RIGHT DIRECTION, WRONG EQUIPMENT

WHY TRANSITION RISKS DO NOT FIT INTO REGULATORY STRESS TESTS

2° Investing Initiative

TRAGEDY OF THE HORIZON
ENERGY TRANSITION RISK
DISCUSSION PAPER
September 2017

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ABOUT THE PAPER AND THE AUTHORS

2° Investing Initiative (2°ii**)** is a not-for-profit think tank working to align the financial sector with the 2°C climate goal and long-term investing needs. With offices in Paris, London, Berlin and New York, the Initiative engages a global network of over 40 partners and members, including financial institutions, investment researchers, asset managers, policymakers, research institutions, academics and NGOs. Our work primarily focuses on three pillars of finance - metrics and tools, investment processes, and financial regulation; the Tragedy of the Horizon project informs all three.

THE AUTHORS. This paper has been written by Jakob Thomä and Stan Dupre, from the 2° Investing Initiative.

THIS PAPER: This report deals with the potential integration of climate-related risks into regulatory stress tests.
It is based on the research work of the 2° Investing Initiative, in the context of four projects:

- The **Tragedy of the Horizon** program, that explores the mismatch of time horizons across the investment chain, and the implications for asset pricing.
- The European project **Energy Transition Risks** that develop a methodological framework to integrate energy transition risks into equity valuation models and credit rating models. The project involves S&P Global, Kepler Markets, Oxford, CO-Firm, Carbon Tracker Initiative, and I4CE.
- The European project **Sustainable Energy Investment Metrics** that developed and road-test with 200 investors a framework and database for assessing the alignment of stock and bond portfolios with climate scenarios. The project involves Kepler Markets, the University of Zurich, Frankfurt School of Finance, CIRED, CDP, CBI, and WWF.
- Our **capital misallocation assessments with financial supervisory authorities** that adapt and road test with supervisors (commissioners, central banks) in the US and various European countries the tools developed in the above mentioned projects, in order to assess the exposure of regulated entities to climate risks.

More specifically, this paper summarizes the presentation 2Dii and the discussion that took place in a workshop of the ESRB stress testing working group in May 2017. During this workshop, the central banks from European countries discussed the implication of the ESRB scientific advisory board's report "Too Late, Too Sudden" that recommends the introduction of a "carbon stress test".

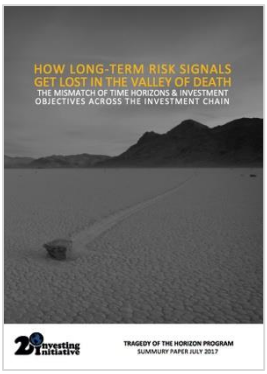
TRAGEDY OF THE HORIZON PROGRAM: In the course of its work on climate-related risks for the finance sector, 2° Investing Initiative faces the question related to what Mark Carney, the governor of the Bank of England called "the tragedy of the horizon": risks that are material for a physical asset (e.g. power plant) or a company (e.g. electric utility) are not necessarily material for their investors and not necessarily priced by financial analysts. As a response, we have initiated the *'Tragedy of the Horizon*' research program. The objective of the program are threefold:

1) **Informing the debate** by quantifying time horizons across the investment chain;
2) **Identifying the unintended consequences** of risk management practices focused on the short-term;
3) **Developing responses** in partnership with the two key stakeholder groups, such as investors and financial policymakers.

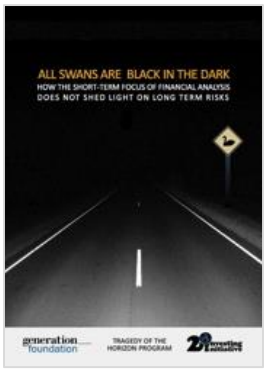
The report was realized with the support of the European Commission, under the Horizon2020 Program (Grant Agreement No. 696004). The views expressed in this report are the sole responsibility of the authors and do not necessarily reflect the views of the sponsors, the ET Risk consortium, or the working group members.

OUR RELATED PUBLICATIONS

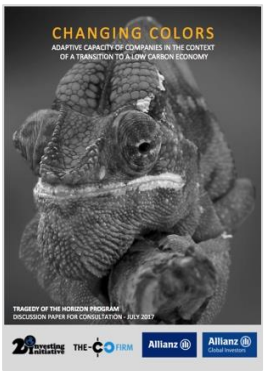
OTHER PUBLICATIONS OF THE TIME HORIZON AND ENERGY TRANSITION RISK PROGRAMS



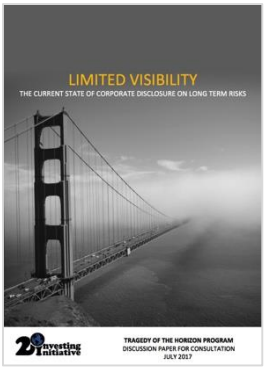
Overview of the time horizon mismatch across the investment chain



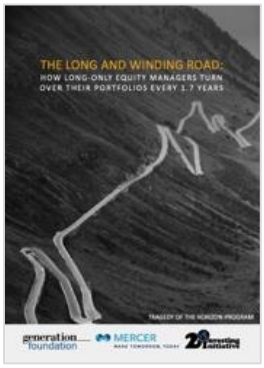
The horizon of equity research and credit risk analysts



How to assess the adaptive capacity of companies that face long-term risks like the energy transition?

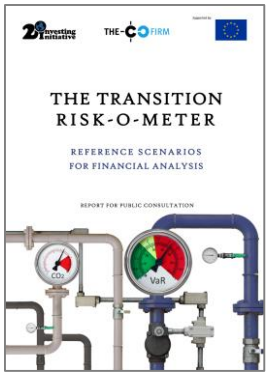


The current state of corporate disclosure on long-term risks and forecasts



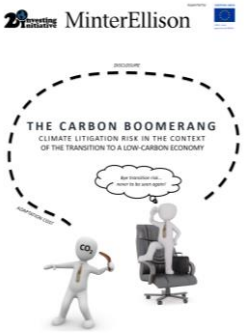
The horizon of long-only equity managers

Upcoming – Implications for EU financial policymakers and regulators



Translation of energy transition scenarios into 'risk parameters', for integration into DCF models

Mapping of methodological options and practical tools and data, for integrating climate-related risk factors into financial analysis



Review of climate litigation risks for companies and their investors

Options for monitoring Art. 2.1c of the Paris Agreement & transition risks

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report seeks to explore options around **integrating transition risk into mainstream stress-test scenarios** used by financial supervisory authorities. It analyses options for integration into macroeconomic, asset-class and sector risk factors. It focuses in particular around the implications of considering the shock described in the '*too late, too sudden*' paper of the ESRB advisory scientific board (2016).

The main findings of the paper are threefold:

1. At macro level, transition risks are **not material enough** in the short-term to impact the existing **macroeconomic parameters** (Fig. ES-1), nor the existing **asset class assumptions** (Fig. ES-2);
2. **At sectoral level in turn, transition risk scenarios become relevant**, but the sectoral detail of these scenarios is too granular and expansive for the existing stress-testing framework;
3. Furthermore, in order to integrate climate factors into stress testing, supervisors face a number of obstacles notably the **mismatch of the time horizon** of risk models (3 years) on the one hand, and the speed and time frame of climate risks materialization, on the other hand – Fig ES-3.

For supervisory authorities, assessing energy transition risks is therefore 'the right direction' to follow, but stress tests are likely to be 'the wrong equipment'. The paper concludes by recommending the development of a specific monitoring process and infrastructure for **assessing the potential systematic mispricing of *long-term, non-cyclical, non linear* risks** (e.g. disruption related to the energy transition, to automation, etc.) by financial markets.

FIG ES-1. IMPACT OF TRANSITION RISK ON GROWTH SCALED TO A 3 YEAR TIME PERIOD (2018-2020)
(Source: Authors, based on ESRB 2016, OECD 2017, IRENA 2017, CISL 2015)

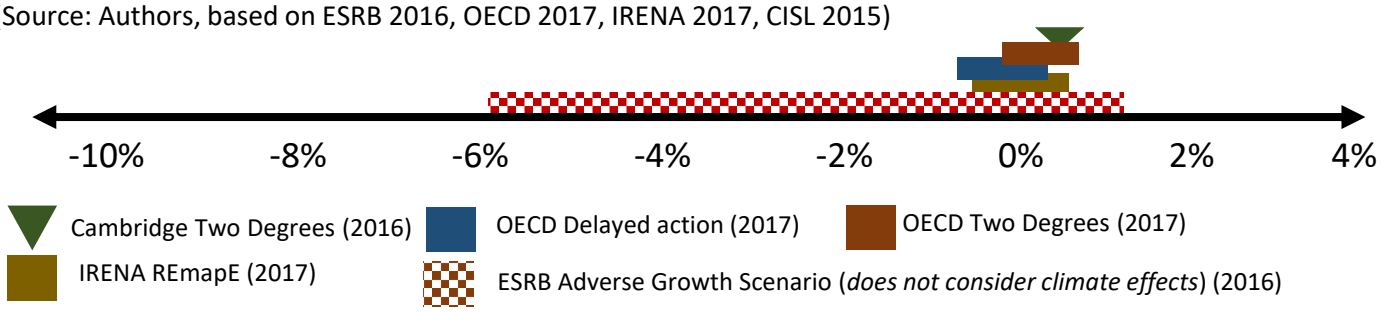


FIG ES-2. IMPACT OF TRANSITION RISK ON STOCK MARKET PRICES (Source: Authors, based on CISL 2015, ESRB 2016)

