2° Investing Initiative

Transition Risk Toolbox

Scenarios, Data, and Models

ET RISK PROJECT

The Energy Transition Risks & Opportunities (ET Risk) research consortium seeks to provide research and tools to assess the financial risk associated with the energy transition. The Consortium is funded by the European Commission and brings together academic researchers (University of Oxford, think tanks (Carbon Tracker Initiative, Institute for Climate Economics, and 2° Investing Initiative), industry experts (The CO-Firm), and financial institutions (Kepler Cheuvreux, S&P Global). A summary of the initiative can be found here.

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ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

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MEET THE BUILDERS - ET RISK CONSORTIUM

The ET Risk consortium, funded by the European Commission, is working to develop the key analytical building blocks (Fig. 0.1) needed for Energy Transition risk assessment and bring them to market over the coming two years.

1. TRANSITION SCENARIOS

The consortium will develop and publicly release two transition risk scenarios, the first representing a 'soft' transition extending current and planned policies and technological trends (e.g. an IEA NPS trajectory), and the second representing an ambitious scenario that expands on the data from the IEA 450S /2DS, the project's asset level data work (see number 2), and relevant third-party literature. The project will also explore more accelerated decarbonization scenarios.

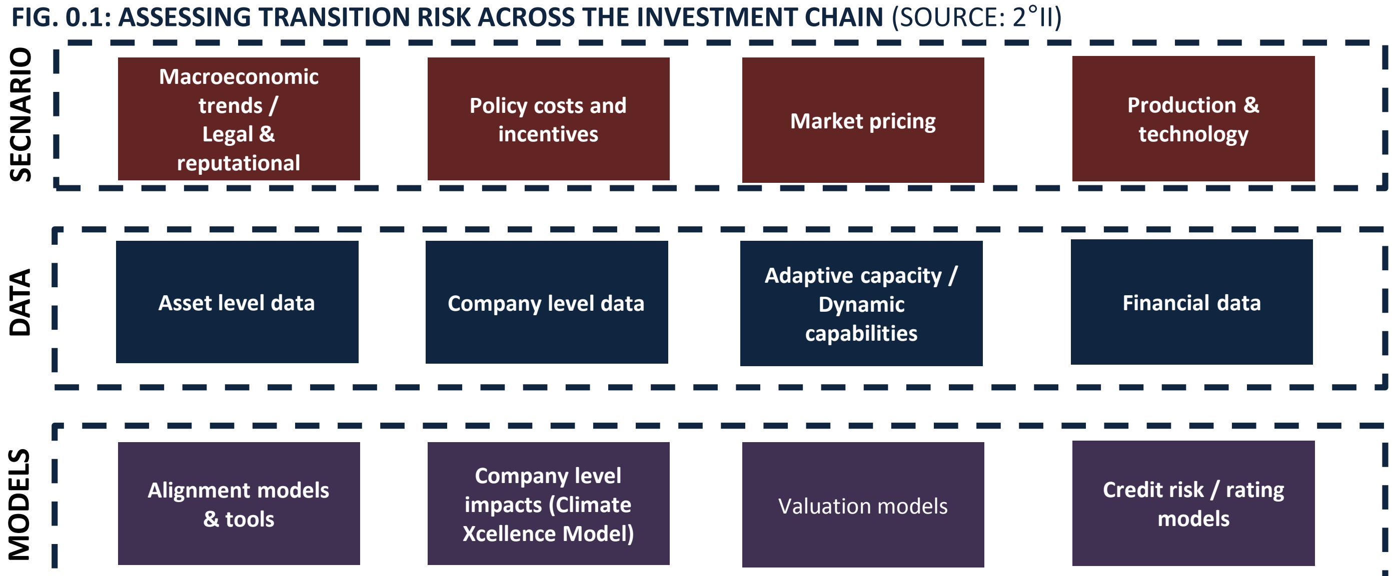
2. COMPANY & FINANCIAL DATA

Oxford Smith School and 2° Investing Initiative will jointly consolidate and analyze asset level information across six energy-relevant sectors (power, automotive, steel, cement, aircraft, shipping), including an assessment of committed emissions and the ability to potentially 'unlock' such emissions (e.g. reducing load factors).

3. VALUATION AND RISK MODELS

a) **2°C portfolio assessment – 2° Investing Initiative.** 2° Investing Initiative will seek to integrate the project results into their 2°C alignment model and portfolio tool and analytics developed as part of the SEI metrics project.
b) **ClimateXcellence Model – The CO-Firm**. This company risk model comprises detailed modeling steps to assess how risk factors impact margins and capital expenditure viability at the company level.
c) **Valuation models – Kepler Cheuvreux.** The above impact on climate- and energy-related changes to company margins and cash flows can be used to feed discounted cash flow and other valuation models of financial analysts. Kepler Cheuvreux will pilot this application as part of their equity research.
d) **Credit risk rating models – S&P Global.** The results of the project will be used by S&P Global to determine if there is a material impact on a company's creditworthiness. S&P Dow Jones Indices, a S&P Global Division, will explore the potential for developing indices integrating transition risk.

FIG. 0.1: ASSESSING TRANSITION RISK ACROSS THE INVESTMENT CHAIN (SOURCE: 2°II)



EXECUTIVE SUMMARY

Dear Reader,

Thank you for your interest in the *Energy Transition Risk and Opportunity consortium* toolbox report for quantifying transition risk in financial markets. The toolbox is designed as a guide for relevant stakeholders seeking to define the 'tools'—scenarios, data needs, and models—required for transition risk modelling. It seeks to map these inputs, how they have been used to date, and the missing pieces requiring further research and analysis.

For the purpose of this report, transition risk is defined as the financial risk associated with the transition to a low-carbon economy. Such risk, alternatively known as carbon risk, carbon asset risk (Ceres et al. 2015; WRI/UNEP FI 2015), and now more commonly transition risk associated with climate change, is on the agenda of the Financial Stability Board (TCFD 2016) and the G20 (UNEP 2016). Reporting on transition risk is now mandatory for institutional investors in France, and many other investors are examining it on their own within the broader context of climate-related financial risks.

Crucially, this paper does not seek to add to the growing body of literature on the potential materiality of transition risk in financial markets (see for example Ceres et al. 2015; WRI/UNEP FI 2015; 2° II/UNEP/CDC 2015; TCFD 2016). Instead, it seeks to introduce the key 'ingredients' stakeholders need to quantify potential transition risk. It further creates the basis for the multi-year, multi-stakeholder research coalition to develop them (the Energy Transition Risk and Opportunity (ET Risk) consortium). In doing so, it builds on past reviews (WRI/UNEPFI 2015; 2° II/UNEP/CDC 2015; Ceres et al. 2015) and more recent developments (PRA 2016; TCFD 2016). The paper will also not cover other climate-related risks (e.g. physical risks).

The paper—as any self-respecting toolbox would—consists of a number of different pieces, notably scenarios (p. 12-17), data (p. 18-21), and models (p. 22-25). We hope you will enjoy it.

Sincerely,
ET Risk Consortium

SETTING UP: AVOIDING 'EASY' MISTAKES

Key questions in the context of assessing transition risk involve who is doing the assessment and thus what is being assessed (e.g. risk in the real economy vs. risk in financial markets) and the objective of the assessment (e.g. improving asset pricing in financial markets or measuring tail risks).

Who: companies vs. investors and regulators. The *Who* is important because impacts on companies' balance sheets and cash flows don't necessarily translate one-to-one into risk for financial institutions. This is true both because operating companies may mitigate the risk themselves before it passes to the ultimate asset owners and because financers and financial market actors may already — indeed are paid to — price risks before they materialize. Thus, the fact that significant amounts of fossil fuel reserves may be 'stranded' or capital expenditure 'wasted' by itself says nothing about risk in financial markets at a point in time. Assessing financial risk requires models that are specifically tailored to the valuation and risk associated with financial assets. Similarly, financial regulators may have different assessment objectives.

Why*: *assessing the expected vs. stressing the unexpected. The *Why* is important because actors seeking to assess transition risk may have different objectives:

- First, to explore the extent to which asset prices — in the real economy or in financial markets — accurately reflect the *expected* impact of the transition to a low-carbon economy (e.g. plausible scenarios);
- Second, to assess the resilience of such assets and institutions to potential *unexpected*, but highly material tail events (e.g. stress-tests related to 'unexpected' scenarios). As a rule, this objective is more likely to be associated with financial regulators.

While these two objectives are related, they require different modelling approaches. Moreover, they will not necessarily inform each other. A future outcome perceived as unlikely (e.g. 5% probability tail risk) will not weigh heavily in a probability-weighted average valuation or risk model. On the other hand, a worldview seeing ambitious decarbonization (e.g. a high chance of a 1.5-2°C global outcome) as the *expected* future will come to a very different result. Scenario analysis is applicable to both worldviews.

MEASURING THE PATHWAYS: CHOOSING THE TRANSITION RISK SCENARIO

Transition risk assessments require a view on the future decarbonization of the economy and associated trends. Transition risk scenarios can define different views and be used by financial market actors in the context of transition risk modelling. Choosing such scenarios involves the following steps:

