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# NAVIGATING CLIMATE TRANSITION: EVALUATING EXPOSURE AND RESILIENCE OF INDONESIAN BANKS' PORTFOLIOS ACROSS HIGH-EMITTING SECTORS. A BOTTOM-UP ANALYSIS

Arnita Rishanty, Retno Puspita K. Wicaksono, Rizkia Sari Yudawinata, Siti Kholifatul Rizkiah, Rafi Aquary, Aurellia Puteri Arfita

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**Abstract**

Energy sector contributes significantly to emitting the largest emissions from fossil fuel combustions. Driven by the transition agenda towards a low-carbon economy, the industrial sector is expected to decarbonize its greenhouse gas (GHG) emissions by shifting from fossil fuels to renewable energy sources. This paper aims to assess climate transition risks and their impact on the banking credit portfolios of high-emitting and energy-producing sectors in Indonesia, namely coal, oil & gas, power, and automotive sectors, using the 1in1000's TRISK framework. Using credit data from 1,567 observations in December 2022, the findings reveal that the majority of banks are expected to experience a notable increase in expected losses (EL) and probability of default (PD) in these sectors. In summary, using the average increase of PD, excluding outlier scenarios, coal sector exhibits the highest increase in PD (45.2%), followed by power (41.5%), oil & gas (0.1%), and, lastly, automotive (0.05%). Although the highest change in PD is observed in coal sector, the highest expected loss is observed in the power sector due to large exposure that the banks have in the power sector. Study signifies the role of banks, including central banks and financial supervisors as the regulatory bodies in facilitating the transition to a low carbon economy and to support the sectoral rebalancing process of high-risk sectors exposures in banks' portfolio. Additionally, this study also presents several recommendations based on the analysis to guide central banks, financial regulators, and the financial sector at large in managing climate risks effectively.

**Keywords:** Banking Stress Testing, Climate Scenario Analysis, Climate Transition Risk, High-Emitting Sectors.

JEL Classifications: Q4, Q2, O1

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# 1. Introduction

As Indonesia continues to burgeon as a manufacturing hub, it relies heavily on abundant energy for production. Unfortunately, the power sector in Indonesia is a significant contributor to greenhouse gas (GHG) emissions, with fossil fuel combustions emitting approximately 224 million tons of $CO_2$ in 2019, supplying over 60% of the country's electricity. Notably, the electricity sector ranks as the largest emitter in Indonesia after the industrial and transportation sectors (IEA, 2022). The primary source of emissions in the country stems from coal-fired generation, followed by oil and gas power generation (IEA, 2022).

From the energy demand side, the industrial sector stands out as the largest energy-consuming sector at 36%, followed by the transportation sector at 29%, while the commercial and household sectors each account for 9%. Total energy demand in Indonesia is expected to increase from 142 MTOE[1] in 2020 to an anticipated 519 MTOE in 2060 under a business as usual scenario. Through the implementation of mitigation measures, energy efficiency, and conservation initiatives, it is estimated that energy demand could be curtailed by 209 MTOE, bringing it down to 310 MTOE by 2060. On the other hand, Indonesia has huge potential for renewable energy compared to other ASEAN countries, but the utilization is still considerably very low. This underutilization can be attributed to various challenges, including Indonesia's unique landscape, socio-economic factors, and political issues (Rishanty et al., 2022). Driven by the imperative of transitioning to a low-carbon economy, the industrial sector is anticipated to undertake decarbonization efforts by shifting from fossil fuels to renewable sources.

At the same time, Indonesia is also exposed to heightened physical climate-related risks. This vulnerability is underscored by the ND-GAIN Index, which assesses a country's susceptibility to climate physical risks in conjunction with its readiness to enhance resilience. Due to a complex interplay of political, geographic, and social factors, Indonesia is identified as vulnerable to climate change impacts, ranking 97th out of 181 countries in the 2020 ND-GAIN Country Index.

Banks, in particular, face exposure to climate-related transition risks through stranded assets from the financial intermediation, including both in deposits and lending activities (Nkwaira & Van der Poll, 2023). Given the regulatory framework governing banks, climate-related damages could adversely impact bank losses, leading to a depreciation of collateral values (Furukawa et al., 2020). If this risk is not accurately measured and effectively mitigated, it has the potential to impede the downstream segments of crucial export sectors as they heavily depend on the energy sector for their production. Additionally, it can impact the profitability of the banking sector due to the financial risks arising from climate change.

This paper aims to assess climate-related risks and their impact on the banking credit portfolio of high-emitting sectors' in Indonesia. This study focuses on four high-emitting sectors, which are oil & gas, power, coal, and automotive. This paper employs a scientifically-based methodology and climate scenarios, consistent with those used globally including by the major off-taker companies and importing countries, to prevent the global temperature from exceeding 1.5°C. The objective is to assess the potential climate transition risks faced by both the industry and financiers. Utilizing a scientifically-backed climate transition risk stress test methodology, the TRISK framework, the research aims to illustrate the potential challenges and opportunities associated with Indonesia's energy sectors that will impact the countries' exports while also assessing the resilience of banks' portfolios on the energy and automotive sectors in the face of climate change. Research on climate-related transition risks on banks' portfolios has been very limited, underscoring the significance of this study in addressing a critical gap in the existing literature.

Therefore, this study would be beneficial for Indonesia and would fill the gap in the literature by examining the transition risks the high-emitting industrial sector is facing and its impact on the resiliency of banks' portfolios. Moreover, the findings have the potential to serve as crucial references for regulators in formulating necessary policies and initiatives to support the resilience of the national financial stability against climate transition shocks.

## 2. Literature Review

The recent Sixth Assessment Report (AR6) from Working Group I of the Intergovernmental Panel on Climate Change (IPCC, 2021) highlights an "alarming trend" of rising temperatures, with the initial two decades of the 21st century identified as the warmest on record. Also, in response to the severe consequences of this warming, there is a resounding consensus among scientific authorities, as emphasized in the IPCC Special Report (IPCC, 2018), affirming the imperative to limit the global temperature increase to 1.5°C. It is acknowledged that the surge in greenhouse gas (GHG) concentration resulting from anthropogenic activities over the years is the primary factor responsible for the observed warming in the atmosphere. Consequently, there is an urgent necessity for a rapid global transition away from high-emitting sectors to prevent the significant dangers of climate change from both environmental and socio-economic standpoints.

Indonesia, a signatory of the Paris Agreement in 2015, has reaffirmed its commitment to substantial GHG emissions reductions through its latest Nationally Determined Contribution (NDC), known as the Enhanced NDC (UNFCCC, 2022). In alignment with Indonesia's Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) 2050, which aims for net-zero emissions by 2060 or earlier, the ENDC outlines specific reduction targets. These include an unconditional target of 31.89% and a conditional target of up to 43.20% compared to the business-as-usual scenario by 2030. As articulated in the LTS-LCCR 2050, failure to transition away from current conditions could lead to significant economic losses, estimated within the range of 0.66% to 3.45% of the national GDP (UNFCCC, 2021). Therefore, the envisioned shift towards a low-carbon development path is crucial. It is seen as a triple-win solution for Indonesia's economy, not only meeting climate goals but also fostering more resilient economic growth (Bappenas, 2019).

Efforts to significantly reduce emissions can manifest through changes in government regulations, climate policies, and advancements in technology. In the ongoing effort of shifting away from carbon-intensive practices, climate-related transition risks will not be impacting only certain sectors but rather have broad implications on the whole economy simultaneously. Industries heavily dependent on carbon-intensive energy may face heightened climate transition risks vulnerability. Addressing these issues could entail certain potential trade-offs. For instance, transitioning from fossil fuels to renewable energy might result in fossil fuel resources becoming stranded assets. Moreover, as highlighted by Dunz & Power (2021), carbon-intensive firms may encounter increased costs due to higher prices and carbon taxes, leading to reduced profitability and potentially devalued assets, creating a ripple effect. The broader economic implications of transitioning away from carbon-intensive sectors are evident. Gourdel et al. (2022) examining the implementation of carbon pricing in China, found that the wider economic impacts included reduced production levels and profitability of coal firms, along with a decline in exports. This is particularly significant for Indonesia, one of the leading producers and exporters of coal (IEA, 2021). The study suggests that these effects may extend to diminished investment and a decrease in GDP, indicating impacts on the real economy. Therefore, the transition from carbon-intensive sectors can have far-reaching economic effects, impacting not only individual firms but also the broader economy, including the financial sector and the real economy (Adrian et al., 2022).

Given the substantial financial risks associated with climate transition risks, there is a significant focus on understanding these risks within the financial sector. The Network for Greening the Financial System (NGFS, 2021) provides a comprehensive analysis of the mechanisms through which climate risks are transmitted to financial risks (refer to transmission channels on p.10). Additionally, several studies by central banks and financial regulators worldwide aim to investigate the potential impact of climate-related risks on financial stability, with potential adverse consequences for the broader economy

The European Central Bank (ECB, 2020) has highlighted that climate-related risks play a pivotal role in influencing various types of risks within the financial sector, including credit risk, market risk, operational risk, and liquidity risk/business model. Transition risks have the potential to impact the market value of specific assets, potentially causing losses to firms and financial institutions, especially those associated with carbon-intensive or fossil fuel-related industries (Furukawa et al., 2020). This perspective is further reinforced by a study conducted by Ferrer et al. (2021), which emphasizes that the primary risks faced by the financial sector concerning climate change are predominantly tied to two key aspects: credit and market exposures.

The quantification of climate risks impacts within the financial sector is crucial, forming the basis for a deeper understanding of risk exposure and potential financial losses within the financial system. A study by Vermeulen et al. (2018) conducted an in-house top-down stress test for the Dutch banking sector, revealing that, compared to other financial institutions like insurers and pension funds, banks have the largest exposure to carbon-intensive industries. This suggests that banks may face more substantial risks associated with these carbon-intensive sectors. Examining the risks banks may encounter, Acharya et al. (2023) underscore the importance of measuring climate risk, particularly through two channels: banks' loan books (e.g., credit risk) and trading portfolios (e.g., market risk). These financial risks have the potential to impact financial stability through their effects on a bank's financial condition.

Several studies have sought to translate climate transition risks into the financial risks faced by financial institutions. For example, utilizing the SYSMO model, Reinders et al. (2021)

identified an increase in non-performing portfolios, ranging from 0.5% to 1.9% across various loan categories. This study highlighted considerable impacts of climate transition risks on the defaulted portfolios of Colombian banks, affirming the vulnerability of credit portfolios in the context of the climate decarbonization pathway. The 2022 climate stress test conducted by the ECB further underscores the vulnerability of banks to an increase in climate transition risk, anticipating a substantial rise in credit risk impairments. The majority of this increase is attributed to the most carbon-intensive sectors, including refined petroleum products, mining, minerals, and land transportation. These findings reflect the significant surge in carbon prices required to achieve a net-zero economy as quickly as possible (ECB, 2022). Similar insights are echoed in a joint study by the Swedish Financial Supervisory Authority (FI) and the Riksbank. Using the PACTA model, FI and Riksbank (2022) suggest that risks and consequences during the transition period are expected to be more significant for loans related to climate-damaging activities.

Employing an in-house stress testing method with a top-down approach, Ferrer et al.,2021) demonstrate that the short-term impacts of transition scenarios on the profitability and stability of the Spanish banking sector are relatively moderate. Notably, sectors more closely linked to GHG emissions would experience a more significant impact. However, the study emphasizes that these exposures to climate transition risks represent only a small fraction of total bank lending to business activities in Spain. These findings align with the estimates by Stolbova & Battiston (2020), indicating that approximately 8% of the total assets held by Dutch banks are exposed to sectors influenced by climate change. Additionally, Sever & Perez-Archila (2021) identify the transportation sector as the second-largest risk imposed on the banking system. In a recent study employing the climate transition risk stress test developed by 1in1000, Thomä (2022) discovers that sectors requiring rapid decarbonization are currently farthest from aligning with climate goals and face the greatest risk of declining profitability. This risk is particularly pronounced in sectors such as coal mining and upstream oil and gas. An analysis involving a Japanese bank reveals that coal mining and oil & gas sectors saw the most substantial increases in mean probability of default (PD) expressed in percentage points. Additionally, the study suggests that segments of the automotive manufacturing and power generation industries that heavily depend on fossil fuels may also be susceptible to these risks.

The climate risks have indeed become a pivotal concern in the IMF's financial surveillance as the Financial Sector Assessment Program (FSAP) has conducted some early analyses which integrate the potential climate risks. Such analysis has been done for Chile, Colombia, Norway and South Africa FSAP (Adrian et al., 2022). Specific to transition risk, the Norway FSAP used debt-at-risk analysis of transition risk posed by carbon tax increases at the level of individual firms and suggests that debt at risk would increase along with the rising carbon prices (IMF, 2020). Moreover, the recent FSAP analyses undertaken in the UK has assessed the transition risks using scenario-based analysis using the "climate Minsky moment" approach. This study primarily focuses on change in firm's valuations, the probabilities of defaults and credit ratings of companies. They found that the transition could cause significantly large losses for financial institutions specifically to banks' corporate loan portfolios. In detail, the average loss would be 1.1% or 3.6% depends on the carbon price path under the alternative transition scenarios which in turn could generate higher credit losses to almost GBP 79 billion from 24 billion (IMF, 2022).

Notably, traditional stress testing gained prominence as a regulatory measure in the aftermath of the 2008 financial crisis, serving as a mechanism to curb excessive risk-taking within the banking sector in alignment with the principles outlined in the Basel Accords. In line with this, Baer et al. (2022) have identified significant heterogeneity issues in the effects of the transition on individual companies and the financial sector, leading to notable distributional disparities. This underscores the importance of conducting detailed, bottom-up stress tests that can provide valuable insights for financial markets and inform the design of financial policies by regulators. Among the available quantification methods, traditional risk quantification methods, relying on historical data and statistical models, fall short in addressing the intricacies of climate risks. As a result, a climate risk stress testing methodology that incorporates forward-looking data and future projections of companies is essential to accurately estimate the potential impacts of climate change in the future. Hence, the 1in1000 developed a climate transition stress test framework that accounts for forward-looking risk measures called the TRISK framework.

In line with Indonesia's commitment towards a low carbon economy transition, this study is conducted to assess climate transition risks and its impact on the banking's credit portfolio of high-emitting sectors' in Indonesia using a bottom-up climate transition risk stress test with the bottom-up approach using bank- and firm-level data. To the best of our knowledge, this is the first study assessing the financial implications of a climate transition risk to the high-emitting sectors in Indonesia and its implications to the Indonesian banks' portfolio.

## 3. Methodology

In the initial stages of development, several climate stress testing methods predominantly rely on historical and current carbon emission data to capture the transition risk. However, these approaches are deemed insufficient for several reasons. First, the approaches fall short in considering factors such as exposure to carbon taxes, demand-driven effects, or phase-out policies (Baer et al., 2022). Furthermore, it lacks the ability to differentiate between transitioning companies and climate laggards within the same industry, given the similarity in disclosed current carbon emissions, indicating a rising of heterogeneity issues on these approaches.

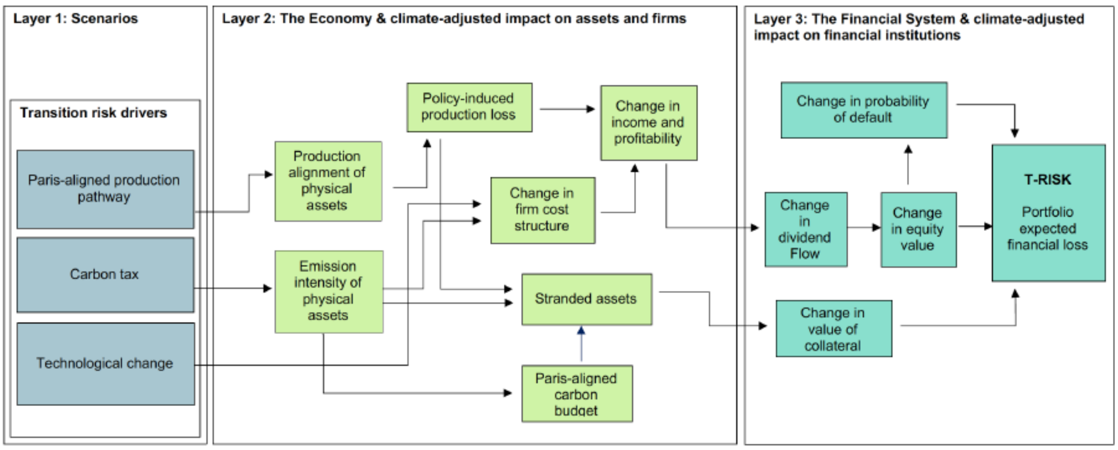
To address these limitations, we utilized the TRISK framework methodology developed by 1in1000. This framework is designed to accommodate these challenges by incorporating forward-looking strategies of firms and accounting the heterogeneity issues associated with transition risks.

### 3.1. The TRISK Framework

TRISK is an asset-level, bottom-up, and microeconomic climate transition risk stress test methodology. It functions as an open-source and free-of charge methodology designed to estimate the potential changes in companies' market valuation (market risk), probabilities of default and bank's expected loss (credit risk) across different climate scenarios. Utilizing the Paris Agreement Capital Transition Assessment (PACTA) alignment approach, TRISK constructs the impact of multiple scenarios of varying climate ambition on the company level until the year 2050 and calculates the financial risk associated with a late and sudden transition. The methodology measures climate transition risk on the financial asset level as well as on the aggregated portfolio in which the portfolio composition is assumed static for the horizon of the stress test. The model takes into consideration the company's forward looking production plans, financial data of the companies, and climate scenarios data. The TRISK framework can be described through three main layers:

1. Scenarios: This layer delineates the source of transition risk, represented by a set of climate-adjusted economic parameters such as carbon emission reduction pathways, cost-structure projections. Carbon tax pathways can also be applied to illustrate different impact of scenarios
2. Calculation of the real economic impact: This layer involves the computation of the actual economic impact of company-level transition risk shocks.
3. Estimation of the impact on financial institutions: This layer focuses on estimating the impact of transition risks on financial institutions, particularly through credit risks.