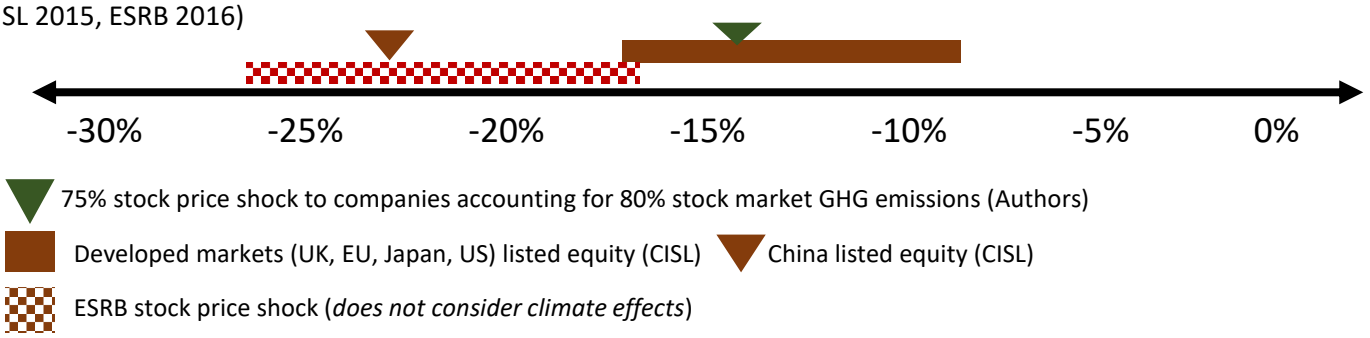
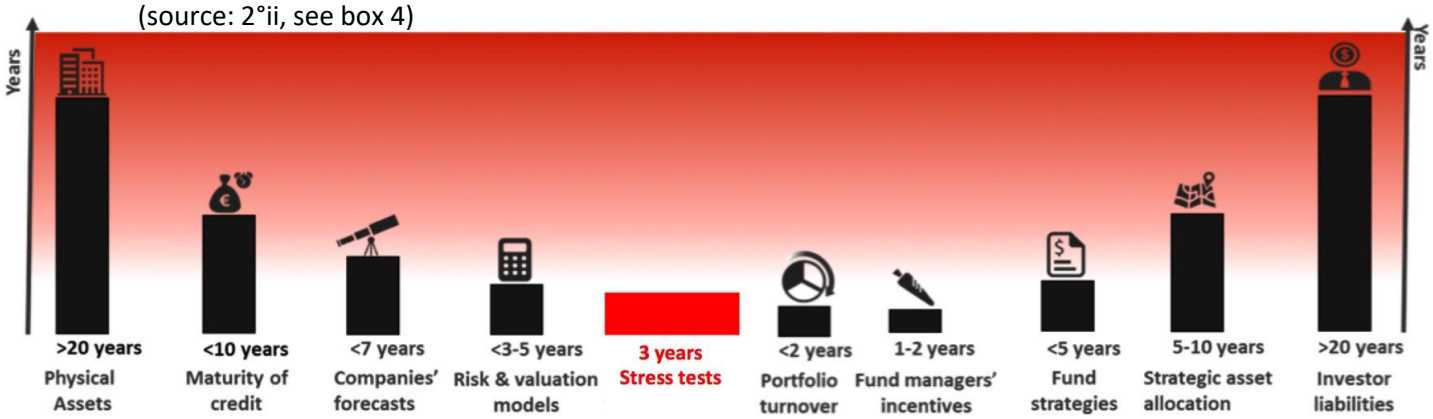


FIG ES-3. TIME FRAMES OF CLIMATE-RELATED RISKS VS. TIME FRAMES OF FINANCIAL RISK MODELS
(source: 2°ii, see box 4)



1 INTRODUCTION

There is a growing debate as to whether transition risk – that is the risk associated with the transition to a low-carbon economy – may be material for financial stability.

The claim is driven by a growing body of evidence that transition risk may create to value destruction for key industrial sectors that are prominently represented in financial markets (e.g. energy, utilities). According to Moody's analysis, $9 trillion of their rated debt may be at immediate or elevated risk of downgrade in response to environmental risks. Around $15-20 trillion of market capitalization in stock markets is tied up with companies that are covered in the decarbonization scenarios of the International Energy Agency. The box on the next page highlights some of the approaches to measuring transition risk

As a result, financial supervisory authorities are starting to explore how transition risk can be integrated into existing stress-testing frameworks.

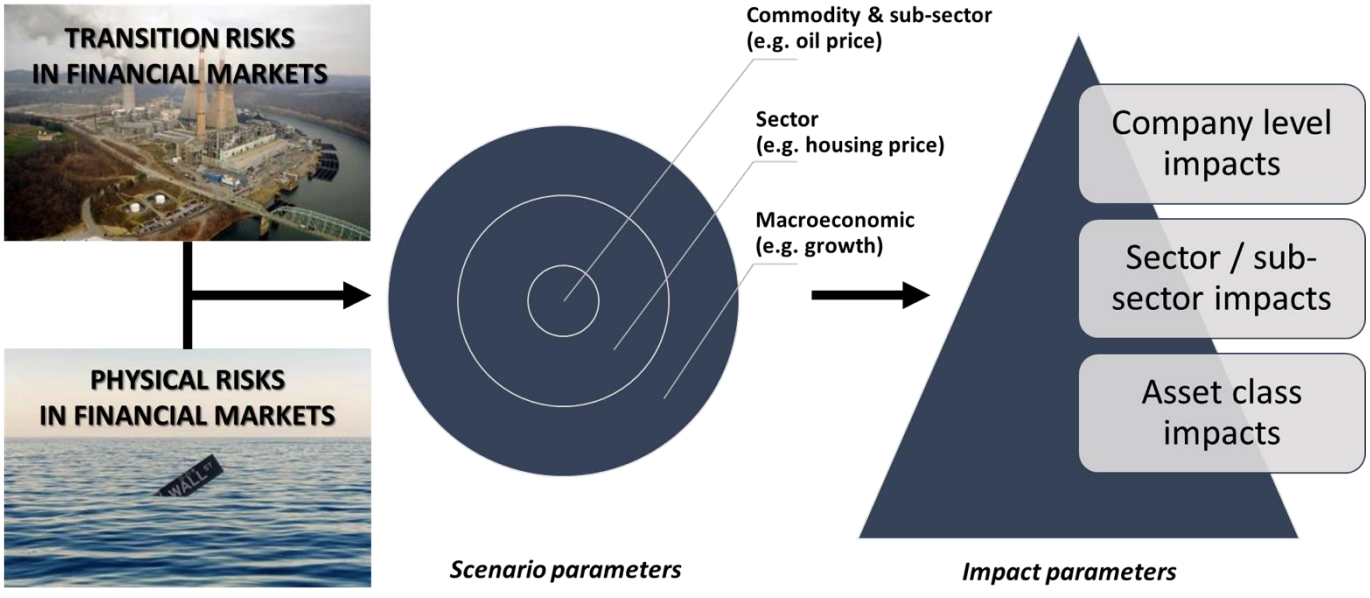
Associated recommendations around integrating such risks have been put forward by the UNEP Inquiry (2Dii / UNEP Inquiry 2015), as well as a number of leading think tanks (Bruegel 2016). Research initiatives along these lines have been launched by the financial supervisory authorities in Sweden, the Netherlands, United Kingdom, and France. The European Systemic Risk Board (ESRB) recommended exploring how transition risks could be integrated into mainstream banking stress-testing frameworks (ESRB 2016).

This report responds to this interest by analyzing the capacity for existing mainstream stress-testing frameworks to absorb 'transition risk scenarios'. It takes the ESRB 2016 stress-testing scenario – used as part of the European Banking Authority (EBA) banks stress-test for the 2016-2018 cycle – as a basis to identify pathways to integrating transition risk into this scenario. The ESRB scenarios consist of two elements (see Fig. below):

- **Scenario parameters:** Macroeconomic scenario parameters (e.g. growth, inflation, employment), as well as sector and commodity / sub-sector specific trends (e.g. housing prices, oil prices);
- **Impact parameters:** Pre-calculated indicators around financial impacts at asset class level (e.g. haircuts on sovereign bonds, impacts on stock prices).

The report analyzes how transition risk scenarios and impact parameters could be integrated into these scenarios and whether integrating these indicators would be likely to increase the materiality of the existing framework.

FIG 1. INTEGRATING TRANSITION SCENARIOS INTO MAINSTREAM BANK STRESS TEST SCENARIOS (Source: Authors)



BOX 1: APPROACHES TO MEASURING TRANSITION RISK

	ASSET-CLASS LEVEL		SECTOR LEVEL	ISSUER LEVEL
WHO DEVELOPED RISK SCENARIOS AND MODELS?	University of Cambridge CISL (using Oxford Economics' GEM)	Mercer (investment consultancy)	Moody's (Credit Rating Agency)	ET RISK (European consortium composed of 2° Investing Initiative, University of Oxford, S&P Global, Kepler, Carbon Tracker, Co-Firm and I4CE…)
WHAT ARE THE OUTPUTS?	Value at risk per per asset class and macro-sector for equity (GICS1)	Value at risk per asset class and macro-sector for equity (GICS1)	4 categories of risk exposure for fixed income sub-sectors	Series of sector specific risk parameters (about 32 total) for 8 energy-related sectors
TIME HORIZON	Shock due to overnight 'sentiment shift' regarding trends in next 5 years	In 10 and 35 years	Over next 3-5 years	Parameters for each year of the next 25 years
MODEL NEEDED TO USE THE RISK FACTORS PROVIDED	Can be applied directly at portfolio level based on asset class and sector allocation	Can be applied directly at portfolio level based on asset class and sector allocation	Can be applied directly at portfolio level based on sector allocation	DCF or/and or Credit Risk Model *(Road tested by Kepler Markets and S&P Ratings)*
AVAILABILITY AFTER 2017	Bespoke publication, regular update not guarantied	Commercially available regular update not fully guarantied	Bespoke publication, regular update not guarantied	Yearly update planned but subject to funding

2 INTEGRATING TRANSITION RISKS INTO SCENARIOS

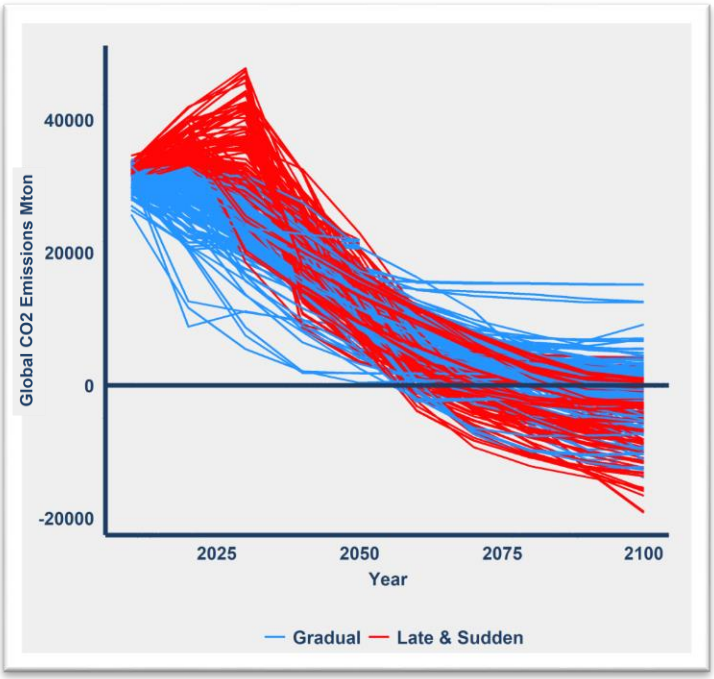
2.1 CHOOSING TRANSITION RISK SCENARIOS

This section analyses how transition risk scenarios can be integrated into the ESRB stress-testing frameworks as one example of a mainstream stress-testing scenario framework administered by a financial supervisory authority.

