




Just in Time



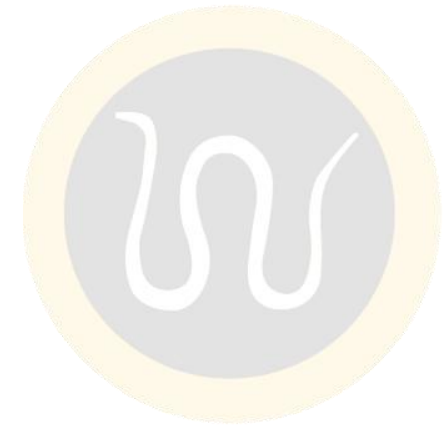
**Incorporating Nature Physical Risks Into
Banks' Credit Risk Models and Insurers'
Market Risk Models:
Focus on Water-related Risks**

May 2026



Executive Summary

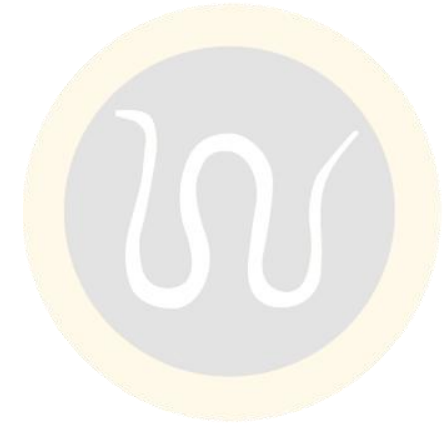
- The [De Nederlandsche Bank Working Paper](#) establishes that **nature-related risks - particularly those linked to biodiversity loss and ecosystem degradation - pose material threats to macroeconomic stability and financial systems**. This recognition is aligned with positions taken by institutions such as NGFS, ECB and FSB.
- The paper highlights a **critical methodological gap**: while exposure-based analyses have demonstrated that financial institutions (FIs) are highly dependent on ecosystem services, there is **no widely accepted framework to translate nature shocks into financial losses**.
- The paper introduces a **top-down stress-testing framework** linking:
 - **Nature shocks**
 - **Macroeconomic impacts**
 - **Firm-level vulnerabilities**
 - **Financial sector losses**
- A key innovation is the **calibration of a nature shock using proxy macroeconomic scenarios**, allowing quantification of **absolute financial stability impacts**, rather than relative comparisons.
- The empirical focus is on **water-related risks**, used as a proxy for broader nature degradation.



At a Glance

01	Data	4
02	Methodology	6
03	Extension to Multi-Shock Scenarios	12
04	Results and Key Findings	14
05	Conclusions & Takeaways	16

Keywords: ESG Risk, Physical Risk, Stress Test, Credit Risk, Market Risk, Insurance



01

Data



Data

The analysis integrates **environmental, macroeconomic and financial supervisory datasets** to quantify vulnerabilities and financial impacts.

Nature Data		Financial and Regulatory Data	
Two main databases are used:	<ol style="list-style-type: none"> ENCORE: provides sector-level dependency on ecosystem services (integrated with with multiregional input-output data) ND-GAIN: provides indicators of nature degradation and vulnerability 	The study combines:	<ol style="list-style-type: none"> Supervisory data: <ul style="list-style-type: none"> AnaCredit (loans) SHS-S (securities holdings) Regulatory disclosures: <ul style="list-style-type: none"> COREP (banks) Solvency II (insurers)
A key methodological challenge arises from mismatched granularity :	<ul style="list-style-type: none"> ENCORE: detailed ecosystem services (e.g., water purification, flow regulation) ND-GAIN: broader categories (e.g., water vulnerability) To reconcile this, the authors apply principal component analysis (PCA) 		The analysis is conducted at two levels:
Ecosystem services cluster into three groups:	<ol style="list-style-type: none"> Water Supply Biomass Provision Education & Research 	This dual-level approach enables:	
This allows:	<ul style="list-style-type: none"> Aggregation of ecosystem services into representative categories Mapping water-related services to a single water vulnerability indicator Additionally: <ul style="list-style-type: none"> Indirect dependencies (via supply chains) are captured using EXIOBASE input-output tables 		

02

Methodology



This section provides the **core analytical framework**, linking nature shocks to financial stability outcomes.



