Financial Markets and Climate Transition

Opportunities, Challenges and Policy Implications

OECD

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Foreword

The accelerating threat of climate change raises the urgency of commitment to climate transition, including the important role of global financial markets to align investment with net zero. This report focuses on the critical contribution financial markets must play towards achieving an orderly transition to low-carbon economies, and the policies needed to support this. Although financial markets are beginning to integrate climate transition risks and opportunities into investment decision making, a number of constraints are preventing the scaling up of investment to foster orderly transitions to low-carbon economies. Notably, insufficient data, financially material metrics and analytical tools to measure and manage climate transition risks remain critical constraints for corporates and financial institutions, which calls for greater attention to policy considerations.

This report on *Financial Markets and Climate Transition* explores the key elements that could factor into market pricing of climate transition risks and opportunities, from stranded assets and production processes to renewables transition strategies. It offers frameworks and case studies to understand how facets of the transition can affect market pricing. In addition, the report reviews the growing range of market products and practices that have emerged to more efficiently channel capital to price and manage opportunities and risks from climate transition. The report puts forward policy options that can support this transition by helping markets incorporate price changes and by incentivising companies to take measures that address climate-related risks and opportunities over time.

The report is part of a multi-year body of work by the OECD Committee on Financial Markets to consider aspects of market resilience as governments and financial market participants address the challenges of the transition to low-carbon economies.

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Preface

Climate change is accelerating. Now more than ever, ambitious and effective global action to address the impacts and future risks of the climate crisis is critical and urgent. Recent momentum behind governments' climate commitments is encouraging. However, turning increased political ambition on climate emergency into outcomes that ensure a net-zero transition by 2050 remains the major challenge. Climate finance continues to grow, yet at the end of 2019, developed countries remained USD 20.4 billion short of meeting the goal of mobilising USD 100 billion a year to support developing countries' green transitions.

A growing number of corporates, financial institutions and institutional investors are also making increasing efforts to assess physical and transition risks, and to publish climate transition plans to achieve net-zero emissions. In turn, financial markets are beginning to integrate climate transition risks and opportunities into investment decision making.

Despite this progress, market participants remain constrained in ways that prevent the needed scaling up of investment to foster an effective and efficient climate transition. There is a lack of progress on globally coordinated carbon pricing. In addition, the Task Force on Climate-related Financial Disclosure (TCFD) has advanced disclosure of climate-related financial information, but data gaps and incomparable metrics continue to hinder portfolio reallocation decisions and effective pricing of capital. Lack of transparency and comparability of environmental, governance and social (ESG) rating methodologies, as well as inconsistent measurement of climate transition factors in environmental pillar scores, further impede portfolio allocations that better align with net-zero pathways.

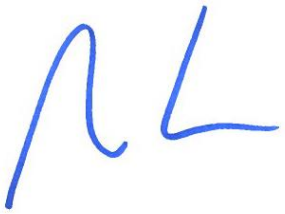
Addressing these challenges will require a thorough reset of the financial system by incorporating climate risks and opportunities across relevant aspects of central banking, supervision, regulation, and market practices for making investment decisions. This includes identifying policies to address biased incentives, capability gaps and inadequate climate risk disclosure that impede a substantial scaling up of low-emissions, resilient investments.

There are significant opportunities to dramatically reduce emissions, shift away from carbon-intensive activities and promote green growth. Financial markets across advanced and developing economies have a critically important role to play in helping to achieve these ambitious climate objectives every step of the way on our path to net zero. Actions by financial authorities and market participants can help strengthen market practices, confidence and integrity by encouraging greater transparency on the current products, practices and tools being used in financial markets, and by supporting the reallocation of capital towards greener alternatives, while discouraging capital flows to carbon intensive projects.

Improving sustainable finance approaches and enhancing market alignment with the climate transition is vital. To support these efforts, this report provides a framework to understand the ways in which financial markets are building capabilities to help facilitate an orderly transition and to allocate capital that helps incentivise companies' transitions. It also includes recommendations to strengthen the comparability of climate-related metrics used in ESG approaches; to encourage transparency and appropriate labelling of climate transition indices, funds and products; to develop climate transition finance indices and funds; to use climate transition plans that rely on science-based targets; and to develop climate transition finance

principles that ensure interoperability of approaches across jurisdictions and international markets. To move this important work forward, the OECD will advance a policy framework to align and integrate ESG factors that support a just transition to climate-resilient, sustainable growth.

The threat of climate change must be addressed as a core economic and financial system challenge. The OECD is committed to supporting whole-of-government actions to foster an effective, efficient and just transition that can enable low-carbon, sustainable and inclusive economic growth.



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OECD Secretary-General

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Executive Summary

In recent years, many governments, international organisations and private institutions have endeavoured to analyse climate transition-related risks and opportunities with respect to the transition to low-carbon economies, including implications for the global financial system. An orderly low-carbon transition through financial systems would require that financial markets efficiently allocate capital, assess and transfer risks, and facilitate price discovery. Such an orderly transition would help manage exposures to stranded assets and obsolete production processes, and to support needed investments in renewable energy, efficient production processes, and green technologies. To do this, policy makers and market participants need to understand how to ensure an orderly low-carbon transition whilst balancing the need to respect pre-agreed commitments to reduce global emissions.

Many market participants acknowledge the importance of a low-carbon transition but current progress and the effective market pricing of positive and negative valuation impacts of a transition is hampered by insufficient data. This includes financially material metrics and analytical tools to measure and manage transition risks, including the lack of policy clarity and consistent sectoral coverage of carbon pricing and support for low-carbon and renewable alternatives. Market products (such as bonds or structured products) and measurement tools (such as ratings and indexing) also need to further evolve to allow investors to better align portfolios with specific climate-related objectives and strategies, from divestment to active engagement and the assessment of ways to strengthen the veracity of transition plans.

This report explores the key elements that could factor into market pricing of climate transition risks and opportunities, from stranded assets and production processes to decarbonisation strategies. It offers frameworks and case studies to understand how facets of the transition can affect market pricing. In addition, the note reviews a growing range of market products and practices that have emerged to more efficiently channel capital to price in and manage opportunities and risks from climate transition.

Section 1, observes that more recent assessments by financial authorities have tended to focus on financial stability risks, including tail risks from the combination of rising physical and transition risks associated with losses on stranded fossil fuel reserves. As such, these assessments are inclined to view successful climate policies and technological breakthroughs that accelerate a low-carbon transition to reduce future physical risks as contributing to potential financial stability risks in the medium-term. Notwithstanding the importance of identifying tail risks, public and international bodies that incorporate market perspectives highlight that potential losses from this transition from stranded assets can be balanced by potential gains on opportunities from a low-carbon transition, as renewable energy, processes and technologies gain scale and contribute to sustainable, climate-resilient economic growth. A host of studies raise questions as to how these competing dynamics are captured by the financial system, to determine its net effect on financial resilience, stability, and sustainable growth.

Section 2 acknowledges these analytical challenges, and *offers a conceptual framework to assess the key factors that may influence market valuations associated with a transition to low-carbon economies,* and sheds light on prospects for an orderly transition. The framework considers factors that contribute to the lowering and increasing of market valuations across both fossil fuel and renewable assets and processes, including competitive factors and pricing, and policies that facilitate transitions by companies

and markets through disincentives on carbon emissions and incentives for lower-carbon processes to reach net-zero.

- ***Downward pressure on market valuations*** can occur due to stranded assets resulting from declining demand for such assets in the future, as well as stranded production processes that become obsolete as the use of fossil fuels become prohibitively expensive. Also, factors such as the decommissioning of machinery to extract and refine carbon assets, if not managed effectively, could bring forward costs. Moreover, policies that add costs to fossil fuels or carbon emissions, or increase the cost of capital, thereby decreases valuations.
- ***Increases in market valuations*** can occur due to a myriad of factors that affect future cash-flows, or lower the cost of capital. Gains on any assets that become in greater demand due to the demand for and consumption of various renewables; on future cash-flows from more efficient processes that use renewable energy, particularly as the cost becomes competitive with fossil fuels; on competition in new markets or through new products, or through the use of green technologies. Also, any policies that support this transition by further penalising fossil fuel usage and CO2 emissions, reducing fossil fuel subsidies where they exist, or incentivising renewable energy and technologies could contribute to the transition.

The *conceptual framework to assess the key factors that may influence market valuations* highlights that with predictable policies and efficient and well-functioning markets, the shift away from stranded assets and toward opportunities for growth has the potential to be orderly over an extended period of time, as obsolete investments in productive assets give way to cleaner and more efficient ways of generating economic output. Nevertheless, the extent to which an accelerated transition could contribute to the widespread repricing of financial assets and its impact on financial system resilience could depend on several factors. First, the quantity of loss, as very high losses, particularly where concentrated, could overwhelm capital buffers of leveraged institutions (e.g. banks, and some insurers) or liquidity buffers (e.g. investment funds) and cause forced asset sales that amplify stress. Second, duration will play a role, as the system is much more capable of absorbing a quantity of loss over a much greater period of time. A transition to a 1.5 degree world would contribute to much sharper devaluations and accelerated depreciations as the real economy would need to dramatically reduce carbon intensity, yet these may be lessened by the mitigation of physical climate-related risks. Third, policy actions can contribute through either stabilising or destabilising effects, depending on the timing and impact. While policy actions that facilitate the transition to low-carbon economies can reduce physical risks over time, they may exacerbate and intensify losses over the short-term which could in extreme forms contribute to amplification of risks. This raises the question for policy makers of how to strike the right balance to facilitate a low-carbon transition, while minimising stability risks and market disruption.

Building on the conceptual valuations framework, **Section 3** analyses ways in which financial markets are starting to address climate transition risks and opportunities, and incorporating these into the valuations of corporations and sectors concerned by the shift. The section demonstrates that financial markets appear to be starting to price in risk, showing cases of increasing valuations for renewable energy companies and declining ones for sectors closely related to carbon intensive industries. Within industries, some carbon-intensive firms that are acknowledging stranded assets and accelerating their transition plans are showing improved valuations. The section identifies key drivers of valuations in line with climate transition, with the aim to shed light on the challenges linked to them (for example how stranded assets are considered in pricing), and provides an assessment of different industries impacted by the low-carbon transition. In particular, it focuses its attention on sectors that could be most affected, such as coal, oil and gas, utilities, renewable energy companies and sectors that are closely linked to carbon intensive activities, such as the automotive industry. Overall, while markets are beginning to price transition risks and opportunities, they remain constrained by a number of impediments, from uncertainties that undermine pricing of externalities to inadequate disclosures of forward looking metrics on net-zero pathways.

Section 4 provides an assessment of the ways in which financial markets are increasingly facilitating the low-carbon transition through a number of financial market products, tools, and practices. Offerings have emerged that encompass instruments for issuers, third party ratings, as well as market indices and portfolio products to help channel financing to transitioning entities, and also to better price the risks and benefits of the transition. While some of these products and tools have supported the unlocking of valuable information for investors and markets, such as through ESG rating and investing, limited interoperability of metrics and insufficient quality of forward looking metrics prevent them from supplying comparable information on transition risks and opportunities across firms and jurisdictions. Climate transition benchmarks and funds, in addition to screening strategies and stewardship (including shareholder activism) show potential to help directly support the transition and can in some cases show potential to deliver higher risk-adjusted returns. Climate scenario analysis and stress testing also show benefits in terms of identifying potential risk factors and stranded assets, and could also be used to help financial market actors identify opportunities (e.g. from new technologies and innovations) in the context of the transition.

These products, tools and practices have been developed to support issuers and investors in activities in line with the climate transition and to achieve higher or similar risk-adjusted returns compared to traditional investments. If fit for purpose, these products, tools and practices could improve information flow, price discovery, market efficiency, and liquidity in support of a low-carbon transition. In particular, they could allow investors to tilt from current market portfolios that include significant exposure to fossil fuels toward either lower-carbon investments, or to actively support transitions where corporates implement transition plans – such as “net zero” carbon use by 2050 – while reducing exposure to firms that oppose such transitions. More importantly, in the event that the transition is disorderly and involves sudden changes in policy coordination, these products could in theory, help markets absorb losses on carbon intensive assets. Certainly, as recent OECD research has highlighted, these various products, tools and practices are growing rapidly from relatively early stages of development making market-oriented policies needed to ensure market resilience, integrity, confidence, and to help strengthen their ability to contribute to this orderly transition.

Section 5 considers the policy implications of these findings. Transition risks can be minimised if the transition begins early and follows a predictable path, therefore helping markets incorporate price changes, and corporates to take measures to address the financial impact. Continued improvement in climate-related disclosures, consistency of climate transition metrics, comparability of valuation methodologies, and verifiability of renewables strategies would all help strengthen valuations. Moreover, it will be equally important to ensure that the growth of ESG climate transition indices, funds, and other traded products uphold standards of market integrity so they aid price discovery and the efficient channelling of capital to support the orderly transition to low-carbon economies.

While there is evidence that the low-carbon transition has begun, with governments and markets taking steps to address this, current estimates suggest that the global economy is not on track to limit CO2 emissions; hence, at some point, abrupt policy changes could have an impact on market prices. Therefore, additional policy measures, where appropriate, could help facilitate an orderly change. Strengthening the tools and methodologies that underpin disclosure, valuations, and stress testing in financial markets and traded products associated with climate will further help support the transition. Preliminary considerations include the following:

- Further strengthen TCFD disclosure practices to improve granularity, reliability and consistency of metrics with respect to climate metrics, targets, and climate transition plans.
- Improve specific ESG environmental (E) pillar data disclosure and use of metrics, and ensure global transparency and comparability of core metrics that can be used as a sub-pillar on climate transition with respect to carbon emissions and intensity, and renewables transition strategies that

include plans for capex and R&D, energy efficiency plans, and new technologies, products and market opportunities.

- Strengthen labelling of indices and funds that contribute to a low-carbon transition so that investors fully understand the transition plans and verification mechanisms associated with a transition.
- Greater commitment to verification processes (including those offered by third-party providers) for renewables strategies and climate transition plans, and encourage the use of science-based interim targets as well as disclosure of annual progress in a quantitative and comparable format within climate transition plans.
- Consider improving the transparency and clarification of stewardship plans of major asset managers and institutional investors in their engagement with Boards and executive management on reduction of climate intensity and commitment to emissions targets. Including guidance and information on the implementation of climate transition plans, and remedial actions when issuers do not adhere to their stated plans.
- Ensure pilot scenario analysis for financial institutions to assess potential losses from carbon exposures and stranded assets against anticipated valuation increases from renewable energy and new green technologies.
- Greater assessment by the appropriate government policy makers on how a range of climate-related policies could better support and incentivise the transition.

More in-depth analysis is needed to assess the progress and challenges in how financial markets facilitate and are impacted by a transition, and can help bring about an orderly transition to low-carbon economies, shifting substantial amounts of capital into renewable and productive assets that can yield considerable returns over time, particularly where the economies of scale bring cost benefits. Financial markets will benefit most from policies that enhance their efficiency to intermediate, provide needed capital and liquidity, and encourage price discovery, all of such support a transition to more resilient, low-carbon, and sustainable economies.

1. Perspectives on financial markets and climate transition

Over the past several years, initiatives are being taken by international organisations, central banks, finance ministries and other public authorities to better explore climate transition, including the risks and benefits associated with the path to low-carbon economies. These assessments include key elements of physical and transition risks from climate change, and the paths and consequences of orderly and disorderly transitions.

- This high-level review of the literature seeks to benchmark three key considerations that motivate the purpose of this OECD report. First, to what extent does the existing policy literature balance the downside risks with upside opportunities that align with the policy imperative to achieve this transition in line with sustainable and inclusive economic growth? Second, how does the literature assess how and to what extent financial markets incorporate both risks and opportunities in market valuations, which is needed to understand if new information – if even abruptly introduced – would lead to *disorderly* repricing of assets? Third, what policies are considered to help foster resilient transitions, to ensure that markets are capable of orderly movements in prices within and across industries, over time.

There are several high level observations from recent literature that has motivated our assessment of how financial markets are already incorporating a low-carbon transition into prices, and the key drivers of transition-impacted valuations.

Assessments suggest that markets are not sufficiently pricing in climate risks, including climate physical and transition risks. There is a growing amount of literature on physical and transition risks that attempt to assess whether markets can price and absorb climate risks. While inclusive, transition risk assessments highlight the wide range of valuation differences over stranded assets, and also high levels of uncertainly over potential declines in market valuations and book values of corporate assets on intermediaries' balance sheets. Also, there is a significant amount of uncertainty due to poor data and gaps. For example, the ESRB's recent work (ESRB, 2020) sought to assess the extent to which financial markets are able to price such shocks, and highlighted the pervasive gaps in carbon information, and potential for greenwashing to avoid reporting on Scope 3 emissions. Indeed, even prior OECD research noted that the E scores of ESG ratings varied widely depending on the extent to which raters gave preference to carbon footprints and intensity, climate risk management, or transition strategies (Boffo, Marshall and Patalano, 2020). Box 1 highlights studies that show the extent to which equity markets are sensitive to new information about climate transition risks, such that firms with a lower E scores suffer losses on the arrival of unexpected transition risk news.

Box 1. Transition versus physical climate risk pricing in euro area financial markets: A text-based approach

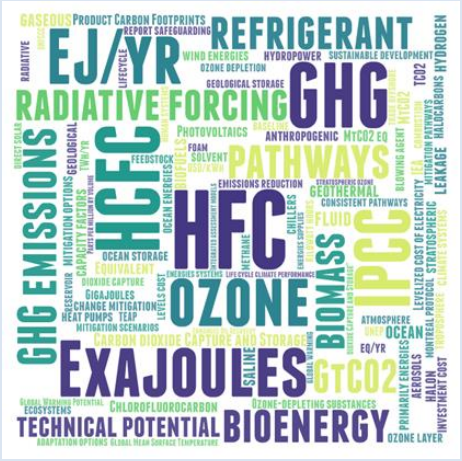
As climate change materialises, the need to curb greenhouse gas emissions to mitigate the consequences of global warming also increases. At the same time, the transition to a carbon-neutral economy represents, together with other climate-related risks, a source of financial risk with potential repercussions for companies, banks, financial stability, and the wider macro-economy (NFGS, 2018). While the academic literature is not conclusive about the presence of risk premia related to climate risks for financial assets, some studies find that investors require additional compensation for holding "brown" assets (particularly since the Paris Agreement)[1] and others provide evidence of price differentials between green and conventional securities.[2]

The main challenges in pricing transition risk relate to both the lack of agreed metrics to measure firms' climate risk exposure and the difficulty in identifying climate risk measures. Particularly, transition risk and physical risk might move in opposite directions in reaction to climate-related events[3] and have different impacts on markets, emphasising the need to distinguish the two of them (NFGS, 2018). Bua et al. (2021) address this need via an identification methodology which separates transition and physical risk by proposing a text-based approach that exploits newspapers content. In addition, the authors empirically test the extent to which financial markets price transition and physical risks by estimating the daily equity market sensitivity to these climate shocks at firm and sectoral levels, taking into consideration a wide range of exposure metrics.

The authors create a transition risk vocabulary and a physical risk vocabulary in line with Engle et al. (2020).[4] Each vocabulary is found to capture the multifaceted characteristics of each climate risk, rather than a single aspect. On one hand, the physical risk vocabulary includes both extreme and chronical hazards directly caused by climate change, excluding natural disasters attributable to other sources. On the other hand, Figure 1 highlights that the transition risk vocabulary includes different aspects of climate risk such as technological advances and environmental policies. Terms such as ecosystems, *sea level*, and *precipitation* are representative of the physical risk topic, while terms such as *hydrofluorocarbon* (HFC), *bioenergy*, and *greenhouse gas* (GHG) are representative of the transition risk topic.

Figure 1. Transition risk vocabulary includes different aspects of climate risk such as technological advances and environmental policies

Word-cloud summary of the transition risk vocabulary where term sizes are proportional to their relevance (*tf-idf*) for the topic.

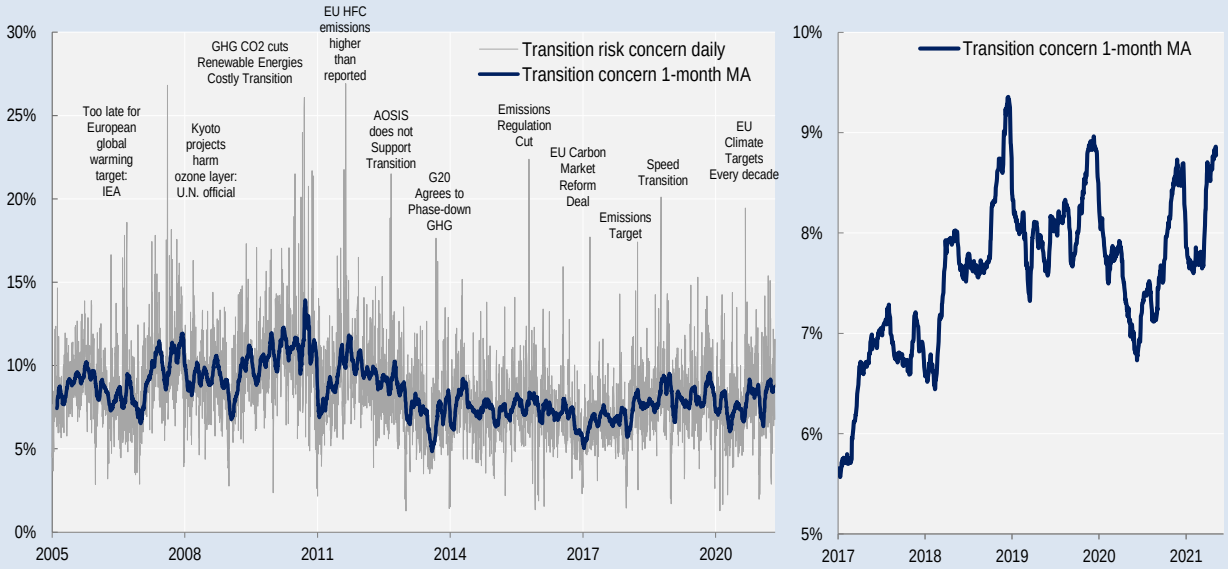


Note: See Annex A for full list of acronyms.
Source: Bua, G., Kapp, D., Ramella, F. and Rognone, L., (2021), "Transition versus physical climate risk pricing in euro area financial markets: A text-based approach. Available at SSRN: https://ssrn.com/abstract=3860234.

Using the climate risk vocabularies to quantify the intensity of the news coverage, or concern, of physical and transition risks, there is evidence of growing media attention towards such risks, with the focus on transition risk superseding that of physical risk. The *Transition Risk Index* (TRI)[5] shows a positive daily drift, spiking on days when new regulation and measures to curb the emission of greenhouse gases are introduced, such as the EU carbon reform deal, and when the urgency to speed-up the transition through technological innovation and renewable energies is discussed. Figure 2 (Panel A) shows the transition risk concern time series and the topic related to the major shocks measured as residuals from an AR(1) model for the period 2005-2021. Figure 2 (Panel B) zooms in on the most recent period and highlights the rise in media concern over the period 2017-2021. While the increase slowed down with the outbreak of COVID-19, it picked up again during late 2020 – around the time when discussions on the EU climate target intensified.

Figure 2. Concerns regarding transition risks in daily news reports have increased since 2017

Percentage of daily news dedicated to the topic of transition risk and transition risk (concern) 1-month moving average (MA) over the period 2017-2021



Note: News from Thomson Reuters news - Factiva. The transition risk concern (%) is calculated as the cosine-similarity between daily news documents and the transition risk vocabulary, roughly denoting the portion of daily news dedicated to transition risk (grey), one-month moving average (blue), and the major *Transition Risk Index* (TRI) shock topics over the period 2005-2021
Source: Bua, G., Kapp, D., Ramella, F. and Rognone, L., (2021), "Transition versus physical climate risk pricing in euro area financial markets: A text-based approach. Available at SSRN: https://ssrn.com/abstract=3860234.

Using the transition risk shock time series TRI[6] to test the sensitivity of daily equity returns of the EuroStoxx 600 Index constituents over the period 2015-2019,[7] indicates that returns of firms with poor environmental and ESG performances and firms with high GHG emission levels and intensity decline when transition risk rises. However, while investors appear to penalise high climate risk exposures, there is no evidence of significant outperformance of less exposed firms, suggesting negative screening as a predominant investment strategy. In addition, the sectoral analysis suggests that investors do not simply use broad measures of sectoral exposures but rather combine it with detailed firm-level characteristics.

Overall, the findings suggest that financial markets appear, at least to some extent, to price physical and transition risk, with equity prices of "brown" firms being particularly sensitive to transition risk news. Results are robust to the use of several exposure metrics.

Note: Box prepared by European Central Bank staff; G. Bua, D. Kapp, L. Rognone, F. Ramella
Source: Bua, G., Kapp, D., Ramella, F. and Rognone, L., (2021), "Transition versus physical climate risk pricing in euro area financial markets: A text-based approach. Available at *SSRN*: https://ssrn.com/abstract=3860234.

Some study findings suggested transition risks associated with the mispricing of fossil fuel and stranded assets could result in abrupt and disruptive changes once markets better appreciate these risks, either due to policy, industry or market events. These assessments were often portrayed within a framework that considers the interplay with policies to address physical risks. It often **portrays a trade-off, in that policy efforts to address physical risks will give rise to transition risks as a**

consequence. Less is said about the fact that the transition may be accelerated, both through lowering the value on carbon and carbon-processing assets, which hastens positive outcomes from the transition to renewable energy and sustainable environments. The Network for the Greening of the Financial System (NGFS) captured the potential paths of physical and transition risks, noting that while one set of paths can lead to an orderly transition pathway in which climate targets are met, there are other pathways that (i) lead to disorder in the financial system due to aggressive policy responses to physical risks which accelerates the transition; (ii) that insufficient climate transition results in the eventual rise of physical risks which creates a disorderly transition at a future point in time; (iii) no further climate action results in a "hothouse world" in which the transition is very disorderly until physical risks eventually overwhelm financial systems and economies.

As for frameworks, our assessments throughout this paper illustrate that such approaches could be reframed to suggest that *irrespective of whether climate policy objectives are met or not, financial authorities can be engaging with financial markets and intermediaries to ensure that the transition through markets and the broader financial system is orderly.* Policies to enhance market resilience and integrity can help with this, well before any costly macroprudential measures might be needed to cover unanticipated losses. Put differently, notwithstanding some policy trade-offs, *policy makers have an incentive and available tools to help preserve orderly markets under various conditions that affect the timing of the transition or extent of potential losses from stranded assets or physical risks*.

Public sector studies often cite absolute drivers of negative price movements from stranded carbon-intensive assets, but do not appear to holistically incorporate the potential for valuation gains from the transition to clean energy and innovations. This focus on assessing absolute losses can be justified given the uncertainty over climate-related pricing, yet such losses do not take into account growing industry or firm-specific transitions to rebalance strategy, businesses and products, which is core to the process of creative destruction in capital markets and dynamic economies.

- For example, by some estimates, under more stringent policy scenarios, oil, gas and coal companies could lose USD 28 trillion in revenues over twenty years, relative to baseline projections, due entirely to reduced sales (Lewis, 2014).[8] Yet, these headline estimates do not appear to take into account any change in corporate strategy or industry adjustments to respond to such gradual demise, and rebalance operations to benefit from the shift to renewables in a rapid decarbonisation scenario.
- At the time of the Paris Agreement, assessments by several international bodies focused on how potential losses from oil and gas companies from lower fossil fuel prices, and sharply rising company debt in leveraged loan markets, could contribute to significant loss, financial stability concerns for leveraged intermediaries, and contagion across the financial system as other carbon assets reprice (Domanski et al, 2015). Incidentally, oil companies in the US subsequently experienced a spike in defaults due to rising shale output and OPEC price wars, which contributed to a collapse in oil prices. Yet, while high losses did occur, they were distributed across the financial system with little effect, as market stress remained contained, and the leverage loan market experienced unprecedented growth.

Stress simulation initiatives at various central banks have focused on the tail risks associated with stressed losses from downward price adjustments to company valuations, placing more emphasis on the potential losses from stranded assets and abrupt downward price adjustments. For example, publications on climate-risk stress testing and environmental risks focus primarily on the absolute downside impacts of physical and transition risks, even including the impact of innovative technologies to foster the climate transition (NGFS, 2020a; NGFS, 2020b). In this respect, a host of factors are noted: clean energy technologies, energy saving technologies, clean transportation, and other green technologies; changes in investor sentiment on certain asset classes; new ways to run businesses that can rapidly gain market shares from traditional businesses (e.g., virtual meetings that significantly reduce business travels). Yet,

these factors are portrayed as *disruptive factors* that could further accelerate the transition, which in turn would contribute to greater losses from stranded assets and obsolete production processes. The assessment mostly features the negative consequences to carbon-intensive industries to bank or asset management portfolios, but does not offer guidance on benefits to market valuation, or the need to net the losses on stranded assets against valuation gains on innovations or economies of scale from growing renewables consumption. More recently, financial authorities have taken steps to more comprehensively assess climate risks and opportunities, and this report seeks to document such efforts through case studies of various initiatives across finance ministries, central banks and regulators.

Yet, entities that have investment objectives or otherwise benefit from investment perspectives have been more inclined to offer a holistic perspective that balances risks and opportunities from climate transition. Several publications have highlighted the process of creative disruption, where old industries and technologies give way to innovations that transform industries, can create opportunities and valuation gains. For example, the TCFD notes that efforts to mitigate and adapt to climate change also produce opportunities in the form of efficiencies and cost reductions, improved competitiveness by exploring new markets, new products and services, and better engagement with stakeholders such as investors, employees and customers, due to green transition policies, all of which could support long-term value. Indeed, the TCFD even incorporates these opportunities into its framework to consider material financial impact.

Public sector entities and policy-oriented bodies that have a long-term investment focus appear to better reflect the aspects of transition that could contribute to enhancing performance and valuations. Sovereign wealth funds provide a clear example of this long-term perspective, as buy and hold strategies could benefit from net gains on climate transition pathways over decades. In 2018, six sovereign wealth funds developed a "One Planet SWF Framework" to consider climate risks.[9] One of the framework principles is to integrate the consideration of climate change-related risks and opportunities into investment management to improve the resilience of long-term investment portfolios, noting that they can benefit from the potential returns on investment opportunities associated with a transitions to low-carbon economies. For example, Norges Bank Investment Management, in its report on climate strategies, notes that Boards should integrate relevant climate change risks and opportunities in their business management (NBIM, 2020). It emphasises that (i) companies engaged in activities with large greenhouse gas emissions or intensities, should have a strategy addressing a transition to a low-emissions economy, and should consider research and development needs to enhance the company's competitiveness under evolving market conditions; and, (ii) they should disclose revenues associated with climate-related opportunities. Given their long-term horizons, SWFs are particularly well positioned to benefit from investment opportunities arising from global efforts to address climate change. It specifies that "drivers of opportunities include shifts in demand, technology, policy incentives and the ability to scale climate solutions to mitigate emissions or adapt to climate change" (Sovereign Wealth Funds, 2019).

Other public sector institutional investors have raised similar interests in balancing risks and opportunities from the transition to low-carbon economies. Japan's Government Pension Investment Fund includes, in its overall assessment of climate risks, scenario analysis of climate change risks and opportunities using Climate Value-at-Risk (CVaR), and the impact of technological opportunities on corporate value. Moreover, the Group of Thirty's report on climate transition recently noted that the transition to a net-zero carbon economy brings opportunities for long-term value to allow the financial system to allocate unprecedented amounts of capital to sustainable companies that transition to green processes and technologies (Group of Thirty, 2020). It notes that "in contrast to the physical consequences of climate change, which lead to the destruction of physical assets, the transition produces winners and losers: an oil company's transition risk is a solar company's opportunity" (Group of Thirty, 2020). Such assessments offer an important reminder of the critical role of financial markets to help assess the net benefits, channel capital to those entities that are embarking on strategic plans to transform for low-carbon futures, and reduce market frictions that can result in disorder and spillovers.

Recent studies have shown that transition investment opportunities are now beginning to be reflected in companies' long-term performance and market valuations. The recent publication of the Climate-Related Market Risk Subcommittee of the US CFTC explored the drivers of market valuations related to climate transition and found evidence that financial markets are already beginning to price in aspects of climate transition, both in terms of risks and opportunities (CFTC, 2020). For example, financial market participants are already implementing ways to manage transition risk in their investment portfolios; recent research suggests that portfolios that over-weigh greener firms will outperform during periods with negative climate news. In addition, investors that are able to identify and invest in superior opportunities in green innovations including technologies can reap excess returns. For this reason, it is not surprising that investors are overwhelmingly calling for consistent, reliable, and comparable disclosures of the risks and opportunities related to climate risk.[10]

There are several observations from this literature review. First, the positive policy direction to strive to achieve higher-growth, decarbonised economies has given way to growing concerns that the transition itself could become a key source of financial stability risk. Second, that assessments by institutions whose mandates include financial stability may be inclined – by virtue of their mandate -- to focus more on the aggregation precise measurements of downside / tail risks, while bodies who receive more financial sector input appear more inclined to balance such downside risks with the economic benefits of the transition. Third, this may have implications for the assessments of market valuations and disorderly financial sector transitions: assessments that do not incorporate the transition benefits from renewables and innovative processes could be more likely to overestimate or draw conclusions about the potential financial stability risks of the transition.

Box 2. The Green Transition: Bank of Greece's strategy

Following the growing investment trend of promoting financial sustainability initiatives, policy makers and investors increasingly recognise climate change's important implications for the stability of the financial sector. Against this backdrop, the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), an expanding group that currently comprises 42 members, including the Bank of Greece (BoG), has embarked on the task of integrating climate-related risks into supervision and financial stability monitoring while strengthening the global response required to meet the goals of the Paris agreement. The Bank of Greece (BoG) participates in the Network through the work of its interdisciplinary Climate Change Impacts Study Committee (CCISC), which comprises three workstreams: (i) microprudential supervision, (ii) macrofinancials and (iii) scaling-up on green finance.

In this context, the banking sector can play an important role in addressing the threats and challenges of climate change. The Bank of Greece has officially endorsed the United Nations Principles for Responsible Banking, which set out sustainability principles in the framework of contemporary banking practice. Currently under consultation, the Principles for Responsible Banking aim to define the role and the responsibilities of the banking sector in a sustainable future, where banks align their business practices with the global community goals and create value for society. Furthermore, BoG has actively engaged on the issue of climate change since 2009 by setting up the Climate Change Impacts Study Committee (CCISC) and has already incorporated climate change considerations in the investment process of its own-funds' portfolios, investing in sovereign and supranational bonds, classified as "green". Finally, it intends to raise the amount of green investments in the long run, as well as to develop an investment strategy, so as to set an example for other Greek financial institutions and help establish a market convention for a greener financial system. Within the CCISC, environmental and energy economists, working with climatologists, physicists, biologists, engineers and social scientists, study the issue of climate change, analyse the economic, social and environmental consequences for Greece, and advise on the way forward. With specific regard to the Greek territory, under an inaction ("business

as usual") scenario, the Greek GDP could, ceteris paribus, fall by 2% annually by 2050 and even further by 2100, while the total cost to the Greek economy could reach a cumulative EUR 701 billion by 2100. Moreover, according to a vulnerability assessment that quantifies and ranks the expected climate risks for Greece, agriculture is the sector expected to be most severely hit by climate while the impacts on tourism and coastal systems will significantly affect household income and the economy as a whole. The water sector is also of particular relevance, given its importance for agriculture and water supply.

In addition to the mitigation actions taken within the framework of European policies, studies show that adaptation actions can also bring about substantial benefits, by shielding the economy and reducing damage. According to estimates, investment in adaptation action in Greece would reduce the cost of climate change by almost 30%. Climate change mitigation policies are, for example, carbon tax and emissions trading systems, which are designed to correct the negative effects of climate change and help transition to a low-emission economy.

Overall, central banks clearly acknowledge the potential threat to the economy posed by climate change and share increased awareness of its impact on the stability of the financial sector. Hence, more in-depth analysis is needed to assess the progress and challenges in how financial markets facilitate and are impacted by this transition can help bring about an orderly transition to low-carbon environments, shifting substantial amounts of capital into renewable and productive assets that can yield considerable returns over time, particularly where the economies of scale bring cost benefits. In conclusion, financial markets will benefit most from policies that enhance their efficiency to intermediate, provide needed capital and liquidity, and encourage price discovery, all of such supports the transition to more resilient, low-carbon, and sustainable economies.

Source: Box prepared by Bank of Greece staff, E. Kostika

2. Market pricing drivers and potential risks related to the low-carbon transition

While the transition to low-carbon economies is a policy imperative, the path could expose financial markets to a range of transition risks. Physical risks are those that result from an increase in extreme events[11] due to climate change (both acute and chronic), for example increased frequency of extreme weather that damages infrastructure or disrupts seasonal demand (in turn increasing insurance costs, default rates or credit losses). On the other hand, transition risks[12] are those that result from the process of adjustment towards a low-carbon economy, and the possibility that shifts in policies or technologies designed to mitigate and adapt to climate change could in turn affect the value of financial assets and liabilities, disrupting intermediation and financial stability. Transition risks can be the result of shifts in climate policy or regulation, or technological innovations that cause a decrease in the competitiveness of high-carbon technologies and infrastructures (in turn leading to increased costs, stranded assets, stranded processes, or credit losses).

Yet, the low-carbon transition can provide both risks and opportunities as economies shift to renewables as well as green markets and products. As the transition materialises, related opportunities combined with abatement benefits from the mitigation of physical risks could contribute to climate-resilient growth. For example, OECD estimates suggest that achieving the 2 degree scenario by 2050 could have a net positive effect on global GDP of up to 5% (OECD, 2017a), with associated benefits for financial markets. Therefore, while policy changes and technological innovation may lead to transition risks, the resulting transparency and efficiency gains could help markets price net benefits over time and better account for uneven distribution across industries, companies and time.

