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Measuring Climate Transition Risk under a Delayed Transition

An Exploratory Analysis of the Japanese Banking Sector

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Abstract

We analyze the loan books of a sample of banks from the Japanese banking sector with regard to climate scenario alignment and exposure to climate transition risk. The Paris Alignment Capital Transition Assessment (PACTA) methodology is applied to the loan books to understand the exposure to climate-relevant technologies of the loan books' counterparties based on a data base that contains company level production plans based on physical assets from a set of climate relevant sectors. We use PACTA to calculate production-based alignment of the analyzed loan books with climate scenarios. This helps identify the sectors, technologies and capital stocks that are on track for the low carbon transition of the economy and those that are not. We further apply the climate transition risk stress test designed by 2 Degrees Investing Initiative (2DII) which uses a unique approach modelling company profits based on company production data and production pathways from climate scenarios. We derive changes to future profits under a business-as-usual scenario and a set of late action shock scenarios that reflect on different degrees a delayed low-carbon transition. A Merton credit risk model is then used to identify potential vulnerabilities in the banking sector.

The analysis shows that Japanese loan books tend to be aligned with ambitious climate scenario targets only for a few sub-sectors (gas-fired power generation and hybrid vehicle manufacturing), whereas misalignment is identified for the remaining sectors covered in PACTA. This translates to some adverse changes in probabilities of default under late action scenarios. The sectors that need to decarbonize fastest and are currently most misaligned, tend to be most at risk of deteriorating profitability. This includes especially the coal mining and upstream oil & gas sectors, but also segments of the automotive and power generation sectors that rely on fossil fuels can be affected.

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In absolute terms, the misaligned and most at-risk sectors do not constitute the largest share of the loan books, as the coverage of the analysis is restricted to some of the most climate relevant sectors. Furthermore, the analysis is based on loan books as of fiscal year 2020 and assuming static loan books. Thus, some improvements related to recent policy initiatives by the Japanese government and financial regulator may not yet be fully captured in the analysis.

Keywords: climate scenario analysis, climate transition risk, stress testing

1. Introduction

The potential impact on the financial sector of the transition to a low-carbon economy is now widely recognized by central banks and financial supervisors. This is highlighted by international platforms such as the Central Banks' and Supervisors' Network for Greening the Financial System (NGFS), that aim to support best practices and contribute to building a climate-resilient financial system.

Climate stress-test and scenario exercises developed by these institutions have highlighted the extent to which a disorderly and delayed transition has higher costs than an early and smooth transition. This finding is a core conclusion of the NGFS Progress Report (NGFS, 2018) and work by individual financial supervisors like the European Insurance and Occupational Pensions Authority (EIOPA, 2020) or the European Central Bank (ECB, 2021). While we know that such a delay comes with higher costs, and scenarios from the OECD and the NGFS highlight the potential additional economic costs of such a delay, research is still limited on the specific annual estimated additional cost to the financial sector of delaying the climate transition.[1)]

This report estimates the vulnerabilities that the Japanese financial sector (represented by an aggregation of the exposures of a few large banks that voluntary participated in this project) may face under delayed climate transition scenarios, measured as the change to probabilities of default of the counterparties in their loan books as of March 2021. We apply a novel bottom-up climate stress testing model that translates climate transition shocks affecting individual firms to the shocks affecting the value of financial assets, focused on the power generation, oil & gas, coal production and automotive industry, and building on asset-based company data based on physical production assets and their forward-looking production plans, to capture the often-neglected adaptive capacity of companies in the transition towards a low carbon economy.

The report also touches on the source of the transition risks we observe, by examining the alignment of the banks' loan books with transition scenario targets, assuming static loan books and that counterparties do not take proactive action toward decarbonization. Misaligned loan books can be understood to be exposed to larger transition risk as they demonstrate a lack of adaptive capacity and transformation by the counterparties. As such, the outcomes can be an input to mitigating transition risk, by engaging with the counterparties underlying the loan books and helping them steer capital towards technologies that are aligned with the transition.

We find material transition risks in all analyzed sectors, with considerable inter and intra sector variation. The amount of risk relates to the severity of misalignment between counterparty production

[1)] See e.g. Baer, et al. (2021): https://2degrees-investing.org/wp-content/uploads/2021/11/The-Cost-for-the-Financial-Sector-if-Firms-Delay-Climate-Action-Nov-2021.pdf plans and climate scenario targets. Where possible, we used Japanese climate scenario targets to measure alignment and risk and in all other cases, we used global scenario targets.[2)] That, combined with the exposures in Japanese loan books, tailors the analysis to the Japanese context as much as possible. The counterparties in the analyzed loan books of Japanese banks seem to be largely misaligned at this point which——if not addressed——makes a late transition more likely. Although this is not the case for all counterparties. In terms of sectors, we find that only gas-fired power capacity and hybrid automotive production are currently aligned with climate scenarios for the analyzed loan books. All other sectors were misaligned to varying degrees. However, in absolute terms the most affected sectors do not make up for the largest share of the outstanding loans. Moreover, the analysis assumes static loan books over the course of the estimation period. Many initiatives toward decarbonizing the financial sector in Japan have taken place especially after October 2020, when the Japanese government declared the target of carbon neutrality by 2050. Some of those initiatives are illustrated in Chapter 2. The loan books as of March 2021 may not fully reflect the long-term transition efforts undertaken since then.

Finally, our sensitivity analysis shows that misalignment in production translates into increasingly severe transition risk, the later the model introduces a shock that corrects for previous production misalignment. This highlights the importance of not delaying the management of climate transition risk by employing a set of measures, such as (i) reducing financial institutions' exposures to particularly at-risk sectors, (ii) reducing the vulnerability of their clients by helping them transition, as well as (iii) continuing efforts by financial supervisors to encourage financial institutions' management of transitions risk both through initiatives by the public and private sectors in Japan. The analysis also highlights the importance of the recent initiatives by the Japanese government to push for carbon neutrality by 2050 and the accompanying policy actions. These took place after the analysis began and so will hopefully lead to improved results over time as these policy actions get internalized by financial market actors.

[2)] The climate scenarios provided by the IEA which we used for this analysis provide a regional breakdown of scenario targets for the power sector, not for automotive manufacturing, coal mining or oil & gas. This correlates largely with the fact that electricity markets are more regional, whereas the markets for the other analyzed sectors are global.

2. Climate Change Transition Risks and Opportunities in Japan

2.1 Japan's Climate Goals and Commitments

According to Japan's Nationally Determined Contribution (NDC), Japan aims to reduce its greenhouse gas emissions by 46 percent in fiscal year 2030 from its fiscal year 2013 levels. This target is aligned with the long-term goal of achieving net-zero by 2050. This commitment sets Japan on a course to become carbon neutral in only 30 years. Japan's approach is based on three principles:

(1) "**promote innovation and technology** as the agents of change in tackling the challenges of global warming"
(2) "**promote green finance** to support the development of innovation and new technologies"
(3) **"support greater international cooperation** for business-led adoption of innovative green technologies." (UNFCCC, 2022)

According to the Ministry of Economy, Trade, and Industry (METI), Japan is on track on its roadmap to become a decarbonized society. Over the last six years Japan reduced its emissions constantly (METI, 2022).

Corresponding to the declared target of reaching carbon neutrality by 2050 by the Japanese government, both financial and non-financial companies have made efforts towards that goal. To facilitate corporates' efforts, the METI declared to establish a "GX League"[3] as a forum for leading companies that are transitioning to carbon neutrality to contribute to the "Green Transformation" of the Japanese economy, in cooperation with the government and academic experts.

In light of those developments and as the second point states, the financial system in Japan is set to transform towards a "green financial system." Japanese banks including Japanese Bankers Association have published their strategies for reaching carbon neutrality. As of the end of June 2022, 26 Japanese financial institutions have joined Alliances under the Glasgow Financial Alliance for Net-Zero,[4] which represent the largest number of participants from Asian economies. The Financial Services Agency, Japan (JFSA) plays an important role in that regard:

- **Membership in international fora.** In June 2018 the JFSA joined the Network for Greening the Financial System, only half a year after it was established. In November 2020, the JFSA became one of the Steering Committee members. With the mission to protect national welfare

[3] https://www.meti.go.jp/english/press/2022/0201_001.html
[4] See https://www.unepfi.org/net-zero-alliance/alliance-members/, https://www.unepfi.org/net-zero-banking/members/, https://www.unepfi.org/net-zero-insurance/ and https://www.netzeroassetmanagers.org/

by enabling sustainable growth, the JFSA warns for climate-related risks impacting the financial system and economy (NGFS, 2021, "In conversation with Mr. Satoshi Ikeda."). JFSA is also an active member of the BCBS TFCR (Basel Committee on Banking Supervision's Task Force on Climate-related Financial Risks), the IAIS CRSG (International Association of Insurance Supervisors' Climate Risk Steering Group) and the SIF (Sustainable Insurance Forum). The JFSA also joined IPSF (International Platform on Sustainable Finance) in November 2020. JFSA has co-chaired some of the working groups related to sustainable finance, including Climate Disclosure Working Stream at the FSB (Financial Stability Board), ESG Ratings and Data Providers Working Group and Assurance Working Group at the IOSCO STF (International Organization of Securities Commissions Task Force on Sustainable Finance), Sustainability Disclosure Working Group and Transition Finance Working Group at the IPSF.

- **Strategy on Sustainable Finance.** In December 2020, the JFSA has established the Expert Panel on Sustainable Finance (EPSF). Based on the report by the EPSF, in August 2021 the JFSA published its strategy on sustainable finance. The JFSA's strategy is divided into four main parts: (1) enhancement of corporate disclosure; (2) demonstration of market functions, i.e., creating an environment in which various domestic and foreign investors can easily invest in a decarbonized economy; (3) the role of financial institutions to support borrowers and investees for transition and manage climate-related risks; and (4) active participation in international discussions (JFSA, 2021). Since then, the JFSA has moved toward mandatory sustainability disclosures, published the draft "Report of the Technical Committee for ESG Evaluation and Data Providers"[5] and the "Progress Report on Enhancing Asset Management Business 2022," the former includes the recommendations which could be the basis of incoming "Code of Conduct" for ESG evaluation and data providers and the latter includes supervisory expectations for asset management firms providing ESG funds[6]. The JFSA also released a draft "Supervisory Guidance on Climate-related Risk Management and Client Engagement," in April 2022. This guidance focuses on how financial institutions can engage with their clients to proactively take measures to respond to challenges posed by climate change, including the transition to a low-carbon economy. All these pieces of the strategy on sustainable finance are expected to be finalized in summer 2022.
- **Promoting Transition Finance.** The JFSA, the METI and the Ministry of the Environment jointly published "Basic Guidelines on Climate Transition Finance"[7] in May 2021 as a reference for companies raising funds for the transition toward carbon neutrality. The JFSA supports the credibility of such transition efforts, for example, by providing the Supervisory Guidance (mentioned above), which focuses on client engagement by financial institutions.

[5] https://www.fsa.go.jp/singi/esg_hyouka/siryou/220519/02.pdf
[6] https://www.fsa.go.jp/en/news/2022/20220527.html
[7] https://www.fsa.go.jp/en/news/2021/20210524.html

- **Climate scenario analysis and stress-testing.** The JFSA, together with the Bank of Japan (BOJ), conducted a pilot exercise on climate scenario analysis covering the country's three biggest banks and three biggest insurance groups.

The author runs a simplified climate transition risk stress test as a first step to understand the exposure of the Japanese financial system based on the Paris Alignment Capital Transition Assessment (PACTA). The results are presented in this report. Even though this exercise is of exploratory nature, it provides solid first insights for potential regulations and requirements (RI, 2020) and could complement the results of pilot exercise taken by the JFSA and the BOJ.

2.2 Japan's climate goals can, if not managed, lead to transition risks to the financial sector

Following Japan's climate goals and the JFSA's involvement in climate actions, the financial system might face climate transition risks if the individual financial institutions and their counterparties do not proactively take action to decarbonize. Transition risks refer to the risks associated with mitigating climate change by decarbonizing – or 'transitioning' – the economy to net zero or low-carbon economy. Risks arise here as a function of changes in the costs of production (both 'policy costs' and 'market costs' related to inputs) and the demand for high-carbon products and services.

Transition risks tend to be focused in high-carbon sectors, as identified by Battiston et al. (2017), or sub-sectoral level (e.g., high-carbon vs. low-carbon fuels in the power sector). From a regional perspective, risks are determined by political boundaries rather than 'physical' boundaries and thus a generally more prominent at country rather than regional level, although of course regional climate policies may drive results. Similarly, transition risks in the short-term can be more concentrated in developed markets, which tend to have more ambitious decarbonization pathways, whereas physical risks appear generally more focused in emerging markets.

Those transition risks can be managed. If investors and financial regulators want to mitigate policy and transition risks more smoothly, they should understand the current misalignment of their investments with climate goals and act now (2DII, 2021). For this, it is important to understand current exposures of banks to high-carbon technologies and sectors. The corresponding analysis is done in this report.

3. Measuring Climate Transition Risk Through Climate Scenario Analysis Using the 2DII Transition Risk

3.1 The 2DII Transition Risk Framework

The transition risk framework of 2 Degrees Investing Initiative (2DII) is a methodology to identify and measure increased financial risk related to the transition to a low-carbon economy. It is specifically designed to model a late and sudden policy shock that ensures carbon intensive sectors of the economy transition in a way that is consistent with the carbon budgets of a given climate scenario. Contrary to many other climate stress tests, it is flexible in terms of financial parameters and the year of the introduction of the policy shock, which means it can be tailored to reflect many relevant scenarios and it can be used as a transparent open-source model that ensures reproducibility of results. It furthermore models the impact of said shocks on the microeconomic actors in the given economic sectors. The impact of the shock to these real companies is then aggregated to the loan book level, to derive changes in company values, probabilities of default and expected losses.
The core principle of the modelling approach chosen here is a sector-based scenario approach, which is consistent with the broader climate policy design in Japan, which is based on a sector- and entity-based approach. One benefit of such approaches is that they capture the dynamics of climate transition scenarios well. We then use a three-layered approach that ties together the levels of (1) climate scenarios, (2) real economic firms and (3) the financial sector. We will discuss each layer in turn below.[8)]

3.2 Climate Scenarios

3.2.1 Criteria for scenarios

As climate scenarios, we use sectoral production pathways based on integrated assessment models (IAMs), which provide production trajectories for the economic sectors that need to decarbonize on a sub-sector or technology level. Using such scenarios implies that if production in all sectors stays within the total production allocated to the sector (and sub sector or technology), the corresponding carbon budget of the sector is not breached and hence the transitions would be in line with the associated climate target.

This means that a requirement for a climate scenario to be compatible with the transition risk framework is that it must be possible to obtain overall production values for a sector over the timeframe of the analysis and a drill down of such production pathways at the technology level. Having this level of granularity of data makes it possible to deduce the required rates of changes in production values that are aligned with the aggregate scenario outcome. For sectors that need to decarbonize, this usually means some clear

8) For a more comprehensive description of the approach, please see Baer et al. (2021) and a much more thorough mathematical description is given in Baer et al. (2022, forthcoming).

pathway toward a reduction in the production of high carbon technologies. For example, in the power sector, the scenario can prescribe a way to decarbonize power generation by phasing out coal fired power plants but compensating the loss of power capacity by building out power generation with renewable sources. Other sectors, such as coal mining, do not have an alternative technology to transition into, but generally need to be phased out, so that a production pathway can still be provided. There are other carbon intensive sectors, especially in the industry, that do not yet have clear ways to decarbonize. However, the demand for their outputs will likely remain high. Such hard-to-abate sectors (aviation, cement, steel) cannot be covered by 2DII's transition risk model at this point.

3.2.2 Sector coverage

At the moment, the transition risk model covers automotive manufacturing, coal mining, upstream oil & gas extraction and power generation, due to the restrictions described above. This will only cover a part of the loan book. The aim of this exercise is to examine the impact of a transition risk shock on the sectors most likely directly affected by transition risk, based on climate scenarios. Of course, this does not mean that other sectors are not affected by transition risk, however, current data limitations mean such exercises either require detailed line-by-line corporate assessments or relatively top-down models that do not meaningfully capture distinctions between different companies. Of particular focus for this study was the ability to bring together granular bottom-up data, climate scenario data, and forward-looking stress-test designs that take into account the adaptive capacity (i.e., alignment) and transformation of the underlying companies. The results can be scaled to the supply chain of the covered sectors by applying similar shocks. An analysis of a broader set of sectors is currently under development. The sectors covered account for roughly 75% of global CO_2 emissions and thus represent a meaningful share of climate transition risks.

Overall, it must be noted though, that transition risk on the loan book level is likely higher than what we measure for our in-scope sectors. Some sectors will face direct transition risk (e.g., the hard-to-abate industries such as cement, steel and aviation), that our model currently cannot capture and in other sectors, there might simply be some correlation with the valuation and/or probability of default of the in-scope sectors. For example, a restaurant associated with a coal mine may face transition risks even if the industry is not directly affected. Extending the stress test to cover such effects while respecting the principle of compensating for misaligned production on the sector and technology level remains a project for the future.