Each of these layers is connected through a set of transmission channels, which propagates the climate-adjusted economic impact to the asset value of firms, and subsequently translates the impacts into the financial market.




Source: (Baer et al., 2022)

Figure 1. Stylistic overview of the model transmission channels from one layer to another

Layer one of the TRISK framework translates the climate scenarios data into sector-level decarbonization pathways, which are subsequently translated into technology-level impacts to individual company production capacity. The level of each company's decarbonization effort is determined by the alignment of the company with a decarbonization pathway (using the forward-looking production plans) and the respective market share of that company within a particular production sector. Two types of decarbonization production pathways are constructed: baseline and climate target pathway. First, the baseline (business-as-usual) production pathway describes a state of 'business as usual', i.e. the production pathway reflects no climate ambition beyond what is assumed in the company's forward-looking production plans. Second, the climate target pathway projects a sustainable mode of production, as it already was on a path of climate transition today and in the future as determined by the input climate scenarios. For each company and company business unit, a baseline (business-as-usual) and target (sustainable) scenarios are constructed from input scenarios via disaggregation using company sector market share. The shock scenario is formed to follow a late and sudden policy migration from baseline to target scenario in a given 'shock year. Late and sudden policy action forces real economic firms to decarbonize. Every firm follows individual production pathways and compensates for misaligned production. In aggregate, production is consistent with scenario level sector targets in each technology and overall carbon budget.

The second layer interacts with the company's decarbonization pathways with real economic projections on costs, price, and general economic developments, as well as the company's financial risk profile. The shock scenario pathway determines the firms' cost structure and production mix across technologies and business units (e.g., electricity produced from solar power plants or coal-fired power plants) and, more importantly, impacts their income and profitability. The baseline and shock scenario production trajectories from the previous step are used as the main building blocks of the calculation of net profits. To derive net profit in a given year t, the production volume is multiplied by unit price and unit cost—this information is also supplied by the input scenario. Company production volume from baseline and 'shock' scenarios drive the bulk of impact on profits while price scenario impact is more subdued and is derived from external scenario providers. Carbon tax (currently only for NGFS GCAM) is applied as an additional emissions cost on a unit of production.

$$Net\ Profit_t = Production\ Volume_t\ x\ (Unit\ Price_t - (Unit\ Cost_t + Carbon\ Tax_t)) \quad (1)$$

The discounted cash flow model helps translate the net profit trajectories into expected company value. According to Gordon's (1959) approach to future dividends' flows, future profits are assumed to be distributed as dividend pay-outs to investors. The net present value (NPV) of a company can therefore be represented as a cumulative discounted sum of future net profits. For a given year of analysis the discounted net profit in a year t is given as

$$Discounted\ Net\ Profit_t = Net\ Profit_t\ /\ (1 + discount\ rate)^t \quad (2)$$

NPV for a given scenario is simply the sum of all future discounted net profits

$$Net\ Present\ Value_t = \sum_{2023}^{2050} Discounted\ Net\ Profit_t \quad (3)$$

In the third layer, TRISK estimates credit risks for the loan exposures associated with the companies analyzed in layers one and two. Building on the second layer, the company equity value change due to transition shock is given as the percentage difference between NPV baseline and NPV shock. This metric constitutes a measure of company market risk as a result of transition shock.

$$Equity\ Value\ Change = NPV_{baseline} - NPV_{shock} \quad (4)$$

Climate risk is captured in the difference in the equity value which enters the credit risk model, while assuming the default threshold to remain constant over time. Adjusted Merton structural credit risk model derives probability of defaults (PDs) under the two scenarios based on counterparties‘ balance sheet (market value of assets and liability structure, equity volatility) and calculates their difference. The probability of default is calculated as the probability that the company value (i.e equity value) falls under the value of liabilities—i.e. the value of debt or the default threshold.

$$PD = \Phi\left(-\left(\frac{\log(\frac{V_0}{L})+(r-\frac{\sigma^2}{2})t)}{\sigma\sqrt{t}}\right)\right) \quad (5)$$

Here, Φ represents the CDF of the standard normal distribution. The expression inside the parentheses is the z-score, and Φ(z) gives the probability that a standard normal random variable is less than or equal to z. The equity value is represented by V0 while the value of debt is L. r represents the risk-free rate, sigma the equity volatility and t is the credit instrument maturity.

The company PDs are calculated both for the baseline and the shock scenarios, with the main output being the difference between those—this is understood as the additional impact on company-level PDs as a result of climate transition shock. The final output of this study consists of average sectoral PDs and bank's expected loss, which resulted from the scenarios production trajectory derived from the applied scenarios.. The average PDs and expected loss are aggregated with following formulas:

$$EL_{sector} = \sum \; PD \;\; x \; Exposure_{company} \; x \; lgd_{company} \quad (6)$$

$$Average \; PD_{sector} = \sum \; (PD_{company} \; x \; Weight_{company}) \quad (7)$$

where $EL_{sector}$ is the expected loss of the sector, $PD_{shock}$ is probability of default under shock scenario, $PD_{baseline}$ is probability of default under baseline scenario, $PD_{shock} - PD_{baseline}$ refers to the probability of default (PD) difference. $Exposure_{company}$ is the loan exposure value of each company, $lgd_{company}$ is loss given default of the company, and $weight_{company}$ is the loan weight of each company that is measured as follows:

$$Weight_{company} = \frac{Company \; exposure}{Total \; portfolio \; sector \; exposure} \quad (8)$$

### 3.2. Data & Parameters

The TRISK framework consists of three types of data inputs to develop a unique climate stress test measure of credit risk for each individual corporate loan book exposure in the dataset: climate scenarios, company-level asset-based and financial data, corporate portfolio/loan book exposure information.

The first type of input data is the climate scenarios which provide a wide set of input data that projects alternate pathways of key variables affecting the economy and the financial system including decarbonisation pathways which are then translated into production pathways for key sectors, unit cost projections and carbon tax pathways illustrating demand shifts and projections on the technological change in energy and industrial system. The climate scenarios used in this study are taken from well-established scenario providers; the Network for Greening the Financial System (NGFS MESSAGE and NGFS GCAM), International Energy Agency (IEA WEO 2022), and the European Commission's Joint Research Centre (Global Energy and Climate Outlook (GECO)).

The second type of input data includes financial and economic data on the individual firms. The asset-level data for individual firms including information on emission intensities, production capacity and company's ownerships are provided by Asset Impact. The key aspect of Asset Impact's asset-level-based production data is its forward-looking nature. It encompasses information not only on the company's current production capacity but also on production plans for the next five years. Additionally, company-level financial information is provided by Refinitiv Eikon. This includes data on market cap, asset volatility, asset drift, structural leverage, and net profit margin.

The third type of input is the information on corporate loan book exposures. The credit outstanding of the covered sectors from the 13 banks with the highest asset value as of December 2022 was selected for the non-automotive sectors. However, it was observed that most automotive companies had loans from Japanese-owned banks and international banks. Therefore, a distinct set of 13 banks was chosen for the automotive sector based on having the highest loan value specifically for the automotive industry. The detail of the data used in the TRISK frameworks is summarized in Appendix Table A2.

We obtained various data using estimated proxies. For instance, we utilized the average 10-year government bond yield in 2023 as a proxy for the discount rate. We also employed the average dividend payout ratio of LQ45 stocks in 2023 to be embedded in the analysis. The market passthrough data is drawn from Ganapati, Shapiro, & Walker (2019), who investigated the market passthrough of carbon tax in several sectors in the United States, including the energy sector. There is a limitation to determine exact value of the market passthrough of carbon tax in emerging economies, as the implementation of carbon taxes in these countries has only recently commenced. The details of the parameters are shown in Table 1.

Table 1. Parameters for the scenario models

| Name | Original Scenarios Model | Shock Year Scenario Model | Carbon Price Scenarios Model |
|---|---|---|---|
| Discount Rate | 0.061 | 0.061 | 0.061 |
| Dividend Payout Ratio | 1 | 1 | 1 |
| Growth Rate | 0.06 | 0.06 | 0.06 |
| Risk Free Rate | 0.01 | 0.01 | 0.01 |
| Shock Year | 2030 | 2025, 2030, 2035 | 2025, 2030, 2035 |
| Carbon Price Model 1 | No carbon tax | No carbon tax | NDC model |
| Carbon Price Model 2 | No carbon tax | No carbon tax | NZ2050 model |
| Market Passthrough | 0 | 0 | 0.7 |
| Start Year | 2022 | 2022 | 2022 |

### 3.3. Climate Scenario

As the climate scenarios serve as the fundamental input to assessing the macro-financial impact, it is crucial to select climate scenarios that are relevant to the particular risks being studied. This study comprises six scenarios derived from several scenario providers, NGFS, IEA, and European Commission's Joint Research Centre. These scenarios were selected due to their widespread recognition among the policymakers and financial institutions. Each scenario is characterized by distinct assumptions and parameters, encompassing the shock year, start year, geographical coverage, and the carbon price model. The different scenario providers enable different regional contextualization which serves as a comparative perspective, including Global, Asia Pacific, and Indonesia. By default, the year 2030 is set as the "shock" year. However, for comparative analysis, we include the NGFS GCAM scenario with additional shock years: 2025, 2030, and 2035. All selected shock scenarios are designed to achieve targets that aim to limit global warming to well below 2°C.

Concerning the carbon price model, it relies on the projected global carbon prices from NGFS GCAM 5.3+ for Nationally Determined Contribution (NDC) and Net Zero 2050 (NZ2050) scenarios. These scenarios have been tailored to align with their implementation within the Indonesian context. In this case, both scenarios have been adjusted to incorporate carbon prices specific to Indonesia. We assume the price to be 2 US$2010 per ton of CO2 starting in 2025, with subsequent adjustments on the parameter, market pass-through is applied to determine and adjust the production cost as it refers to how much the carbon tax burden is distributed to the consumers. For both scenarios, a market pass-through assumption of 0.7 has been applied, drawing from the reference in Ganapati, Shapiro, & Walker (2019).

### 3.4. Data & Parameters

The climate scenarios outlined above provide production trajectories for the economic sector that need to decarbonize on a sub-sector or technology level. The focus is on shifting away from carbon-intensive technologies. In the specific context of Indonesia, there has been a consistent heavy reliance on fossil fuels, including coal, oil and gas (Malahayati & Masui, 2021). Additionally, Indonesia's Ministry of Industry has set ambitious targets to achieve net zero by 2050 for the industrial sector—a decade earlier than the official government's position. The ministry also aims to significantly increase the production of electric vehicles to reduce reliance on fossil fuels in the automotive industry.

As part of the transition towards a low-carbon economy, different sectors may need to adopt changes at varying speeds and ways. Particularly, high-emitting n sectors mentioned earlier need to make quicker transitions compared to other economic sectors. Therefore, this study covers high-emitting sectors which include oil and gas, coal, power generation, and automotive. As the third type of this study input is the corporate loan book data, hence which include:

1. Lending to companies involved in oil and gas extraction.
2. Lending to companies involved in power generation.
3. Lending to companies involved in coal mining.
4. Lending to light duty vehicles (LDVs) manufacturer companies

### 3.5. Data Selection

When choosing the sample data for this research, we primarily relied on the Indonesian company dataset covered by the Asset Impact database. Subsequently, we selected companies within the Asset Impact dataset that are within the portfolios of the 11 biggest Indonesian banks covered in the study. In the final dataset, we obtained 101 unique companies from the Asset Impact database under oil & gas, coal, power, and automotive sectors that are matched with the portfolio from 11 Indonesian banks. It is noteworthy that certain companies may fall under multiple sectors classification, as they engage in business operations across several sectors. The forward-looking production data of companies from Asset Impact are categorized according to the specific sectors in which they operate. For instance, Company A might exhibit distinct data projections for the two sectors in which it is involved, e.g., oil & gas and power. However, in some exceptional cases, we could not distinguish the use of the lending in the loan book data (i.e., whether the loan is used for their oil & gas or power activities by the company). Consequently, in this special case, a uniform loan value is applied across all sectors to which companies operate. It is crucial to acknowledge that this approach may potentially result in a double counting. However, since the number of companies under this special case is less than 10% of the sample, the plausible double counting of the data would not result in a significant deviation. The total unique companies covered in this study by sector is shown in Table 2.

Table 2. Number of Company per Sector

| Sector | Number of Company |
|---|---|
| Coal | 20 |
| Oil & Gas | 14 |
| Power | 47 |
| Both Coal and Power | 5 |
| Both Oil & Gas and Power | 3 |
| Coal, Power, and Oil & Gas | 1 |
| Automotive | 11 |
| **Total** | **101** |

Source: Authors’ Calculation

## 4. Results / Analysis

### 4.1. Technology Share and Production Trajectory Pathways Based on Scenario Data

We attempted to analyze the changes of technology share for power and automotive sectors from 2022 to 2050 using different baseline and shock scenarios data, as shown in Appendix Figure A1. In all of the target scenarios there is a decrease in the technology share of brown technology within the power sectors (i.e., coal and oil powered capacity), while green technology (i.e., renewable capacity) experiences an increase. Gas power capacity, on the other hand, is frequently considered a transitional measure since natural gas emits the least amount of carbon dioxide into the air when combusted, compared to other fossil fuels. Consequently, we observe an increase in gas power capacity in all of the target scenarios in 2050. Moreover, in the GCAM scenarios which are tailored to Indonesia's context, we note the highest increase in gas power capacity compared to the WEO (Asia Pacific) and NGFS MESSAGE (global).

On the surge of green technology in the power sector, it is noteworthy that the NGFS GCAM (Indonesia) scenarios exhibit the least increase in hydropower capacity compared to the WEO (Asia Pacific) and NGFS MESSAGE (Global). In the NGFS GCAM scenarios, the technology share of hydropower capacity is anticipated to be less than 10% in 2050, contrasting with the WEO and NGFS MESSAGE scenarios, which project a share exceeding 10%. The NGFS GCAM scenario also implies that in 2050, Indonesia's power generation is expected to be primarily dominated by gas, followed by non-hydro renewable energy (hereinafter, referred as renewable energy), and only then by hydro capacity.

For the technology share of the automotive sector under the GECO scenario, the scenario data shows that the share of electric and hybrid vehicles will increase in 2040. However, internal combustion engine (ICE) technology still dominates, albeit with a decreasing trend. This can be explained by the fact that the share of electric and hybrid vehicles in Indonesia is nearly zero in 2022. Consequently, even as the production of these two technologies multiplies over the years, their share is expected to remain below 10% by 2040. This could also be attributed to the high cost of charging infrastructure. It is essential to note, however, that we lack comparative scenarios as a robustness check for GECO. As GECO scenarios use the global based data, other providers outside the scope of the study might anticipate a higher share of electric and hybrid vehicles in the near future. Other scenario providers outside the scope of the study might anticipate a higher share of electric and hybrid vehicles in the near future. Therefore, it is crucial to develop country-specific scenarios that capture Indonesian context.

In addition to analyzing technology shares, we have examined the trajectory pathways of each sector in all baseline and target scenarios, as illustrated in Appendix Figure A2. In the WEO scenario (Asia Pacific), the results indicate that even in the baseline scenario (Stated Policies Scenario (STEPS)), both coal and oil extraction are expected to decrease by 2040. This trend is even more pronounced in the target scenario (the Sustainable Development Scenario (SDS)), which shows a significantly large decrease in both coal and oil extraction. Consistent with the earlier explanation regarding the market share of natural gas as a transitional measure, gas extraction is expected to increase under the WEO STEPS scenario. However, under the SDS scenarios, gas extraction is required to decrease, implying that even though natural gas is considered cleaner compared to oil and coal, it is still not a completely clean source of energy. In addition, gas reserve in Indonesia is projected to run out in the mid-century. Meanwhile, in the power sector, the production from renewable capacity is expected to increase in both baseline and target scenarios, with a significantly higher rate of increase observed in the target scenario (SDS). The anticipated decline in coal power capacity is evident in both scenarios; however, the extent of reduction is notably minimal under the STEPS scenario. Conversely, the SDS scenario necessitates a nearly complete elimination of coal-fired power capacity production by the year 2050. Under the SDS scenario, there is an expected phase-out of oil power capacity. Concurrently, there is a modest projected increase in hydro and gas capacity. The nuclear power capacity in the region is projected to exhibit zero generation throughout the entire period. This is attributed to the absence of any existing nuclear capacity in the region, and hence it is not expected that the region should target or build out in it. Rather, decarbonization efforts are made up from other low carbon technologies alternatives (renewables) and transition technology (gas).

In contrast to the WEO scenario, the NGFS GCAM scenario (Indonesia) reveals an increase in coal production under the baseline (Current Policies (CP)) but a sharp decrease under the target scenario (Beyond 2°C Scenario (B2DS)). This suggests that, within the specific scenario tailored for Indonesia, there is a projected steady rise in coal as an energy source based on the current policy outlook. This trend can be attributed to the operating lifetimes of coal-fired power plants, which may last for 40–60 years. It is likely that the existing coal-fired power plants will remain in use into the next few decades. The current policy outlook supporting captive coal for the industrial sector can also be attributed. Mostly to supply nickel, cobalt and aluminium smelters supporting the electric vehicle sector as well as the country's coal energy mix in 2050 suggesting to decrease to 25%.

On the other hand, oil production appears to increase until 2030, followed by a subsequent decline afterwards under both scenarios. The gas sector exhibits an increase in production until the 2040s, followed by a sharp decrease towards 2050. The changes in production in the power sector align with those in the WEO scenario.