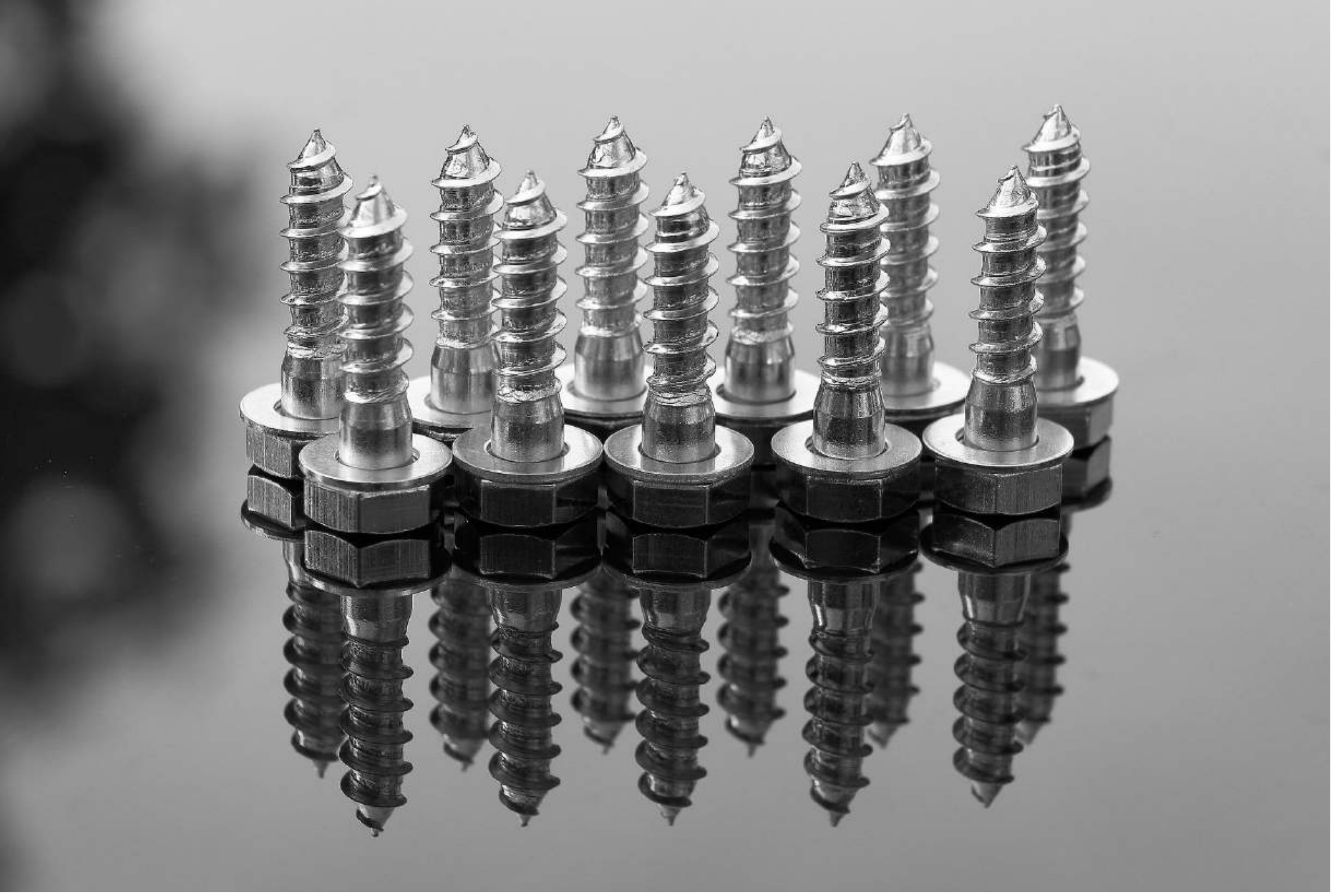
1. **Define high-level scenario needs.** Assessing transition risk requires specific scenarios that reflect transition trends. These are in particular the energy-technology scenarios developed by the IEA and other modelling agencies. Such scenarios can then be enriched (next step) to inform transition risk assessment.

2. **Define the needed scenario parameters.** The second step after choosing the type of scenario requires defining the specific scenario parameters. Specifically, key parameters include:

    1. **Macroeconomic trends** (e.g. GDP, inflation, other potential economic shocks);
    2. **Policy costs and incentives** (e.g. feed-in tariff, carbon tax, etc.);
    3. **Market pricing** (e.g. oil & gas prices, battery costs, etc.);
    4. **Production & technology** (e.g. oil production, power generation, electric vehicle sales);
    5. **Legal and reputational** (e.g. litigation costs, reputational shocks);

3. **Choose the scenario ambition.** Risk management requires a view on the future. Climate-related transition scenarios can thus involve different levels of ambition and views on how the objective is achieved. Notable types are ‘business as usual’ (e.g. 6° C warming), ‘soft decarbonization’ (e.g. 3-4° C warming) or ‘ambitious decarbonization’ (e.g. 2° C or less warming). Each of these scenarios are associated with different probabilities around achieving a range of degrees of warming.

4. **Choose the scenario speed.** Finally, one critical distinguishing feature in scenarios is the assumption around the speed or ‘disruptiveness’ / non-linearity of the transition. This element is important for risk assessment as more sudden, abrupt impacts are likely to create more significant risks than ‘smooth’ transitions.



COMBINING THE RIGHT CLIMATE & FINANCIAL DATA

The third step involves developing the climate and financial data required to assess physical assets, companies, securities, portfolios, and / or financial institutions:

1. **Define the transition data needs.** The first step involves defining the characteristics the transition data needs to likely satisfy and creating an awareness of the different data types (e.g. green / brown data, carbon data, qualitative data). For example, the 2°C alignment model developed by the 2° Investing Initiative relies primarily on technology data.

2. **Start with physical asset-level data.** High quality transition risk assessment will in almost all cases have to rely on asset level data in order to provide forward-looking, geographic granularity around potential risk exposure. While at this stage access to such data can be expensive and difficult to connect to financial portfolios, a number of initiatives are underway to reduce search and transaction costs (e.g. Asset Data Initiative, involving the 2° Investing Initiative, Oxford University, CDP, and Stanford University).

3. **Complement with company data.** In many cases, the analysis is also likely to benefit from additional company level data. This could include, for example, R&D or governance data. The scope around using this data depends on the granularity of the model and the approach (e.g. top-down modelling approaches are likely to require less data than bottom-up). More clarity on data options and reporting is expected to be provided by the Financial Stability Board Task Force On Climate-Related Financial Disclosures (TCFD).

4. **Connect physical assets / company data to financial data.** The next step is adding financial data. Financial data is required both for allocation rules around exposures to various financial assets. For example, for listed equity a traditional approach is to assign 1% of the company's exposure to a portfolio manager if they own 1% of the company. Financial data is also critical for risk models, for example in order to understand balance sheet resilience to shocks.

BUILDING AND APPLYING TRANSITION RISK MODELS

The final step involves the actual design and application of transition risk models:

1. **Decide which model fits the objective best.** Different models serve different objectives. Objectives could include an assessment of potential capital misallocation (i.e. investments / assets misaligned with the scenario), quantification of impacts on financial assets value, or stress-testing 'tail scenarios.' It is important to decide what you want to assess before picking the appropriate model. Options include traditional discounted cash flow and / or credit risk models, as well as models around economic asset impairment.

2. **Map macro impacts to micro actors.** A crucial modelling decision relates to macro trend impacts on microeconomic actors. Here, the choices involve applying one of three approaches:

    1. **Fair share approach** uses a simple 'fair share' allocation rule where all sector-level production and capacity trends are proportionally distributed across companies based on market share.
    2. **Cost approach** uses sector-level variables, such as demand and price, as a constraint interacting with the production costs of companies, arguing that the 'marginal' product is produced at the lowest cost.
    3. **Bottom-up company analysis** seeks to identify each company's individual positioning relative to macro trends in a bottom-up manner, tracking assets, pricing power, market positioning, and other parameters. From a financial and economic risk perspective, it is the most appropriate and can be applied to all companies. The challenge of this approach is the cost of application and the availability of data.

3. **Making parameter choices.** The next step is making choices around the appropriate parameters and modelling decisions e.g. time horizon of the assessment, assumptions around adaptive capacity, etc. Crucially, these need to respond to the key challenges models currently face in assessing transition risk (e.g. time horizon, modelling adaptive capacity, probability distribution).

4. **Calculate results.** Once these parameter choices are made, the model can integrate the data and scenarios.

1. SETTING UP THE MODEL

1.1 MEASURING RISKS IN THE REAL ECONOMY VS. FINANCIAL RISK

The figure below shows the framework around transition risk. It shows the mechanism through which financial risk in the real economy passes through into financial markets. It demonstrates that potential risks in the real economy do not necessarily imply risk in financial markets**.** Capital investments and assets in the real economy may be subject to economic shocks *if* companies misread transition trends in demand and prices. This impacts financial assets only *if* financial market actors equally misread these trends, either through original analysis or by the use of incorrect assumptions from investee companies.

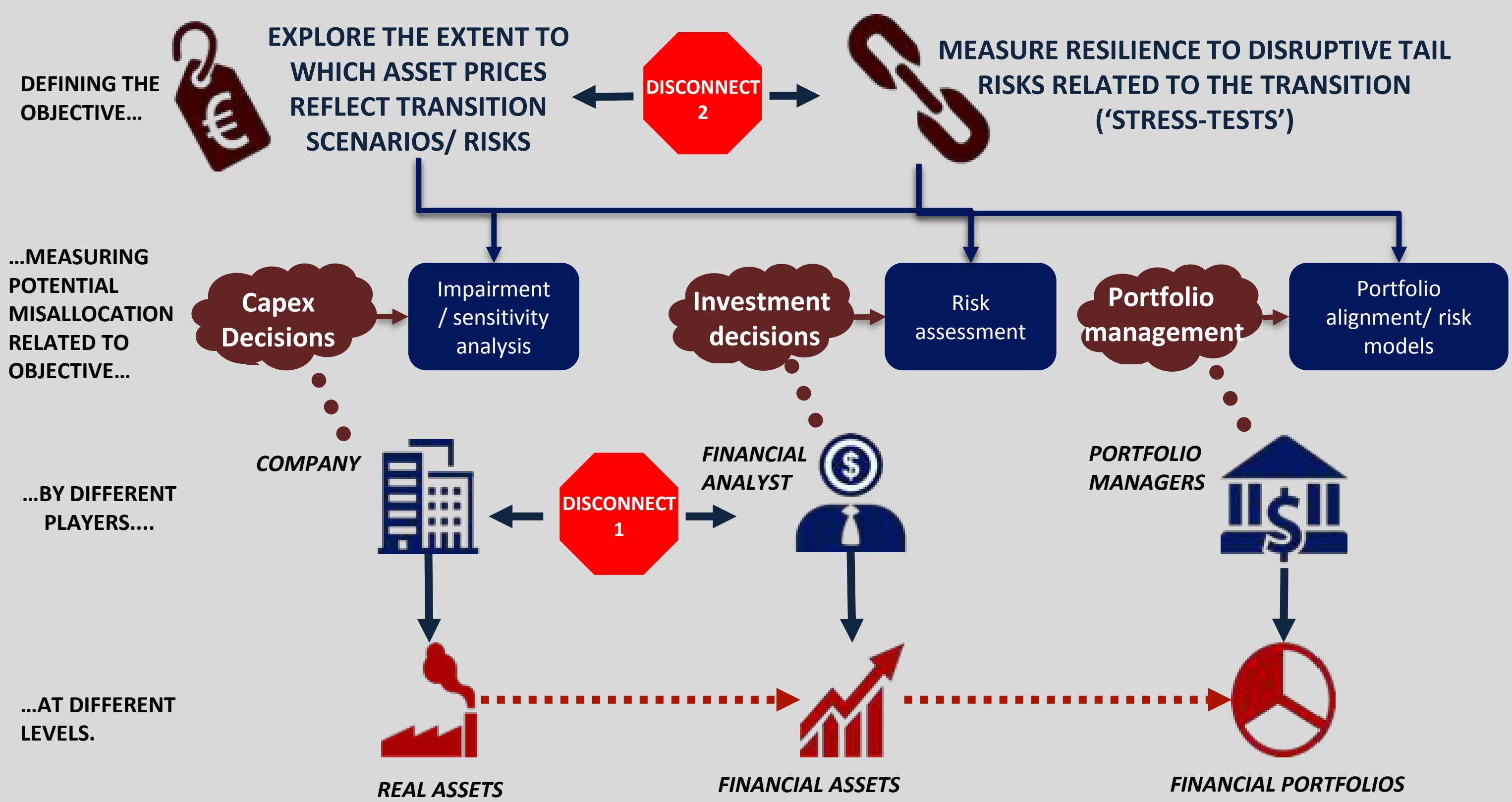
Measuring a potential misallocation in the real economy requires comparing physical assets and investment plans to transition roadmaps. This can be assessed at company or financial portfolio level and expressed in production capacity (e.g. MW), $ investment, $ revenues, and / or CO_2e emissions.