3.2.3 Scenario targets

2DII's transition risk model borrows its methodology for setting production targets from the PACTA methodology.[9] In short, targets are set by applying sector-technology level rates of change as seen in the

[9] Production targets in PACTA are calculated using the market share approach, which aims at prescribing changes to production levels that maintain the overall market shares of each company for a given sector. A more detailed explanation can

aggregate scenario production pathways to the production forecasts of all included real economic companies. This is known as the market share approach, as applying the same rates of change to all companies' production levels keeps the market share in terms of production constant while forcing all companies to align to the scenario. Thus, applying this method to derive scenario targets ensures that, in aggregate, scenario production values are met and, by extension, the carbon budget relating to the scenario is not breached.

3.3 Real economy

The second layer of the analysis related to real economic firms. These are the actors that will initially get shocked by a late and sudden climate transition policy and we will model the impact of that shock on their future profits.

3.3.1 Asset-based company data

The underlying production data used to describe the real economic firms is sourced from the data provider Asset Resolution (AR). Their data contain asset-based company data (ABCD) and provides detailed company information on technology level production plans for a five-year forward-looking timeframe. This means it is possible to derive the overall technology mix of the underlying production sites that a company owns for the present year and how that technology mix changes for five years into the future.[10)]

3.3.2 Alignment

Calculating company level targets is now possible by applying the relative targets from the climate scenarios (market share approach) to the production values in the start year of the production data, mapped to the same types of sectors and technologies. This gives us two different sets of time series, one reflecting the production forecast per company and technology, and the other the production targets per company and technology for a given climate scenario. Out of these two series, it is possible to derive the alignment of a company with a climate scenario either at the company level or, by adding another step of weighting, at the loan book or portfolio level.

3.3.3 Scenario construction

For our transition risk stress test, we want to consider a longer time horizon than five years forward looking, because a late and sudden policy shock may arrive much later. We also assume the production plans over

be found here: https://2degreesinvesting.github.io/r2dii.analysis/articles/target-market-share.html.

[10)] For more information on ABCD provided by AR, please view their documentation on https://asset-resolution.com/.

the forecast period provided by the ABCD are already locked in in this model. For the company production targets, it is straightforward to extend the time frame covered simply by extending the time series with the relative changes prescribed by the scenario. Applying the relative changes of an ambitious scenario (usually one that aims for a temperature rise of somewhere between 1.5°C to 1.8°C above pre-industrial levels) directly to the start values of the companies' production values gives us trajectories for the target scenario in the stress test.

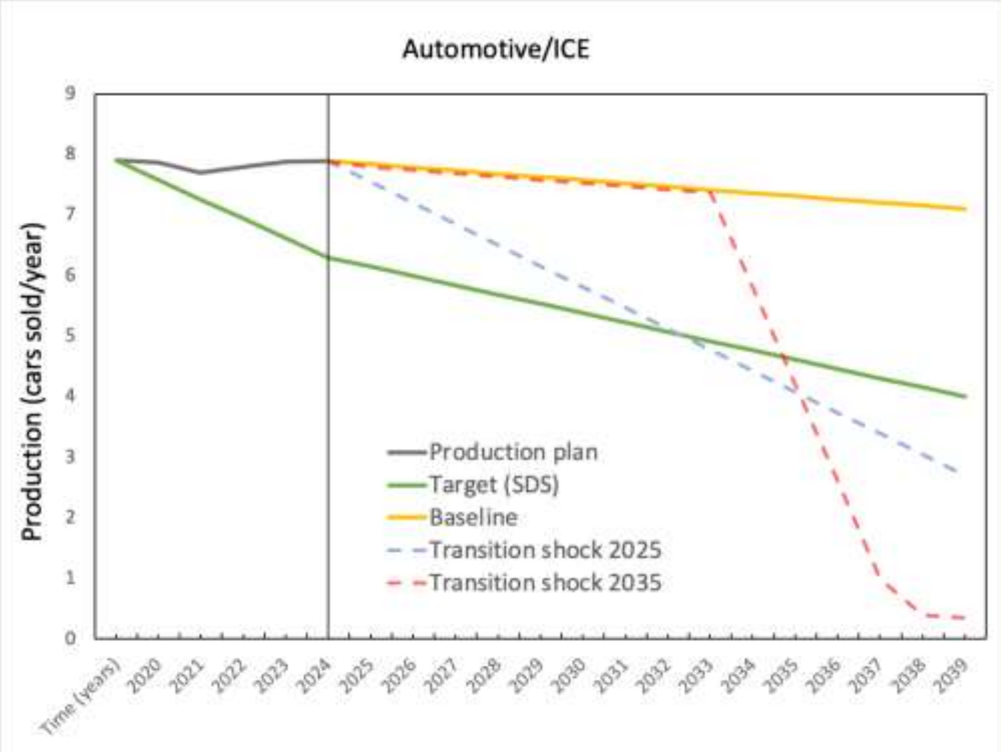
For the baseline scenario of our analysis, we construct a business-as-usual scenario by extrapolating the company production forecasts beyond the given five years with the relative changes of a stated policies scenario. In effect, this means that the baseline scenario follows some less ambitious stated policies scenario, with an offset of the production forecast for the first five years. Using this company-specific production offset allows us to discriminate the impacts on the company level and, since it covers the adjustment to company production plans in the future, it takes the adaptive capacity of companies into account. This is of particular importance to ensure that companies which are on track to transition are not shocked equally strongly as other companies that simply follow their traditional high-carbon business model or even build it out.

The shock scenario is then constructed by having the real economic firms follow their baseline production plans up to a shock year. In that shock year, a policy shock introduces regulation that forces all companies to adjust their production levels within each technology so that the overall carbon budget per technology is not breached over the course of the entire time frame of the analysis. This means that companies which have been misaligned in comparison to the production trajectory laid out by the target scenario, must compensate for their excess production after the shock (see figure 1 for a stylized graphic example). We do this by adjusting their production trajectory post shock so that the sum of the overall production in that technology is the same as the sum of the allocated production under the target.

A consequence of the requirement to stay within the carbon budget for each of the technologies, is that the longer a company is misaligned with its target production, the larger the cumulative production value that it needs to compensate post shock. Hence, with a finite end year of the analysis, this implies a much sharper adjustment of production, the later the policy is introduced.

Figure 1: Comparison of Baseline, Target, and two late and sudden climate transition scenarios. Stylized example for automotive manufacturing of light duty vehicles with internal combustion engine (ICE)

Source: author



3.3.4 Future profits

The forward-looking production trajectories for the baseline and the shock scenarios can now be used to derive projections of future profits. We calculate profits in the following way:

Net profits = production volume * (unit price – unit cost)

where market prices and/or unit costs are also used from the scenario sources and vary by baseline and target scenario. In the shock scenario, we let the prices follow the baseline until the year of the policy shock and then let it adjust linearly to match the target market price at the end of the adjustment period, which coincides with the end year of the analysis. We get either the market price or the unit cost from the scenarios, depending on the sector. The other of the two variables is then approximated using company level net profit margins, taken from third party financial data providers. This way, for each company, we generate a set of individual time series of future profit developments under the baseline and the shock scenarios, taking into account the technology mix employed by the company and its strategic buildout or winding down of technologies over the years.

3.4 Financial Sector

The future profit trajectories for each of the real economic companies under both the baseline and shock scenarios can now be used to derive the relative impact of a policy shock on the company valuation, and - by extension - on the credit risk of the companies. This is the basis to examine the effects of such a late and sudden transition to a low-carbon economy on the probabilities of default of the loans in banks' loan books and the corresponding effects on expected losses.

3.4.1 Company valuation

We use a Dividend Discount Model, with future profits used as futures dividends to derive the net present values (NPVs) of the real economic firms, both for the baseline and the shock scenarios. The ratio of the NPVs is the relative change of company value due to the transition policy shock.

3.4.2 Credit risk

To understand what the impact of said shock means for credit risk, we employ a structural Merton model. The Merton model can be used to calculate the probability of default (PD) of a debt instrument. It requires as inputs company value in the start year, debt level (which acts as the default threshold and is calculated using the debt-equity ratio), volatility of the financial asset, risk-free interest rate, the term structure. We use the debt-equity ratio and asset volatility based on third party financial data providers.
We calculate the baseline and shock PDs by using the company valuation calculated in the previous step and then derive the change between baseline and shock PDs in percentage points. Note that this is a simplified way to calculate company level credit risk. The resulting PDs should not be understood as precise estimates of PD levels. Rather they serve the purpose to find the relatively more vulnerable sectors and companies in the economy and understand their sensitivities to a transition shock.

Once the PDs are calculated both for the baseline and shock scenarios, we can approximate changes to the expected loss (EL) for the banks' loan books, using the following equation:

Diff(EL) = EL(shock scenario) – EL (baseline scenario),

with:

EL = PD * LGD * EAD

where the loss given default (LGD) can be set according to the defaults suggested in the Basel framework[11] and the exposure at default (EAD) corresponds to the outstanding loan amount provided in the input loan book data. This implies the assumption that loans are rolled over on a yearly basis, such that the exposure in the shock year corresponds to the input values for the loan amount outstanding. Again, the approximations for changes in the expected losses are to be seen more as relative indicators rather than precise predictions in our model. In this aggregate overview of the results, we therefore do not report point estimates of expected loss values, but rather use this section to highlight how one can go about using the PD changes to do that.

[11] See: Basel Framework – Calculation of RWA for Credit Risk: https://www.bis.org/basel_framework/chapter/CRE/32.htm.

4. Climate Transition Risk Using 2DII Transition Risk – A Case Study with Selected Japanese Banks

4.1 Scope

Lending Portfolio Data: The corporate loan data of the sample banks was taken from the fiscal year 2020 (March 2021) data. The financial variable used to allocate company production to the respective loan books, known as the portfolio weighted approach, was 'debt outstanding.'[12] In other words, the total amount of credit drawn by each client as of Q1 2021 was used as the weighting factor. The focus within the lending portfolio was on the sectors described above. Globally, these sectors represent roughly 75% of CO_2 emissions and 90% of energy-related emissions.

The production forecasts of companies: The production forecasts were provided by Asset Resolution (AR) through their Asset-Based Company Dataset. These data are updated annually and contains 40,000 companies. The data are five years forward looking and based on third party business intelligence data sets.

Climate scenario data: The International Energy Agency's (IEA) World Energy Outlook (WEO) scenarios were used, namely the Stated Policies Scenario (STEPS, denoted as "SPS" in the output figures) and the Sustainable Development Scenario (SDS) and the IEA's Energy Technology Perspective (ETP) scenario for Automotive. These scenarios were chosen as they are widely recognized by policy makers and financial institutions. The SDS is considered as a Paris aligned scenario and the STEPS encapsulated countries' Nationally Determined Contributions (NDC) under the Paris Agreement and some policy initiatives beyond that. It does not have a specific climate target outcome and is designed as a more conservative benchmark.[13] This scenario choice allows for a comparison to a "well below 2°C" pathway (SDS) and against countries' announced climate commitments (STEPS). Furthermore, the WEO allows for regional contextualization of the power sector. Two regional benchmarks are used: Global and/or Japan. The Japan scenario alignment target is inferred from the scenario's requirement for Japan only. This may be more or less ambitious (depending on the technology) than the global target.[14]

Market Benchmark: In this analysis, a comparison is made to the global corporate economy and the Japanese corporate economy, i.e., all the physical assets in the world and all the assets in Japan within

[12] There is optionality in the PACTA for Banks methodology and supporting software to use other financial variables. For example, the credit limit or the exposure at default. The debt outstanding was chosen here as it is interpreted as risk-based weighting. i.e., the drawn amount (debt outstanding) is the potential amount that is at risk of being impacted by climate transition risk whilst also representing the banks contribution to activities of the client.
[13] See IEA WEO Stated Policies Scenario: https://www.iea.org/reports/world-energy-model/stated-policies-scenario-steps
[14] Scenario alignment targets are set for production assets within the defined region.

the ABCD. This is effectively the investable universe as defined by the data universe of the ABCD.

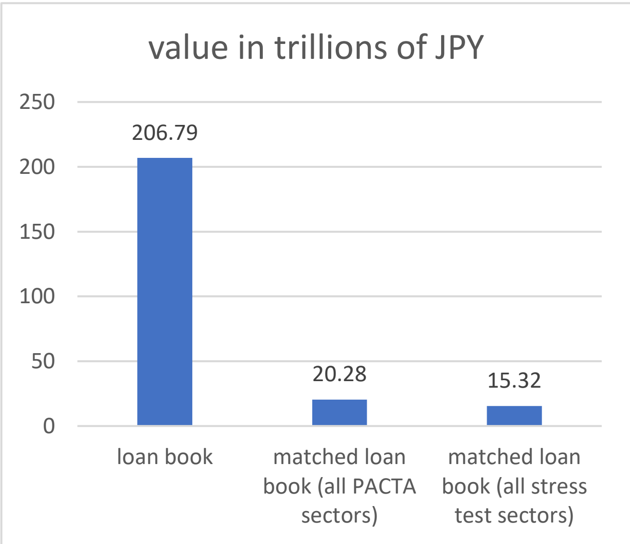
Aggregation of banks portfolios: The results have been aggregated and anonymized to preserve the anonymity of the individual participating banks. Through this process, the "portfolio" being shown is an average of the selected banks. Hence the plots should be interpreted as the average transition risks of a Japanese bank (based on the participating banks) and its (mis-)alignment based on the sample set of banks.

Match success rate: The percentage of in-scope loans, matched to production values in the real economy (i.e., the ABCD). This figure is calculated by loan exposure, given by sector and is taken as the average of the sample banks.

For this analysis, we examined the climate transition risk of the loan books a subset of Japanese banks. In aggregate, the outstanding loan size of the loan books was 206.79 trillion Japanese Yen (JPY). Out of these, 20.28 trillion JPY were matched with PACTA sectors, and 15.32 trillion JPY were matched in sectors with production pathways, so that we were able to include them in the analysis.

Figure 2: Matched loan book in trillions of Japanese Yen

Source: author



For the sectors with production pathways, i.e., the ones we can cover in the transition risk stress test, this leads to a coverage of around 7.4% of the aggregate loan book (see figure 2). Based on our estimate, as outlined above, this represents around 70-80% of CO_2 emissions. Given that most banks do not focus their lending specifically on the PACTA sectors, this is a ratio that is within the range of what can be expected in terms of coverage.

The match success rate within sector was largely in line with expectations (see figure 3).[15] After re-classifying the sectors of some loans with misclassified sector information as "not in scope," we find the following within-sector match success rates in the given aggregate loan book:

Figure 3: Match success rate within sectors

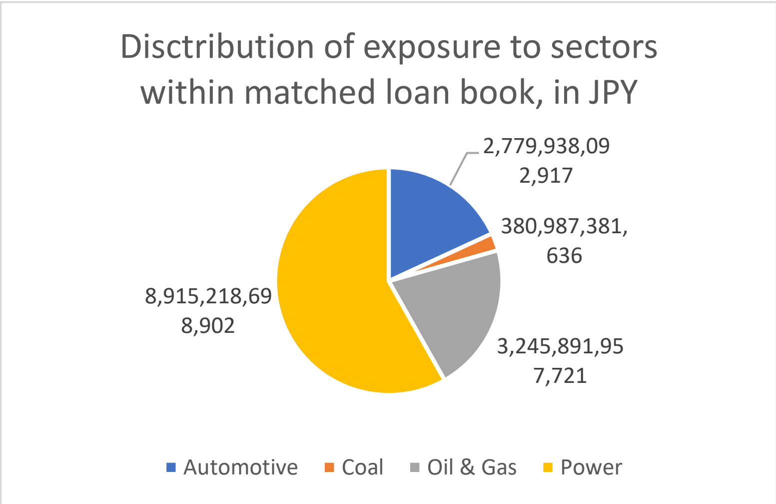
Source: author

Sector	Automotive	Coal	Oil & Gas	Power
Match success rate in percent of outstanding loan size	88%	63%	99%	95%

We make use of the PACTA methodology to derive sector (figure 4) and technology level exposures (see technology mix charts) of the aggregate loan book to the climate relevant technologies covered in this analysis.[16] The exposure to oil & gas upstream appears to be a bit lower for Japanese banks than for some Western banks.[17] Precise comparisons based on PACTA cannot be included here, as the results of other analyses are not public.

Figure 4: Distribution of matched sample loan book between sectors with production pathways, weighted by loan size outstanding

Source: author



4.2 Composition of the Capital Stock

We get an overview of the composition of capital stock within the sectors using the PACTA tech mix charts.

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[15] Based on similar PACTA exercises an 80% match success rate on average per sector is expected.