Lastly, the NGFS MESSAGE (Global) scenario results in an extreme decrease in the production of coal and oil under the target scenario, signifying that under this scenario coal and oil will be phased out completely by 2050. Similar to NGFS GCAM, the gas sector shows an increase until 2040, followed by a gradual decrease towards 2050 under the B2DS scenario. The power sector under NGFS MESSAGE scenarios behave more or less the same way as the projection under the WEO and NGFS GCAM scenario. It is worth noting that gas technology behaves differently across scenario providers, even for scenarios with similar climate ambition. Specifically, WEO SDS foresees gas technology to steadily decrease over the time horizon. In the case of GCAM scenarios however, they project an increase in gas for certain regions until the mid-century, and only then a further decrease in the technology until 2100. In our model, we cover only the first half of the century until 2050, and thus the decarbonization happening in the later stages is not captured. The likely reason for GCAM assumption about gas technology being on the rise is that the scenario provider treats gas as a transition technology in the Indonesia specific geography. Gas is assumed in GCAM to be a cleaner technology than Oil or Coal and GCAM expects strong economic, social and demographic growth in Indonesia with increased demand for energy which will be covered by Gas rather than Oil or Coal. The reason why Gas is increasing for one scenario and decreasing for another scenario provider, is driven by heterogeneity in key assumptions of the Integrated Assessment Models. It can also be impacted by data availability on regional granularity.

## 4.2. Descriptive Analysis

The dataset contains credit data from 1,567 observations across the four sectors and eleven banks in December 2022. Table 3 shows the loan value per sectors and banks for each non-automotive and automotive sector and Table A4 in Appendix shows the weighted average maturity of each sector's and each bank's loan.

Table 3. Number of Observation and Total Loan Value

| Bank / Sector | Coal | | Oil&Gas | | Power | | Automotive | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Obs | Value (USD) | Obs | Value (USD | Obs | Value (USD) | Obs | Value (USD) | Obs | Value (USD) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Bank A** | 11 | 430,048,352 | 1 | 128,081,976 | 42 | 1,222,488,192 | 2 | 2,576,140 | 56 | 1,783,194,660 |
| **Bank B** | 6 | 430,081,856 | 1 | 114,650,176 | 5 | 549,565,504 | - | - | 12 | 1,094,297,536 |
| **Bank C** | 4 | 198,883,440 | - | - | 31 | 516,700,320 | - | - | 35 | 715,583,760 |
| **Bank D** | 30 | 1,234,380,032 | 13 | 149,371,952 | 208 | 3,843,897,600 | - | - | 251 | 5,227,649,584 |
| **Bank E** | 29 | 435,759,040 | 663 | 366,773,440 | 160 | 2,042,431,104 | 1 | 576,369 | 853 | 2,845,539,953 |
| **Bank F** | 1 | 29,875,510 | 4 | 36,530,308 | 7 | 192,172,128 | - | - | 12 | 258,577,946 |
| **Bank H** | 3 | 8,174,168 | 2 | 96,061,480 | 11 | 319,981,344 | - | - | 16 | 424,216,992 |
| **Bank I** | 12 | 597,404,480 | 3 | 14,638,395 | 56 | 2,198,653,440 | - | - | 71 | 2,810,696,315 |
| **Bank J** | 8 | 135,956,976 | 2 | 96,061,480 | 212 | 474,788,992 | - | - | 222 | 706,807,448 |
| **Bank L** | - | - | 2 | 41,784,272 | - | - | - | - | 2 | 41,784,272 |
| **Bank M** | 1 | 37,166,644 | - | - | 12 | 195,890,784 | - | - | 13 | 233,057,428 |
| **Bank N** | - | - | | - | | - | 6 | 124,185,240 | 6 | 124,185,240 |
| **Bank O** | - | - | | - | | - | 3 | 72,589,136 | 3 | 72,589,136 |
| **Bank P** | - | - | | - | | - | 3 | 49,863,384 | 3 | 49,863,384 |
| **Bank Q** | - | - | | - | | - | 1 | 24,923,952 | 1 | 24,923,952 |
| **Bank R** | - | - | | - | | - | 1 | 29,908,742 | 1 | 29,908,742 |
| **Bank S** | - | - | | - | | - | 1 | 29,908,742 | 1 | 29,908,742 |
| **Bank T** | - | - | | - | | - | 1 | 14,954,371 | 1 | 14,954,371 |
| **Bank U** | - | - | | - | | - | 2 | 8,352,583 | 2 | 8,352,583 |
| **Bank V** | - | - | | - | | - | 6 | 6,417,580 | 6 | 6,417,580 |
| **Total** | 105 | 3,537,730,498 | 691 | 1,043,953,479 | 744 | 11,556,569,408 | 27 | 364,256,238 | 1,567 | 16,502,509,623 |

Source: Authors' Calculation, Notes: Bank D, E, and I are state-owned banks

The table shows that banks' portfolios have the highest exposure to the power sector compared to other sectors covered in the study, even though companies in the oil & gas sector have a greater quantity of loans to the banks. This suggests that banks provide higher amounts of loans to companies in the power sector. However, coal sector has the longest weighted-average maturity.

The table also shows that two out of three state-owned banks, which includes Bank D and E have extended the biggest loans to the coal, oil & gas, and power sectors compared to other banks in the sample. In contrast, companies from the automotive sector mostly obtain loans from Japanese-owned banks. However, Bank N, a subsidiary of a Japanese-owned bank, distributes the majority of loans to automotive companies. This could be attributed to the fact that many companies in the automotive sector are Japanese-owned, while companies in non-automotive sectors are predominantly state-owned and national companies.

With a significant portion of loans concentrated in a few banks, these banks may face higher financial risk stemming from the climate transition risk. Banks that are most affected are likely to be those with the highest exposure in carbon-intensive activities. However, due to data limitations, we could not specify which loans are used for investing in brown or green technology. However, it is important to note that the companies under these sectors are exposed to climate transition risk regardless of the activities that the banks finance.

Table 4. Data Ratio Per Bank and Per Sector

| Bank | Share of sectoral sample's portfolio over sectoral bank's portfolio | | | | Share of banks sectoral exposure over total individual bank's portfolio | | | | Share of total samples' of select 4 sectors over bank's total portfolio |
|---|---|---|---|---|---|---|---|---|---|
| | Coal | Oil&Gas | Power | Automotive | Coal | Oil&Gas | Power | Automotive | |
| **Bank A** | 92.12% | 47.58% | 95.46% | 46.22% | 1.50% | 0.86% | 4.11% | 4.01% | 5.72% |
| **Bank B** | 95.13% | 95.31% | 99.49% | - | 19.90% | 5.30% | 24.31% | - | 48.17% |
| **Bank C** | 96.58% | - | 98.12% | - | 2.69% | - | 6.88% | - | 9.35% |
| **Bank D** | 47.41% | 7.19% | 80.52% | - | 6.20% | 4.95% | 11.37% | - | 12.45% |
| **Bank E** | 45.46% | 22.73% | 92.79% | 47.64% | 3.33% | 5.60% | 7.64% | 2.73% | 9.88% |
| **Bank F** | 72.71% | 43.21% | 94.73% | - | 0.63% | 1.30% | 3.11% | - | 3.97% |
| **Bank H** | 20.42% | 50.45% | 94.98% | - | 0.64% | 3.07% | 5.42% | - | 6.83% |
| **Bank I** | 58.19% | 3.17% | 87.36% | - | 6.12% | 2.75% | 15.00% | - | 16.75% |
| **Bank J** | 74.70% | 66.99% | 90.34% | - | 4.07% | 3.20% | 11.74% | - | 15.79% |
| **Bank L** | - | 95.95% | - | - | - | 1.53% | - | - | 1.47% |
| **Bank M** | 85.52% | - | 91.00% | - | 0.83% | - | 4.11% | - | 4.45% |
| **Bank N** | - | - | - | 75.84% | - | - | - | 3.50% | 2.65% |
| **Bank O** | - | - | - | 100% | - | - | - | 1.52% | 1.52% |
| **Bank P** | - | - | - | 100% | - | - | - | 5.26% | 5.26% |
| **Bank Q** | - | - | - | 92.23% | - | - | - | 1.70% | 1.57% |
| **Bank R** | - | - | - | 86.71% | - | - | - | 1.30% | 1.13% |
| **Bank S** | - | - | - | 14.67% | - | - | - | 1.72% | 0.25% |
| **Bank T** | - | - | - | 12.31% | - | - | - | 1.02% | 0.13% |
| **Bank U** | - | - | - | 1.19% | - | - | - | 0.70% | 0.003% |
| **Bank V** | - | - | - | 2.32% | - | - | - | 0.09% | 0.001% |

Source: Authors' Calculation

Table 4 shows how our sample and the sectoral credit data represent the overall Indonesian banks' credit data. For the non-automotive sectors, especially in the power sector, most of the sample portfolio data represents the sectoral portfolio data of each bank. However, the sectoral data of each bank is relatively small compared to the total of each banks' portfolio, except for Bank B.

### 4.3. TRISK Stress Test Results: Expected Loss and Probability of Default

Table 5 below summarizes the average change of PD for companies within the portfolios of the 13 Indonesian banks, categorized by sector. In summary, using the average increase of PD, excluding outlier scenarios, the coal sector exhibits the highest increase in PD (45.2%), followed by power (41.5%), oil & gas (0.1%), and, lastly, automotive (0.05%). The change in PD in the automotive sector shows a notably low increase, as the GECO scenario still expects high production of ICE vehicles in the next decade, hence it does not seem to impact the portfolio significantly. Different scenario providers might show different results. However, due to limitations in the available scenarios for the automotive sector that have been translated into the TRISK methodology, we are unable to provide a comparative analysis with other scenarios for the automotive sector.

The change in PD in the Oil & gas sector is also notably lower, due to the fact that in this exercise, loan and PD for oil and gas extraction activities are calculated together, due to the loan book data categorization. Most companies in the oil & gas dataset also show that the same companies are involved in both oil & gas extraction. The expected increase in gas extraction as transitional measures might counteract the high increase in PD in the oil sector, resulting in a very low change in oil & gas PD.

It is worth noting that some scenarios yield notably different results compared to others. For instance, the NGFS_GCAM_NZ scenario, which takes into account Net Zero 2050 Indonesia's carbon price market assumption in the model, shows a high spike in the change of PD for the oil & gas sector. This implies that if Indonesia were to adopt the carbon price needed to achieve Net Zero 2050, both gas and oil would have to be phased out. With this in mind, we propose to focus on the average change in PD, excluding this outlier scenario.

Table 6 shows the aggregated additional expected loss for the 13 banks across different sectors. Although the highest change in PD is observed in the coal sector, the highest additional expected loss is observed in the power sector. This is due to the large exposure that the banks have in the power sector.

Table 5. Summary of Average Change of PD Across Sectors

| **Scenario** | **Geography** | **Shock year** | **Coal Average Change of PD** | **Oil & Gas Average Change of PD** | **Power Average Change of PD** | **Auto Average Change of PD** |
|---|---|---|---|---|---|---|
| WEO | Asia Pacific | 2030 | 11.3% | 0.5% | 43.1% | N/A |
| NGFS MESSAGEix | Global | 2030 | 61.6% | 0.0% | 39.6% | N/A |
| NGFS GCAM | Indonesia | 2030 | 49.5% | 0.0% | 39.9% | N/A |
| NGFS_GCAM_Shock1 | Indonesia | 2025 | 25.5% | 0.0% | 38.9% | N/A |
| NGFS_GCAM_Shock2 | Indonesia | 2030 | 49.5% | 0.0% | 39.9% | N/A |
| NGFS_GCAM_Shock3 | Indonesia | 2035 | 50.2% | 0.0% | 40.6% | N/A |

| Scenario | Geography | Shock year | Coal Average Change of PD | Oil & Gas Average Change of PD | Power Average Change of PD | Auto Average Change of PD |
|---|---|---|---|---|---|---|
| NGFS_GCAM_NZ | Indonesia | 2030 | 62.7% | 53.7% | 50.1% | N/A |
| NGFS_GCAM_NDC | Indonesia | 2030 | 51.1% | 0.0% | 40.0% | N/A |
| GECO | Global | 2030 | N/A | N/A | N/A | 0.05% |
| Average of PD_diff excluding outlier scenario | | | 45.2% | 0.1% | 41.5% | 0.05% |

Source: Authors' Calculation, Notes: The grey coloured figure is an outlier that behave differently from other scenarios

Table 6. Summary of Additional Expected Loss Across Sectors

| Scenario | Geography | Shock year | Coal EL (USD) | Oil & Gas EL (USD) | Power EL (USD) | Auto EL (USD) |
|---|---|---|---|---|---|---|
| WEO | Asia Pacific | 2030 | 40,029,541 | 1,265,666 | 948,790,114 | N/A |
| NGFS MESSAGEix | Global | 2030 | 210,057,164 | 23,951 | 870,489,585 | N/A |
| NGFS GCAM | Indonesia | 2030 | 169,131,142 | 13,629 | 877,686,125 | N/A |
| NGFS_GCAM_Shock1 | Indonesia | 2025 | 88,073,949 | 13,607 | 855,634,579 | N/A |
| NGFS_GCAM_Shock2 | Indonesia | 2030 | 169,131,142 | 13,629 | 877,686,125 | N/A |
| NGFS_GCAM_Shock3 | Indonesia | 2035 | 171,577,714 | 13,640 | 892,614,799 | N/A |
| NGFS_GCAM_NZ | Indonesia | 2030 | 213,479,880 | 135,058,986 | 1,101,139,838 | N/A |
| NGFS_GCAM_NDC | Indonesia | 2030 | 174,611,327 | 18,498 | 878,786,170 | N/A |
| GECO | Global | 2030 | N/A | N/A | N/A | 10,310,317 |
| Average of EL excluding outlier scenario | | | 154,511,482 | 194,660 | 912,853,417 | 10,310,317 |

Source: Authors' Calculation, Notes: The grey coloured figure is an outlier that behave differently from other scenarios

Figure 2 shows the additional expected loss resulting from the transition risk shock per sector and per bank. The higher the expected loss value of a bank's portfolio, the higher the risk of loss faced by the bank if it is exposed to the climate transition shocks. The average PD under baseline, shock and the difference between the two for each scenario are shown in Appendix Figure A3. The higher PD of a bank’s portfolio, the higher risk of default faced by banks if it is exposed to the climate transition shocks.

Based on the figures, by comparing the expected loss result under baseline and shock, the expected loss in the IEA WEO scenario, NGFS GCAM scenario, NGFS MESSAGE scenario, and GECO scenario shows that the majority of the banks have significantly increasing expected loss for all sectors. From all sectors, banks that give loans to the power sector have the highest magnitude of increase in expected loss. This can be explained by the high loan exposure the banks have on the power sector. Meanwhile, banks that give loans to oil & gas companies have the lowest increase in expected loss. In the NGFS GCAM scenario, with and without a shock year and carbon price model, the increase of expected loss of banks in the oil & gas sector is even smaller. This is likely due to the fact that the oil & gas sector bundles both oil and gas extraction—while oil extraction is a technology predicted to be at risk of climate transition, gas, in the context of the Indonesian economy, is a technology that the climate scenario project to benefit from climate transition due to its lower emissions’ intensity. The positive production shock on gas therefore offsets any drop in the oil technology production. In the GECO scenario for the automotive sector, the expected loss of the banks is also increasing although the magnitude is not as high as in other sectors.

For the sensitivity analysis in Indonesia's context, this study modifies NGFS GCAM scenarios with several configurations: adding different shock years, NDC carbon model, and NZ2050 carbon model. We find the results are not significantly different. Under the NZ2050 carbon price model, the expected loss of banks in the oil & gas sector is significantly higher. In the model where we introduced shock years, the result also shows an increase in all three shock years. However, the increase is not considerably high.

The significant increase in expected loss can be attributed to the change in probability of default (PD). The most substantial increase in PD is observed in banks that provide loans to the power sector in most scenarios, consistent with the expected loss result. Conversely, a slight decrease is observed in the oil & gas sector, particularly in the NGFS GCAM scenario, NGFS GCAM with three different shock years, and NGFS GCAM with NDC carbon price model.

The expected loss results of under the baseline scenario in all scenarios and model configurations reveal that Bank E, Bank L, Bank H, and Bank P have the highest expected loss values in the coal, oil & gas, power, and automotive sectors, respectively. Specifically, in the coal sector, Bank E (a state-owned bank) demonstrates the highest expected loss compared to all banks across all sectors. Interestingly, the total loan value of those banks mentioned above (B, E, L, H, and P) are not the highest, we suspect that the elevated number is due to the high change of PD for companies obtaining loans from those banks. However, in the automotive sector, we observe that Bank Q, R, and T have the highest average PD.

In comparison to the coal, oil & gas, and power sectors, banks providing loans to companies in the power sector exhibit relatively high expected losses in all scenarios. However, the bank with the highest expected loss varies across scenarios and configurations. In the WEO scenario, it is evident that banks providing loans to the power sector experience the highest expected loss compared to banks in other sectors. Specifically, Bank D has the highest expected loss among all banks. In the NGFS GCAM scenario, NGFS GCAM scenario with shock years, and NGFS GCAM scenario with NDC carbon price model, Bank I registers the highest expected loss. This finding differs from the NGFS GCAM scenario with the NZ2050 carbon price model, which indicates that Bank D has the highest expected loss. The NGFS MESSAGE scenario also points to Bank I having the highest expected loss. Meanwhile, in the GECO scenario for the automotive sector, Bank P shows the highest expected loss. Certainly, the outcomes are largely influenced by the magnitude of the banks' exposure to the sector. However, it will be a worthy exercise to further investigate the PD changes of the individual companies to find the best in class and worst performing companies within a sector for further risk management strategies.