Unlike physical risks which will worsen unless policy actions are taken, climate transition risks are transitory, meaning that policy steps are also more likely to enhance the impact of the transition process on financial markets. As such, taking steps to limit the impact of transition risks on markets should be considered, and include measures that are: (i) within policy makers' purview aimed at alleviating market impediments to support a gradual transition of prices in a manner that reflects accurate information about the pace and magnitude of the transition, and; (ii) support the market transfer of risks such that they can be distributed, or at least hedged, throughout the financial system in an efficient manner.[13]

Without taking steps to limit the impact of transition risks, the scale and intensity of such risks could be exacerbated, increasing financial stability risks that could eventually have a destabilising effect on the wider financial system. Should policy changes be abrupt and uncoordinated, this could increase the likelihood that losses resulting from stranded assets[14] and processes are not efficiently distributed throughout the financial system (ESRB, 2016). These could in theory, be manageable in aggregate in the event that there is sufficient time to address and absorb such losses, but should there be additional measures that need to be taken to address physical climate-related risks, or an abrupt

reassessment in the value of assets based on new information, this will have inordinate implications for the financial system.

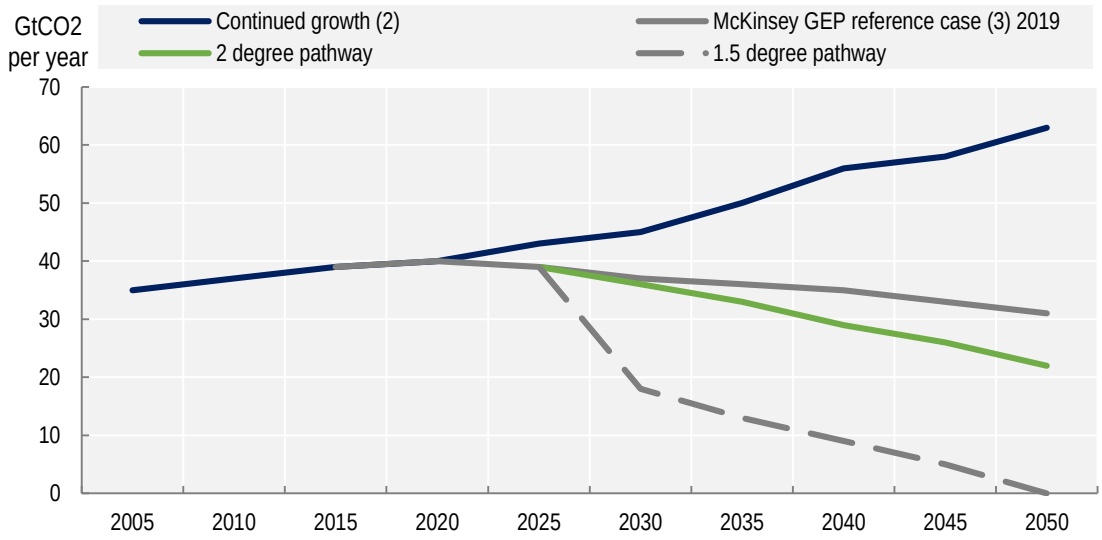
To further explore market pricing drivers, this section will outline potential transition risks and opportunities to financial markets, and set out a framework to understand what drives valuations within the context of the transition to low-carbon economies. The aim of this section is to set the scene for a more detailed exploration and assessment of sources of market price change in Section 3, which explores the extent to which asset prices in a number of industries may accurately reflect the expected impact of the low-carbon transition. As such, this section will also introduce additional considerations related to stranded assets and processes, such as cost provisions and the impact that the management of stranded processes may have on valuations.

2.1. Impact of the low-carbon transition on asset value: conceptual framework

Meeting the Paris Agreement targets and transitioning to low-carbon economies will require a rapid decline in carbon emissions and carbon intensive activities across almost all sectors and companies within economies globally. Should any source of emissions delay a transition, others may need to compensate through further carbon[15] emissions reductions (in the event that there is the political and private will) to achieve the 2 degree target. This could either occur through an orderly transition (in which governments, private and financial sectors are able to predict, manage and address potential transition risks) or in the event that coordinated action is delayed, a disorderly transition which would require sudden or rapid policy changes to achieve the declines in CO2 emissions needed to meet a 2 degree target by the end of the century (see Figure 3). Both eventualities have associated transition risks for financial markets, yet these would be significantly more pronounced in the case of a disorderly transition.

Figure 3. Achieving the 2 degree target by the end of the century requires rapid declines in CO2 emissions in the coming years

Projected global CO2 emissions per scenario, metric gigatons of CO2 (GtCO2) per year



Note: In addition to energy-related CO2 emissions, all pathways include industry-process emissions (e.g. from cement productions), emissions from deforestation and wage, and negative emissions (e.g. from reforestations and carbon-removal technologies such as bioenergy with carbon capture and storage, or BECCS, and direct air carbon or storage, or DACCS). Conversely, emissions from biotic feedbacks (e.g. from permafrost thawing, wildfires) are not included. 2) The lower bound for 'continued growth' pathway is akin to the IEA's World Energy Outlook 2019 Current Policies Scenario; higher bound based on IPCC's Representative Concentration Pathway 8.5. 3) GEP= Global Energy Perspective; reference case factors in potential adoption of renewable energy and electric vehicles
Source: McKinsey & Company (2020), Climate Math: What a 1.5-degree Pathway Would Take.

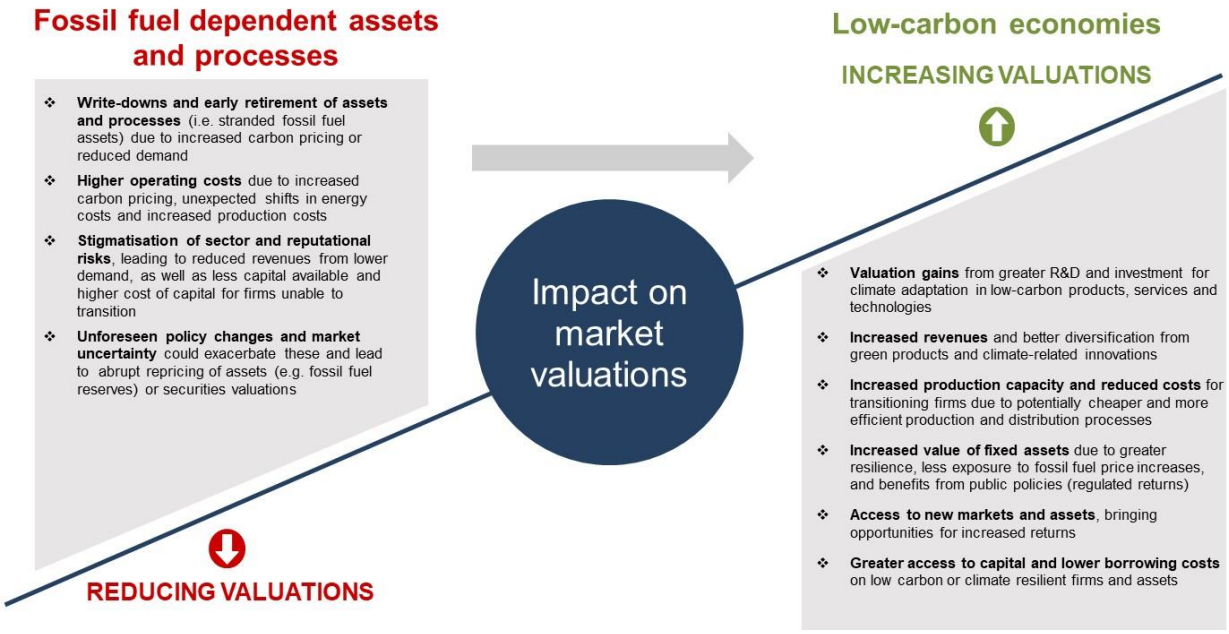
The overall economic cost of facilitating the low-carbon transition can vary depending on the character of the economy, choice of carbon price and use of fiscal policy. Current estimates for the total expected losses, from efficiency losses and foregone output, resulting from transition activities vary across sources. Schroders asset management, for example, builds on a number of approaches to estimate the transition costs for selected economies in line with 30-year returns analysis. The choice of carbon price and the extent of use of fiscal policy will impact the estimated economic cost.[16] For example, for more service-oriented economies, including many OECD countries, the difference is only 20 or 30 basis points of GDP a year, but for commodity focused economies, such as China and India, the range can reach 100 basis points. For illustrative purposes, the research suggests that some economies may face limited estimated transition costs, as they have a negligible carbon reduction need. On the other hand, more carbon-intensive economies may see higher costs, though these could be manageable in more modest transition scenarios and with a more efficient use of resulting revenues.

The economic cost of the transition away from fossil fuels will in turn have an impact on market losses, therefore the choice of policies used to mitigate climate transition risks will inevitably impact the extent to which investors will need to manage losses throughout the financial system. These choices will influence the extent to which the low-carbon transition is orderly or disorderly and will affect how notably the transition contributes to sharp changes in asset price valuations, including book and market values. Should an orderly transition occur, the changes in asset prices need not, in themselves, amount to losses that pose risks to financial stability in the event that these can be absorbed throughout the financial system. Rather, they could represent price adjustments based on efficient financial markets, in a well-functioning financial system, that channels investment towards low-carbon or carbon-neutral investments.[17] This could occur even in light of market failures due to the under-pricing of externalities associated with carbon emissions. However, a disorderly transition, triggered by a sudden and unexpected change in public policy or technology relevant to transition, could cause sudden price changes and heighten volatility due to uncertainty and risk aversion, which in turn could contribute to market contagion across exposures to climate transition.[18]

With predictable policies and efficient and well-functioning markets, the shift away from stranded assets and toward opportunities for growth has the potential to be orderly over an extended period of time, as obsolete investments in productive assets give way to greener and more efficient ways of generating economic output.[19] Figure 4 offers a conceptual framework to better understand these dynamics, and to assess the key factors that may influence market pricing associated with the transition to low-carbon economies. The framework considers factors that contribute to lowering and increasing market valuations across both fossil fuel and renewable assets and processes, including competitive factors and pricing, and policies that facilitate the transition through disincentives on carbon and incentives on renewables. It can also be used to better explore how financial markets are incorporating corporate behaviours in different industries with respect to how they are embarking on such a transition (see Section 3).

Figure 4. Conceptual framework to assess climate transition impacts on valuations, with a number of factors contributing to the lowering and increasing of market valuations

OECD conceptual valuation framework to understand and assess key factors that may influence market pricing associated with a transition to low-carbon economies.



Note: Non-exhaustive illustration.
Source: OECD staff assessment. Adapted from aspects of TCFD reporting with respect to climate transition risks and opportunities, and other market considerations.

A key driver of downward pressure on market valuations is from stranded assets that result from anticipated declines in demand for fossil fuels in the future, as well as stranded production processes that become obsolete as the use of fossil fuels become prohibitively expensive (assessed by monetary costs or reputational risks). Stranded assets refer to fossil fuel dependent assets that suffer from unanticipated or premature write-downs, devaluations, or conversion to liabilities.[20] Factors such as decommissioning of machinery to extract and refine carbon assets can also bring forward costs. Moreover, policies that add costs to fossil fuels or carbon emissions, or increases the cost of capital, can thereby decrease valuations.

Increases in market valuations can occur due to a myriad of factors that improve market expectations of future cash flows, or lower the cost of capital. Gains on any assets that become in greater demand due to the rising consumption of various renewables; on future cash flows from more efficient processes that use renewable energies, particularly as the cost becomes competitive with fossil fuels; on competition in new markets or through new products, or through the use of green technologies. Also, any policies that support this transition by further penalising fossil fuel usage and CO2 emissions, reducing fossil fuel subsidies where they exist, or incentivising renewable energy and technologies could contribute to the transition.

The extent to which an accelerated transition could contribute to widespread repricing of financial assets and its impact on financial system resilience could depend on several factors, including quantity and duration of losses. First, on the sheer quantity of loss, as high, unexpected and concentrated losses could have greater potential to overwhelm provisions, capital and liquidity buffers that are already being eroded from the consequences of COVID-19, causing forced asset sales that amplify

stress. Clearly, there is enormous upside from growth opportunities, but these may appear in different markets and parts of the system and thus credit losses could weigh on leveraged institutions such as banks and insurers. Second, the duration of losses over time. The global financial system is already capable of absorbing trillions of dollars in losses over multiple business cycles, through defaults on high yield bonds, leveraged loans, real estate and bank loans. Likewise, corporates depreciate many trillions as they write down the economic lives of plants and equipment over one or more business cycles, depending on industries, from which they reinvest in new technologies. This creative disruption can occur in a relatively orderly fashion where losses are offset by gains on green investments over time, and therefore assessing this transition within individual companies is imperative for well-functioning markets.

Policy actions can also contribute by having either stabilising or destabilising effects on the climate transition, depending on the timing and impact. While policy actions that facilitate the transition to low-carbon economies can reduce physical risks over time, they may also exacerbate and intensify losses over the short-term which could in extreme forms contribute to amplification of risks. Yet, this need not happen if there is policy clarity to support a transition that is gradual, measured, transparent, and verifiable to ensure market confidence. For example, losses from stranded assets can be replaced with regulated returns or valuation gains from the development of new markets. One of the key challenges for market participants, therefore, is how to extract these competing forces, as increasingly the transition from brown (or potentially stranded) assets to climate-resilient assets is occurring within industries and individual firms, so market valuations should account for both factors. The following subsections of this section will outline factors contributing to downward or upward pressure on market valuations in the context of the conceptual valuations framework in Figure 4.

2.1.1. Downward pressure reducing market valuations

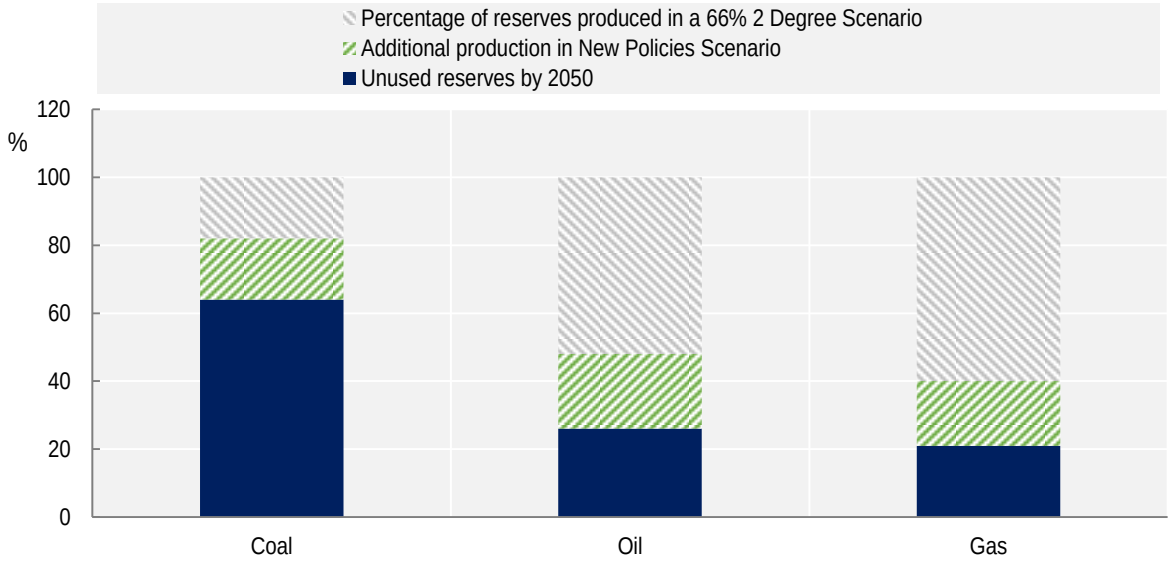
The low-carbon transition and limiting of global carbon emissions implies that the quantity of fossil fuels burnt will need to reduce significantly causing stranded assets from unanticipated or premature write-downs, devaluations, or conversion to liabilities of fossil fuel dependent assets (see Annex B for further information on the estimation and characterisation of stranded assets)**.** This can include stranded reserves, that is, fossil fuel reserves that are no longer recoverable, or stranded / underutilised capital, that is, sunk capital investments that would become obsolete, for example, an oil platform that will never be used (IMF, 2015). Stranded assets can occur either in the event that carbon intensive assets are no longer able to earn an economic return due to changes associated with a low-carbon transition (e.g. policy action, technology), or simply because the asset value is less than expected as a result of changes associated with an energy transition or in the event that it is costly or impossible to shift around the underlying capital stocks in the carbon-intensive industries to productive use elsewhere.[21] This may predominantly affect four types of assets: resources, such as the oil and gas currently in the ground awaiting production (including reserves); exploration and development assets (e.g. drilling rigs / seismic vessels); production and processing facilities (e.g. processing terminals), and; distribution infrastructure, (e.g. pipelines, tankers).

The pace of the transition, and the extent to which existing fossil fuel reserves will need to remain idle will have an impact on the scale and value of stranded assets. To limit the increase in global temperatures to 2 degrees, as set out in the Paris Agreement, it is expected that a fraction of the existing reserves of fossil fuels must remain in the ground, thereby becoming stranded assets. Current reported fossil fuel reserves globally consist of around 1 trillion tonnes of coal, 1 700 billion barrels of oil and 200 trillion cubic meters of gas (IEA, 2017). Analysis from the International Energy Agency (IEA) finds that the CO2 emissions that would result from combusting these reserves account for around 2 800 Gt of CO2, which is more than three times the carbon budget allowed in a 2 degree scenario (which is equal to 880 Gt) (IEA, 2017). As a result, the IEA highlights that, globally, almost 40% of gas reserves, 50% and oil reserves, and over 80% of current coal reserves would need to remain unused in order to meet the 2 degree target (see Figure 5) and therefore be subject to stranding. These findings are echoed by a number

of similar studies, in which it is also suggested that different warming scenarios can impact the scale of the asset stranding effect (McGlade and Ekins, 2015). Although these studies may represent an oversimplification in cases, they do illustrate that if governments impose policies to limit the market supply of fossil fuel resources, proven reserves (which are estimates to be extracted profitably at current prices) may need to remain undeveloped.

Figure 5. In a 2 degree scenario, an estimated 80% of remaining coal reserves, 50% oil reserves and 40% gas reserves would not be produced before 2050

Proportion of fossil fuel reserves produced in the 2 degree (66% scenario) and new policies scenarios, 2015-2050[22]



Source: International Energy Agency (2017), Perspectives for the Energy Transition.

The costs of decommissioning are material and will increase as more assets reach the end of their life, in part due to stranding, with few operators putting aside sufficient funds to effectively decommission assets, which could in turn erode corporate value. Looking at coal for example, in Europe, the use of coal has decreased by 24% over the last 25 years, with the average age and operating life of a European coal plant being around 25 to 35 years (Alves Dias et al, 2018). In the US, the average age of the 911 operating coal plants was reported to be 43 years, with almost a third aged 50 years or more (Raimi, 2017). Thus, a sharp increase in decommissioning-related expenses can be expected in both the US and Europe, irrespective of a low-carbon transition. Looking at oil and gas in the UK for example, the decommissioning of 320 fixed installations, 3 000 pipelines and 5 000 wells in the North Sea along will be estimated to cost the UK's Oil and Gas Authority between GBP 45 billion and GBP 77 billion. In 2019, the UK House of Commons Public Accounts Committee report noted that due to insufficient planning and provisions for such end of life decommissioning, this could cost the government as much as GBP 24 billion, noting that the UK government has given tax reliefs for oil and gas decommissioning of an average GBP 1 billion per year since 2013 and forecasts that tax reliefs for decommissioning will continue to rise in future due to potential climate targets (UK House of Commons, 2019).[23]

As a result, stranded physical assets and the associated cost of decommissioning[24] could erode value, with a speeding up of the transition further eroding corporate valuations (all else equal). If increasing policy measures are taken to speed up a low-carbon transition, this will not only result in pre-end of life decommissioning costs and a curtailing of the payback time of assets, but the acceleration of decommissioning liabilities that will increase their net present cost. For example, if assets are required to

be decommissioned earlier than the traditional life span of the asset, in turn speeding up disbursements expected under a provision, it would increase its present and book value of liabilities. If the company has additional provisioning or capital expenditure (capex) requirements as a result, this could impact their financial position, regardless of whether they have been able to effectively depreciate the associated assets.

Increases in capital expenditure to address climate transition related requirements and to support climate-related risk mitigation and adaption would increase operating costs. During the investment phase of the low-carbon transition, additional capital expenditures (for example, retrofitting or replacing physical infrastructure and assets) would increase production and operating expenses in carbon intensive industries. This could be more pronounced in the event that additional regulatory requirements for carbon intensive activities are implemented. For example, decarbonising the US power grid in 10-20 years is estimated to cost upward of USD 4.5 trillion (Wood MacKenzie, 2019), with additional costs relating to transition transportation, agriculture, and industry (of course, there are also significant economic opportunities which will be discussed in the next sub-section). In addition, and in cases, these costs may be less than business-as-usual costs that would be required to mitigate and adapt to increasing extreme events as a result of physical climate-related risks which could be expected to double the cost of building and operating power generation facilities and networks by 2030 or in the case of futures markets could lead to high volatility in certain agricultural commodity prices (Wood MacKenzie, 2019; See Box 3).

Box 3. Transition risk and weak commodity currencies

The Norwegian economy is structurally dependent on its large offshore oil sector and its spillovers to the mainland economy. This dependence is reflected in the high correlation between the oil price and the Norwegian krone. The heavy drop in the oil price in the second half of 2014 provides a vivid example of the historical correlation: When the oil price fell by more than 30 percent, the oil sector suffered which also dragged down the rest of the Norwegian economy. Consequently, the Norwegian krone depreciated sharply against e.g. the dollar and the euro. While the oil price recovered somewhat in the following years, the krone did not follow as expected. This was reflected in Norges Bank's Monetary Policy report in September 2019:

"*The krone has been weaker for some time than projected in the Monetary Policy Report. [...] Prospects for lower activity in the petroleum sector and uncertainty about the need for restructuring in the Norwegian economy may also have weighed on the krone."*

A BI Norwegian Business School and Norges Bank research project, titled "Climate Risk and Commodity Currencies" investigates if climate change transition risk can explain weak exchange rates for the commodity exporting economies, Norway, Australia, Brazil, Canada, Malaysia, Mexico, Russia, and South Africa. To the extent that climate change puts pressure on fossil fuel production and consumption, economic theory on structural transformation due to changes in natural resource income (Dutch disease theory) suggests it should.

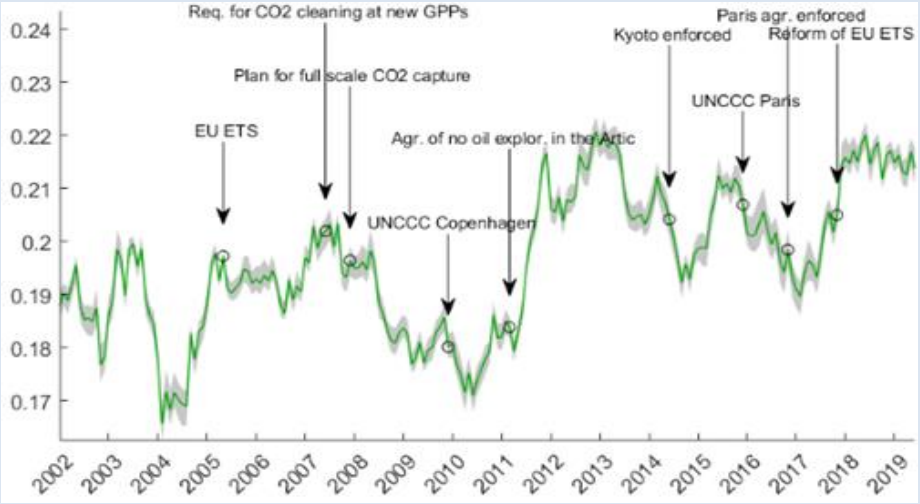
Measuring climate change transition risk

The novelty of the study is how it measures climate change transition risk, which uses news media coverage from the *Dow Jones Newswires Archive (DJ)* together with word-embedding models to derive country-specific risk measures. Word-embedding models can capture linguistic regularities and patterns among words, and allow for arithmetic operations capturing associative meaning. By doing this, the study assesses how a country is associated with "the structural change and policies aimed at reducing

environmental and climate change" in a given month based on the similarity of (weighted) word embeddings. The degree of association then constitutes the transition risk measure.

Figure 6 shows how the transition risk for Norway has evolved over time, together with some historical events aimed on mitigating climate change. For each country, the study include the country specific transition risk together with a commodity price index and standard covariates in a Behavioral Equilibrium Exchange Rate (BEER) model to understand the extent to which such a model can help explain unexpected movements in the exchange rate.

Figure 6. Transition risk for Norway has evolved over time

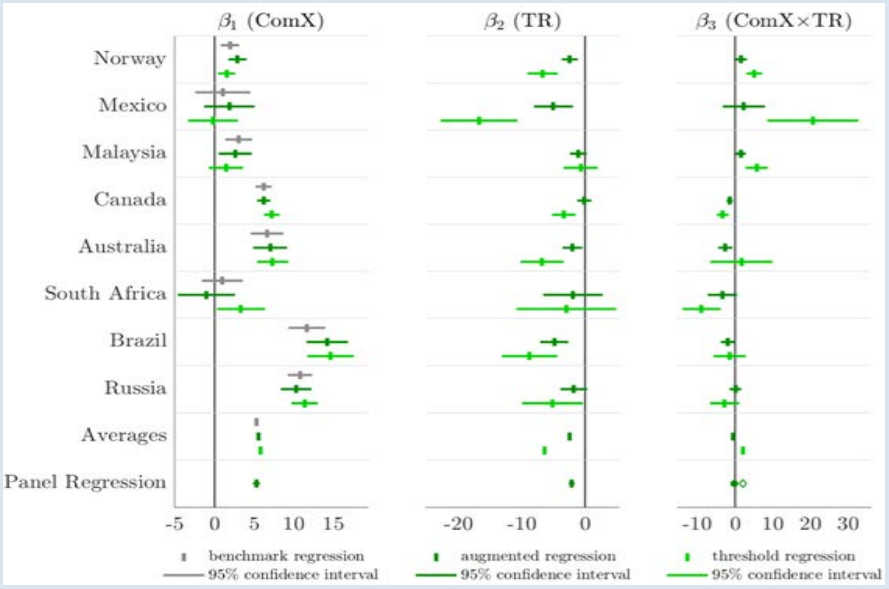


The effect of transition risk on commodity currencies

Figure 7 summarises the main results of the study. For each of the countries, the table reports the estimated response to a change in the commodity price (column 1), the estimated response to a change in the climate change transition risk (column 2), and the estimated response to an interaction term combining the commodity price and the transition risk (column 3). First, the analysis confirms the well-known finding that higher commodity prices strengthens the currency for all the countries. Second, an increase in the transition risk leads to a persistent depreciation of commodity currencies. Third, the sign of the coefficient on the interaction term varies between different countries. The interpretation is that climate risk is associated with a substitution effect between fossil fuel products, potentially benefiting exporters of gas at the expense of exporters of coal and heavy oil.

Overall, the study finds that when climate change transition risk is high, commodity currencies experience a persistent depreciation and the relationship between commodity prices and currencies tends to become weaker. This is in line with economic theory on the structural transformation due to changes in natural resource income (Dutch disease theory), and standard terms-of-trade arguments.

Figure 7. Exchange rates, commodity prices and transition risk estimates



Source: Box prepared by F. Kapfhammer and L Anders Thorsrud (BI Norwegian Business School) and V. H. Larsen (Norges Bank)

The cost of capital for carbon-intensive assets could increase both as a result of factors related to asset performance (as highlighted above) and expected changes in prudential and other investment regulation. There is growing consensus among financial regulators that prudential policy could target or be used to disincentivise investment in fossil fuel assets, for example, via higher capital requirements or asset concentration limits. In an orderly transition, market participants will likely anticipate that such regulatory changes could impact the cost of financing fossil fuel assets, and in turn have a negative effect on valuations through higher discounts on future cash flows used to value assets. In the event of a disorderly transition, unforeseen regulatory changes or increased market uncertainty could exacerbate these and lead to abrupt repricing of fossil fuel assets.

Policies such as carbon pricing may also result in a shift in input costs and operating expenses (depending on business activities) which could reduce earnings of firms that remain dependent on fossil fuels. As of end 2020, around 44 countries and 31 provinces or cities (which together account for around 60% of global GDP) were operating a carbon-pricing scheme, through either a carbon tax and/or an Emissions Trading System. Despite this progress, OECD research suggest that a carbon price gap remains,[25] indicating that governments continue to under-price externalities from carbon emissions. Currently, this may impact the ability of markets to price risks associated with carbon-intensive activities and transition to low-carbon alternatives. While there are clear upsides to effective carbon-pricing, notably reduced costs associated with physical climate-related risks and increased relative cost effectiveness of renewable energy (discussed in the next sub-section), addressing the mispricing of carbon and effectively pricing carbon-intensive activities could also lead to an increase in input costs and operating costs in a range of carbon-intensive industries through direct costs, and a speeding up of asset stranding.

Stigmatisation of carbon intensive sectors and reputational risks could impact sales, expenses, and access to and cost of capital for carbon intensive firms unable or unwilling to transition.[26] Stigmatisation of a sector or reputational risk refers to the potential for negative publicity, public perception due to shifting attitudes towards carbon intensive companies and sectors, to the extent that it affects

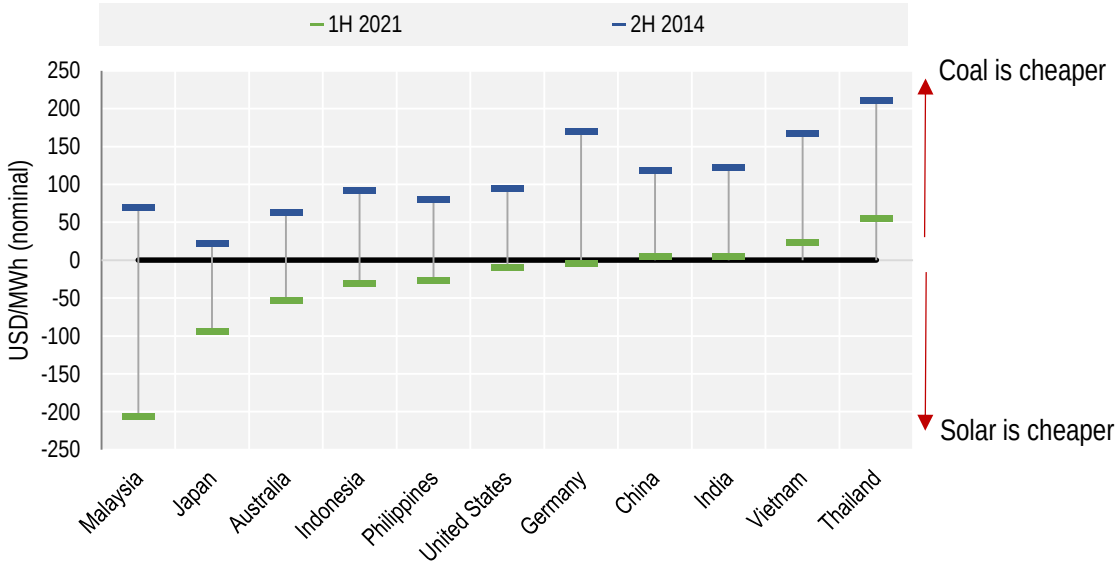
revenues, and access and cost of capital, and even operating costs from legal challenges to recover climate-change related expenses.[27] Reduced oil demand as a result of measures to contain the spread of COVID-19 in 2020, have already brought a repricing of risk to the energy sector. These companies have in turn faced new challenges from both a funding perspective, including how revenues and earnings can support new expenditures on corporate balance sheets, as well as a financing perspective relating to how debt and equity can be raised to supplement corporate and government funds. The low-carbon transition may result in permanently lower demand for carbon intensive energy, products or processes - either as a result of lower use, divestment or stigmatisation – which could impact operational performance and cost of capital.

2.1.2. Upward pressure increasing market valuations

Valuation gains may result from companies' investments and R&D in climate adaptation or clean energy technologies, and products that use renewables. One of the largest opportunities in the low-carbon transition is technology. The value proposition of low-carbon solutions is continuously improving due to rapid advances in technology and decreasing costs of solutions such as distributed generation (e.g., solar photovoltaics (PV) and battery storage). For example, the cost of solar per MWh has decreased by more than a factor of three between 2010 and 2019. Provided there is sufficient revenue certainty and policy stability, the outlook is that energy companies could deliver lower cost electricity using mainstream renewables compared to coal-fired technologies on a levelised cost basis,[28] with this already being the case in some OECD and non-OECD countries (see Figure 8). Some estimates also suggest that renewables could be set to undercut commissioned coal plants globally by 2030 (McKinsey & Company, 2018). These trends suggest that there is a justification for momentum in market valuations to reward companies that are showing promise in strategic transitions to low-carbon assets, processes, and products to both contribute to and benefit from the rewards of low-carbon economies.

Figure 8. In a number of OECD and non-OECD countries new wind and solar electricity projects have become cheaper than coal equivalent projects

Evolution of the relative cost of new solar photovoltaic (PV) and coal projects, USD difference in the cost of electricity of solar photovoltaic and coal



Note: Solar photovoltaic (PV), levelised cost of electricity (LCOE). H = Semester.

Source: Bloomberg New Energy Finance (2021), Financing the Low-Carbon Future: A Private Sector View on Mobilising Climate Finance, with updated data shared by Bloomberg NEF

Increased production capacity and reduced operating expenses for transitioning firms due to potentially cheaper and more efficient production and distribution processes. Energy efficiency improvements can both reduce emissions and save money for businesses or consumers through reductions in energy use, input costs and even improve the efficiency of production and distribution processes in the medium term (once up-front capital costs and operating expenditures are taken into consideration).[29] Studies suggest that operational low-carbon energy infrastructure could become less expensive to operate over time, primarily because of avoided operating costs associated with extracting and transporting coal and gas (with some studies suggesting that total savings could total USD 4.6 trillion) (Climate Policy Initiative, 2014; IEA/ NEA, 2021). In addition, lower risk and net amortisation savings frees up reserves and enables investment in further growth, as longer asset life could free up cash for investment that would otherwise be needed for asset replacement.

Capital investment into energy efficient processes could increase productivity over time, due to the capital and knowledge intensive nature of low-carbon energy supplies. It is likely that the global electricity generation industry (including fuel extraction, generation, and transmission and distribution) could see higher capital investment under a low-carbon transition in the short and medium term, as low-carbon energy tends to be more capital-intensive than fossil fuel energy. Low-carbon investments tend to have slightly longer lives, somewhat offsetting the higher investment levels, and studies suggest that in the medium to long term this reallocation of resources towards high-productivity economic activities can lead to higher levels of total factor productivity (value-added) (Berg et al., 2012; Stotsky and Ghazanchyan, 2013; Calderon and Serven, 2014).

In addition, accounting for capital and operational costs, the net financial benefits of the abatement of carbon emissions could be significant. An abatement cost is the financial cost of reducing environmental negatives such as pollution or environmental degradation. While implicitly a cost is incurred, many abatement options can have a net positive financial benefits. For example limiting deforestation and extreme weather events could increase agriculture output and reduce input and raw material costs (in particular in agriculture, forestry, fisheries, aquaculture and ecotourism) (OECD, 2019). Retrofitting or developing new low-carbon and climate-resilient infrastructure can also reduce operational costs for businesses and households. In particular, abatement options that increase energy efficiency with multiple benefits will increasingly see an overall benefit, notably in cases in which coal use is heavily reduced.

The low-carbon transition could bring increased value of fixed assets due to greater resilience, less exposure to fossil fuel price increases, and public policies that incentivise clean energy usage. While fossil fuel generation technologies are well established, fossil fuel investment can be associated with risks across the supply chain, including exploration and transportation of the fuel, which can be observed through historically volatile prices.[30] On the other hand renewable energy assets have an inherent low risk and show greater resilience to fossil fuel and climate related vulnerabilities and volatilities (Bachner, Mayer, Steininger, 2019). In addition, policies that support the transition by further penalising fossil fuel usage and carbon emissions (i.e. through carbon pricing, taxes or the removal of fossil fuel subsidies where they exist) can further contribute to an increasing value of fixed assets by companies that transition to low-carbon assets and processes. Whether the inherent low risk of renewable energy translates to a low cost of capital depends on the policy and market structures in place. For example, should renewable energy generators participate alongside fossil fuel generators in a competitive market, and without supportive policies, they may still receive a market price based on fossil fuel costs — and may be exposed to fossil fuel price risk. However, should policies be implemented to support renewable energy generators or in the event that they can sign long-term contracts to provide power to credible off-takers, they will reduce this exposure. This could then, given the right circumstances lead to lower overall financing costs as equity investors require a lower rate of return, and more of the total investment can be financed through debt. The lower financing

costs could reduce energy prices and free capital for savings and investment. From the investor side, relatively risk-tolerant capital is then freed to invest in new businesses elsewhere in the economy.

Access to new markets can bring opportunities for new investment and increased returns due to greater demand for low-emission infrastructure, technologies and services. While policy action will be needed to support financial markets to efficiently allocate capital, assess and transfer risks, and facilitate price discovery, to reduce exposures to stranded assets and support needed investments in renewable energy (including efficient production processes and green technologies), estimates on the potential opportunities from new markets and climate-related business opportunities are valued at around USD 2.1 trillion, which stands at around 7 times current reliable estimates on the cost of the low-carbon transition (excluding losses on stranded assets) (Carbon Disclosure Project, 2019). These opportunities include increased revenue through demand for low emissions products and services (such as electric vehicles), shifting consumer preferences and increasing capital availability as financial institutions increasingly favour low-emissions producers, that will in turn translate into opportunities for increased returns in financial markets. Even in a number of currently high-emissions sectors such as auto manufacturing, better diversification from green products and climate-related innovations could also be driving increased valuations in companies with clear transition strategies.