[16] More on the methodology and assumptions of PACTA can be found here: https://www.transitionmonitor.com/pacta-for-banks-2020/methodology-and-supporting-materials/

[17] Compare the oil & gas expansion, e.g. here: https://www.banktrack.org/download/banking_on_climate_chaos_2022/2022_banking_on_climate_chaos.pdf.

For coal mining there are no in-sector low-carbon alternatives and the same goes for oil & gas extraction, both of which need to wind down albeit at different speeds. While there are some nuances, the PACTA tech mix charts provide limited insight into these sectors, but the charts can be found in the annex for completeness. For power (figure 5 and 6) and automotive (figure 7), the charts show the current distribution between low and high carbon capital stock in the portfolio, in the corporate economy (as a benchmark) and according to the target scenario for 2020 and 2025.[18] This gives a high-level overview, if the underlying counterparties are transitioning to the degree necessary for the overall loan book to match scenario targets without reallocating funds. A failure to match the scenario targets in 2025 will likely point to misalignment in one or more sub-sectors, which is a potential source of transition risk.

Some noteworthy patterns are the relatively large share of hybrid vehicle production for the companies in the aggregate loan book (See figure 7: "Portfolio" compared to "Benchmark"), which seems to reflect particularly Toyota's strong focus on hybrid vehicles.[19] Another noteworthy pattern is the seemingly low share of coal fired power in the aggregate loan book (figures 5: "Portfolio" compared to the global "Benchmark" and 6: "Portfolio" compared to the Japanese "Benchmark"). This can be explained by the fact that the graphs show installed capacity for power generation, not actual generation. This means the distribution of power generation by technology depends on the load factors for each type of power generation. Based on the IEA Stated Policies Scenario, coal fired power generation has a higher load factor than other sources of power generation in Japan (which means that a version of figure 6 that translates power capacity to power generation would show a relatively larger share for coal-fired power) and additionally the load factor of Japanese coal fired power plants is higher than the global load factor for coal fired power generation.[20] This means the low relative capacity for coal-fired power plants in the loan book compared to the benchmark in figure 5 will be less pronounced when translating this to power generation.

An important aspect to keep in mind when looking at the shares of different types of power generation, car types or other sub-sectors in the capital stock is that the tech mix graph may indicate a comparably high share e.g., in a low-carbon technology in power generation. This share alone does not signal alignment or misalignment based on PACTA or the stress test model. As described above, targets are set assuming constant market shares for all counterparties within each sector. This means that, relative to their starting

[18] How to read the technology mix chart: Each row shows the within-sector distribution of the relevant production capacity by technology. That is, for the counterparties in a loan book that were successfully mapped to the power generation sector, we see a breakdown of how the matched power capacity distributes across different forms of power generation. This distribution reflects the capacity as provided by the ABCD. The top three rows show distributions for the start year of the analysis, one for the counterparties in the loan book ("Portfolio"), one for all production sites in that sector for the selected region ("Benchmark") and one for a hypothetical aligned loan book, that tracks the development of the changes of the target climate scenario (in this case the IEA SDS scenario). The lower three bars do the same thing for the distribution of capacities five years in the future. This assumes a static loan book that retains the same counterparties so that all changes can be attributed to actual changes in production levels or capacities.

[19] See for example: (https://www.toyota-europe.com/world-of-toyota/feel/environment/better-air/hybrid-vehicle)

[20] This is based on numbers from the IEA Stated Policies Scenario which aims to reflect the status quo of production levels and how these will change based on nationally determined contributions (NDCs). Load factors can be derived from the relationship between power generation and power capacity in the scenario.

values of production, every company must increase or decrease their capital stock at the same rate derived from the scenario. While there may be other ways to construct a transition scenario at the micro level, this model only supports an approach of constant market shares as any other approach would require numerous additional assumptions.

Figure 5: Technology mix for all matched companies of the aggregated loan book in the power sector with global physical production assets

Source: author

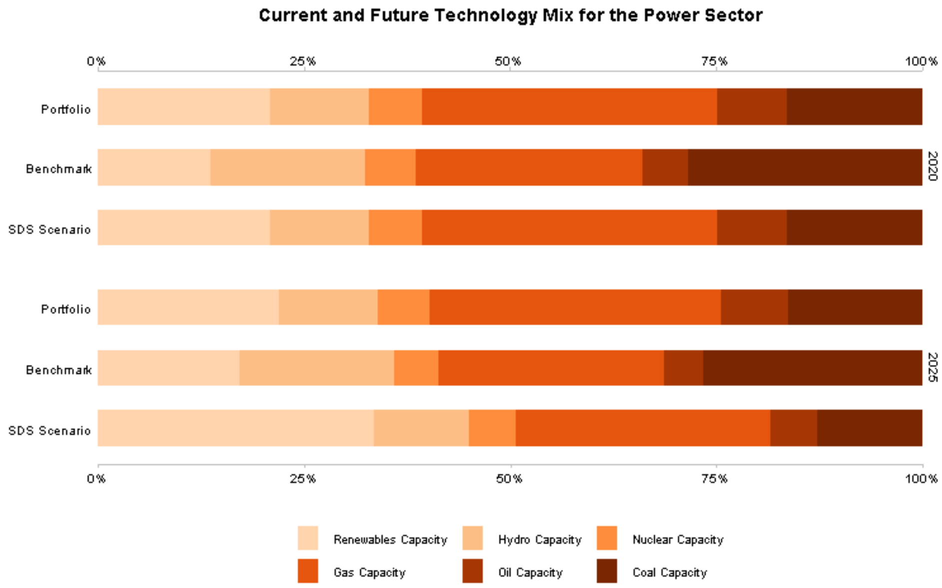


Figure 6: Technology mix for all matched companies of the aggregated loan book in the power sector with physical production assets within Japan

Source: author

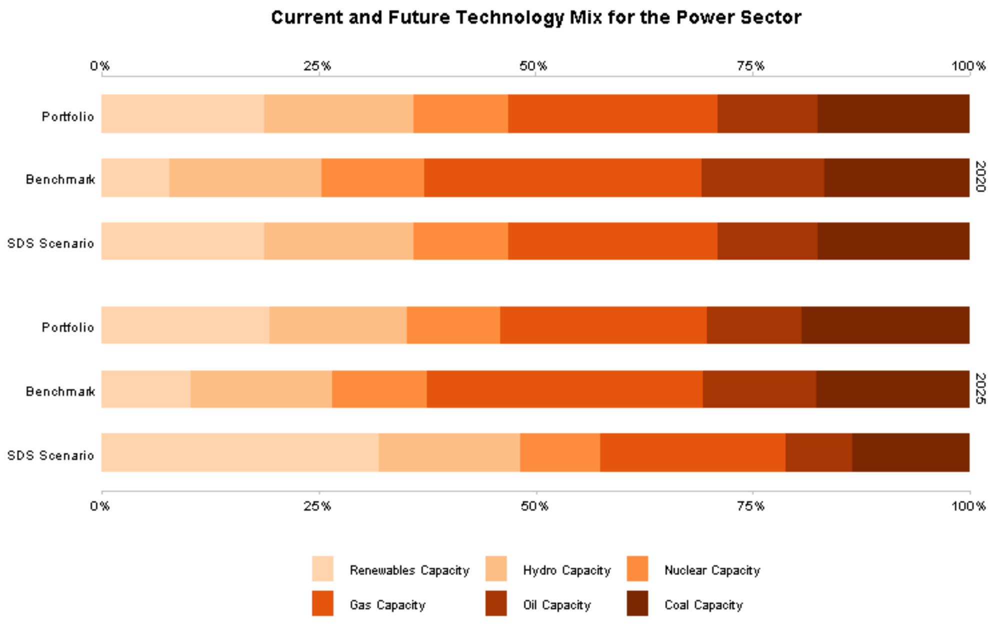
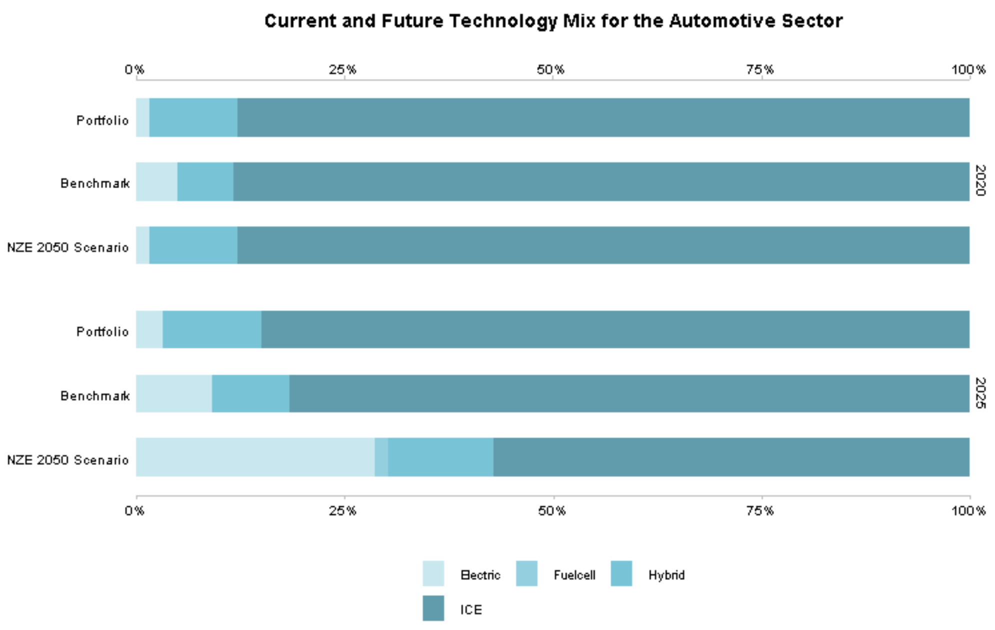


Figure 7: Technology mix for all matched companies of the aggregated loan book in the automotive manufacturing sector with global physical production assets

Source: author



4.3 Transition Risk Model Results

We ran the transition risk model using the following financial parameters:

- Risk free interest rate: 0.02 (based on the 30-year US treasury rate in 2021)
- Discount rate: 0.07
- Dividend ratio: 1 (since we focus on rather mature sectors)
- Loss given default: 0.45 (based on Basel standards for senior loans)
- Maturity of loans in expected loss calculation: 2 years
- Shock year: 2030
- Additionally, we ran a sensitivity analysis of the stress test using three different shock years, representing different degrees of a delayed transition: 2026, 2030 and 2035

4.3.1 Transition risk model results for shock year 2030

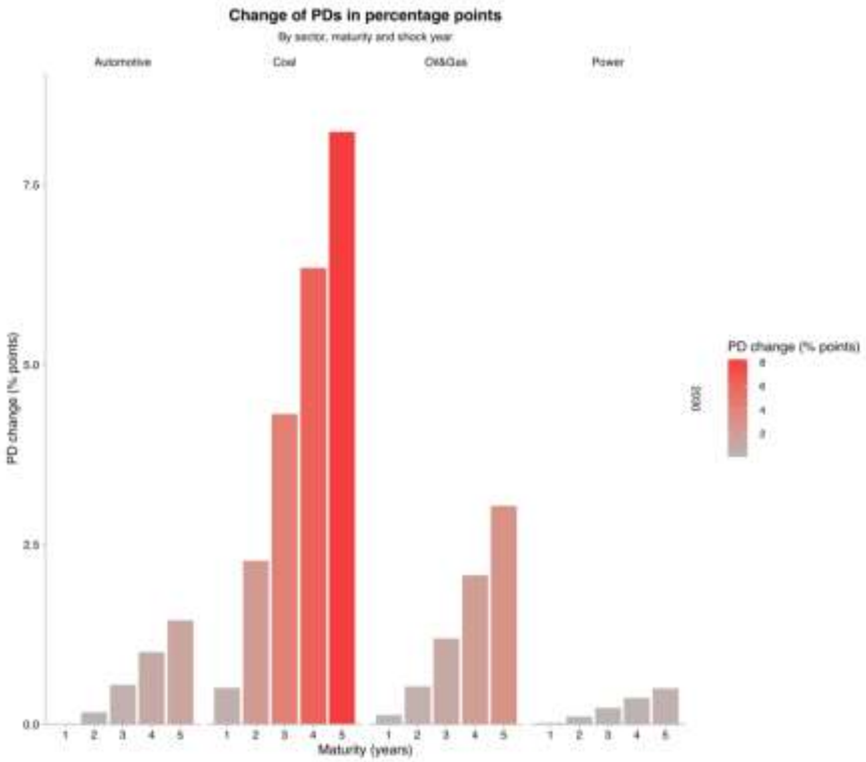
For the shock year 2030, we find that all four in-scope sectors have increasing probabilities of default, which all grow with longer maturities (figure 8). The sector with the largest increases in PDs is coal mining, followed by the oil & gas sector. For all three, this is driven by an increased planned production over the next five years, as shown in the trajectory charts (annex). This increase is strongly misaligned with scenario targets. Hence the transition risk framework will force the underlying companies to drastically adjust their business activity in these sectors after the shock.

Power and automotive sectors are also negatively affected for similar reasons, but the adjustment is not quite as strong. This is due to offsetting effects from some low carbon technologies that need to be built out rather than reduced, which can increase the future profits for some real counterparties. Also, we can see that for some of the technologies both in the automotive sector (for hybrid vehicles) and in the power sector (for gas-fired power generation, figure 9), the production pathways are almost aligned or even fully aligned with target scenarios.[21] In such cases, the compensation required from the company will be much lower, which leads to a smaller impact on profits.

[21] Alignment is judged by comparing the forward-looking production plans compared to the production targets. Production targets in PACTA are calculated using the market share approach, which aims at prescribing changes to production levels that maintain the overall market shares of each company for a given sector. A more detailed explanation can be found here: https://2degreesinvesting.github.io/r2dii.analysis/articles/target-market-share.html. In general, this means that if for a given type of capital stock (e.g. coal fired power capacity), the production capacity needs to decrease and the production forecast does not decrease in the prescribed way or more, that type of capital stock is considered misaligned. If a type of capital stock (e.g. electric vehicles) needs to be built out and the production forecast is not built out at the prescribed rate, that type of capital stock is considered misaligned.

Figure 8: Average change in probabilities of default by sector and maturity of loans in percentage points

Source: author, based on Baer et al. (2021) and Baer et al. (2022, forthcoming)



The direction of the shocks can by and large be derived from the aggregate misalignment of the production. The exact misalignment per technology can be seen in the production trajectory charts in the annex. A simplified overview of the differences between production and scenario targets in year five of the forecast gives an indication:

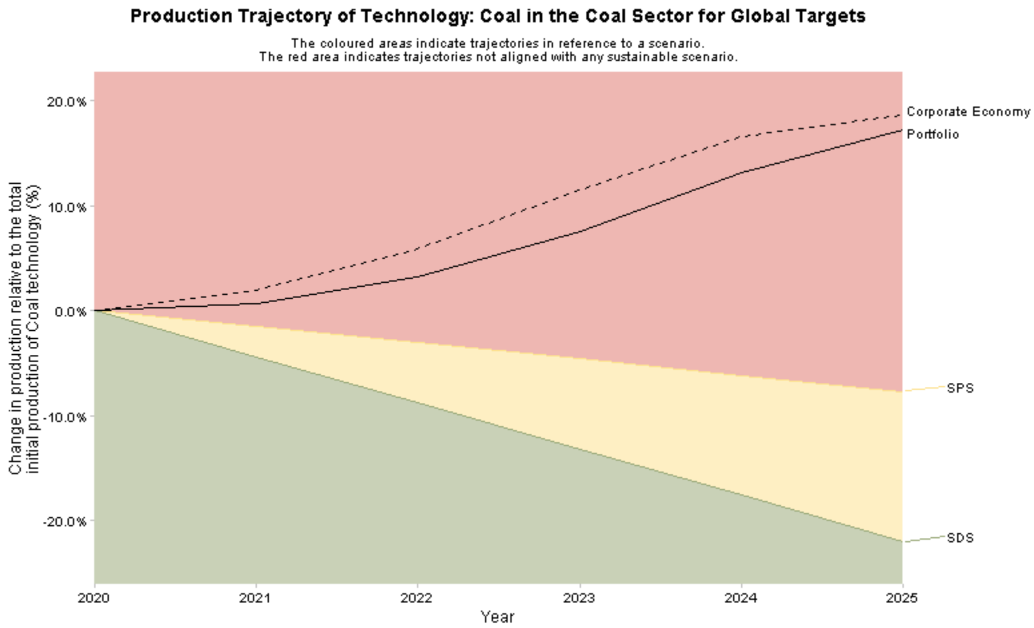
Figure 9: Relative misalignment between target scenario and portfolio weighted production in year t5

Source: author

Sector	Power						Automotive			Coal	Oil & Gas	
Technology	Coal	Gas	Hydro	Nuclear	Oil	Renewables	Electric	Hybrid	ICE	Coal	Oil	Gas
Divergence from target in % points	22	0	-1.5	-0.35	20	-19	-24	1	50	35	14	25
Aligned												

The aggregate loan book is misaligned in almost all technologies in scope of the analysis. The degree of misalignment varies quite significantly, with ICE vehicle production and coal mining (figure 10) being most severely misaligned, whereas hybrid vehicle production is looking to overperform its target slightly under the IEA's Net Zero Emissions by 2050 Scenario (NZE scenario), not under IEA ETP, and gas-fired power generation being right on track for the target (figure 11).[22]

Figure 10: Production volume trajectory chart for coal mining over a five-year forward looking time frame compared to scenario targets and compared against a global benchmark
Source: author



These patterns of production misalignment propagate to the change in company valuation to some degree when we apply a policy shock that forces companies to adjust their production after the year 2030.