When contrasting the PD under baseline and shock scenarios, the PD differences exhibit a more diverse range of results across the scenarios. In the WEO scenario and NGFS GCAM scenario with the NZ2050 carbon model, all expected loss values are positive. Notably, banks extending credit to the power sector tend to incur higher expected losses, with Bank D registering the highest expected loss among all banks. In the NGFS GCAM scenario, specifically in scenarios with shock years and the NDC carbon price model, positive expected loss values are observed for banks involved in loans to the coal and power sector. Conversely, banks extending loans to the oil & gas sector show negative expected loss values. When comparing all banks and sectors, Bank I, operating in the power sector, records the highest expected loss. In the NGFS MESSAGE scenario, only Bank L in the oil & gas sector displays a negative expected loss value, suggesting a potential resilience to losses in the face of the transition. The overarching pattern reveals that banks providing loans to the power sector tend to exhibit higher expected loss values, with Bank I standing out with the highest expected loss. Turning to the GECO scenario for the automotive sector, Bank P continues to hold the highest expected loss value compared to all other banks.

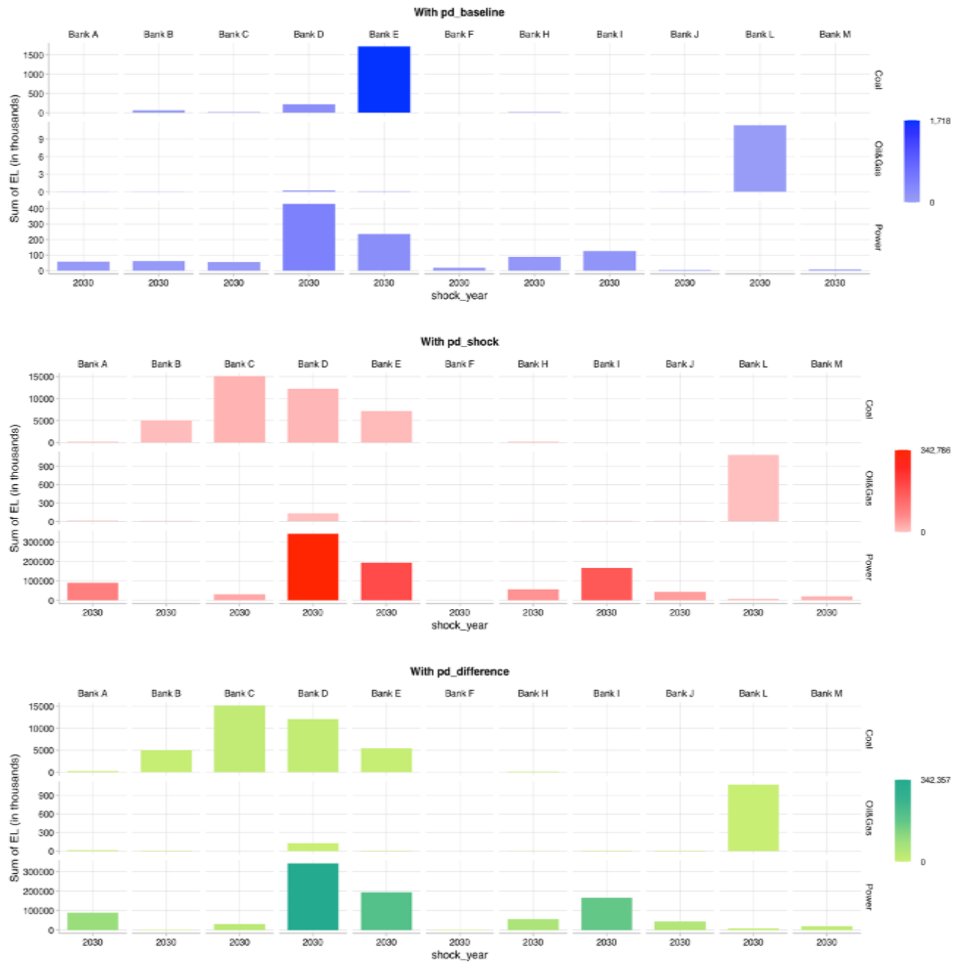
Meanwhile, the average PD under PD difference shows that, in the majority of scenarios, banks providing loans to the coal sector have higher change of PD compared to other sectors. From the figures, Bank C, which distributes loans to coal companies, has the highest change of PD compared to other banks. The NGFS GCAM, both with and without the configurations, as well as the NGFS Message scenarios show the significant increase of average PD in coal and power sector.

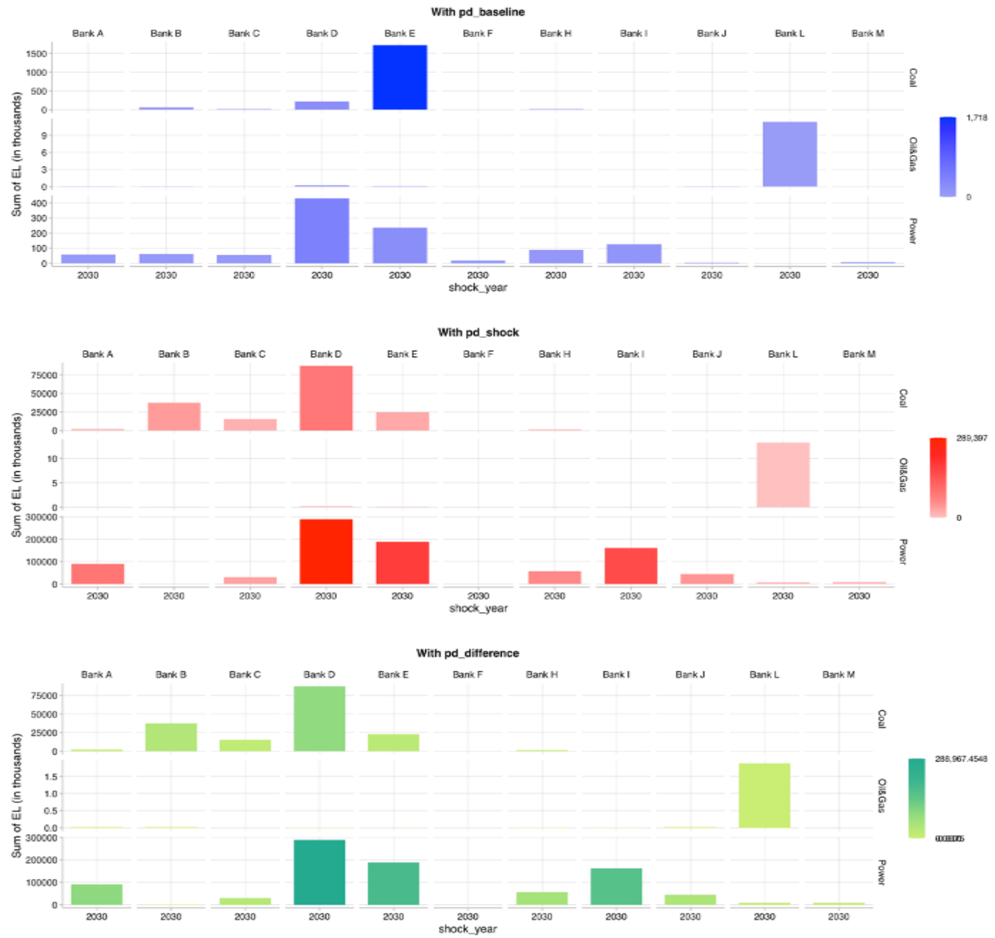
### 4.4. Discussion

Based on our findings, we have identified two primary concerns: the coal sector, which exhibits the highest PD difference, and the power sector, where the largest expected losses are observed. This can be attributed to climate transition risk, particularly in the context of planning for a coal phase-out. The term "phasing out coal" refers to policies and efforts aimed at gradually reducing or discontinuing the use of coal as an energy source, ultimately reducing Indonesia's reliance on coal-fired power plants. This initiative aligns with the core effort to meet global climate agreement targets outlined in the Paris Agreement. Moreover, during COP26, Indonesia committed to transitioning away from unabated coal power generation by the 2040s or sooner. In contrast, there is currently a less robust commitment to phasing out the oil and gas sector, with natural gas still being considered a viable alternative for transitioning, primarily due to its recognition as the "cleanest" fossil fuel.

WEO Scenario

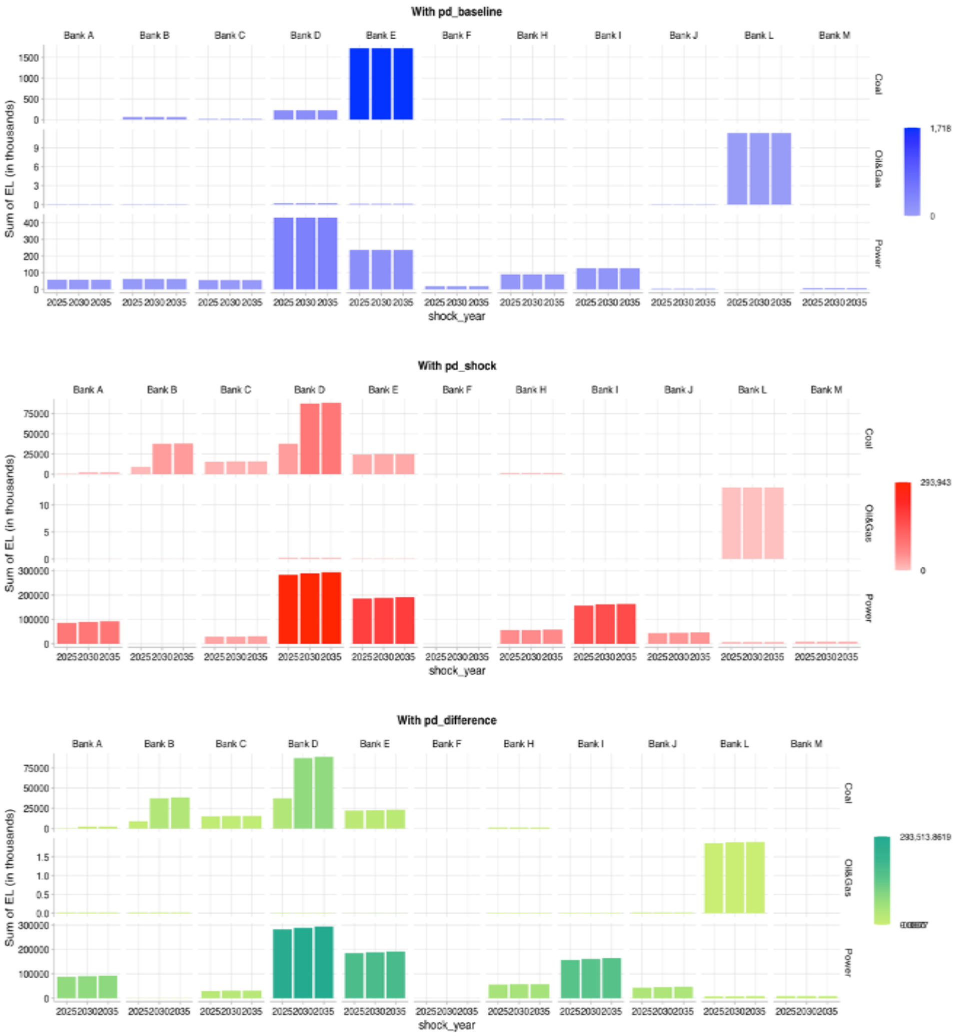
NGFS GCAM Scenario



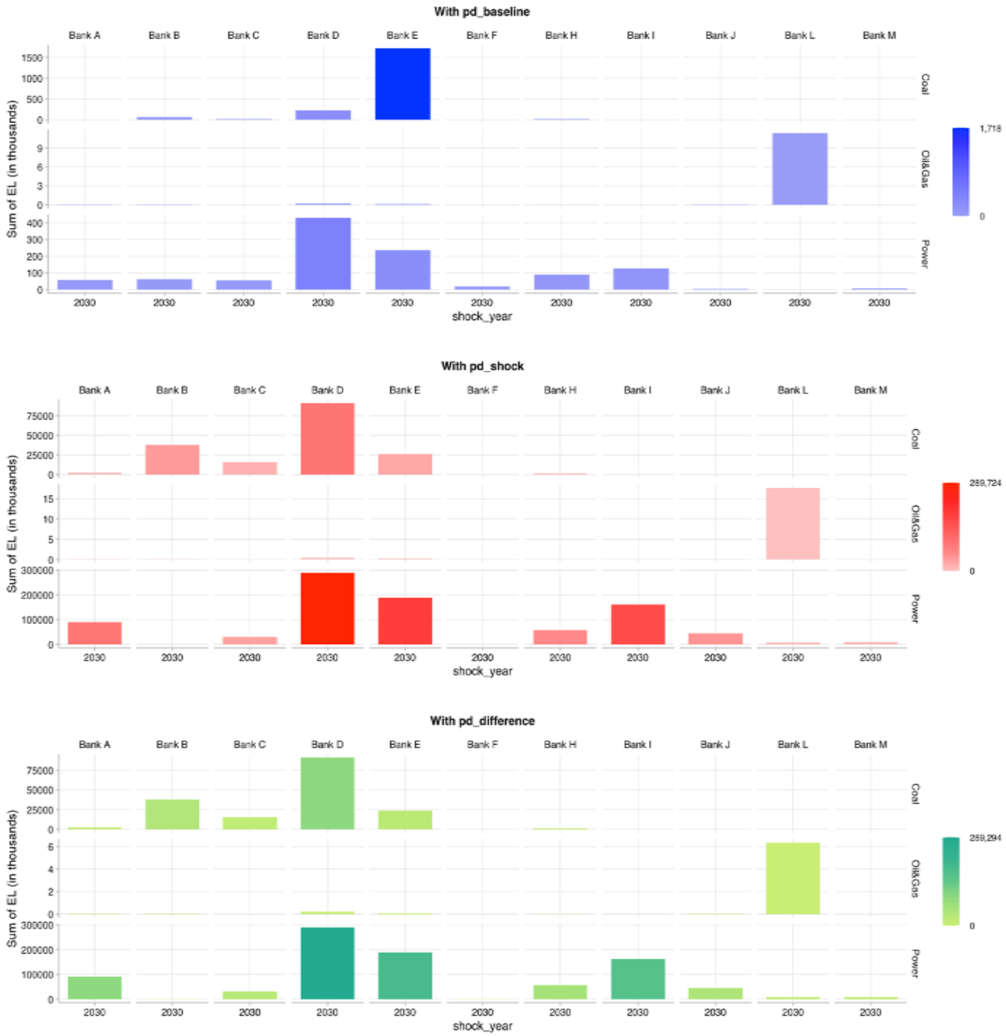




NGFS GCAM Scenario with Shock Years

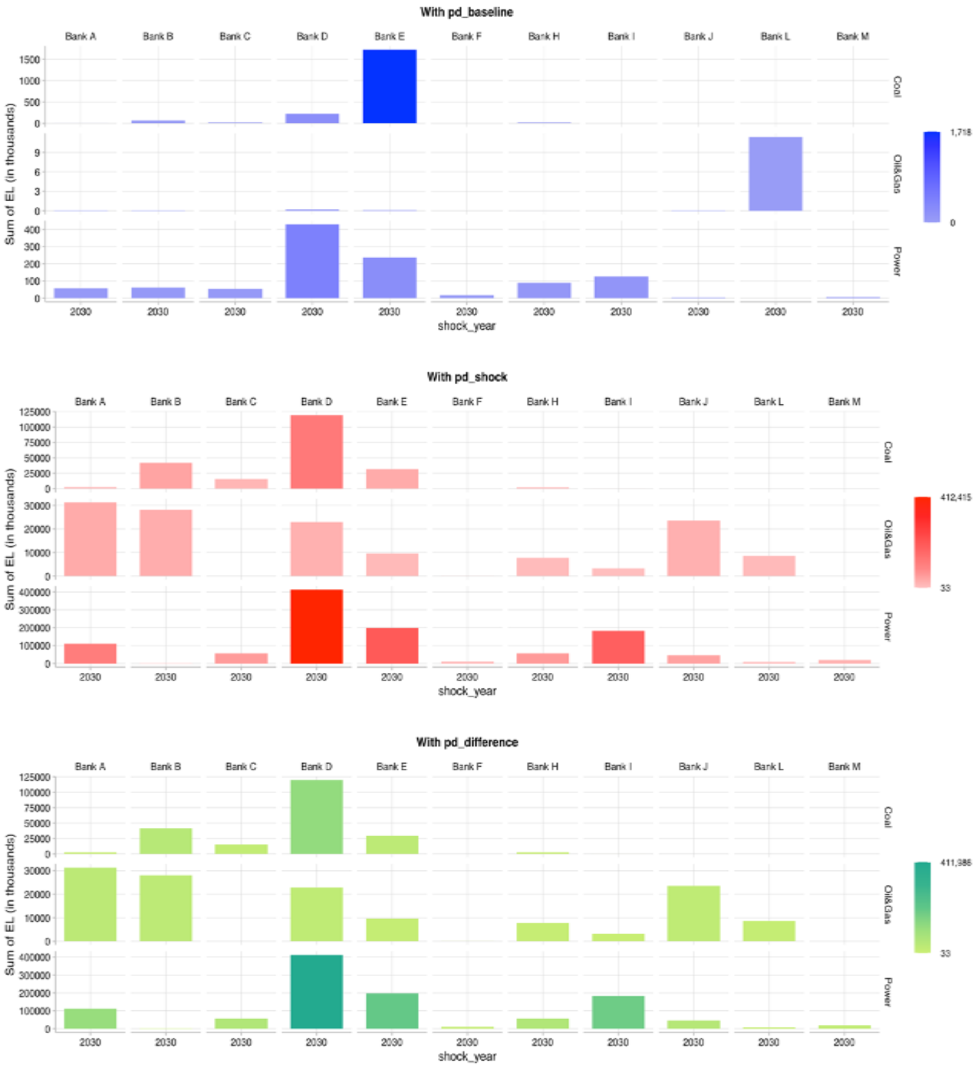
NGFS GCAM Scenario with Carbon Price NDC Model