While transition risks for companies in the real economy *may* lead to financial risk for investors and creditors, the pass-through is not likely to be one-to-one (Disconnect 1):

- Financial market actors may already — and indeed are expected to — price certain type of risks before they materialize. This is true whether or not the companies themselves have identified and mitigated such risk.
- Equally, market expectations of the transition may 'overshoot' the actual effects of the transition in the real economy as a result of overly optimistic/pessimistic market expectations about future trends or missing insights on risk mitigation measures of companies.

In other words, risk and valuation models can *in theory* estimate the impact of future risks and already take them into account before they happen. *In practice*, though, there are a range of factors that may prevent financial market actors from doing this.

FIG. 1.1: ASSESSING TRANSITION RISK ACROSS THE INVESTMENT CHAIN (SOURCE: 2°II)



1.2 STRESS-TESTING VS. IMPROVING ASSET PRICING

Different applications for different objectives. Two broad objectives drive transition risk and opportunity assessment — exploring if expected transition trends are priced correctly and stress-testing resilience under tail risks. These objectives may be more or less relevant to different market players. 'Pricing' concerns will likely be particularly relevant for companies, analysts, and investors. 'Resilience' concerns are likely more relevant for financial regulators with financial stability as part of their mandate, though may be used by analysts to test worst case conditions. This market-driven use is reflected in the current debates by the FSB Task Force on Climate-Related Financial Disclosures (TCFD).

Different application in practice. Conceptually, the difference between the two can be reduced to distinguishing a 'likely' outcome (pricing/valuation) from a 'best/worst case' outcome (stress test), in other words probability assumptions. The relevant scenario, model, etc. clearly depends on what the user requires, whether defining the 'likely' or 'best/worst case' outcome. However, communicating on the basis of such likelihoods is problematic, as different users have different perceptions of the likelihood of different outcomes. Fig 1.2 shows two illustrative worldviews, measured notionally in the commonly known global temperature rise unit (with 1.5-2°C representing the global goal for limiting warming). These plots are purely for illustration, though future work by the authors will survey analysts on their actual likelihood assessments.

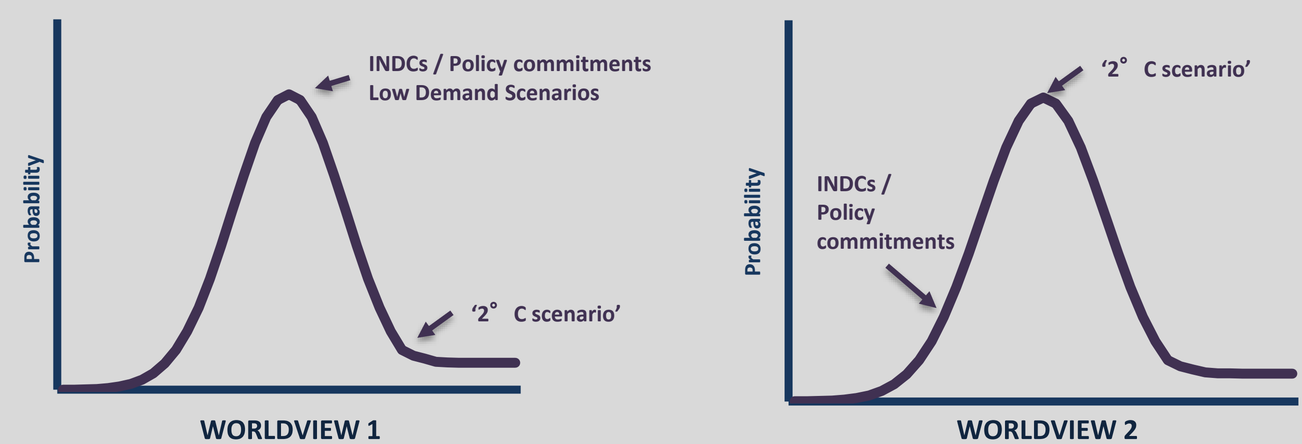
- In **Worldview 1**, the user believes current climate policy commitments (e.g. INDCs, as reflected e.g. in the IEA NPS Scenario; see Chapter 2 for further detail) are the most likely short term outcome and uses this for their valuation. A stress test for transition risk would then use a '2°C scenario' (e.g. IEA 450 Scenario).

- In **Worldview 2**, the analyst believes the 2°C scenario is the most likely and uses that for their base case model. This use of 2° C scenario is then not a stress test. In this worldview, a stress test would apply an even more ambitious scenario (e.g. an accelerated <2°C scenario, see pg. 11 and 12)

Different actors may have different views on the likelihood of such outcomes. Some energy companies have publicly stated that their demand projections are higher than the International Energy Agency's 'base case' (CTI 2015a,b). On the other hand, many in the NGO or ESG communities see the Paris Agreement, which called for a 1.5°C outcome, as making a <2°C outcome very likely. These differences are crucial, particularly for analysts valuing or rating securities.

Implications for risk and valuation. The term 'stress-test' is most often associated with tail risk or shock, which by definition implies a small probability (e.g. <5%; IMF 2012). This has important implications for probability-weighted risk or valuation results, as an ambitious transition scenario (e.g. 2°C compliant, see discussion on pg. 11) will have only a small effect on valuation if it is considered to be a tail risk (e.g. Worldview 1 in Fig 1.3) but would strongly affect model results under Worldview 2 given that it is assumed to be the most likely outcome. This paper looks at the nuts and bolts of the process, allowing individual users to assign their own probability.

FIG. 1.2: ILLUSTRATIVE DISTRIBUTION OF TRANSITION OUTCOMES FOR DIFFERENT WORLDVIEWS (SOURCE: 2° II 2015)



2. TRANSITION RISK SCENARIOS

2.1 DEFINING TRANSITION SCENARIOS AND RISK FACTORS

Scenarios alter economic variables, usually related to prices and outputs, in order to test the sensitivity of changes to these variables on the value of an asset, company, portfolio, etc.

In the context of transition risk, a "transition scenario" can thus be defined as a scenario providing the full range of information and parameters necessary to test the impact of the transition to a low-carbon economy on the financial value at asset, company, or portfolio level.

Transition risk has two characteristics critical to financial analysis:

- **Focus on 'transition sectors.'** The transition will affect some sectors more than others, notably producers of energy goods and services and sectors highly reliant on energy or producing energy-intensive goods. This has two implications. First, transition scenarios must provide significantly more detail in such sectors and on the risk factors (policy, market, legal/reputational, etc.) that affect them most. Second, because many energy markets and policies are national/regional in nature, scenarios for many variables need to be country- or region-specific.

- **Long term.** Because of the inertia of energy systems, transition modelling must be conducted over long time-frames. This means that long-term changes to the economy that are not specific to energy dependent sectors may still be relevant. Moreover, small variations in assumptions over annual average productivity growth rate end up having significant impact on the amount of GHG reduction between a BAU baseline and a 2°C pathway.

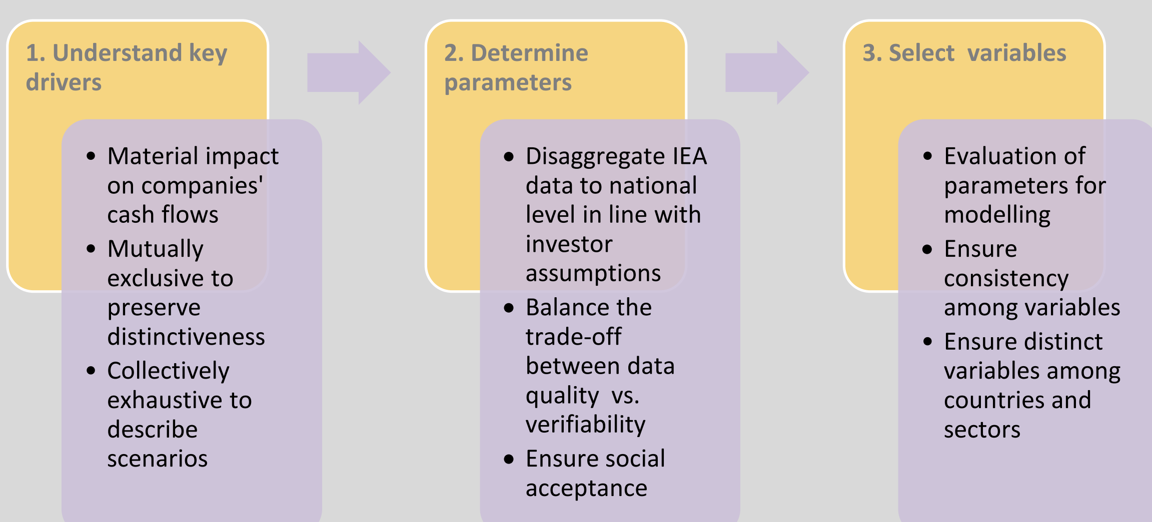
Fig. 2.1 below provides a summary for determining the scenario data and parameters needed to build transition scenarios and arriving at the taxonomy described on the previous page:

- Understanding the key drivers is necessary to determine which parameters are relevant. Key drivers relate to identifying issues that have a material impact on companies' cash flows, are mutually exclusive to preserve distinctiveness, and are collectively exhaustible.

- The scenarios built in the context of the ET Risk project started with over 50 types of risk parameters, a number that has been reduced to around a dozen related to five broad 'groups' (see next page). This in particular requires balancing the trade-off between data quality versus verifiability.

- The final step is selecting the values the scenarios should take to allow for risk modelling. One key requirement is ensuring consistency among variables.

FIG. 2.1: TRANSITION SCENARIO ELEMENTS AND THEIR CASH FLOW / RISK IMPACTS (SOURCE: CO-FIRM)



2.2 DATA AND PARAMETERS FOR TRANSITION SCENARIOS

Based on the process described on the previous page, the ET Risk project has developed the following taxonomy of scenario parameters (Fig. 2.2):

1. Policy costs and incentives parameters cover policy-related parameters driving the transition. They may include creation of markets (e.g. ETS), taxes / levies (e.g. carbon tax), subsidies, standards (e.g. emissions, technology, performance), and other mechanisms. Policy costs and incentives are usually seen as the primary driver of transition risk (also sometimes framed as regulatory risk), although there is a growing focus on market pricing drivers (see second point). Some scenarios reduce regulatory risk to 'carbon pricing,' which can in theory be neatly linked to GHG emissions data from companies. The challenge with such simplified policy modelling relates to its inaccuracy in identifying risks. One example relates to the fact that many sectors don't face direct carbon prices (e.g. automobile sector) and that in some sectors, GHG-intensive manufacturers (e.g. Ferrari) may be more affected by GHG emissions standards than policy costs that they are likely able to pass on to their customers.