2.2. Getting the balance right to navigate the low-carbon transition

The conceptual framework outlined in this section highlights that in an orderly transition, losses on carbon intensive assets from the low-carbon transition could be offset by various positive effects, which could contribute to net gains. For example, stranded assets, in the form of reserves and production processes that consume carbon energy, will increasingly weigh down valuations, while transitions to renewable energies or assets that utilise renewable energy, or innovative products or technologies that support energy efficiency, will help contribute to improved market valuations (other factors remaining constant). In this respect, while an unanticipated increase in policy commitment to transition away from fossil fuels could contribute to widespread repricing of financial assets whose valuations would be determined in part by carbon prices, the extent to which this is not absorbed by markets and the financial system depends on a number of factors. First, the quantity of loss, as very high losses, particularly where concentrated, could overwhelm capital buffers of leveraged institutions (e.g. banks, and some insurers) or liquidity buffers (e.g. investment funds) and cause forced asset sales that amplify stress. Second, duration, as the system is much more capable of absorbing a quantity of loss over a much greater period of time. Clearly, a transition to a 1.5 degree world would contribute to much sharper devaluations and accelerated depreciations, which would need to be managed, as the real economy would need to dramatically reduce carbon intensity.

The improvement of climate-related disclosures, consistency of climate transition metrics, and verifiability of renewables strategies all could help strengthen valuations in line with a low-carbon transition. To support this, there has been a multitude of valuable taxonomies, principles and corporate reporting frameworks developed, yet the underlying rationale for each can differ which may hinder the effective quantification and assessment of climate-related risks and opportunities. For example, the Carbon Disclosure Project aims to improve corporate disclosure on the environmental impact of their operations in order to curb environmental degradation and climate related impacts. SASB focuses on what might be material and financially relevant for each sector in order to maintain risk-adjusted returns for companies, and to provide greater information in line with this to the market. Whereas, the TCFD recommendations aim to help companies produce consistent, comparable, clear and reliable corporate disclosures on climate-related information to support informed decision-making and capital allocation by investors, lenders and insurance underwriters. In doing this, TCFD also focuses on how companies can improve risk management oversight as well and environmental strategies and overall governance of climate-related factors.

Policy actions to facilitate the transition, such that policies to encourage the transition to renewable energies, processes, technologies, and products could – other factors remaining constant – improve the competitive dynamics that allow transitioning firms to have better (more patient, less costly) access to capital to support the transition. Policies aimed at achieving structural economic change could boost innovation and investment, including in less climate-intensive technologies (NGFS, 2019). This could, in theory, benefit some parts of the global economy, and result in the increase in some asset prices.[31] In addition, greater transparency on the scale of stranded assets due to a low-carbon transition can help companies and investors identify where capital expenditure may be re-allocated to investments and assets that show risk-adjusted returns as decarbonisation occurs. Therefore, to further support the low-carbon transition, there will be a need for both policies that encourage innovations, such as solar photovoltaics, and policies that support the orderly reduction of carbon-intensive technologies and processes for those companies that chose to commit to transition (see Box 4 and also Section 5 for a more detailed discussion on policy considerations). Importantly, such policies should enlist a variety of instruments that adapt over time.

Box 4. How financial markets are finally getting a grip on how to price climate risk and return – and what needs to happen next

Perspectives from the Bank of England

To meet a 1.5 degree temperature goal, the UN Environment Programme estimates that global greenhouse gas emissions must be cut by 7.6% in each and every year from now until 2030 (UNEP, 2019). This will require huge investment, estimated to be at least USD 3.5 trillion per annum, for the foreseeable future (IEA, 2017; Irena, 2019). Funding this investment will fall, in part, to governments around the world, and in part to the banking system. But increasingly the task will also fall to the capital markets.

Well-functioning capital markets are an essential tool for supporting the transition to a net-zero carbon economy.[32] Their power lies in creating price incentives that reward investments which are aligned with that goal, and penalise investments which are not. Establishing those incentives requires three key building blocks:

- First, credible public metrics of the climate impact of specific investment projects and corporate activities, and the financial risk and return involved.
- Second, effective capital market instruments to package that risk and return and match it with growing investor demand.
- Third, asset allocation strategies allowing those investors to construct portfolios aligned with, and facilitating, the transition to a carbon neutral economy.

Climate disclosures

Companies that are climate leaders have increasingly strong business incentives to disclose (see examples summarised in Table 1). These incentives are starting to show in capital markets too. Disclosing plans can improve a company's credit rating, broaden its investor base, reduce its cost of finance, and economise on the fixed costs of meeting increasingly vocal investor requests for information. A recent large-scale study of some 6,000 corporate disclosures found that firms that published data on their Environmental, Social, and Governance (ESG) performance received cheaper debt funding, with environmental disclosures having the largest effect (Eliwa et al, 2019). Where firms fail to provide their own authoritative disclosures, customers, investors and rating agencies will attempt to construct their own. And disagreement between different measures of a firm's climate performance, whether driven by poor

data or otherwise, increases equity risk premia, and hence the cost of raising investment finance (Gibson et al, 2020).

When it comes to what makes good disclosures, according to the TCFD, disclosures should be: consistent (complete, and comparable across time and issuers); 'decision useful' (relevant to investment decisions, specific, reliable, verifiable); and forward looking (showing not just where a company has been, but where it is going, and how) (TCFD, 2017). This final characteristic is particularly important for capital markets, because a climate asset's value will be determined far more by where it is going in the future, than by where it is in the present or has been in the past.

Table 1. Potential economic benefits of disclosing climate metrics (and costs of not)

		Potential issuer benefits from disclosing	Potential issuer costs from not disclosing
Financing terms and asset valuations	Credit rating	Improved rating	Worse rating
	Lower uncertainty risk premium	Higher asset valuations	Lower asset valuations
	Size of investor base	Access to more investors	Shrinking investor base
	Financing rate	Cheaper finance	More expensive finance as raters/investors apply a risk premium
	Fixed cost of investor engagement	Lower cost of engaging with investors	Confusion drives increasing costs of investor engagement
Business management	Management of own risks	Improved understanding and ability to manage risks	Weaker awareness internally and externally
	Retail consumer expectations / demand	Improved brand image and hence demand / revenues	Customer boycotts harm firms' positions in contested markets
	Supply chain expectations / demand	Awarded more contracts from firms seeking lower 'Scope 3' scores	Cut out of contracts from firms seeking lower 'Scope 3' scores
	Human resources	Attracting, motivating, and retaining staff	Challenges in hiring and retaining key staff
Regulation	Regulatory compliance	Clean regulatory record	Fines and infractions

Capital instruments

When climate considerations are fully integrated into markets, a separate class of climate assets may not be needed. But climate-linked capital instruments may be helpful on the transition path by giving focus to the need for change, helping meet specific investor needs, and providing credible commitments from issuers to deliver on specific projects or targets.

A wide variety of new climate-linked markets have begun or are under discussion, including for example Voluntary Carbon Offsets, derivatives products to manage risks in renewable energy or green mortgage-backed securities. One of the most prominent examples is that of climate-linked, or 'green' bonds.

Green bonds come in different forms, the dominant model being the 'use of proceeds' bond, designed to raise funds for specific earmarked investment projects that the issuer sees as climate-positive. An alternative approach, now starting to gain traction, is to link some element of the financial return on the bond to the achievement by the issuer of a particular climate or sustainability outcome, without linking the bond to specific green expenditures. Such 'sustainability-linked bonds' illustrate the type of innovation now underway in capital markets as investors turn their attention to investing not only in green companies, but also in transition companies that may currently have a high carbon footprint but are seeking a greener path.

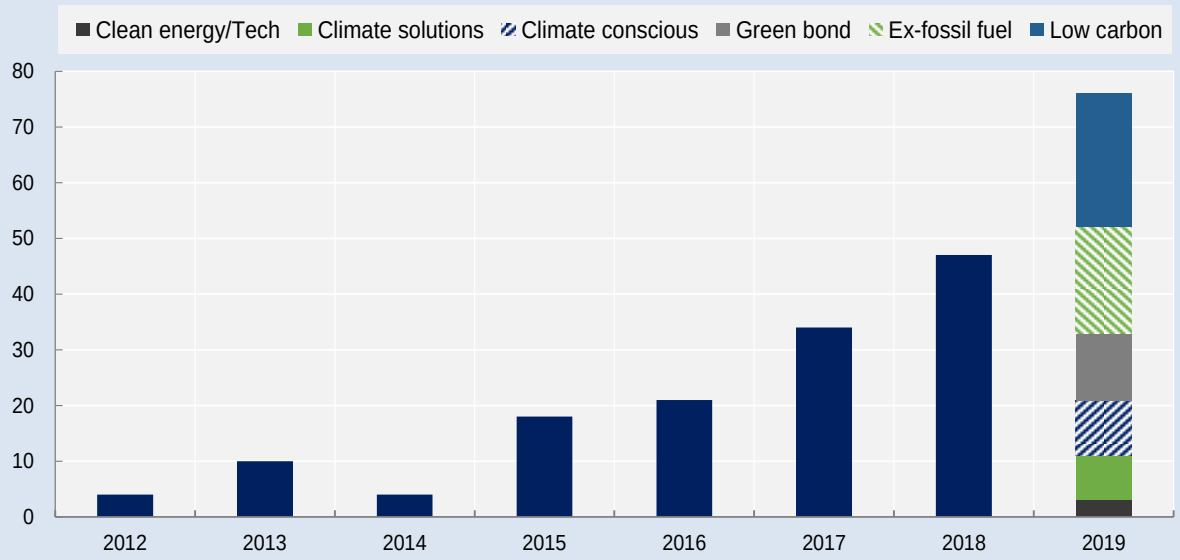
Governments' interest in issuing green bonds is also growing rapidly. The direct benefits to government finances are similar to those in the corporate sector, and include the ability to lock in commitments to undertake climate-improving investment, while reducing issuance costs and reaching a larger, more

diverse investor base. There are also potential indirect benefits for their national economies: establishing a 'green risk free curve' for private issuers to use as a benchmark for green pricing; setting conventions for issuance, including definitions of acceptably green projects or climate goals; providing assets for hedging and collateralising borrowing; and encouraging the development of climate finance expertise in the local financial services community, driving wider product innovation.

Asset allocation strategies

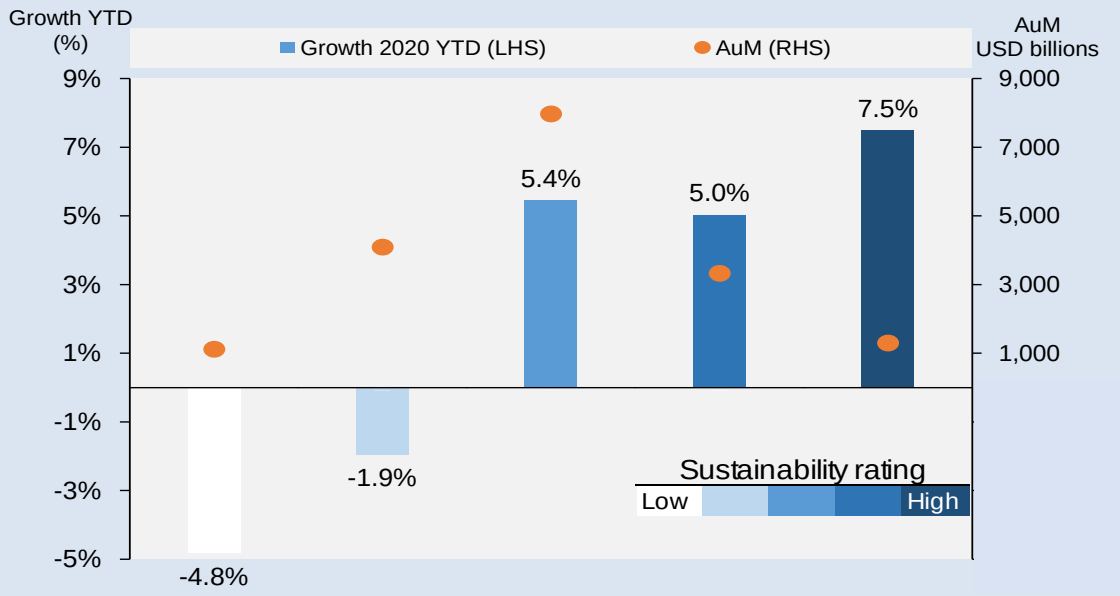
Gripped by an improving awareness of the scale of the climate challenge, and the impact of past and expected future policy change, investors are increasingly demanding that those in charge of their savings demonstrate that they can measure, and direct, their investments in ways that are sensitive to the climate impact of those flows. Asset managers have launched an ever-increasing range of 'climate aware' funds in recent years (Figure 9), and invested heavily in internal expertise, building systems, and hiring in specialists (or buying their firms outright).[33] The consequent shift in assets under management towards funds with higher sustainability ratings, and away from those with lower ratings, is striking (Figure 10).

Figure 9. **The number of new 'climate aware' funds has increased**



Source: Morningstar data; Bank of England calculations

Figure 10. Net flows to high sustainability-rated open ended funds have increased



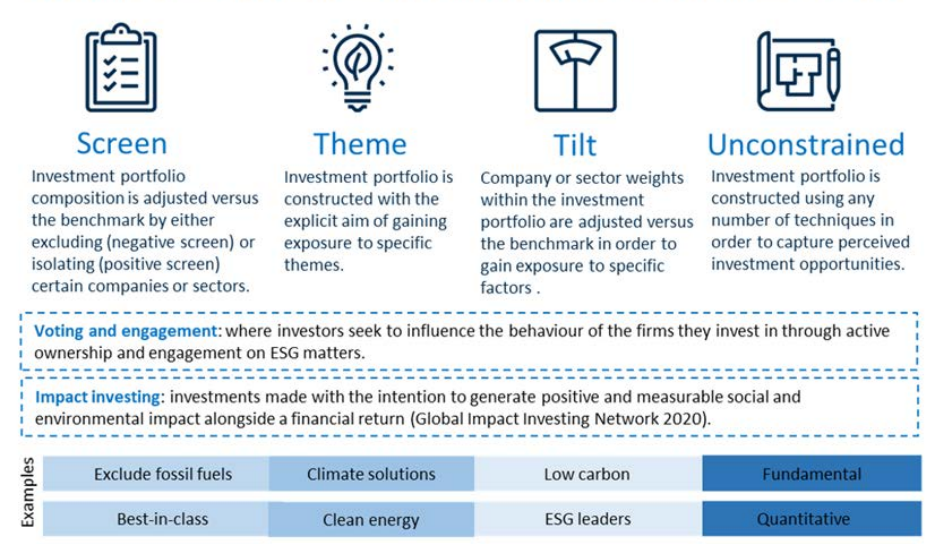
Source: Morningstar, Sustainalytics; Bank of England calculations

So-called 'ESG integration' is frequently cited as the ultimate end goal for climate-linked asset allocation strategies - where climate is just one more risk factor in an otherwise fully integrated risk/return framework. Whilst appealing in theory, ESG integration can be difficult to implement in practice given the limitations of today's climate disclosures, climate modelling and asset universe. The challenge facing asset managers today is how to build, subject to these constraints, a robust but consciously partial or second-best investment strategy that meets investors' desires to express a particular view on climate risk and return.

Figure 11 shows a range of such strategies. The simplest approach is a 'screen', in which the asset manager constructs a portfolio by including, or excluding, certain companies or sectors. Such approaches are currently popular, but they cannot provide much of the solution to a credible path to a carbon neutral economy. While individual investors may be able to divest, the financial system as a whole cannot. And divestment strategies based on backward-looking carbon metrics give no scope for incentivising climate-enhancing investment in high-carbon sectors, nor for capturing the returns that will accrue when heavy polluters transition to credibly green. 'Tilt' strategies avoid this binary composition issue, and can be dynamic in nature as the parameters used to construct the portfolios evolve. But they may be more reliant on consistent, decision useful and forward looking metrics, which are not yet universally available.

This comparison illustrates the interaction between the quality of climate disclosures, the structure of the asset management industry and the scope for rapid growth in the role of capital markets in climate investment. Poor disclosures force investors either to form crude portfolios – which cannot send particular finely graduated price signals – or to seek active management – which, being costly, is not available to all. Neither is ideal. This underlies the importance of establishing mature and reliable climate disclosures and metrics as a means of unlocking the full range of modern asset allocation techniques for the purpose of climate risk and return analysis.

Figure 11. A range of strategies for integrating climate considerations in asset allocation decisions have emerged



Source: Bank of England representation.

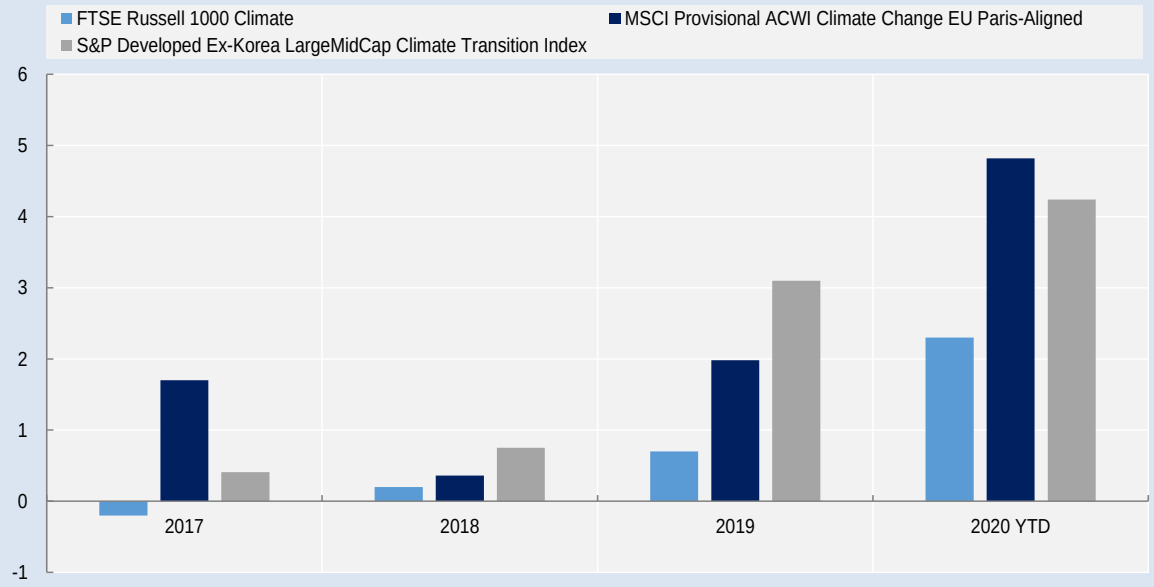
There is a lot to be positive about – capital markets are innovating, and rapidly, in response to the very real rise in demand from clients, businesses, investors and public authorities to take climate risk and return seriously. And, in 2020, there were some encouraging signs of markets discriminating in favour of climate-positive investment.

- Climate oriented equity indices outperformed the broader market by 2-5% in 2020, as economic activity has shifted away from travel and other fossil fuel-intensive sectors, and towards online commerce and technology (Figure 12). With a similar trend observable in bond markets (Figure 13).
- Companies such as VW and Daimler also secured material reductions in financing costs (or 'greeniums') when issuing their first green bonds, linked to the development of low-emission technologies. Indeed, green bonds issued by European companies in September 2020 priced on average nearly 10 basis points inside existing curves, and tighter than other non-green issuance over the same time period (Figure 14).

However, some significant challenges remain:

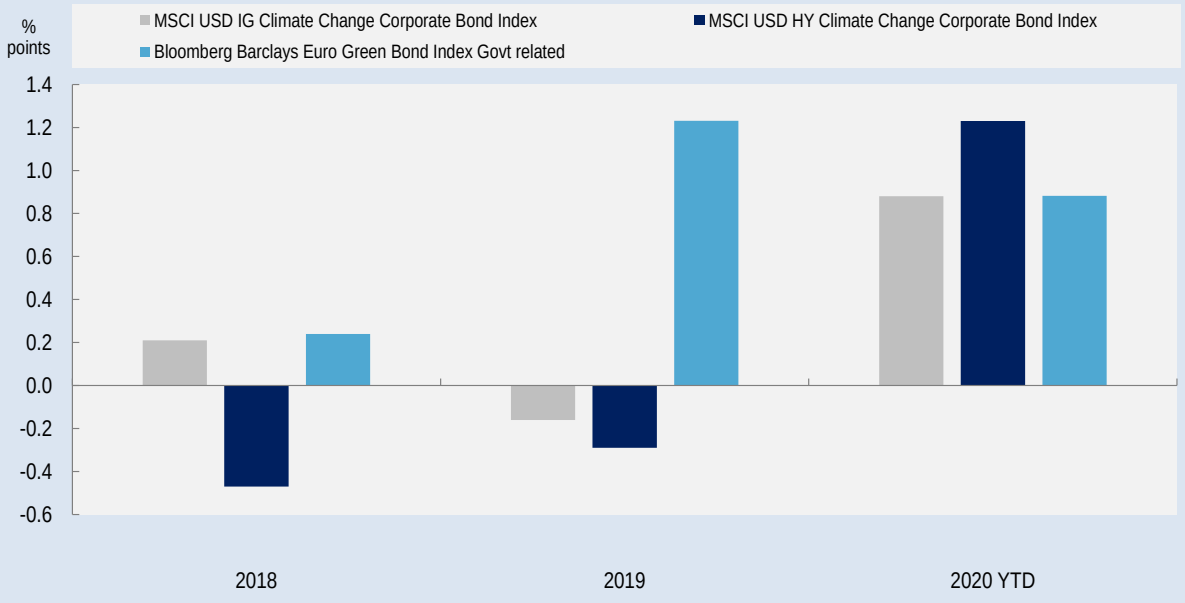
- On disclosures, to reach the goal of securing a fully consistent, decision useful and forward looking set of metrics requires standard setters to agree on a single framework; for it to be made mandatory; and for corporates to measure, model and disclose;
- On instruments, there is evidence of a further scaling up in the range and depth of tools providing credible incentives for green investment and more effective transparency for investors on performance against climate goals. That will drive broader-based price discrimination between climate-positive and climate-negative assets, which in turn will provide powerful incentives for further adjustment; and
- On asset allocation strategies, there needs to be a coalescing around terminology and approaches, providing a clear and credible choice for clients and investors, on that journey towards full integration, and more research on what works and what does not.

Figure 12. Excess returns can be observed for green equity indices versus the relevant market-wide benchmark



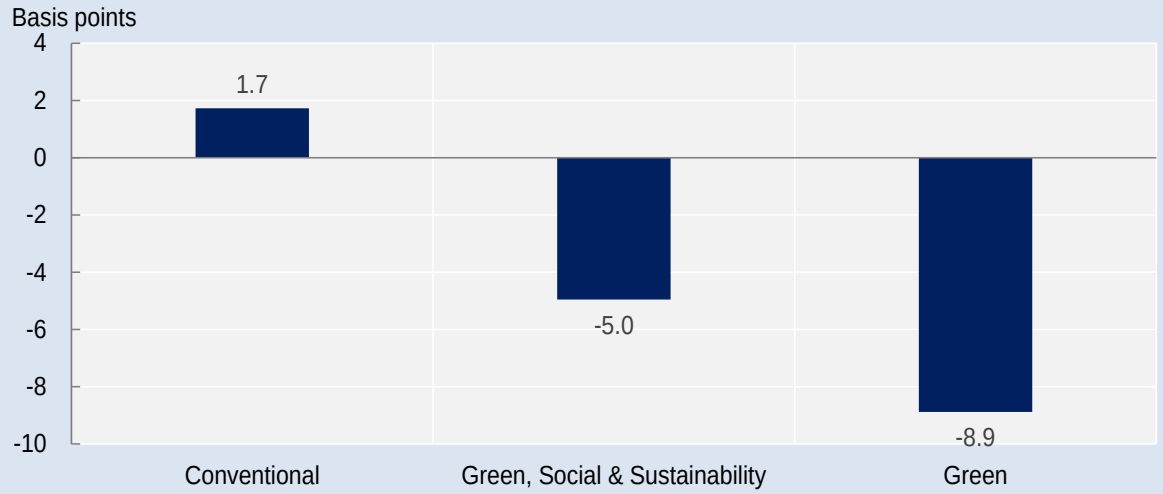
Source: FTSE Russell, MSCI, S&P Dow Jones Indices; Bank of England calculations.

Figure 13. Excess returns can also be observed for green bond indices versus the relevant market-wide benchmark



Source: MSCI, Bloomberg Finance L.P.; Bank of England calculations

Figure 14. Green, social and sustainability labelled EUR bonds issue at low or negative premia (September 2020)



Source: Bloomberg Finance L.P.; Bank of England calculations
Box source: Prepared by Bank of England staff, B. Bowry, for the OECD Committee on Financial Markets, based on the Speech by Andrew Hauser, Executive Director for Markets at the Bank of England: "From hot air to cold hard facts: how financial markets are finally getting a grip on how to price climate risk and return – and what needs to happen next"

3. Evidence of pricing of transition-related risks and opportunities in financial markets

This Section will use the *conceptual framework on the key factors that may influence market valuations associated with a transition to low-carbon economies* to identify the key drivers of low-carbon transition in financial markets, including how stranded assets and opportunities are considered in pricing and analysis of different industries impacted by the transition. This section will further explore the factors outlined in the conceptual framework in Section 2 to assess the extent to which asset prices and financial ratios in markets accurately reflect the expected impact of the transition to low-carbon economies. In addition, and where market data is available, this Section will provide more detailed evidence on these transitions within specific industries, namely in oil and gas, automobile and renewable energy. It will focus on trends derived from available data across the factors outlined in the conceptual framework, and compare equity market pricing across key companies in each of the targeted industries.

While there have been isolated movements in the cost of capital for some fossil fuel dependent sectors, there does appear to be a material change in market conditions to benefit the renewable energy sector. While individual results depend on company and market factors, the top oil and gas companies have historically enjoyed higher returns relative to the cost of capital, but with greater volatility. However, the financial performance of power companies have been improving, with returns edging upwards and a declining cost of capital. In line with the conceptual framework set out in Section 2, this could suggest that the cost of capital is *beginning* to reduce to benefit climate-resilient companies, such as those in the renewable energy sector, yet further data would need to be assessed. This section will further explore these factors and assess the extent to which funding conditions and valuations are increasingly influenced by climate transition-related strategies that are gaining confidence in markets.

This section builds on existing OECD work on climate reporting and ESG rating and investing to provide initial analysis to help policy makers understand the extent to which climate transition risks may be impacting valuations. The objective of this analysis is to provide context to and better understand the extent to which financial markets are being impacted by inconsistencies in climate-related risk reporting within current ESG frameworks and to explore the extent to which other factors could be driving the limited alignment of companies' ESG ratings with the outcomes of relevant climate-transition metrics (see OECD, 2021). To support this, financial and anecdotal analysis that uses methods to estimate stock prices for selected industries has been conducted, with predefined assumptions (see Annex C), to compare possible stock prices of companies against continued growth at the historical market growth rate. Findings suggest that some industries could be exposed to a greater level of stranded assets that are not yet factored into valuations.

While limited studies have been conducted to assess the extent to which financial markets are pricing in climate-related transition risks, these signal that financial market participants are trying

to use the information available them to incorporate potential transition risks into investment decisions. Indeed, of those that may be relevant to the policy discussion in this report, the focus remains on specific controlled assessments or certain markets. Bernardini et al. (2019) analyse equity returns of European energy companies and find that companies with an energy mix tilted towards fossil fuels registered significant write-downs, which affected operating results by reducing equity values and increasing leverage. Monasterolo and De Angelis (2018) provide an empirical analysis of the low-carbon and carbon-intensive indices at the EU, US and global stock markets levels, in terms of systematic risk (beta), before and after the Paris Agreement, findings that market participants may perceive carbon-intensive assets as riskier and hence more subject to the climate transition risk. Nag et al. (2021) analyse the carbon transition risk premium in the stocks of firms by performing a cross-section analysis. The results show a significant carbon risk premium for large cap companies in US markets (S&P500 firms), which could imply investor awareness about future exposure to a low-carbon transition. Bolton et al. (2021) look at how stock returns may reflect investor concerns about carbon transition risk, finding that in some cases the rise in the use of renewable technology coincides with the decrease in stock prices of oil majors. This seems to be a sign of changing investor perceptions of risk, which now incorporates risks associated with the climate transition. In this example, the demand for "green stocks" increases because they are perceived to be less risky, unlike "brown stocks" which show, vice versa, a higher carbon risk premium. In addition, Bua et al. (2021) (see Box 1) analyse the pricing of climate risk (transition risk and physical risk) in equity markets, highlighting that news on transition risks can impact asset prices.

Overall, while progress is being made, market pricing of the positive and negative valuation impacts from the climate transition is hampered by insufficient data, and lack of comparability of financially material metrics and analytical tools to measure and manage climate transition risks, as well as lack of policy clarity regarding carbon pricing and support for renewables. In cases there is evidence of increasing valuations for renewable energy companies and declining valuations for companies in carbon intensive sectors that show little sign of transitioning (i.e. absence of carbon reduction strategies and planning), at the same time there is also evidence that oil and gas companies that invest heavily in alternative energy sources, acknowledge stranded assets or implement internal carbon practices are not seeing notable valuation gains, whereas the auto manufacturing industry is seeing more sensitive price movements in response to transition strategies such as increased production of electric vehicles. This may be in part due to oil and gas companies being highly dependent on oil price movements. In sum, our initial analysis suggests that financial market actors are increasingly using the information available to them to make investment decisions that affect price and cost of capital, yet this information may not yet be sufficient to effectively motivate and price the capital re-allocation needed for the low-carbon transition.

3.1. Oil and gas industry

As investors increasingly look to reduce their exposure to climate change as well as manage the risk of stranded assets; oil and gas companies have been under pressure to shift their business model to a more sustainable one. In 2020, following the vulnerabilities highlighted by the COVID-19 pandemic, oil prices sharply decreased, resulting in losses by major oil companies. Following these events, many corporations in the industry have claimed a willingness to shift their business models and invest in alternative energy sources, thus reducing their involvement in oil and gas.

Pressure is mounting to reduce greenhouse gas emissions in line with a sustainable climate transition for oil companies, which are facing the strategic challenge of balancing short-term returns with long-term sustainability. Oil companies' assets write-downs exceeded more than 100 billion in 2020 in Europe and the United State, as prospects of low oil prices for years to come weighed on existing projects.

The application of the valuation framework from section 2 suggests that market participants are not pricing in the possible downside risks of a faster-than expected need to shift to green energy in the oil sector, including the possibility of stranded assets, instead reflecting the slower adoption of alternative energy sources. The following are among the factors that could contribute to downward pressure on valuations, which in turn could disrupt markets:

Write-downs and early retirement of assets and processes: In 2020, the oil industry saw more than 150 billion US dollars of write-downs related to the diminished short-term value of assets (potentially compounded by a view that oil prices may not fully recover) equivalent to roughly 10% of the companies' collective market value. Despite these announcements, companies' price in the industry remained highly correlated to oil prices, with announcements of changes in corporate strategies having little to no effect on prices, which could illustrate a reluctance of the market to capture increasing downside risk.

Operating costs: The oil and gas industry saw a reduction in net margins in 2020, of -7.2% down from +7.8% in 2019 for integrated oil and gas, and -78.8% down from 9.5% in 2019 for oil production and exploration companies. Similarly, operating expenses to sales increased from 2019 to 2020. While the increase might be due to temporary conditions from the COVID-19 pandemic, there is a concern that the trend could continue in the long-term as the crisis acts as a catalyst to accelerate permanent shifts in the industry's ecosystem.

Unforeseen policy changes and market uncertainty: The oil sector in particular is highly sensitive to policy changes, particularly with respect to carbon emissions policies, which could affect the valuations of proven and unproven reserves. Should policies foster effective climate transition along a two degree pathway, oil companies may be forced to enact further write-downs on stranded assets due to the expectation of an accelerated decrease fossil fuel demand. Moreover, various policy changes among central banks, supervisors and regulators, could have a negative impact on the cost of capital of fossil fuel related activities. While these factors can be more difficult to integrate into company valuations, some large oil and gas companies are set to make a switch to energy companies that supply a diverse range of fuels, electricity and other energy services to consumers. This means moving into sectors, notably electricity, where there is already a large range of specialised actors and where the financial characteristics and scale of most low-carbon investment opportunities are (with the partial exception of offshore wind) a long way from traditional oil and gas projects.

Stigmatisation of the sector and reputational risk: These risks are particularly relevant for the oil and gas industry given past incidents that led to environmental and reputational damages for the companies involved. In this regard, the risk of future liabilities linked to legal causes for damages to the environment could be higher in the future. Furthermore, oil companies risk increased stigmatisation through lower ESG scores, and lower weighting attributions in climate-transition investments as investors reduce exposure to fossil fuels.

On the other hand, there are a number of opportunities that could contribute to increases in valuations in the oil and gas industry, if their climate strategies are properly implemented.

Increased revenues: Over the next decade, alternative energy markets are expected to grow 15 times by 2030 relative to their current size, and become a USD 15 billion to USD 40 billion a year market, allowing oil companies that want to transition new possible sources of revenues.[34] The opportunity to shift to more sustainable energy sources could allow oil and gas companies to diversify their current portfolio, reducing risks while at the same time improving profitability.

Increased production capacity and reduced costs: Actions to improve operating efficiency and efforts to decarbonise operations can mitigate carbon-price exposure. While depending on the asset type there is a large variance of emissions, technology improvements made in the renewable energy sector could help oil companies to reduce overall costs and increase production while shifting to a more sustainable model.

Increased value of fixed assets: Given the possibility of stranded assets with regards to oil reserves, increased investments in fixed assets in the renewable energy sector could provide higher cash-flow stability in the long-term. Retiring the least productive and most carbon-intensive wells and associated assets can improve both emissions performance and profitability of existing oil and gas companies.

Access to new markets and assets: As fossil fuel demand is expected to decrease in non-OECD countries, the shift to renewable energy sources could provide important entrance points to new markets, allowing oil companies to capture global opportunities now emerging in low-carbon markets, including renewable power, bioenergy, next-generation mobility, energy services, and hydrogen. Thus far, the experience of oil companies varies, with some making more committed investments, while others remain heavily invested in existing lines of business.

Greater access to capital and lower borrowing costs: As previously mentioned, alternative energy markets are expected to increase significantly in the coming years, allowing oil companies that want to transition greater access to capital. At the same time, there are some market signals suggesting that investors are rewarding oil companies for signalling stranded assets and their plans to pivot to alternative energy sources. Moreover, improvements in renewable energy technology, coupled with increasing reliability, is decreasing the cost of capital for projects in the alternative energy space, thanks also to incentives from jurisdictions in the area.

Table 2. Selected oil companies climate transition strategies and write-downs

	Transition strategy	2020 write-downs
BP	Net-zero across entire operations (Scopes 1 and 2) and net-zero across carbon in its upstream oil and gas production (Scope 3). The company is aiming to cut the carbon intensity of the products it sells (i.e., oil and gas extracted by other companies and processed by BP) 50% by 2050 or sooner.	USD 17.5 billion
Chevron	Cut net greenhouse gas emissions intensity in upstream oil 5% to 10% and in upstream gas 2% to 5% by 2023. Aims to reduce methane emissions intensity 20% to 25% by 2023.	USD 8.3 billion
Equinor	Net-zero emissions (Scopes 1, 2, 3). It also aims to reduce greenhouse gas emissions from its operating offshore fields and onshore plants in Norway 40% by 2030, 70% by 2040 and near zero by 2050. At a global level, it aims to achieve carbon neutrality in its operations by 2030. Targets are to grow renewable energy capacity 10-fold by 2026, to develop as a global offshore wind major and to have 12-16 GW of installed renewables by 2035.	USD 2.9 billion
Exxon	The 2025 target will be supported by a 40-50% decrease in methane intensity and a 35-45% decrease in flaring intensity across its global operations. No targets to 2050 and no targets for renewables.	USD 20 billion
Royal Dutch Shell	Cut emission intensity 30% by 2035 and 65% by 2050 (Scope 3). In April 2020, the company announced its aim to become a net-zero emission company by 2050 in its own oil and gas production and energy it uses (Scopes 1 and 2).	USD 22 billion
Total	Aims for net-zero emissions across its own production, as well as across the energy products used by European customers by 2050. For global production the target is 60% by 2050.	USD 8 billion

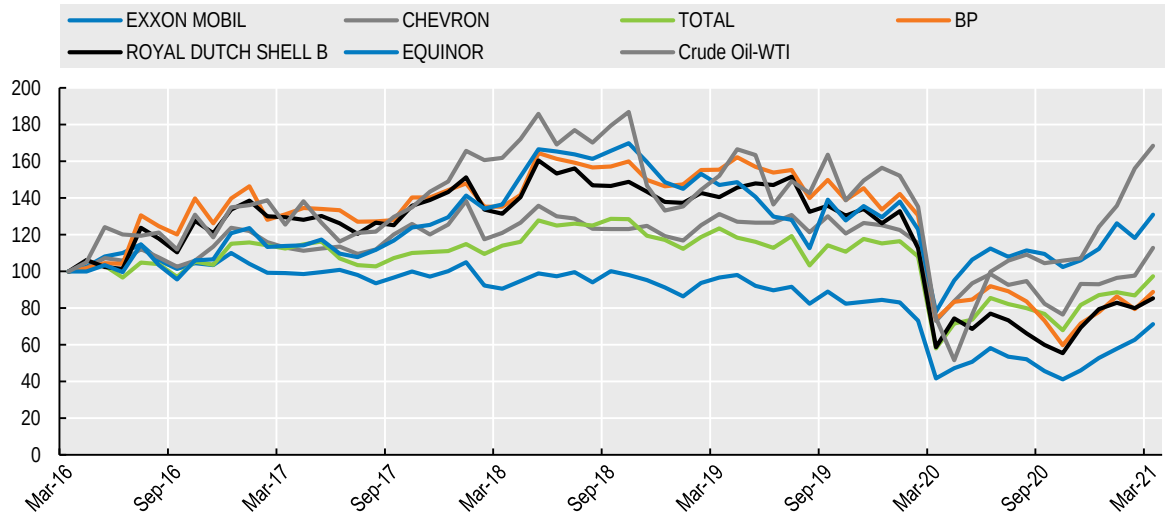
Source: Companies' disclosure, International Renewable Energy Agency's (IRENA), Refinitiv

Yet, current valuations of oil and gas companies remain tightly correlated with oil prices and have little relationship with the level of carbon intensity, suggesting that financial markets are not yet reflecting transition plans adopted by some of the oil companies, in which they suggest higher investments in alternative energy sources or carbon reducing technologies. This might be due to the fact that oil and gas companies' current capital spending in low-carbon technologies remains very limited, as the majority of their revenues are still tied to oil and gas. While some companies have written down oil-related assets and reserves, diversifying their energy operations to include renewables and other low-carbon technologies, average investment in non-core areas has so far been limited to around 1% of total capital spending, with the largest outlays going to solar PV and wind. Some oil and gas companies

have also diversified by acquiring existing non-core businesses – for example in electricity distribution, electric-vehicle charging, and batteries – while stepping up research and development activity. But overall, there are few signs of the large-scale change in capital allocation needed to put the world on a more sustainable path (IEA, 2020).