Among the high carbon technologies that need to decline in the long term, we see the largest relative changes in value in coal mining, coal-fired power generation, upstream oil, ICE vehicle manufacturing. Beyond the fact that these technologies need to be wound down fast and additionally compensate for

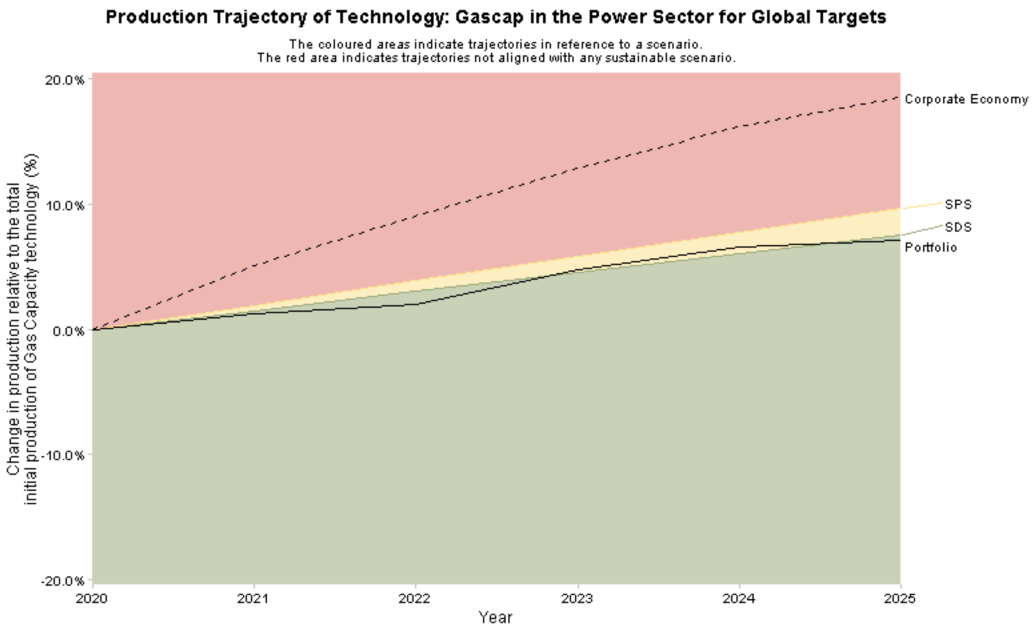
22 How to read the alignment chart: The black line (labeled "Portfolio") depicts the production (capacity) of the given type of capital stock for the counterparties in the loan book, weighted by their respective "portfolio weights" (see PACTA for Banks methodology document for more details on that). In essence, it reflects the aggregated forward-looking production plans underlying the counterparties in the loan book. The dashed line (labeled "Corporate Economy") is a benchmark that considers the forward-looking production plans of all physical assets in the given type of capital stock and scoped to the same region – regardless of whether they are owned by a counterparty or not. In that sense, they reflect the investible universe. The lines between the different background colors denote the required year on year change of production capacity based on the market share approach for the given type of capital stock. If the "Portfolio" line follows one such scenario line exactly, it would be perfectly on target for a given scenario (e. g. SDS or SPS). If the production trajectory is within the red section of the graph, it is always misaligned. If it is in the green section of the graph, it is aligned with the most ambitious climate scenario that we consider in the given analysis.

overproduction, the price channel also has an impact (we see this in gas-fired power generation, which is aligned, but has an unfavorable development of costs in the shock scenario over the long term). But misalignment of high carbon technologies is a very good indicator of the severity of adverse shocks.

By the same token, companies that own physical assets using technologies that need to be built out and/or that benefit from positive developments to the unit costs, can see valuation gains. This is particularly the case in the Automotive and Power sectors, which both have some low carbon alternatives. On the sector level, this means the direction of the effect of a policy shock is more ambiguous and the low carbon technologies can at least offset some of the usually negative impact on high carbon technologies. We can see this pattern in the changes to the overall probabilities of default of the companies in the aggregate portfolio.

Figure 11: Production volume trajectory chart for gas-fired power capacity over a five-year forward looking time frame compared to scenario targets and compared against a global benchmark

Source: author



See the remaining production volume trajectory charts in the annex.

Changes in relative company values are the main driver for changes to PDs in our model, as it changes the distance to the default threshold in the Merton credit risk model. Coal mining and upstream oil & gas only contain high carbon technologies, as such the impact on PDs is unambiguous and rather strong (See figure 7 above: e.g., an increase of around 8 percentage points on loans to coal mining companies with a 5-year maturity in the year of the shock, and an increase of around 3.5 percentage points in the PD on loans to oil and gas companies with maturities of five years). Note that recently the risk-free interest rate may be rising a bit compared to the two percent that we assumed in the analysis, which could dampen the impact of the transition risk on the PDs somewhat, based on the Merton credit risk model. However, generally that does not change the magnitude of the results in our model.

Beyond the mean PD changes per sector, we can observe some relevant variation in how the counterparties are affected. Figure 12 shows the distribution of PD changes in percentage points for each of the sectors for one-year maturities (excluding outliers with PD changes greater than 10 percentage points) and figure 13 shows the same for five-year maturities (including all observations). At this point, it is important to keep in mind that such changes in PDs are not to be understood as a forecast, but rather as a scenario analysis with assumptions of static loan books. As such, it cannot be derived that (i) a given number of counterparties will default, as the banks may react in the interim and (ii) that the companies will not be able to adapt and reduce risks before such a policy shock is introduced. It is helpful bearing in mind that this analysis explores vulnerabilities if no additional measures are undertaken until the tested shock years.

Beyond the obvious fact that PD changes for shorter maturities are much lower, we can see that PD changes in the power sector tend to be closer to zero including some cases of decreasing PDs, which can be expected as some companies will make use of the options to transition to low carbon technologies in the power sector. Such action significantly reduces transition risk. The patterns are more clearly visible for longer maturities, shown in figure 13. We see that most companies in the power and automotive sectors have comparably lower transition risk than the ones in coal and oil & gas. In all cases, within sector variation is significant though, varying between close to no change in PDs and up to around 20 percentage points. Such variation highlights the importance for banks to understand whether their counterparties are preparing for transition or not.

Figure 12: Distribution of PD changes in percentage points for loans with one-year maturities, by sector

Source: author

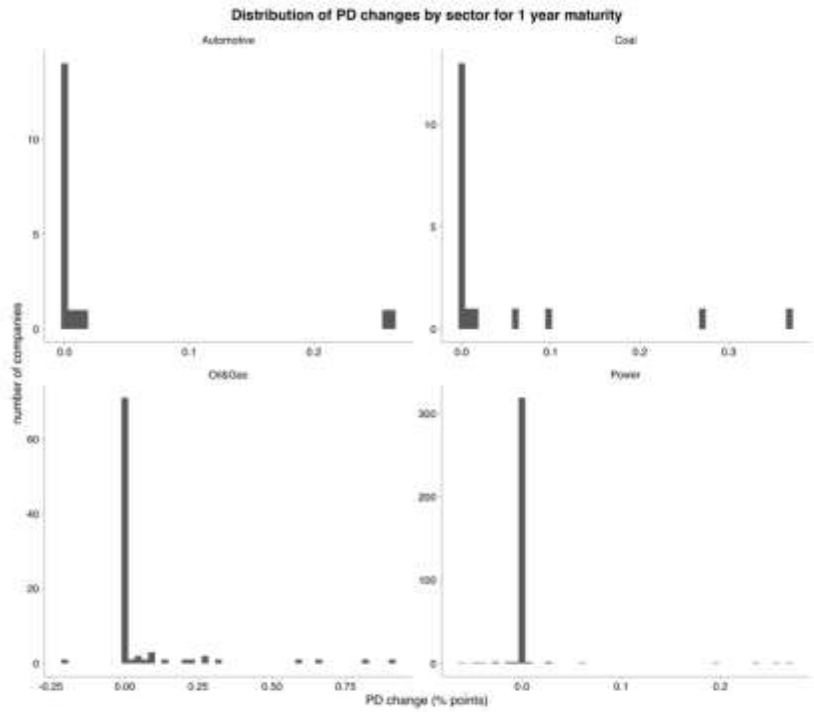
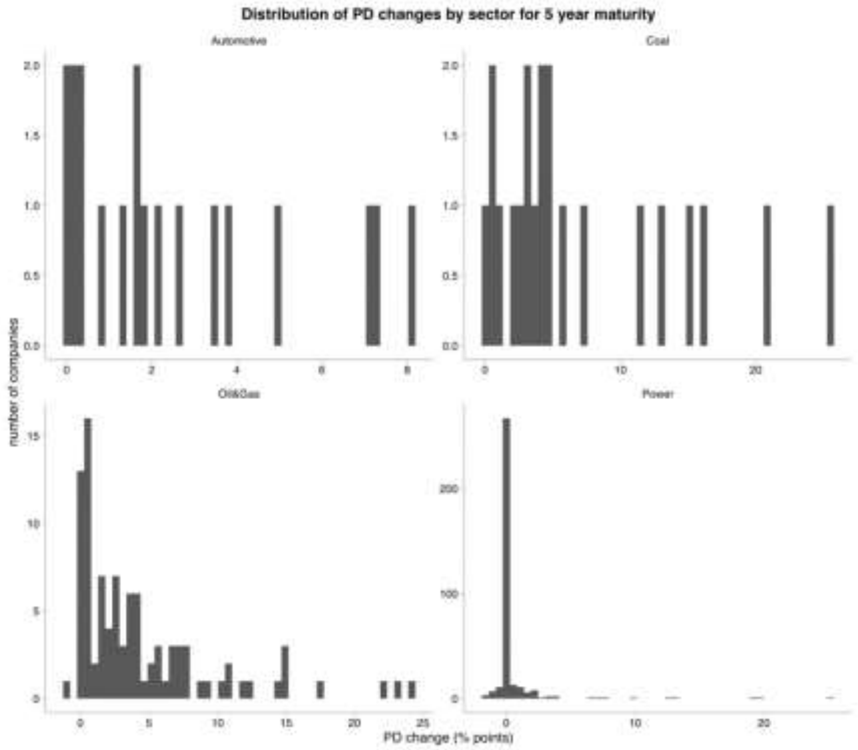

Distribution of PD changes by sector for 1 year maturity
Automotive
Coal
Oil&Gas
Power
number of companies
PD change (% points)
0.0
0.1
0.2
0.3
-0.25
0.00
0.25
0.50
0.75
0
5
10
20
40
60
100
200
300

Figure 13: Distribution of PD changes in percentage points for loans with five-year maturities, by sector

Source: author



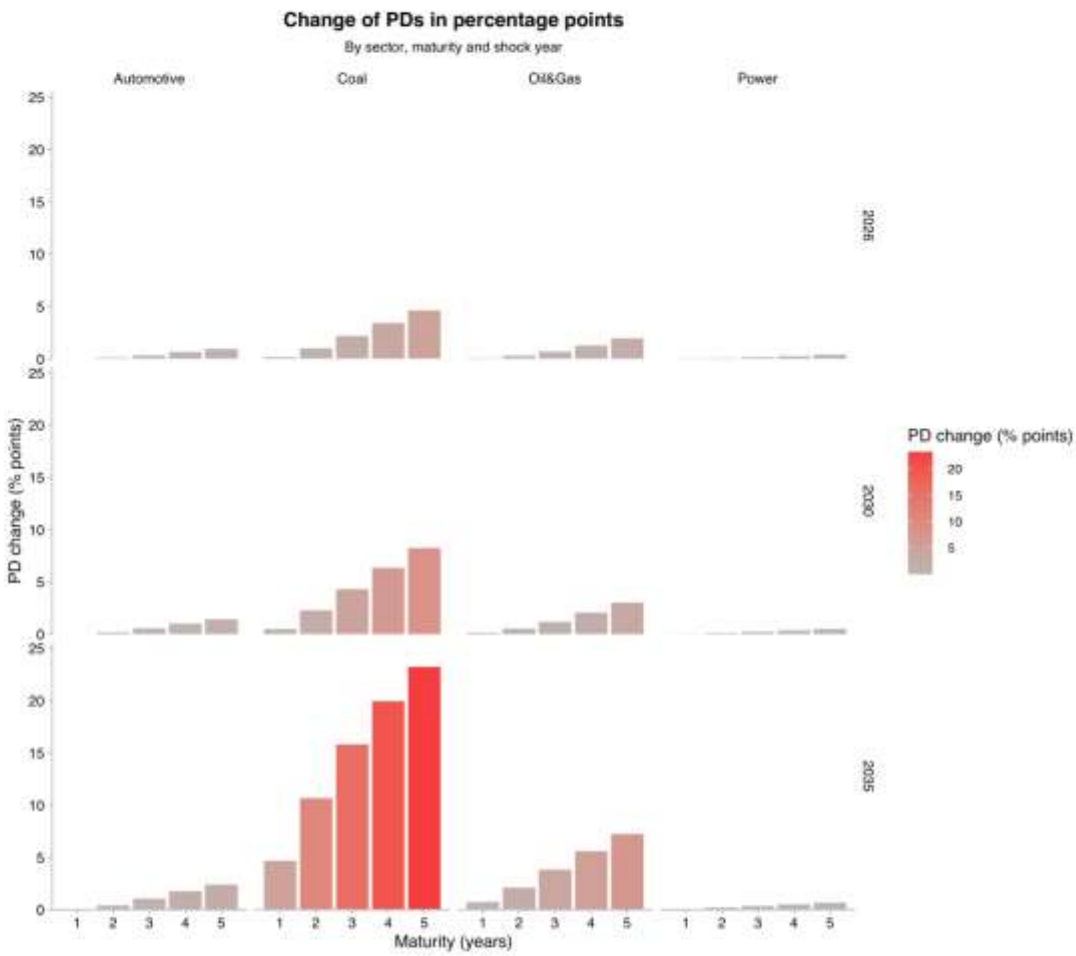
4.3.2 Sensitivity analysis of the shock year

When comparing the results across shock years, we see that the impact of the policy shock grows, the longer it is delayed. We ran the model with shock years 2026, 2030, and 2035. The longer we allow the business to continue its business-as-usual operations, the stronger the effect of transition shock on the PDs (figure 14).

Our analysis shows that a delayed transition can substantially increase the change in PDs. For the sectors that are facing a quick phase out in the target scenario (coal mining and to a varying degree also both upstream oil and gas extraction). It seems later shocks could highly increase the risk of driving some counterparties into bankruptcy, given that loans of a longer maturity in the coal sector see increases in their average PDs of more than 10 percentage points. In oil & gas, the effects are a bit less drastic, but still worrisome.

Figure 14: Average change of probabilities of default in the aggregate loan book by sector and for different shock years.

Source: author, based on Baer et al. (2021) and Baer et al. (2022, forthcoming)



4.4 Key Findings

The key results from the exploratory climate transition risk stress test of the given sample of Japanese banks are as follows:

- The sectors that are most misaligned based on PACTA, tend to also exhibit the highest transition risk among the in-scope sectors. All in-scope sectors are misaligned at this point leading to varying levels of transition risk. There are only few exceptions at the sub-sectoral level, where gas-fired power capacity and hybrid automotive manufacturing are aligned, within overall misaligned power and automotive sectors. This analysis should not be read as a statement on how the analyzed Japanese banks fare compared to banks in other regions. While the specific pattern of alignment and misalignment is, of course, unique to each financial institution, it is common not just in this analysis but across most applications of PACTA to find misaligned loan books.
- For the Japanese banks included in the analysis, the coal mining and oil & gas sectors are most seriously affected in relative terms, with the highest changes to the mean PDs in percentage points.
- However, in absolute terms these most affected sectors do not make up for the largest share of the outstanding loans and the misalignments are smaller than benchmark in many cases, especially in the power sector when compared to the benchmark of overall Japanese power capacity.
- Within sectors there is considerable variation in how counterparties' PDs change due to transition risk. This implies that some counterparties are significantly more misaligned with climate scenarios than others and it points to a lever of managing transition risk and engaging in enhancing clients' resiliency.
- A sensitivity analysis that reflects on the impact of the shock year in which a regulation induces a sudden shift towards a low-carbon economy shows that a delayed transition builds up stronger misalignment and thus leads to increased risk, as the correction of production levels needs to be more severe to remain within carbon budgets of the climate scenarios.
- Given the static nature of the analysis, the result does not reflect the efforts made since March 2021 and being made in the future. As highlighted in Introduction and Chapter 2, both public and private sectors have taken various measures especially after the Japanese government declared the target of carbon neutrality by 2050 and set intermediate GHG emission reduction targets.