2. Market pricing parameters are associated with product and technology assumptions. This type of parameter covers all non-policy cost and price drivers in markets, notably related to commodities, products and services. They may also cover prices from policy-created markets (e.g. emissions trading systems, although this risk driver could also be considered a policy cost), that although policy-created, involve a market mechanism to determine prices. Market pricing covers the products and services sold in the market (e.g. electric vehicle vs. diesel, etc.), the technology associated with the product itself and / or the production process (e.g. fuels in power generation), and the market costs / prices associated with the production process and sold products / services (e.g. oil and gas price, battery prices, etc.). While growing in prominence, this indicator is traditionally the least developed.

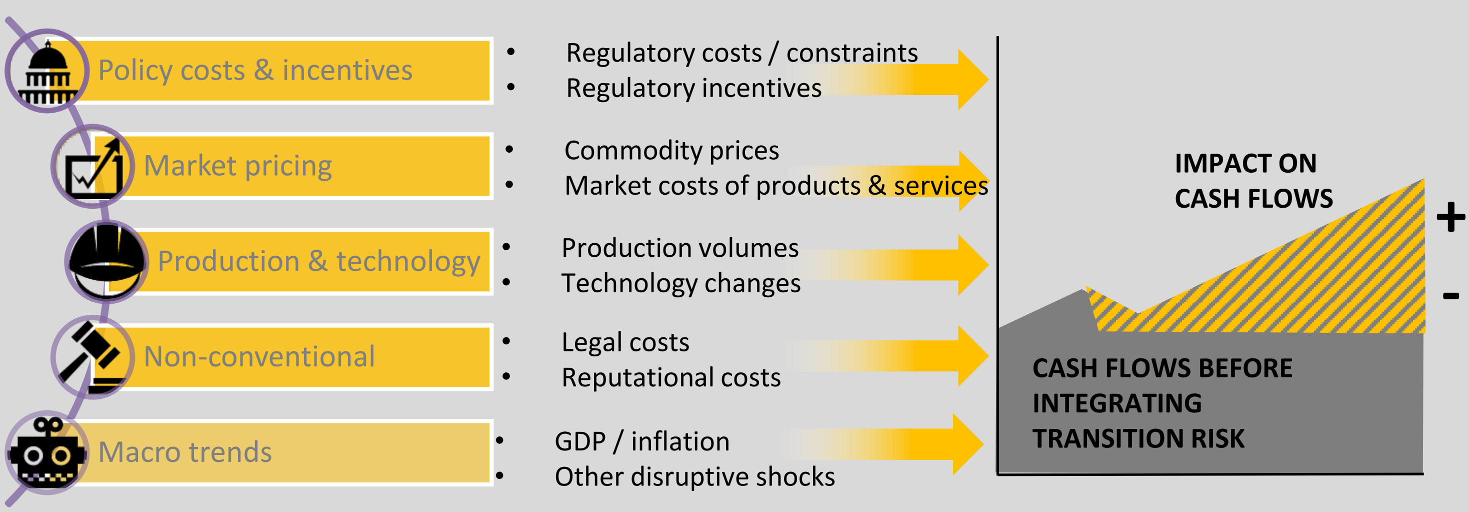
3. Production and technology assumptions involve assumptions around the evolution of products, services, and resource use, as well as technology inputs in the production process. This indicator is usually the primary focus of existing transition scenarios and thus the most developed, in particular for the fossil fuel, power, and transport sectors. It tends to be less developed for industry (e.g. steel, cement). Production and technology assumptions can also be thought of as being a function of policy costs and incentives as well as market pricing and associated consumer preferences.

4. Non-conventional indicators covering other, 'non-conventional' trends related to the transition, notably legal risks. This group of indicators relates to other risk drivers not covered by the first two category, for example legal risks (see forthcoming report by 2° Investing Initiative / MinterEllison) or insurance premiums

5. Macro trends framing broader economic trends, including GDP, inflation, population growth, etc., but also potentially other economic trends that may impact the nature of transition risks (e.g. AI, robots, etc.).

The ET Risk consortium plans to release its first comprehensive transition risk roadmap covering these areas in the first half of 2017

FIG. 2.2: DEVELOPING SCENARIO PARAMETERS & VARIABLES (SOURCE: ET RISK CONSORTIUM)



2.3 TRANSITION AMBITION

Three key types of transition scenarios can generally be identified in terms of their ambition (Fig. 2.3):

1. **Business as usual (BAU) scenarios** assume that policy and markets continue to develop along the same trend as in the past. This involves a large share of fossil fuels in the energy mix and limited low carbon technology deployment. Such scenarios don't integrate any change into current policies, and are thus labeled the 'current policy scenario' by the International Energy Agency (IEA). Mercer (2015) labels this scenario as the "Fragmentation Scenario" in their analysis. These types of scenarios, although developed by energy modeling organizations, are not strictly transition risk scenarios since they don't involve economic shifts.

2. **'Soft' transition scenarios** are *forecasts* that take into account 'plausible' policy, market, and technology shifts as a result of announced, passed, or planned legislation as well as expert projections of trends. The IEA has two scenarios in this category: the New Policy Scenario (NPS) and the Bridge Scenario. Other examples include Carbon Tracker Initiative's "Low Demand Scenario" (Carbon Tracker, 2015), Mercer's "Coordination Scenario" (Mercer, 2015), and The CO-Firm's scenario (Cambridge and The CO Firm 2016).

3. **Ambitious transition scenarios** involve the aggressive deployment of renewable technology and new zero carbon innovations becoming market-ready in the near future. Rather than *forecast* current trends into the future, these scenarios often work *backward* from a constraint, generally 2°C warming or 450 ppm CO_2 globally. The International Energy Agency (IEA) is arguably the most prominent example. Alternatives have been developed by Greenpeace, the IPCC, WWF, Deep Decarbonization Pathways Project, and others.

While these groups are relevant delineation points, scenarios within each category can differ widely including on:

- **Macro-assumptions** on demographics, macroeconomic trends, GDP growth;

- Different constraints in terms of the **probabilities of achieving the 2°C objective** as a basis. For instance, the IEA 450 scenario only has a 50% chance of not breaching 2°C, whereas the Greenpeace scenario has an 80% probability.

- Further, different scenarios may assume **different burden sharing** in reducing GHG emissions between regions and across sectors – reflecting economic as well as political questions of 'equity' and perceived fairness;

- **Different technology assumptions** can yield very different results – notable examples being carbon capture and storage (CCS) and nuclear power, which have been prominent in IEA ambitious transition pathways in the past, but less so in scenarios more bullish on renewables (Fig 2.4).

FIG. 2.3: POWER GENERATION-RELATED CO2 EMISSIONS BY SCENARIO (SOURCE: IEA 2014)

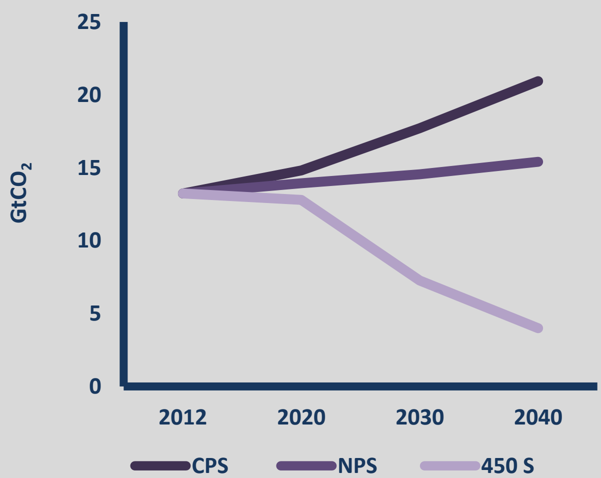
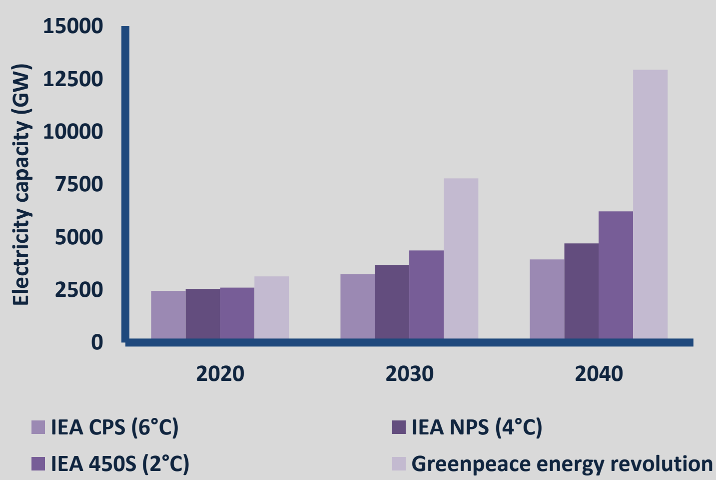


FIG. 2.4: CUMULATIVE RENEWABLE CAPACITY UNDER IEA WEO 2015 AND GREENPEACE SCENARIOS (SOURCE: 2°II)



2.4 SPEED OF THE SCENARIO

Transition scenarios, notably those of the IEA, tend to relegate significant changes to the energy system to the long-term.

This is due to assumed long lifetimes/capital replacement rates of many energy system assets (power plants, etc.) and availability of cost-effective alternatives. As an example, for the time period 2015-2020, the cumulative oil and gas production in the IEA scenarios is less than 5% lower under a 2°C versus a 6°C scenario, but for oil, this figure jumps to nearly 30% by 2035. Similar short-term constraints can be identified for other energy-relevant technologies, though nearer term differences are seen in some variables such as in renewables in some scenarios (Fig 2.5).