As a result, oil and gas companies are still highly dependent on oil price movements as shown in Figure 15, and a transition would require high capital expenditures in order to prepare for the shift in the coming years. Without higher investments in alternative energy sources, oil companies risk accumulating assets that could become stranded otherwise.

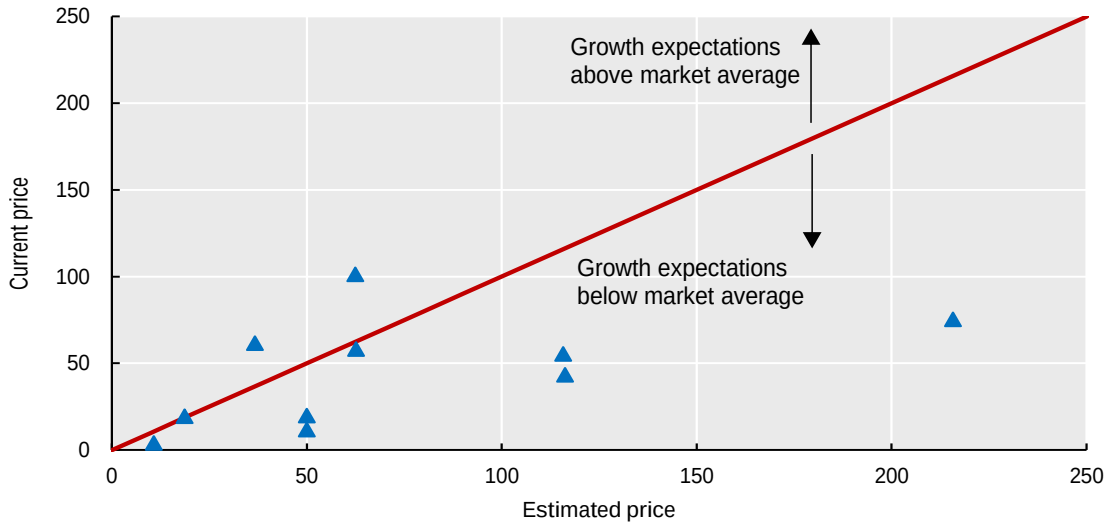
Figure 15. Major oil **companies' stock prices are highly correlated to oil prices**



Note: Crude Oil-WTI Spot Cushing USD/BBL
Source: Refinitiv, OECD calculations

With oil company stock prices highly correlated to oil movements, questions arise regarding the extent to which climate information could be contributing to price movements. Despite some oil and gas companies' commitments to implement more defined climate strategies, there seems to be some outperformers, while companies disregarding transition plans seem to be the ones underperforming. Markets seem to be pricing the need for oil and gas companies to change their business model, showing some evidence of market change in prices for the companies that are implementing climate transition strategies and investing more in renewable energy assets.

Figure 16. Most major oil companies in OECD economies could be expected to grow less than the market average

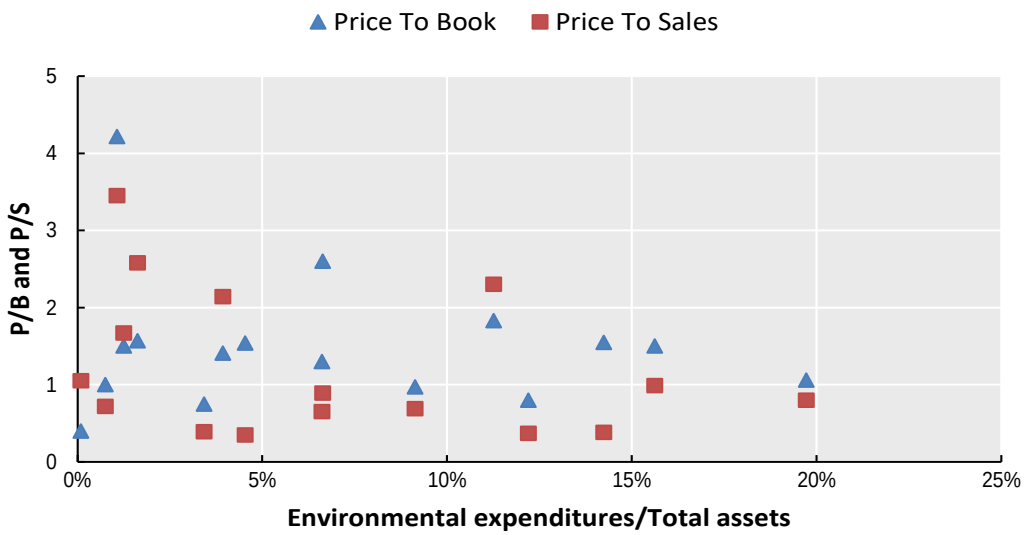


Note: See Annex C for additional information on the analysis.
Source: Refinitiv, OECD calculations

The analysis in Figure 16 uses a simple methodology to compare current prices with a simulation of prices based on historical market growth rate assumptions (see Annex C)**.** Nonetheless, while this is a simplified approach, the aim is to help policy makers understanding the wide range of current and estimated prices to determine if investors think future growth will differ significantly from the past. The figure could indicate that investors might be expecting oil companies to be exposed to stranded assets or grow at a lower level compared to market growth rates on average, except for some outliers. The analysis highlights ten major oil companies incorporated in OECD countries, which have been analysed using predetermined assumptions on market rates. In this case there are differences among oil companies analysed, as companies above the line could be expected to grow more than the market average, while companies below the line are expected to grow at less than the market average.

While there are many factors affecting valuations, the analysis[35] highlights that investors may not have strong trust in oil companies' climate transition plans, as even companies expecting to grow above the average market rate have yet to implement strong and well defined transition plans. The lower valuations anticipated for certain oil companies could suggest the expectation of stranded assets that might need to be dismissed in the future. Nonetheless, even in this case prices could depend on the current outlook for oil, and to the strong interest of stakeholders to shift to greener opportunities, which in turn might be affecting market valuations. In this regard, even among companies that implemented climate transition plans and laid out a strategy to reduce their carbon emissions, investors remain sceptical of their future performance, despite many of the involved companies having written-down billions in carbon intensive assets. Nonetheless, the correlation of Price-to-Book and Price-to-Sales ratios to a metric on Environmental Expenditures to Total Assets is low, showing that there is a slight tendency for markets to be unable to capture the benefits of environmental expenditures in future earnings calculations, relative to other factors that might drive valuations.

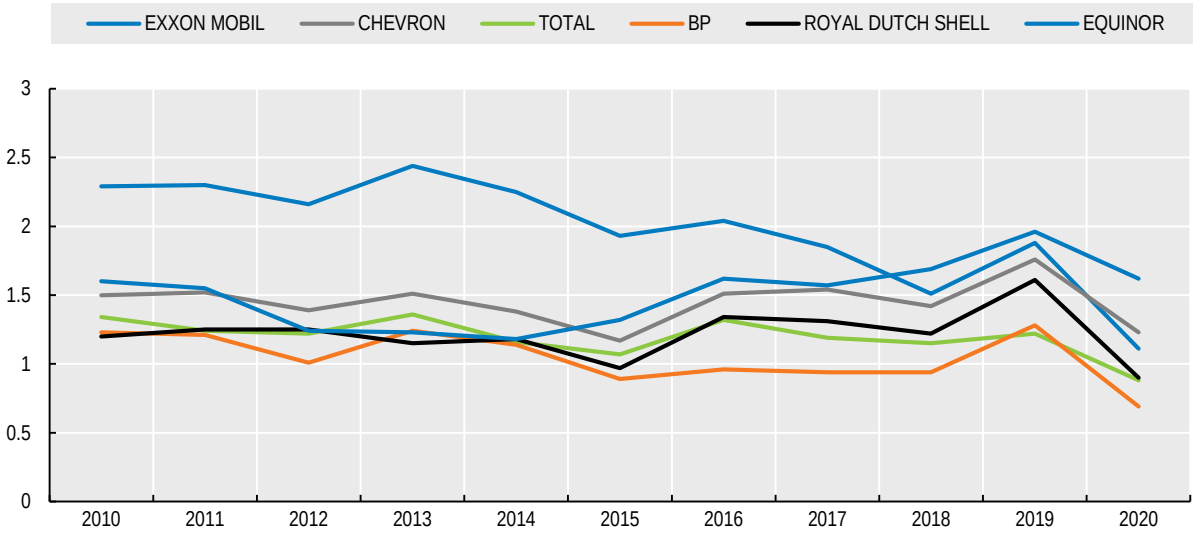
Figure 17. Price-to-Book and Price-to-Sales ratios show little correlation with environmental expenditures over total assets



Note: Total amount of environmental expenditures measured as all investment and expenditures for environmental protection or to prevent, reduce, control environmental aspects, impacts, and hazards. It also includes disposal, treatment, sanitation, and clean-up expenditure. Note: The Price-to-Book ratio is calculated by dividing a company's stock price per share by its book value per share (BVPS)
Source: Refinitiv, OECD calculations

The analysis of the Price-to-Book ratio of major oil companies shows a declining trend, which could imply unfavourable future prospects.

Figure 18. **Major oil companies' Price**-to-Book ratios have declined in recent years

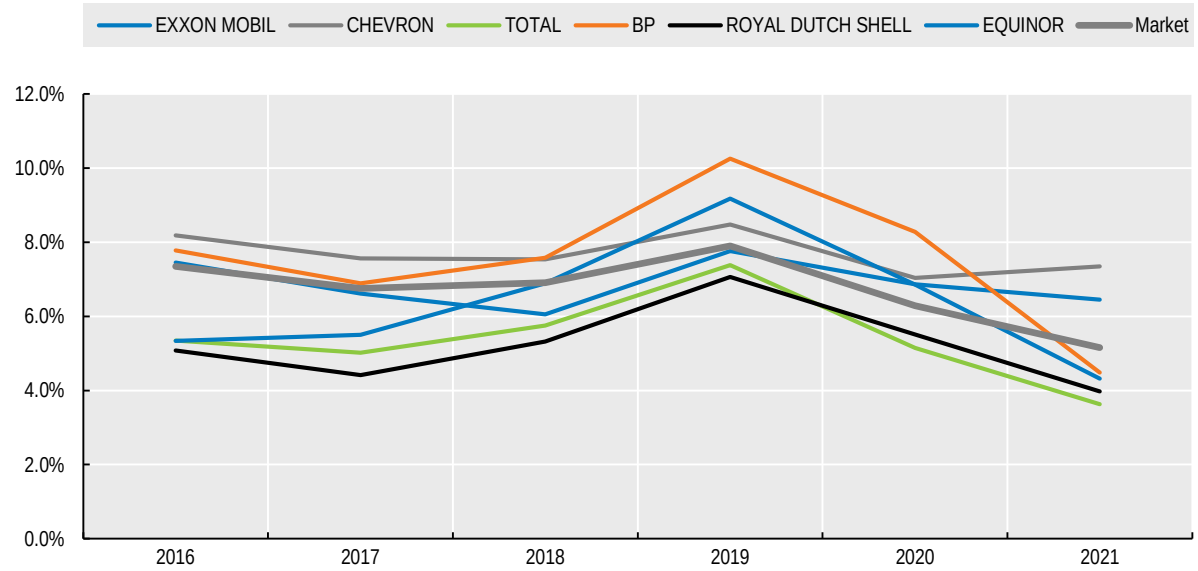


Note: The Price-to-Book ratio is calculated by dividing a company's stock price per share by its book value per share (BVPS).
Source: Refinitiv, OECD calculations

At the same time, the Weighted Average Cost of Capital (WACC) has decreased more for companies based in Europe than for companies based in the United States in recent years. WACCs for Exxon

and Chevron, for example, remain much higher than competitors, which could depend on several factors, ranging from the amount of debt on the balance sheets of the selected companies to their credit grade, to the possibility that investors might be pricing in climate prospects for the future.

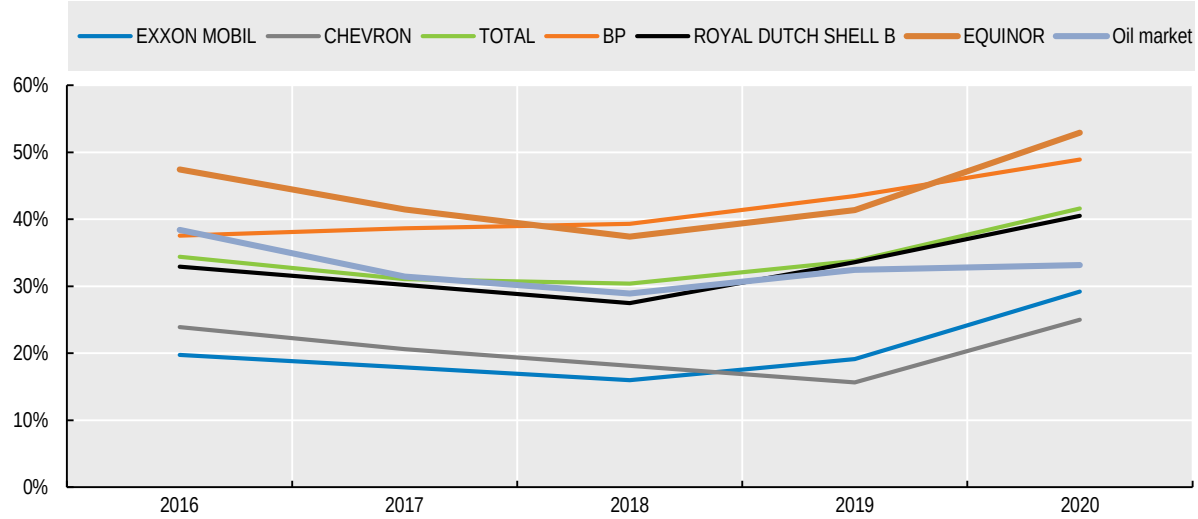
Figure 19. The WACC of major oil companies is lower for companies based in Europe



Note: WACC (weighted average cost of capital) as provided by Refinitiv. The WACC is a financial metric used to calculate a firm's cost of capital in which each category of capital is proportionately weighted. All sources of capital including equity stock, preferred stock and debt are included in the calculation.
Source: Refinitiv, OECD calculations

Moreover, major oil companies seem to have increased their debt-to-capital ratio despite a more stable trend for the overall oil market. As shown in Figure 20, oil companies disclosing climate transition plans seem to be the ones increasing their debt ratio the most, possibly due to higher investments in alternative energy sources, which is evidenced by R&D spending of major oil companies (which has increased in the last 2-3 years). For example, some of these companies are investing with the aim to increase their renewable energy exposure through deals to buy companies already operating in the sector. For example, BP has written in their transition plan that they intend to significantly pivot towards clean energy.

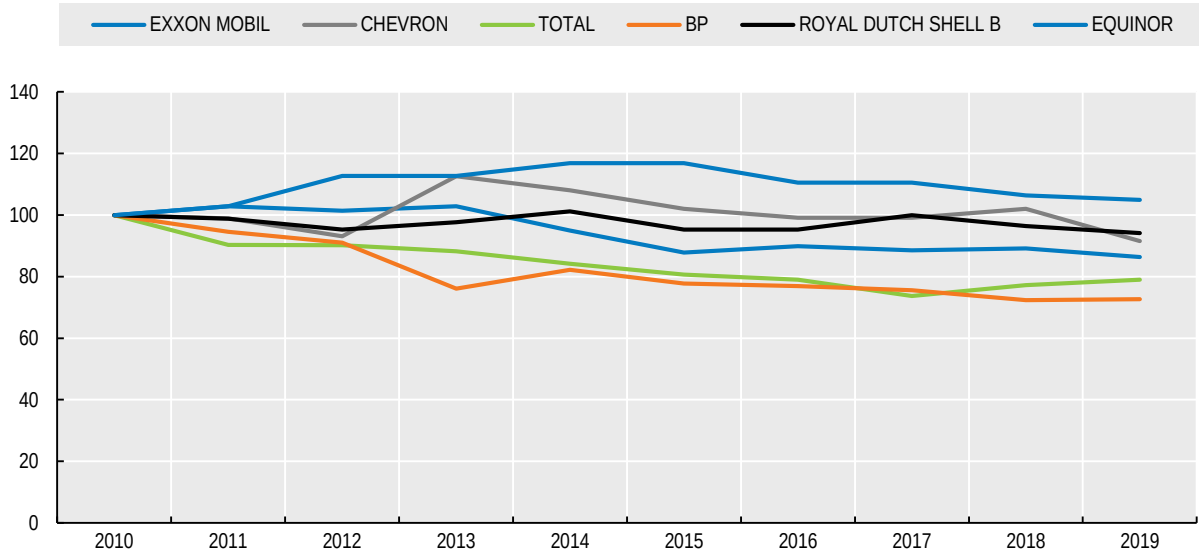
Figure 20. Different major oil companies have increased their Debt to Capital ratio despite an overall stable market trend



Source: Refinitiv, OECD calculations

Different major oil companies have reduced their relative carbon emissions over the past ten years, showing mixed progress in an effort to meet climate change targets. Among selected major international oil companies, the majority have maintained or decreased their carbon intensity in the past decade, with European companies leading this trend.

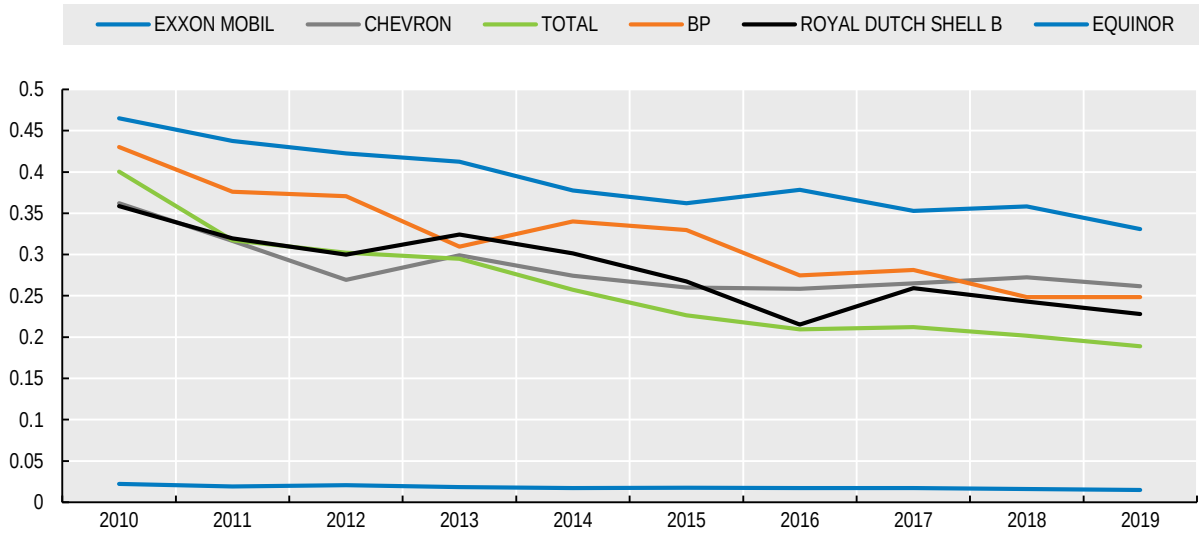
Figure 21. Total CO2 emissions have decreased for some oil companies with the highest emissions



Note: Total carbon dioxide (CO2) and CO2 equivalents emission in tonnes (Scope 1 and 2)
Source: Refinitiv, OECD calculations

Results appear to be slightly better when taking into account the total assets of the oil companies analysed. In this case, carbon emissions have remained relatively stable over time or have decreased, even as total assets have increased over time.

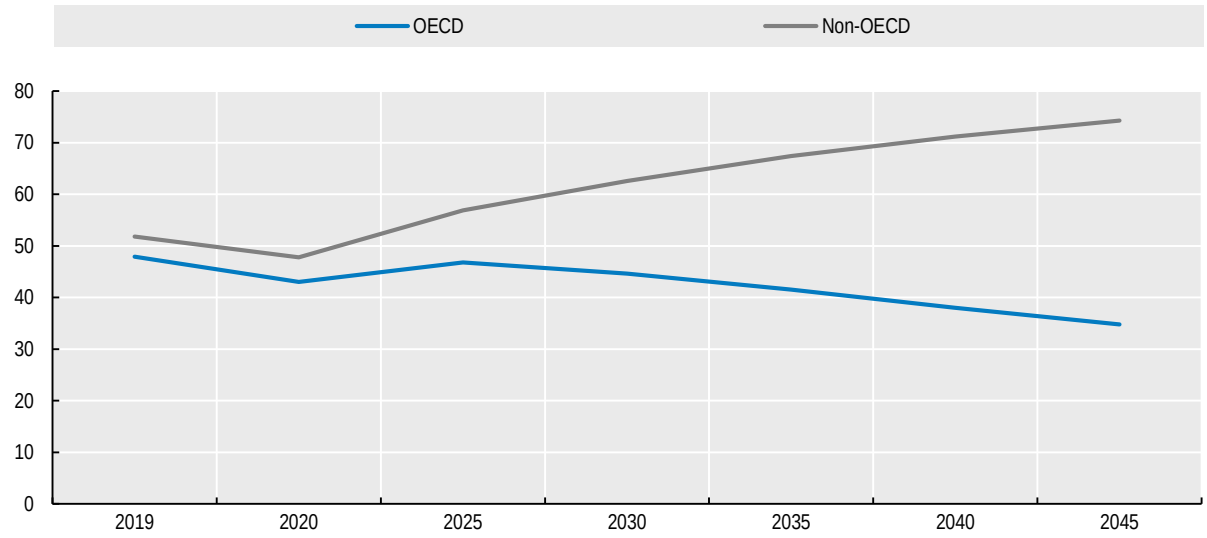
Figure 22. CO2 emissions to total assets remain high for some oil companies despite a slight decrease in the past decade



Note: Measured as total CO2 and CO2 equivalents emission in tonnes divided by total assets in USD in million.
Source: Refinitiv, OECD staff calculations

Moreover, the slower incorporation of climate transition factors into the stock price of oil companies could be dependent on the uncertainty regarding the demand for fossil fuels in the longer term. Energy demand, including oil, depends on the strength of the global economy, as well as the expansion of developing economies such as China and India. In this respect, demand is shifting from developed economies and transportation fuels to Asia and petrochemicals (IEA, 2021), as increasing consumer demand for plastic drives demand for oil. In this regard, the Organization of the Petroleum Exporting Countries (OPEC) forecasted a long-term decrease for oil demand in OECD economies in the next 25 years, while it forecasted an increase for non-OECD economies, led by India and China, as shown in Figure 23 (OPEC, 2020).

Figure 23. Oil demand in OECD and non-OECD countries has diverged



Note: Calculated as demand for million barrels a day
Source: OPEC

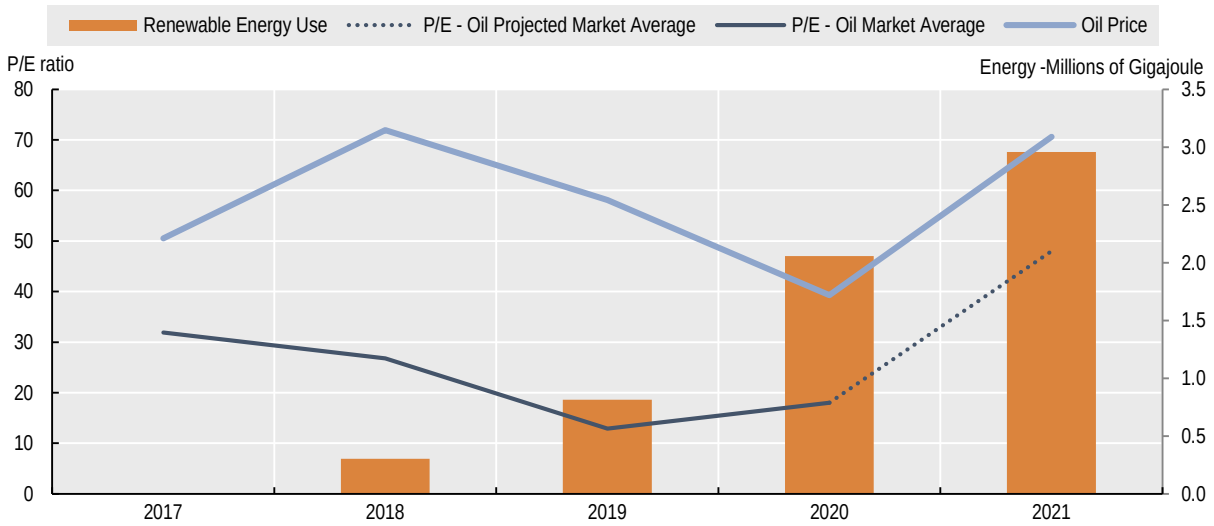
Concerns about the credit quality of oil and gas companies are increasing, following a high number of bankruptcies, in part as a consequence of the COVID-19 pandemic, raising uncertainties regarding future investment in green growth due to higher leverage. As of October 2020, the total number of producer bankruptcies in North America have exceeded 250 (Haynes and Boone, 2020). Standard & Poor's said it believed debt restructurings in the energy industry will increase in the coming months and that banks broadly will have to boost their energy loan-loss reserves, downgrading by one notch the credit ratings of four US regional banks. Similarly, according to Moody's rating agency, oil and gas company defaults reached 14.5% in 2020 (compared with the broader high-yield default rate of 3.1%), and accounted for 30% of defaults in Q2 of 2020 (Moody's Research, 2020a and 2020b).

Despite estimates on potential stranded fossil fuel assets, correlations between the size and lifespan of proven reserves with enterprise value suggests that investors may still be pricing in the value of proven reserves beyond the current lifespan. Current estimates suggest that achieving the 2 degree scenario would require that between 60% and 80% of all known, proven and probable, fossil fuel reserves must remain in the ground and unburnt.[36] For oil alone, this estimate is between 40% and 60%.[37] Using this logic, as much as 60% of current proven and probable oil reserves could become stranded assets. While the amount of time that the average large oil companies' reserves will last has fallen by 30% from 15 to 10 years of coverage since 2000, some companies such as Repsol and Total for example have commercial reserves (proven plus probable) which would last 18 and 25 years respectively (Bernstein Research, 2019). Despite these estimations there is a clear correlation between the size and lifespan of proven oil reserves and enterprise value of oil companies, which could suggest that investors are still pricing in proven reserves (Bernstein Research, 2019). This could be due to mixed policy signals across jurisdictions and market views that even after the oil demand peaks in 2030, forecasters still see oil products remaining in demand for several decades, particularly for aviation and marine fuels and petrochemicals (Bernstein Research, 2019).

Although the oil sector is still closely linked to trends in oil prices, there has been an increase in renewable energy use in the past several years (despite at a lesser extent than other industries). While Price-to-Earnings (P/E) ratios may be more closely linked to oil prices, the extent to which companies

in the industry can increase investment in, and use of renewable energy, will help them manage risks and opportunities associated with a low-carbon transition.

Figure 24. The Price-to-Earnings (P/E) ratio of selected oil companies showed a sharp decline and recovery and while there is growing renewable energy use, ratios closely follow oil prices



Note: P/E ratio Average against Renewable Energy Use Average of a sample based on market capitalisation of ten selected companies in the Oil and Gas industry: TOTAL, SHELL, ENI, EQUINOR, BP, MARATHON PETROLEUM, PHILIPPS 66, EXXON MOBIL, NESTE, CHEVRON. The P/E Projected Market Average is calculated for the firms in the sample for which data are available in 2021. Oil price: Crude Oil-WTI Spot Cushing USD/BBL
Source: Refinitiv, OECD calculations

In sum, the extent to which current market valuations reflect oil companies' climate transition strategies appears limited, with stock prices remaining tightly correlated to oil prices and having little relationship with the level of carbon intensity or new opportunities. In addition, and notwithstanding efforts by some companies, oil and gas companies' investment in renewables and the low-carbon transition remain low on average. While there has been an increasing flow of investment by oil and gas companies into low-carbon technologies or renewable energy projects, from USD 1.5 billion in 2015 to USD 2.1 billion in 2019, this still represents less than 1% of total capital investment for the largest oil and gas companies (IEA, 2020c). Largely this investment is flowing into solar PV and onshore wind, with companies such as Total and Royal Dutch Shell also investing in biofuels and carbon capture use and storage technologies. Looking ahead, for oil and gas companies to meet emissions reductions targets and implement transition strategies, capital investment in renewable projects may need to increase considerably.

3.2. Automobile industry

The automotive industry provides a contrast to the example of oil and gas regarding climate transition strategies and implementation, for several reasons. While automobiles have been a major source of fossil fuel consumption, both in their creation and their usage, a number of large automobile companies are undergoing a transformation in reducing their fossil fuel inputs, and also their design of products that are increasingly lowering carbon emissions, such as electric cars. Furthermore, given the relatively moderate depreciation schedule of automobile manufacturers, as well as the lack of stranded assets, the switching costs appear manageable. In this respect, the automotive industry exhibits a

transition from a largely brown industry to one that is increasingly competing, particularly in some parts of the world, on the acceleration toward green efficiencies. Policy and regulatory certainty is also supporting these trends, and efforts of financial market participants, which appear to be capturing these in market pricing.

The automobile industry is providing evidence of a shift to a sustainable business model, reflecting increasing demand for zero-emission vehicles and deadlines set by many countries to meet net-zero by 2050. Over the past decade, major automakers have changed their product lines to keep up with changing demands and increasing concerns over climate change and by 2022 it is expected that there will be over 500 different EV models available globally.

Auto companies might face fewer challenges in the implementation of effective low-carbon transition plans due to more flexibility in their business models[38]. On one hand, they are not likely to suffer excessive amounts of stranded assets; for example, existing factories can be repurposed for the production of green vehicles. Moreover, current capital expenditures in alternative vehicles represent an important part of their investments, making a complete transition more certain. As of today, almost all major automakers have implemented policies to reduce carbon emissions and to improve transparency and disclosure related to Scope 1, 2 and 3 emissions.[39] Nonetheless, a more complete transition will happen when all automakers transform their production from Internal Combustion Engines (ICE) to alternative low-carbon engines, such as electric or hydrogen. While at the beginning of 2020 only five global automakers derived more than 10% of revenues from non-ICE vehicles, with Tesla being the only one selling exclusively electric vehicles, there have been strong improvements in the commitment to produce green vehicles.

13 countries have announced plans to phase out sales of internal combustion vehicles, with the majority of car markets offering forms of subsidies or tax reduction for the purchase of electric vehicles. In 2019 and 2020, different jurisdictions implemented CO2 emission standards with specific requirements for electric vehicles, among which the European Union, China and India were recognised as key players. Other countries with increasing policy activity to support EVs are Canada, Costa Rica, Chile and New Zealand.

The application of the valuation framework reflects the incorporation of industry changes in the increase in market prices:

Valuations gains on R&D: The shift to electric vehicles by many automakers is reflected in the increase in their stock price following announcements on the implementation of transition strategies and electric vehicles. Recent price spikes could be due to market confidence in the transition strategies adopted by automakers. Many companies that recently implemented a climate transition strategy are already benefitting from R&D to produce new alternative vehicles and investments are being redirected toward an increase in production of such vehicles.

Increased revenues: Increases in the sales of electric cars grew 9% year on year in 2019, with more than 2 million cars sold, following several years of over 40% annual sales growth. While these accounted for 2.6% of global car sales, there is growing demand for these type of vehicles, particularly as reliability increases and costs decrease. In this regard, China was the world's largest market (1.06 million electric cars sold in 2019), followed by Europe (560 000) and the United States (326 000).

Increased production capacity and reduced costs: Increasing progress in the technologies to produce electric vehicles is reducing costs and improving production capacity. In terms of production efficiency, automakers reduced by 35% (on average) resource consumption per vehicle,[40] resulting in a substantial positive impact on production cost.[41] Moreover, one of the main costs for electric vehicles, batteries has decreased rapidly in recent years. In 2019, the average sales-weighted battery price fell 13% compared to 2018 and is expected to continue to decrease through the conjunction of increasing battery pack size, battery chemistry changes and economies of scale thanks to larger manufacturing plants (IEA, 2020).

Increased value of fixed assets: Electric vehicle automakers are expected to be more capital efficient than traditional automakers, allowing for higher long-term value of fixed assets. The amount of capital required to produce an internal combustion engine car in the US has been rising in the last five years. Therefore, Ford and other automakers have suggested that electric vehicles could be produced at 50% of the capital investment necessary for vehicles with internal combustion engines.

Access to new markets and assets: Several jurisdictions globally are implementing policy efforts to electrify transportation and to incentivise the use of non-ICE vehicles to reduce carbon emissions. Among the key players, the European Union approved a new standard for cars and vans for 2021-2030, with specific requirements or bonuses for electric vehicles[42]. Similarly, China and India have noted their intention to implement support for the decarbonisation of vehicles.

Greater access to capital and lower borrowing costs: As seen from the IPO frenzy in 2020,[43] electric vehicles companies are able to have greater access to capital thanks to the increasing investor attraction to both long-term value and the path to net zero for many auto companies. Improving valuations and cost of capital are highlighted in this section.

On the other hand, there are a number of factors that could contribute to reducing valuations if not properly addressed:

Write-downs and early retirement of assets and processes: New technologies needed with respect to current transition strategies require significant research and development investments, as well as overhauled production lines to accommodate battery packs, road sensors, and complex machines. While elements of the business model may be flexible, manufacturers must rethink their entire design, manufacturing and sales processes, and consider carbon intensity across this full chain.[44] Therefore, existing fixed assets that are used to create internal combustion engine vehicles could become stranded in the future, facing difficult to manage accelerated depreciation and additional unforeseen costs, if processes are not repurposed quickly and effectively, following automakers' plans to produce a significant part of their fleet as alternative energy vehicles.

Operating costs: As the majority of automakers plan to shift to their existing production to alternative energy vehicles, there could be the risk that investments that are currently going towards improving internal combustion engine technologies are shifted to alternative types of vehicles. Smaller investments as well as lower technology improvements, might increase operating costs, thus reducing the profitability from carbon intensive vehicles.

Unforeseen policy changes and market uncertainty: While many jurisdiction have already laid out plans to phase out sales of internal combustion engine vehicles, there is the possibility that new regulation to reduce carbon emissions, including the possibility of carbon taxes, would add additional costs for the automakers that do not plan to transition or that are slower to implement an effective transition.

Stigmatisation of sector and reputational risk: While some automakers are already producing exclusively alternative energy vehicles, there is a risk that investors lose trust in companies not respecting the implementation of the announced transition strategy, or others that remain focused on the reliance of fossil fuels. Other reputational risks could emerge if companies are not transparent regarding their environmental data, as for example the Volkswagen emissions scandal highlighted.

Among the largest automakers in the world, plans have been disclosed to transform their production processes, which appears to have been subsequently reflected in stock prices and in the increasing valuations of companies making such announcements. Volkswagen, competing with Toyota to be the world's biggest vehicle seller by volume, laid out its plan to turn 70% of European sales electric. Their stock price increased 30% year-to-date as of the 31st of August, taking its market value to over EUR 120 billion. Moreover, in their climate transition plan (see Volkswagen Sustainability Report 2019) if on the one hand Volkswagen aim, through a 50% reduction in emissions for vehicles of all plants compared to 2010, to achieve full energy efficiency and to offer zero-emission products for the entire life

cycle, on the other hand they state that they foresee an improvement in company performances. The ROI (Return on Investment) in the automotive division is expected to be greater than 14% for 2025 (-0.2% in 2010), the pay-out ratio is expected to be greater than 14% for 2025 (< 0.0% in 2010) and, looking at the short term, the increase in Net Asset Value in the last pre-COVID year was about 6.5 %.[45] Similarly, BMW, aims for half of its sales to be non-fossil fuel vehicles by 2030, and that around 90% of its market categories would have fully-electric models available by 2023, with a stock increase of about 10% year-to-date. While, in terms of economic valuations, revenues of the group showed an increase of 7.6% in the last pre-COVID year, the ROI is expected to be above 10% for the next 5 years and the Profit before tax show a "*significant increase".*[46] This kind of results recurs for almost all the major companies in the automotive sector,[47] which express a commitment to progress in the implementation of climate transition plans.

Looking at the market in more general terms, the automotive industry has undergone evident global changes in the last decade, within the context of technological transition. Electric car deployment has been growing rapidly over the past ten years, with the global stock of electric passenger cars passing 5 million in 2018, an increase of 63% from the previous year. Around 45% of electric cars (2.3 million) on the road in 2018 were in China, compared to 39% in 2017. In comparison, Europe accounted for 24% of the global fleet, and the United States 22% (IEA, 2019). Moreover, the automotive industry, like other sectors, will be heavily influenced by other dynamics not directly related to the climate transition, making the latter only one of several competitive factors within the sector. In addition, there are therefore several factors that can affect both economic company performances and speed up full compliance with climate transition plans.