The first step in identifying the ability to integrate these scenarios is choosing the appropriate transition risk scenario. The ESRB scientific advisory board's report *"Too Late, too sudden?*[1]*"* identified two types of scenario outcomes, a 'gradual', smooth ambitious scenario and a late sudden outcome.

The Fig.2 on the right shows the two types of categories as exemplified in a broad sample of IPCC scenarios filtered by ambition that can be linked to a 50% or higher probability of limiting global warming to 2°C above pre-industrial levels. In addition to the two more ambitious scenarios, transition outcomes could also of course involve a 'do nothing' approach or a limited climate transition ambition. Given that the interest is in transition risks, these two outcomes – likely to be less material – will not be further considered in this analysis.

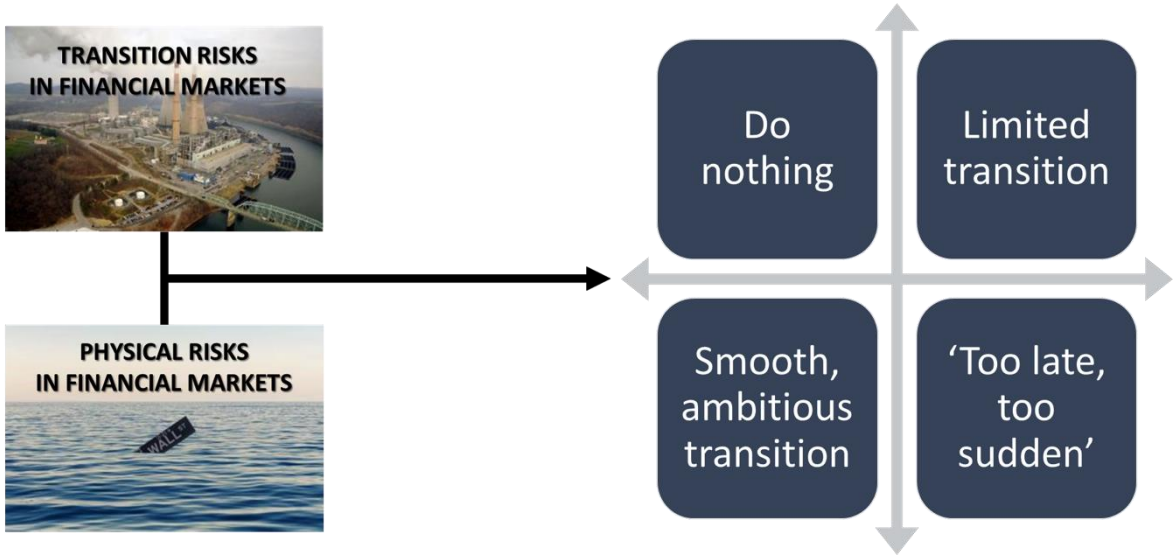
FIG 2. 2°C ALIGNED SCENARIO OUTCOMES IN THE IPCC SCENARIO DATABASE (Source: Authors, based on IPCC 2013)



There are a number of questions marks around the technical feasibility and probability of either of the more ambitious transition scenarios. Given the current level of ambition, a *too late, too sudden* outcome may be more likely than a smooth transition. On the other hand, it is unclear whether policymakers can bring themselves to fundamentally damage significant parts of their economy (given the hesitation to do it now), even in the face of overwhelming costs associated with inaction.

The next pages will focus on how either outcome can be integrated into the ESRB stress-testing outcome and the implications of choosing one or the other.

FIG 3. TYPES OF CLIMATE SCENARIO OUTCOMES (Source: Authors)



2.2 INTEGRATING TRANSITION RISK INTO MACROECONOMIC PARAMETERS

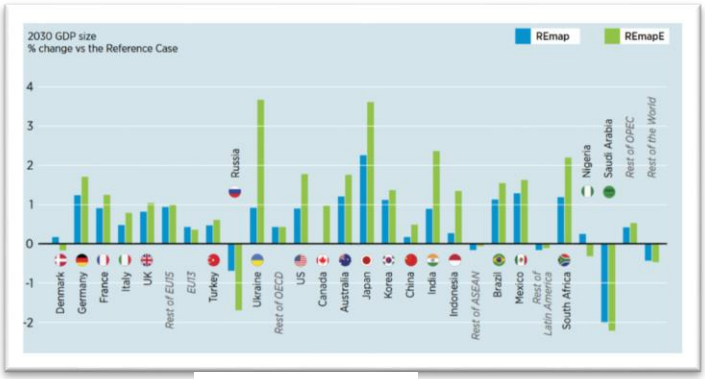
Growth, inflation, employment. Macroeconomic parameters are at the heart of stress-testing scenarios, usually covering in particular growth, inflation, employment. In terms of financial risk, theoretically, it would likely be particularly growth that would be of interest, although there are expected employment effects. The ESRB scientific advisory board's report highlights potential negative impacts on growth under a *too late, too sudden* scenario (as a result of transition trends) as potentially material from a stress-testing perspective.

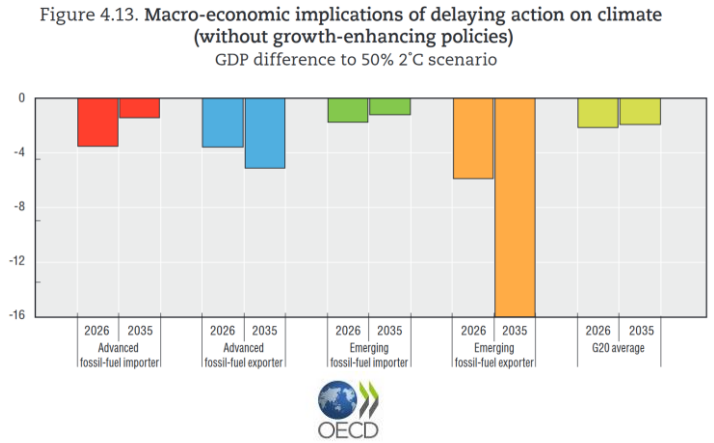
Unclear impact of transition risks. One key challenge in exploring opportunities for integrating growth assumptions in the scenarios is that many transition scenarios treat growth as an exogenous variable, in other words a variable that is not affected by the transition. Notable example in this regard are the scenarios from the International Energy Agency (IEA). Thus, granular and sophisticated analysis on growth impacts is relatively limited and in much of the literature focused on specific countries.

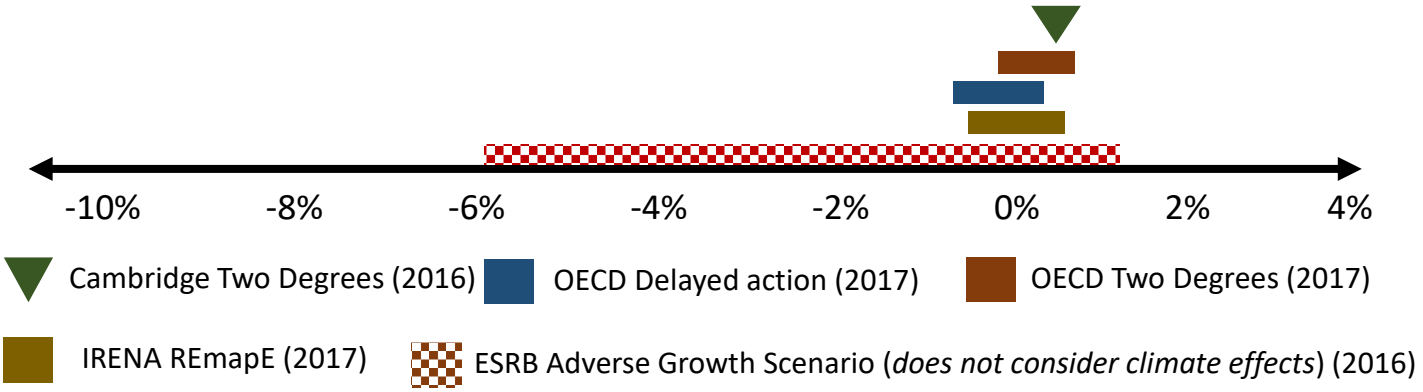
Limited impact on the short term. More recent cross-country analysis exists across a range of sources actually suggests positive growth impacts (see Fig. 4). Admittedly, some of the organization associated with the research represent an interest in depicting a positive growth narrative related to the low-carbon transition. That notwithstanding, even if it was assumed that the most dramatic negative growth impact (affecting Saudi Arabia) would come to pass across all economies, the scaled, 3 year growth impact range is still orders of magnitude lower than the ESRB scenario, which comes in at a range of a negative growth impact between around 4-9%. This result is consistent across four different scenarios associated with a variant of either a smooth or delayed ambitious transition. Even a 'no mitigation' scenario related to increased physical climate risks involves limited short-term growth impacts of -0.3% over three quarters (CISL 2015).

The Fig. below summarizes these different results. The implications of this analysis suggest that transition risks over the short-term are not a relevant indicator to integrate into macroeconomic adverse growth scenarios of regulatory stress-tests.

FIG 4. IMPACT OF TRANSITION RISK ON GROWTH SCALED TO A 3 YEAR TIME PERIOD (2018-2020) (Source: Authors, based on ESRB 2016, OECD 2017, IRENA 2017, CISL 2015)







2.3. INTEGRATING BUSINESS-SPECIFIC PARAMETERS INTO STRESS-TEST SCENARIOS

While macroeconomic effects may be more muted, sector and sub-sector trends may be significant. This may be material for financial institutions with a high sector specific exposure. Capturing these sector and sub-sector trends in turn requires indicators that operate at that level.