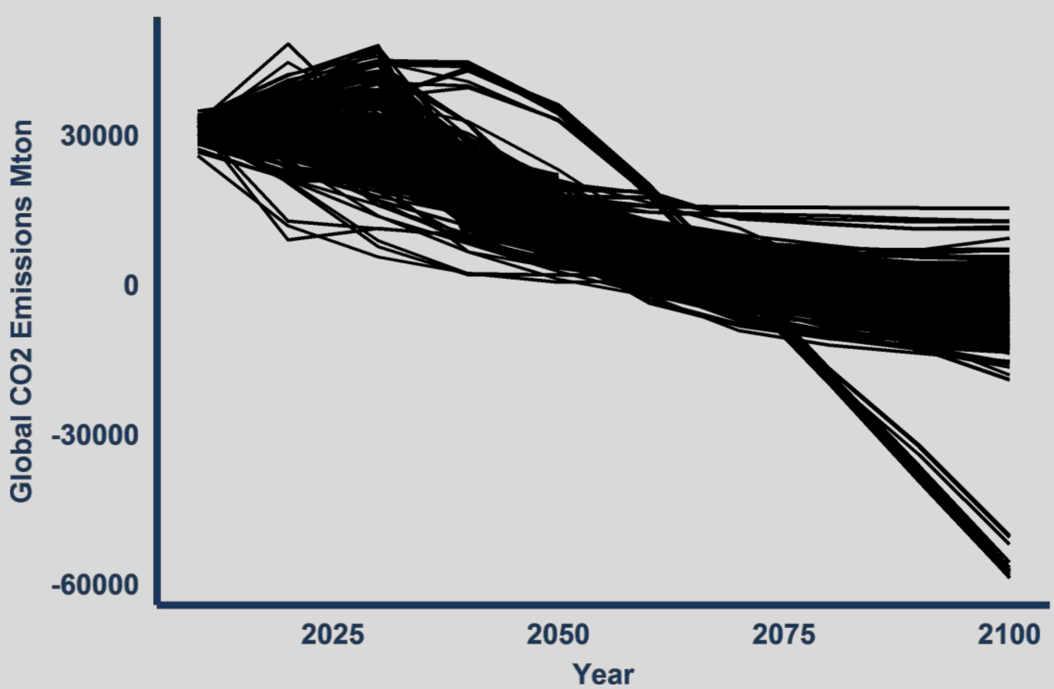
Because of this inertia, using even ambitious transition scenarios over typical 5-10 year time horizons for risk assessment is unlikely to lead to material differences.

This shows the need for a long-term approach to modeling transition risk (pg. 10). Alternatively, a more disruptive pathway could be produced, such as in the recent European Systemic Risk Board (ESRB 2016) report, which assumed by design in its adverse scenario a delayed but rather severe policy response or a major energy technology breakthrough. 2°C compliant models used by the IPCC likewise produce some scenarios with rather fast reductions in global CO_2 emissions. The approach in this project in turn will seek to emphasize an "early start, soft landing" scenario, although more disruptive scenarios will be explored.

This question of when large shocks occur is critical for assessing risk to financial securities and portfolios.

While an outcome such as the ESRB's adverse scenario would lead to large economic losses in the future, a pressing question is whether such abrupt behaviour, either in the real or financial economies, could occur in the near-term and thus within typical time horizons of existing risk models. The ET Risk Consortium will explore such possibilities (sudden policy changes, "announcement effects" of technology breakthroughs, etc.) in coming reports and in the production of its ambitious decarbonisation scenario.

FIG. 2.5: ~2°C COMPLIANT SCENARIOS ANALYZED BY IPCC IN THE 5TH ASSESSMENT REPORT
(SOURCE: 2ii, ADAPTED FROM IPCC 2014)



Transition scenarios are generally built to inform policymakers. Their applicability for risk assessment is thus limited:

- **Geography and time dimensions.** Most energy systems models generally work in 5-10 year time periods and over aggregated geographical regions (~10-50 aggregated regions in models for the latest IPCC report; IPCC 2014) though some large countries are broken out into their own region (e.g. USA, China, India for the IEA). Using this level of aggregation may be necessary, for instance if matching asset- or company-level data are not available at the same level of detail or over the less detailed second or third phases of a cash flow model. However, for the important first phase cash flow and for assessing the effects of specific policies, regional averages at 5 year timescales will not be sufficient, and additional detail may be needed from other sources (Fig. 2.6).

- **Macroeconomic context.** Transition risk scenarios will require being situated in a broader macroeconomic context. Different assumptions around general price levels/inflation in the economy, overall GDP growth, and prices in key commodity markets may alter the results of the risk assessment. Transition scenarios thus should contain standard macroeconomic variables, modeled specific to the scenario or taken from existing mainstream economic forecasts (IMF, OECD, etc.). The IEA provides estimates of some macroeconomic variables in their scenarios (these are either inputs to or outputs from the underlying energy systems model) as part of their methodology document.

- **Sector and technology coverage**. Energy system models contain higher technological resolution in some sectors than others. For instance, while nearly all models separate fuel mixes in the electric power sector, residential and commercial buildings may be aggregated and most models do not separate different energy-intensive industries (e.g. steel vs. cement vs. aluminum). As an example, the IEA World Energy Outlook results are broken down by four broad consumption sectors (industry, transport, buildings, other) with seven fuels/technologies (coal, oil, gas, nuclear, hydro, bioenergy, and renewables). Further, this limitation is enhanced by the fact that public access to modeling results can aggregate detail to the "least common denominator" for simplicity even if more granular results are available. On the flipside, more granular results may be associated with higher uncertainty.

- **Other long-term trends.** Given their long term nature, such scenarios must interact with other economic trends. There are a range of such long-term trends that are likely to constitute fundamental risks to financial markets and may either reinforce or mitigate climate-related risks. Some of these trends directly relate to transition risks. In the case of transport for example, the rise of autonomous cars, drones, virtual presence technologies, etc. could fundamentally shift consumption patterns. They will also have implications for which companies are likely to benefit and suffer from the technology and modal shifts.

FIG. 2.6: TYPICAL COVERAGE OF SCENARIO NEEDS IN ENERGY SYSTEM MODELS (SOURCE: 2° II)

Needed Element	Typical Coverage in Energy System Models	Additional potential needs (use-case dependent)	Additional potential sources
Macro trends	Inputs to model (GDP, inflation)	Alternative assumptions; additional geographical detail	IMF, OECD, Carbon Tracker etc.
Policy costs & incentives	Existing and announced policy measures are incorporated but not fully disclosed in results	Specific policy measures at country/sector levels; Long-term policy goals not yet legislated	Grantham Global Policy Legislation Database; Country INDCs; IPCC 2014
Market pricing	Market modelling for energy commodities; price/cost assumptions and results available	Price/cost of breakthrough technologies; additional geographical detail	Primary research; commodity futures data
Production & technology	Available for most relevant technologies (fossil; power gen) by region	Additional geographical detail; sectors not covered in detail; breakthrough technologies	Industry and asset-level databases
Non-conventional	Not typically covered in detail	Likely litigation, decisions, and impacts	Sabin Center Climate Litigation Database ; primary research

BOX: TRANSITION SCENARIO NARRATIVE DESCRIPTION

Providing a qualitative context. Beyond the parameters discussed above, a qualitative context is crucial for transition scenarios. Such context helps to provide the basis explaining *why* things happen the way they do (e.g. extreme weather event leads to policy rethink), as well as *how* they happen (e.g. massive R&D investment leads to breakthrough on zero-carbon technology for aviation). This is particularly true in the case of an abrupt change or high-speed transition (e.g. what causes the sudden change from no decarbonization to abrupt decarbonization for ESRB scenarios). They also help define the probability with which such a change could occur, including increasing the plausibility of seemingly unlikely scenarios. The following briefly provides an example of a qualitative context that can underlie an ambitious transition scenario.

The Market Scenario Narrative. The market scenario provides macro level information on changes in the global market context for low and high carbon technology and commodities. The main contextual drivers identified for an ambitious transition scenario include currently available technology improvements and costs, disruptive technology breakthroughs, changes in consumer preferences and changes in commodity prices such as oil, gas and coal:

Incremental technology improvement. Existing low-carbon technologies continue to see significant price and efficiency improvements thanks to increased investment in R&D and as a result of a feedback loop from growing deployment.

Technology breakthrough. Sudden innovation-driven cost changes in breakthrough technologies (e.g. energy storage technologies, zero carbon cement) accelerate their economic competitiveness and their ability to start to be seen as commercial alternatives.

Commodity prices. Market expectations in commodity futures markets increasingly reflect 2° C transition pathways.

The Policy Scenario Narrative. The policy scenario provides macro level information on changes in national and regional policy and sets the context for more specific variable changes. The main contextual drivers identified for an ambitious scenario include the ratcheting up of conventional policy tools (e.g. subsidies, taxes, carbon price) and multinational policy agreements. The following provides some narrative *examples* of such policy changes.

Multinational policy agreement. Major international policy agreements such as the Paris Agreement are ratified by major polluters and oil-exporting countries and is seen as evidence on the Paris commitment of the well-below 2° C objective. Evidence of early attempts at increasing ambition becomes prominent.

Policy announcements and tools. Policymakers commit to instating a carbon price post-2020 with a price floor and a ‘ratcheting’ up of ambition. As well as this, fossil fuel subsidies are phased out by G7 countries by 2020 and similar commitments are made by a number of G20 countries.

X Factors in the narrative. While the above provide some examples of more conventional drivers in the scenario description, there are also X-factors based around major shifts in the socio-economic landscape that could in fact play the defining role in a shift to a 2 degree world. The following provide some examples of these shifts.

Litigation. Breakthrough in science allows for the allocation of responsibility on climate change and climate change events on individual companies. This provides the ability to launch class action lawsuits against individual companies leading to multi-billion dollar settlements.

Extreme weather event. Extreme weather events that impact investor centers on the US East Coast, China, and Western Europe in the same year strengthen investors’ beliefs in policy action to mitigate climate change and force policymakers’ hands to ratchet up ambition.

‘Black swan’ events. Other ‘black swan’ events that cause major social change may also impact transition risks. Examples such as the Fukushima nuclear accident, health pandemics, and the rise of artificial intelligence and its associated disruptions may in many cases amplify or dampen transition risks.

3. TRANSITION AND FINANCIAL DATA

3.1 PHYSICAL ASSET LEVEL DATA

The first key data input to measuring transition risk is what can be labelled ‘transition data’ or climate-related data. A landscape review of climate-related data by the Portfolio Carbon Initiative (2°II/UNEP-FI/WRI 2015) identified three main types of climate-related data currently in use by investors and banks:

- **Carbon data** involves all types of GHG emissions data, notably carbon footprinting of companies and assets/projects;
- **Green / brown metrics** are sector-specific indicators that distinguish activities and technologies either directly (e.g. oil production, renewable power capacity) or through taxonomies (e.g. ‘green share’, green bond taxonomies);
- **Qualitative data / scores** are qualitative scores provided by specialized ESG analysts.

The associated data needs to satisfy a number of conditions to be useful for transition risk assessment:

- **Geography-specific (ideally geolocational)** in order to track risk exposures in specific geographies;
- **Forward-looking** in order to reflect exposure to future trends and risks;
- **Comprehensive** in order to cover all potential exposures (e.g. private and public companies, etc.);
- **Disaggregated by technology** in order to distinguish technology-specific risk exposures.

Satisfying these conditions requires — where possible — resorting to asset-level data.

A growing number of organizations are sourcing this data for their work, notably the 2° Investing Initiative as part of their 2°C portfolio assessments (Sustainable Energy Investing Metrics project), the Carbon Tracker Initiative in the context of their cost curves work, the Oxford Smith School in its analysis on coal, S&P for their Green Portfolio Analytics (building on the work of the 2° Investing Initiative) and The CO-Firm in the context of its development of the ClimateXcellence Model. Asset level data exists with a high quality for a number of key transition sectors (Fig. 3.1).