The creation of new business models is encouraged on the one hand by the need to adapt the sector to energy and climate considerations, and on the other hand by new key elements such as shared mobility, connectivity services and feature upgrades. Some studies suggest that this could expand automotive revenue pools by about 30%, adding up to USD 1.5 trillion by 2030, diversifying significantly towards on-demand mobility services and data-driven services.[48] A 2% increase in annual global increase in vehicle unit sales will be driven by macroeconomic dynamics, which will see the growth of emerging economies as a driving force and in particular price premiums paid for electric powertrains and autonomous driving technology features, as elements of attraction for the automobile market. Kepler Cheuvreux Transition Research suggests that, in terms of forward-looking analysis and climate change scenarios, the automobile sector show EBITDA growth of about 85% on average to 2050. More precisely, referring to two different scenarios, the Limited Climate Transition (LCT) scenario and the Ambitious Climate Transition's (ACT) scenario, EBITDA could be expected to grow by 110% in the LCT and about the 60% in the ACT scenario. In general, earnings growth is stronger for companies that are already considered financially strong (in terms of higher sales revenues). Moreover, it is expected that R&D investments are required for efficiency improvements of internal combustion engine (ICE) vehicles, and financial stress caused by increased spending can be better weathered by companies considered financially strong.[49]

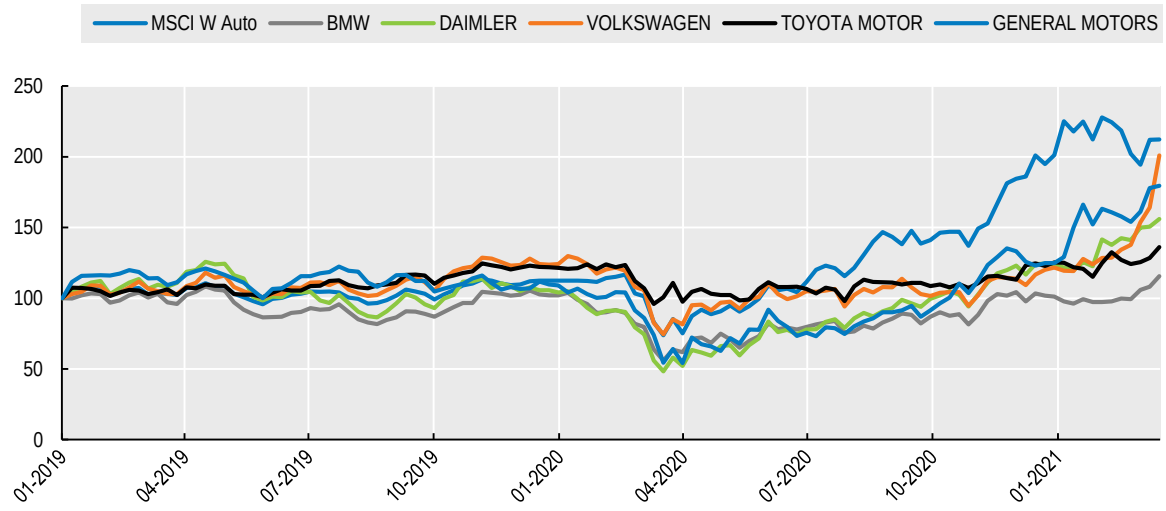
Table 3. Selected automakers climate transition strategies

	Transition strategy	2019 production of non-ICE vehicles
BMW	Reduce emissions (Scope 1 and 2) by a 80% from 2019 levels by 2030 and reduce CO2 emissions from vehicles by 40% per kilometer driven	5.7%
Daimler	Reduce emissions (Scope 1 and 2) and energy purchases by 50% compared to 2018 by 2030 and reduce emissions of vehicle fleet by 40% compared to 2018 by 2030	1.7%
General Motors	Reduce emissions by 31% (Scope 1 and 2) by 2030 while ensuring at least 50 percent sustainable material content in GM vehicles by 2030. Ensure 100% of targeted GM suppliers are reporting data to CDP Supply Chain by 2022. Source 100% renewable electricity in the US by 2030 and globally by 2040.	1.3%

Toyota	Reduce emissions from: vehicles by 90% by 2050, compared to 2010; global plants by 35% by 2030 compared to 2013; the vehicle lifecycle by 25% by 2030 compared to 2013;	15.6%
Volkswagen	Reduce emissions from production and use of vehicles by 30% compared to 2018 by 2030 and plans to gradually increase the proportion of renewable energy in externally sourced electricity for production to 100% renewable by 2030	0.8%

Source: Companies' disclosure, Refinitiv

Figure 25. Major automakers have seen strong increases in their stock price following announcements to accelerate global electric vehicles production

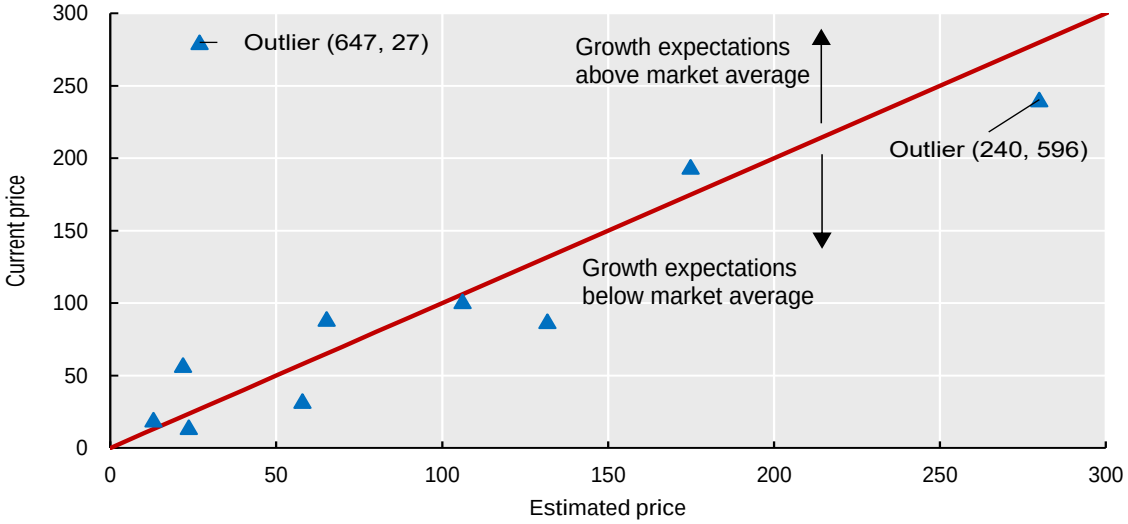


Note: Stock price in USD
Source: Refinitiv, OECD calculations

The analysis in Figure 26 uses a simple methodology to compare current prices with a simulation of prices based on historical market growth rate assumptions (see Annex C). Nonetheless, while this is a simplified approach, the aim is to help policy makers understanding the wide range of current and estimated prices to determine if investors think future growth will differ significantly from the past. The results suggest that investors might be expecting automakers to grow at a similar level compared to average market growth rates, except for some outliers. The analysis highlights ten automotive companies incorporated in OECD countries, which have been analysed using predetermined assumptions on market rates. In this case there are differences among automakers analysed, as companies above the line are expected to grow more than the market average rate, while companies below the line are expected to grow less than the market average rate. Among the outliers for example is Tesla, which seems to be expected to grow much more than average market growth rates, therefore the very low estimated stock price. Even in this case prices could depend on the current outlook of the electrical R&D investments, due to the strong interest of stakeholders to shift to greener opportunities and the possibility of the company to increase its market share in the electrical vehicles market.

While there are many factors affecting valuations, investors seem to be expecting automakers that are implementing a stronger and more defined climate transition plan to grow at market rate levels on average. This could relate to the climate reporting for the companies analysed,[50] which, while being implemented broadly from automakers, still has to show concrete results. Even in this case that prices could depend on the current outlook of electric vehicles production, due to the strong interest of stakeholders to shift to greener opportunities, which in turn might be affecting market valuations.

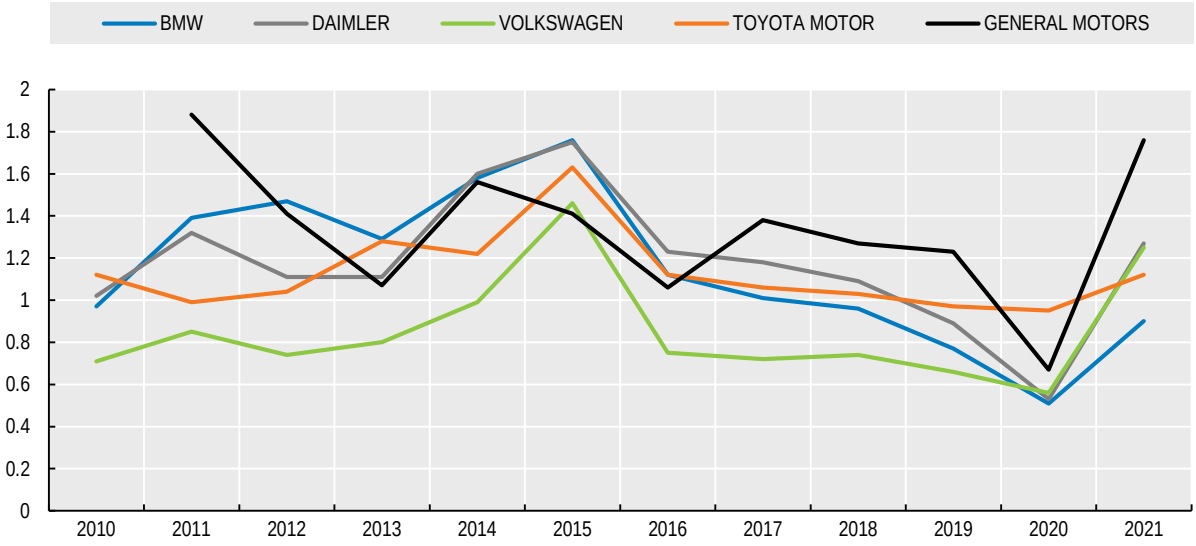
Figure 26. Most automakers in OECD economies are expected to grow at a similar rate to the market average



Note: See Annex C for additional information on the analysis.
Source: Refinitiv, OECD calculations

Similarly to valuations, the Price-to-Book ratio for the industry has spiked following almost a decade of decrease. While a certain aspect of the post-COVID recovery is shaping this valuation gain, as car purchases are rising, this could also indicate renewed market confidence in the transition strategies recently adopted by automakers.

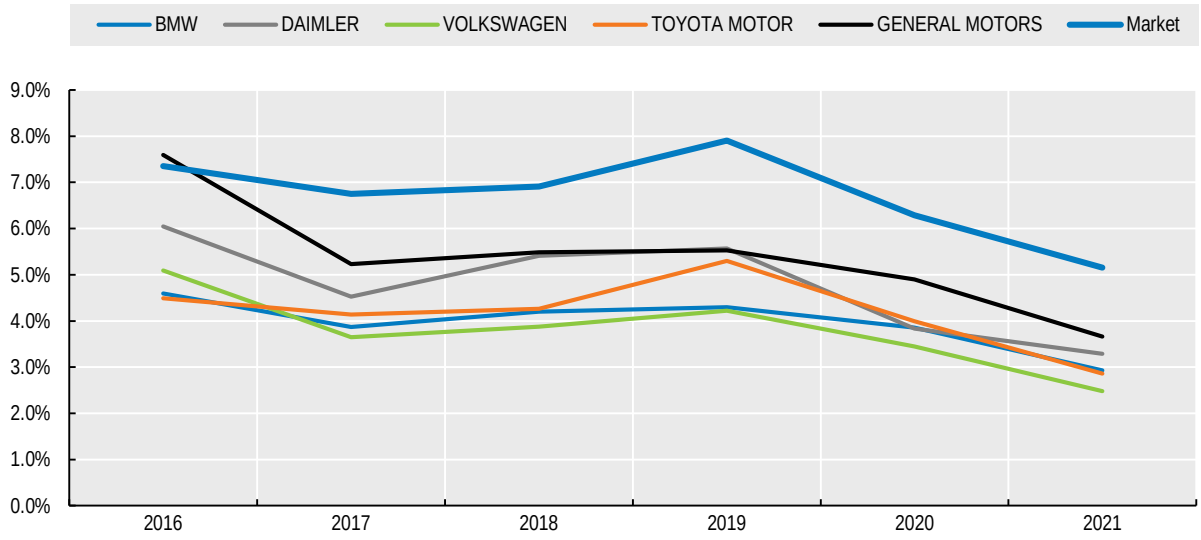
Figure 27. The Price-to-Book ratio for the automobile industry has sharply rebounded



Note: The Price-to-Book ratio is calculated by dividing a company's stock price per share by its book value per share (BVPS).
Source: Refinitiv, OECD calculations

The WACC for the automobile industry has also seen a strong decrease compared to five years ago, possibly showing signs of increased market trust in the industry. This could be also due to the high debt levels of automakers, which have benefitted from decreasing cost of debt in recent years.

Figure 28. The WACC for companies in the automobile industry have followed a decreasing trend in recent years

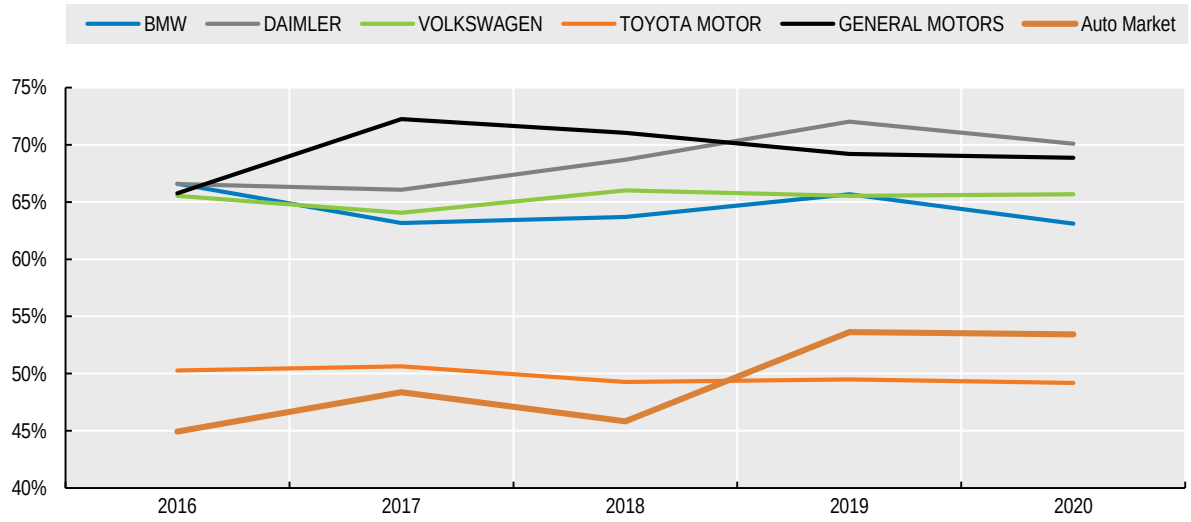


Note: WACC (weighted average cost of capital) as provided by Refinitiv. The WACC is a financial metric used to calculate a firm's cost of capital in which each category of capital is proportionately weighted. All sources of capital including equity stock, preferred stock and debt are included in the calculation.
Source: Refinitiv, OECD calculations

Moreover, major automakers seem to have relatively stable debt-to-capital ratios, despite an overall increase for the automobile industry. As shown in Figure 29, many automakers have capital intensive business models, with high debt-to-capital ratios, which are generally used for R&D and reinvestment purposes. Despite the COVID-19 pandemic, automotive research and development (R&D) spending is

expected to grow an average of 6.5% throughout 2021. (HIS Markit, 2021). In absolute terms, Toyota and Volkswagen are investing the most in R&D among the companies analysed.

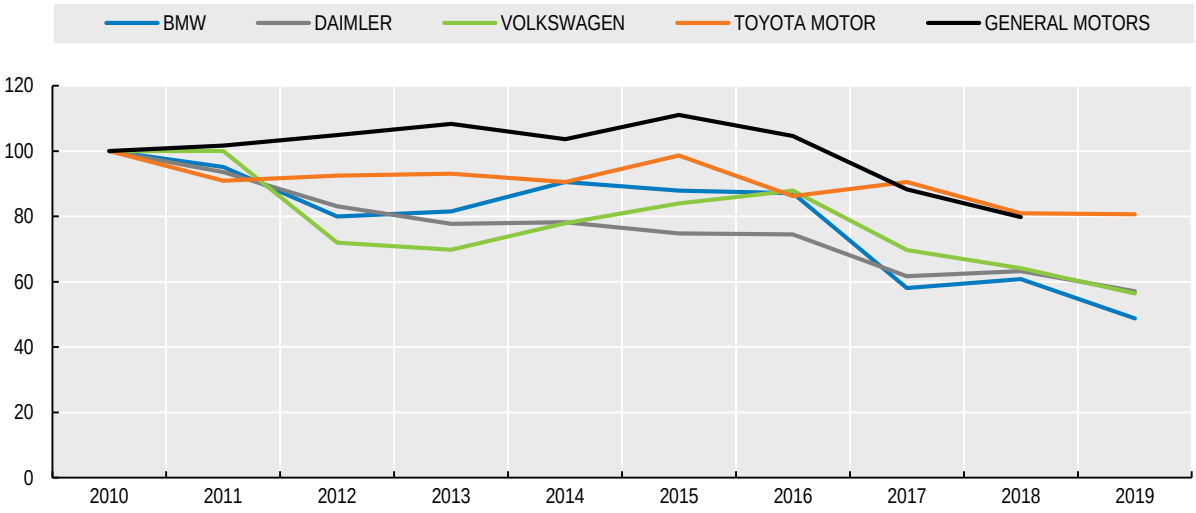
Figure 29. The Debt to Capital ratio has been in line with market developments



Source: Refinitiv, OECD calculations

In concomitance to the implementation of transition strategies, automakers have reduced their carbon intensity in the past decade, showing a stronger commitment to climate change. The majority of large automakers have reduced their carbon intensity, some of them reducing them more than 50% from 2010 levels.

Figure 30. **Selected automakers' carbon intensity has decreased in recent years**



Note: Carbon intensity measured as Total CO2 and CO2 equivalents emission in tonnes divided by net sales or revenue in US dollars in million.
Source: Refinitiv, OECD staff calculations

The increasing interest in non-ICE automakers is reflected in the number of IPOs and reverse mergers through SPACs in recent years. In 2020, more than five new companies related to electric vehicles went public, each of them with a valuation over USD 1 billion despite zero or very little revenues. While these companies are still in the early phases of the business cycle, their technologies are trying to implement disruptive changes in the auto industry.

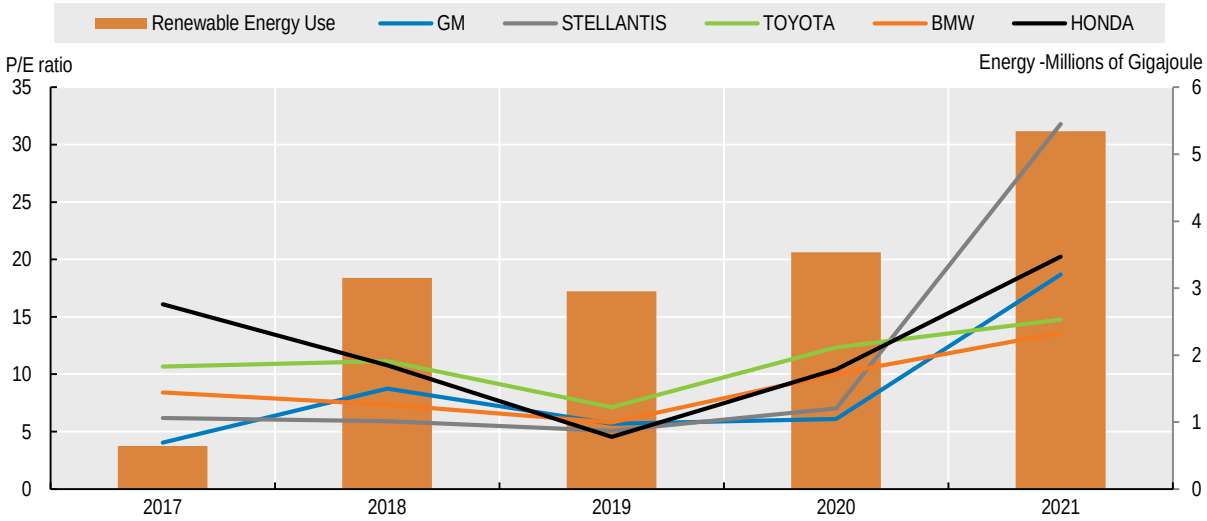
Table 4. Selected indicators for electric vehicle (EV) companies that went public in 2020 via SPACs

	Specialisation	Market capitalisation (USD billion)	Exchange listed
Nikola Corporation	Hydrogen trucks	5.97	Nasdaq
Hyliion Holdings Corp.	Electric trucks	2.79	NYSE
Fisker Inc.	Electric SUV	1.01	NYSE
Lordstown Motors Corp.	Electric pickups	3.37	Nasdaq
QuantumScape Corp.	EV batteries	30.74	NYSE

Note: Market capitalisation expressed in USD billion, January 2021
Source: Refinitiv, OECD calculations

Evidence from increasing valuations and alignment of automakers to shift to non-ICE engines seems to suggest that markets are showing greater interest in automakers that are implementing transition strategies and shifting to low-carbon business models. Notably, the auto manufacturing industry has seen increasing capital investment in R&D and intangibles to support the low-carbon transition, spending on average more than any other sector on R&D investment relating to renewable energy and electric vehicle technologies and projects, which totalled around USD 30 billion in 2019 (IEA, 2020a). Many of these projects are in the more advanced stages with lessons learnt on existing technologies for the auto industry showing benefits for the scalability of electric vehicles. In addition, the auto manufacturing industry has seen a steady decrease in the cost of capital (as measured by the WACC)[51] from 4.7% in April 2019 to 3.3% in April 2020. While in concept this may impact the enterprise value of companies in the sector, a number of other factors may also impact this, and will be discussed in the remainder of this section. Furthermore, while further analysis would be needed to assess the relationship, Figure 31 shows an improvement in Price to Earnings (P/E) ratios by selected automobile companies, that have occurred alongside an increase in renewable energy use, which may serve as a proxy for the broader transition strategies.

Figure 31. The Price-to-Earnings (P/E) ratio of selected automobile companies have increased alongside renewable energy use



Note: Trailing P/E ratio against Renewable Energy Use Average for selected companies in the Auto industry. The Renewable Energy Use Average is calculated on a sample of ten companies based on market capitalization: AUDI, DAIMLER, GM, STELLANTIS, TOYOTA, BMW, VOLKSWAGEN, TESLA, FORD, HONDA.
Source: Refinitiv, OECD calculations

3.3. Renewable energy industry

The renewable energy industry is distinct from the oil and gas and automobile industries, in that it is heavily focused on the scalability of R&D, and does not suffer from legacy assets and processes that face being stranded, decommissioned, or affected by write-downs. However, renewable energy activities that are the product of R&D or acquisitions from larger traditional power players may be burdened by stranded assets or processes, creating cumbersome switching costs. At the same time, the investment in renewables still remains relatively modest, and government support remains needed to ensure that scalability and efficiency can be achieved.

The renewable energy industry might benefit from the early implementation of climate transition strategies and high investments in the longer term. Among other industries which will have to repurpose existing facilities or increase the investments in green assets, renewable energy companies have already started to implement radical changes in their business models. In this regard, implementing a low-carbon transition will require both significant capital and operational expertise. Companies with extensive operating experience and knowledge of renewable power, infrastructure and business transformation are well positioned to become more competitive in the future (Brookfield, 2021).

A greater focus on climate transition and the growing need for alternative energy sources might be driving the recent increase in valuations for the companies analysed. The fact that renewable energy companies are focusing on the production and distribution of clean energy gives them a competitive advantage over other industries which might need more intensive investments to transition. For example, according to the Transition Pathway Initiative, the majority of large utilities companies are aware of climate related issues and are building capacity to tackle the issue.

The application of section two conceptual framework reflects the incorporation of industry changes in the increase in market prices:

Valuations gains on R&D: Valuations have increased for many renewable energy companies, in part due to the benefits from years of R&D that have shown the technology can be scalable. Moreover, economic stimulus measures focused on clean energy can directly or indirectly support renewable energy companies' valuation.

Increased revenues: Renewable energy companies have seen an increase in revenues thanks to a stronger demand from consumers due to their use in the electricity sector**.** Even with electricity demand falling because of lockdown measures throughout the COVID-19 pandemic in 2020, low operating costs and priority access to the grid in many markets allowed renewables to operate at near full capacity, enabling renewable generation to grow. Strong policy support is also expected to drive strong renewables growth in the future. In this regard, the clean energy and electricity sectors will likely experience unprecedented growth as demand for conventional, hydrocarbon-based energy wanes (Wellington Management, 2021).

Increased production capacity and reduced costs: Investments and innovative technologies are driving down the cost of renewable energy, improving the production process. Solar PV and onshore wind are already the cheapest ways of adding new electricity-generating plants (despite support) in a number of countries today, representing a challenge for fossil fuels.

Increased value of fixed assets: Contrarily to fossil fuel and carbon intensive assets, which could be under pressure to be retired to make space to build other forms of power generation, investments in sustainable and green assets could provide higher value of fixed assets. Moreover, thanks to longer holding periods and investment horizons, companies investing in the climate transition tend to be more sensitised to changes in relative valuations. These climate-related shifts in asset prices incentivise investors to reduce carbon footprints and deploy capital into green energy and related storage technology, according to the Carlyle Group, a private equity firm that invested more than US 100 million in renewable energy.

Access to new markets and assets: More and more governments are implementing or planning to implement policies to sustain a low-carbon transition, which will allow renewable energy companies to access new markets. Over the next years, relevant capital will be invested into modernising the global electric grid to accommodate increased electrification and the rising share of renewable energy sources, in turn providing new markets and sources of revenues for utilities companies (Wellington Management, 2021).

Greater access to capital and lower borrowing costs: With increasing pressure and incentives from governments to shift to low-carbon economies, firms investing in alternative energy sources should have greater possibilities to access capital and as the industry solidifies the cost of debt should decrease to reflect the improved financial situation of companies.

On the other hand, there are a series of risk factors that could contribute to reduced valuations if not addressed:

Write-downs and early retirement of assets and processes: While this type of risk is present in many industries, including the renewable energy industry, it is less likely to present itself as companies are investing heavily in low-carbon alternative assets.

Operating costs: While operating costs are less likely to increase thanks to the advancement in alternative energy technology, a slower than expected take up of investments in green energy could mean fewer projects and generally higher operating costs. Moreover, a higher cost of capital is expected for hydrocarbon developments projects (Brookfield, 2021).

Unforeseen policy changes and market uncertainty: While policies favouring a quicker climate transition and a possible reduction of carbon emissions might favour companies in the renewable energy area, there is the possibility that the implementation of such policies could be slower than expected, leading

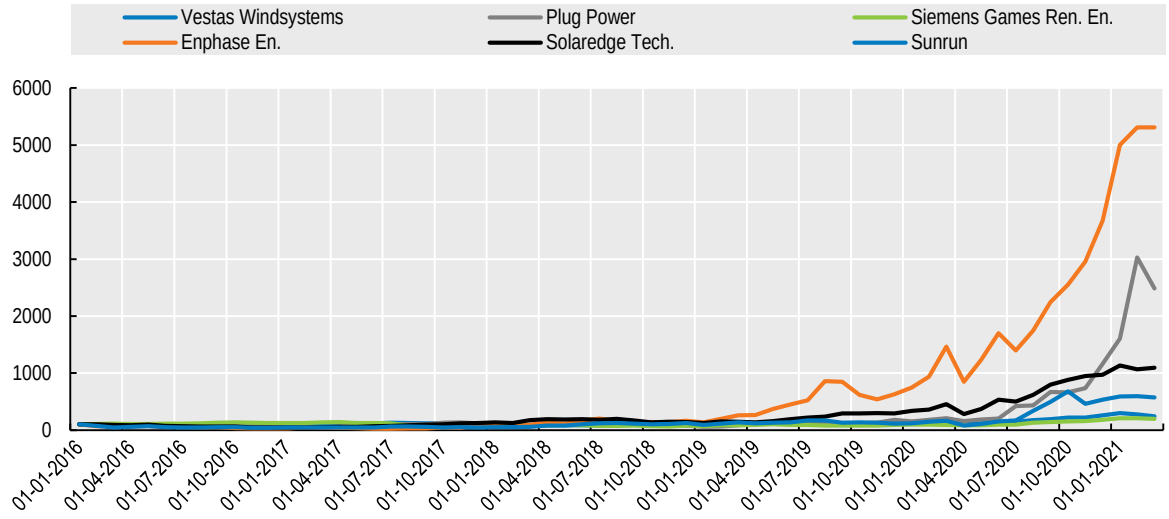
to fewer investments that could affect the profitability of green projects. Moreover, the competitive pricing of forms of renewable energy relative to fossil fuels is volatile, and it may take concerted policy interventions to ensure that various forms of renewable energy remain commercially viable.

Stigmatisation of sector and reputational risk: As renewable energy companies have reduced their levels of CO2 emissions, there seems to be little-to-no reputational risks involved with respect to climate factors (beyond potential failures of certain emerging business models or products; such risk should reduce with scale and adoption). Nonetheless, these risks remain for traditional utilities that have not yet shifted their business model.

As opportunities currently appear to outnumber risks, markets seem to be pricing in the possible upsides of the renewable energy industry. In recent years, renewable energy companies have seen skyrocketing valuations in part due to decreasing costs and increasing climate concerns, allowing for strong growth opportunities with relatively low climate transition business models risks. As shown in figure 32 some companies in the sector have seen returns of more than 100% to 6000% in a couple of years, from very low levels. The renewable energy sector saw significant demand from most market segments. Renewable energy consumption by residential and commercial customers increased 6% and 5%, respectively, through June 2019 compared with the previous year. These, alongside other factors, drove investors to move their investments to the alternative energy sector, which pushed up prices and valuations of companies in the industry.

This growth has been facilitated by decreasing costs and improvements in the scalability and enhancement of renewable technology efficiency, which has allowed improving profit margins, along with increased competitiveness of battery storage. Cost of onshore wind declined by 10%, offshore wind by 24%, solar by 18% and batteries storage by 35%. New wind and solar technologies have become more cost-competitive than coal in parts of the world (BNEF, 2019). The cost decline has made renewables more competitive, adding value to the industry compared to traditional energy sources. The cost reduction is reflected in the fact that for the first time ever, in April 2019, renewable energy outpaced coal by providing 23% of US power generation, compared to coal's 20% share.

Figure 32. Some renewable energy companies have seen skyrocketing valuations



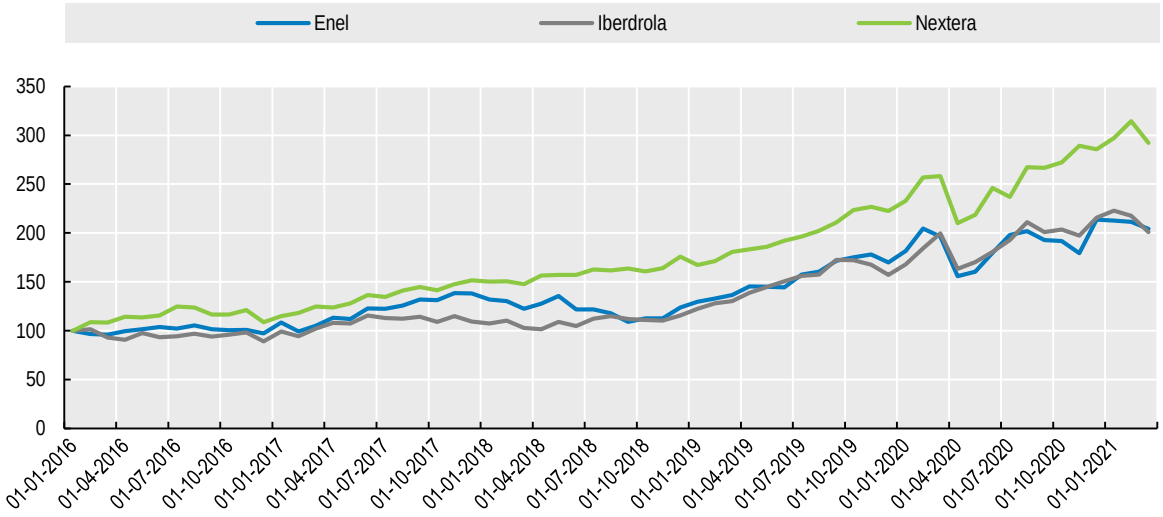
Note: Companies selection based on market capitalisation and Refinitiv industry classification
Source: Refinitiv, OECD calculations

In sharp contrast to declining demand for all other energy sources, renewables energy demand grew 1% in 2020 and at the same time, renewables used for generating electricity grew by almost 7%. The renewable energy sector includes solar, wind, hydropower and biomass technologies among others and they provide for electricity production, heating and transportation. Driven by China and the United States, renewable capacity grew by nearly 4% globally in 2020, with additions of wind and hydropower taking global renewable capacity additions to a new record, accounting for almost 90% of the increase in total power capacity worldwide. In the European Union, capacity additions are forecasted by the IEA to jump in 2021 as a result of solar PV and wind projects in France and Germany. Growth is supported by jurisdictions' policies to meet the 2030 renewable energy target and by the EU recovery fund providing low-cost financing and grants.

Other renewable energy companies include utilities companies, which are shifting their business models to renewable energy sources, with positive effects on their valuations. Examples of utilities shifting to renewable include Enel, a large Italian utility, Iberdrola, a Spanish utility, and NextEra, a US based company, among others. NextEra for example developed its first wind farm more than two decades ago. More recently, it has invested heavily into solar, now standing as the single largest solar fleet outside of China, according to Wood Mackenzie data (Green Tech Media, 2020). The early shift to renewable energy is reflected their Price-to-Earnings ratio, which increased steadily in recent years.

Low-carbon emitters are trading at increasingly elevated premiums compared to high carbon emitters (Brookfield, 2021). This is reflected in the valuation of utilities investing heavily into renewables compared to the rest of the market. For example, Iberdrola has announced investments up to USD 75 billion over the next five years to increase its renewable energy capacity. Similarly, Enel announced that it would invest over USD 70 billion during the next decade on growing its renewable power capacity.

Figure 33. Utilities investing heavily into renewables assets have increased their valuations



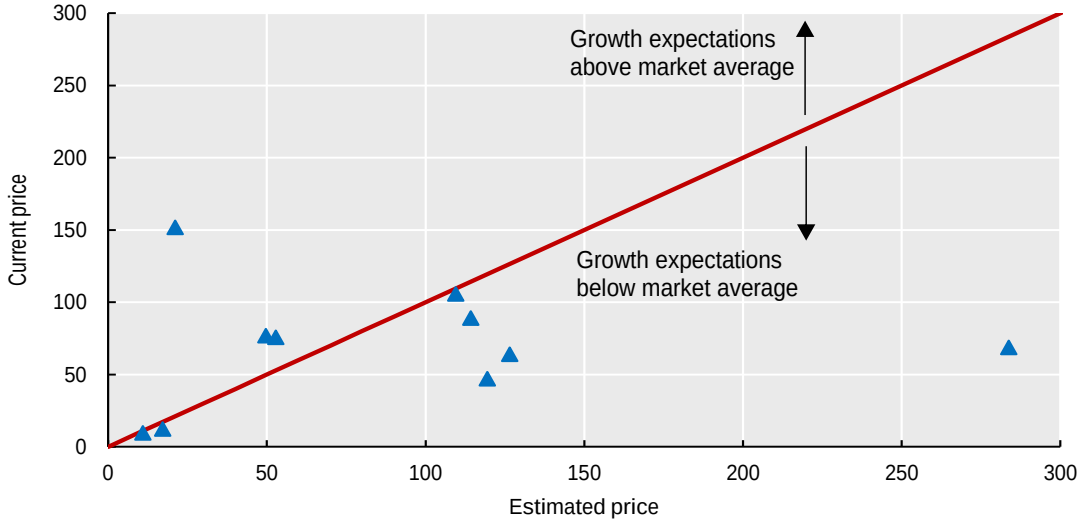
Note: Selected utilities companies based on market capitalization.
Source: Refinitiv, OECD calculations

The analysis in Figure 34 uses a simple methodology to compare current prices with a simulation of prices based on historical market growth rate assumptions (see Annex C). Nonetheless, while this is a simplified approach, the aim is to help policy makers understanding the wide range of current and estimated prices to determine if investors think future growth will differ significantly from the past. The Figure suggests that investors might be expecting utilities to grow at a slightly lower level compared to market growth rates on average, with the exception of some outliers. The analysis highlights ten utilities

companies incorporated in OECD countries, which have been analysed using predetermined assumptions on market rates. In this case there are differences among utilities analysed, as companies above the line are expected to grow more than the market, while companies below the line are expected to grow less than the market average growth rate. While there are many factors affecting valuation, the evidence from climate reporting for the companies analysed is that companies that are implementing a stronger and more defined climate transition plan are seeing their stock prices increase and are generally expected to grow more than average market growth rates.

According to the analysis,[52] some renewable energy utilities companies are generally expected to grow more than the market, possibly due to their high investment in renewable energy products and infrastructure. For example, among companies that could be expected to grow more than the market average rate there is NextEra Energy, a company that is investing heavily into renewable energy sources compared to other competitors, including solar and wind. Even in this case prices could depend on the current outlook of the renewable energy situation, due to the strong interest of stakeholders to shift to greener opportunities, which in turn might be affecting market valuations.