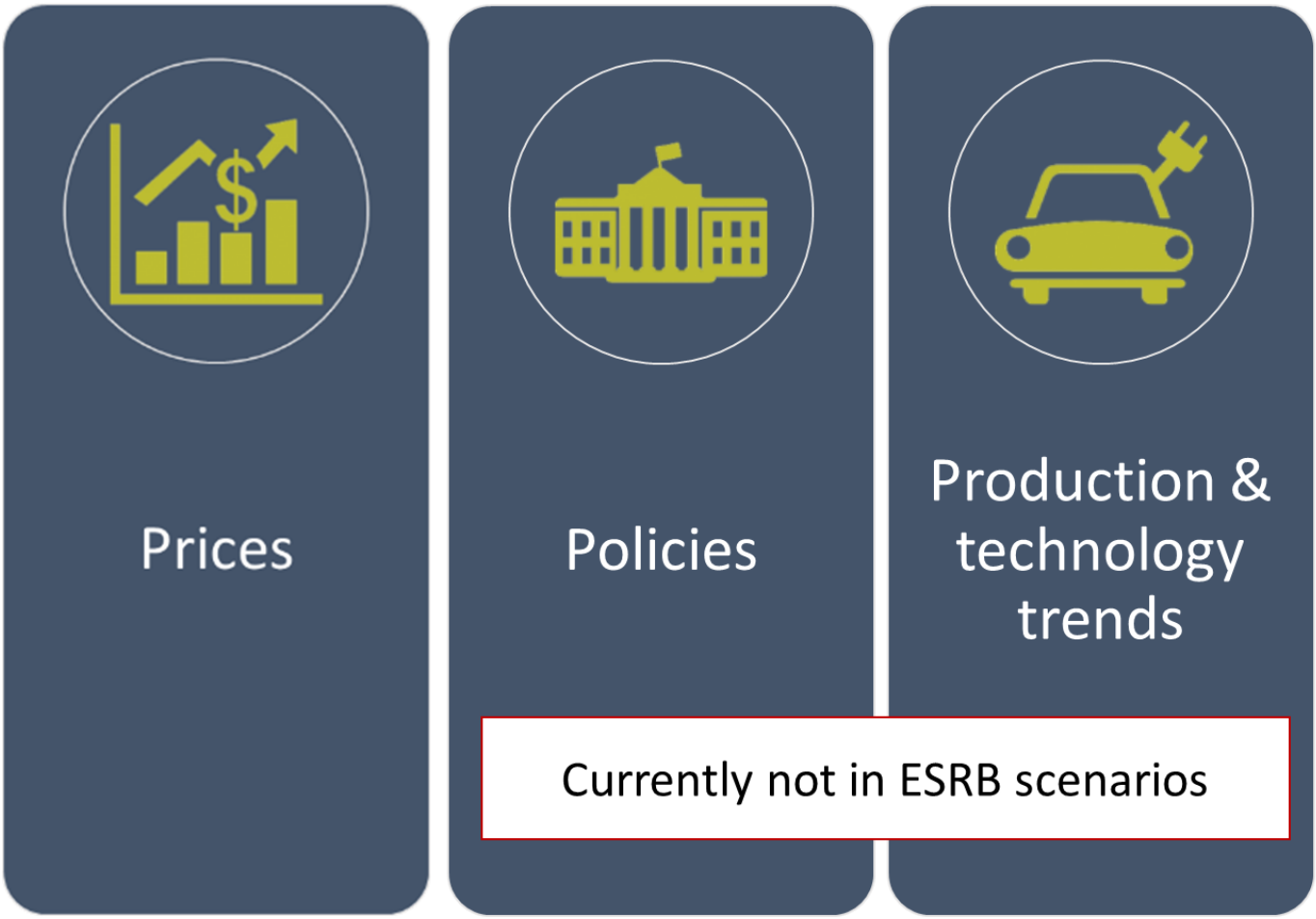
Transition risk scenarios generally contain at least three core elements, with potential additional factors related to more idiosyncratic risk drivers (e.g. litigation). These are production, market prices, and costs (e.g. oil prices, battery costs, carbon fibre costs, electricity prices), policy (e.g. carbon tax, feed-in tariffs, fuel efficiency standards), and production and technology (e.g. oil production, electricity production, electric vehicle production) (ET Risk 2016, see Fig. below). A comprehensive scenario for the key sectors (e.g. oil & gas, electric power, cement) may cover over 30 indicators (see next page (ET Risk 2017).

When looking at ESRB scenarios, currently only the equivalent of the *prices* element of transition risk can be found in the ESRB scenarios, notably oil process, housing prices, exchange rates, etc. Policy elements and production & technology trends are not captured or in the case of production only captured at macro level (e.g. growth).

In addition, there is a question of digestibility. ESRB scenarios are relatively constrained focusing on only a few critical sector or sub-sector / commodity prices that are expected to be critical in driving macro trends and play an outstanding role for significant asset classes (e.g. oil for derivatives, housing prices for mortgages). Adding two dozen or more indicators on transition risk may break the contained framework of the existing scenario. While an attempt could be made to focus only on the most critical elements, there is a question as to how effective a stripped down scenario would be in practice.

As a result, while sector- and sub-sector / commodity indicators are relevant for transition risk scenarios and in allowing for a stress-test that emphasizes concentration risks, this is unlikely to be digestible in the current ESRB stress-testing-framework, both given the sheer number of indicators as well as their categorization.

FIG 5. TYPES OF TRANSITION RISK SCENARIO PARAMETERS (Source: Authors, based on ET Risk 2016)



2.4. ESTIMATING ASSET CLASS LEVEL IMPACTS

The ESRB stress-testing frameworks cover both economic scenario as well as financial impact assumptions across different asset classes. Notable examples include haircuts on sovereign bonds and stock price shocks (Fig. 6).

Macro climate impacts across asset classes have only been modeled by the investment consultancy Mercer in 2016 as part of their Climate TRIPS model. This work is the closest third-party equivalent to the types of impacts modeled by the ESRB, although based on proprietary models. The impact analysis runs on all of the four outcomes highlighted earlier. For corporate bonds and listed equity, further research exists, modeled both bottom-up (by e.g. the ET Risk consortium) and top-down (Battiston et al. 2016).

For the purpose of this report, a hypothetical impact of 75% on the share price of the sum total of companies accounting for ~80% of GHG emissions (Scope 1 and Scope 2, sectors include energy, utilities, materials, industrials, based on Exane 2015) was assumed. The objective is to understand how potentially highly disruptive impacts on transition risk compare to existing stock market level shocks in the scenarios.

FIG 6. ESRB STRESS-TEST STOCK PRICE SHOCKS 2016-2018 (Source: ESRB 2016)

Table 4: Stock price shocks

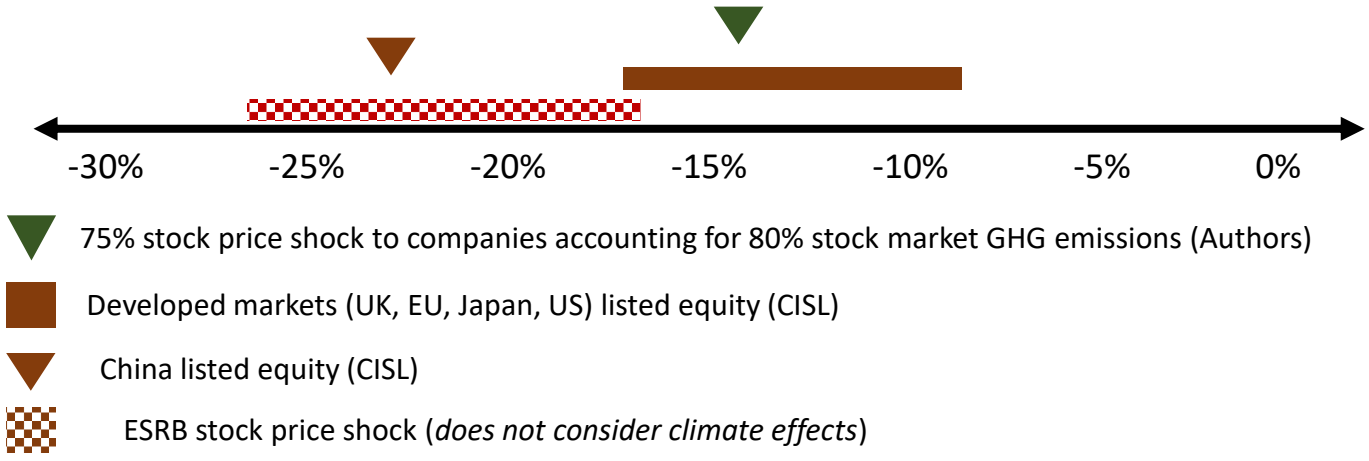
(annual average percentage deviations from baseline levels)

	2016	2017	2018
Belgium	-25.5	-24.3	-16.1
Bulgaria	-10.3	-12.4	-8.2
Czech Republic	-23.3	-20.9	-13.9
Denmark	-20.4	-22.0	-14.6
Germany	-24.6	-25.6	-17.0
Estonia	-14.1	-16.9	-11.2
Ireland	-25.6	-25.0	-16.6
Greece	-26.4	-23.6	-15.7
Spain	-26.0	-24.9	-16.6
France	-28.0	-26.5	-17.6
Croatia	-12.1	-14.7	-9.7
Italy	-28.8	-25.3	-16.8
Cyprus	-21.4	-23.1	-15.4
Latvia	-10.0	-10.3	-6.8
Lithuania	-12.2	-15.2	-10.1
Luxembourg	-22.1	-20.7	-13.7
Hungary	-17.4	-19.9	-13.2
Malta	-11.2	-13.8	-9.2
Netherlands	-25.5	-25.5	-16.9
Austria	-30.5	-25.4	-16.9
Poland	-19.4	-19.9	-13.2
Portugal	-24.0	-20.3	-13.5
Romania	-18.6	-22.1	-14.7
Slovenia	-9.8	-12.1	-8.0
Slovakia	-11.4	-13.4	-8.9
Finland	-23.0	-25.4	-16.9
Sweden	-23.9	-24.7	-16.4
United Kingdom	-25.3	-24.6	-16.3
Euro area	**-26.2**	**-25.2**	**-16.7**
European Union	**-25.4**	**-24.7**	**-16.4**

Note: the baseline assumes unchanged stock prices in 2016-18.