FIG. 3.1: EXAMPLES OF ASSET LEVEL DATABASE PROVIDERS IN ENERGY-RELEVANT SECTORS (SOURCE: 2°II)

Sector	Segments available	Example Databases/Providers
Oil & gas	Upstream/E&P; Refining	WoodMackenzie, GlobalData, Rystad, Platts
Coal	Mining	WoodMackenzie, Platts
Electric & Heat Utilities	Power Generation	GlobalData, Platts, Enerdata, US EIA Surveys
Light & heavy duty passenger vehicles	LDV/HDV production	WardsAuto, Automotive World, IHS, Marklines
Aviation	Aircraft production and ownership; Airports	CAPA, FlightAscend, FlightRadar24
Shipping	Shipbuilding and ownership	Clarksons, shippingefficiency.org
Cement	Cement production	International Cement Review, Global Cement Database, WBSCD GNR
Steel	Steel production	Plantfacts
Real Estate	Commercial buildings	GRESB, Geophy
Cross-sector Government Regulatory Data	Asset-level data in certain sectors (e.g. electric power)	EU ETS, US GHG Reporting Program, South

3.2 COMPANY LEVEL DATA

While asset data can provide broadly comprehensive information on a company's assets, investments, and planned production, other company level information will be relevant as well. Three data points stand out in this regard:

- **R&D and qualitative 'transition plans'** can help communicate the planned transition of the company and its adaptive capacity in the context of the transition. A few companies in the past have reported this type of information (Fig. 3.2), but reporting has so far been limited to a handful of examples. Aggregated R&D figures on the other hand (Fig.3.3) may not be as useful;

- **Company announcements / targets** can help signal a company's targets. Assessing targets requires reviewing both the ambition of the target and the credibility. For example, a growing number of companies (nearly 200 as of October 2016) have reported on "Science-based" GHG Targets at the company level. Nevertheless, most voluntary targets are not reported consistently, limiting use and comparability (Exane BNP 2015), and further are only reported by a minority of companies, mostly in sectors less critical to the transition;

- **Governance** is a critical indicator of how a company will manage the transition to a low-carbon economy. This type of information can relate to a range of qualitative features of a company's governance.

The ultimate use of this company-level data depends on a number of factors:

- **Quality & scope:** Company-level data is usually reported in a way to shed the best possible light on a company. It thus may not always come with the quality and scope required for risk assessment. Confidentiality issues may also apply, as companies will refuse to disclose certain type of information.

- **Cost / benefit associated with procurement.** Aggregating and analysing broad datasets at company level will require significant data and analytical resources that may not always be commensurate with the benefit of using this information, beyond the level of information / granularity achieved through asset-level data. This depends on the specific use case.

- **User preferences.** Finally, the use of company level data hinges on user preferences. For example, some analysts may put significant stock in company targets, whereas other see these non-binding targets as attempts at 'greenwashing'.

FIG. 3.2: EXAMPLE OF R&D REPORTING BY EDF 2008 (SOURCE: 2°II 2015)

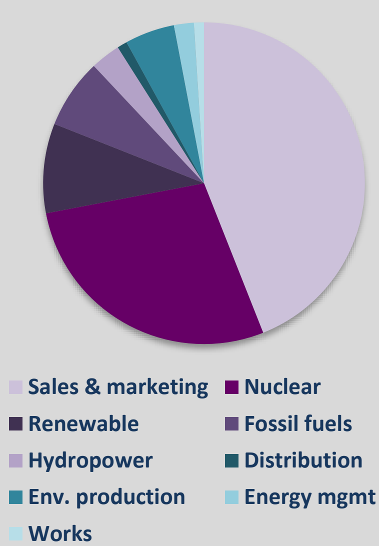
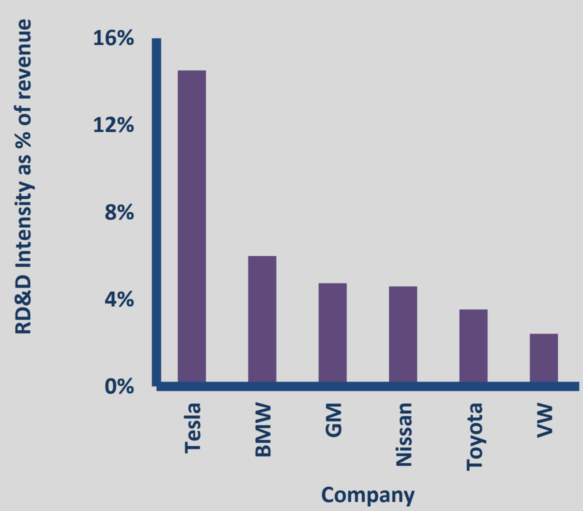


FIG. 3.3: RELATIVE PERFORMANCE (SOURCE: 2°II 2015)



3.3 DYNAMIC CAPABILITIES / ADAPTIVE CAPACITY

One critical data input that needs to be estimated in the context of the transition to a low-carbon economy is the assumption around adaptive capacity.

Few people question the viability of Apple's business model in 20-30 years even if there is high certainty that the current generation of technologies and products from Apple won't be around anymore. This is because of the trust in Apple's ability to adapt. In some sense, sectors affected by the transition to a low-carbon economy face the same situation. In the case of transition risk, there is an explicit or implicit assumption that adaptive capacity will be limited, given the nature of the economic change and the potential capital misallocation by companies that may come with it. Transition risk assessment, however, needs to in some form comment on this adaptive capacity. In the short-run, adaptive capacity is easier to estimate, given the visibility on short-term capex plans and trends. This, indeed, is in principle, what financial market research is about.

The particular challenge arises when it comes to long-term adaptive capacity, given the long-term nature of these risks. There are three estimation options:

- **>=100% adaptive capacity** assumes that companies will adjust fully. This is the often the assumption in equity research and is very likely wrong in this case given the nature of the economic transition (see below).

- **0<x<100% adaptive capacity** assumes a transition risk to which companies can't fully adapt. The key challenge then becomes quantifying the scale for adaption. For long-run estimates, there is no known role model in the academic literature on how to parameterize this. Further work is needed to not have to rely solely on simple guess work.

- **0% adaptive capacity** assumes that companies have zero ability to adapt to the change. This may be true in the extreme cases related to pure play coal companies, but is unlikely to be correct in the majority of cases.

The extent to which any individual company or sector will adapt to macroeconomic trends is a function of both external and internal forces.

Some external trends lend themselves more to adaption than others. Intuitively, growth that is evenly distributed across all sectors is the easiest to adapt to. All it requires is a scaling of existing production processes. Inversely, a number of different aspects will make certain macroeconomic trends very hard to adapt to individual sectors. This assumes then that these macroeconomic trends are not evenly distributed across all sectors. This distinction between external and internal drivers is important because the more the adaptive capacity can be assumed to be driven by external drivers, the less relevant company-specific analysis becomes. Companies are likely to be less able to adapt in response to external drivers that involve large scale, rapid, idiosyncratic, and secular change not part of a typical business cycle.

The nature of external changes interfaces with internal factors in a company, which can amplify or mitigate the barriers to adapting.

These include the key company level information already flagged on the previous page, notably governance, capital lock-in, balance sheet strength, dynamism / R&D, and product diversity. Beyond the factors mentioned here, there may be other internal factors that drive the adaptive capacity of a company (e.g. regulatory influence, systemic relevance of institution, etc.).

At this stage, any such estimates are educated 'guesses', given the lack of modelling capacity.

These guesses are already taking place in valuation models—namely an implicit assumption of 100% adaptive capacity—but appear highly unrealistic. The truth then for most exposed companies is likely to be somewhere between 0% and 100%. Using the external and internal factors and historical evidence for parameters, financial analysts could potentially estimate long-term adaptation by companies. It remains unclear however if the cost-benefit equation of such a sophisticated analysis would hold, given the likely huge uncertainties associated with them. On the flipside, it probably makes sense to fine-tune the 100% adaptive capacity assumption based on historical evidence around potential adaptive capacity.

3.4 LINKING PHYSICAL ASSETS TO FINANCIAL ASSETS

The final piece of the 'data' alphabet soup is financial data. Financial data can serve two purposes:

- **Estimate exposure of portfolios**. For example, estimating the ownership and, by extension, risk exposure of a portfolio owning stock in an oil and gas company requires understanding the total number of shares to estimate the relative ownership of the portfolio manager in the company. This relationship may need to be mapped across a series of subsidiaries and financial networks (Fig. 3.4).

- **Estimate liquidity and credit risk.** Financial data will also be required for risk assessment in order to understand the company's balance sheet and thus resilience to risk. This requires for example information around the financing structure of companies and the nature of its outstanding debt.

Financial data is usually readily and comprehensively available on mainstream financial databases and already considered in many risk models.

Financial databases like Bloomberg, S&P Market Intelligence, Factset, and others provide financial data to portfolio managers. This data already provides inputs into the credit risk model of S&P for example. One element that is critical in this regard is financial data communicating ownership structures of companies. Thus, one significant challenge related to asset-level data is correctly mapping this data to companies and ultimate owners. This requires databases like S&P Cross-Reference Services or Orbis. Since much of the relevant transition data is likely to be at asset level, this type of matching becomes more important as opposed to just looking at company reporting.

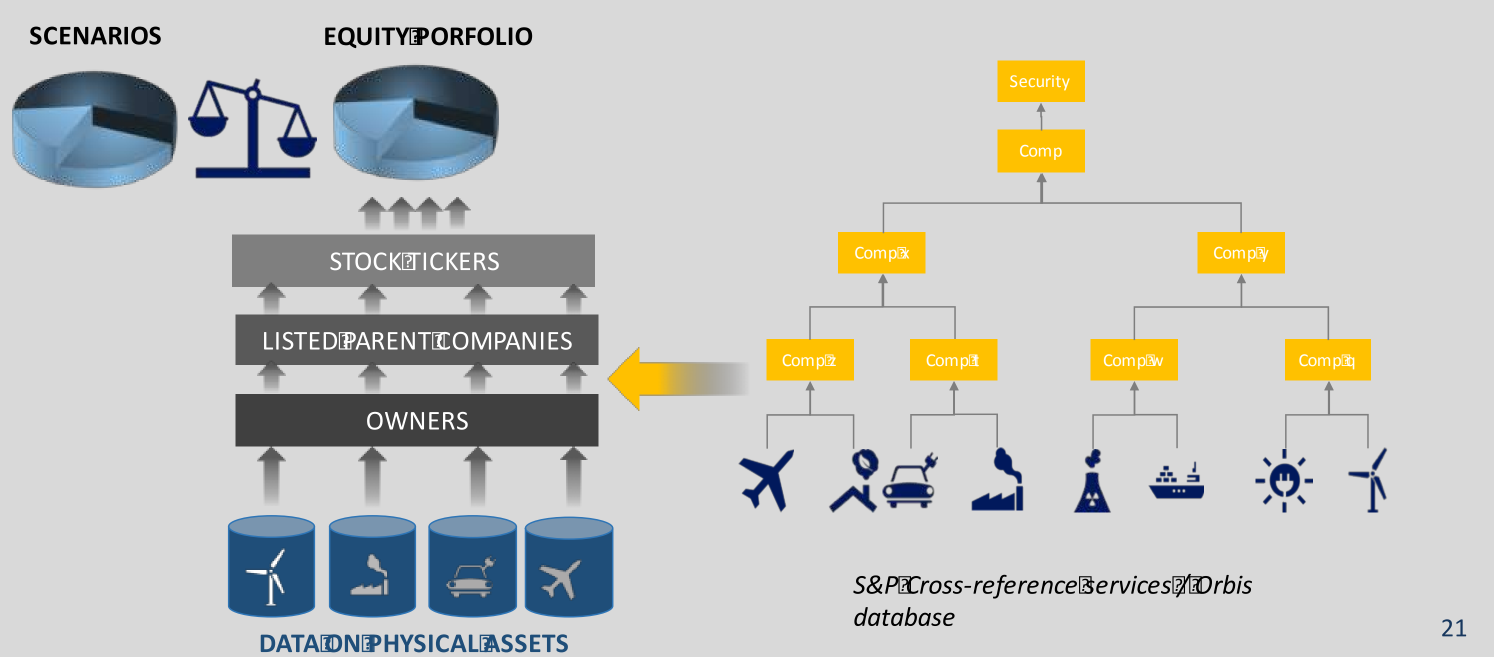
One key challenge is the lack of integration of financial data with transition data.