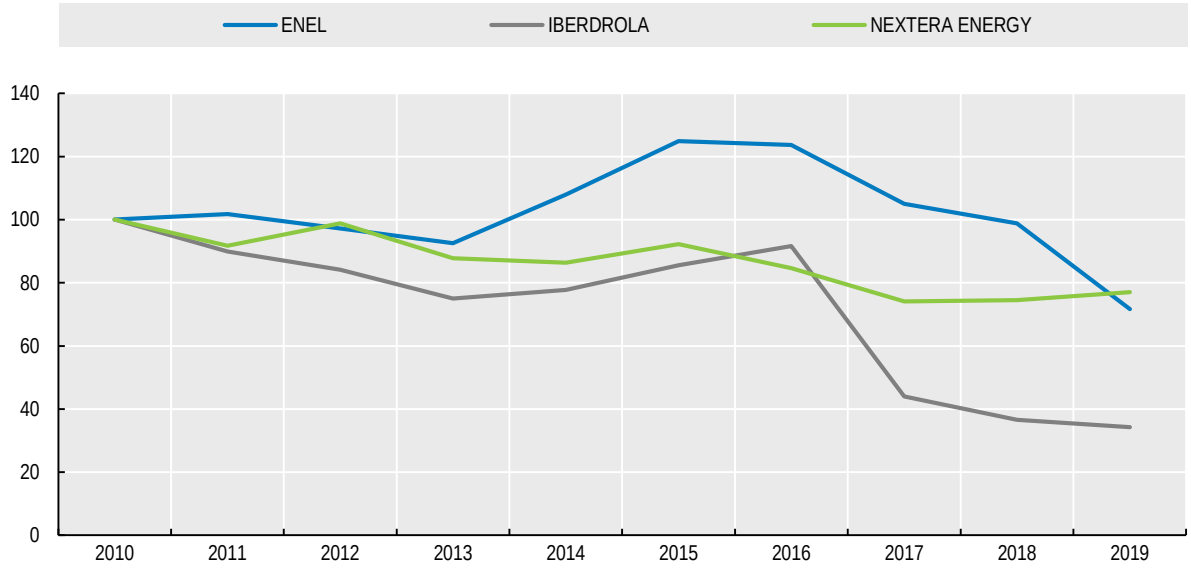
Figure 34. Some major utilities in OECD economies could be expected to grow at a higher rate than the market average



Note: See Annex C for additional information on the analysis.
Source: Refinitiv, OECD calculations

Moreover, utilities companies investing in renewable energies have seen their carbon intensity decrease dramatically in the past decade. Some utilities companies have recently improved efforts to shift to a more sustainable business model, reflecting changes in their operations emissions and increasing their investments in green assets. Global renewable energy capital expenditure is set to increase 14% in the five years ending 2025, compared with spending in the 2015-2019 period, according to IHS Markit.

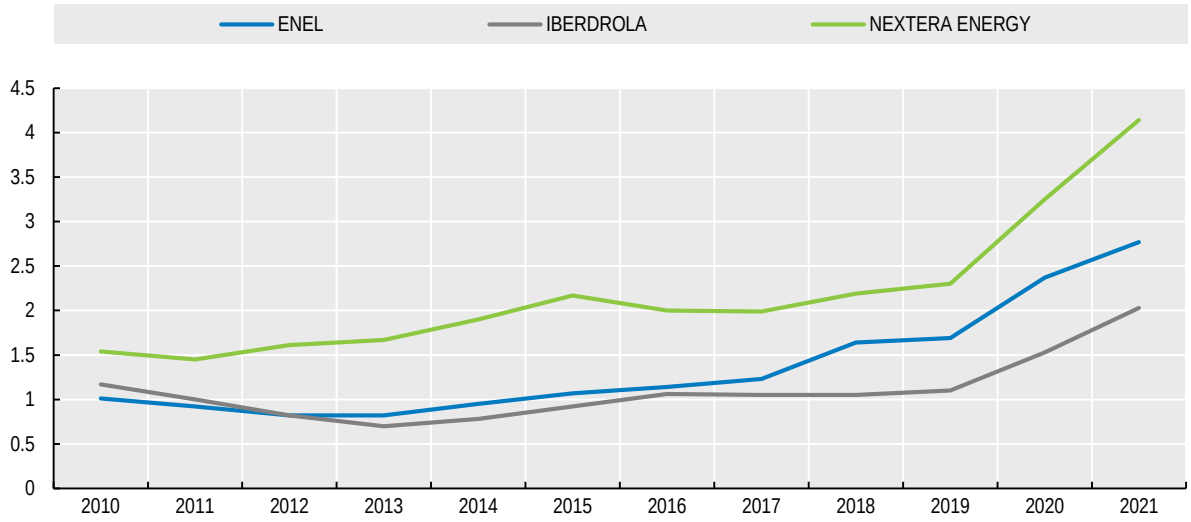
Figure 35. **Selected utilities' carbon intensity has decreased in recent years**



Note: Carbon intensity measured as Total CO2 and CO2 equivalents emission in tonnes divided by net sales or revenue in US dollars in million.
Source: Refinitiv, OECD calculations

Similarly to stock valuations, the Price-to-Book ratio for the selected companies has increased steadily in the past decade, with a further spike more recently. The recent spike could reflect increasing awareness of the climate transition needs. The Price-to-Book ratio for the companies analysed is higher than the industry average, which equals to 1.84 in 2021.

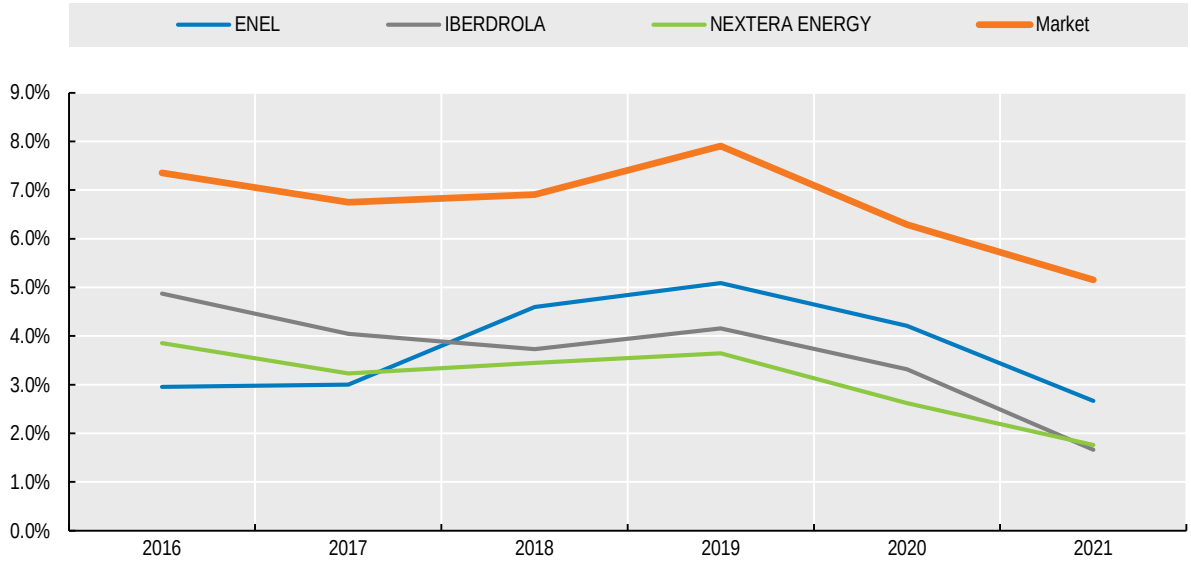
Figure 36. The Price-to-book ratio increase could reflect improved prospects in renewable energy utilities



Note: The Price-to-Book ratio is calculated by dividing a company's stock price per share by its book value per share (BVPS).
Source: Refinitiv, OECD calculations

At the same time, the WACC has decreased in recent years for companies investing heavily into renewables. This decrease could reflect improvements in the efficiency of alternative energy source technologies as well as cost reductions which should make the industry more profitable in the long term. Normally, this could be related to the decreasing cost of debt in recent years, which benefitted companies with capital intensive models, but this is not the case for the selected companies as shown in figure 37. Nonetheless, the WACC of these companies is not only decreasing, but lower than industry average.

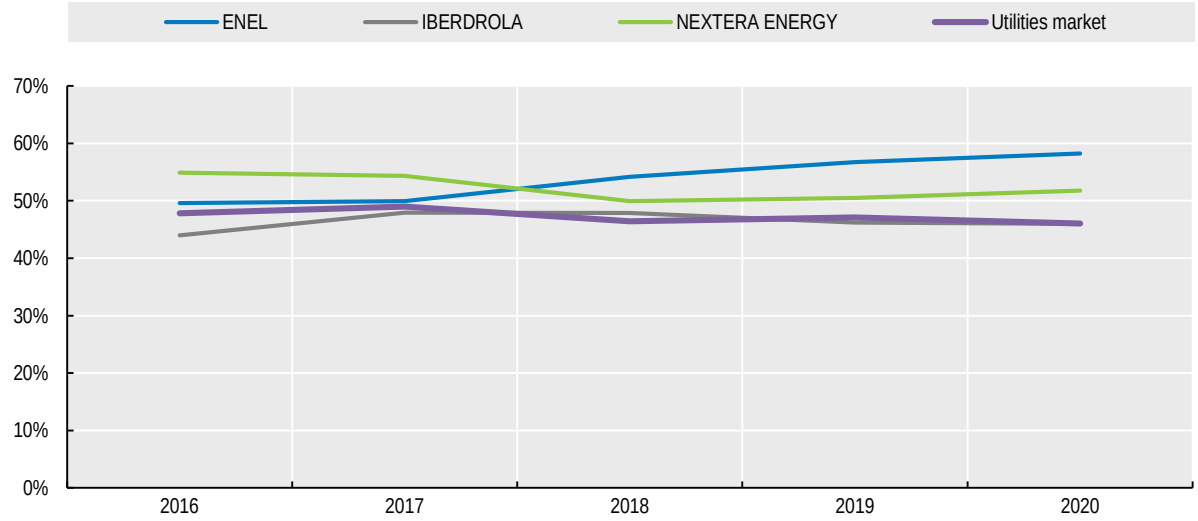
Figure 37. Investments into renewable energy projects have decreased the WACC of utilities



Note: The WACC (weighted average cost of capital) is a financial metric used to calculate a firm's cost of capital in which each category of capital is proportionately weighted. All sources of capital including equity stock, preferred stock and debt are included in the calculation.
Source: Refinitiv, OECD calculations

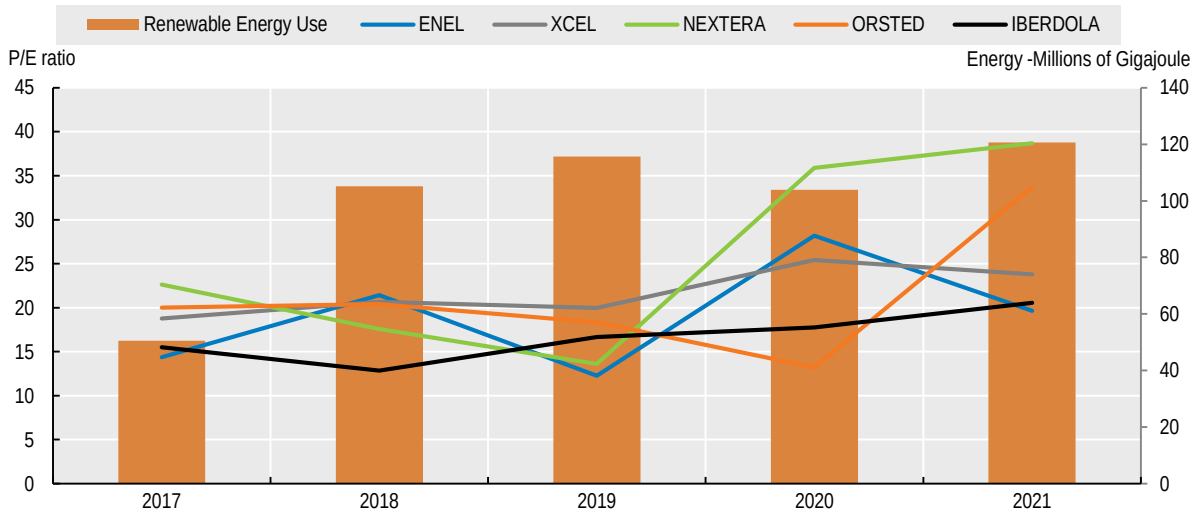
Moreover, major utilities companies seem to have maintained a stable debt-to-capital ratio very similar to the trend for the overall utilities market. This could be due to utilities' business models, which generally require companies to take on relatively large amounts of debt to finance the investments in infrastructure and to improve their efficiency.

Figure 38. The Debt-to-Capital ratio has remained relatively stable for utilities companies



Source: Refinitiv, OECD calculations

Figure 39. The Price-to-Earnings (P/E) ratio of utilities companies has increased from already high levels alongside a greater use of renewable energy



Note: Trailing P/E ratio against Renewable Energy Use Average for selected companies in the Utilities industry. The Renewable Energy Use Average is calculated on a sample of ten companies based on market capitalization: ENEL, XCEL, SOUTHERM, AMERICAN ELECTRIC, DUKE, NEXTERA, ORSTED, IBERDOLA, DOMINION ENERGY, EXELON.
Source: Refinitiv, OECD calculations

There seems to be a stronger differentiation between climate transition opportunities and risks in the utilities sector, where the transition appears to affect many aspects of companies' strategy, making climate transition plans' implementation more likely to influence valuations over time. The low-carbon transition could make current capital investment stranded assets, preventing shareholders from reaping the gains of current expenditures. Renewable energy technologies, on the other hand have seen decreasing costs in the past decade, due to efficiency improvements and investments, which has in turn

attracted customers and investors. While markets are starting to prepare for the transition, governments need to lay out a clear framework to avoid chaotic situations that could damage the economy.

Nonetheless, there appear to be strong differences in market pricing of industries that have committed to implement climate transition strategies. The oil and gas industry, despite the commitment of many players to reduce their carbon emissions and to shift their core business model to a more sustainable one, seem to be correlated to oil price movements, suggesting that financial markets may not yet be reflecting the announced changes. This might be due to the fact that oil and gas companies' current capital spending in low-carbon technologies remains very limited compared to overall expenditures, raising questions as to the timeline of the transition.

On the other hand, markets seem to be starting to price innovation in the auto industry, particularly as many are creating new factories and implementing substantial changes to include alternative energy vehicles in their existing fleets. The current pricing could be due to the fact that auto companies might face fewer challenges in implementing actionable climate transition plans due to their business model, given the relatively easy possibility to repurpose existing factories for the production of green vehicles and that current capital expenditures represent an important part of their investments.

Similarly, the renewable energy industry has a temporal advantage, which seems to be reflected in financial markets. Valuations of renewable energy companies have increased considerably in recent years, as opportunities appear to outnumber risks and increasing investments have improved scalability and enhanced technology efficiency, allowing reduced costs and improved profit margins.

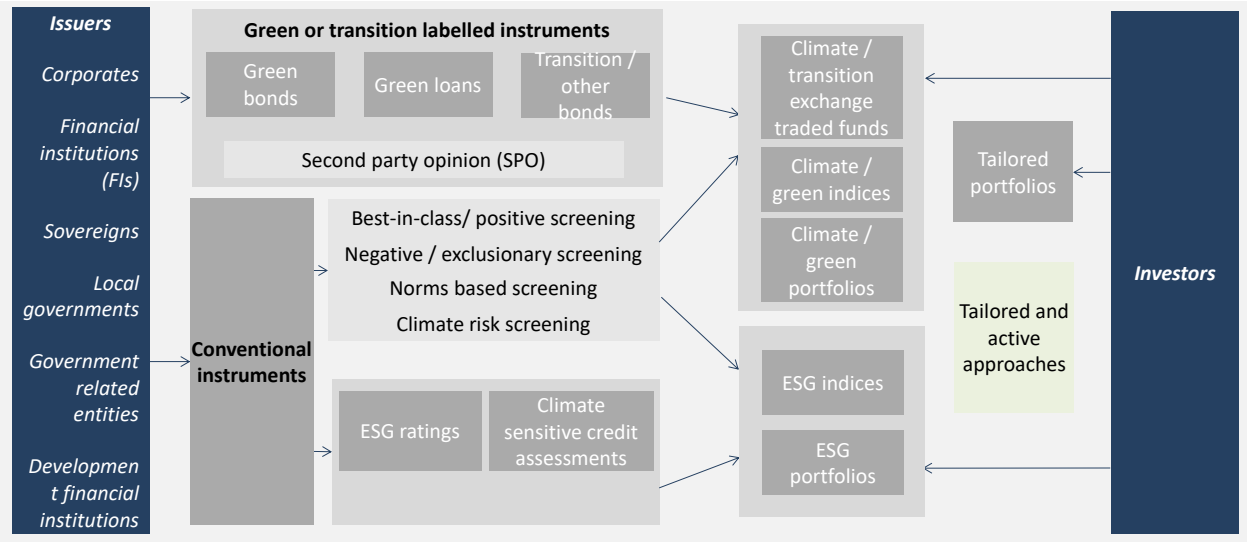
While markets appear to be pricing the industries analysed differently based on future prospects and other factors (benefitting from an increasing amount of information available), data gaps remain, particularly with regards to the Environmental Pillar data of ESG rating, and the relative subcategories associated with climate transition risks and opportunities (Boffo, R., C. Marshall and R. Patalano, 2020). This lack of interoperable and comparable data hinders the confidence with which market participants can assess strategies and forward looking information to incorporate into valuations, and in turn can result in a risk premia due to information asymmetries. Nonetheless, it is likely that as progress is made in the data quality, markets will be able to discern better over time where there are potential upside opportunities driving future value.

Further assessment is therefore needed to understand the valuation prospects of firms that are actively embracing the climate transition, in their strategies, capital investments, and operations, as well as to make sure that climate transition plans announced are reported, implemented and ultimately verified against science-based targets to make sure investors are properly able to assess how companies are navigating a low-carbon transition.

4. Financial market products and practices to support the low-carbon transition

To support the low-carbon transition, a growing number of financial market products, practices, and tools have emerged. They encompass instruments for issuers, third party ratings, principles and guidance, as well as index and portfolio products to help channel financing to transitioning entities, and also to better price the risks and benefits of the transition (Figure 40). These products, practices and tools have been developed to support issuers and investors in activities in line with the climate transition and to achieve risk-adjusted returns. If fit for purpose, they have the potential to improve information flow, price discovery, market efficiency, and liquidity in support of a low-carbon transition. More importantly, in the event that the transition is disorderly and involves sudden changes in policy coordination, these products, practices and tool could help markets manage exposure, absorb losses on carbon-intensive assets, and redirect investments to parts of the market that will efficiently contribute to the transition. In doing this, the growing array of products, practices and tools could help make markets more agile in facilitating an orderly transition through price discovery and capital flows.

Figure 40. A growing number of financial market products, practices and tools are emerging with the aim to facilitate a low-carbon transition



Note: Non-exhaustive illustration
Source: OECD research

Improvements to these, including through greater transparency, interoperability, and comparability of metrics and methodologies, could bolster the appropriate use (i.e. absence of ESG or green washing) of such products and tools to support an orderly transition. To further assess this, this section will provide a non-exhaustive overview of selected products, practices and tools with a focus on ESG ratings and investment, green bond markets, climate indices and portfolios, principles and guidance, and the integration of climate sensitive risk assessments into credit ratings and stress testing exercises.[53]

4.1. Climate-related taxonomies, definitions, principles, and disclosure frameworks

In recent years, a number of taxonomies, definitions, principles and disclosure frameworks have been developed that define and govern financial market products to support the climate transition. Notably, a number of jurisdictions have started to create official definitions of sustainable finance, including the EU, China, Japan (Box 5), France and the Netherlands among others, which include official definitions for green loans and green bonds. Of these definitions, taxonomies are typically definitions or comprehensive classification systems of climate-aligned financial products or instruments, while principles tend to be broader guidance that could aid the further development of regulation or taxonomies in future (OECD, 2020b). In addition, dialogues across governments, and between public and private financial institutions, including multilateral organisations have given rise to an array of disclosure frameworks with varying focuses and objectives.

Box 5. Japan's approach for promoting climate transition

The Japanese government aims to achieve carbon neutrality and a decarbonised society by 2050, declared by Prime Minister Suga in his first policy speech on October 26, 2020, therefore economic transition is vital in order to achieve this. Following multiple discussions, the Japanese Ministry of Economy Trade and Industry (METI)[54] in cooperation with Japan's Financial Services Agency (FSA) and the Ministry of Environment set out in December 2020 the new study group to develop basic principles for financing transition bonds and loans. The principles, set out in the Basic Guidelines on Climate Transition Finance, were finalised in May 2021[55], building on the ICMA's Climate Transition Finance Handbook[56], which was published in December 2020 as the output by the ICMA's study group. In particular, the principles outline issuer-level disclosure relevant to transition finance, notably for 'hard-to-abate' sectors and provides recommendations in four key areas:

(i) issuer's climate transition strategy and governance;
(ii) business model environmental materiality;
(iii) climate transition strategy to be 'science-based' including targets and pathways; and
iv) implementation transparency.

To implement the recommendations, the METI established a taskforce composed of industry, finance and environmental experts to establish targets and decarbonisation pathways across sectors (called as the industry's roadmap) to encourage industry transition efforts in line with the Paris Agreement and reduction targets in line with Japan's nationally determined contribution (NDC).

In parallel, the FSA established an Expert Panel on Sustainable Finance in December 2020 to discuss sustainable finance issues and policy approaches related to financial institutions, as well as financial and capital markets more broadly. The Expert Panel report,[57] published in June 2021 focuses on 1. The enhancement of corporate disclosure, 2. demonstration of capital market function in line with a transition, and 3. financial institutions' support for borrowers and risk management. The report

concluded that the FSA should continue to discuss with financial institutions on the effective use of scenario analysis and encourage them to develop a risk management system for climate change. Following which, the FSA and Bank of Japan (BOJ) initiated a pilot exercise on scenario analysis using NGFS scenarios with major financial institutions. The purpose of the exercise is, through the discussion with the participating financial institutions, to better assess climate-related risks for financial institutions and identify challenges for financial institutions in the methodology of their ongoing scenario analysis practices and in utilising scenario analysis for strategic planning, including to support borrower's transitions to low-carbon business models. Various divisions within the FSA and the BOJ are taking part in the exercise to facilitate cross-sectoral discussions.

Meanwhile, in June 2021, the BOJ decided to introduce a new fund-provisioning measure to support private financial institutions in their efforts to address climate change issues. The measure provides funds to financial institutions against investment or loans they make to address climate change issues. It allows private financial institutions to respond flexibly to firms' funding needs and to contribute to addressing climate change. The fund provisioning through this measure will likely to be launched within 2021.

On strengthening corporate disclosure, Tokyo Stock Exchange revised the Corporate Governance Code[58] in June 2021. Based on the Code, future Prime Market listed companies will be asked to enhance the quality and quantity of climate-related disclosure based on TCFD recommendations or equivalent international frameworks. In addition, the FSA announced the establishment of a working group under the Financial System Council to discuss further (with a broad range of stakeholders) disclosure systems including sustainability-related disclosure and contribute to a constructive dialogue between listed companies and investors. The FSA has also co-hosted a workshop with the Carbon Disclosure Project (CDP) on Scope 3 financed emissions by financial institutions and to distribute information on the PCAF (Partnership for Carbon Accounting Financials). Furthermore, a newly established Sustainable Finance Office of the FSA has been established to engage with the clients' and support an effective climate transition.

Source: Box prepared by Japan Financial Services Agency (FSA), Ministry of Economy, Trade and Industry (METI), and Ministry of Environment (MoE).

Taxonomies may be designed to serve domestic or regional environmental or climate-related objectives, with a need for interoperability across markets to guide corporate and financial actors in issuer disclosure, index creation and rating methodologies. To serve their purpose effectively, taxonomies should be properly designed to assess not only the extent to which a company's activities are 'brown' or 'green', but the extent to which a company is taking verifiable steps to transition to low-carbon activities in a given timeframe. Currently, taxonomies, definitions and principles take into consideration a range of objectives on environment, climate, social and governance, and in large part assess the extent to which companies overall activities are 'brown' or 'green'. A number of taxonomies, definitions and principles also endeavour to take a systems approach in which they try to differentiate between economic activities and account for a range of different pathways that could lead to longer-term climate-resilient or low-carbon transition objectives. Doing this effectively would also require that innovations, technological developments and potential opportunities are all captured within taxonomies, definitions and principles. These will also need to be sufficiently easy to understand, interpret and use for end users, issuers and investors, which is important for quick and efficient market uptake, not to mention that data should be available and verifiable in line with scientific-based or industry recognised standards.[59]

When appropriately designed, sustainable finance definitions and taxonomies can bring potential benefits that improve market efficiency and integrity and support the appropriate market pricing of climate-related risks and opportunities. In particular, taxonomies can help avoid green washing, reduce market fragmentation, and accelerate the flow of investment to sustainable economic activities. Taxonomies can serve as a basis to develop incentives for channelling investments to desired objectives. They can also facilitate the monitoring of such flows. However, given that the terms green and sustainable

are in cases used interchangeably and in other cases used distinctly (to refer to a range of objectives), greater clarity and interoperability may be needed across taxonomies, definitions and principles.

In addition, a number of non-binding reporting frameworks have emerged that provide guidance as to environmental and climate-related corporate disclosure (Table 5).[60] The Carbon Disclosure Project releases annual disclosure questionnaires with a focus on climate change, forests and water security. The Global Reporting Initiative has released several iterations of guidelines with relevant metrics to measure environmental impact for multiple sectors. The Sustainability Accounting Standards Board (SASB) identifies standards that are likely to constitute material information targeted to specific sectors. The International Integrated Reporting Council (IIRC) draws on a number of standards to identify areas for integrated accounting of non-financial information relating to the environmental and governance activities. The FSB's Task Force Climate-related Financial Disclosures (TCFD) provides company reporting guidelines on climate, energy, and waste and water management. Additionally, the Climate Disclosure Standards Board's (CDSB) guidelines focus on the management of environmental policies, strategy and targets, including risks and opportunities in line with the TCFD framework. In 2019, Nasdaq released their second ESG reporting guidance for listed companies across 30 categories, with 55 corresponding metrics, including 17 within the environmental pillar, which provide a benchmark and reporting prioritisation for companies.

Table 5. Corporate reporting frameworks with environmental or climate-related guidelines

	Year	Purpose	Scope
Carbon Disclosure Project	2002	Releases annual disclosure guidelines on emissions, climate hazards and mitigation, water and governance	CDP provide questionnaires for company disclosure across climate change, forests and water security that cover emissions, carbon pricing, and governance
Global Reporting Initiative	2006	Global standards for companies to report on economic, environmental and social impact	The G4 sustainability reporting guidelines provide 34 metrics to measure environmental impact across a range of sectors
Sustainability Accounting Standards Board	2011	Provides basic concepts, principles, definitions, and objectives to guide sustainability accounting	Sector specific guidelines with between 10 and 29 environmental metrics per sector, and a median of five disclosure topics
International Integrated Reporting Council	2012	Framework to identify areas for disclosure and reporting relating to the environmental and governance activities of companies with the aim to maintain value creation over time	Outlines the context for environmental performance data and clarifies how value relevant information fits into operations or a business, and may help make company decisions more long-term
Task Force Climate-related Financial Disclosures	2015	Provides company financial reporting guidelines on climate, energy, waste and water management	TCFD make recommendations on targets and metrics that cover 28 key issues, with complementary guidance on management and processes
Climate Disclosure Standards Board	2015	Provide material information for investors and financial markets through the integration of climate change-related information into mainstream financial reporting	Provides non-sector specific guidelines across 12 categories for companies to report on environmental and climate change matters, including environmental policies, strategies and targets including guidelines for the assessment of impact
Nasdaq ESG Reporting Guide	2019	Provide guidance to listed companies on environmental reporting, and promote dialogue between investors and companies of the performance signal of better data on the topic	Outlines 17 metrics across 10 categories to assess environmental and climate related performance. Guidance is also given on measurement methodology of each metric

Source: OECD views based on publicly available information. The Nasdaq Guide provides an example of progress made by stock exchanges around the world.

Box 6. Bank of England approach to the supervision of climate-related risks and climate disclosure

The objective of the Bank's work on climate change is to '*build a UK financial system resilient to the risks from climate change and supportive of the transition to a net-zero economy*'. This box sets out how the Bank has applied this objective in the context of two key areas of its broader climate strategy: (i) prudential supervision of banks and insurers and (ii) support for TCFD-aligned climate disclosure.

PRA supervisory expectations for enhancing banks and insurers' approaches to managing the financial risks from climate change

Mark Carney's Tragedy of the Horizon speech in 2015 highlighted the Bank's growing concern with financial risks from the physical effects of climate change and the transition to a carbon-neutral economy. The Prudential Regulation Authority (PRA) explored this further in a report on the UK banking sector in 2018 and found that only 10% of firms were taking a strategic approach to climate risk. To address this, in April 2019, the PRA became the first prudential regulator to detail comprehensive supervisory expectations for banks and insurers on how they should manage financial risks from climate change through the publication of Supervisory Statement 3/19 (SS3/19).

These supervisory expectations were designed to help ensure that firms take a strategic approach to managing climate-related financial risk. To meet these expectations firms are expected to: embed climate risk into their governance framework; incorporate climate risk into existing risk management frameworks; undertake longer-term scenario analysis to inform strategy and risk assessment; and develop an appropriate approach to climate disclosure.

These represent material and in many ways unprecedented changes, so the PRA did not initially set a date for them to be fully embedded. Instead, firms were required to submit plans by October 2019 for how they intend to embed these expectations. Whilst plans showed firms had made a reasonable start, there was a significant divergence in responses between more pro-active firms and those who had only recently begun to consider the issue.

In July 2020, the PRA followed up SS3/19 with a Dear CEO letter. The letter gives sector-wide feedback on progress against the expectations set out in SS3/19 and provides more detailed guidance for firms. In light of this feedback, the letter set a deadline of end-2021 for firms to have fully embedded the PRA's expectations. The letter also notes that the PRA will work with firms to better understand how they are linking their understanding of climate risks to capital requirements. Whilst the PRA has not said that climate risks will be a formal part of its capital framework, as set out by Andrew Bailey in his November 2020 Green Horizon Speech, firms should seek to avoid defaulting to zero capital on the grounds of insufficient data.

Since the launch of its supervisory expectations, the PRA has actively engaged with financial firms to build understanding of its expectations on climate change and support efforts to develop capabilities. In June 2020, the CFRF published a guide for the financial sector containing practical tools, information and case studies on climate risk management, scenario analysis, disclosure, and innovation. The PRA's supervisory focus for 2021 will be on assessing firms against its supervisory expectations in the lead up to the deadline at the end of the year.

Climate disclosure

The Bank of England considers climate-related financial disclosure to be critical for consumers, businesses, financial firms, investors, policy makers and other stakeholders to make informed decisions. Disclosure is important for not only transparency and risk management purposes, but also

as a way to enable the flow of capital towards investments that are consistent with an orderly transition to net-zero emissions. Consequently, it is also integral to the UK's legislative commitment to reach net-zero emissions by 2050.

The Bank supports the adoption of the disclosure framework established by the FSB's Taskforce on Climate-related Financial Disclosure (TCFD). The information in these disclosures needs to be consistent, comparable, comprehensive, and available within a short timeframe to be useful.

On 9 November 2020, the UK Government announced its intention to make TCFD-aligned disclosures mandatory across the economy by 2025, with a significant portion of mandatory requirements in place by 2023. This was the culmination of the work of a UK Government-Regulator taskforce, set up to examine the most effective way to approach climate-related financial disclosures. An indicative path to UK mandatory disclosure was set out by the taskforce in a report and roadmap. A significant proportion of the economy will be captured, including listed commercial companies, UK-registered large private companies, UK-authorised asset managers, life insurers, FCA-regulated pension schemes and occupational pension schemes. These requirements are complemented by the PRA's existing expectation that banks and insurers should report their climate-related financial risks as part of their supervisory disclosures.

The Bank of England holds itself to the same high standards as the firms it regulates. Therefore, in June 2020, the Bank published its own TCFD-aligned climate report setting out its approach to managing the risks from climate change across its entire operations and what it is doing to improve its understanding of these risks. This sets out the Bank's broader climate strategy which is one of its strategic goals.

Source: Box prepared by Bank of England staff, E. Denbee, Z.Jamal, T. Lober, and J. Lowe.

The multiplicity of definitions of 'green' and 'climate-resilient' investments is an important barrier to improving market efficiency and integrity to support the reallocation of capital in line with a low-carbon transition (OECD, 2020b). Within this, two factors need to be taken into consideration. First, investors and markets need accurate and comparable information on companies' environmental and climate-related performance and activities in order to assess to what extent this fits with investment strategies they have in place today. Second, and perhaps more difficult, investors and markets also need products that accurately integrate information on how companies are assessing and responding to risks posed to their operations in the medium and long-term as a result of carbon transition. Therefore, in light of the present and future requirements a low-carbon transition, taxonomies, definitions, principles, and disclosure frameworks will need to ensure that they take both environmental performance today but also forward looking transition processes into consideration.

Box 7. Swiss Federal Department of Finance's approach to climate disclosures

On 26 June 2019, the Swiss Government established a working group to assess the existing framework and evaluate the need of regulatory measures to enable Sustainable Finance to thrive. Based on this first analysis, the Government instructed the Federal Department of Finance (FDF) on 6 December 2019 and 24 June 2020 to assess the need for action in the areas of sustainability related transparency and risk assessment by the end of 2020 and, if necessary, to submit proposals for legal adjustments. On 24 June 2020, the Government also adopted a report and guidelines on sustainability in the financial sector: The Swiss financial centre should further strengthen its position as a leading location for sustainable financial services.

In February 2020, the FDF formed two technical working groups consisting of industry representatives, NGOs and government agencies: "Sustainable Finance - Transparency and Due Diligence" and "Sustainable Finance - Risk and Stability". The two key findings were:

1. For an optimal allocation of financial resources with regard to their environmental impact, as well as for the consideration of environmental risks, it is most effective and efficient to internalise the external costs that arise from environmental and climate damage in the real economy (e.g. by means of a global C02 levy).
2. Decision-ready and forward-looking disclosures of high quality and comparability on sustainability related risks and impacts from companies are of key importance. They allow financial institutions and their customers to incorporate sustainability into their decision-making, thus reducing systemic risk and promoting the alignment of financial flows with international goals and commitments.

On 11 December 2020, the Government presented concrete proposals on how to strengthen Switzerland's role as a global leader in sustainable financial services. In this context, the Government called on Swiss companies from all sectors of the economy to implement the recommendations of the Task Force on Climate related Financial Disclosures (TCFD) on a voluntary basis. The authorities are to prepare the binding implementation of these recommendations by Swiss companies in all sectors of the economy. On 12 January 2021, Switzerland officially became a supporter of the Task Force on Climate-related Financial Disclosures (TCFD).

For financial institutions, the repercussions of climate change can entail significant longer-term financial risks. In principle, financial institutions can build on their existing risk management systems. However, new developments in this sphere and new risk drivers in risk management must also be effectively identified and appropriately managed. In the area of disclosure of climate-related financial risks, the Swiss Financial Market Supervisory Authority (FINMA) has identified a targeted need for regulatory action in the balance sheets of its supervised entities and is setting out the corresponding regulatory details accordingly. The regulatory approach of FINMA is based on the TCFD recommendations. A consultation on the amended circulars ended on 19 January 2021.

Climate alignment disclosures

Financing and investments are considered climate compatible when they are in line with the internationally agreed climate target of keeping global warming under 2 degrees. The federal government periodically records the climate impact of voluntary efforts.

After 2017, the Federal Office for the Environment and the FDF initiated a second, comprehensive test in 2020 to analyse the climate goal alignment of financial portfolios. This test is being carried out under the title PACTA 2020 (Paris Agreement Capital Transition Assessment). All Swiss banks, asset managers, pension funds and insurance companies could test their portfolios anonymously on a

voluntary basis. The pension fund association ASIP, the Swiss Insurance Association SVV, the Bankers' Association SBA, the Fund and Asset Managers' Association SFAMA and the Conference for Investment Foundations KGAST support the climate compatibility tests.

A total of 179 financial institutions voluntarily participated this time – more than twice as many as in 2017. The results show a representative picture of the whole Swiss financial market: around 80 per cent of investments in global equity and corporate bonds, half of all properties held by institutional investors and three-quarters of Swiss residential buildings covered by mortgages were assessed. Moreover, a qualitative survey provides information about climate-relevant strategies, while a stress test highlights risks. The results of these representative tests create transparency while supporting the efforts of the financial institutions involved to guide their investments onto a climate compatible pathway. At the same time, the results show, that there is still work to be done.

Selected international Initiatives

In April 2019, both FINMA and the Swiss National Bank (SNB) became members of the Network for Greening the Financial System (NGFS). On 2 October 2019, Switzerland joined the Coalition of Finance Ministers for Climate Action. In joint webinars with the Netherlands, Switzerland shares experience with its climate alignment tests. On 4 March 2020, Switzerland joined the International Platform on Sustainable Finance (IPSF). It co-chairs a working group on sustainability disclosures, together with the European Union and Japan.

Source: Box prepared by Swiss State Secretariat of International Finance (SIF) staff.

4.2. ESG investing and the Environmental Pillar

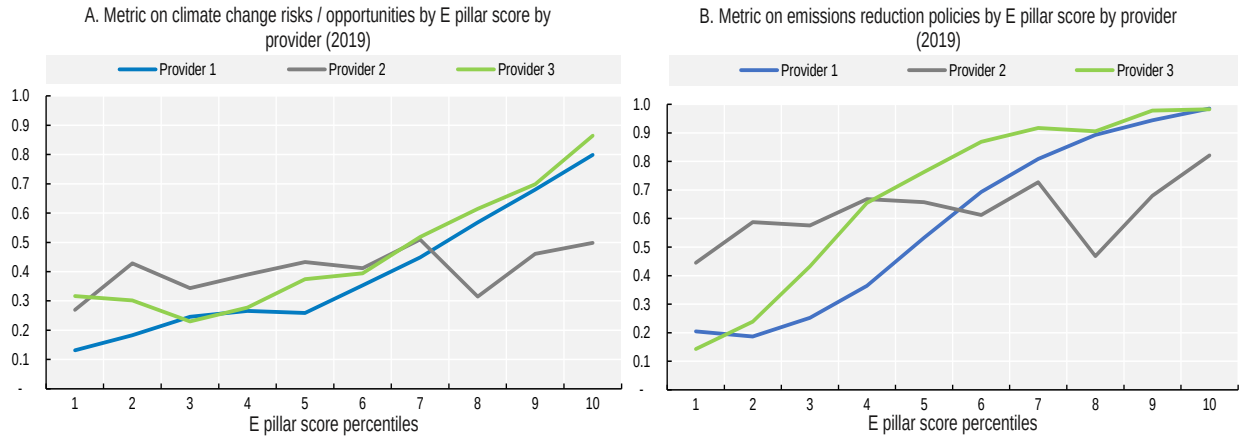
Environmental, Social and Governance (ESG) investing approaches have grown considerably and are increasingly used as a tool to align finance with long-term value, including climate-related risks and opportunities, yet more could be done to ensure that these align with carbon intensity and transition-related opportunities to better support valuations. Environmental "E" pillar scores and indices produced by rating providers and investment funds strive to integrate metrics aligned with environmental performance, climate risk mitigation, and strategies towards renewable energy (among other topics). ESG ratings are then used by a range of market participations to integrate ESG considerations into investment strategies, including asset managers, institutional investors and central banks (Box 8), among others. As a result, ESG ratings[61] are constructive in concept, and can be potentially useful in driving the disclosure of valuable forward looking information on companies in line with climate transition risks. However, in practice, there are a number of challenges that may undermine the use of ESG ratings or even E scores to effectively support reallocation of capital and appropriate valuations in the context of a low-carbon transition (Boffo and Patalano, 2020).