5. Managing Climate Transition Risk in Japan

Having analyzed the exposure to transition risk for the given sample of Japanese banks, there are several ways how banks, financial supervisors and central banks can manage the corresponding financial risk. The recommendations are based on the two roles that the financial system can play in the climate crisis:

- First, as seen in this report, financial markets are exposed to climate-related risks and thus, are impacted by them.
- Second, the financial sector can also contribute to the reduction of climate related risks and thus can control, to a certain extent, the impact and magnitude of them. There are three ways on how the financial sector can reduce the risks. The first one is to be resilient and to reduce the impact of the risk on their own balance sheets. The second one is to invest in adaptation and mitigation measures to actively reduce investment and lending risk. The third one is to actively drive positive change, allocate capital in impact investing and thus reduce the risk for the whole society (Thomä and Schönauer, 2021).

It should also be noted that risk management should always consider potential side effects. For example, if a bank starts divesting from certain high-carbon activities, and a lot of banks follow, it might be good for climate change but challenging from a social perspective. Sudden divestment might also trigger social issues, such as high unemployment that would need to be addressed by the state, e.g., through social policies. A well-managed just and fast transition requires coordination amongst national and international agents.

With this in mind, we split our recommendations in three sections and put forward recommendations for banks and financial supervisors. These recommendations made by the author are not immediately reflected to Japanese banking regulation and supervision or endorsed by the Japanese banking supervisor.

5.1 Recommendations on Managing Climate Risks for Banks

We divide banks' management in three categories: (i) reducing own exposure, i.e., reducing their own balance sheet risks; (ii) reducing the vulnerability of their clients, i.e., for example supporting mitigation and adaptation measures; and (iii) engaging with policies. Each of the underneath measures will have an impact on the financial market through signaling effects, supporting new/undersupplied markets or active engagement with counterparties or policymakers (please see Figure 17). They will also have different impacts on final climate outcomes in the real economy.

In each of those recommendations, the time component is important. The earlier the action the smoother the transition. Actions that make highly carbon intensive companies produce less at an early stage, can prevent the build-up of high transition shocks at a later stage. Our findings suggest that the impact of transitioning from 2026 onwards on PD changes is two to five times lower (depending on the sector) for loans with maturities of five years in the shock year compared to a very delayed transition starting in 2035. For shorter term loans, the difference between a transition starting in 2026 versus 2035 becomes even larger, although the overall increase stays lower, see figures 15 and 16. Of course, action today reduces again the transition risks significantly.

Figure 15: Average change of probabilities of default in the aggregate loan book by sector and shock years, for five-year maturities in the year of the shock

Source: author

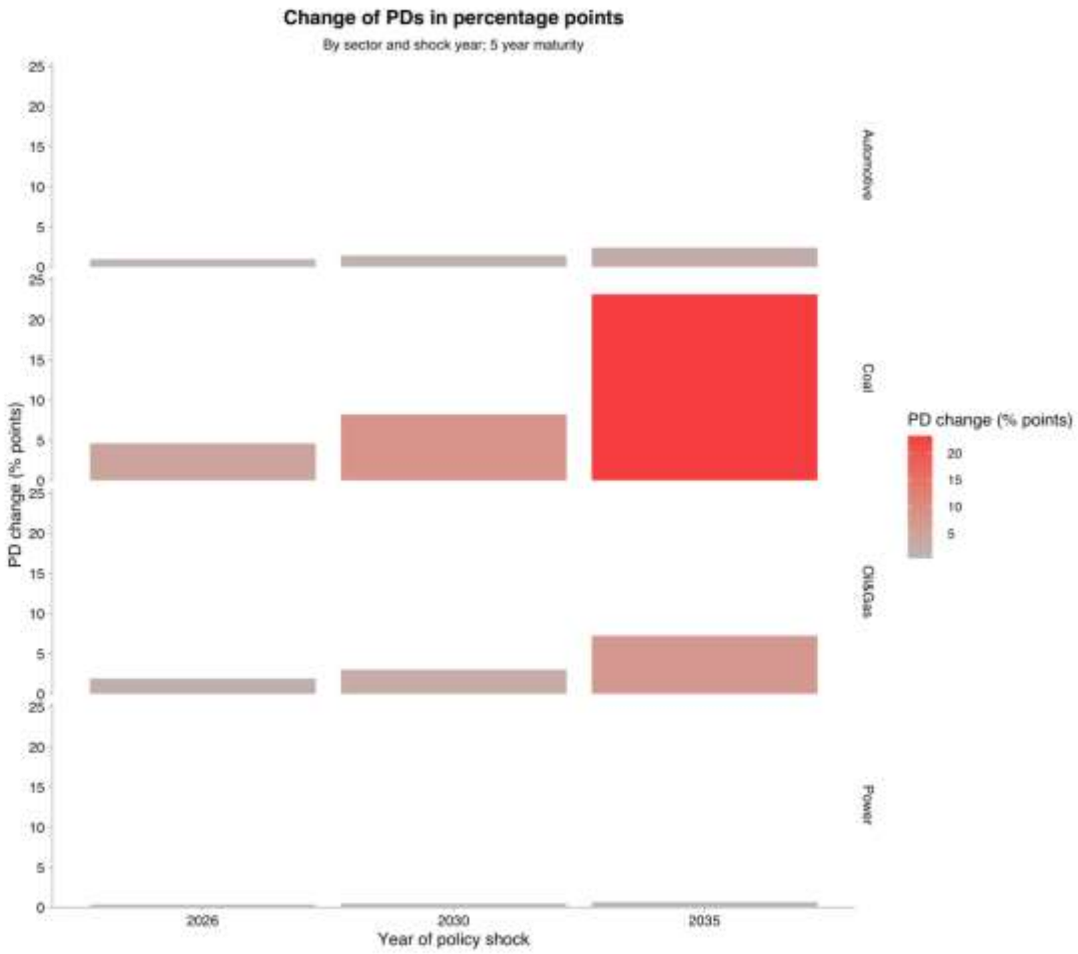
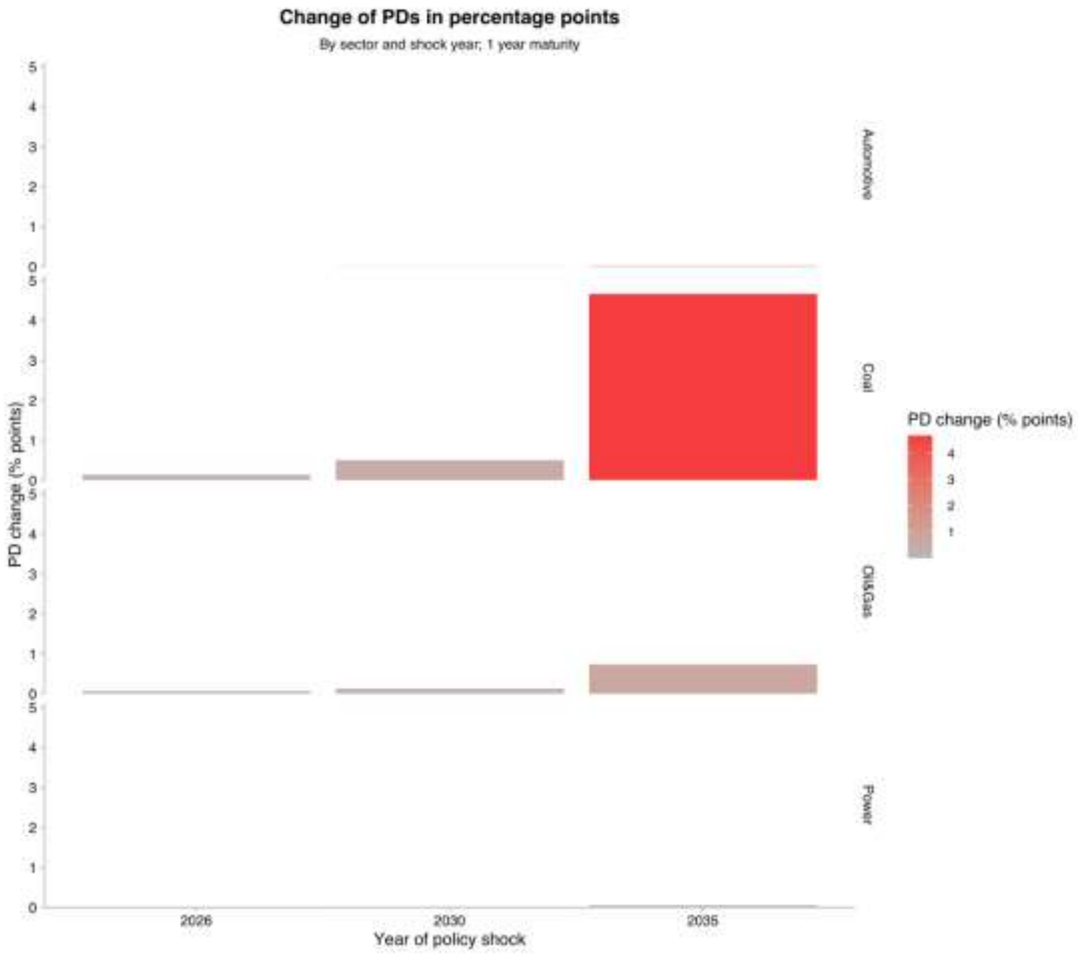


Figure 16: Average change of probabilities of default in the aggregate loan book by sector and shock years, for one-year maturities in the year of the shock
Source: author



5.1.1 Reducing own exposure

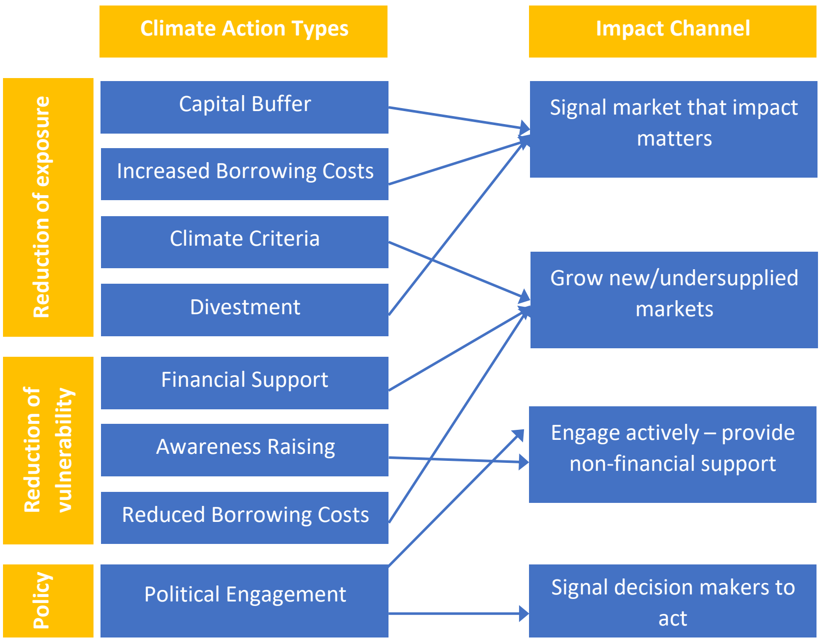
To manage climate transition risks, banks can already start building up a capital buffer for the investments facing transition risks. Furthermore, they could increase borrowing costs for investments with higher transition risks and identify climate-related minimum criteria to issue loans. If a company or a sector is prone to large transition risks (e.g., fossil fuel industry) a bank can consider to not grant loans to these companies at all or also to divest. However, banks should be aware that while these options reduce own risks, the impact on the real-world decarbonization is unclear as divestment, for example, might only be effective if many banks act cooperatively (Ralite et al., 2022).

5.1.2 Encourage counterparties to reduce their vulnerability to climate risks

Banks could engage with their counterparties to try and influence their business plans. Doing that will directly reduce the misalignment of real economic firms' production plans and——regardless of when a regulation may be introduced to enforce transition to a low carbon economy——the required adaptation would be much smaller and less disruptive. The engagement can happen through awareness raising, for example, supporting clients in understanding climate-related risks and which mitigation measures would help to reduce the exposure. Furthermore, banks can financially support their clients and finance mitigation and adaptation measures. A good incentive for clients to implement mitigation and adaptation measures could also be lower borrowing costs for those companies implementing those measures (Ralite et al 2022).

Figure 17: Overview of climate-related risk management of banks

Source: Own illustration. Based on: Ralite et al. (2022)



5.2 Recommendations on Managing Climate Risks for Financial Supervisors

To facilitate and encourage climate-related risk management by banks as described in 5.1, we think financial supervisors can also take steps, such as the ones described below.

5.2.1 Micro-prudential supervision (supervisory expectations)

Through micro-prudential supervision, supervisors can set expectations for banks and thereby influence banks to take more action against climate change. For example, expectations setting could require banks to integrate climate-related risks in their business strategy, develop sector policies, or it could outline minimum climate-related risk management requirements and the integration of climate-related risks in their decision-making and risk management processes. Furthermore, financial supervisors can also expect from banks to assess their exposure to climate-related risks by using forward-looking scenario analysis and stress testing or to align their portfolio with Japan's climate goals.

5.2.2 Micro-prudential supervision (rule-based)

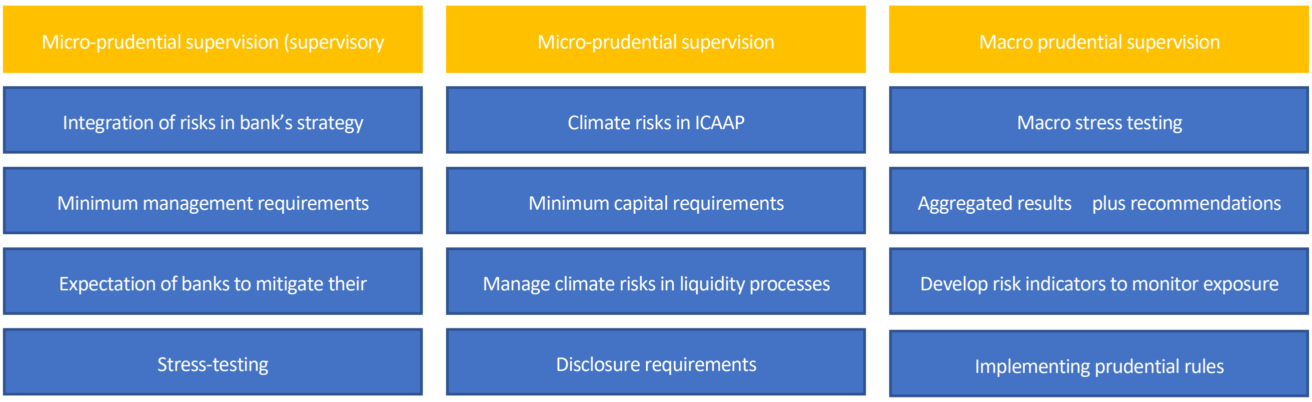
Supervisors could also expect banks to integrate climate-related risks in their capital adequacy assessment process (ICAAP). Furthermore, minimum capital requirements or capital add-ons for banks could be another instrument to make banks consider climate change. Another aspect would be to expect banks to integrate climate change in their liquidity processes. Other micro-prudential supervision instruments would be disclosure requirements. Banks are expected to disclose their misalignment to climate goals and their exposure to climate-related risks.

5.2.3 Macro-prudential supervision

Another aspect that financial supervisors could have in mind is the potential effects on financial system stability. For this, supervisors can assess the exposure of all significant banks in the system by using forward-looking scenario analysis and stress testing. Furthermore, supervisors can publish the aggregated results and formulate recommendations and expectations for banks. Another step would be the development of specific risk indicators to monitor the exposures. Issuing prudential rules to limit the exposure of banks to certain high-carbon activities will also prevent the build-up of systemic risks.

Figure 18: Overview of risk management of supervisors

Source: Own illustrations.



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https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Japan%20First/JAPAN_FIRST%20NDC%20(UPDATED%20SUBMISSION).pdf

7. Annex

7.1 Graphs

Figure A.1: Production volume trajectory chart for coal-fired power capacity with global assets compared against a global benchmark

Source: Own illustrations.