The results suggest that under such an assumption, the impact would still be significantly lower than the lower bound of stock price impact for the Euro area or European union (-16.4%-26.2%), at roughly 13-15% (depending on data source and definition of stock market universe). Even increasing that figure to 100%, implying total bankruptcy, this would just hit barely the lower bound of the ESRB price shock. This suggests that macro impacts, at least for stock market as one asset class – which based on Mercer analysis would be one particularly affected – does not meaningfully inform the scenario beyond what is already assumed. One caveat in this regard is that financial institutions with different portfolios may have different results. Moreover, if the entire energy and mobility sector goes bankrupt, there would for sure be secondary and tertiary effects. The credibility of this assumption, even under an ambitious, disruptive scenario, of total bankruptcy for the sector, is low, even for a stress-test.

FIG 7. IMPACT OF TRANSITION RISK ON STOCK MARKET PRICES (Source: Authors, based on CISL 2015, ESRB 2016)

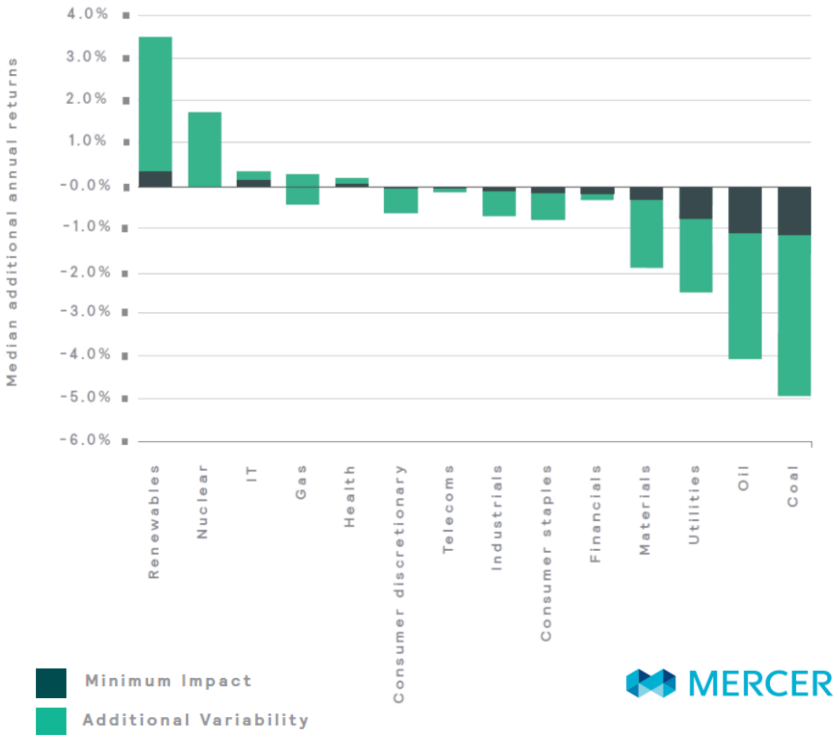


2.5. SECTOR OR SUB-SECTOR / COMMODITY IMPACTS

As outlined above, a sector specific approach on scenario parameters can help isolate the specific risk drivers and portfolio exposure to these. By extension, such an approach can also extend to scenarios around sector impacts. The TRIPS model from Mercer provides for these at sector level for listed equities. Moody's in turn developed a 'heatmap' of environmental risks on their rated universe, categorizing risks of downgrade as immediate elevated, emerging elevated, and emerging moderate. While not specifically quantifying risks, such downgrade risks could be converted into risks for portfolios in terms of probability of default and loss at default.

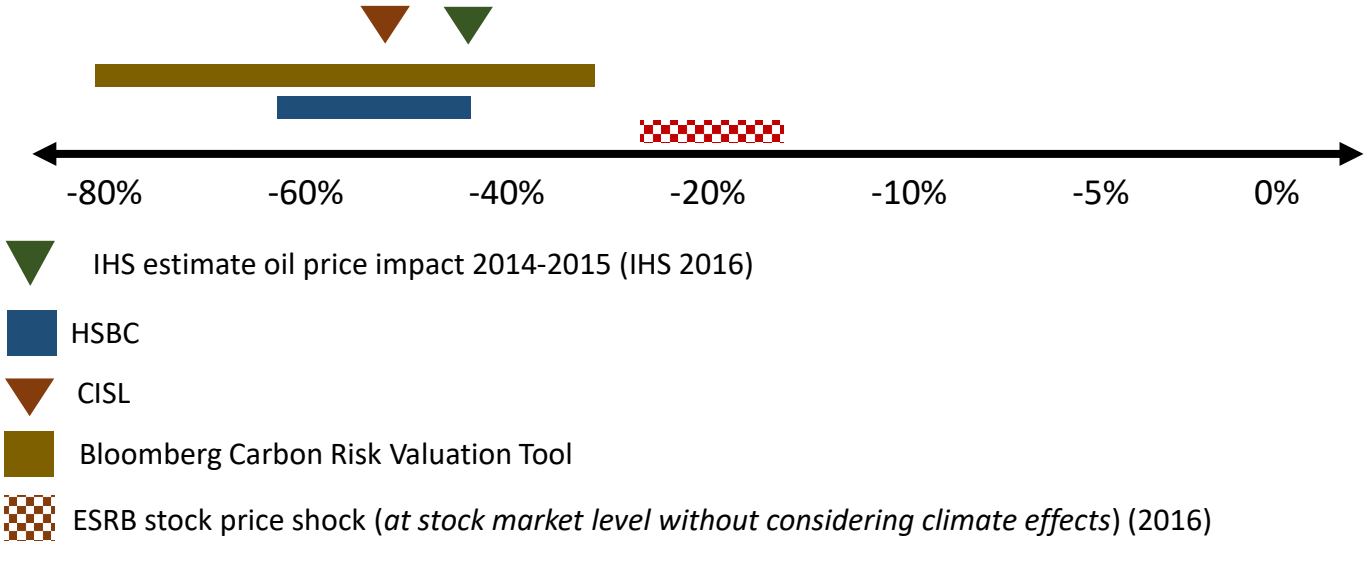
Currently, mainstream stress-testing scenarios do not contain sector specific impacts. Moreover, at macro level the results appear more muted.

FIG 8. SECTORAL IMPACT ESTIMATES FROM MERCER (Source: Mercer 2015)



However, sector-specific impacts may be material for portfolios with concentrated exposures. The figure below highlights the scale of potential impact based on third-party research for developed markets oil & gas exposure.
While the literature is limited, it suggests that under a sudden sentiment change as to the long-term prospects of certain sectors (e.g. oil & gas), share prices can move significantly more than the sectoral effects in the ESRB stress-test scenario. Indeed, research by IHS suggests that this movement was visible between 2014-2015 under the recent oil price shock. The research also points out that these effects did not lead to any financial stability concerns, underlying the effect that macro effects may be muted. Sustained and more broad share price impacts however may create challenges for individual financial institutions with higher exposures to these sectors.

FIG 9. ESTIMATED EQUITY PRICE IMPACTS FOR DEVELOPED MARKETS OIL & GAS EQUITIES (Source: Authors, based on CISL 2015, HSBC 2013, IHS 2016)



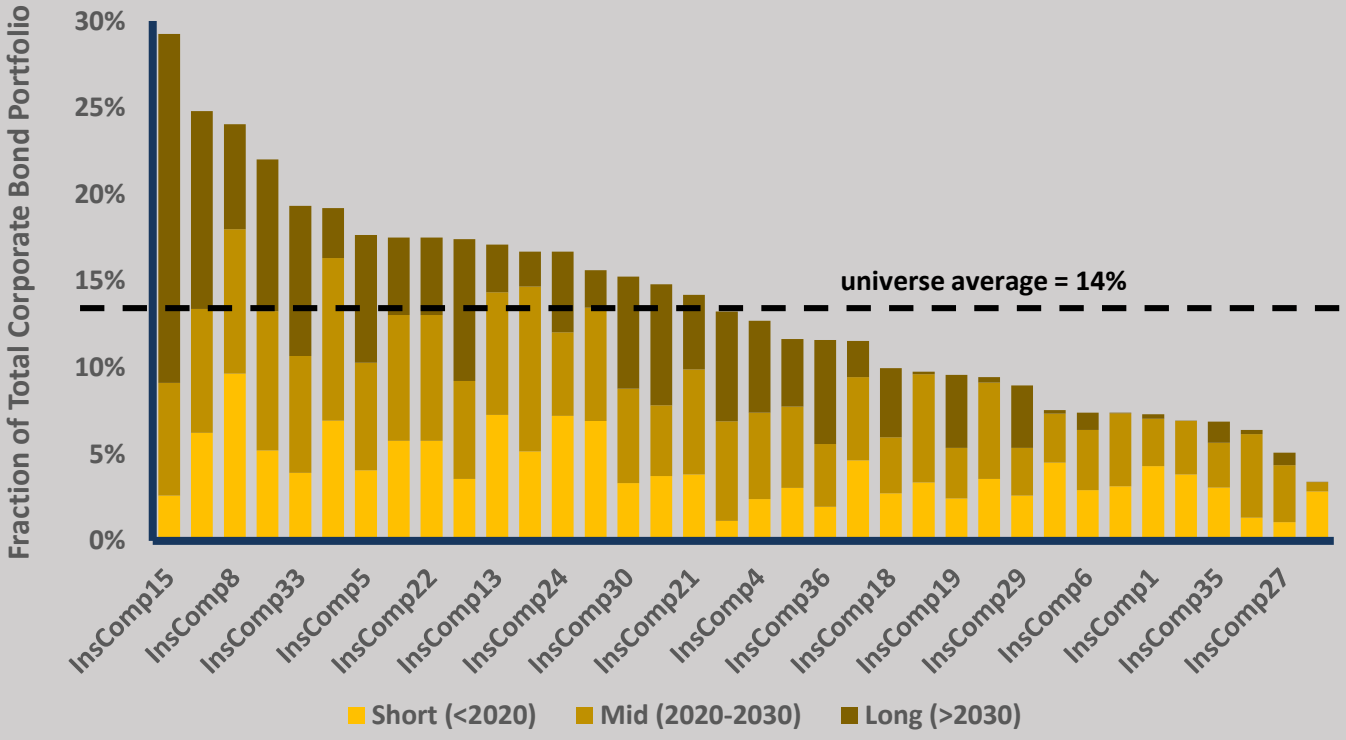
BOX 2: CONCENTRATION RISK AND TRANSITION SECTOR EXPOSURE

In 2015, Moody's investors service published an analysis of the sensitivity of their credit ratings to more stringent climate and environmental policies. The output is a categorization of subsectors based on the likelihood of downgrade in the next 3 years or after 3 years, as presented in the table below. The assessment is based on specific trend review per industry, and the integration of the related risk parameters in the industry-specific credit rating model.