Mainstream financial data providers currently do not host asset-level data linked to financial assets on their platform. Analysts are thus required to match data across platforms, significantly increasing transaction and search costs. A number of initiatives are seeking to facilitate the access to this data, notably in the context of the ET Risk and SEI metrics project. This involves two key accounting challenges and questions from a risk perspective:

- **Accounting rules around assets**: Individual physical assets may have multiple owners. These ideally are mapped based on ownership shares to reflect the relative exposure to cash flows associated with that asset.

- **Accounting rules around companies:** Frequently, companies will have their exposures through subsidiaries, which they don't fully own. Current disclosures involve different accounting rules used by different companies. The choice of allocation rule here (based on management principle where majority owners get allocated 100% or based on actual ownership) may significantly change the risk perception.

FIG. 3.4: LINKING PHYSICAL ASSETS TO FINANCIAL ASSETS (SOURCE: 2°II)



4. TRANSITION RISK MODELS

4.1 MODELLING OPTIONS

The first step when integrating data and scenarios into models is choosing the model and level of application. Models can be applied at asset, company / security, or industry level (e.g Mercer approach). Relevant models can include:

- **Alignment models** testing the misalignment of a portfolio or individual companies exposure with a future benchmark transition trajectory (e.g. 2°C) and quantifying the economic impact of potential (mis)alignment (e.g. SEI metrics 2° C portfolio tool, Carbon Tracker Initiative cost curves, etc.). Thee models then form the basis of meaningful risk and valuation modelling;

- **Company risk models** testing the potential economic risks of a company in terms of cash flows, net margin impact and capital expenditure changes;

- **Credit risk models** testing change in creditworthiness of an issuer (i.e. change in default risk) under a given scenario.

- **Valuation models** designed to estimate the value of financial assets can be applied under different transition assumptions. Surveys suggests that cash flow-based approaches are among the most common (Fig. 4.1). Our analysis suggests a 2 or 3 stage DCF may be the most useful framework for transition risk modelling (Fig 4.2), as it provides modelling flexibility around medium- and long-run trends.

Three critical modelling choices are required independent of the model chosen:

- **Time horizon / discount rate.** The time horizon or discount rate of the model is critical to determining the materiality of transition risk and its assessment. The discount rate will determine to what extent long-term impacts are considered today. The time horizon will also relate to the length over which impacts are modelled. Thus, discounted cash flow models in theory go out over decades, but the actual modelling is limited to 3-5 years after which cash flows are extrapolated in line with a terminal growth assumption.

- **Probability.** As outlined in Section 2, choices around the probability associated with different scenarios will be critical to determining different risk outcomes. This is also a factor for the model itself. Thus, valuation models typically use normal distributions around a central assumption, an assumption that could be altered for transition risk assessment.

- **Mapping macro to micro.** Finally, a key modelling assumption naturally relates to how macro impacts are reflected by microeconomic actors. This element is further explored on the next page.

FIG. 4.1: FREQUENCE OF VALUATION MODEL USAGE BY SELL-SIDE ANALYSTS (SOURCE: BROWN ET AL. 2015)

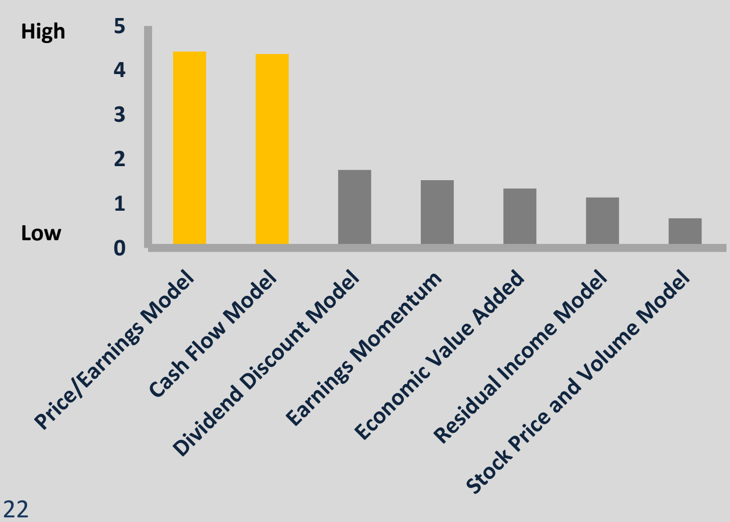
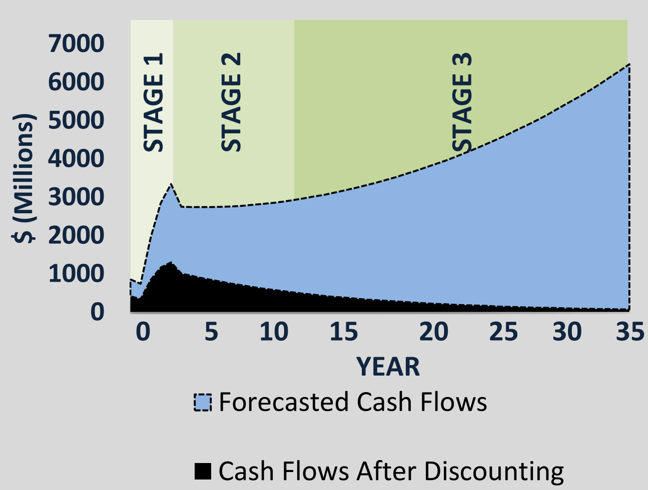
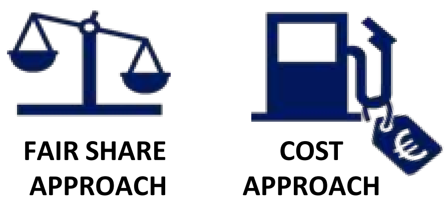


FIG. 4.2: ILLUSTRATIVE THREE STAGE DCF (SOURCE: ET RISK CONSORTIUM)



4.2 APPLYING MACRO IMPACTS TO MICRO ACTORS

A core challenge around transition risk assessment relates to questions of the impact of a set of macro- and sector-level variables on individual companies, financial assets, portfolios, etc. There are three possible approaches in this regard:



- **Fair share approach*:* This approach uses a simple 'fair share' allocation rule where all sector-level production and capacity trends are proportionally distributed across companies based on market share.**

This approach is particularly relevant for assessing 'contribution' or 'responsibility', as it treats all companies equally by assuming constant market share through time. In terms of measuring financial risk for an individual company, however, this is likely to be a relatively crude approach. It is used in the context of the 2°C portfolio tests developed as part of the SEI metrics project (Fig. 4.3). Its advantage is that it can be applied at very low cost to a large universe.

- **Cost approach*:* This approach uses sector-level output variables, such as demand and price, as a constraint interacting with the production costs of individual companies, arguing that the 'marginal' product is produced at the lowest cost.**

The cost approach uses the cost structure of a company's existing, planned, and potential capital stock to estimate which assets meet a sector-wide output constraint under the assumption that low-cost assets will be deployed first. This logic has been applied by the Carbon Tracker Initiative for oil, gas, and coal production and capital expenditure (CTI 2014; 2016). This approach is intuitive and *relatively* easily applied given asset-level data with associated production cost models (though production cost models can of course be debated) (Fig. 4.4).

- **Bottom-up company analysis**: **This approach seeks to identify each company's individual positioning relative to macro trends in a bottom-up manner, tracking assets, pricing power, market positioning, and other parameters.**

From a financial and economic risk perspective, it is the most appropriate and can be applied to all companies. The challenge of this approach is the cost of application and the availability of data, since it must be applied using company-by-company analysis. However, given its advantages we focus the remainder of the assessment on its application.

FIG. 4.3: POTENTIAL COAL RETIREMENT AS SHARE OF TOTAL INSTALLED CAPACITY BY COMPANY USING FAIR SHARE APPROACH (SOURCE: 2° II)

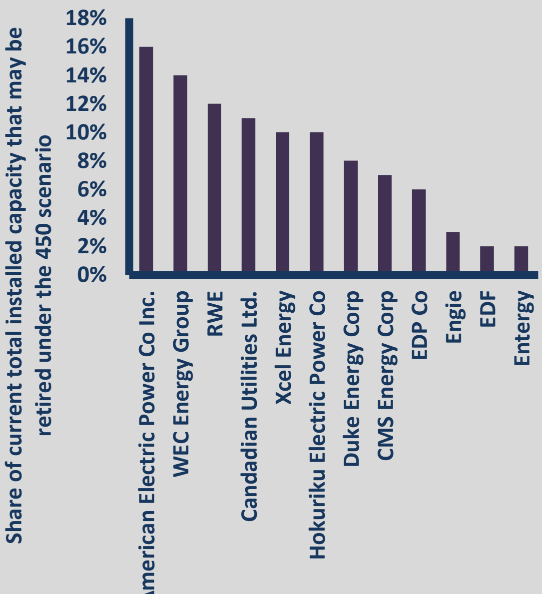
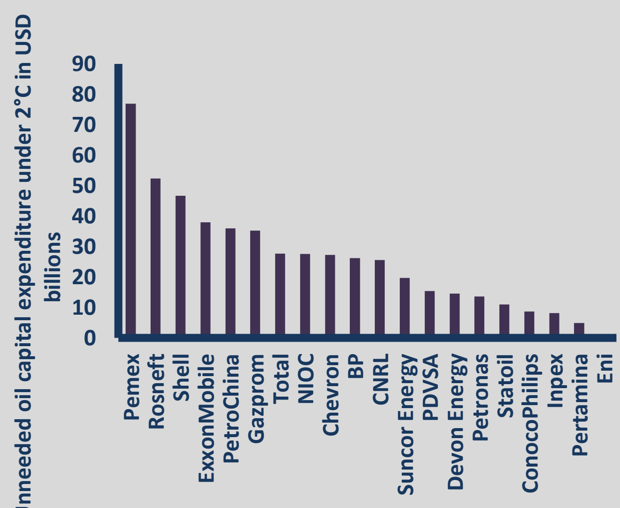


FIG. 4.4: POTENTIAL OIL CAPITAL EXPENDITURE 2015-2025 PER COMPANY THAT IS 'UNNEEDED' UNDER A 2° C PATHWAY USING COST APPROACH (SOURCE: CARBON TRACKER INITIATIVE 2015)



4.3 CHALLENGES IN TRANSITION RISK MODELING

Even ambitious decarbonization scenarios imply in the short-term limited shocks to macroeconomic indicators.