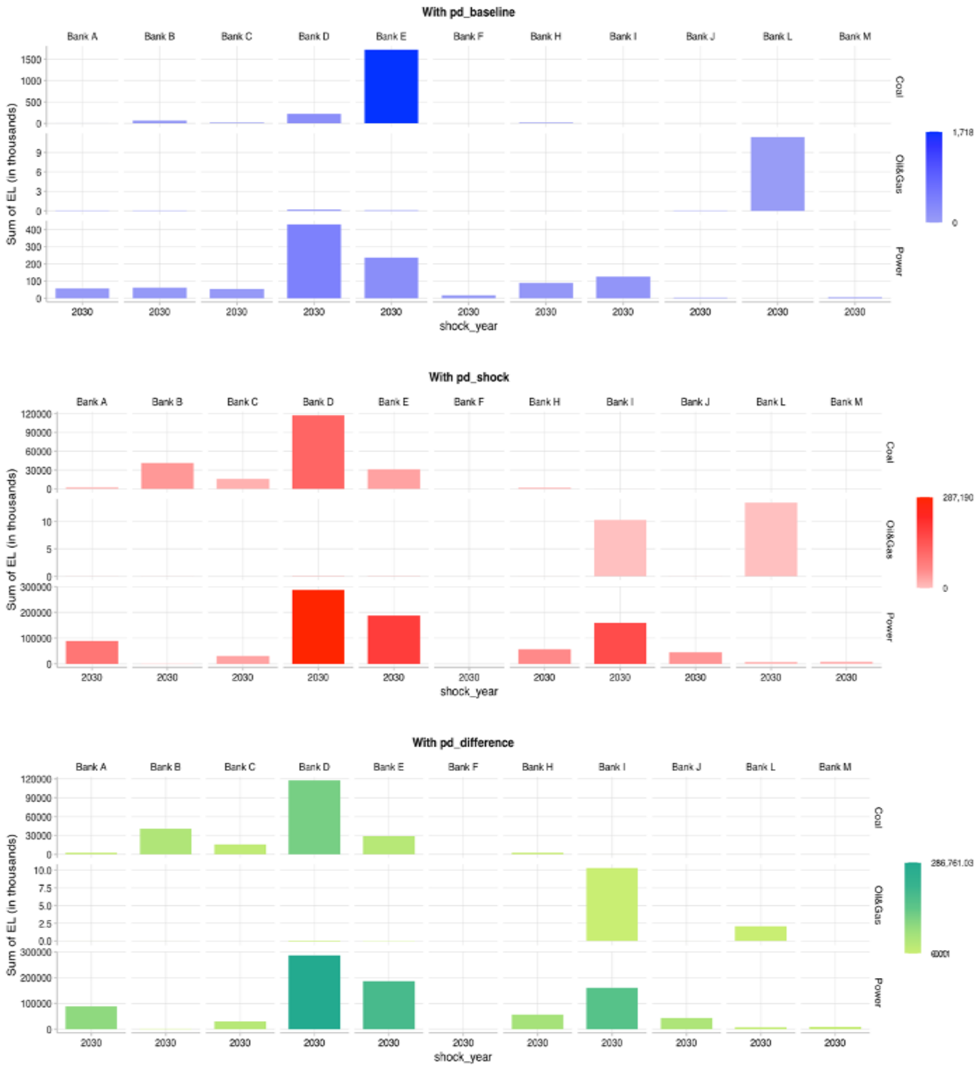



NGFS GCAM Scenario with Carbon Price NZ2050 Model




NGFS Message Scenario




GECO Scenario

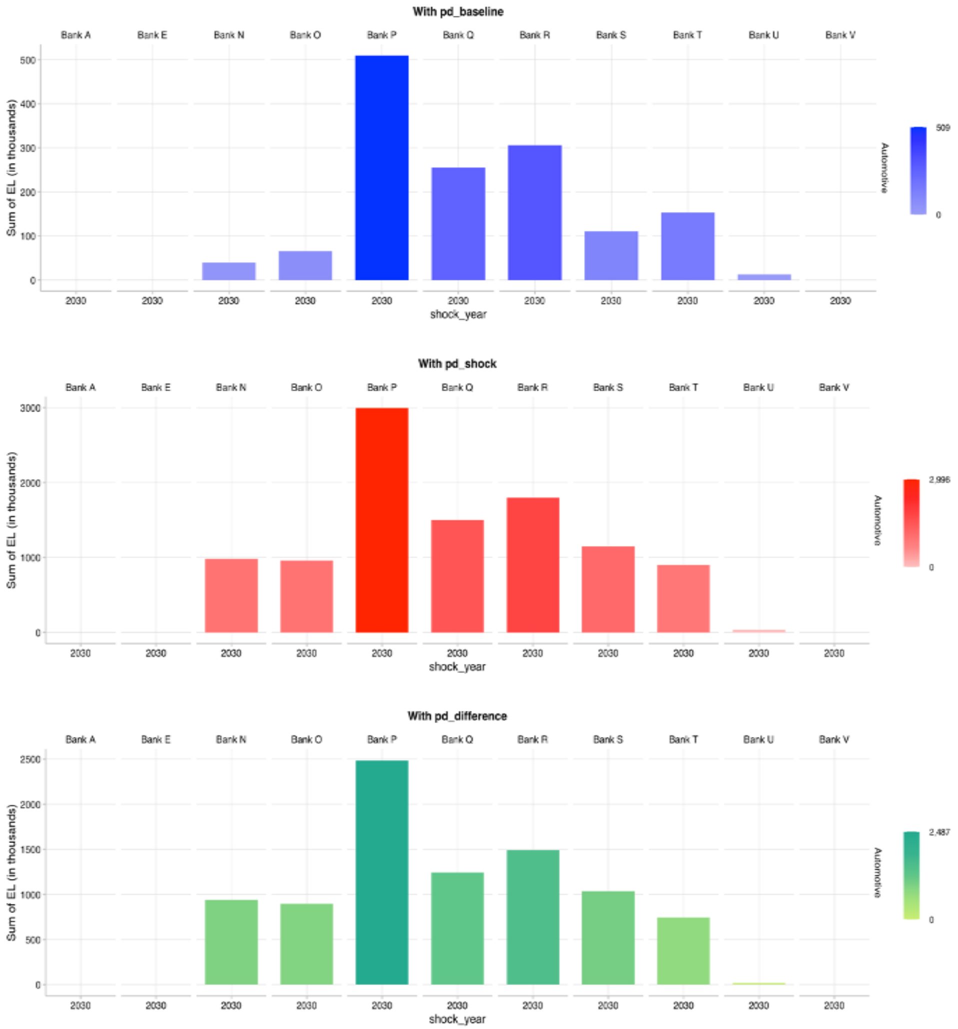



Figure 2. Expected Loss per Sector and Banks

This coal transition plan makes coal become less economically viable which in turn makes coal companies may experience reduced profitability. Additionally, the early implementation of the carbon tax is linked to higher production costs. The conjunction of reduced revenue due to low demand and increased costs will undermine their profitability. Declining profitability may pose challenges for coal companies in generating adequate cash flows to cover operational expenses, debt service, and other financial commitments. This, in turn, creates more difficult conditions for meeting financial obligations, including loan repayments. Consequently, the probability of default on loans in the coal sector is expected to increase.

This coal phase-out also seems responsible for the high expected loss of the power sector. As coal becomes less economically viable due to environmental regulations and climate policies, power companies reliant on coal-fired electricity production may face higher production costs and reduced profitability. In addition, as governments and regulatory bodies worldwide increasingly introduce carbon pricing mechanisms, such as carbon taxes, power companies emitting high levels of greenhouse gases may face additional costs. This imposition can significantly impact their financial health and escalate the expected loss on loans extended to them.

Furthermore, with the accelerating transition to cleaner energy sources, coal mining companies and power companies heavily invested in coal-based infrastructure face the risk of stranded assets. The shift toward cleaner energy sources, including renewables, may necessitate substantial capital investments in new technologies and infrastructure, straining the financial resources of both companies. These factors collectively elevate financial risk and contribute to increase in probability of default and a higher expected loss on loans to companies within the coal mining and power sector.

Additionally, the forced shutdown of coal companies can have detrimental effects on the local economy, posing the risk of sudden large-scale layoffs affecting thousands of employees and local businesses. This underscores the crucial role of banks, including central banks, in financing economic transitions and supporting the sectoral rebalancing process.

This finding is also relevant as Indonesia is a large producer and exporter of fossil fuels, primarily coal. We identified similar findings to previous research in the context of other coal exporters. For instance, Wang et al. (2022) that there is a significant impact observed in coal power company' profitability due to trillions of stranded assets as a result of the transition in China which further affects the company's cash flow and subsequently to the credit default risk. Research in Australia, (APRA, 2022) also found an aggregate increase in lending losses which most dominantly affected the mining sector in a delayed transition scenario. As the Bank responds to these potential losses, they estimate a reduction of 90% of coal mining exposure as a result of the transition. Further, a study in Colombia utilized a delayed scenario with the highest GHG reduction target of 51% in 2030, revealing that banking sectors are affected to transition which resulted in substantial losses (Reinders et al., 2021).However, they also noted that Banks in Colombia have publicly communicated that there will be a reduction in their exposure to coal-related activities to zero over the coming decades. It highlights that as coal exporters, they have taken urgent actions to address the potential implications to the banking sector. Therefore, following that regard, Indonesia may need to take a serious pathway and strategies upon the potential impact arising from transition to a lower carbon economy in financial stability.

## 5. Implication / Policy Recommendation

Given the identified potential implications in financial instability arising from climate transition risk, this study reveals, under the NGFS GCAM scenario for Indonesia, there will be an increase in coal production if Indonesia continues to adhere to its current policies. This indicates a projected steady rise in coal as an energy source based on existing policies. Therefore, if key stakeholders persist in endorsing a non-Paris-aligned approach, it poses a substantial risk due to the anticipated increase in high-emission production.

For instance, if the central bank incentivizes financing for the coal value-added processes sector, it may encourage firms to boost their coal production. These potential implications need to be taken into account by regulators in order to refine the current green taxonomy development. Consequently, it is imperative for the policy maker to provide a more explicit and concise directive toward adopting a Paris-aligned framework. This, in turn, will guide financial institutions and corporations to conduct their business plans in a clearer direction.

This study serves as an early warning signal for key stakeholders to follow up with necessary actions. Therefore, considering the research and the conclusions drawn from our analysis, we put forth the following recommendations:

1. **Macroprudential**
    a. Reinforcing the Paris-aligned macroprudential framework and instruments such as **enhancing current macroprudential policy instruments to incentivize more financing towards low carbon emissions activities, and disincentivize financing towards high emitting activities**. Bank Indonesia has issued an incentive mechanism linked to reserve requirement secondary policy in 2023, similar measures can also be applied to disincentivize banks to mitigate harmful transition risks. In addition, disincentivizing can also limit bank's concentration of their portfolio on activities and sectors that are most exposed and vulnerable to climate transition.
    b. In line with the central bank's role in analysing and providing signals of the potential systemic risk, it's essential for Bank Indonesia to **conduct an analysis of the potential systemic risks that may arise due to an increased probability of default** within banks' portfolio due to climate transition risks as outlined in this study. This is important to understand the interconnectedness and complexity of banks' financial systems.
    c. **Set a higher capital and liquidity requirements for high-risk activities.**
    Macro prudential policies should act as a complement to impactful micro-prudential measures, particularly in implementing a capital buffer for banks heavily exposed to the high-emitting industries. Recognizing the potential increase in credit risk, financial institutions with portfolio exposure in these sectors need to be prepared with adequate

capital when extending lending and investment to these activities. As the additional capital serves as a financial cushion to absorb potential losses that may arise from the transition risk, therefore the necessity to set a higher capital buffer needs to take their current credit risk profile into consideration. WWF has formulated a list of 'Always Environmentally Harmful' activities, as outlined in their Central Banking and Financial Supervision Roadmap. This list serves as a valuable reference for this purpose.

**2. Micro-prudential Supervision**

Establish supervisory requirements for financial institutions to govern their climate risk management. These requirements serve as a framework to ensure that banks have well-defined and comprehensive strategies in place to address the evolving challenges posed by climate change, such as:

a. Following the science behind the climate scenario models that this study showcases, **the high emitting sectors** (coal, oil, coal fired power generation, oil power generation, and ICE vehicle manufacturing) **should be designated as unsustainable or non-eligible in the national green taxonomy classification**. In particular, coal extraction and coal fired power generation have been identified as having the **potential to significantly increase the probability of default (PD) and the expected loss of banking institutions**.

**b. Implement concentration limits on high-risk sectors.**
Financial institutions should, at some point, manage the concentration of their portfolio so as not to be overly exposed to activities and sectors that are most exposed and vulnerable to climate transition. In pursuit of this, financial supervisors can establish explicit maximum limits for credit provision (BPMK) specific to ensure that financial institutions do not take excessive risk associated with climate-related transition.

**c. Adopting credit and financing restructuring policy for banks impacted by the transition risk.**
In essence to prepare a financial relief, regulators may take a proactive approach by adopting credit and financing restructuring policy for banks struggling by this transition. By adjusting the terms of existing loans of high-emitting companies in implementing their transition plans to make them more manageable to ease the financial burden. Through this policy, banks might avoid a substantial increase in their non-performing losses due to rising credit risk.

d. **Set climate-related minimum criteria for issuing loans integrated with due diligence and credit risk modelling processes.** In cases where a company or sector (i.e. the fossil fuel industry) carries significant transition risks, banks have the option to abstain from granting loans or even divest from such entities[1]. Additionally, banks can also raise borrowing costs for investments associated with higher transition risks.

e. **Set climate target setting and develop comprehensive transition plans.** Financial institutions should be expected to set credible climate targets and issue a transition plan to contribute to the national net zero target. Concurrently, it's equally important for financial institutions to assess the transition plans of their clients, making sure the financial flows are directed to activities that contribute to a low-carbon economy.

f. **Conduct client engagement to influence their business plans.** This engagement involves a multifaceted approach, including raising awareness among clients, providing financial support such as offering lower borrowing costs for sustainable projects or creating specialized financial products tied to sustainability goals. Additionally, technical assistance can be extended to clients to help them develop transition strategies tailored to their business.

3. **Monetary policy and central banking activities**

   a. **Utilize all monetary policy instruments to enhance overall contribution to the goal of limiting global warming to 1.5°C**. As the monetary policy mandate is to achieve price stability, the monetary policy instrument cannot directly be used to minimize the risks of banking portfolio through targeting finance towards sectoral business, yet they can help to ensure adequate liquidity in the banking system in case of the possible credit losses occurred due to transition risk. Therefore, while the role of monetary policy is not linked directly to mitigate the potential credit risk in banking portfolio, these instruments such as asset purchase programs, collateral framework, foreign exchange reserve management, and adjustment of reserve requirement could help contribute to limiting 1.5-degree warming, and hence indirectly mitigating the risks posed by the banks and the real economy.

   b. **Set up a dedicated green refinancing fund to support climate action by incentivizing and directing financial institutions toward environmentally sustainable and climate-friendly activities.** The People Bank of China through the relending program has disbursed $41bn to provide cheaper funding to banks for green projects and at the same time promotes information disclosure by lenders. Bank of Japan in 2021 rolled out a funding scheme of a total $26bn of zero-interest loans targeting activities aimed at combating climate change.

4. **Climate scenario analysis & stress testing design**

   a. **Integrate climate stress testing to the regular stress testing under the financial stability review by the Central Bank as well as part of the Financial Sector Assessment Program (FSAP).** Currently the climate risk stress test is not an integral part of the regular stress tests as well as the FSAP. However, it is really important to conduct this climate stress test on a regular basis and make it part of the regular supervisory monitoring reviews to inform the supervisors about the potential magnitude of climate-related risks in their jurisdictions and help deepen the understanding of the transmission channels from climate-related risks to the financial system.

   b. **Improve climate stress testing models for a more accurate evaluation of climate risks.** Many current stress testing models underestimate the actual impact of climate change, potentially creating a misleading sense of security among institutions and policymakers who rely on these models for an all-encompassing risk assessment. Climate risk modelling should continuously be improved as the methodologies and data used to analyse these risks mature over time and analytical gaps are addressed, enabling a more accurate analysis. On top of this, policymakers should translate the results derived from the exercise into the capital framework, concentration limit, and other tangible supervisory requirements (WWF, 2023).

c. **There is a pressing need to conduct further analyses that encompass both transition risk and physical risk.** Achieving a more effective risk management strategy requires a comprehensive understanding of the overall climate-risk exposure to the financial sector. This underscores the importance of assessing both climate-related risks—transition risk and physical risk in future climate stress testing or scenario analysis exercise.

d. **Further conducting estimation for derived or embedded industries that are closely related to high-emitting sectors** to capture other large potential sources of emissions.

e. **Efforts and research are essential to incorporate nature into scenario development or stress testing.** Climate and nature are intricately interconnected, and addressing one without considering the other is unwise. Governments and regulators should support the development and incorporation of nature-related risks into scenarios development and modelling. In the context of Indonesia, major banks have a significant portion to both high-emitting sectors from energy and land-use activities. Therefore, it is a priority to identify the potential impact coming from high-emitting sectors that are related to land-use activities, such as agriculture and land-use change to provide a more comprehensive estimation of the sectors financed by the bank.