Risk Level	Sector	
Immediate Elevated	Independent Power Producers, Coal & Consumable Fuels	Next 3 years
Emerging Elevated	Steel, Aluminum, Oil & Gas E&P, Construction Materials, Diversified Metals & Mining, Auto Manufacturers	After 3 years
Emerging Moderate	Regulated Utilities, Airlines, Integrated Oil & Gas, Paper, Oil & Gas services, Auto Parts, Gas Utilities	
Low	Marine, Diversified Chemicals, Industrial Gases, Marine Ports	

Based on these categories, 2° Investing Initiative and CERES, in collaboration with US insurance commissioners have assessed the exposure of top US insurers fixed-income portfolios to these sectors: 14% of total studied bond portfolios are in 'risky' sectors, with a considerable variation between insurers (3 to 28%). The output is an 'exposure' indicator, that can be converted into a value at risk based on historical correlations between downgrades and market prices. Given the variation in results, analyzing exposure of individual financial institutions at sector or technology level appears as a relevant way forward.

FIG 10. **EXPOSURE OF TOP US INSURERS TO BONDS ISSUED BY SUB-SECTORS WITH ELEVATED RISKS BASED ON MOODY'S, BROKEN DOWN BY MATURITY** (Source: 2° Investing Initiative/CERES, based on Moody's Environmental Risk Heat Map and AM Best data, 2016)



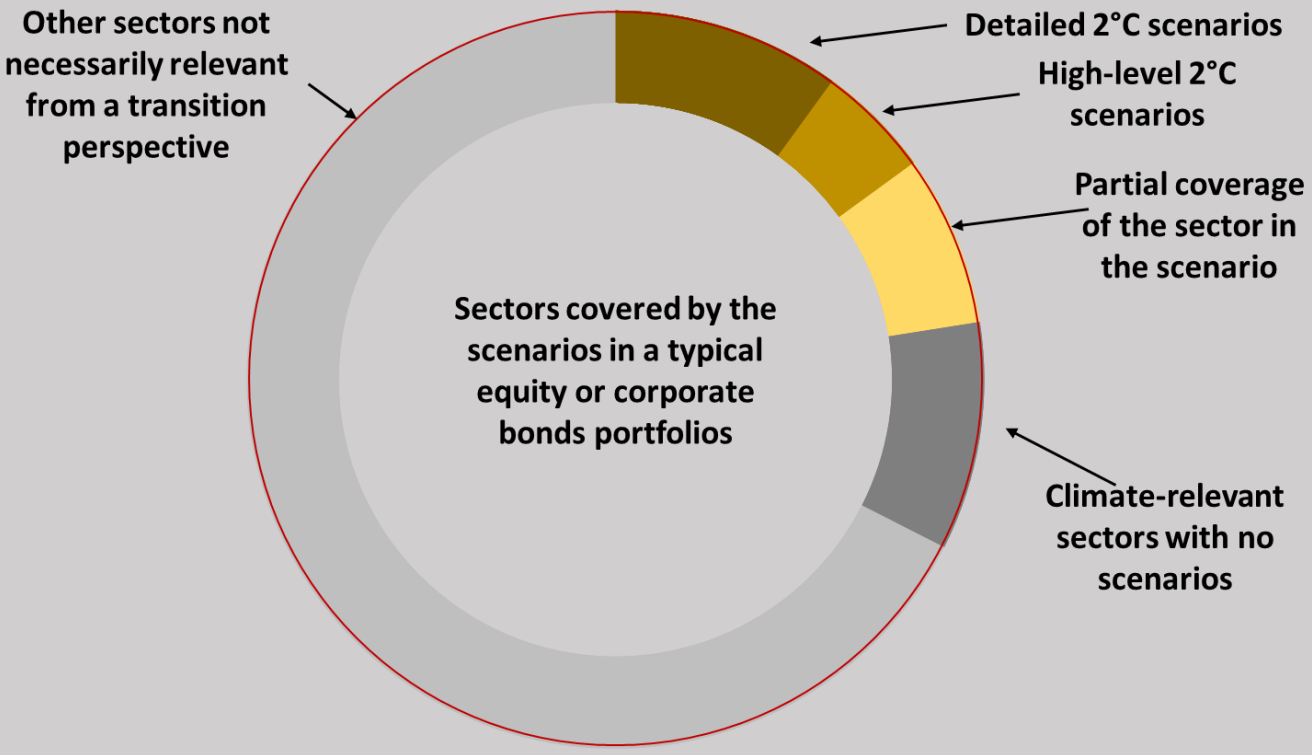
BOX 3: SECTOR COVERAGE OF CLIMATE SCENARIOS

Current transition scenarios of the kind published by the International Energy Agency only cover products and services delivered by a subset of companies in a typical financial portfolio of a bank or institutional investor. The Fig. below showcases estimates as to the sectoral coverage. Generally, this can be broken down into:

- *Detailed 2°C scenarios* cover notably the oil & gas, electric utility, and automotive sector, for which detailed, technology-specific transition scenarios are developed
- *High-level 2°C scenarios* cover sector for which high-level decarbonization scenarios exist, albeit only at high level, that is to say with limited information on technologies (e.g. cement, steel).
- *Partial coverage of the sector* involves companies, who have a minority of their business in sectors covered by the scenario. These usually be classified in other sectors (e.g. IT).
- *Climate-relevant sectors with no scenarios* involve those companies that are highly relevant from a climate change perspective (e.g. agriculture, forestry), but are not reflected in energy and technology scenarios of the kind produced by the International Energy Agency. This could also hypothetically include financial institutions, which would increase the dark grey share obviously.

The light grey in turn covers all sectors. By extension, risks may be idiosyncratic and financial institutions whose actual exposure diverges significantly from the market may have much higher (or lower) percentages.

FIG 10. **SHARE OF SCENARIO COVERAGE IN A TYPICAL PORTFOLIO** (Source: Authors)



3 BARRIERS TO MATERIALITY

3.1. SENTIMENT SHOCK AND THE TRAGEDY OF THE HORIZON

Perhaps the most obvious challenge is what Mark Carney labeled the *tragedy of the horizons*:

- On the one hand, corporate and financial disclosures, credit risk and equity research models, as well as portfolio management is limited to 3-5 years and sometimes even shorter (see chart below and box 4). For stocks, upwards of 80% of cash flows in discounted cash flows are simply extrapolated (Fig 11). The concrete implication is that a risk that is not likely to start materializing in this 3-5 year time frame is unlikely to be priced now. Regulatory stress-test models in Europe in turn are over a three year time horizon.
- On the other hand, the *'too late, too sudden'* story thus becomes difficult to consider when the *'too late'* part takes place after the end of the stress-test time horizon, and the *'too sudden'* part (see potential triggers in box 5) takes more than three years to materialize, with weak signals giving enough time to the market to gradually re-price assets.

Thus, while a sentiment shock assumption may hold some appeal, that is neither how current models are applied, nor is it clear whether such sentiment shock, given discount rates, would be truly powerful at systemic level.

FIG 11. BREAKDOWN OF AN EQUITY PORTFOLIO NPV BY TIME PERIOD
Sources: 2°ii, Morningstar DCF for equities.

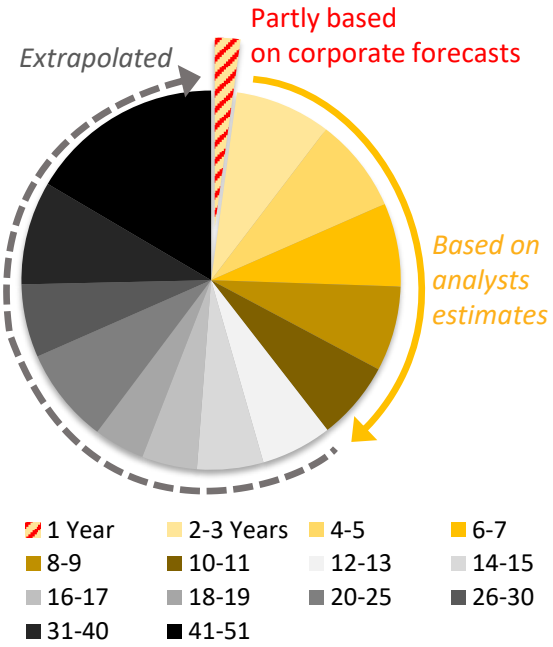
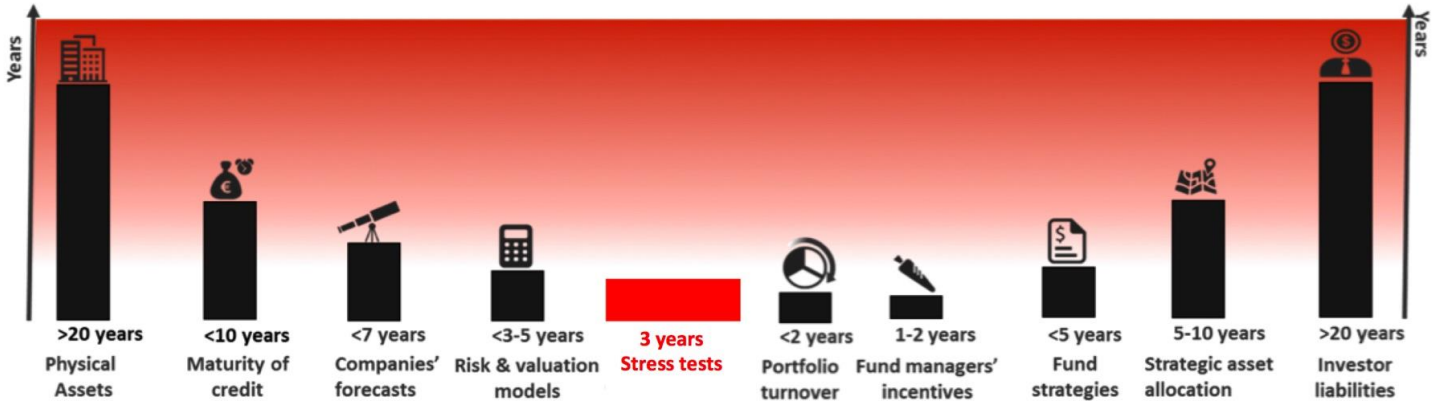


FIG 12. TIME FRAMES OF CLIMATE-RELATED RISKS VS. TIME FRAMES OF FINANCIAL RISK MODELS
(source: 2°ii, see box 4)



3.2 ADAPTIVE CAPACITY

Another key challenge is understanding the role of adaptive capacity,[1] both of financial institutions and companies, in responding to these risks. More long-term risks extend the 'landing strip' for companies and financial institutions to adjust. This process will likely yield losers and winners, with uncertainty as to who those will be. Different macroeconomic or even sectoral trends will impact different actors in different ways. These trends will yield positive and negative feedback loops, including potentially even positive influences on financial stability as trade flow imbalances associated with carbon may be reduced.

