance sheet
- ‘t’ is the maturity of the period over which the probability is being assessed
- ‘$K_t$’ is the value of the balance sheet at which the MDB becomes unviable ($E_{MIN}$ is reached) at time ‘t’
- ‘σ’ is the volatility of the MDB balance sheet

There are complications with setting the parameters for the model in the case of MDBs. First, there is no quoted equity price to measure the volatility of equity. This means that the volatility of the total assets on the balance sheet needs to be estimated. Second, calculating the actual forward value of the balance sheet entails calculating a growth parameter as assets will grow in proportion to the increase in equity, but with a lag as the funds are deployed.

## Setting parameters for the model

This section describes the process for estimating the balance sheet volatility (σ) and the forward value of the MDB balance sheet (F) as input parameters to the model.

### Balance sheet volatility

The overall volatility of the total assets (σ) of the balance sheet is given by:

$$\sigma^2 = \sum_{\mathrm{i,j}=1}^{\mathrm{N}} \mathrm{w_i w_j} \rho_{\mathrm{ij}} \sigma_{\mathrm{i}} \sigma_{\mathrm{j}} \qquad \ldots(8)$$

Where,
'σ' is the volatility of the MDB balance sheet
'$w_{\mathrm{i}}$' and '$w_{\mathrm{j}}$' are the percentage weights of assets i and j
'$\sigma_{\mathrm{i}}$' and '$\sigma_{\mathrm{j}}$' are the volatilities of assets i and j
'$\rho_{\mathrm{ij}}$' is the correlation between assets i and j
'N' is the number of different asset types

As MDB balance sheets have a fairly simple structure of loans, investments and (in some cases) equity investments, this essentially becomes either a 2-factor or 3-factor problem with the individual volatilities and correlations to be estimated. Other balance sheet assets are not significant in comparison to the main asset classes, although they have been included using a correlation of zero and a fixed income level of volatility (5%).

The weights wi and wj can be observed directly from the financial accounts. The volatility of the investment portfolio is not explicit in the financial accounts, although from MDB annual reports showing Value at Risk (VaR), the investment portfolios appear to be high grade credit bonds that are asset-swapped to minimise interest rate and foreign exchange risk. The investment portfolio would therefore be left with credit spread volatility to the maturity of the assets (with the interest rate volatility having been largely hedged away).

### Investment portfolio volatility

With the principal exposure in the investment portfolio appearing to come from credit spreads, the volatility of the investment portfolio could be estimated from credit indices such as iTraxx Main and CDX IG. The annualised normal volatility of the CDS index spreads from Bloomberg in the last three years is in the region of 35–45%. Translating that into a volatility for the loan book would require knowledge of the credit sensitivity of the investment portfolio to a basis point change in credit spreads ('cs01'), and some insight into the credit profile of the bonds. However, for the purposes of the modelling, the volatility has been set at 5%.

Similarly, the correlation ($\rho_A$) between the loan portfolio and the investment portfolio could be estimated using the log correlation between iTraxx Main and Sov indices, although the quality of the sovereign data is not very consistent, or a good match for the profile of the borrowers in the loan book. As a substitute, the correlation was fixed at 80% (loan book to investment portfolio) by looking at the correlations between iTraxx & CDX for high- and low-grade borrowers. Using data from Bloomberg for the last three years in Table 7 on the principal corporate indices, the correlations are relatively high even when comparing cross border indices. Using 80% seemed like a fair reflection of the risk.