This requires models capable of long term forecasting. However, extending the time horizon of models to cover such horizons (see pg. 20) increases uncertainty significantly, even in sectors with low industry risk (e.g high barriers to entry, high profit margins, etc.). Currently, analyst time horizons are limited to < 5 years (Fig. 4.5)

Modeling short-term adaptive capacity is easier given natural constraints to 'switching strategies' and the investment lag.

The uncertainty around long-term adaptive capacity is much larger, however, and could be anywhere between zero (effectively bankruptcy) or >100% — in effect changing business models more aggressively. Given the long-term nature of transition risk, this is a significant concern. In the case of stress-testing, one solution is to limit the assessment to a specific business segment (and thus not rely on company level adaptive capacity). In a sense, this results in a 'worst case scenario' in the long run by assuming no adaptation. One challenge is the use of a terminal growth rate where even optimistic scenarios undershoot GDP growth rate estimates for high-carbon technologies (Fig. 4.6)

The discount rate includes a company specific and industry influenced risk premium.

Time plays a crucial role here. The more certain and the longer the time frame of specific cash flows the less need the discount rate needs to reflect high levels of structural uncertainty. However, it is very much like the terminal growth rate assumption and has significant impacts on the overall Net Present Value derived from a DCF. So another approach is to vary the risk premium to reflect increased uncertainty over long term cash flows rather than long term growth itself. The issue is of course how to best estimate that.

Even for sell-side analysts covering 5-10 stocks, the time requirements of long-term risk modelling may be prohibitive.

This is even more true of the buy-side or for ESG data providers, where analysts may cover a large universe and spend less than 1 day per company in a year. The current costs of integrating these risks properly, given the lack of modelling infrastructure, capacity, and at times data availability, implies that it is currently too expensive to integrate these risks into daily coverage by analysts. This is true even if initial fixed costs are covered by public funding. This appears in the context of shrinking research budgets (Fig. 4.7).

This means that publication of transition risk research by equity research analysts has been limited to date to bespoke 'idea reports' that usually don't involve comments on price targets (e.g. Kepler-Cheuvreux).

FIG. 4.5: TIME HORIZON OF EQUITY RESESARCH ANALYSTS OF CASH FLOWS AS REPORTED TO BLOOMBERG(SOURCE: 2° II)

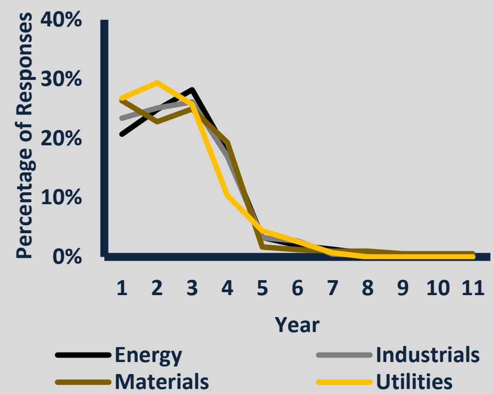


FIG. 4.6: CUMULATIVE OIL PRODUCTION ASSUMING PRODUCTION GROWTH IN LINE WITH GDP AND UNDER VARIOUS IEA SCENARIOS (SOURCE: 2° II, BASED ON IEA 2015)

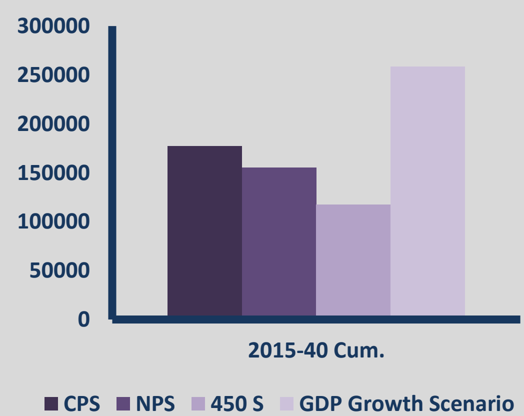
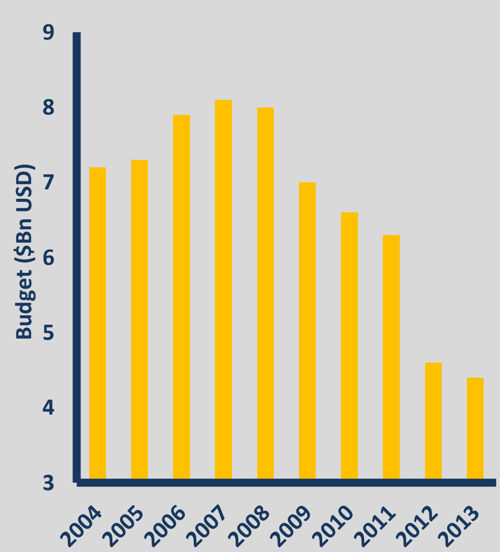


FIG. 4.7: ESTIMATED AGGREGATE BUDGET OF GLOBAL SELL-SIDE EQUITY RESEARCH FIRMS (SOURCE: 2° II, BASED ON FROST CONSULTING DATA)



4.4 OPERATIONALIZING TRANSITION RISK ASSESSMENT

There are three main ways to integrate transition scenarios into current risk and valuation models, none of which are mutually exclusive and all of which will be explored in the context of the ET Risk consortium (Fig. 4.8):

1) **Adjusting short-term margins / cash flows / credit assessments** involves using scenarios to change the assumptions around the short-term (<5-10 years) costs, prices, and volumes (e.g. revenues). While this is the approach most aligned with current modeling practices, it will fail to capture the long-term, and thus the majority of transition scenario impacts and most potential disruptive shocks. An example for this approach the net margin impact modeling work of ILG/CISL and The CO-Firm.

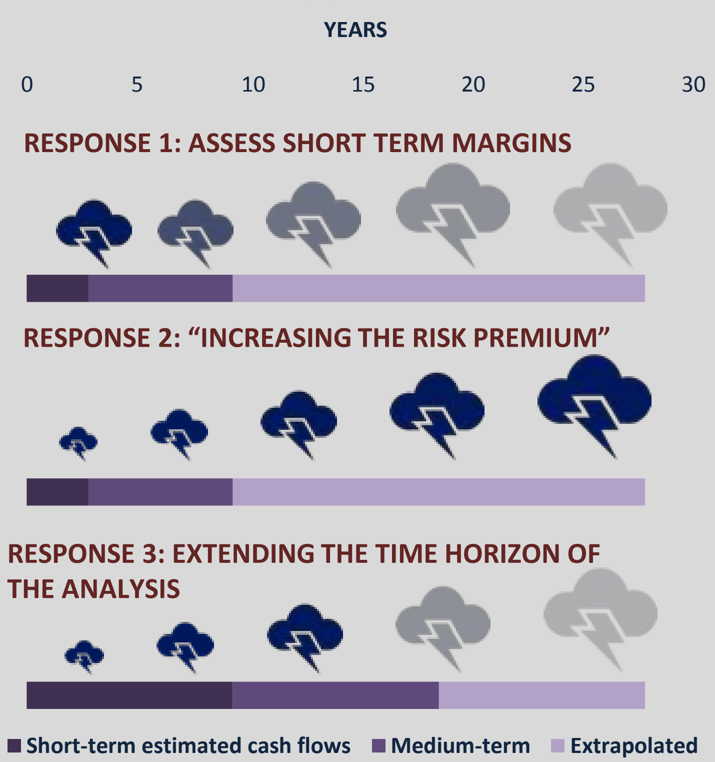
2) **Adjusting the risk premium** implies adjusting the discount rate rather than the cash flows themselves. This approach has been reviewed by academia (Bassen 2009) and recently applied by Carbon Tracker - in combination with estimating long-term impacts (CTI 2016). It is in line with current practices and modelling frameworks and can reflect long-term risks; however, a framework for applying this approach is currently missing.

3) **Estimating long-term impacts** requires making estimates around long-term cash flows of companies. An example for this approach is the "Fossilized Revenues" report by Kepler-Cheuvreux in 2014 (Kepler Cheuvreux 2014). This approach would enable an integration of long-term changes, a clear advantage. However, it is currently not in line with existing modeling practices and raises critical questions around the ability to accurately reflect long-term trends in cash flows. As part of the ET Risk Consortium, The CO-Firm will adapt their net margin model to provide a qualitative assessment of margins out to 2040.

The tools developed as a part of the ET Risk research consortium should help to alleviate some of the business model challenges with transition risk assessment though many will still remain.

The most important factor in operationalizing transition risk assessment may be investor demand; if investors express support publicly and privately (in mandates and engagement with asset managers), increased effort may help to spur commercial offers.

FIG. 4.8: POTENTIAL SOLUTIONS TO TECHNICAL CHALLENGES IN ASSESSING TRANSITION RISK (SOURCE: 2° II)



	PRO	CON
Response 1: Short-term margins	Easy to measure Aligned with current modeling practices	Hard to capture long-term, disruptive materiality of scenario
Response 2: Adjusting the risk premium	Aligned with current modeling practices Aligned with long-term nature of scenario	No quantitative framework in place to implement this Considered 'arbitrary'
Response 3: Estimating long-term impacts	Aligned with long-term nature of scenarios Captures long-term changes	Hard to accurately measure, misaligned with current modeling practices

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ABOUT 2° INVESTING INITIATIVE

The 2° Investing Initiative [2° ii] is a multi-stakeholder think tank working to align the financial sector with 2° C climate goals. Our research work seeks to align investment processes of financial institutions with climate goals; develop the metrics and tools to measure the climate friendliness of financial institutions; and mobilize regulatory and policy incentives to shift capital to energy transition financing. The association was founded in 2012 and has offices in Paris, London, Berlin, and New York City.

ET RISK PROJECT

The Energy Transition Risks & Opportunities (ET Risk) research consortium seeks to provide research and tools to assess the financial risk associated with the energy transition. The Consortium is funded by the European Commission and brings together academic researchers (University of Oxford, think tanks (Carbon Tracker Initiative, Institute for Climate Economics, and 2° Investing Initiative), industry experts (The CO-Firm), and financial institutions (Kepler Cheuvreux, S&P Global). A summary of the initiative can be found here.

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