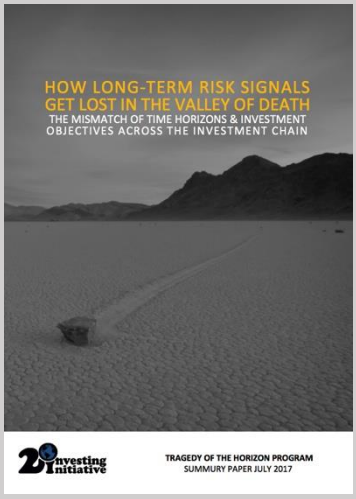
All of these elements are almost entirely ignored to date. While they may be less material over a three year time horizon to adjust, 10 or 15 years is a long time to turn things around. While this factor is critical to thinking about market pricing, it becomes perhaps somewhat less of a concern for a stress-test, which is more interested in thinking about worst case scenarios where perhaps adaptive capacity then is close to zero.

1. *Changing colors: the adaptive capacity of companies in the context of the energy transition*, Co-Firm/2Dii/Allianz 2017

BOX 4: MISMATCH OF TIME HORIZONS ACROSS THE INVESTMENT CHAIN

Player in the chain	Facts	Drivers and implications
Physical assets	In many sectors the value of companies is heavily based on long-term assets.	These assets create a locked-in effect and are exposed to long-term risks.
	In these sectors, companies plan capital expenditures for the next 5-7 years.	In some sectors, the inertia of corporate strategies and locked-in effect is possible to assess.
Investee companies and other issuers	80% of the NPV of listed equities is based on post-5 year cash flows. 75% of the NPV of bonds is based on post 5 year cash flows.	In a low interest rate environment, capital markets are highly exposed to long-term risks. Potential mispricing of these risks might lead to sub-optimal returns for long-term investors
	Most companies do not disclose forward-looking data beyond 1 year and do not discuss long-term risk. Viability statements only exist in the UK and SA. The scenarios behind of impairments tests are rarely disclosed.	Forward-looking corporate disclosures primarily respond to the demand for quarterly reporting and do not support long-term risk assessment.
Financial data and analysts	Based on corporate disclosure, analysts produce forecasts for the next 5 years, and target prices for the next 12 months	Even though companies may be able to disclose mid-term forecasts and plans, this task is left to analysts. This situation is to a large extent due to the legal framework on forward-looking disclosure.
	12 month forecasts are on average 20% wrong, but the dispersion among analysts is limited to 1%.	Equity analysts' job is to be aligned with their peers in 12 months, not to produce accurate long-term pricing of assets.
	Equity research analysts value companies based on forecasts for the next 5 years, and then extrapolate.	There is no risk analysis beyond 3-5 years. Weak signals that are not likely to turn in material risks in this time frame are generally ignored.
	Credit ratings are primarily based on the 'financial cushion' of issuers, but also assess their ability to sustain free cash flows, based on forecasts for the next 3-5 years.	Rating agencies prioritize accuracy over a 3 year timeframe. They usually rely on equity research to identify weak signals and do not price them before equity markets.
Regulators	Market authorities provide very vague and limited guidance on the discussion of long-term risks in fillings and usually do not monitor compliance on this topic.	Discussion of the viability of the company's business model is only mandatory in the UK and usually limited to a 1 to 3 year timeframe. Companies have no incentive to discuss long term risks.
	The timeframe for Stress tests conducted by central banks is three years.	Risks that are likely to materialize slowly over the next several decades are not stress tested.

Player in the chain	Facts	Drivers and implications
Investors	Due to the heavy weighting of short term traders in the total number of transactions, the average holding period is 7 months for stocks and 18 months for bonds.	The overall demand for risk analysis is focused on the short-term. Given the weight of hedge funds in total trading commissions, sell-side research sees them as an important audience / client. Similarly rating agencies primarily serve the needs of bond traders.
	Long-only equity managers turn over their portfolio every 1.7 year on average, and in less then 3 years for 90% of them.	There is no demand for financial risk analysis beyond a 3-5 year timeframe (holding period x2). There is hardly any offer of such analysis.
	Institutional investors are increasingly adopting passive strategies that perform better on average. Active managers are usually incentivized based on their performance vs. benchmarks on a 1 year horizon and face constraints in terms of tracking error. Cap weighted benchmarks dominate.	This situation contributes to dramatically reinforce the herding effect of stock markets: active managers are incentivized to mimic their peers in order to reduce the tracking error vs. the benchmark, and passive strategies mimic stock markets by design.
	The strategic asset allocation of long-term investors underweights illiquid assets due to governance and regulatory constraints.	The allocation to real assets is artificially low, reducing the availability of capital for newcomers and businesses. On the other hand, allocation to liquid assets is not associated with long-term risk analysis.
Ultimate asset owners and beneficiaries	A significant part of financial asset owners and ultimate beneficiaries have long-term horizons.	These investors are exposed to 'long-term' risks that will affect the returns of stocks and bonds even if no one actually assesses these risks.



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www.tragedyofthehorizon.com

BOX 5: TRIGGERS OF THE 'SENTIMENT SHOCK' IN CISL'S SCENARIOS

Trigger	Two Degrees	No Mitigation
New Scientific Evidence and Technology	• New technological breakthrough in low-carbon technology (e.g. fusion, solar) • Increased accuracy in the monitoring and measurement of emissions for attribution	• New scientific evidence on the unstoppable and runaway effects of climate change • Thermohaline circulation shuts down • Permafrost melts releasing vast quantities of methane into the atmosphere • Greenland and Antarctica ice sheet begins to melt • Glaciers begin to disappear
New policy announcements	• Announcement of global agreement to limit GHG with a tax or a cap • Election of new political party that pushes climate change mitigation • Forced nationalization of selected state assets • Commitment to stop the implicit subsidy of fossil fuels	• Chaos and breakdown in global discussion on GHG policy • Continued subsidy and government action to open new oil fields • Rollback on the price of carbon from all major economies (e.g., China, Europe, USA)
New legal developments	• Introduction of new case law on the legality of emitting CO_2 emissions based on existing law • Increase in the number of lawsuits and liabilities placed against companies that emit CO_2 or with disregard for the environment	• Climate change mitigation legal challenges defeated in court
Increased social awareness	• Increasing social awareness on the risk of GHG emissions and increasing reputational risk for companies that emit GHG • Increased social awareness and pressure from shareholders, employees and activists to reduce emissions	• Increasing social awareness of changing growing seasons and lower agricultural yields • Increase mechanization and carbon-intensity on farmlands for fear of failed crops
Economic factors	• Achievement of price parity between renewable technology and fossil fuels • Stranded fossil fuel assets	• Persistent low fossil fuel prices • Clean technology bubble collapse

CISL (2015) "Unhedgeable Risk: How Climate Change Sentiments Impact Investment"

3.3. OTHER OBSTACLES TO RISK TRANSFER

The table below presents an overview of the different economic players that can be impacted (column 1) by climate-related risks, of the way the risk is transferred across the investment and lending chain (column 2) and provides examples of obstacles to this transfer. It illustrates how a risk can be material at the 'bottom' of the chain without necessarily being material at the 'top'. The main obstacle to the risk transfer include:

- The investment horizon that might be shorter than the window of materialization (see 3.1),
- The speed of materialization that might let time to adapt (discussed in 3.2)
- The buffers (pricing power, insurance, etc.).

These obstacles to the transmission of risks across the investment chain explain why externalities associated with a portfolio (e.g. CO_2 emissions) are not a good proxy for climate-related risk exposure of this portfolio.[1]

Who ?	Nature of risk transfer	Example of obstacle to the risk transfer
Society	A power producer emits large amounts of CO_2, associated with a cost for society: the damages related to future physical impacts of climate change (social cost of carbon)	
Physical assets	If the country is likely to introduce climate constraints (e.g. taxes, caps) at some point in time, the power plants located there might be shut down or face extra costs.	In the absence of foreseeable policy that likely to be implemented in the remaining lifetime of the asset, the risk remains an 'externality' impacting Society only.
The owner of the physical asset	The owner of the plant then faces impairments and higher costs, impacting its P&L and balance sheet	However, if the regulation allows it to transfer the cost to consumers, the impact can be partly or fully offset
The security issued by the owner (e.g. bond)	The credit rating of the producer can be downgraded, thus leading to a drop in the market value of the bond	But the company may also have a financial cushion big enough to absorb the losses and maintain its credit rating.
The owner of the security	The investor's portfolio will lose value when the bond is downgraded	But if the bond comes to maturity before the risk of downgrade materializes, the portfolio will not lose value
The financial system as a whole / Financial stability	The climate constraints apply to other power producers and other sectors and the materialization and transmission of risk occur quickly, some large financial institution might default and create a domino effect	But if the risk materializes more gradually, or that the portfolio of financial institutions is not exposed enough to the sectors at risk, the risk might not affect the finance system as a whole.