Challenges include limited usability and transparency, lack of comparability of ESG criteria and rating methodologies, and limited clarity on the extent to which ESG ratings can unlock information relevant to valuations in line with the low-carbon transition. A multitude of metrics exist for ESG factors with respect to climate, and include carbon emissions, climate change mitigation, adaptation, water, biodiversity, as well as renewables innovations and green opportunities. However, different ESG rating providers apply these metrics in distinct ways, using different sources and types of data, parameters, weightings, and assumptions to fill gaps and supplementary issues factored into scoring (OECD, 2020a). Further, providers appear to under-weigh some negative climate-related metrics such as carbon intensity over time, while over-weighing the 'existence' of climate-related corporate policies, thereby privileging companies for disclosure of transition strategies rather than performance against such strategies. In sum,

these challenges may compromise market integrity and investor confidence and may potentially impede the pace and scale of capital reallocation needed to achieve tangible progress in line with the low-carbon transition.

Notably, the E pillar scores of prominent ESG ratings companies show a lack of alignment with carbon intensity and with the measurement of forward looking metrics leaving room for improvement in order to better support valuations in line with the low-carbon transition. Carbon emissions will need to reduce over time to meet climate transition objectives and to mitigate physical climate-related risks. However, for some ESG rating providers, high E pillar scores positively correlate with high carbon emissions (Boffo, Marshall and Patalano, 2020). While this is not unexpected, it confirms that other factors are driving E scores, including metrics on carbon reduction transition plans (Figure 41), suggesting that the commitment to effectively implement such plans is critical to greening the financial system. One concerning point however, is that many forward looking transition metrics such as climate change risks and opportunities or emission reduction processes, are currently binary disclosure metrics meaning that they give credit to issuers for having transition plans, rather than rating issuers according to a comprehensive analytical framework consistent with interim science-based targets (Ibid, 2020). Therefore, the combined opacity of ESG rating methodologies, non-standardised firm-level disclosures and inconsistencies in selection and measurement of ESG rating metrics, reduces the ability of users – from central banks to private investors -- to assess how externalities from climate change may affect markets and separately how issuers' collective actions contribute to such externalities.

Figure 41. While E scores appear to show a correlation with forward looking transition metrics, these do not reflect **the quality of issuers' transition plans** or represent concrete actions to support a transition



Note: Climate Change Risks/Opportunities metric = "Is the company aware that climate change can represent commercial risks and/or opportunities?" and Emission Reduction Processes/Policies = "Does the company have a policy to improve emission reduction?". The metrics range from 0 to 1, and are commonly binary options (Yes=1 or No=0)
Source: Bloomberg, MSCI, Refinitiv, OECD calculations

Box 8. Growth, performance and resilience of ESG funds

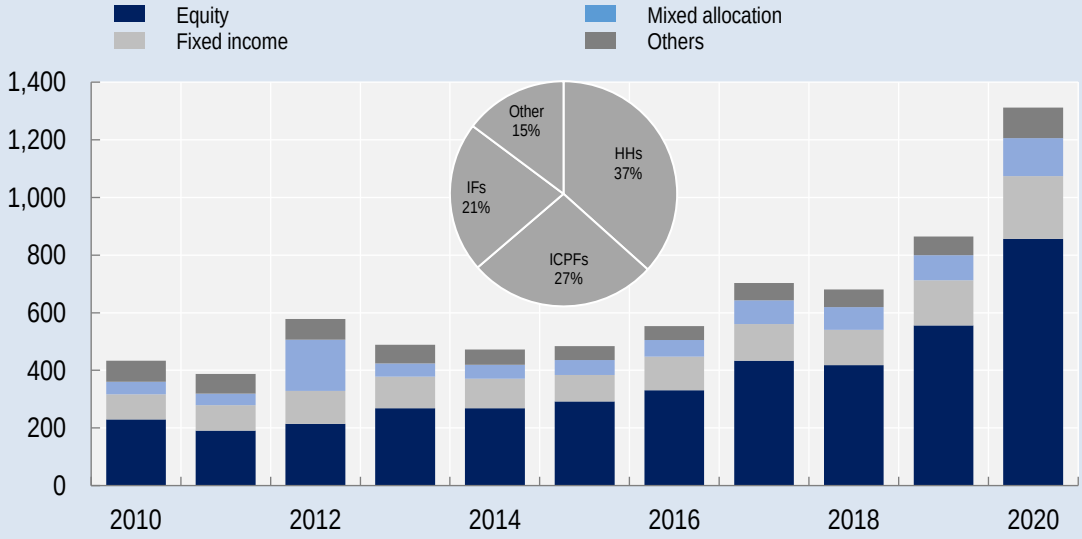
Funds with an environmental, social and corporate governance (ESG) mandate have tripled their assets globally since 2015 and this growth is expected to be sustained over the next years by, among other trends, intergenerational wealth transfer to Gen-Z, rising climate concerns, and better disclosure and understanding of ESG risks. During the market turmoil in spring 2020, ESG funds suffered lower

outflows than non-ESG peers, despite achieving similar performance. This box shows that a possible explanation for this resilience lies in a lower sensitivity of ESG investors to negative performance, which in part reflects their longer-term investment horizon.

Green finance has experienced remarkable growth in recent years, largely driven by euro area agents. Notably, the assets under management (AUM) of ESG funds domiciled in the euro area increased from EUR 250 billion in 2015 to EUR 660 billion at the end of 2020. Euro area households, insurance corporations and pension funds are the main investors, holding over 60% of these assets (Figure 42).

Figure 42. ESG **funds** have grown rapidly in recent years

Assets of global ESG funds, broken down by asset class, and distribution of holding across euro area sectors (Market values in EUR billions; Holdings in pie chart: Q2 2020)

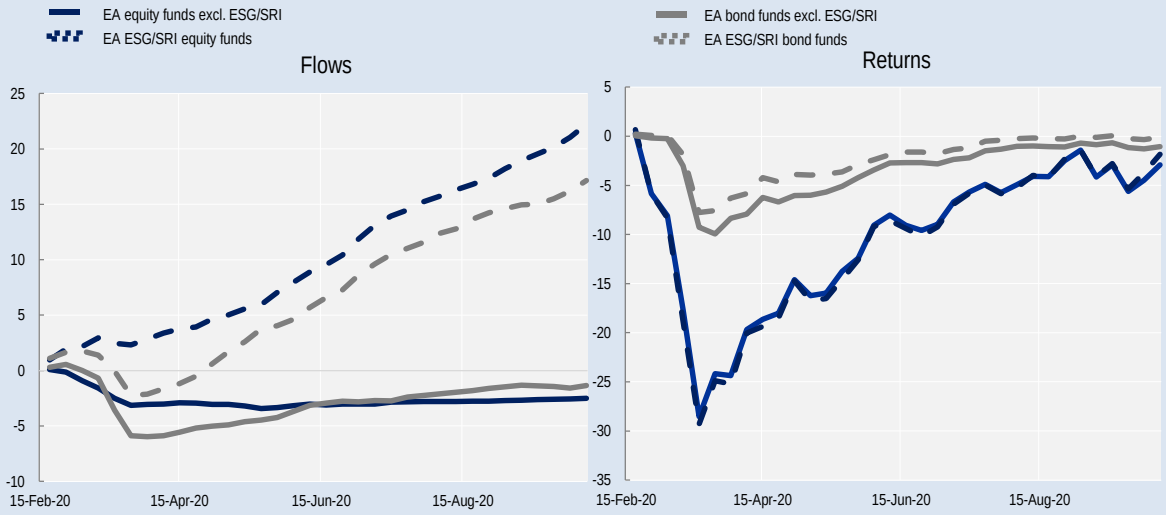


Note: The bars show the assets of funds listed as ESG in Bloomberg. The pie chart shows the holdings of euro area ESG funds across euro area sectors. HHs: households; ICPFs: insurance corporations and pension funds; IFs: investment funds.
Source: Bloomberg Finance L.P., Lipper, Securities Holdings Statistics by Sector, ECB calculations.

During the COVID-19 pandemic-related market turmoil in spring 2020, ESG funds performed as well as their non-ESG peers while also exhibiting greater resilience. After some outflows at the end of March 2020, ESG funds saw over 10% of cumulative inflows in the second quarter of 2020, while traditional equity and bond funds did not recover as much. They also achieved similar performance in terms of returns, suggesting that investors do not need to sacrifice performance to invest in green markets (Figure 43). The exposure of ESG and non-ESG funds to underperforming sectors is also similar. A comparison between the sectoral holdings of equity ESG and non-ESG funds with the same geographical focus shows that the former invests slightly more in IT and health care, at the expense of energy and consumer discretionary, but the difference is small.

Figure 43. ESG funds performed similarly to non-ESG funds last year but suffered lower outflows in March

Cumulative flows and returns of euro area ESG and non-ESG funds (Percentage of total net assets; Feb-Oct 2020)

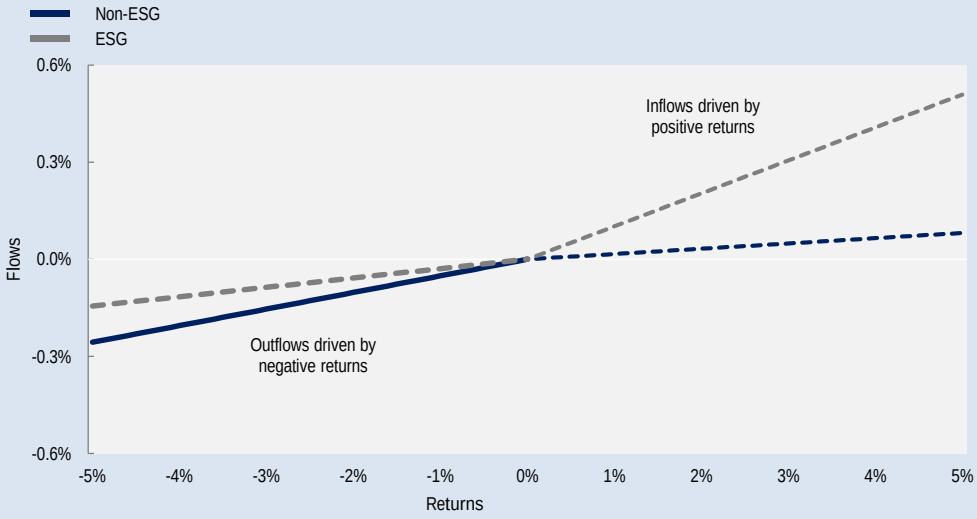


Note: "ESG" stands for "Environmental, Social and corporate Governance", "SRI" for "socially responsible investments". The two types of funds cannot be split in the database.
Source: EPFR and ECB calculations.

Empirical analysis on corporate bond funds suggests that ESG investors are insensitive to negative returns, in contrast to their non-ESG peers. Over the last four years, the sensitivity of ESG fund flows to negative performance has not been statistically significantly different from zero (Figure 44). This differs from non-ESG funds, which exhibit a clear flow-performance relationship following negative returns, consistent with a wide literature.[62] Financial markets can help to support the transition to a more sustainable economy, thereby helping to reduce the vulnerability to climate-related and other sustainability-related risks. Although the lack of a regulatory definition of ESG funds raises concerns over 'greenwashing' risk, by which the continuing shift towards ESG funds can help to foster the green transition, especially given the potentially important role of equity markets in financing green projects.[63]

Figure 44. ESG flows do not appear sensitive to negative fund performance

Flow sensitivities to returns for ESG and non-ESG corporate bond funds between January 2016 and September 2020



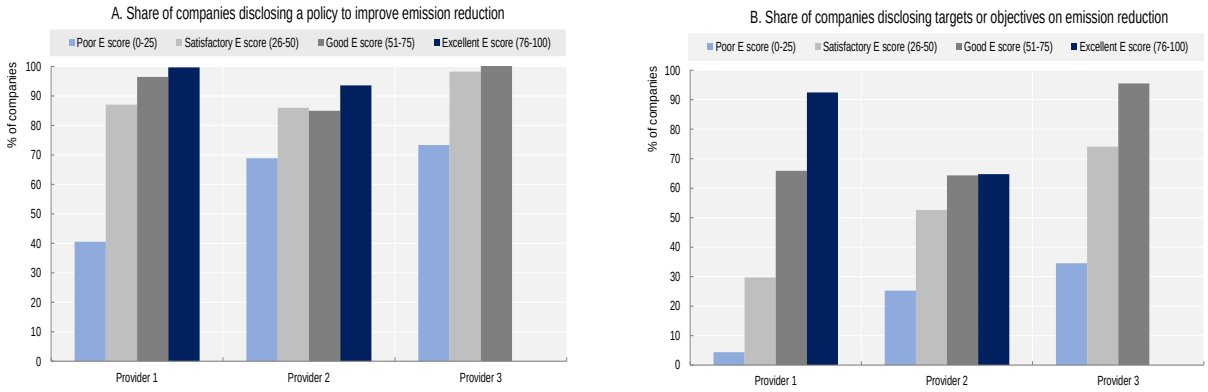
Note: The chart shows the relationship between net flows as a percentage of a fund's lagged total net assets and lagged fund returns. It is based on a sample of 2700 non-ESG shares and 293 ESG shares of corporate bond funds domiciled in the euro area between January 2016 and September 2020. Controls include fund age, fund size, lagged flows and total expense ratio. Time fixed effects are included, and standard errors are clustered at a share level. Dotted lines indicate that estimates are not statistically significantly different from zero at 5% level.
Source: Lipper and ECB calculations.

Source: Box prepared by European Central Bank (ECB) staff, L. Capotă, M. Giuzio, D. Salakhova.

ESG rating providers appear to be giving a higher weight to metrics on the disclosure of company policies, targets and objectives, rather than metrics that measure reduction in carbon emissions and carbon intensity over time combined with increased investment in climate mitigation, adaption and renewable energy. Almost all companies with a high E pillar score disclose company policies to improve emission reduction, and a majority share disclose targets and objectives to implement such policies (Figure 45). In contrast low E pillar scoring companies tend to have a much lower rate of disclosure for both company policies and targets and objectives on emissions reduction. While disclosure is an important first step, company targets and objectives to implement emission reduction policies should be based on a credible decarbonisation approach and should be supported by the latest climate science deemed necessary to meet the goals of the Paris Agreement.

Figure 45. High E pillar scoring companies are being rewarded for disclosing company policies and targets on emission reduction

Share of companies disclosing a policy to improve emission reduction and targets or objectives to implement such policies



Note: Metrics on disclosure of policies are binary (1=true (company policy disclosed); 2=false (company policy not disclosed). Information provided for 2870 companies. Classification is based on Refinitiv ESG scores' quartiles [Poor: E pillar score between 0 and 25; Satisfactory: 26-50; Good: 51 -75; Excellent: 76 to 100].
Source: Bloomberg, MSCI, Refinitiv, OECD calculations

Addressing challenges in ESG rating and investing could support the more appropriate use of ESG indices and related products to improve reallocation of capital in line with a low-carbon transition. Already, the proliferation of ESG ratings, and in turn E scores, cover companies with an estimated[64] 80% share of global market capitalisation of public companies. This is equally high in OECD countries, at an estimated 95% in the United States, 89% in the European Union and 78% in Japan (OECD, 2020a). In addition, the use of exclusionary screening to integrate ESG criteria into indices and portfolios for ESG investing, can entail the exclusion of high-carbon industries or activities such as fossil fuel exploration and production from these indices and portfolios (in the case of environmental focused strategies). This has been successful in reducing the fossil fuel content of some ESG indices and portfolios, yet will only be effective in supporting an orderly low-carbon transition if ESG ratings can better differentiate between companies that are implementing measures to address transition risks and have strategies to reduce the carbon-intensive nature of their business activities over time.

Box 9. The integration of ESG criteria in the investment policy of Banca d'Italia

As a public investor, Banca d'Italia started to integrate ESG (Environmental, Social and Governance) criteria into its investment policy in 2019.[65] After the adoption of such criteria for the internally managed portfolios of Italian and euro area equity, in 2020 sustainable investment criteria were gradually extended to US and Japanese equity funds as well as to corporate bond portfolios. Lastly, a portfolio of green bonds issued by supranationals and agencies was set up.

The way in which ESG criteria are implemented changes across portfolios.

As for equity portfolios, Banca d'Italia's investment strategies have traditionally embedded the general principles of risk diversification and market neutrality.[66] Investments are diversified across economic regions (Italy, the euro area and, to a lesser extent, the USA and Japan). Market neutrality is pursued by tracking broad-market indexes. Two additional principles are the prevention of conflicts of interest and conflicts with institutional functions (securities issued by companies from the banking, financial

services, insurance and media sectors are excluded) and mitigation of market impact (daily trading limits that aim to avoid interference with market functioning and monetary policy implementation). These general principles have been supplemented by two ESG criteria: (1) eligible assets do not include securities issued by companies mostly operating in sectors that are not compliant with the UN Global Compact principles (i.e. controversial activities in high-risk sectors such as tobacco and chemical or biological weapons); (2) portfolio allocation favours companies with the highest ESG scores, as assessed by a carefully selected data provider using a best-in-class approach. Given these ESG-enhanced general investment principles, the objective is to minimize the *ex-ante* tracking error volatility of the portfolio (i.e. the standard deviation of the gap between portfolio and index returns), while setting iteratively the constraints in order to increase portfolio's ESG score and reduce its carbon intensity against the benchmark.[67]

The Italian equity portfolio tracks a benchmark index (customized to prevent conflicts of interest, as explained above) including the shares of companies with a market capitalisation greater than EUR 500 million. While the weights of individual shares in the index are proportional to market value, portfolio weights are set to a level that minimises the tracking error, while enhancing the ESG score and reducing the carbon intensity, and is subject to the following constraints:

- The shareholding in each company may vary depending on the ESG score but has to remain within a ±0,25% relative to the index's corresponding stake;
- Each sector weight cannot exceed the corresponding weight in the benchmark by more than 3.5 percentage points.

The euro area equity portfolio tracks a broad market index excluding the shares of Italian listed companies as well as financials to avoid conflicts with institutional functions. To keep transaction and operational costs low, Banca d'Italia only invests in a subsample of around 80 securities; the latter are selected through an econometric model that is based on five macroeconomic factors and one ESG constraint – namely, securities with an ESG score below a given percentile threshold are excluded. In the mimicking portfolio, the weights of individual shares are computed by minimising tracking error volatility subject to the following constraints:

- They can marginally deviate from the index with respect to both weights and shareholding in each company;
- Each sector weight cannot exceed the corresponding weight in the benchmark index by more than one percentage point.

Both the Italian and euro-area equity portfolios are rebalanced every quarter. As for the US and Japanese equity portfolios, they are composed of shares of passive funds tracking ESG indices.[68] Banca d'Italia has already significantly improved the environmental footprint of its equity investments. The total greenhouse gas emissions of companies included in the new portfolio at the end of 2019 were about one quarter lower than those recorded in the previous portfolio. Energy and water consumptions have also come down significantly.

The sustainable criteria have been extended in 2020 at corporate bonds and green bonds mostly issued by governments, public agencies and supranational institutions. Banca d'Italia has disclosed the methodologies and results of its sustainable investment policy to the public (through, for instance, its annual Report on operations and activity of the Banca d'Italia) and at international level, by sharing its experience in the NGFS publications as well as in early stocktaking exercises carried out by the OECD. In July 2021 it also published a Charter on sustainable investments, to further raise the public's awareness of sustainability matters, to present its vision and identify principles and lines of actions for sustainable investment. Banca d'Italia is also committed to foster research on sustainable investment.[69]

Note: Box prepared by Banca d'Italia staff; E. Bernardini, I. Faiella and G. Grande

Source: Bernardini E., I. Faiella, L. Lavecchia, A. Mistretta, F. Natoli (2021), ""Central banks, climate risks and sustainable finance", Banca d'Italia - Occasional Papers, No. 608, March; Lanza A, E. Bernardini, I. Faiella (2020), "Mind the gap! Machine learning, ESG metrics and sustainable investment", Banca d'Italia – Occasional Papers, No. 561, June; Signorini L. F. (2020), "Sustainable investment in uncertain times: The future of public sector asset management", speech by the Deputy Director General of the Banca d'Italia at the OMFIF Roundtable for Public Sector Asset Managers, London, 6 February 2020; Visco I. (2019), "Sustainable development and climate risks: the role of central banks", speech by the Governor of the Banca d'Italia at the 18th International Conference for Credit Risk Evaluation on "Assessing and Managing Climate Change Risk: Opportunities for Financial Institutions", Venice, 26 September 2019.

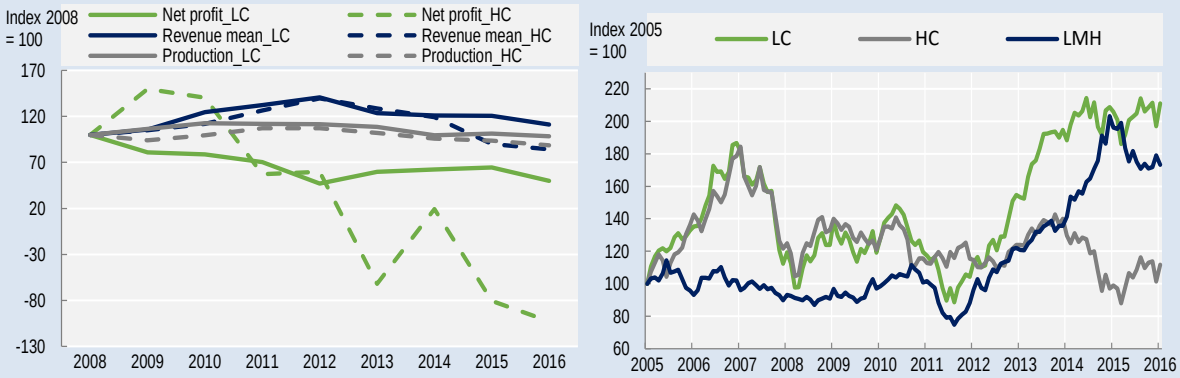
Therefore, policy steps are needed to strengthen ESG disclosures, metrics and methodologies so that they can be used for monitoring, assessment and investment decision-making that aligns with an orderly transition to low-carbon economies. Market participants, regulators and rating providers will need to address challenges relating to how information and sub-metrics that feed into calculating financially material metrics may differ, and the extent to which disclosures and methodological practices to report and aggregate this information can be improved (OECD, 2020c). As a first step, to unlock the valuable information to help green the financial system and facilitate an orderly transition to low-carbon economies, more work is needed to align disclosures with verifiable climate transition plans. This includes by embedding metrics outlined in already internationally agreed approaches such as the TCFD and the OECD Due Diligence Guidance for Responsible Business Conduct to support better risk management. At the same time, these should also capture the significant opportunities through ESG and climate transition investing, as the potential value proposition from renewable assets and processes and a range of green innovations could far outweigh losses on stranded assets.

Box 10. Carbon transition risk and environmental materiality for investments: asset pricing appraisals

Two recent studies carried out by Banca d'Italia experts[70] investigate how to properly assess and incorporate transition risks and environmental factors into investors' portfolio strategies.

A first paper[71] studies the impact of carbon risk on equity returns in the period 2006-2016 by focusing on the sector of European Electric Utilities (EEUs), where equity and debt securities represent a significant share of institutional investors' portfolios. The EEUs' value-creation model has been challenged by the deep transformation of European energy systems. Binding targets on greenhouse gas (GHG) emissions reductions, together with the creation of the world's first market for GHG emissions (European Emissions Trading System – EU ETS), have deeply affected the EEU sector (which rely on a substantial share of fossil fuels in their power mix), forcing them to write down their carbon-intensive activities, with a negative impact on their operating income, equity and leverage. The analysis shows how carbon risk can be embedded in an investment strategy that accounts for issuers' carbon intensity, in order to spot climate-related risks as well as opportunities. By using asset pricing models, the paper finds that during the years in which the decarbonisation process has accelerated (after mid-2012) there was a significant low-carbon premium; in that period, an investment strategy that favoured low-carbon companies (LC) to high-carbon ones (HC) would have delivered higher returns without affecting the risk profile of the overall portfolio (Figure 46).

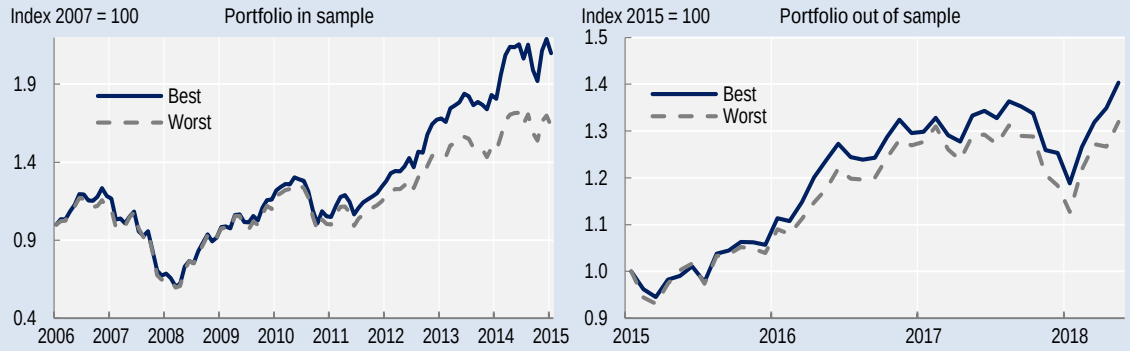
Figure 46. Revenue, Energy Production and Net Profit are beginning to differ among high-carbon and low-carbon portfolios



Note: Legend: LC: low-carbon; HC: high-carbon; LMH: low minus high carbon.
Source: Bloomberg and balance sheet data, Banca d'Italia staff calculations

A second study[72] focuses on the use of ESG scores, and investigates whether additional information extracted by granular environmental data allows to improve the construction of risk-return efficient portfolios. Given the current challenges related to the coverage, quality and comparability of ESG data, as well as their large heterogeneity across providers compared with traditional credit ratings, the study analyses granular ESG data by means of a machine learning (ML) technique, which is model-free. In particular, it sheds light on environmental data, which usually are less heterogeneous and controversial than those on social and governance factors, because quantitative data and conceptual models on environmental factors are more easily available. By applying ML (namely, decision trees) to around 220 ESG metrics, along a time span from 2007 to 2019 and for around 250 euro-area listed companies, the study identifies what are the prominent ESG indicators in determining risk and return differentials, even after controlling for standard Fama-French style factors or, alternatively, macroeconomic factors. A comparison of the return indices of the portfolios with best and worst E-metrics is shown in Figure 47. The most material environmental metrics include, among others, carbon and waste intensity, energy efficiency and some scores produced by providers. The scores signal the relevance of the forward-looking evaluation of environmental issues and climate-change risk, namely of transition risk.

Figure 47. Slight variations in return indices of the portfolios with best and worst E-metrics are beginning to be observed



Source: Box prepared by Banca d'Italia staff, E. Bernardini and I. Faiella

4.3. Climate transition indices and investment products

Distinct from ESG investing indices and portfolios, there has been a growth in dedicated renewables investment, including climate transition indices and portfolios, and dedicated climate transition funds and exchange traded funds (ETFs). Climate transition indices and portfolios use climate-related risk and impact screening methodologies to develop holistic or sector-specific investment strategies with the aim of addressing specific carbon reduction objectives or to support carbon-neutral strategies. Typically, these products will include stocks of renewable energy companies, or track those that have issued green bonds or undertaken specific low-carbon, conservation or renewables projects.

Public and private investors have invested almost USD 200 billion per year since 2015 in renewables asset finance, with a number of indices and products being made available to investors on the secondary market. In cases, these secondary market products may track green markets such as PIMCO Climate Bond Fund or Blackrock iShares Global Green Bond ETF. In other cases screening strategies will be used to develop products with a focus on sectors or activities deemed to support climate transitions, such as the Invesco WilderHill Clean Energy ETF. These funds focus on investing in green bonds as well as equities from issuers with a focus on green, renewable or low-carbon activities. The bonds and loans in which the investments are made are certified to be green by second party opinion frameworks or by institutional investors and third parties internally, thereby providing investors with a level of assurance that the investment mechanisms are supportive of the transition to low-carbon economies.[73] In line with this, PIMCO and iShares funds invest in bonds of companies and countries specifically issued to back green projects, while the Invesco fund invests in equities that are involved in renewable and clean energy. These may increase with the implementation of the European Commission's climate benchmarks, which began in 2019.

Table 6. Comparison of climate transition related **funds' top five holdings**

PIMCO Climate Bond Fund	iShares Global Green Bond ETF*	Invesco WilderHill Clean Energy ETF
BNP	France	Ballard Power Systems
ING	EIB	Plug Power
Central Japan Rail	KFW	Tesla
HSBC	Societe du Grand Paris	Enphase Energy
Danone	Netherlands	Ameresco

Note: For illustrative purpose only. * The iShares Global Green Bond ETF tracks the Bloomberg Barclays MSCI Green Bond Index
Source: Blackrock, Invesco, PIMCO, Refinitiv

Given that the portfolio composition for these indices deviates more from the traditional indices compared to ESG indices and portfolios, the returns and variance might differ from a standard portfolio, and therefore may not align with existing investment strategies of portfolio managers. However, for investors that have flexibility of portfolio composition within their strategies, existing metrics and investment products allow investors to construct portfolios that appear to align with transitions to low-carbon economies. These types of investments might, for example, be benchmarked to specialised climate funds, such as the Bloomberg Barclays MSCI Green Bond Index which tracks the global market for fixed income instruments that are certifiably invested in green projects.

Box 11. Fund portfolio networks : a climate risk perspective

Within the European financial sector, investment funds are considered to have the largest exposure to climate-sensitive economic sectors such as utilities, transport and fossil fuel extraction (ESRB, 2020;

Battiston et al., 2017). While a number of efforts have been made to conduct climate-related financial risk assessments of the European banking and insurance sectors, there has been little analysis of the European investment fund universe (Allen et al., 2020; Bank of England, 2015, 2018, 2019; EIOPA, 2020; ESRB, 2020). The analysis outlined in this Box aims to help fill this gap, based on a hitherto unexplored data set of EUR 8 trillion of European investment funds' portfolio holdings of approximately 14 million direct and indirect exposures to equity and corporate bond instruments.

Portfolios from 23 332 EU-domiciled investment funds have been recovered; the largest investment positions held by funds are equities (*c*. EUR 3 trillion), and corporate bonds (*c*. EUR 1.3 trillion), which are spread over 21 107 unique companies (located anywhere in the world). Holdings of shares issued by other investment funds are also included (*c*. EUR 1.1 trillion, spread out over 12 290 funds)[74]. Sovereign and supranational debt instruments, and cash holdings make up the largest remaining categories of investment positions. For the purposes of this article, the focus is on holdings of equities, corporate bonds and lastly shares issued by other investment funds. This is merged with the latest available issuer information for the equity and corporate bonds held by the investment funds, in particular total CO_2 and CO_2-equivalent firm emissions. Both direct emissions and emissions arising from the generation of energy purchased by the firm are included (i.e. scope 1 and 2 emissions).[75]

The analysis applies a network perspective to investment funds' exposures to climate (transition) risk.[76] Such a perspective could be critical when considering financial stability, because:

- In addition to buying equities, corporate bonds, sovereign debt and other such assets, investment funds can also invest in other funds, which themselves have exposures to climate-sensitive sectors. It is necessary to look through these exposures in order to 'unpack' the indirect exposure of investment funds to climate risks, via their holdings of other funds' shares.
- The extent to which climate risk shocks affect multiple funds at the same time depends on how similar their portfolios are (i.e. how dense are the interconnections between investment funds).

Using this approach and data set, the analysis aims to answer the following questions:

- How can investment fund portfolios be compared from a climate risk perspective?
- What methods exist to assess the density of the network of fund portfolio holdings, and how can these methods shed light on investment funds' relative (and joint) vulnerability to future climate-related financial shocks?
- Given a set of climate risk scenarios, which funds suffer the greatest asset losses, and what are key areas of focus for supervisors and policy makers as a result of this exercise?

With respect to these questions, it appears that many fund portfolios underweight green firms and overweight brown firms, which are defined as firms whose CO_2-equivalent emissions are below (resp. above) the 33rd (resp. 67th) percentile in the sample population. In addition, funds whose portfolios are tilted towards more polluting assets (brown funds) distribute their portfolio over a larger number of companies than funds with cleaner portfolios (green funds). This apparent diversification hides a concentration risk: brown funds are more closely connected with each other (have more similar portfolios) than green fund portfolios, which tend to 'herd' less (have less similar portfolios to those of other green funds) (see Figure 48). This suggests that widespread climate-related financial shocks are likely to disproportionately affect brown funds.

A preliminary climate risk scenario exercise is conducted, based on scenarios developed by Vermeulen et al. (2018) and employed by ESRB (2020). Four different transition-risk scenarios with NACE sector-specific impacts are included.

The scenario exercise confirms the finding above that widespread climate-related financial shocks are likely to disproportionately affect brown funds: besides total system-wide losses of EUR 152 billion to

EUR 443 billion, most brown funds' losses range from about 9% to 18% of affected assets, in contrast to green funds' losses, which usually range from 3% to 8%. In addition, brown funds have more systemic impact: they contribute more to total system-wide losses (by virtue of their greater interconnections within the fund universe) than green funds. These findings provide support for ongoing EU regulatory and supervisory initiatives on sustainable finance, including how both investors and supervisors can rank and compare funds from the perspective of climate risk (in terms of both contribution to and vulnerability from climate risk), as well as ESG ratings for investment funds, the need for greater fund transparency on exposure to climate-sensitive sectors, and the need for high-quality emissions-related disclosures by downstream firms are also crucial. ESMA will continue to work on these topics, as part of the risk assessment pillar of its sustainable finance strategy.

Figure 48. Funds with more polluting portfolios have greater interconnections (i.e. greater portfolio similarity)

Visualising the investment funds portfolio universe, categorised by extent of average portfolio emissions

Note: The chart displays the 0.5 % largest portfolio overlaps among EU investment fund portfolios. Portfolio overlap/similarity is measured as the number of common investments between two investment funds, normalised by the total number of firms considered by either the two funds. This portfolio similarity measure indicates how often two funds co-invest relative to the number of times that they could have, given their portfolios. Funds are segmented into five groups, based on the weighted (by value of the investment position) average emissions of their portfolios: black (no emissions data available for any firms held in the fund portfolio), dark green (fund portfolio is in the cleanest quarter of funds in the sample, i.e. the 0–25 % range in terms of weighted average emissions), light green (fund portfolio is in the next-cleanest quarter, i.e. the 25–50 % range), yellow-brown (fund portfolio is in the third quarter, i.e. the 50–75 % range) and brown (fund portfolio is in the fourth quarter, i.e. its portfolio weighted average emissions is among the top 75 % of funds in the sample). Emissions are CO2 and CO2-equivalent emissions (scopes 1 and 2 included).
Source: Morningstar, Refinitiv, ESMA

Source: Prepared by European Securities and Markets Authority staff, A. Amzallag. Based on the article A. Amzallag (2021), "Fund portfolio networks : a climate risk perspective", Article in ESMA Trends, Risks, and Vulnerabilities report No. 1, March. (see page 73 onwards here).

In addition to green bond and renewables market tracked instruments, a number of dedicated climate transition and renewables focused indices are now available. These typically track climate transition (decarbonisation trajectories) or Paris-aligned benchmarks by incorporating stringent carbon limitations in the context of overall long-term global warming targets with greenhouse gas intensity reduction requirements (normally between 40% to 60%). Examples include the STOXX Climate Transition

and Paris-Aligned Benchmark Indices; MSCI Climate Change Indices; S&P Climate Transition and Paris-Aligned Climate Indices, and the FTSE TPI Climate Transition Index (Table 7). To further support this, the European Union (EU) is in the process of finalising standards for defining Climate-Transition Benchmarks (CTB) and Paris-aligned Benchmarks (PAB), with new rules being set out in July 2020 on the minimum technical requirements for the methodology of EU climate-related benchmarks (Box 11).

Box 12. Summary of climate objectives required by the EU Climate Transition Benchmark (EU CTB) minimum standards

- Reduce the GHG emissions intensity of the index at 7% year-on-year, to align with carbon neutrality by 2050, using scopes 1, 2, and 3 emissions for each company from inception.
- Overweight companies with publicly disclosed science-based targets that meet certain thresholds as defined by the EU.
- Improve or maintain green-to-brown revenue share within the index.

Source: The EU Technical Expert Group on Sustainable Finance. (2019). TEG Final Report on Climate Benchmarks and Benchmarks' ESG Disclosures.

Table 7. Description of selected climate transition indices

	Index descriptions
STOXX Climate Transition and Paris-Aligned Benchmark Indices	The indices follow the EU Climate Transition Benchmark (EU CTB) requirements outlined by the Technical Expert Group (TEG) on climate benchmarks. In addition, companies identified as non-compliant based on Sustainalytics Global Standards Screening (GSS) assessment or are involved in Controversial Weapons are not eligible for selection. Tobacco Producers, as identified by ISS ESG, are not eligible.
MSCI Climate Change Indices (Low-carbon Index, Ex Fossil Fuel Index, and Environmental Index)	The indices reweights traditional MSCI indices based on EU Climate Transition Benchmark (EU CTB) requirements and factors in opportunities and risks associated with the transition to a low-carbon economy as recommended by the TCFD using MSCI metrics in line with low-carbon transition categories' scores.
S&P Climate Transition and Paris Aligned Climate Indices	The indices use weighting in line with EU Climate Transition Benchmark (EU CTB) requirements and the objectives of a 1.5 degree scenario. In addition, the S&P methodology takes into consideration transition risks, physical risks, and the opportunities from climate change, as recommended by the TCFD.
FTSE TPI Climate Transition Index	Index constituent weights are adjusted using five transparent criteria: company exposure to specific climate related risks (carbon emissions; fossil fuel reserves) and opportunities (green revenues) as well as the extent of climate governance activities (management quality) and commitments to 2 degree aligned emissions pathways (carbon performance).