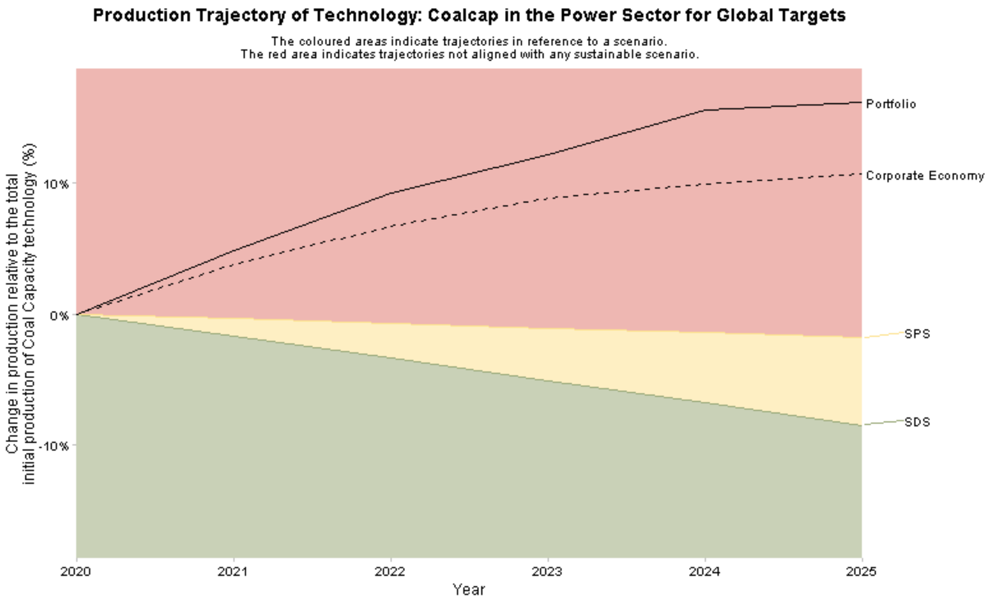


Figure A.2: Production volume trajectory chart for coal-fired power capacity with Japanese assets compared against a Japanese benchmark

Source: Own illustrations.

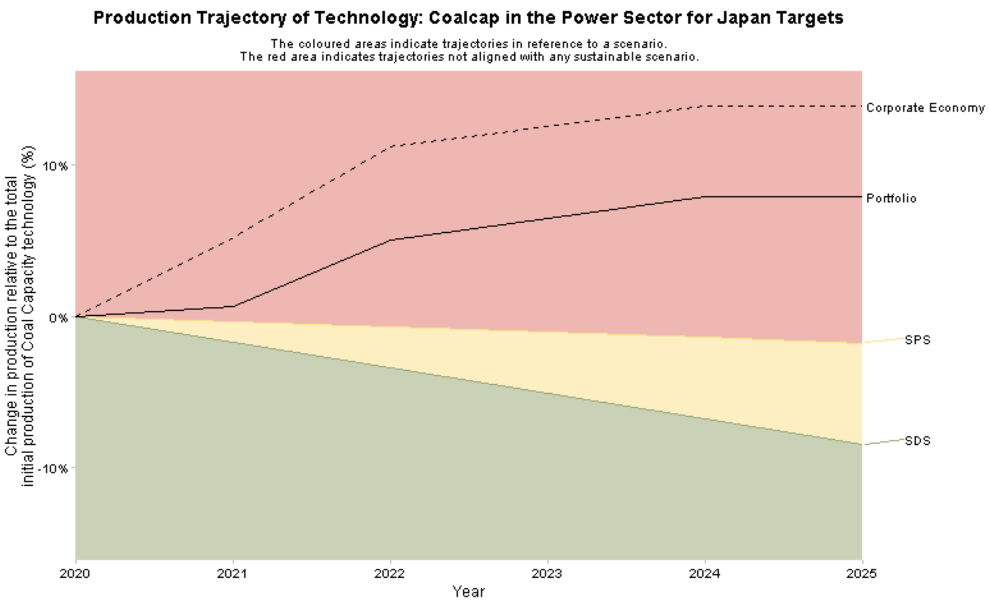


Figure A.3: Production volume trajectory chart for gas-fired power capacity with global assets compared against a global benchmark

Source: Own illustrations.

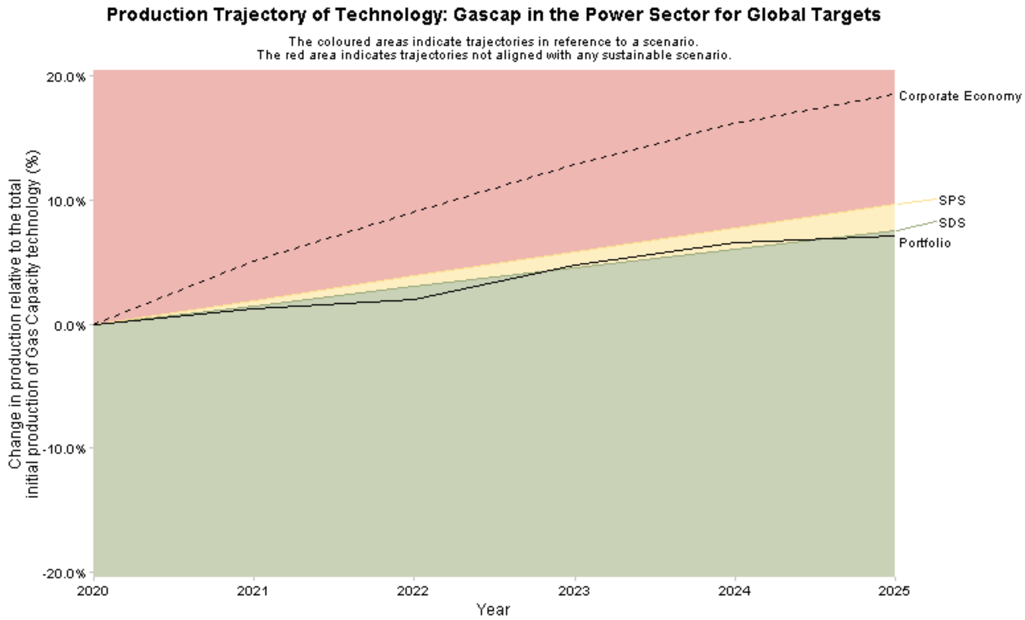


Figure A.4: Production volume trajectory chart for gas-fired power capacity with Japanese assets compared against a Japanese benchmark

Source: Own illustrations.

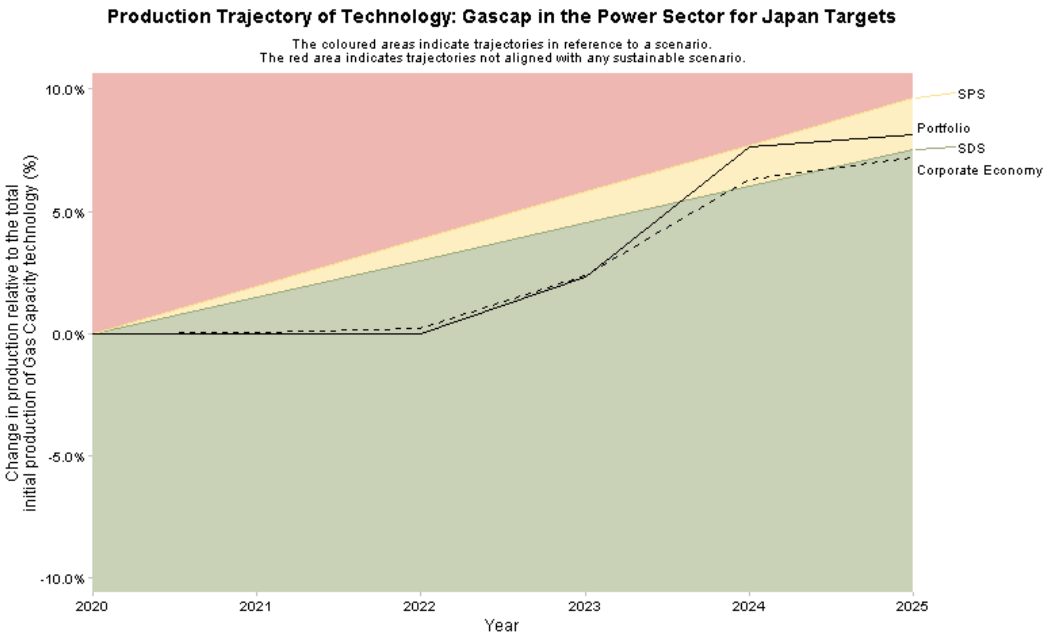


Figure A.5: Production volume trajectory chart for hydro power capacity with global assets compared against a global benchmark

Source: Own illustrations.

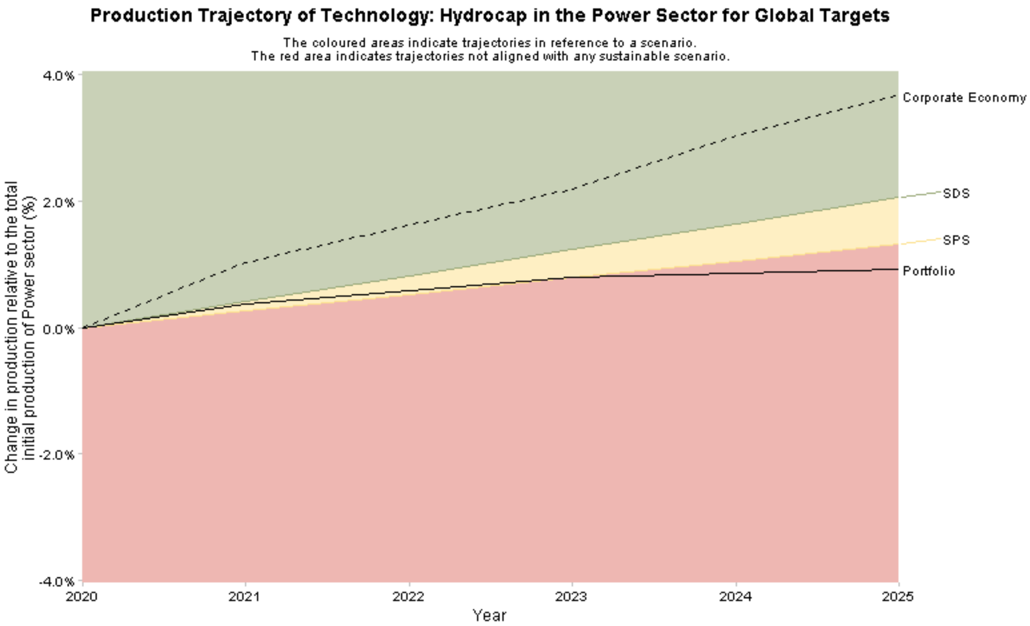


Figure A.6: Production volume trajectory chart for hydro power capacity with Japanese assets compared against a Japanese benchmark

Source: Own illustrations.

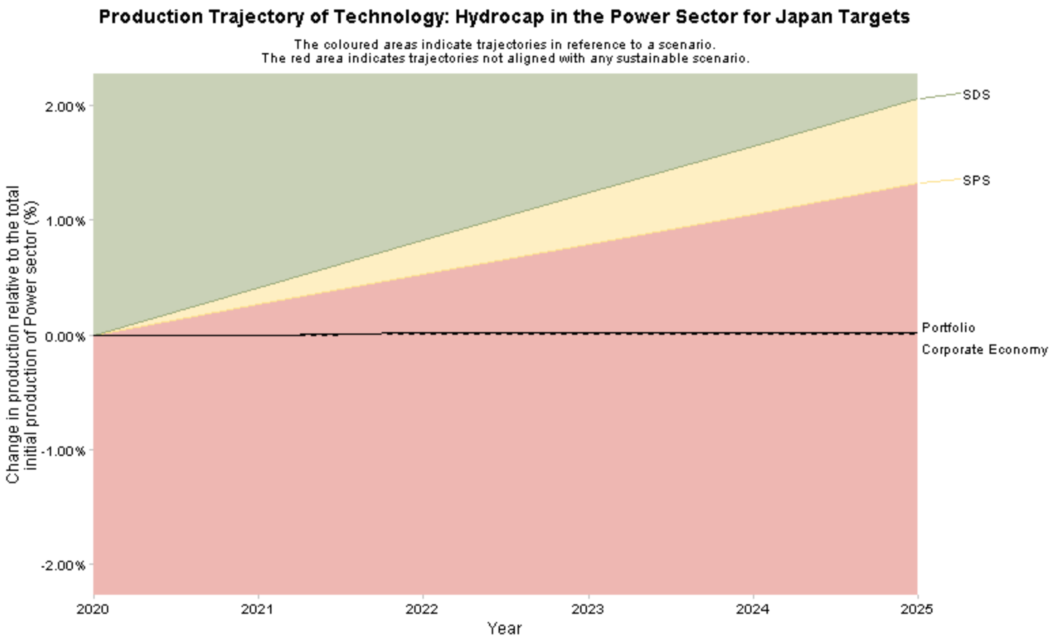


Figure A.7: Production volume trajectory chart for nuclear power capacity with global assets compared against a global benchmark[23)]

Source: Own illustrations.

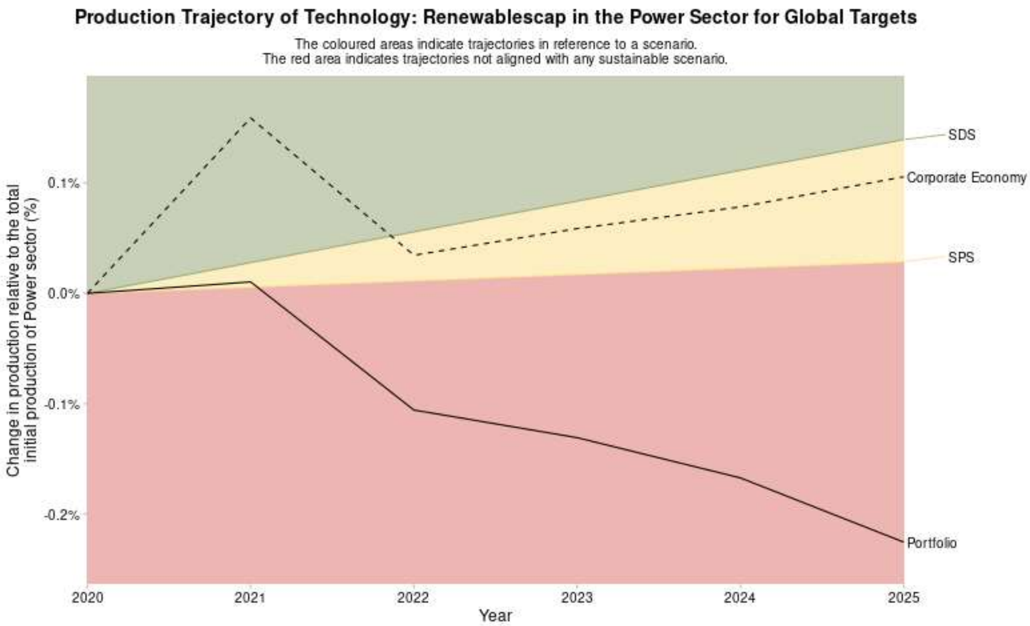
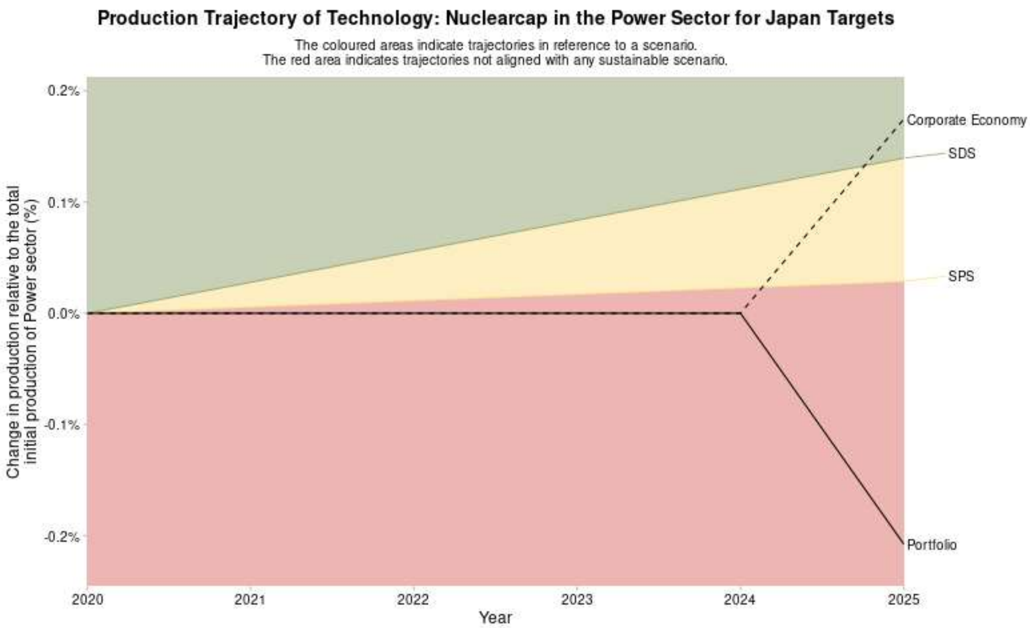


Figure A.8: Production volume trajectory chart for nuclear power capacity with Japanese assets compared against a Japanese benchmark

Source: Own illustrations.



