

# Banking on Decarbonization: A Risk-Return Framework for Climate Finance - Methodological Note

Laurent Millischer  
World Bank

Max Fandl  
Joint Vienna Institute

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## 1 Introduction

Meeting the world's climate goals requires a fundamental reallocation of capital. Substantial investment in low-carbon infrastructure must be financed while simultaneously phasing out high-carbon activities.

This methodological note accompanies the SUERF Policy Note "Banking on decarbonization: A risk and return approach to financing the transition" and presents the detailed technical framework underlying the risk-return model described therein. The model analyzes how private capital flows to clean and polluting investment projects under different policy environments. It captures key features of project finance, including equity investor risk aversion, bank capital constraints, and credit risk assessments. The framework identifies which projects receive spontaneous private-sector financing and determines the optimal mix of equity and debt, supporting the design of public policies that crowd-in private finance at scale to accelerate low-carbon project pipelines.

## 2 Investment Projects and Risk-Return Profiles

Consider a set of independent investment projects—think of wind farms or coal-fired power plants—each requiring initial financing  $A$  and generating payoff  $A_{t+1}$  one period later. The project’s *return on assets* (RoA) is defined as

$$\text{RoA} = \frac{A_{t+1}}{A_t} - 1. \quad (1)$$

For analytical tractability, we assume RoA follows a normal distribution,  $\text{RoA} \sim \mathcal{N}(\mu, \sigma^2)$ , where  $\mu$  represents expected project return and  $\sigma > 0$  measures total risk. Low-carbon projects typically exhibit lower risk profiles and potentially lower returns, while high-carbon projects may offer higher returns but with elevated risk exposure. Project characteristics  $(\mu, \sigma)$  are taken as given, reflecting market fundamentals and technology-specific factors.

### 2.1 Project financing structure

Equity investors choose the fraction  $k \in (0, 1]$  of project assets financed with equity, with the remainder  $(1 - k)$  financed through bank loans. Denoting equity investment by  $E$  and the loan by  $L$ :

$$E = kA, \quad L = (1 - k)A. \quad (2)$$

We assume investors cannot short projects, so  $k \geq 0$ . When  $k = 1$  the project is entirely equity-financed, while  $k \rightarrow 0$  corresponds to highly leveraged project finance structures typical in infrastructure investments.

## 3 Bank Credit Assessment and Pricing

Banks assess project risk and quote interest rates  $i$  on project finance loans. They operate under regulatory capital requirements and must manage credit risk exposure through probability of default (PD) assessments.

### 3.1 Credit risk assessment

At maturity, equity value equals:

$$E_{t+1} = A_{t+1} - L_{t+1} = A_{t+1} - L(1 + i). \quad (3)$$

Project default occurs when  $E_{t+1} < 0$ . Under normal return assumptions, the project’s *return on equity* (RoE) distribution is (derivation in Section A):

$$\text{RoE} \equiv \frac{E_{t+1}}{E_t} - 1 = \frac{\text{RoA} - i(1 - k)}{k} \sim \mathcal{N}\left(\frac{\mu - i(1 - k)}{k}, \frac{\sigma^2}{k^2}\right). \quad (4)$$

It follows that the probability of default (PD) is

$$\text{PD}(i, k; \mu, \sigma) = \Pr(E_{t+1} < 0) = \Pr(1 + \text{RoE} < 0) = \Phi\left(-\frac{1 + \mu_{\text{RoE}}}{\sigma_{\text{RoE}}}\right), \quad (5)$$

where  $\Phi$  denotes the standard normal cumulative distribution function and  $\mu_{\text{RoE}}, \sigma_{\text{RoE}}$  are the mean and standard deviation in (4). Substituting those moments yields an explicit expression for PD as a function of  $i$  and  $k$ :

$$\text{PD}(i, k; \mu, \sigma) = \Phi\left(\frac{(i - k)i - k - \mu}{\sigma}\right). \quad (6)$$

The bank refuses to lend if PD exceeds a maximum tolerable level  $\text{PD}_{\max}$  (e.g. 5%)<sup>1</sup>.

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<sup>1</sup>This assumption formalises the idea that banks avoid projects with excessively high default risk.

### 3.2 Interest rate determination

Bank interest rate quotes reflect three cost components:

1. *Cost of capital (CoC)*: Regulatory capital ratio  $\rho$  and risk weight  $RW$  require funding fraction  $\rho \cdot RW$  of the loan with bank equity at cost CoE.
2. *Cost of funding (CoF)*: Remaining loan portion funded through bank debt at cost CoD.
3. *Cost of risk (CoR)*: Expected losses equal probability of default times loss given default:  $CoR = PD \cdot LGD$ .

The bank pricing equation becomes:

$$i = \rho \cdot RW \cdot CoE + (1 - \rho \cdot RW)CoD + PD(i, k; \mu, \sigma) \cdot LGD. \quad (7)$$

Parameters such as  $\rho \approx 15\%$ ,  $CoE \approx 15\%$ ,  $CoD \approx 2\%$ ,  $LGD \approx 50\%$  and  $RW \approx 100\%$  are taken as exogenous. Because  $PD$  depends on  $i$  through (6), the bank must solve the nonlinear equation (7) for  $i$ . In practice the equilibrium interest rate  $i$  is found numerically using a root-finding algorithm.