5. **General recommendations**

a. **Incorporate a precautionary approach in policy making design.** Adopting the precautionary principle[1] emphasizes that, in the face of threats of serious or irreversible damage, the absence of full scientific certainty should not hinder the implementation of cost-effective measures to prevent environmental harm. This study, like many other similar studies, may not reflect the actual true impact of climate change due to the limitation in data and methodologies. A precautionary financial policy approach recognizes the importance of accurately assessing risks while prioritizing proactive measures to mitigate uncertain and potentially catastrophic environmental threats, even without perfect data and models. Concretely this would mean applying a margin of conservatism in macro and micro prudential requirements for banks that are the most exposed to climate related financial risks.

b. **Consider the consequences of down streaming incentive policy for hard to abate industries on increasing significant emission from production activities.** Down streaming incentives will provide a boost to high-emitting sectors for production, potentially leading to pro-cyclicality in financing towards these high-emission sectors. This might hinder the country in achieving its net zero by 2060 goal.

c. **Collective efforts to address climate and environmental data gaps.** Big climate and environmental data gaps are often found in this region with high costs often

[1] Principle 15 of the 1992 Rio Declaration

charged by data providers for acquiring key data. This hampers the industry and key actors in conducting thorough assessments and managing their climate risks. To address these challenges, it is imperative to promote collective efforts that bring together a diverse array of stakeholders, including relevant government agencies, corporations, financial institutions, data providers, and others to make the needed data available at little to no cost.

# 6. Conclusion and Further Research

## 6.1. Conclusion

This study presents the first climate stress test in Indonesia, jointly conducted by the Bank Indonesia Institute and WWF-Indonesia. The analysis is centered on transition risks stemming from climate policies aimed at reducing CO2 emissions and their potential impact on high-emitting sectors. Employing the climate stress test developed by 1in1000, we examine changes in credit risk under both a business-as-usual scenario and a series of late action shock scenarios reflecting various degrees of a delayed low-carbon transition.

The study's findings reveal a notable increase in expected losses for the majority of banks' lending to coal, oil & gas, power, and automotive sectors. Notably, banks' lending to the power sector experiences the most significant increase in expected loss, while banks financing oil & gas companies exhibit the smallest increase in the expected loss. In the automotive sector, banks also witness an increase in expected losses, though the magnitude is not as pronounced as in other sectors.

Results based on the average of the Probability of Default (PD) differences suggest that, in most scenarios, banks' lending to the coal sector have the highest PD compared to other sectors associated with the coal phase-out plan. This is particularly relevant as the coal phase-out commitment is more advanced compared to the oil and gas sector, where there is still reliance on natural gas as a viable alternative option. The study signifies the role of banks, central banks, financial supervisors, and the financial sector at large in facilitating the transition to a low carbon economy and to support the sectoral rebalancing process of high risk sectors exposures in banks' portfolio.

## 6.2. Limitations

In the conventional stress testing approach, all credit risk exposures from all sectors are typically taken into consideration. However, the portfolios analyzed in this study are limited to the select sectors due to methodology and data availability constraint. Nonetheless, the study found that even a relatively small portion of the banks' loan portfolios within the select sectors, is exposed to companies identified as having the most significant impact from climate transition risk. Despite the study's restricted scope, it is evident that climate-related transition risks exist, and the Indonesian banking system needs to address these risks.

## References


Acharya, V. V, Berner, R., Engle, R., Jung, H., Stroebel, J., Zeng, X., & Zhao, Y. (2023). *Climate Stress Testing*. https://www.newyorkfed.org/research/staff_reports/sr1059.html.

Adrian, T., Grippa, P., Gross, M., Haksa, V., Krznar, I., Lamicchane, S., Lepore, C., Lipinsky, F., Oura, H., & Panagiotopoulos, A. (2022). *Approaches to Climate Risk Analysis in FSAPs*. IMF Staff Climate Note 2022/005, International Monetary Fund.

Baer, M., Caldecott, B., Kastl, J., Kleinnijenhuis, A. M., & Ranger, N. (2022). TRISK - A Climate Stress Test for Transition Risk. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4254114

Bappenas, - Ministry of National Development Planning/National Development Planning Agency. (2019). *Policymakers' Summary. Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*.

Berenguer, M., Cardona, M., & Evain, J. (2020). *Integrating Climate-related Risks into Banks' Capital Requirements*.

Dunz, N., & Power, S. (2021). *Climate-Related Risks for Ministries of Finance: An Overview*. www.financeministersforclimate.org

ECB, - European Central Bank. (2020). *Guide on climate-related and environmental risks: Supervisory expectations relating to risk management and disclosure*.

ECB, - European Central Bank. (2022). *2022 Climate Risk Stress Test*.

Ferrer, A., García Villasur, J., Lavín, N., Pablos Nuevo, I., & Pérez Montes, C. (2021). An initial analysis of energy transition risks using the Banco de España's FLESB stress-testing framework. *Financial Stability Review, Banco de España, 41*.

FI and Riksbank. (2022). *Transition risks in the banks' loan portfolios – an application of PACTA*.

Furukawa, K., Ichiue, H., & Shiraki, N. (2020). *How Does Climate Change Interact with the Financial System? A Survey How Does Climate Change Interact with the Financial System? A Survey **.

Ganapati, S., Shapiro, J. S., & Walker, R. (2019). *Energy Cost Pass-Through In U.S. Manufacturing: Estimates And Implications For Carbon Taxes*. http://www.nber.org/papers/w22281

Gourdel, R., Monasterolo, I., & Gallagher, K. P. (2022). *Climate Transition Spillovers and Sovereign Risk*.

IEA. (2022). An Energy Sector Roadmap to Net Zero Emissions in Indonesia. In *International Energy Agency Special Report*. https://doi.org/10.1787/4a9e9439-en

IEA, - International Energy Agency. (2021). *https://www.iea.org/countries/indonesia*.

IPCC. (2018). *Summary for Policymakers. In: Global warming of 1.5°C An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*.

IPCC, - Intergovernmental Panel on Climate Change. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working I to the Sixth Assessment Report*.

Malahayati, M., & Masui, T. (2021). Potential impact of introducing emission mitigation policies in Indonesia: how much will Indonesia have to spend? *Mitigation and Adaptation Strategies for Global Change*, *26*(8), 37. https://doi.org/10.1007/s11027-021-09973-2

NGFS, - Network for Greening The Financial System. (2021). *NGFS Climate Scenarios: for central banks and supervisors*.

Nkwaira, C., & Van der Poll, H. M. (2023). Anticipating the Unforeseen and Expecting the Unexpected: Effectiveness of Macro-Prudential Policies in Curbing the Impact of Stranded Assets in the Banking Sector. *Risks*, *11*(5). https://doi.org/10.3390/risks11050087

OJK. (2021). *Laporan Profil Industri Perbankan Triwulan IV 2021*.

Reinders, H. J., Regelink, M., Calice, P., & Uribe, M. E. (2021). *Not-So-Magical Realism: A Climate Stress Test of the Colombian Banking System*.

Rishanty, A., Sambodo, M. T., Anugrah, D. F., & Wicaksono, R. P. K. (2022). *Energy transition: Prospect and Challenges at ASEAN Plus Three Countries* (WP/08/2022). https://www.bi.go.id/en/publikasi/kajian/Documents/WP_08_2022.pdf

Sever, C., & Perez-Archila, M. (2021). *Climate-Related Stress Testing: Transition Risk in Colombia*.

Stolbova, V., & Battiston, S. (2020). *Climate change, financial system and real economy: estimation of exposure of the Euro Area to climate change-related financial risks and gains*.

Thomä, J. (2022). *Measuring Climate Transition Risk under a Delayed Transition An Exploratory Analysis of the Japanese Banking Sector*. http://www.fsa.go.jp/frtc/english/index.html

UNFCCC. (2021). *Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050*. https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf

UNFCCC. (2022). *Enhanced Nationally Determined Contribution, Republic of Indonesia*. https://unfccc.int/sites/default/files/NDC/2022-09/23.09.2022_Enhanced%20NDC%20Indonesia.pdf

van Benthem, A. A., Crooks, E., Giglio, S., Schwob, E., & Stroebel, J. (2022). The effect of climate risks on the interactions between financial markets and energy companies. In

*Nature Energy* (Vol. 7, Issue 8, pp. 690–697). Nature Research. https://doi.org/10.1038/s41560-022-01070-1

Vermeulen, R., Schets, E., Lohuis, M., Kölbl, B., Jansen, D.-J., & Heeringa, W. (2018). *DNB Occasional Studies: An energy transition risk stress test for the financial system of the Netherlands*. www.dnb.nl

WWF. (2023). *2023: Susreg Annual Report: An Assessment Of Sustainable Financial Regulations And Central Bank Activities*.

# Appendix

Table A1. Table of Literature Studies

| Authors | Authorities | Objective | Participants | Findings |
|---|---|---|---|---|
| (Reinders et al., 2021) | The World Bank | First, to analyse climate-related risks in the banking sector by estimating the impact on non-performing loans, employing the credit risk model by the Central Bank of Colombia (BR). Second, to establish approaches for conducting stress tests specifically tailored for emerging markets. | 21 Banks, includes state owned, domestic and foreign | The analysis of the impact stemming from the transition risk indicates that Colombian banks are expected to experience significant losses under severe decarbonization scenarios. In detail, with an ambitious GHG reduction target and delayed policy implementation, the aggregated loan losses can range from 0.2% to 2.7% of total assets. This variation reflects that the least vulnerable banks are facing lower losses and the most vulnerable potentially experiencing higher losses. |
| (Sever & Perez-Archila, 2021) | International Monetary Fund | To develop a framework using bank and firm data levels to measure the financial stability implications of climate-related transition risks, specifically using the domestic carbon tax, on the banking system. | 56 Banks | In the scenario with the potential impacts of a US$70 carbon tax increase, the water supply sector stands out as the most affected with a substantial 66.2% of firms encountering financial stress. Following closely, agriculture, transportation, electricity, manufacturing and accommodation sectors also face significant impacts, with 46.2%, 31.6%, 24.4%, 15.7%, and 11.4%, respectively. Further, this study finds that the concentration of stress among small firms, due to their comparatively high levels of liabilities relative to their asset size, highlights a potential fragility in the small business landscape. However, this study argues that at the aggregate level, the stress that can be transmitted to the banking system is potentially significant but these risks are still manageable. |
| (Thomä, 2022) | Japan's Financial Services Agency Institute | To identify and assess bank loan books alignment with the climate-related scenarios and evaluate the potential exposure associated with the transition to a low-carbon economy. | 3 Largest Bank | The alignment of Japanese loan books with ambitious climate scenario targets is observed only in a limited sub-sectors (gas fired power generation and hybrid vehicle manufacturing). For the rest of the misalignment, reflecting potential adverse changes in probabilities of default. This study further mentioned that sectors that need to decarbonize rapidly and are currently most misaligned, such as coal mining, upstream oil and gas, and certain segments of automotive manufacturing and power generation will face a substantial decrease in their profitability. |

| | | | | |
|---|---|---|---|---|
| (FI and Riksbank, 2022) | Riksbank and Finansinspektionen | The main objective of this study is to quantitatively assess transition risks within credit portfolios of Swedish banks. In addition to providing a forward-looking perspective on the transition risks. this study aims to enhance the capabilities through innovative methods, tools and data usage | 17 Banks | The study confirms the identification of transition risk within the banks' loan portfolios. It is known that over half of the bank lending is directed toward activities deemed directly harmful to the environment (fossil fuel extraction) and with regards to the climate targets alignment. This study also found that many companies that need transition are struggling to meet the climate goals for the next five years. |
| (ECB, 2022) | European Central Bank | The ECB climate stress test 2022 aims to encompasses comprehensive analysis using in-house climate risk stress testing capabilities on the bank within the research scope with a particular emphasis on understanding the short-term and long-term transition risks | 41 Banks | This report reveals that the majority of the institution, particularly those heavily involved in activities related to industries emitting GHGs have substantial implications related to the climate risks. Under two different scenarios, losses incurred during the shift to a more sustainable environment are expected to be significantly lower when there is an orderly and phased policy. On the other hand, with delayed and disorderly scenarios, losses are projected to be higher. In addition to identifying bank's current capabilities, ECB found that approximately 60% of banks still lack a well-integrated climate risk stress testing framework, highlighting a current gap in preparedness within the banking sector. |
| (Ferrer et al., 2021) | World Bank | Particularly analyse short term transition risks, this study aims to establish framework to identify the potential impact of the starting phases of transition environmental policies on the banking sector in Spain | Three groups of Spanish institutions: International SIs, Other SIs, LSIs). | In the face of the implementation of environmental policies aimed at reducing emissions, the average probability of default in the most affected sector (manufacture of coke and refined petroleum products) could potentially increase by up to 0.8%. The findings of this study also highlight that the banking sector is expected to absorb the costs associated with the initiation of climate transition policies. However, the severity of the impact on individual banks' profitability varies, with some potentially experiencing more substantial challenges. |
| (Stolbova & Battiston, 2020) | Federal Institute of Technology Zurich | To establish a comprehensive framework for evaluating financial gains and losses related to climate change draws on the recent development on climate policy assessment, climate-stress testing and risk analysis. Using macro-level and micro-level data, this study estimates climate policy risks specifically in the Euro Area and | TBD | The primary direct exposures to the real economy among the financial agents is banks and it is concentrated in loans and bonds. This study also reveals that banks have relatively light direct exposure to sectors of the economy that are sensitive to climate change. Therefore, it has been suggested that banks may find it interesting to support and align with climate policies that promote decarbonization. |

| | | | | |
|---|---|---|---|---|
| | | subsequently evaluating the implications for financial stability | | |
| (IMF, 2022) | International Monetary Fund | The FSAP UK adopted an approach referred to as the “climate Minsky moment” to evaluate the exposure of financial institutions associated with the potential consequences stemming from a policy change as a form of shock within the implementation of a high and steep trajectory of carbon prices. The specification of potential impact will focus through the lens of credit and market losses, over a five-year horizon. | 8 Largest banks | The findings observed an notable effect experienced by the UK banks under an orderly scenario. However, the study mentioned that overall financial stability is not expected to be compromised. In detail, losses on the bank's corporate loan portfolio are projected to be slightly higher than 1%on average, amounting to GBP 24 billion. This study also measures the aggregate economic losses of all corporate exposures for banks, with a total amount of GBP 31 billion. Additionally, there are substantial changes when the study examining an alternative olderly scenario which indicates a higher ambition for decarbonization |
| (Wang et al., 2022) | Energy Foundation China | To investigate and analyze how the shift to a low-carbon economy affects the value of coal power assets associated with the stranded assets and the impact on the credit default risks for entities involved in the coal power sector. However, this study only involves firm-level data. | 3500 unit-level databases (2991 operating coal-fired power projects, with a total installed capacity of 1043 billion kW | This study finds under two distinct scenarios, the expected credit default rate for national coal power is approximately 14.82% for the benchmark scenario. Meanwhile it is higher in the early retirement scenario implying a higher climate target. It is observed that the credit default probability for coal power entities is projected to rise to 17.09%. Furthermore, in case of coal power flexibility operation, the credit default probability is anticipated to reach a significantly higher level of 36.67%. |
| (APRA, 2022) | Australian Prudential Regulation Authority (APRA) | To investigate the financial risks that banks in the research scope might face as a result of climate related transition risks, particularly identified the potential credit risk as this type of risk is measurable and can serve as key aspects of the substantial changes in the transmission channel through which climate risks affect banking institutions. | Australia’s five largest banks | This study observed that under both current policies and delayed transition scenarios, there is a significant rise in overall lending losses resulting from transition risks within bank’s lending activities. In detail, under a delayed transition scenario to a lower emissions economy, businesses may face a more adverse effect as the potential losses are higher than in the current policies scenarios. This study also mentioned that the possibility of the higher impact can be explained through the transition results on the business operational. |

Source: WWF SUSREG Tools, UNEP FI, Various Countries’ Climate Stress Test Report

Table A2. Data Description and Sources

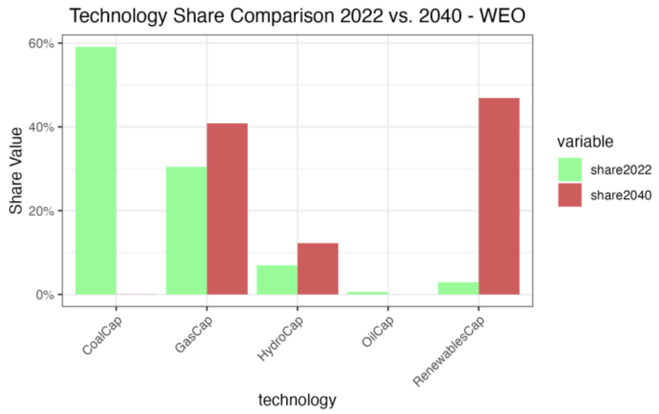
| Data | Description | Sources |
|---|---|---|
| **Scenario Data** | | |
| Decarbonisation Pathways | Involves the trajectories and strategies aimed at reducing carbon emissions and transitioning to a low-carbon economy. | IEA, NGFS, European Commision’s JRC |
| Unit Cost of Projections | Measure the costs associated with producing one unit of output in a particular sector, using a specific technology under a given scenario. | IEA, NGFS, European Commision’s JRC |
| Carbon Tax Pathways | Involves the additional costs trajectories and strategies associated with the implementation of pricing carbon emissions. | IEA, NGFS, European Commision’s JRC |
| **Asset Level Production Data** | | |
| 5-year forward-looking projections of production | Asset-level data of company production projection in the next five years using historical production data, emission intensity and companies’ ownership data. | Asset Impact |
| **Company-level Financial Data** | | |
| Company Market Cap | The total market value for all relevant issue-level company shares | Refinitiv Eikon |
| Leverage Ratio | Ratio of the default point to the market value of the company’s assets. The lower the value the farther the firm is from its default point | Refinitiv Eikon |
| Net Profit Margin | Measures the percentage of profit earned by a company in relation to its revenue | Refinitiv Eikon |
| Asset Volatility | Measure of the fluctuation in the value of a firm's assets | Refinitiv Eikon |
| Asset Drift | Measure the expected average rate of return or growth in the value of a firm's assets over time | Refinitiv Eikon |
| **Loan Book Portfolio Exposure Data** | | |
| Starting Probability of Default | The probability of a company credit default in a 1 year | Refinitiv Eikon |
| Company Credit Exposure | Outstanding value of company credit as of Dec 2022 | Bank Indonesia |
| Maturity term | The maturity period of each company’s credit outstanding | Bank Indonesia |
| Exchange rate | The average of exchange rate in Dec 2022 | Bank Indonesia |
| **Data Parameters** | | |
| Discount rate | The rate of return used to discount future cash flows back to their present value | Bloomberg |
| Growth rate | Projection of Indonesia’s growth rate during steady state | Bank Indonesia |
| Market Passthrough | The average companies’ ability to pass the costs associated with a carbon tax onto the consumer | Ganapati, Shapiro, & Walker (2019) |

| Data | Description | Sources |
|---|---|---|
| Carbon price | An instrument that captures the external costs of GHG emissions, in the form of a price on the CO2 emitted. As for the starting year, we use the carbon tax value announced by the Government of Indonesia and calculate the price projections by using interpolation | World Bank |
| Dividend Payout Ratio | Future net profits that are assumed to be distributed to the firm's equity shareholders as divided payments | Bloomberg |
| Risk free rate | The return received on zero-risk assets meaning there is no risk of default associated with the investment which sets as a benchmark for the minimum return investors would require on riskier assets | Bank Indonesia |