23) (Note: The graph shows the nuclear production trajectory and is mislabeled.)

Figure A.9: Production volume trajectory chart for oil-fired power capacity with global assets compared against a global benchmark

Source: Own illustrations.

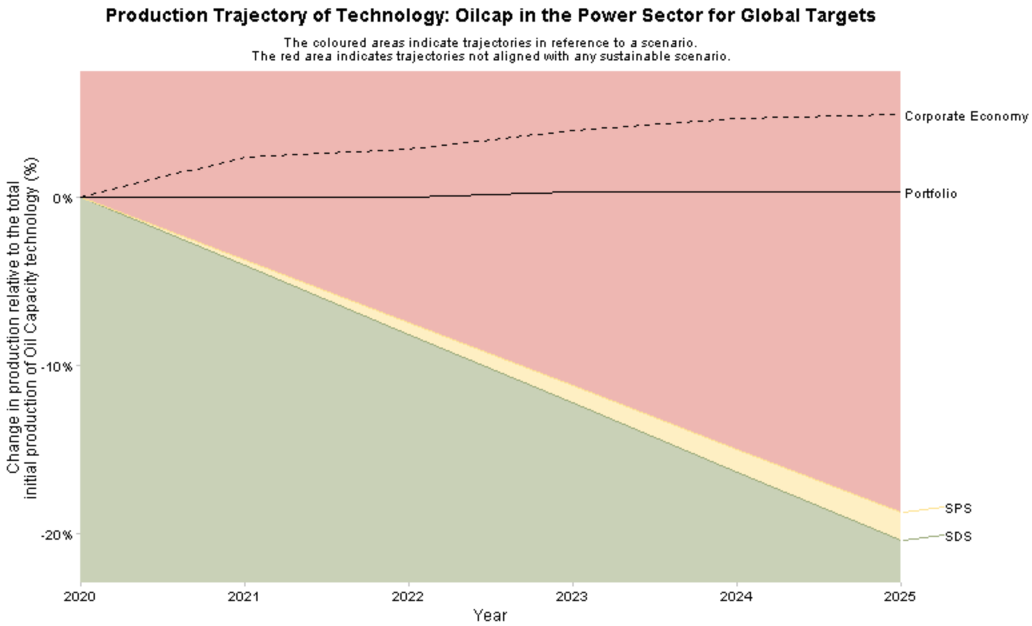


Figure A.10: Production volume trajectory chart for oil-fired power capacity with Japanese assets compared against a Japanese benchmark

Source: Own illustrations.

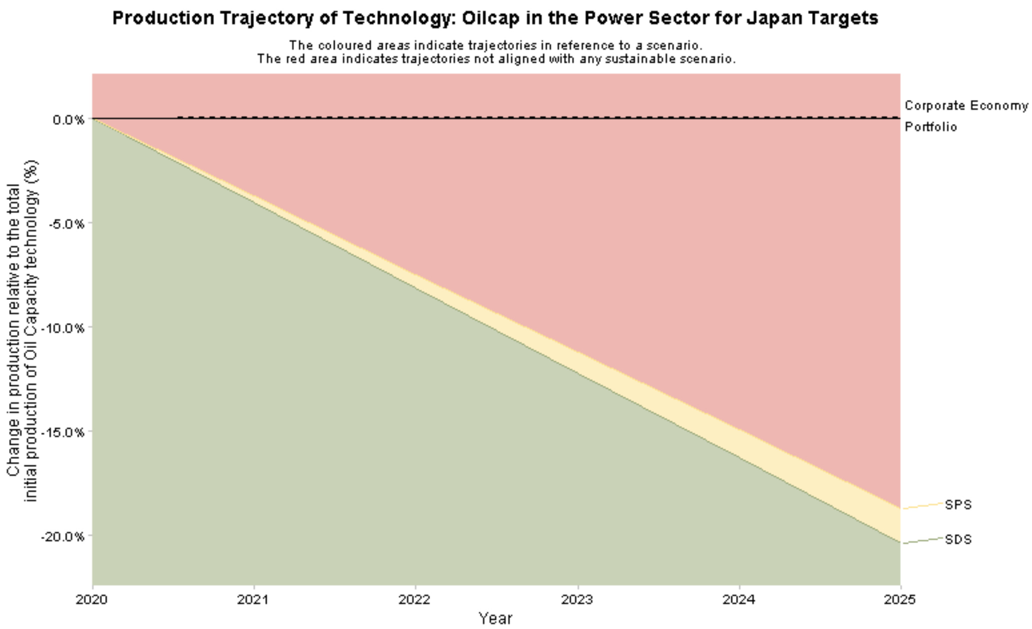


Figure A.11: Production volume trajectory chart for renewables power capacity with global assets compared against a global benchmark

Source: Own illustrations.

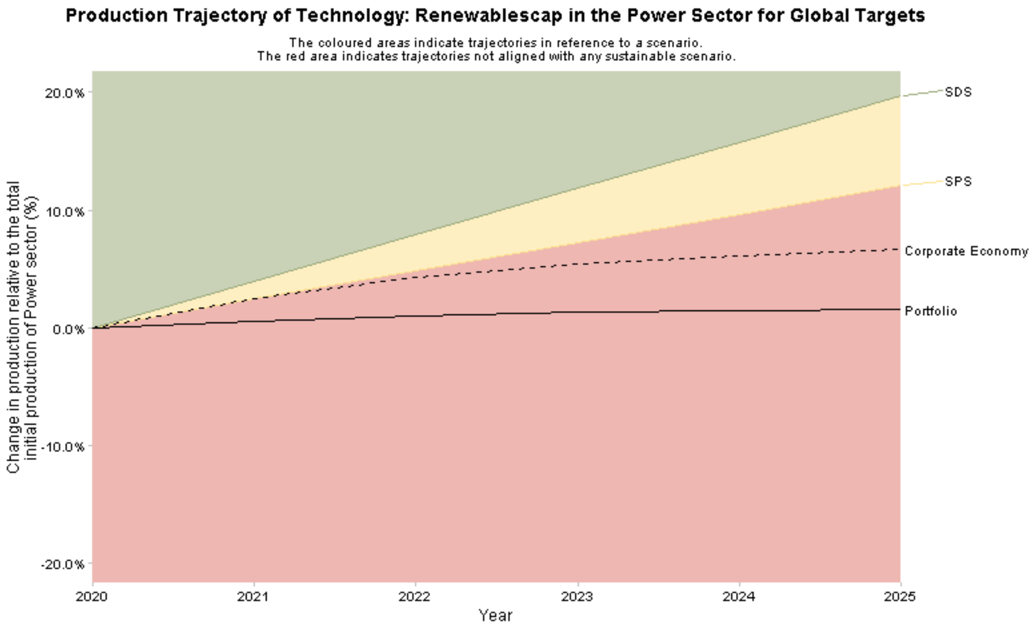


Figure A.12: Production volume trajectory chart for renewables power capacity with Japanese assets compared against a Japanese benchmark

Source: Own illustrations.

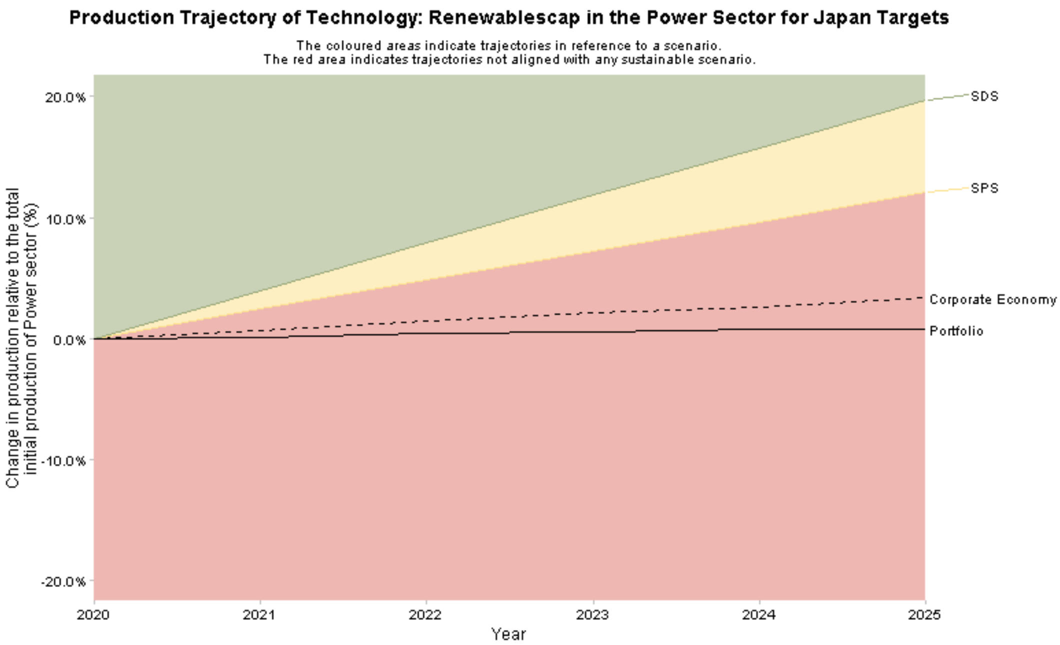


Figure A.13: Production volume trajectory chart for electric vehicle production compared against a global benchmark. Based on IEA NZE scenario

Source: Own illustrations.

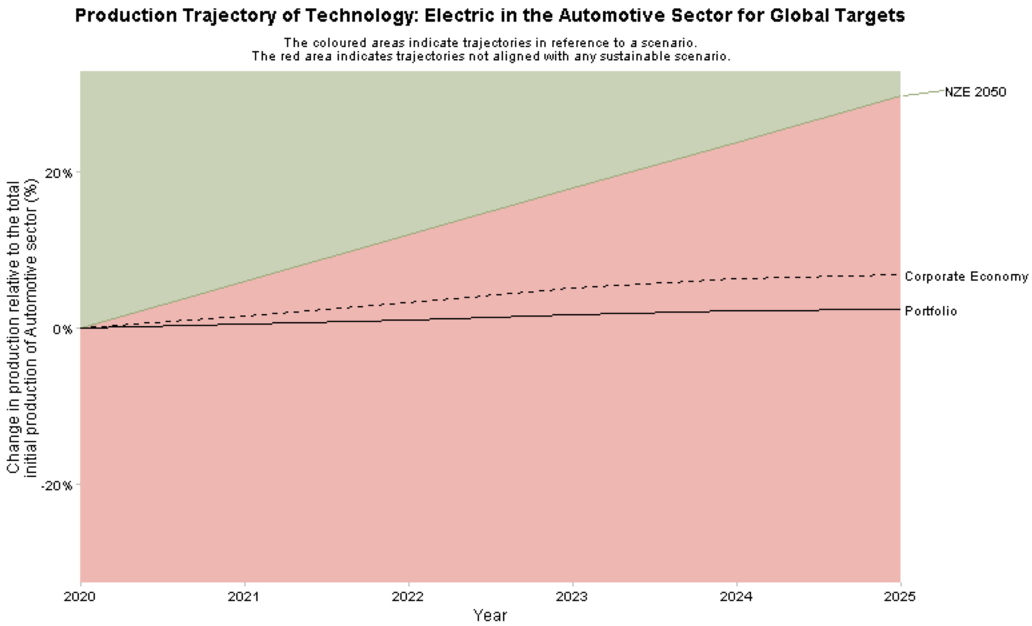


Figure A.14: Production volume trajectory chart for electric vehicle production compared against a global benchmark. Based on IEA ETP 2017 scenario (used in stress test)

Source: Own illustrations.

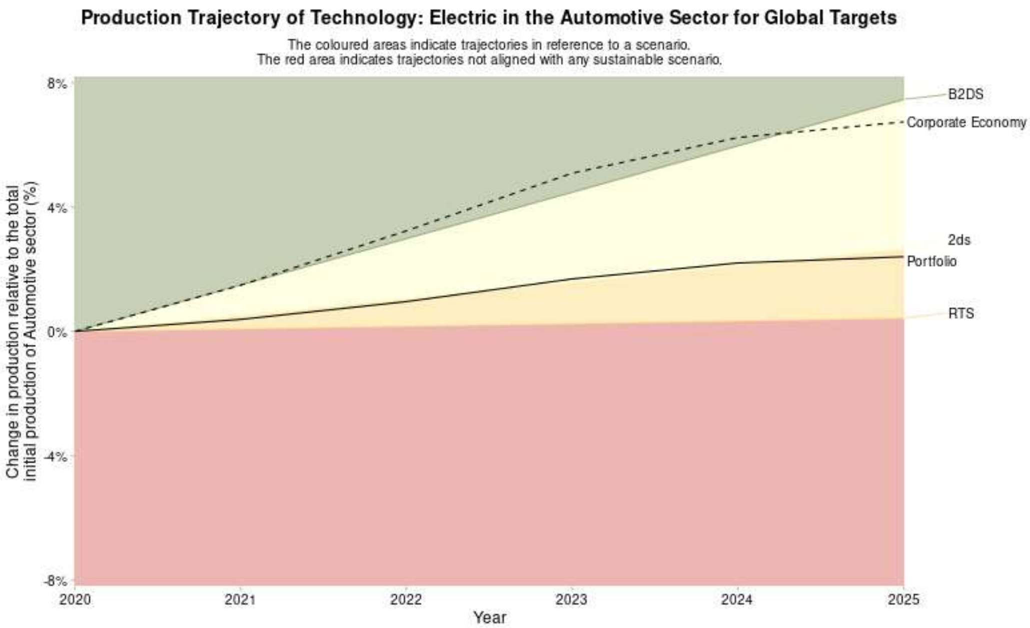


Figure A.15: Production volume trajectory chart for hybrid vehicle production compared against a global benchmark. Based on IEA NZE scenario

Source: Own illustrations.

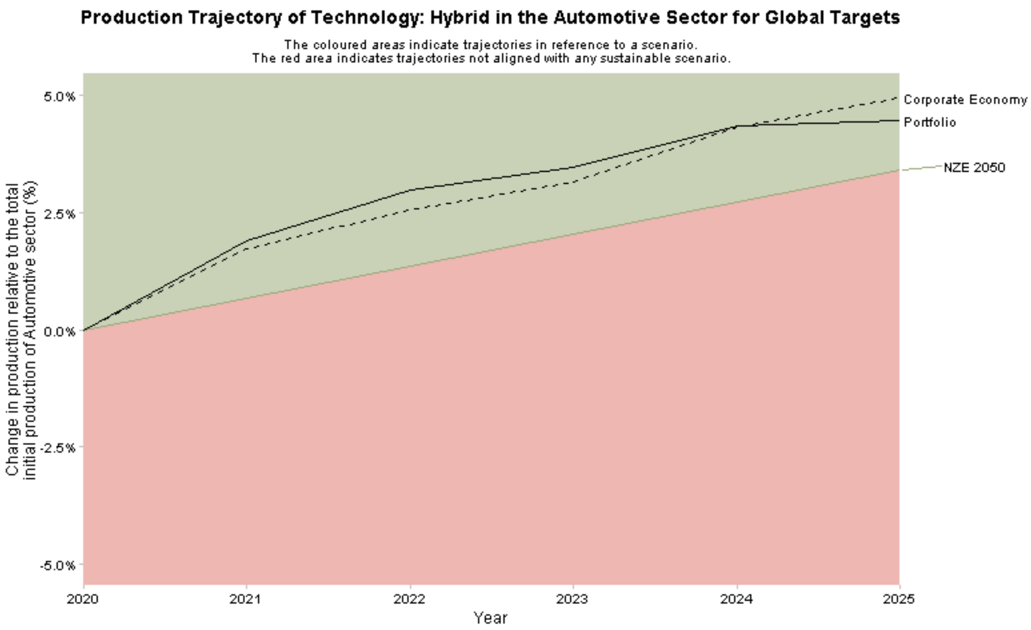


Figure A.16: Production volume trajectory chart for hybrid vehicle production. Based on IEA ETP 2017 scenario (used in stress test) compared against a global benchmark

Source: Own illustrations.