Proxy Scenarios for Nature Shocks

Due to limitations in nature-to-economy modelling, the paper uses **three proxy scenarios**:

Historical production variability

Climate-driven temperature impacts
(water-cycle linkages)

Long-term environmental stress models
(Limits to Growth framework)

These scenarios converge on a **benchmark assumption**:

10% EU-wide production loss

This serves as:

- A **calibration anchor**, not a forecast
- A “**severe but plausible**” stress scenario

A key modelling assumption:

- Markets **instantaneously price in the shock**

Methodology 2/5



Calibration of Nature Shock

Nature-related risk is defined as:



The framework applies vulnerability to **production**, consistent with ENCORE definitions.

Vulnerability to Nature

Vulnerability is defined as function of **dependence on nature** and the **size** of nature **degradation**. It incorporates:

- **Direct dependencies** (firm activity)
- **Indirect dependencies** (supply chains)

Using input-output tables, the framework computes upstream exposure ratios. This allows estimation of firm-level vulnerability at sector-country level.

Key advancement: improved measurement of **government and financial sector dependencies**, which are underestimated in ENCORE.

Key Insight

The **aggregate macro shock is distributed across firms** based on their **vulnerability profiles**, leading to **heterogeneous impacts**.

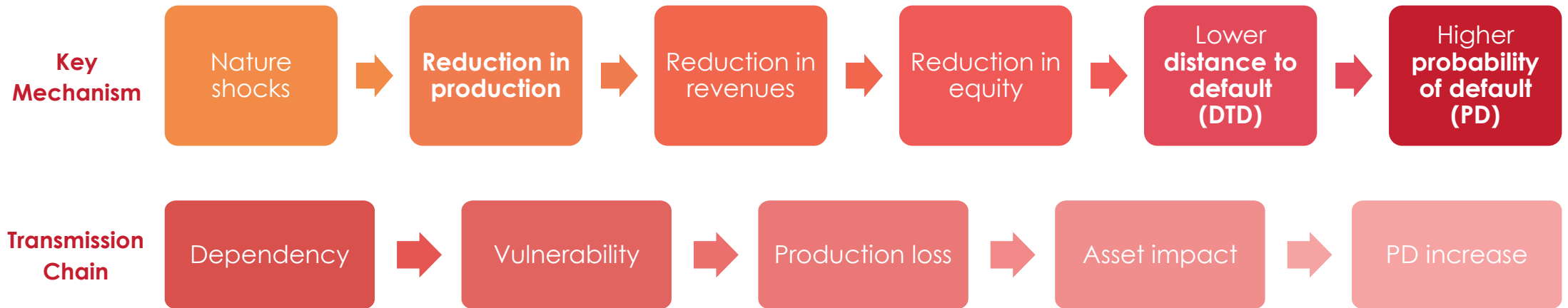
A **central innovation** is:

- ❖ Endogenous calibration of the nature shock (α) such that aggregate production loss matches the scenario (10%)



Microeconomic Impact (Merton Model Extension)

The paper modifies the **Merton structural credit risk model** to incorporate nature shocks.



Key Innovation

Translation of **production vulnerability into asset vulnerability**, using:

- Return on revenue
- Cost of Equity

This ensures consistency between **macroeconomic shocks** and **firm-level balance sheet impacts**



Financial Market Impact

The increase in PD drives:

Bond price declines

Bond prices decrease due to:

- **Higher PD**
- **Higher expected losses** (LGD adjustments)

Equity valuation losses

Equity is modelled as a call option on firm assets (Black-Scholes framework).