**Table 7 Correlations between principal corporate credit indices**

| | ITRX XOVER CDSI GEN 5Y | ITRX EUR CDSI GEN 5Y | CDX IG CDSI GEN 5Y | CDX HY CDSI GEN 5Y |
|---|---|---|---|---|
| ITRX XOVER CDSI GEN 5Y | 1.00 | 0.97 | 0.73 | 0.68 |
| ITRX EUR CDSI GEN 5Y | 0.97 | 1.00 | 0.73 | 0.66 |
| CDX IG CDSI GEN 5Y | 0.73 | 0.73 | 1.00 | 0.00 |
| CDX HY CDSI GEN 5Y | 0.68 | 0.66 | 0.90 | 1.00 |

## Loan portfolio volatility

Estimating the volatility of the loan portfolio for an MDB is complicated by the different business models (sovereign/private mix) and geographic lending patterns. A way to parameterise the model is to use the Vasicek formula (Hull, 2018, p. 587), which underlies the Basel III capital adequacy framework. This has the advantage of being able to specify the combination of probability of default (PD) and loss given default (LGD) for the portfolio and can be adjusted for stress (high correlation) or for PCT (lower PD/LGD combinations). The Vasicek formula (Equation 9) gives the Credit VaR (value at risk) of the loan portfolio over a one-year period.

$$V(X) = N\left(\frac{N^{-1}[\lambda] + \sqrt{\rho_L}N^{-1}[X]}{\sqrt{1-\rho_L}}\right) \quad \ldots(9)$$

Where,

- 'N' and 'N-1' are the normal and inverse normal distributions respectively
- '$\lambda$' is the average probability of default over 1 year adjusted for the MDB's sovereign/private sector risk profile

- '$\rho_L$' is the Gaussian copula for the portfolio which assumes a single correlation between all exposures (fixed at 30% for this analysis)
- 'X' is threshold to which Credit VaR is being measured over 1 year (e.g., 0.9999)

The credit VaR figure V(X) is further multiplied by the LGD to calculate the expected credit VaR. This also presents issues as the preferred method for accounting for MDB sovereign lending is to calculate interest on non-accruing loans. However, recent work on estimating LGD equivalence for PCT suggests that 10% might be a fair, but conservative, figure for sovereign lending (Lütkebohmert et al., 2023; Risk Control, 2022). The private sector LGD is fixed at 45% and a blended LGD is used for each MDB to reflect the mix of its business.

Equity volatility is difficult to estimate and not material for most of the MDBs in the group. However, it was included assuming a volatility of 20%. The correlation grid for the volatility calculation in Equation 8 is shown in Table 8.

**Table 8 Correlations for volatility matrix**

| | Loans | Inv | Equity | Other |
|---|---|---|---|---|
| Loans | 1.0 | 0.8 | 0.5 | 0.0 |
| Inv | 0.8 | 1.0 | 0.5 | 0.0 |
| Equity | 0.5 | 0.5 | 1.0 | 0.0 |
| Other | 0.0 | 0.0 | 0.0 | 1.0 |

## Setting the effective forward rate and option strike

The Sustainable Growth Rate (SGR) is used as defined in Appendix 1, Equation 6. This is repeated below (Equation 10) for reference in this Appendix. The construction of the model allows for a one-year time lag for lending so that expected year-end lending ($L_{i+1}$) is set at the start of a year based on the available equity ($E_i$). The other variation is that the actual growth rate can be varied by $\delta g$ relative to the sustainable growth rate '$g$' (Equation 11).

$$g = \frac{(1-\lambda).m_L + \frac{(1-w_L)}{w_L}.m_I - \lambda.LGD}{\kappa} \quad \text{...(10)}$$

$$g' = g + \delta g \quad \text{...(11)}$$

Where

- '$\delta g$' is a marginal growth parameter that is adjusted to calibrate the probability of stress as defined in Equation 7 to a defined number

Further, to complete the required inputs for the BSM model in Equation 7:

$$F_t = A_0(1 + g)^t \qquad \text{…(12)}$$

$$A_t = A_0(1 + g')^{t-1} \qquad \text{…(13)}$$

$$E_t = E_0(1 + g')^t \qquad \text{…(14)}$$

$$K_t = A_t - \gamma . E_t \qquad \text{…(15)}$$

Where,
'$\gamma$' is the percentage of capital ($E_t$) lost that would trigger stress
'$A_0$' and '$A_t$' are the total MDB assets at the start, and after t years
'$E_0$' and '$E_t$' is the value of equity at the start, and after t years
'$F_t$' is the potential future value of the balance sheet