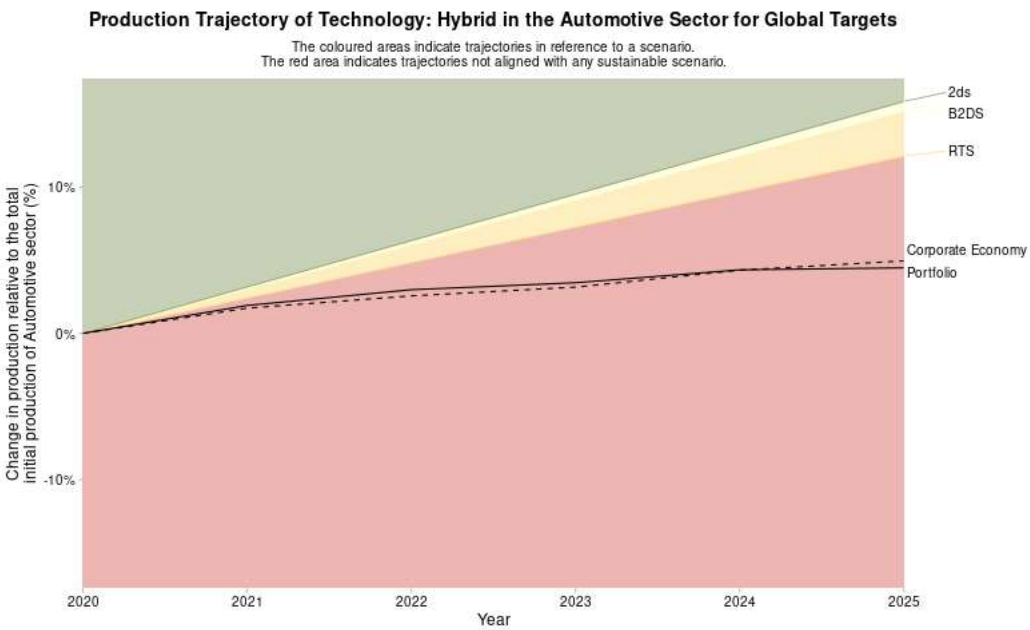


Figure A.17: Production volume trajectory chart for ICE vehicle production compared against a global benchmark. Based on IEA NZE scenario

Source: Own illustrations.

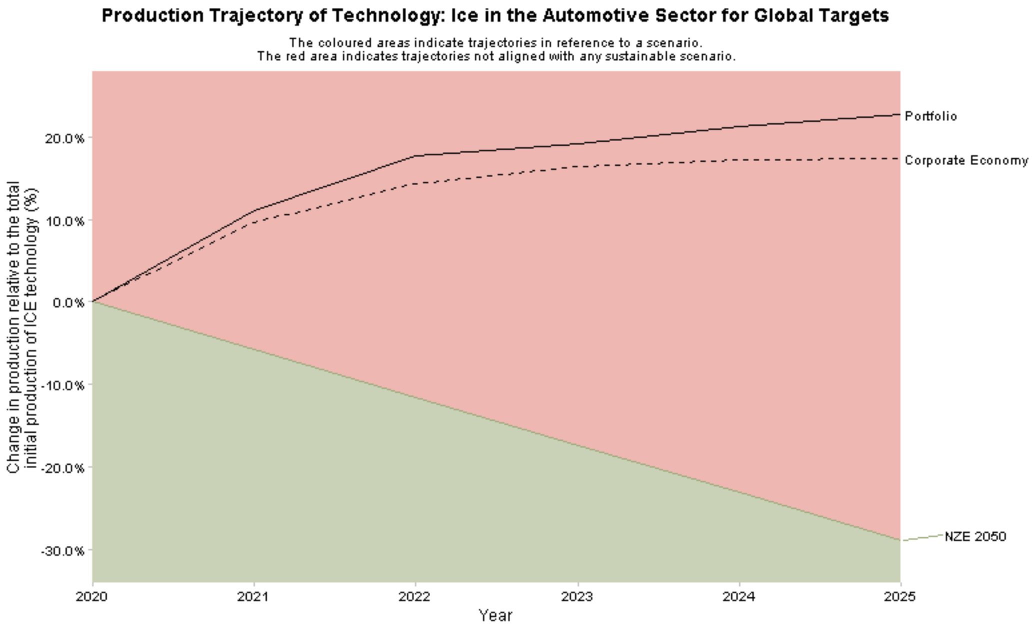


Figure A.18: Production volume trajectory chart for ICE vehicle production. Based on IEA ETP 2017 scenario (used in stress test) compared against a global benchmark

Source: Own illustrations.

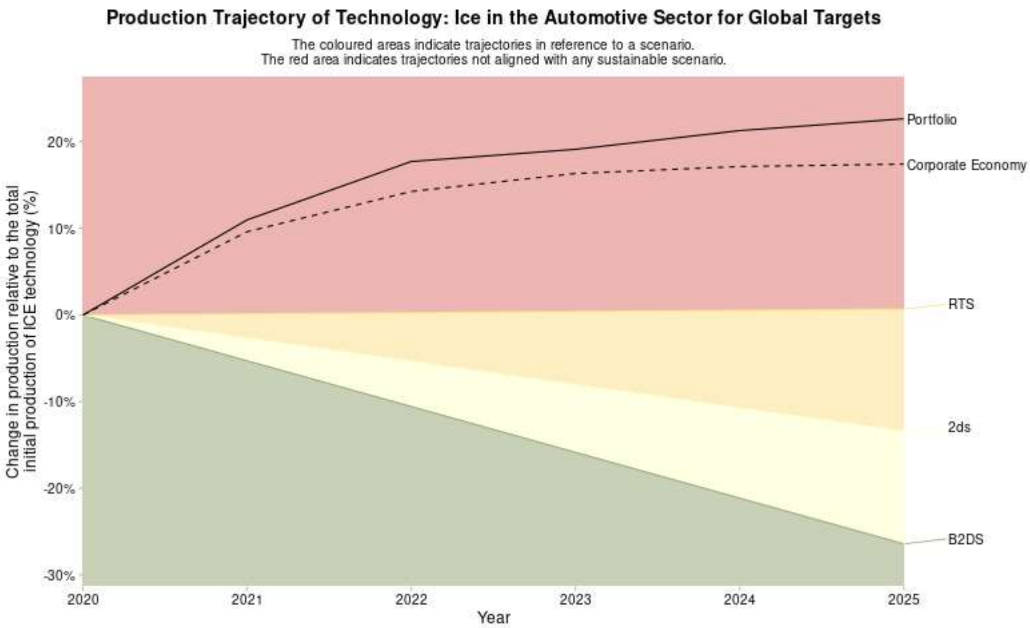


Figure A.19: Production volume trajectory chart for coal mining compared against a global benchmark

Source: Own illustrations.

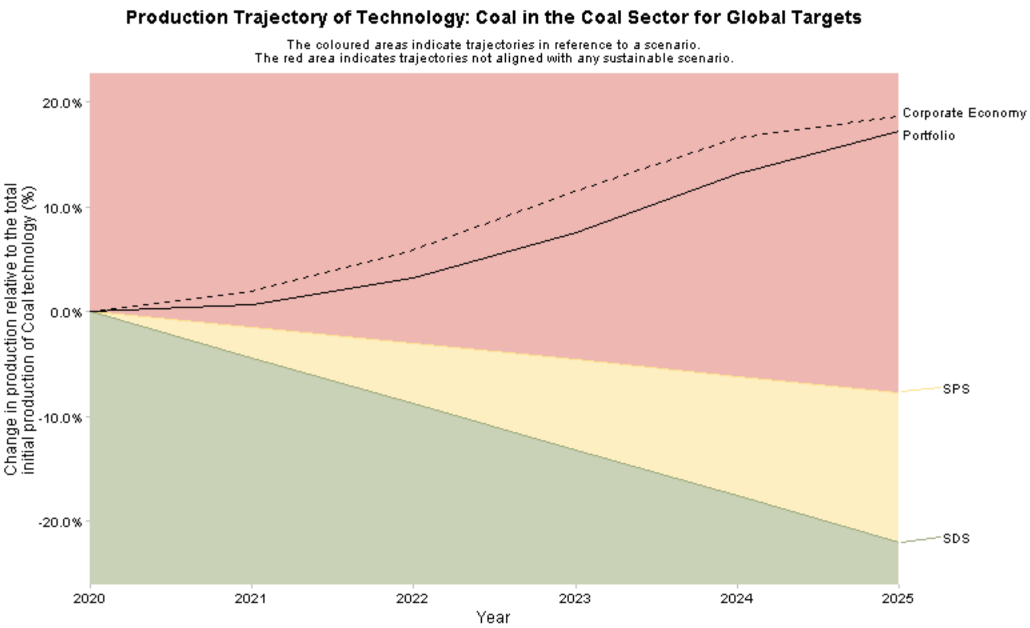


Figure A.20: Production volume trajectory chart for upstream oil extraction compared against a global benchmark

Source: Own illustrations.

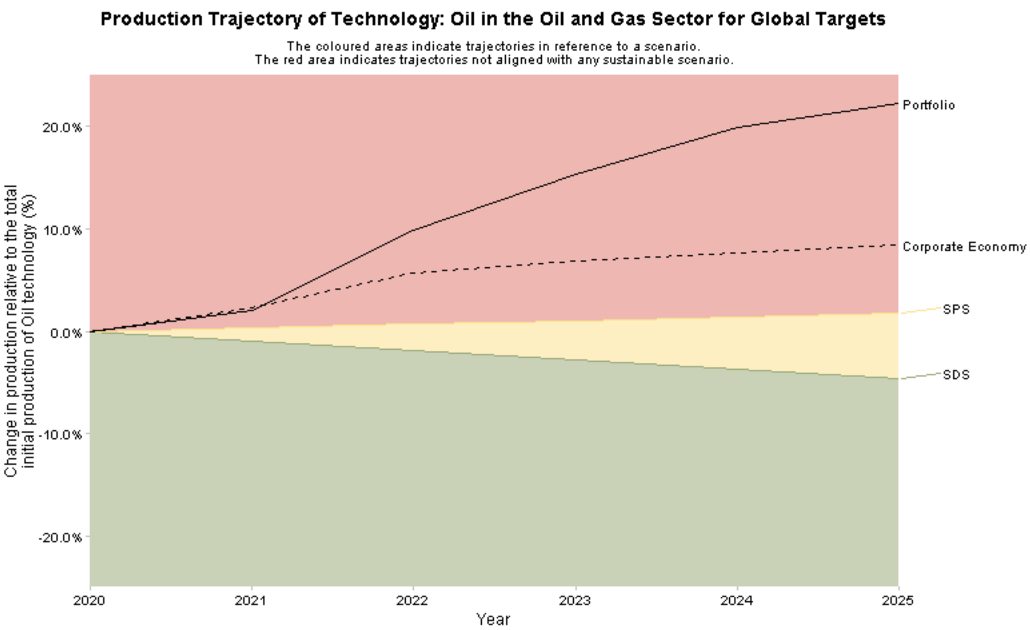


Figure A.21: Production volume trajectory chart for gas extraction compared against a global benchmark

Source: Own illustrations.

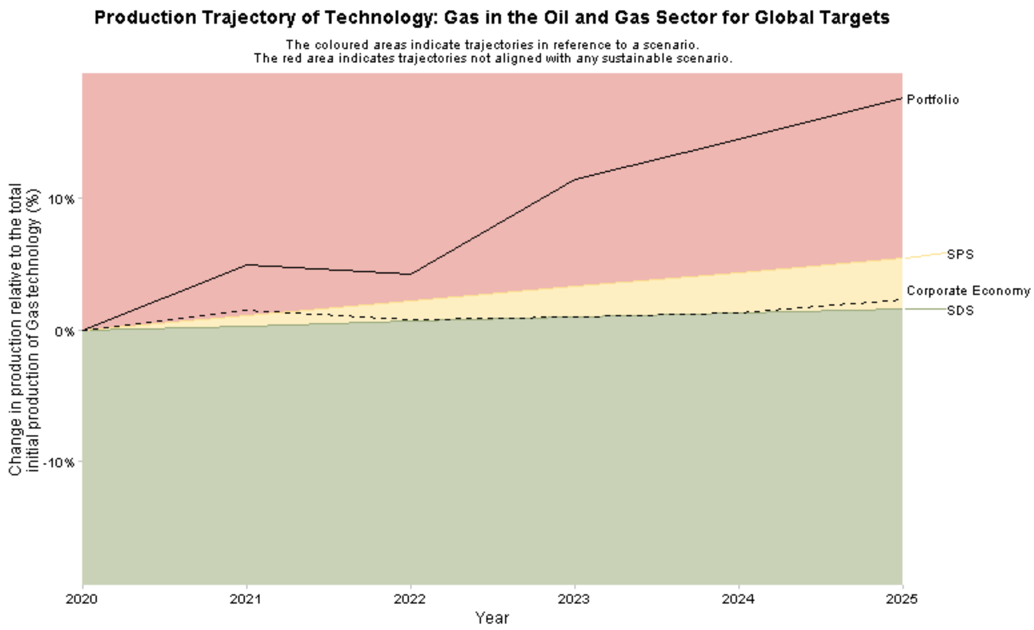


Figure A.22: Technology mix for all matched companies of the aggregated loan book in the oil & gas sector with global physical production assets compared against a global benchmark

Source: author

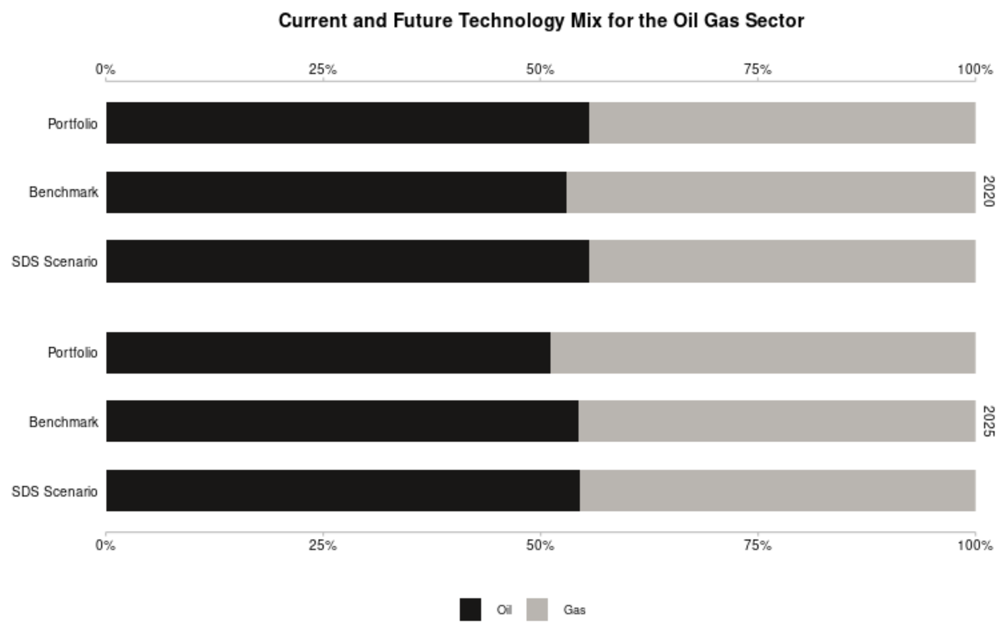
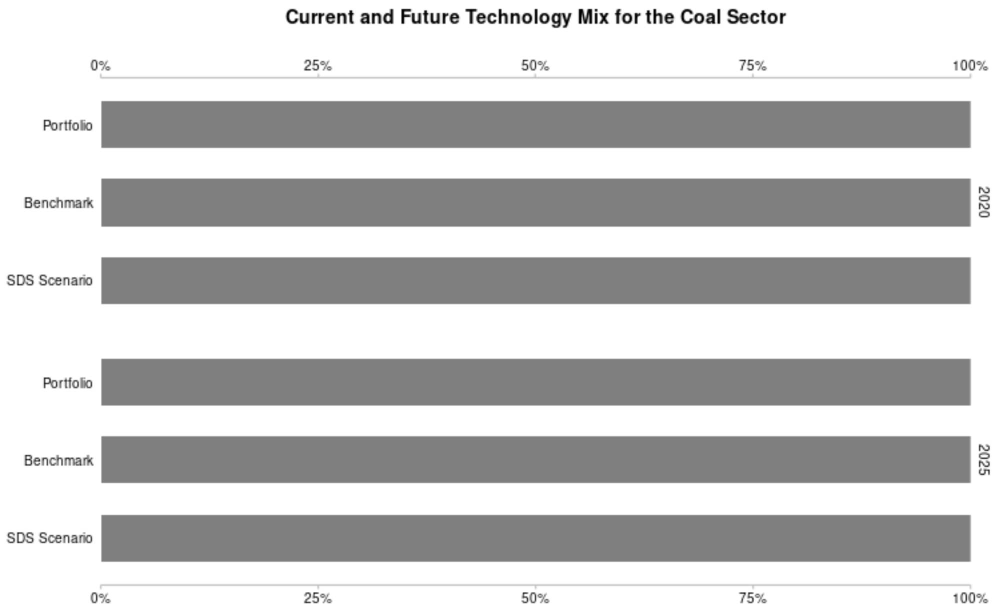


Figure A.23: Technology mix for all matched companies of the aggregated loan book in the coal sector with global physical production assets compared against a global benchmark

Source: author



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