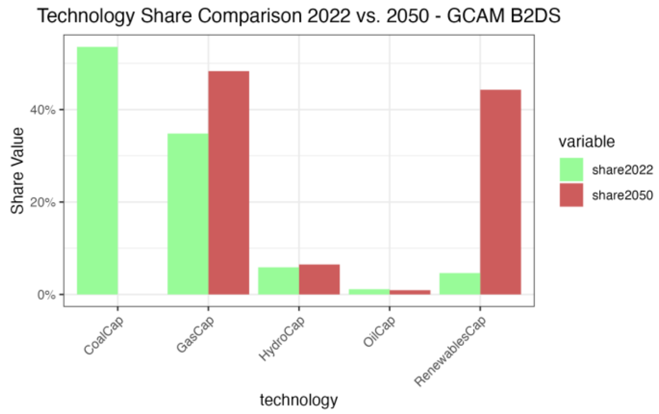
Table A3. Climate Scenarios

| Scenario Provider | Baseline Scenario | Shock Scenario | Geography | Sectors covered | Start Year | Shock Year | Market passthrough | Carbon Price Model |
|---|---|---|---|---|---|---|---|---|
| WEO | WEO 2021 STEPS (Stated Policies Scenario | WEO 2021 SDS (Sustainable Development Scenario) | Asia Pacific | Coal, Oil & Gas, Power | 2022 | 2030 | 0 | No Carbon Tax |
| GECO | GECO 2021 CurPol (Current Policy) | GECO 2021 1.5°C Uniform Scenario | Global | Automotive | 2022 | 2030 | 0 | No Carbon Tax |
| NGFS MESSAGEix | NGFS 2021 MESSAGE Current Policies Scenario | NGFS 2021 Message B2DS (Below 2°C) Scenario | Global | Coal, Oil & Gas, Power | 2022 | 2030 | 0 | No Carbon Tax |
| NGFS GCAM | NGFS 2021 GCAM Current Policies Scenario | NGFS 2021 GCAM B2DS (Below 2°C) Scenario | Indonesia | Coal, Oil & Gas, Power | 2022 | 2030 | 0 | No Carbon Tax |
| NGFS GCAM with Three Shock Years | NGFS 2021 GCAM Current Policies Scenario | NGFS 2021 GCAM B2DS (Below 2°C) Scenario | Indonesia | Coal, Oil & Gas, Power | 2022 | 2025, 2030, 2035 | 0 | No Carbon Tax |
| NGFS GCAM with Carbon Price: Net Zero 2050 Indonesia (market assumption) | NGFS 2021 GCAM Current Policies Scenario | NGFS 2021 GCAM B2DS (Below 2°C) Scenario | Indonesia | Coal, Oil & Gas, Power | 2022 | 2025, 2030, 2035 | 0.7 | NZ2050 Indonesia Market Assumption |
| NGFS GCAM with Carbon Price: NDC Indonesia (moderate assumption) | NGFS 2021 GCAM Current Policies Scenario | NGFS 2021 GCAM B2DS (Below 2°C) Scenario | Indonesia | Coal, Oil & Gas, Power | 2022 | 2025, 2030, 2035 | 0.7 | NDC Indonesia Moderate |

WEO Scenario

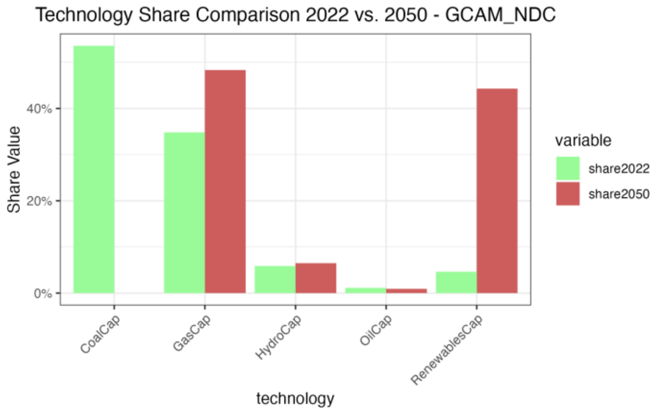


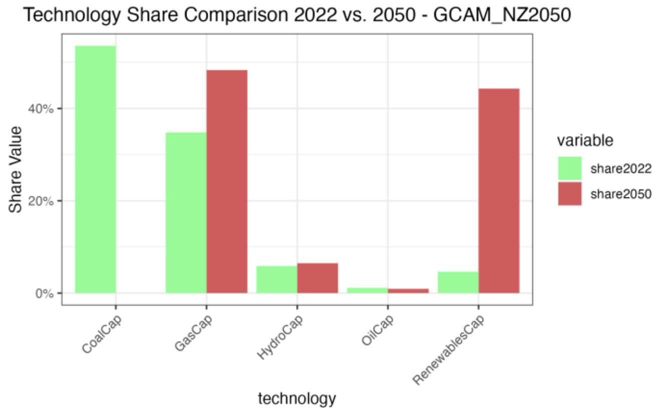

NGFS GCAM Scenario



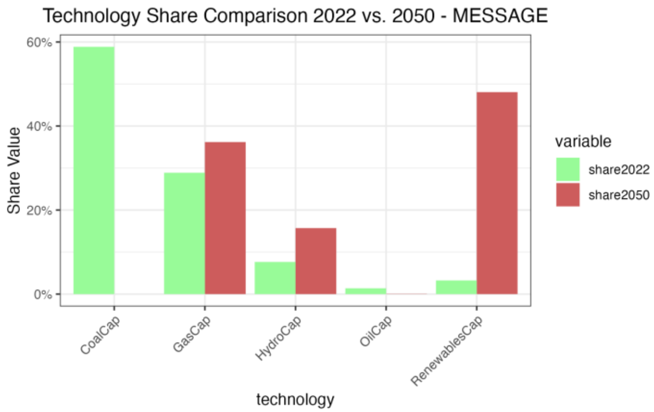

NGFS GCAM Scenario with Carbon Price NDC Model

NGFS GCAM Scenario with Carbon Price NZ2050 Model




NGFS Message Scenario




GECO Scenario

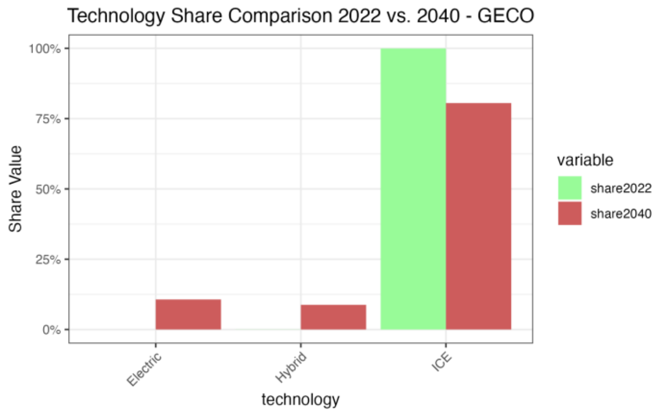
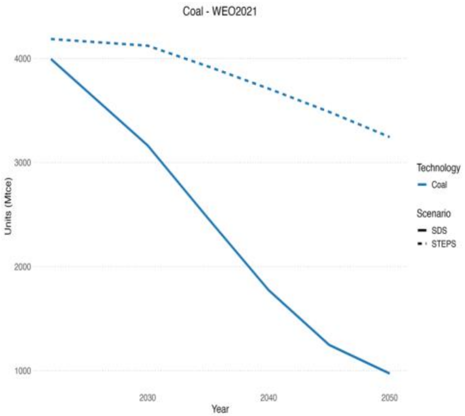
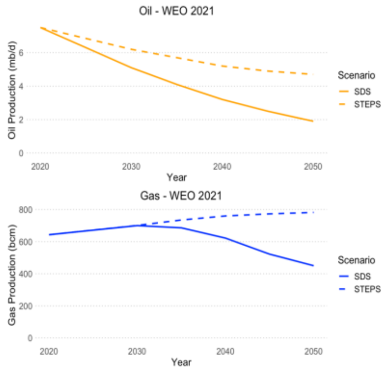
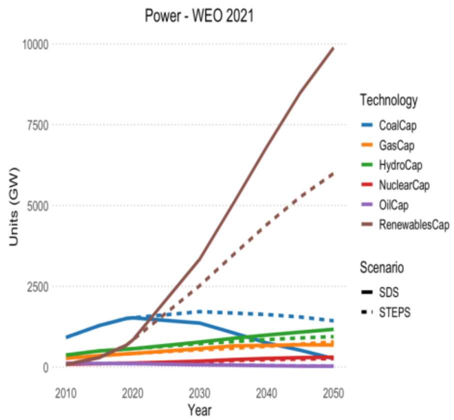



Figure A1. Power Sector Technology Share per Scenario

WEO - Coal | WEO - Oil & Gas | WEO - Power



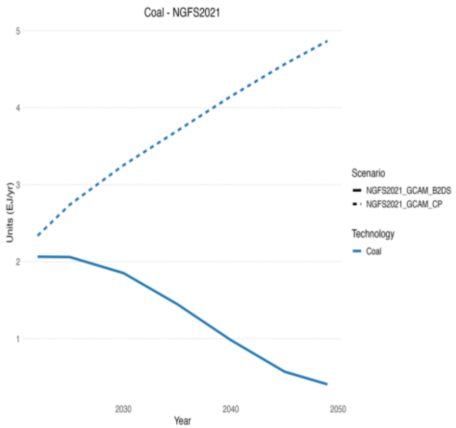



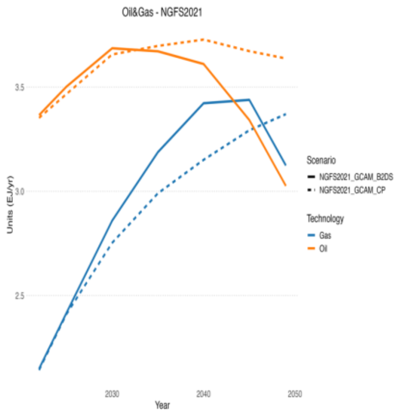



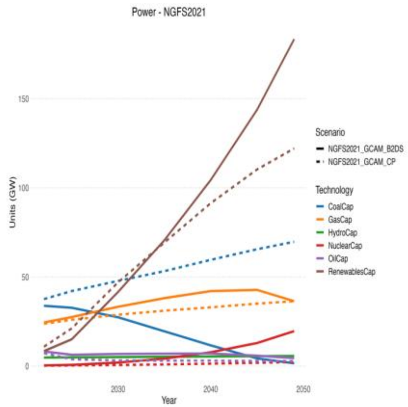

NGFS GCAM - Coal

NGFS GCAM - Oil & Gas

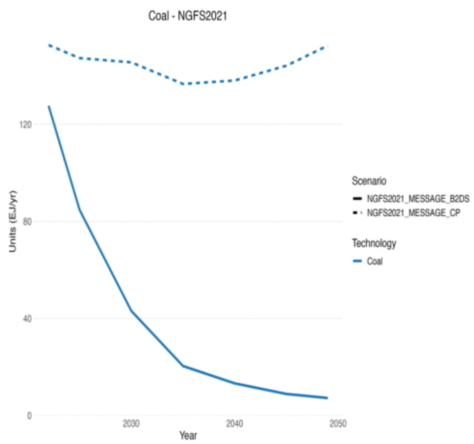
NGFS GCAM - Power



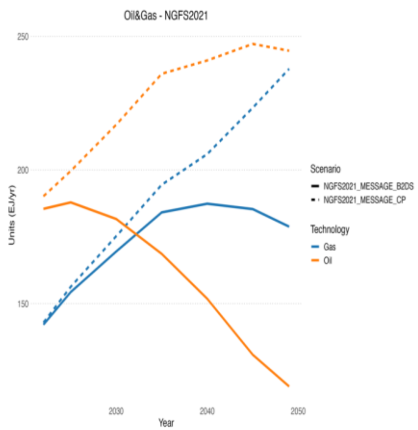



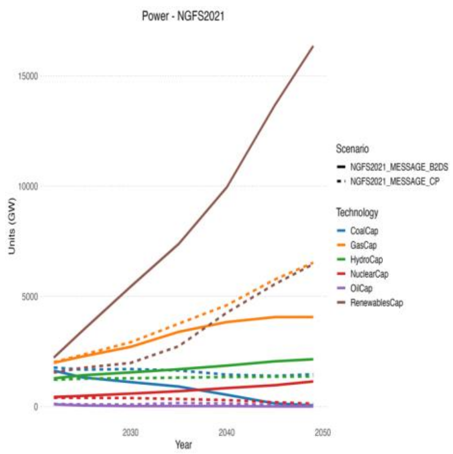
NGFS Message - Coal




NGFS Message - Oil & Gas




NGFS Message - Power



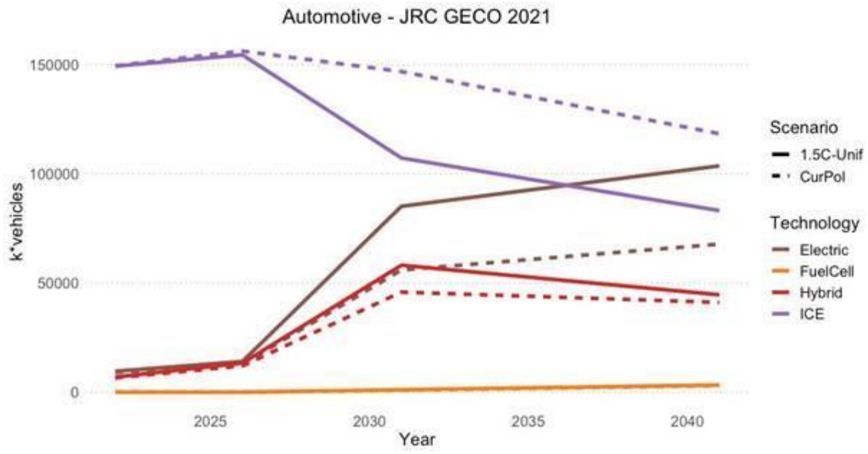



Figure A2. Scenario Production Trajectory Pathway

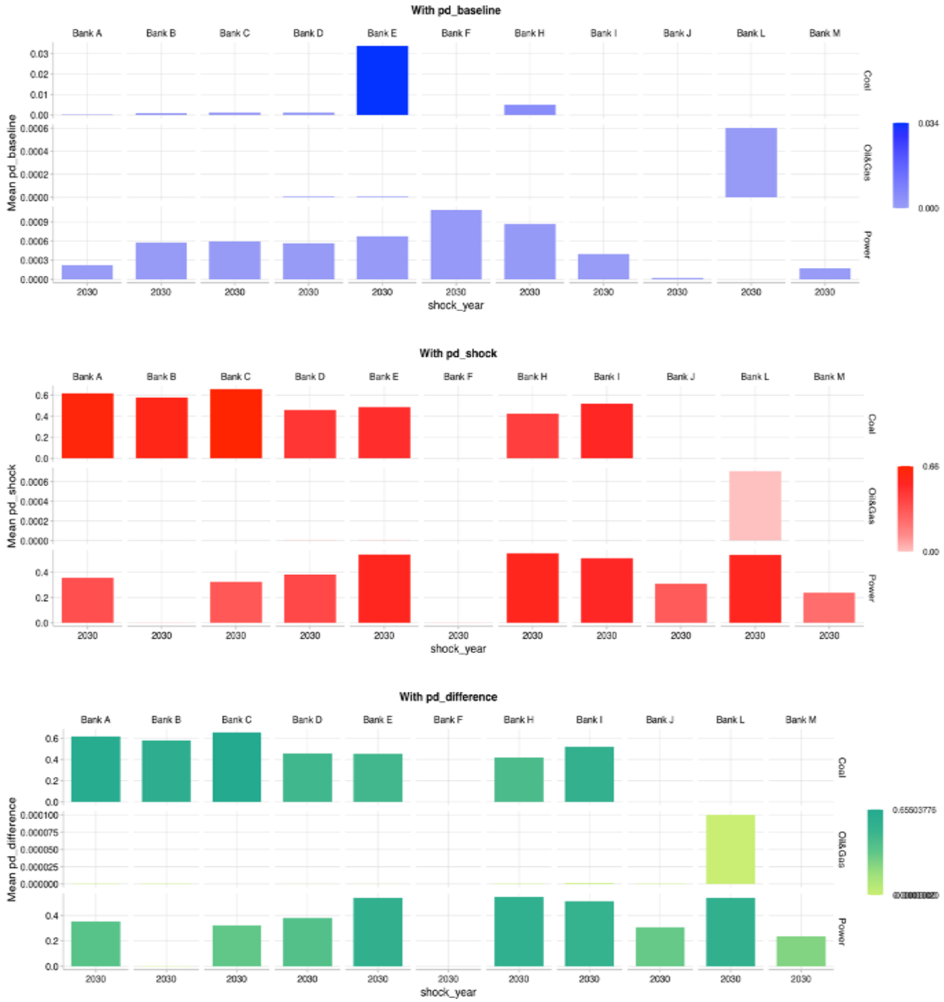
Table A4. Weighted-Average Maturity

| Bank | Coal | Oil&Gas | Power | Automotive |
|---|---|---|---|---|
| **Bank A** | 9.75 | 1.00 | 5.84 | 1.04 |
| **Bank B** | 8.18 | 1.01 | 6.77 | |
| **Bank C** | 4.74 | | 5.08 | |
| **Bank D** | 7.60 | 3.96 | 5.71 | |
| **Bank E** | 7.68 | 7.40 | 6.50 | 0.17 |
| **Bank F** | 6.11 | 5.84 | 6.69 | |
| **Bank H** | 4.26 | 5.32 | 4.75 | |
| **Bank I** | 9.91 | 0.09 | 7.27 | |
| **Bank J** | 8.28 | 1.00 | 3.53 | |
| **Bank L** | | 5.00 | | |
| **Bank M** | 9.08 | | 5.36 | |
| **Bank N** | | | | 1.49 |
| **Bank O** | | | | 1.80 |
| **Bank P** | | | | 3.01 |
| **Bank Q** | | | | 3.00 |
| **Bank R** | | | | 3.00 |
| **Bank S** | | | | 3.00 |
| **Bank T** | | | | 3.08 |
| **Bank U** | | | | 1.85 |
| **Bank V** | | | | 0.10 |
| **All Banks** | 8.19 | 4.39 | 5.82 | 2.15 |