## 4 Equity Investment Decisions and Risk Management

Equity investors optimize leverage ratio  $k$  and invest only when expected returns adequately compensate for risk exposure. Under our one-period framework, investors apply Capital Asset Pricing Model (CAPM) hurdle rates. With risk-free rate  $i_{RF}$  and market portfolio parameters  $\mu_m$  and  $\sigma_m$ , a project qualifies as *investable* only if:

$$\mu_{RoE} \geq i_{RF} + \frac{\sigma_{RoE}}{\sigma_m} (\mu_m - i_{RF}), \quad (8)$$

where  $\mu_{RoE}$  and  $\sigma_{RoE}$  come from (4). If the inequality fails the project's risk–return profile is unattractive relative to diversified market opportunities. In addition, equity investors are assumed to have constant absolute risk aversion (CARA). For CARA utility  $U(W) = -\exp(-aW)$  with risk aversion parameter  $a > 0$ , the certainty-equivalent return of (4) is  $\mu_{RoE} - \frac{a}{2}\sigma_{RoE}^2$ . Maximising this with respect to  $k$  yields an *optimal leverage* that balances the benefits of debt finance against increased volatility. Because  $i$  itself depends on  $k$  through (7), determining the optimal  $k$  generally requires a numerical search over admissible leverage ratios.

## 5 Market Financing Outcomes and Capital Allocation

Integrating bank credit assessment and equity investment decisions creates a mapping from project characteristics  $(\mu, \sigma)$  to feasible financing configurations. For given project parameters, the analytical procedure follows:

1. For each equity share  $k \in (0, 1]$  compute the equilibrium interest rate  $i(k)$  solving (7) subject to  $PD$  staying below  $PD_{max}$ .
2. For that  $i(k)$  compute  $\mu_{RoE}$  and  $\sigma_{RoE}$  using (4) and evaluate the CAPM hurdle (8). If the hurdle fails the configuration is not investable.
3. Among the investable  $k$  choose the one that maximises the equity holder's certainty-equivalent return. This yields the *optimal capital structure*.

Projects for which no  $k$  satisfies both the bank's PD constraint and the investor's hurdle are unattractive to the private sector. Such projects may still merit public funding due to their social benefits. Conversely, projects with low risk and high debt capacity are predominantly funded by banks. Medium-risk projects with moderate debt capacity are financed through equity markets. Projects on the margin, where private financing is insufficient, may require government guarantees or co-financing.

### 5.1 Bankable and investable sets

The *bankable* set consists of  $(\mu, \sigma, k)$  such that  $\text{PD}(i, k) \leq \text{PD}_{\max}$ . High leverage (small  $k$ ) increases  $\sigma_{\text{RoE}}$  and pushes PD up; consequently, excessively high leverage is ruled out for risky projects. Within the bankable set, the CAPM condition (8) defines an *investable* subset. For fixed  $(\mu, \sigma)$  the admissible leverages  $k$  form an interval. Projects outside this region must rely on non-commercial sources of finance.

## 6 Policy Instruments

Public policy can alter the position of projects in the risk–return space or change financial constraints. We summarise several levers:

- **Carbon pricing and green subsidies** change the expected project return  $\mu$ . A carbon tax reduces  $\mu$  for high-carbon projects while a subsidy increases  $\mu$  for low-carbon projects.
- **Contracts for differences, feed-in tariffs and guarantees** reduce project risk  $\sigma$  by providing revenue stability.
- **Bank capital regulation** influences the cost of capital component in (7). A “brown-penalising factor” that increases risk weights for high-carbon loans raises the bank interest rate and shrinks the bankable set.
- **Co-financing and credit enhancements** lower the private sector’s funding share, effectively increasing  $k$  and reducing risk. They can crowd in private capital for otherwise unbankable projects.

By shifting project returns or risks, or by altering financial parameters, these policies move projects between the financing zones identified above. An optimal policy mix maximises the number of low-carbon projects financed subject to fiscal and regulatory constraints.

## 7 Empirical Implementation and Model Extensions

Practical model application requires calibration with project-level data on returns and risks. Data sources include the International Renewable Energy Agency (IRENA), BloombergNEF (BNEF), and development bank project portfolios, providing estimates of  $\mu$  and  $\sigma$  across technologies and jurisdictions. Financial market parameters—bank capital ratios, equity risk premia, investor risk aversion—can be calibrated from market data and regulatory frameworks.

Calibrated models enable simulation of financing outcomes across project portfolios, quantitative assessment of policy intervention impacts, and optimization of policy instrument design for maximum private capital mobilization.

Extensions could relax normality and CAPM assumptions, incorporate liquidity constraints, enable dynamic multiperiod analysis, or model project interactions. The framework demonstrates how project characteristics, financial market frictions, and policy instruments interact to determine climate finance allocation.

On a conceptual level, the risk-return approach departs from potential misperceptions about savings-investment relationships under flow-of-funds frameworks. Rather than mechanically constraining low-carbon investment through available savings, financial markets and bank credit creation can provide necessary resources when countries pursue supportive public policies that optimize private capital mobilization for the low-carbon transition.

## A Derivation of the return on equity

Here we derive equation (4). The project's asset value at  $t+1$  is  $A_{t+1} = A_t(1 + \text{RoA})$ . The loan at maturity is  $L_{t+1} = L(1 + i) = A_t(1 - k)(1 + i)$ . Equity at maturity is  $E_{t+1} = A_{t+1} - L_{t+1}$ . Since  $E_t = kA_t$ , the one-period equity return is

$$\frac{E_{t+1}}{E_t} - 1 = \frac{A_t[1 + \text{RoA} - (1 - k)(1 + i)]}{kA_t} - 1 \quad (9)$$

$$= \frac{\text{RoA} - i(1 - k)}{k}. \quad (10)$$

Because  $\text{RoA} \sim \mathcal{N}(\mu, \sigma^2)$  and  $i$  is constant conditional on  $k$ , the result in (4) follows.