3.4. LIMITED RELEVANCE OF ASSESSING CLIMATE RISKS IN ISOLATION

Feedback loops. One key uncertainty relates to the nature of feedback loops and network effects. An industrial meltdown in energy and transport sectors – the lifeblood of the current economy – will undoubtedly create economic disruption at a scale that will impact financial market stability. Individual financial institutions highly exposed to transition risks may generate counterparty risk that affects other financial institutions. All of this, while perhaps unlikely, is in the realm of the possible and yet for all intents and purposes not understood at all in the current landscape of models and analysis. The scale of exposures here are significantly larger than the subprime housing market in 2007. However, it was not the subprime market, but its domino effects that triggered the financial crisis. At a glance, it is unclear how transition risk would generate a total meltdown of energy and transport sectors, while these services will still be in demand, and served with other technologies.

1. *Hit and Miss – About TCFD Disclosure Guidance for Financial Institutions*, 2Dii 2017
2. *Diminishing returns: Why investors may need to lower their expectations*, McKinsey Global Institute, 2016
3. *A future that works: Automation, employment, and productivity,* McKinsey Global Institute, 2017

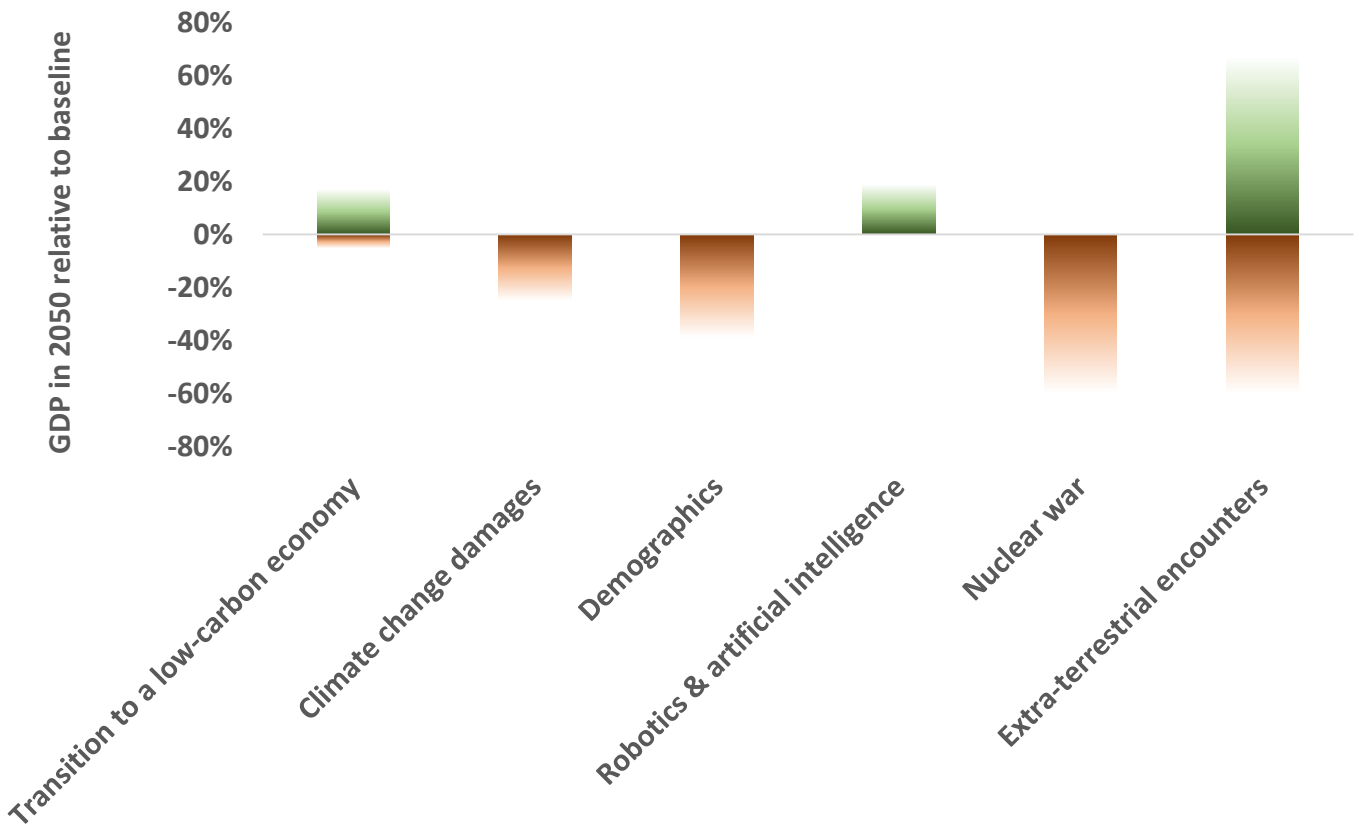
Other disruptive trends. Finally, if the time horizon of risk analysis is extended, other 'almost certain' disruptive trends come into play. The economy of tomorrow will likely be very different from today. All things being equal, the average returns per asset class is expected to be lower than what has been experimented over the past 30 years, due to factors such as global aging and emerging economies reaching maturity, etc.).[1]

Moreover, there are a range of disruptive trends and potential shocks that from a macroeconomic perspective are likely to be more impactful than the transition to a low-carbon economy. The Fig. below highlights a sample of these potential trends, based on a range of third party literature. As shown by the graph, from a pure GDP effect perspective, demographic trends are likely to have a higher impact on GDP than both the transition to a low-carbon economy and climate change damages.

Demographic trends however are unlikely to have disruptive effects related to 'sentiment shocks' of the kind described by CISL (2016) for climate damages. At the same time, robotics and artificial intelligence are expected to have significant positive impacts. Finally, disruptive 'shocks' like a nuclear war or extra-terrestrial encounters can have extreme and sudden consequences, which are fundamentally difficult to anticipate (even if a few organizations are looking to quantify this and – in the case of extra-terrestrial encounters – historical role models from colonialization abound).

Looking at these risks in conjunction is critical both from the broader objective of anticipating long-term risks and potentially disruptive risks to financial markets, understanding the potential interplay between the risks (e.g. demographic trends, artificial intelligence, and climate change are all risks and opportunities that influence each other), and potential policy responses.

FIG 13. TIME FRAMES OF CLIMATE-RELATED RISKS VS. TIME FRAMES OF FINANCIAL RISK MODELS
(source: 2°ii, based on CISL 2016, Capital Economics 2017, Acemoglu et al. 2012, MGI 2017, OECD 2017, 2ii 2017b)



1. *Diminishing returns: Why investors may need to lower their expectations*, McKinsey Global Institute, 2016
2. *A future that works: Automation, employment, and productivity,* McKinsey Global Institute, 2017

4 CONCLUSIONS & RECOMMENDATIONS

Right direction, wrong equipment. This report sought to highlight the capacity of transition risk scenarios to be integrated into traditional risk models. The results suggest that while the exercise follows the 'right direction', it involves the 'wrong equipment'.

At macro level, transition risks are not material to impact the existing macroeconomic parameter assumptions in the short-term, nor the existing macro asset class assumptions. At sectoral level in turn, transition risk scenarios become relevant, but the sectoral detail of these scenarios is likely too granular and expansive for the existing stress-testing framework. On the flipside, sectoral impact assumptions can be relevant from a microprudential perspective where individual financial institutions exhibit significant exposures, however currently do not exist in mainstream scenarios.

Integrating transition risk scenarios into these frameworks thus would require either a restating of the scope of stress-testing scenarios or developing stand-alone parallel scenarios. The first seems unlikely, given the still limited evidence of materiality and the adjustment of other factors (time horizons) that would likely be required. Moreover, materiality would likely require a degree of ambition that due to its lack political buy-in would be unlikely to trigger responses on the back of the assessment. The key challenge identified in this analysis can thus be summarized as follows:

Current supervisory risk management instruments are not designed to capture long-term systemic risks to the global economy, whether related to climate-related risks, or other long-term economic risks (e.g. robotics, demographics, artificial intelligence).

There is currently no infrastructure in place to anticipate and potentially respond to these risks.

Recommendations. There are two two areas of actions that can respond to this challenge

1. **Long-term response: develop 'long-term risk' supervision.** One solution could be to develop a risk assessment and supervision 'infrastructure' to identify and quantify risks that are almost certain, will impact the economy and financial markets at scale, but are beyond the horizon of current risk models (e.g. climate change, automation, artificial intelligence, etc.) and thus likely to be mispriced. This monitoring function could be develop by financial supervisors directly (e.g. collaboration between central banks and market authorities), or/and by the IMF (as the 'missing link' between the World Economic Outlook and the Global Financial Stability report). It could also involve (as co-funder, partners and users) universal asset owners, such as large pension funds, which have a direct interest in seeing these risks properly addressed. Such a monitoring infrastructure could also recommend and develop responses such as industry-led initiatives, and financial policy actions.

2. **Short term responses: monitor misalignment of capital allocation with climate policy goals.** Assuming no change in mandates and priorities, financial supervisory authorities may still have an incentive and interest to analyze these risks as part of their supervisory activities. Such an analysis could help to identify whether concentration risks do exist for specific banks and institutional investors. The rational for immediate action is twofold:

    - **Economic research role of central banks**. Even if it doesn't reach systemic level, an adverse climate scenario can negatively impact the financial sector's ability to intermediate capital efficiently and in the interest of economic growth. Assessing such a risk is likely relevant for supervisory authorities as well as economic and climate policymakers interested in understanding the trajectory of climate policy goals and the integration of associated policy and market signals by private sector actors. In this context, financial supervisory authorities, given their access to a range of data on financial institutions, are uniquely equipped to provide this information, in the spirit of other economic analysis by central banks that policymakers already rely on to date.

    - **Progress already underway.** The specific exercise described in the paragraph above is already being pursued by three European financial supervisory authorities on insurance companies and pension funds, with the opportunity to expand the analysis to banks once the EU Anacredit system is up and running in 2018. This work can speak both to climate issues, but also the broader challenge of understanding the interface between prices, policies, and economic activity in the real economy and financial instruments that intermediate these activities to financial institutions. Not the least, it can help identify whether the economy and financial markets are on a least cost pathway more generally.

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