Key mechanism:

Reduced
asset value



Higher PD



Lower equity
prices

The framework isolates **credit spread effects**, excluding risk-free rate changes

Methodology 5/5



Prudential Impact

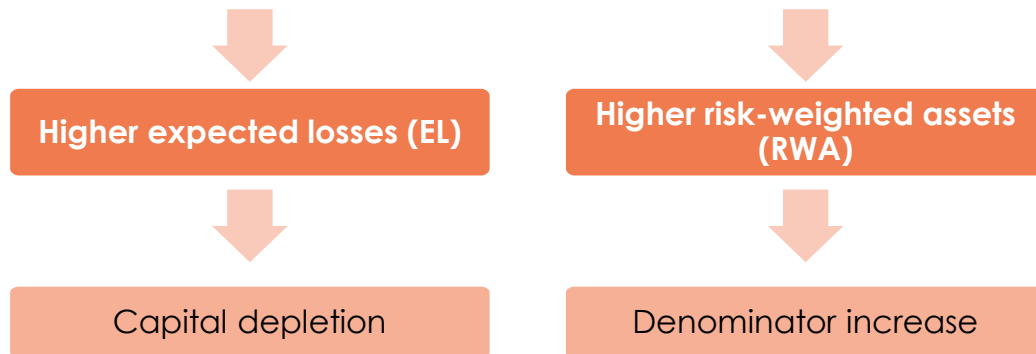
Banks (CET1 Ratio)

The CET1 ratio impact can be expressed as follows:

$$\Delta CET1_{ratio} = \frac{CET1 - \Delta EL}{RWA + \Delta RWA} - CET1_{ratio}$$

Where ΔEL represents the change in expected loss amounts, ΔRWA is the increase in RWA resulting from the deterioration in credit quality and $CET1_{ratio}$ stands for the bank's initial CET1 ratio prior to the shock.

Impact channels



The CET1 ratio declines due to both effects.

Insurers (SCR Ratio)

Impact assessed through **revaluation of bond and equity portfolios**.

The change in the SCR ratio can be presented as follows:

$$\Delta SCR_{ratio} = \frac{EOF - \Delta EOF}{SCR + \Delta SCR} - SCR_{ratio}$$

Where EOF is the Eligible Own Funds defined under the Solvency II, ΔEOF represents the proportion of the loss attributable to shareholders and $\Delta SCR = 0$.

Key Assumptions:

- No immediate recalibration of SCR
- Partial offset** via **loss absorption capacity of liabilities**

03

Extension to Multi-Shock Scenarios

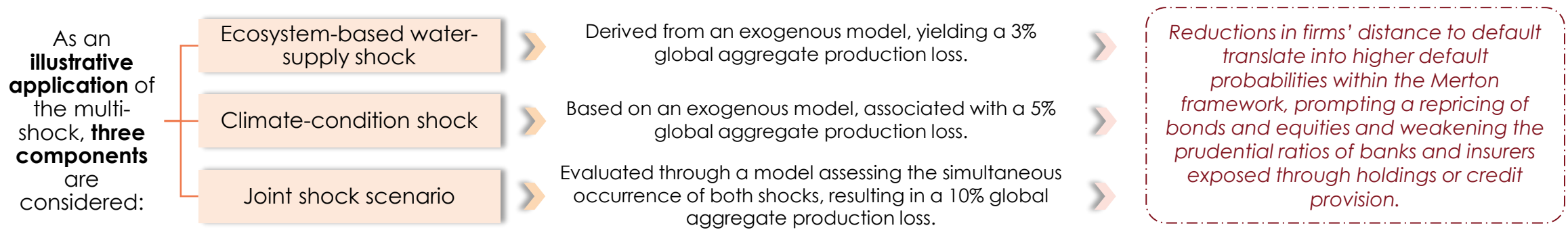
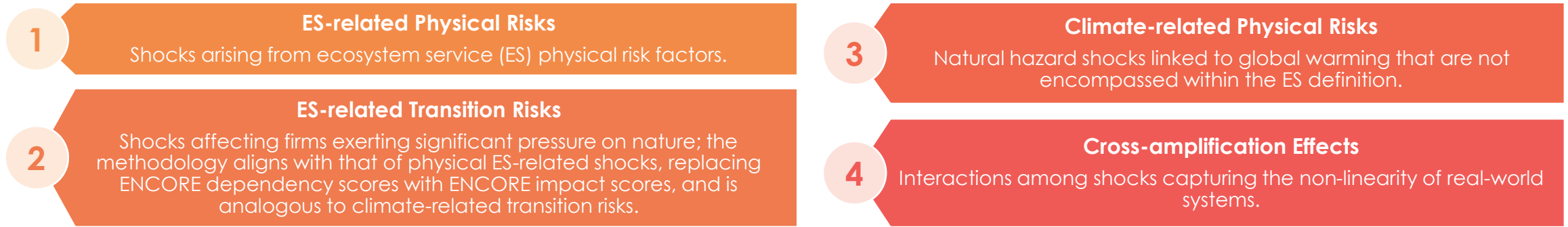