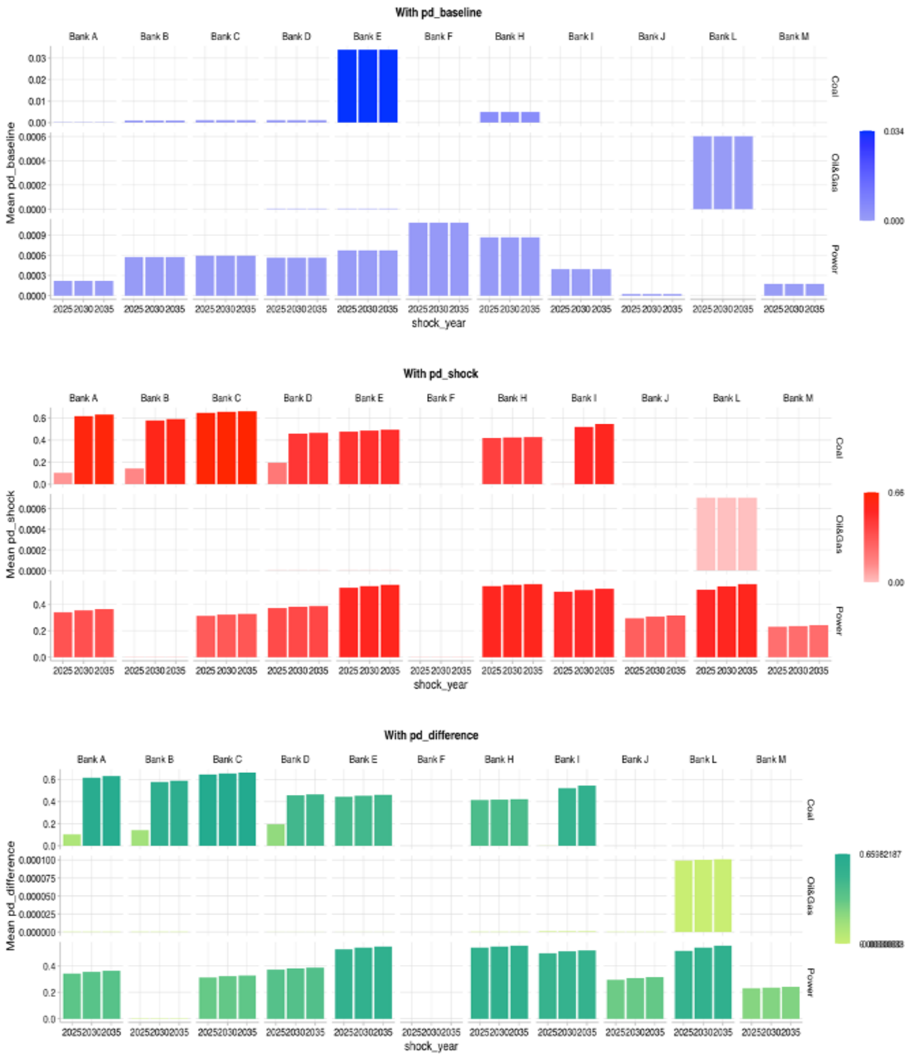
Source: Authors' Calculation, Notes: Bank D, E, and I are state-owned banks

WEO Scenario

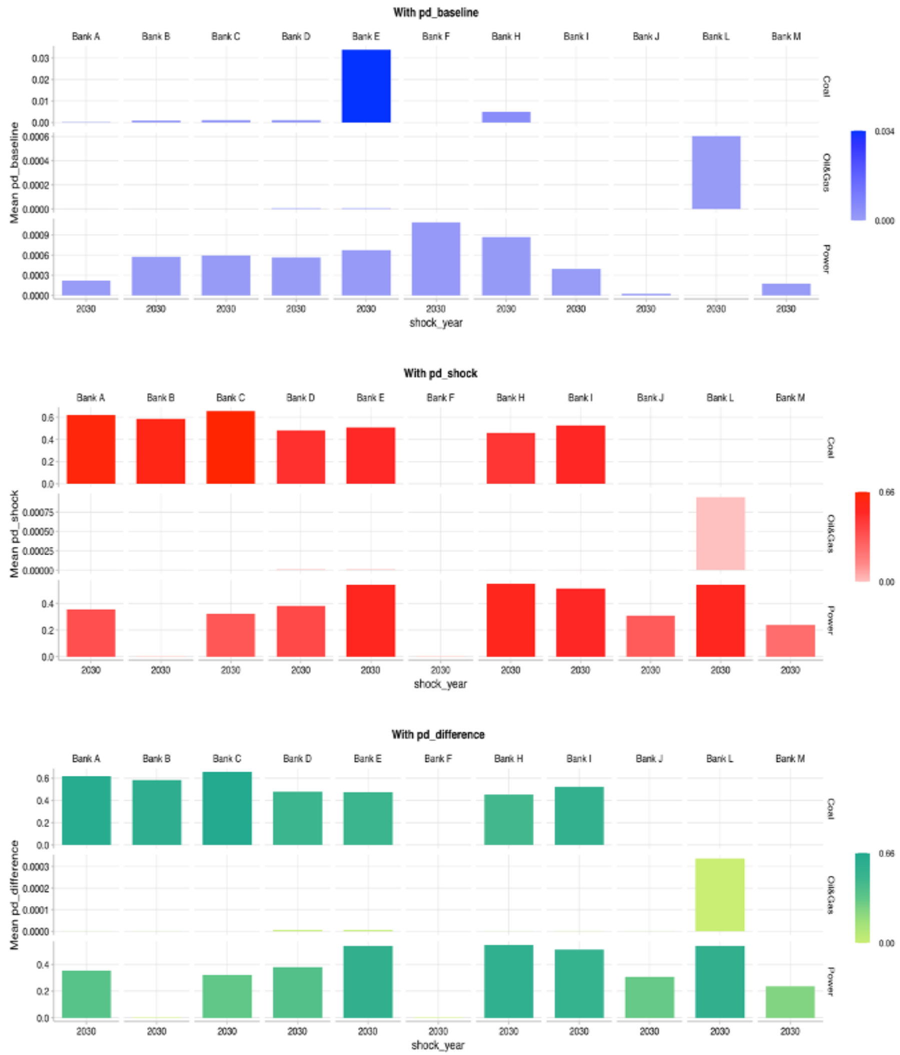

NGFS GCAM Scenario



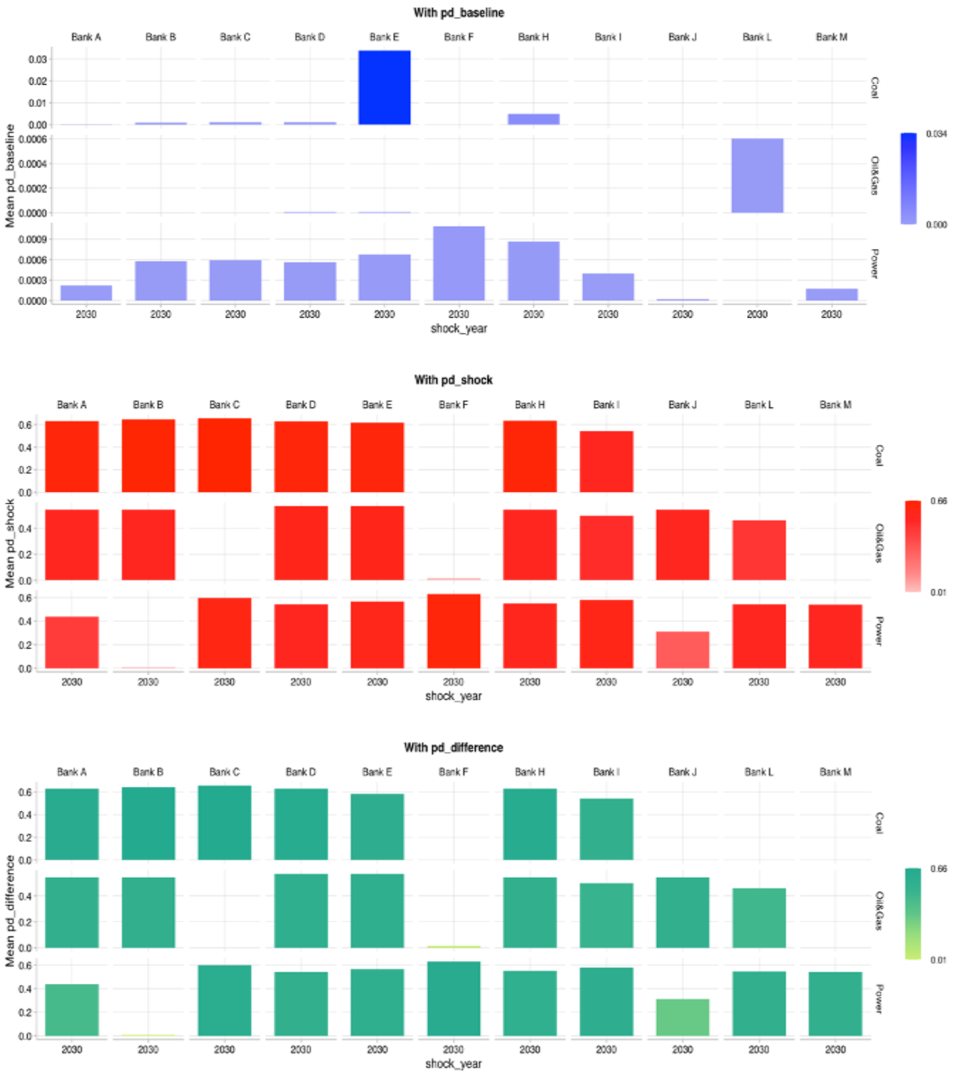
NGFS GCAM Scenario with Shock Years



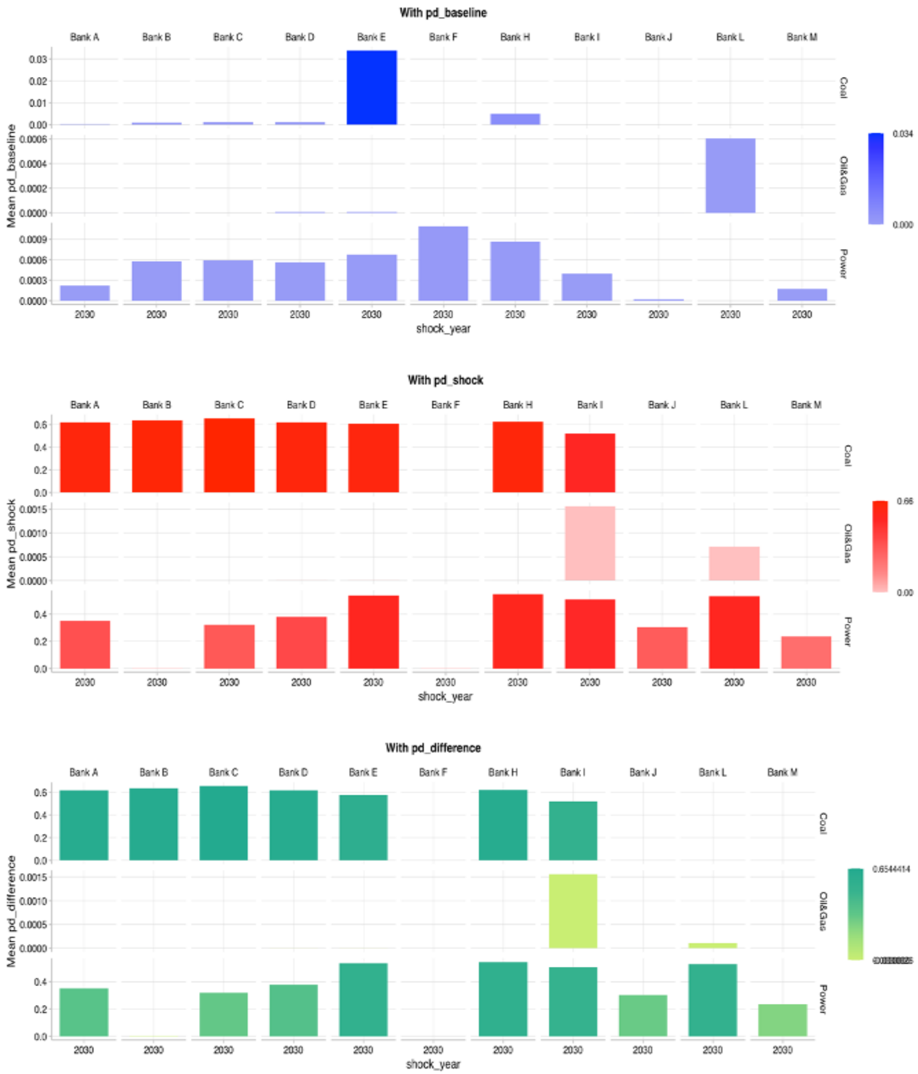

NGFS GCAM Scenario with Carbon Price NDC Model



NGFS GCAM Scenario with Carbon Price NZ2050 Model




NGFS Message Scenario



GECO Scenario

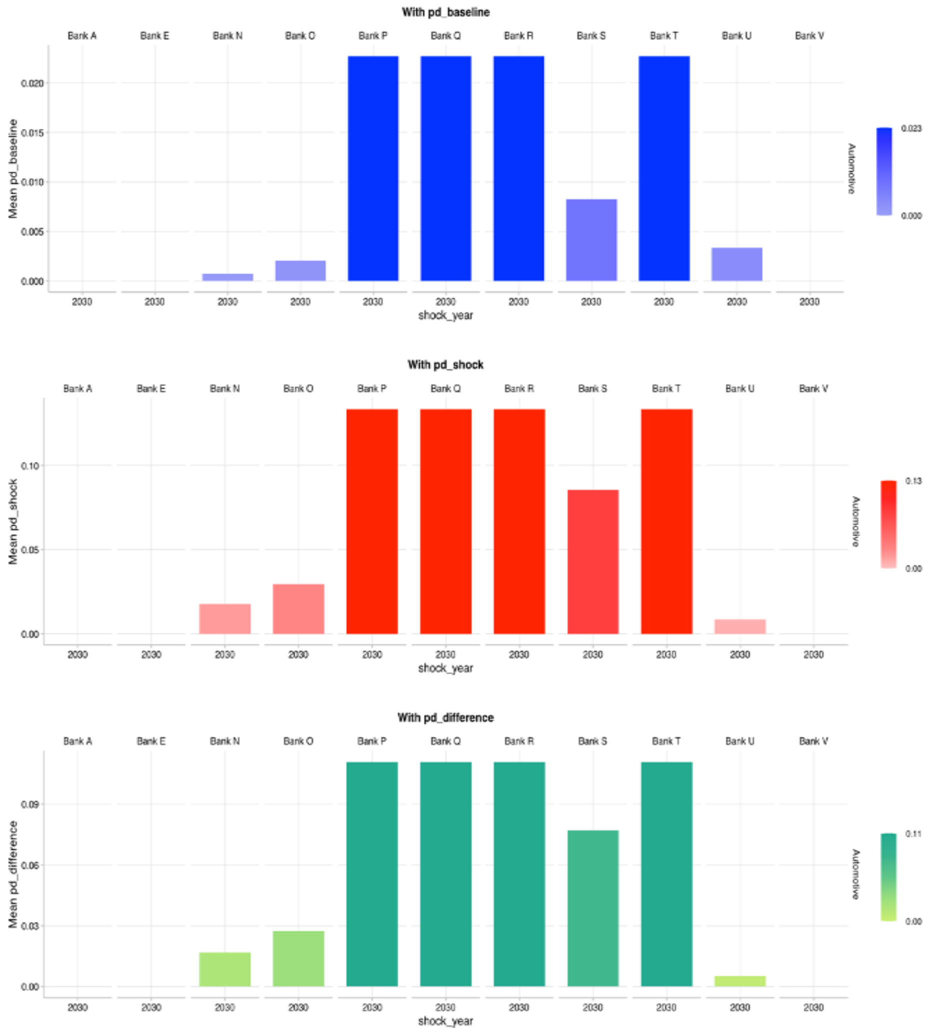



Figure A3. Average PD per Sectors and Banks