Extension to Multi-Shock Scenarios

The framework is extended to include:



The overall relative **variation in production** for a given sector–country pair can be expressed as the **weighted sum of the multiple shocks** and their corresponding **sector–country vulnerabilities**. A **multi-shock** can be delineated into **four core building blocks** of risk sources:



04

Results and Key Findings



Results and Key Findings

The framework produces **granular and policy-relevant outputs**.

Macroeconomic Impacts

- EU-wide production loss: **10% (assumption)**
- **Country-level variation:**
 - Finland: ~ -6.3%
 - Netherlands: ~ -14.6%

Financial Market Impacts

- Decline in **value of debt** and **equity holdings:**
~ **-5% (EUR 500 billion)**

Banking Sector

- **CET1 ratio** impact:
 - **-5.4% to -14.4%**
(with RWA effects)
 - Lower when excluding RWA channel

Insurance Sector

- **SCR ratio** impact:
-0.6% to -50.4%

Key Insight

Losses are **highly heterogeneous**, driven by:

- **Sectoral dependencies**
- **Geographic exposure**
- **Supply chain linkages**

05

Conclusions & Takeaways



Conclusions & Takeaways

Methodological Contributions	Implications for Supervisors and Institutions	Policy-Relevant Insights	Key Takeaways
<ul style="list-style-type: none"> • Calibration of nature shocks from macro scenarios • Operationalization of vulnerability (dependence × degradation) • Integration into Merton-based credit risk modelling • Extension to insurers' market risk and prudential metrics 	<ul style="list-style-type: none"> • Stress testing frameworks should incorporate nature risks • Sectoral and geographic heterogeneity must be explicitly considered • Data gaps (especially firm-level dependencies) remain a key constraint • Joint climate-nature risk modelling is critical for forward-looking supervision 	<ul style="list-style-type: none"> • Nature degradation can: <ul style="list-style-type: none"> • Trigger systemic financial losses • Affect prudential ratios significantly • Results support: <ul style="list-style-type: none"> • Development of NGFS nature scenarios • Integration into Pillar 2 supervisory expectations 	<ul style="list-style-type: none"> • Nature-related risks are financially material and can be integrated into stress-testing frameworks • A top-down approach linking: nature → economy → finance is feasible and operational • Water-related risks serve as a robust proxy for broader ecosystem degradation

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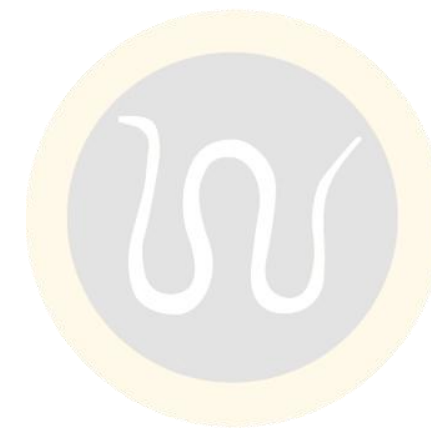
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Dario Esposito



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