Note: Non-exhaustive summary
Source: MSCI (2019), Introducing MSCI Climate Change Indexes; S&P (2020) Transition to a 1.5°C World with the S&P Paris-Aligned & Climate Transition Indices; STOXX (n.d.), STOXX Climate Transition Benchmark (CTB) and STOXX Paris-Aligned Benchmark (PAB) Indices, Accessed 8 April 2021; FTSE Russell (2020) FTSE TPI Climate Transition Index Series Overview.

As a result of these targeted indices, portfolios and funds, investment in clean energy and renewable strategies has rapidly increased, yet gaps remain to meet the levels needed for the low-carbon transition. The TCFD estimate that around USD 1 trillion investment is required per year in support of the low-carbon transition for the foreseeable future (TCFD, 2017), which could likely generate new investment opportunities. Global investment in renewables projects[77] stood at around USD 60 billion per year between 2004 and 2009, and has grown to over USD 300 billion per year since 2010. Solar and wind energy account for the largest share of this, with new technological innovations within these fields helping to reduce generating costs. National policy incentives have been essential to unlocking a large

part of clean energy investment to date, with policy makers often combining guaranteed tariffs with renewable portfolio standards for utilities, tax incentives, pollution regulation and carbon pricing policies.

4.3.1. Asset manager and asset owner initiatives

Beyond indices and benchmarks, broader asset managers' and asset owners' initiatives are shaping expectations about engagement with corporate issuers and transitions to net-zero climate paths. The largest 30 asset managers that manage USD 9 trillion in assets committed to a Net Zero Asset Managers Initiative,[78] launched in December, to use stewardship engagement with their invested firms to facilitate the path to net zero by 2050. The initiative intends to include the use and review of interim targets. Also, the UN-convened Net-Zero Asset Owners Alliance issued a *Draft 2025 Target Setting Protocol Net-Zero*, which includes a monitoring, reporting, and verification track. The Alliance recommends members use science-based ranges, targets and methodologies, and align interim 2025 targets at the sub-portfolio, sector, engagement, and financial levels. It is worth noting that these two initiatives, while similar in theme, have considerably different forms of targets and specificity. Also, while the UN report acknowledges that targeting and verification need to be embedded in the investment review process, there is little explanation of the consequences of issuers who do not meet these targets.

Box 13. Towards achieving net zero: the example of the Paris financial centre's commitment to adopt clear coal exit strategies

Coal combustion is the world's largest source of greenhouse gas. It emits 50% more CO_2 than oil per unit of energy produced, and 100% more than natural gas. This reality makes stopping coal financing a necessity to achieve carbon neutrality. It is also in the interest of the resilience of the financial system to the risks posed by climate change.

Under the leadership of the Minister for the Economy and Finance, the Paris' financial centre committed in July 2019 to publish individual coal exit strategies with the explicit goal to help reach the objective established by France and the European Union of net zero carbon emissions by 2050. These Paris commitments mean that by 2030 most French financial institutions will no longer finance coal in EU Member States and in OECD countries, and from 2040 onwards in the rest of the world. The commitment provides that financial institutions should (i) from 2020 include reference in non-financial reporting to their coal divestment strategy, with a defined divestment timetable; (ii) promote the dissemination and open source standardisation of methodologies, for example on the assessment of portfolio exposure to climate risks or on the alignment of investment portfolios with a 2 degree scenario.

To ensure the credibility of these commitments, controls have been put in place by French supervisors and by the financial sector itself.

- French supervisors, including the Financial Markets Authority (AMF) and the Prudential Supervision and Resolution Authority (ACPR), are working to identify and measure the risks arising from climate change and to monitor and assess climate commitments. A little more than a year after the commitments made by the financial community, supervisory work has shown varying levels of ambition and effort on the part of financial institutions. The content of the coal phase-out plans differs significantly between institutions, as does the scope of banking and financial services covered by the policies, and the definition of coal itself. The AMF and ACPR hence made recommendations to financial institutions through an assessment report published at the end of 2020. They however also concluded on a relatively low exposure, on average, to the coal sector, both for banks and insurance companies and for asset managers. Exposure of

the French financial sector appears to be substantially lower than 1% of total assets for each sector.

- The Sustainable Finance Observatory, launched in October 2020 by Finance for Tomorrow, the French sustainable finance association, together with the professional associations, aims to ensure a high level of transparency around the transformation of the financial center towards carbon neutrality by 2050. It gathers consolidated indicators on French financial institutions commitments and achievements in the field of sustainable finance, focusing on four areas (coal exit strategies; financing the transition to a low-carbon economy; responsible investment in accordance with ESG criteria; responsible product offerings). Its scientific committee, chaired by mathematician Pierre-Louis Lions (1994 Fields Medal), carries out work to make progress on common definitions and methodologies. It published recommendations in February 2021 aimed at promoting a common set of criteria for coal divestment across the financial center.

July 2020 was also the occasion to take stock of progress made on the 2019 coal divestment commitment. The signatory professional associations and Finance for Tomorrow found that:

- *Major French banks have a proactive policy in view to phasing out coal*. Each one has adopted exclusion criteria as well as hard deadlines beyond which they will no longer do business with companies that fail to meet their policies' requirements.
- *All insurers possess a coal exclusion policy.* Some ten of these have updated their policies between July 2019 and July 2020. Some fifteen or so companies, representing over 70% of assets managed by insurers, are planning a date for full divestment of coal and/or a gradual lowering of exclusion thresholds in their policies. In 2019, insurers divested more than EUR 750 million from coal as a result of implementing these policies.
- *Two thirds of assets managed by portfolio management companies in France are subject to coal-exclusion strategies.* The professional associations for asset management (AFG), the banking sector (FBF) and the insurance sector (FFA) are helping their members implement coal exit strategies by the end of 2020. The AFG and the FFA, in particular, have each published a handbook and recommendations for their members.

During a speech at the 2020 Climate Finance Day, the Minister of the Economy, Finance and Recovery called on the Paris financial center to renew its commitment to coal only on the basis of detailed criteria shared by all. He also asked the Paris financial center, as it does for coal, to develop an exit strategy for the financing of non-conventional fossil fuels activities. This would be in line with the French export finance strategy published in October 2020, aiming to support French companies, operating in highly emissive sectors, to successfully reduce the carbon-intensity of their activities and transition to new export markets compatible with France's environmental objectives. The French new export finance strategy notably provides a trajectory to end support for the financing of fossil fuels abroad. As of 1 January 2021, France no longer grants export guarantees for projects of extra-heavy oil, oil shale and bituminous sands exploration and exploitation. From 2025, this exclusion will be extended to projects for the exploration and exploitation of new conventional oil deposits. Finally, French exporters positioning themselves on new gas exploration and exploitation projects will cease to be eligible for public export support by 2035.

In addition, the Banque de France announced a tightening of its investment policy towards coal-related companies, which should lead to the definitive exclusion of this sector by 2024 (here). Since 2018, the Banque de France has been implementing a responsible investment policy on the EUR 22 billion of its own investments and as part of this framework, it already excluded coal mining or coal-based energy companies with more than 20% of their turnover linked to thermal coal. With regard to the oil and gas sector, the Banque de France will moreover stop financing non-conventional hydrocarbons starting

2021. It also plans to adopt for 2024 an exclusion of all companies for which oil represents more than 10% of their turnover or 50% for gas.

It is crucial to ensure coherence in sustainable finance frameworks (national, regional and international ones). This means that the different regulatory initiatives have to be well articulated with one another (e.g. disclosure requirements for investors, corporate reporting rules, a green/sustainable taxonomy, sustainable labels and standards, etc.), as well as with sector wide-commitments – for example on coal – in order to reinforce them.

France tried to do just this with article 29 of the Energy-Climate Law.

Article 173-VI of the Law of 17 August 2015 marked the beginning of a systematic integration of ESG factors into the investment decision-making and risk management procedures of institutional investors (insurers, pension funds and asset management firms), while encouraging specific consideration of climate risks (climate-related exposure and mitigation policy). Since the European Sustainable Finance Disclosure Regulation of 2019 allows national rules related to financial institutions' reporting to be maintained, France has introduced a new arrangement, that of Article 29 of the Energy-Climate Law. Article 29 refers directly to the European regulation and aims to complement it, while building up existing national provisions and introducing new ones.

Through the decree implementing Article 29, published in May 2021, French financial institutions are required to report on:

- the alignment of investment strategies with the objectives of the Paris agreement (including quantitative targets for greenhouse gas emissions every five years until 2050)
- the alignment of outstanding amounts (or their balance sheet) with the EU taxonomy
- biodiversity-related risks and impacts (including the publication of a strategy to align with international biodiversity preservation objectives, with quantified targets)
- the portion of their investments exposed to fossil fuels in line with the financial sector's commitment on coal financing
- the full integration of ESG factors in the risk management, governance and transition support systems (notably shareholder engagement) of market participants.

Moreover, it asks financial institutions to structure their ESG information on the basis of the TCFD recommendations and of its four pillars (strategy, governance, risk management, metrics and targets).

Moreover, a recently published research paper by the *Banque de France*[79] has investigated the real effects of mandatory climate-related disclosure by financial institutions on the funding of carbon-intensive industries. Using a dataset of security-level portfolio holdings by each institutional sector in each euro area country, the paper has compared the portfolio choices of French institutional investors with those of French banks (not subject to former "Article 173-VI") and all financial institutions located in other European Area countries. It found that investors subject to "Article 173-VI" disclosure requirements have curtailed their financing of fossil energy companies by some 40% compared to investors in the control group. Such research suggests that, while voluntary moves for enhanced carbon disclosure are welcome, more stringent regulations on GHG reporting are of the essence to effectively speed up the alignment of finance with transition needs.

Source: Box prepared by French Treasury (DG Tresor) staff, Margaux Sauvaget.

4.4. Green bond markets

Green bonds are increasingly used to finance 'green' projects through 'use of proceeds'[80] or asset-linked bonds, among others, to support a transition to low-carbon economies. Green bonds can be issued by either public or private actors up-front to raise capital for projects or for refinancing purposes (Table 8). As of end-2019 the global annual issuance of green bonds stood at almost USD 263 billion, showing a more than 50% increase from 2018 issuance, and representing 1 788 green bonds from 496 issuers across 51 jurisdictions (Climate Bond Initiative, 2020). This remained at similar levels in 2020 at almost USD 270 billion. These figures include green bonds issued by sovereigns, government backed entities, local governments, development banks, financial and non-financial corporates, loans, as well as asset-backed securities (Figure 49). In terms of geographical composition, the largest share of green bond issuance in 2019 was in the United States (USD 51 billion), followed by China (USD 31 billion), France (USD 30 billion), Germany (USD 18 billion), and the Netherlands (USD 14 billion).

Table 8. Green bonds are used to fund projects with environmental or climate-related objectives

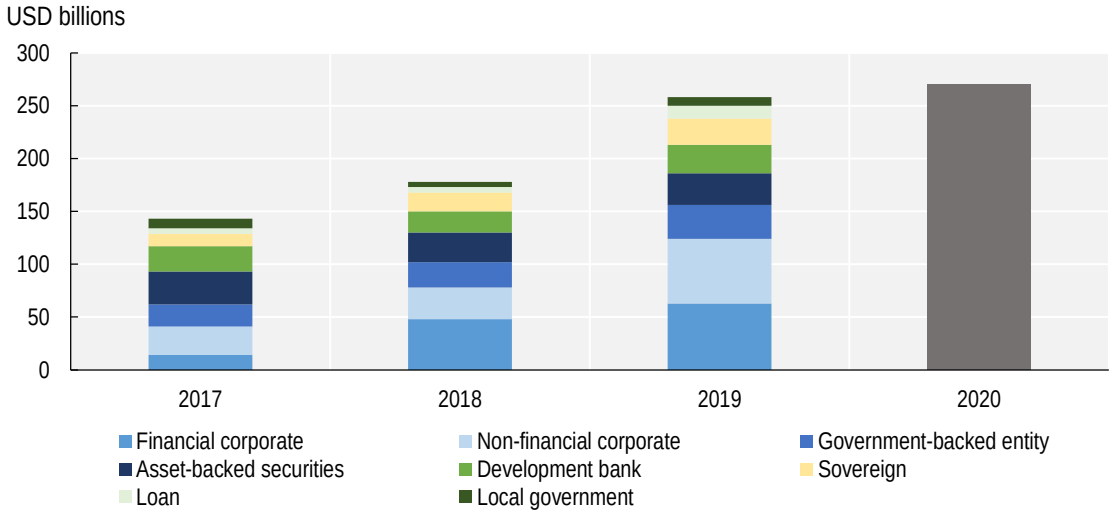
Types of green bonds, their use and examples

Type	Proceeds action	Debt recourse	Examples
Use of proceeds bond	Earmarked for green projects	Recourse to the issuer: same credit rating applies as issuer's other bonds	EIB 'Climate Awareness Bond (backed by EIB); Barclays Green Bond
Use of proceeds revenue bond or ABS	Earmarked for or refinances green projects	Revenue streams from the issuers though fees, taxes etc are collateral for the debt	Hawaii State (backed by fee on electricity bills of the state utilities)
Project bond	Ring-fenced for the specific underlying green project(s)	Recourse is only to the project's assets and balance sheet	Invenergy Wind Farm (backed by Invenergy Campo Palomas wind farm)
Securitisation bond (ABS)	Refinance portfolios of green projects or proceeds are earmarked for green projects	Recourse is to a group of projects that have been grouped together (e.g. solar leases or green mortgages)	Tesla Energy (backed by residential solar leases); Obvion (backed by green mortgages)
Covered bond	Earmarked for eligible projects included in the covered pool	Recourse to the issuer and, if the issuer is unable to repay the bond, to the covered pool	Berlin Hyp green Pfandbrief; Sparebank 1 Bolligkredit green covered bond
Loan	Earmarked for eligible projects or secured on eligible assets	Full recourse to the borrower(s) in the case of unsecured loans. Recourse to the collateral in the case of secured loans, but may also feature limited recourse to the borrower(s)	MEP Werke, Ivanhoe Cambridge and Natixis Assurances (DUO), OVG
Hybrid instrument	Earmarked for eligible projects with distinctive criteria	Varies	Convertible Bonds or Notes, Schuldschein, Commercial Paper, Sukuk, Debentures

Note: ABS, Asset-backed Security
Source: Climate Bond Initiative (n.d), Explaining Green Bonds, Accessed 29 March, 2021. https://www.climatebonds.net/market/explaining-green-bonds, OECD research

Figure 49. The green bond market has grown significantly in recent years, but still represents a fraction of the estimated amount needed to support a transition to low-carbon economies

Green bond issuance (USD billion) by issuer type, 2017-2020



Note: Issuer type breakdown not available for 2020

Source: OECD calculations based on Climate Bonds Initiative (2020) 2019 Green Bond Market Summary and Climate Bond Initiative (2021) Update, data from Thomson Reuters EIKON, Bloomberg Terminal and Wind Financial Terminal, supplemented with information from green bond exchange venues.

Green bond project definitions and requirements include the disclosure of the use of proceeds, which could in theory increase their credibility in supporting a low-carbon transition and if implemented correctly could help avoid potential green washing. These assessments are known as second party opinions (SPOs). Globally, the most widely accepted standards used for these assessments are the Green Bond Principles (GBP), which are a set of voluntary guidelines developed by key market participants under the co-ordination of the International Capital Market Association (ICMA), and the Climate Bonds Standard, which also includes sector-specific criteria, developed by scientific experts under the stewardship of the Climate Bonds Initiative (CBI). The Green Bond Principles define green bonds as "any type of bond instrument where the [issuance] proceeds will be exclusively applied to finance or re-finance in part or in full new and/or existing eligible Green Projects" and "which are aligned with the four core components of the Green Bond Principles".[81] While green bond frameworks benefit from an assessment of information available on issuers engagement to meet a low-carbon transition, studies show mixed results as to effective implementation. For example, some studies suggest little evidence of a reduction in emissions and carbon intensity over time (Ehlers et al, 2020), while others find that public companies issuing green bonds may improve their environmental performance through signalling (Flammer, 2020).

While an almost cumulative USD 1 trillion has been raised through green bonds since 2014, further scaling up green bonds and improvement of verification could better support an orderly low-carbon transition. The marketed growth of green bonds since 2017 is promising in the event that disclosure and monitoring of green bond projects suggests a less pertinent green washing than in other products. In financial terms, green bonds tend to price tighter than initial price guidance and tend to be oversubscribed. They generally offer similar yields to comparable conventional bonds.[82] However, there is evidence that, in some market segments, issuers can borrow at lower rates than via conventional bonds (ESRB, 2020). Green bonds are well suited for projects with a long-term investment horizon, large capital costs and secured income streams, such as those of renewable energy infrastructure, therefore the further

development of standards and capacity to support the mainstreaming of green bonds could help contribute to an orderly transition to low-carbon economies.

4.5. Climate-sensitive credit risk assessments

Transition risks have the potential to impact borrowers' capacity to generate sufficient income to service and repay their debt, as well as capital and collateral that back loans, possibly leading to both higher probabilities of default and higher losses given default in the event that financial markets are not able to absorb losses or enact an orderly transition. Climate scenario and climate stress test methodologies can help financial institutions understand the extent of exposure and reflect on actions that need to be taken to strengthen resilience in this respect. As a result, credit rating agencies are beginning to routinely integrate climate-related transition risks (including policy and legal, technology, markets and reputational) and opportunities (resource and energy efficiency, new products/ services, markets and resilience) into credit assessments. Including the addition of climate risk and transition analysis into mainstream credit ratings to help identify issuers and corporations that are best positioned in a transition to low-carbon economies.

Although in infancy for a number of credit rating agencies, this can include risk and scenario analysis to provide credit risk assessments of companies under a range of climate scenarios. For example, by 2017 Standard & Poor's Global Ratings had identified 717 cases where environmental and climate concerns were relevant to the credit rating profile of a company, and 106 cases where environmental and climate factors – both event driven and those occurring over a longer time horizon – resulted in a change of rating, outlook, or a CreditWatch action for a company (S&P, 2017). Of the examples that had an environmental or climate-related factor that was key to a rating change (56% in a negative direction, while 44% were in a positive direction), most are noted to fit into the TCFD's definition of physical climate risks or opportunities. The second most widely applicable category was policy and legal risk. Volkswagen's October 2015 downgrade, for example, met the TCFD's definitions of 'reputational risk' and also 'policy and legal risk' (Ibid, 2017).

In addition, some credit rating agencies are opting to conduct distinct climate transition assessments outside of their traditional credit ratings. Notably they are doing this with the aim to inform markets on the ability of issuers to withstand carbon transition risks, yet they also recognise that their methodology may need to be further developed before it is integrated into the core credit rating methodology. Moody's for example, conduct climate transition assessments to address elements of risk that may be relevant to investors and material for credit analysis, but are not within their current credit rating framework. This includes a scorecard across four components: (i) the current business profile; (ii) medium-term technology, market and policy exposure; (iii) medium-term response activities; and (iv) longer-term resilience (with an equal 25% weighting across each component) (Moody's Research, 2019).

4.6. Climate-sensitive stress testing by banks and central banks

Over time, transition risks have the potential to erode bank capital and potentially endanger the stability of the financial sector, with a number of central banks considering the use of capital requirements to address both the climate investment gap and climate-related risks. In addition, both central banks and banks are exploring the objectives that need to be met to deal with climate-related risks and integrate these into their risk assessment frameworks. This includes tools such as climate scenarios and stress testing. In 2020, TCFD released its first set of climate scenarios to explore the risks from both physical impacts of climate change and the transition to a low-carbon economy. With the goal to provide a common framework that will allow central banks, supervisors and financial firms to assess and manage future climate-related risks (NGFS, 2020a).

Box 14. An energy **transition risk stress test for a central banks' balance sheet**

In 2020, De Nederlandsche Bank (DNB) performed an inaugural energy-transition risk stress test on its balance sheet. This energy-transition stress test (henceforth the 'stress test') was motivated by the climate strategy in DNB's Responsible Investment Charter. The purpose of the stress test was to inform stakeholders about the nature and size of DNB's balance sheet's exposures to energy-transition risks. This box explains the design of the stress test.

The DNB approach is based on a top-down methodology developed by DNB's Financial Stability division in 'An energy-transition risk stress test for the financial system of the Netherlands'.[83] In this methodology four different scenarios are considered, focusing on the two main drivers of transition risk: government policy and technological developments. Shocks to the economy and financial markets are introduced via an increase in energy prices and a change to the mix of energy sources. The DNB methodology assumes that the scenarios materialise within a horizon of five years. Figure 50 shows the scenarios that were developed by DNB before the Network for Greening the Financial System (NGFS) scenarios became available.[84] A brief description of the scenarios is as follows.

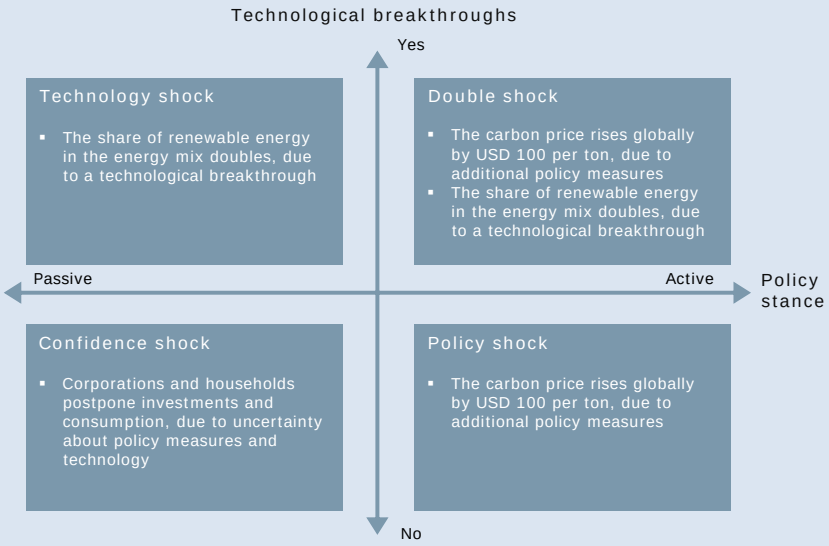
- "Technology shock": As a consequence of unanticipated technological breakthroughs the share of renewable energy in the energy mix doubles in five years.
- "Confidence shock": Uncertainty regarding government policies to combat climate change causes a sudden drop in the confidence of consumers, producers and investors.
- "Double shock": Climate mitigation policies are abruptly implemented together while unanticipated technological breakthroughs occur at the same time.
- "Policy shock": Policies to reduce carbon emissions are abruptly implemented leading to a large increase in the global carbon price of USD 100 per ton of carbon emissions.

The macroeconomic impact of each scenario is expressed in GDP growth, inflation, global stock prices and the ten-year euro area market interest rate. This translation is done using NiGEM, a multi-country macro-econometric model. The next step is to disaggregate the macroeconomic impact into an effect on a meso level using a Transition Vulnerability Factor (TVF) to capture the heterogeneity among industries. The method for constructing these TVFs is derived from the Capital Asset Pricing Model and for each industry it is based on assessing the suppliers and customers and the total amount of embodied CO_2 emitted in the production process.[85] An industry that, for instance, sells products that contain twice as much embodied CO_2 as the average of the economy, will be hit twice as hard. The resulting TVFs not only vary across industries but also across the four scenarios. The TVFs allow for the translation of the macroeconomic variables in each scenario to industry-specific effects. In total, DNB considers 56 industries grouped by NACE codes.[86]

In particular the TFVs are used to derive equity and bond returns for each industry in each scenario. An industry's equity return follows from multiplying the global market return with the industry's TVF in the specific scenario. For example, in the double shock scenario the global equity market return is -2.8% and the mining industry has a TVF of 13.5. This translates into an equity return of the mining industry of (-2.8% * 13.5 =) -37.8%. The industry-specific bond return is derived from a parallel shift in the term structure of interest rates using the change in the ten-year euro area bond yield, the change in the rating-specific credit spread and rating migrations. Furthermore, a link is made between industry specific stock returns and credit rating downgrades. This is to reflect that industries that suffer large equity losses, due to higher TVFs, also suffer a deterioration in credit quality. Bonds receive an additional notch downgrade (e.g., from A- to BBB+) if the industry stock price index decreases by more than 20 %. In case the stock price decreases by more than 30% the rating downgrade is two notches, by more than 40% three notches, etc.

Key outcome of the stress test is the impact on profits and risk exposures. The stress scenarios lead to different levels of interest rate income and costs for DNB and to (market-to-market) losses from the stress scenarios on the investment portfolios. The stress test shows that the change in profits is largely driven by the impact of the energy-transition on market interest rates under the various scenarios. The stress test furthermore shows that the change in risk exposures is driven by a small part of the total portfolio, in particular the part with the highest TVFs. DNB disclosed the qualitative results of the stress test in its 2020 annual report.[87]

Figure 50. The DNB stress test identified four disruptive energy-transition scenarios



Source: Box prepared by De Nederlandsche Bank staff, D. Broeders and S. Bisschop

Transition climate-related risks could also induce, through direct or indirect exposure, a deterioration in issuer credit-worthiness. A small but growing number of central banks have embarked on climate scenario analysis to inform monetary policy and assess financial system risks. The different methodologies applied by central banks make use of climate scenario analysis for these stress testing exercises. For example, the Banque de France, De Nederlandsche Bank, and Bank of Canada have all conducted quantitative top-down studies, and found a substantial potential risk (De Nederlandsche Bank, 2019; Banque de France, 2020; Bank of Canada, 2020). The Bank of England has also announced that it is planning to incorporate bottom-up participation by financial firms for stress testing the UK financial system to climate risks (Bank of England, 2019a).

Box 15. **"Green Swans" and radical uncertainty –** How to estimate climate-related risks through forward-looking, scenario-based analysis? The example of Banque de France/ACPR

Under certain circumstances, the physical and transition risks of climate change could lead to a systemic crisis triggered by "Green Swan" events (Bolton et al., 2020). This concept finds its inspiration in the now concept of the "Black Swan" developed by Nassim Nicholas Taleb (2007). "Black Swan" events have three characteristics: (i) they are unexpected in light of past events; (ii) their impacts are wide-ranging or extreme; and (iii) they are rationalised by conceptual frameworks developed after the fact (retrospective rationalisation). In addition to these three characteristics, "Green Swans" present two more significant qualities. First, it is nearly certain today that some climate-related risks will materialise (e.g. as the climate tipping point is crossed), even though there is profound uncertainty as to where, when and how they will emerge. Second, "Green Swans" may be even more extreme than "Black Swans", as they can be irreversible and potentially *civilisational* (Ripple et al., 2020).

As a result, the integration of climate-related risks into financial stability supervision and prudential regulation presents a significant challenge: traditional approaches to risk, based on historical data and normal distribution assumptions, will necessarily lead to a poor appreciation of both the likeliness and consequences of "Green Swans".

While rapid decarbonisation is without a doubt essential to avoid the worst physical risks of climate change, it may also trigger transition risks or "Green Swans". Indeed, the policies, technologies and consumer preferences that will enable a low-carbon transition are subject to a great deal of uncertainty and could lead to abrupt financial re-evaluations. In particular, the literature on stranded assets (i.e. the existing fossil fuel reserves that should remain in the ground to limit global warming to less than 1.5 or 2 degrees) indicates that significant economic and financial losses could result from the low-carbon transition (e.g. Mercure et al., 2016). These losses could be amplified when accounting for the fact that: (i) on the "real" economy side, the value added of many sectors dependent on fossil fuels (e.g. the car industry) could also be impacted through "cascades of stranded assets" (Cahen-Fourot et al., 2019); and (ii) on the "financial" side, a sudden reevaluation of the value of stranded assets by investors could lead to fire sales and ensuing pro-cyclical market behaviors potentially leading to a "climate Minsky moment" (Carney, 2016), i.e. a systemic financial crisis.

In order to account for at least part of the risks discussed above, the community of central banks and supervisors engaged in the NGFS (2019) now agrees that forward-looking risk assessments are critical. These are based on scenario analysis, which use plausible hypotheses for the future without assigning probabilities of materialisation to these hypotheses.

The Banque de France/ACPR have been engaging with banks and insurance firms since April 2019 and are currently conducting a pilot risk assessment exercise to assess the impact of climate-related risks on financial firms. The aim is to assess the resilience of banks and insurers to climate-related financial risks, with a focus on enhancing a methodological discussion and ensuring that firms are properly equipped to measure and monitor these new risks. Engaged on a voluntary basis, all the major French financial institutions are participating. To this end, the Banque de France/ACPR have developed a framework to develop scenarios for climate-related risk assessment, building on the NGFS scenario framework. The exercise translates the NGFS high-level scenarios into economic and financial variables relevant to French firms for both an orderly and disorderly transition. The approach disaggregates the GDP impact of simulated shocks into 55 sectors and their associated asset prices. It also generates paths for key macrofinancial variables (interest rates, unemployment, etc.). In addition, the exposure of the liabilities of the insurance sector to physical risks is assessed based on the IPCC's RCP8.5 scenario. Insurers are expected to estimate the evolution of property damage claims due to the

increased frequency and severity of extreme events, such as windstorms, droughts and floods. Increases in health sector claims due to deterioration of air quality or the spread of vector-borne diseases is also considered. The release of the results is expected for April 2021.

Finally, it is noteworthy that some argue that existing transition risks do not sufficiently account for the opportunities generated by a low-carbon transition. For instance, UNEP-FI (2019) estimates that profits generated by a low-carbon transition could amount to more than USD 2 trillion. Many of these opportunities are related to the significant investments needed for the low-carbon transition. For instance, the additional annual average energy-related investments needed to limit global warming to 1.5°C (over the period 2016 to 2050, compared to the baseline) could reach USD 1 700 billion (IPCC, 2018), while global investments needed in sustainable infrastructure for the period 2015–30 may amount to USD 100 trillion (Bhattacharya et al., 2016). Moreover, investments in sectors such as building energy efficiency retrofits and low-carbon infrastructure tend to display high returns in terms of employment and CO2 reductions (Hepburn et al., 2020a). In this context, public investments in the low-carbon transition could become critical to stimulate private investments (Mazzucato and Perez, 2015).

Accounting for such opportunities at a granular level nevertheless brings considerable methodological challenges, as it requiring anticipating which firms will be more aligned with specific decarbonisation paths. In this regard, the emergence of "climate alignment" methodologies (for a comprehensive and critical overview, see Raynaud et al., 2020) may provide insights to both financial institutions and central banks (e.g. Oustry et al., 2020) into which firms' business models and investment strategies are more compatible with specific decarbonisation scenarios.

Source: Box prepared by Banque de France staff, T. Allen and R. Svartzman

Financial institutions and banks are also developing methodologies, including climate stress testing, to enable them to assess climate risks as well as support and seize opportunities related to the transition. Climate risk assessment frameworks used by financial institutions broadly fall into two categories: (i) Frameworks which assess the impact of financial institutions on climate change, and; (ii) Frameworks which assess the impact of climate change on portfolios. Within these, stress testing is used to analyse how portfolios, and therefore banks behave under various hypothetical macroeconomic scenarios of the future and are formed by a set of assigned variables on the potential climate transition. This could involve a portfolio level assessment (top down mechanism) reinforced with borrower level calibration (bottom-up mechanism). Typically, they focus on the impact of a carbon tax shock on the market value of their balance sheets and credit adequacy. At the same time, studies are beginning to explore how climate policies adversely affect the value of financial institutions' balance sheets and, for extreme scenarios, can cause systemic financial crises, or even in some cases building in macroeconomic stress test methods. Looking ahead, it will be important to further assess the impact of climate transition policies on the financial system, and in particular on debt instruments. Currently, the ECB is the only regulator to make clear that climate scenario analysis and stress testing should explicitly feed into banks' capital adequacy (Fitch Ratings, 2020), with signs that others may also introduce requirements.

Box 16. OECD workshops on climate science, policy, regulation and practice

To support the development of climate-sensitive stress testing by banks and central banks, the OECD Centre on Green Finance and Investment launched a series of OECD workshops to take place from 2020 to 2022 on **Climate Science, Policy, Regulation and Practice,** with the aim to foster an outcome-oriented, interactive dialogue between climate researchers, financial regulators, supervisors, climate policy makers and industry practitioners.

The OECD held a first virtual workshop on 3-4 September 2020 focusing on "Climate Change: Assumptions, Uncertainties and Surprises", which highlighted key issues relevant to the design and use of climate research and science within policy, regulation and practice. It framed key issues to support economic and financial decision actors (private and public) to interpret and use scientific evidence and modelling in their approaches to climate risks. In particular, physical and transition risks (e.g. to undertake climate stress tests and scenario analysis), and in their consistency assessments against mitigation and resilience, were addressed. Subsequent workshops will examine in more detail how to implement climate risk management and climate policy alignment goals across areas relevant to physical and transition risks or impacts from climate change. They will discuss implications for financial regulators, industry practitioners, as well as policy makers.

4.7. Conclusion

While increased demand for products, practices and tools that support the low-carbon transition is promising, further efforts are needed to improve the verifiability of underlying information regarding aspects of issuers' climate transitions. Tools such as ESG rating and investing, despite showing room for improvement, can help provide investors with valuable data on environmental performance. Climate transition benchmarks and funds, in addition to screening strategies and stewardship (including shareholder activism) show greater potential to help directly support the transition and can in cases show potential to deliver risk-adjusted returns. In addition, while green bonds show promise, improvement of labelling and use of proceeds monitoring could further improve their effectiveness. Climate scenario analysis and stress testing also show benefits in terms of identifying potential risk factors and stranded assets, and could also be used in future to help financial market actors identify the opportunities, not only in terms of companies and assets that show a greater resilience in the long term, but also those that have the potential to make gains (i.e. from new technologies and innovations) in the context of the transition. Looking ahead, it will be important to take steps to greater align some products, notably ESG rating and investing approaches and taxonomies, definitions, principles, and disclosure frameworks, with forward looking information on climate-transition risk management and strategies to implement low-carbon transition plans.

5. Policy considerations

In the past decade, governments, international organisations and private institutions have made strides to implement climate policies that help catalyse the low-carbon transition. This includes policies to redirect capital towards greener alternatives, while discouraging capital flows to carbon intensive projects. In this context, this report outlines ways that financial markets are building capabilities to help facilitate an orderly transition and to allocate capital which helps incentivise companies' transitions, including both opportunities and risks. Stranded assets in the form of reserves and production processes (that consume carbon energy), are prone to increasingly weigh down valuations, whereas transitions to renewable energies or assets that utilise renewable energy, as well as innovative products and technologies that support energy efficiency, could help contribute to improved market valuations. As such, the depreciation of some assets as a result of the transition to a low-carbon economy might also be offset by higher returns and positive effects resulting from less climate intensive growth. Put differently, where market valuations appear to be insensitive to climate transition risks, it may be that competing influences on valuations are at play. Whether the current prices are the net effects of price discovery in efficient markets, or are subject to distortions due to lack of consistency of disclosure, metrics, and reporting frameworks is a key issue for policy consideration.

Despite progress, insufficient data, financially material metrics and analytical tools to measure and manage climate transition risks remain a critical constraint for corporates and financial institutions, which calls for greater attention to policy considerations. The lack of common definitions and standards for climate transition data and financial products are also hindering the ability of market participants and regulators to identify, monitor and manage risks and opportunities. In addition, the absence of clear and appropriate policies to support a transition to low-carbon economies is at a minimum stalling progress, and should implementation of such policies be delayed this could create a cliff edge scenario followed by a disorderly adjustment of prices.

While some jurisdictions have moved faster than others in recent years, regulators and market participants are generally in the early stages of understanding and experimenting with how best to monitor and manage climate transition risks, and to incentivise the capture of opportunities. Given the current and considerable data limitations, regulators and market participants may want to adopt a pragmatic approach that stresses continual monitoring and global coordination, especially as refinement of transition risks and opportunities continue to advance and new data and tools become available.

International progress to support an effective carbon price could further support financial markets in their role to channel resources efficiently to activities that reduce carbon intensity by reflecting the true cost of carbon emissions. An orderly low-carbon transition will require stronger policy frameworks that incentivise the fair and effective reduction of carbon emissions. In the absence of such a price, financial markets may operate sub optimally, and capital could continue to flow in indiscriminate directions, rather than toward accelerating the transition to low-carbon economies.

Using the conceptual framework set out in Section 2, transition risks could in theory be minimised if the transition begins early and follows a more gradual and predictable path, therefore helping markets incorporate price changes, and helping corporates to take measures to address the financial impact over a longer period of time to accommodate their productive asset depreciation schedules. While there is evidence that the low-carbon transition has begun, with markets taking steps to

address this, current estimates suggests that the global economy is not on track to reach the 2 degree target. Therefore, the risk that sudden policy changes or technological advances may have an impact on market prices remains.

Additional policy measures, where appropriate, could help facilitate this orderly change. Notably, strengthening the tools and methodologies that underpin disclosure, valuations, and stress testing in financial markets and traded products associated with climate will further help support this transition. This includes through:

- **Improving specific ESG Environmental Pillar data disclosure, and strengthening of the E pillar subcategories associated with climate transition risks and opportunities**. In particular, financial market authorities could facilitate greater transparency on the high-level purpose of the environmental pillar by ESG rating providers so that market participants understand the extent to which their methodology aligns with long-term value and/ or with climate related risks and opportunities. This could include guidance from central banks, supervisors and financial market regulators on categories of metrics and methodological good practices within the E pillar and outline the extent to which these may be more or less relevant for climate resilience. In addition, clear boundaries could be defined as to which areas of the E pillar are relevant to long-term financial value. In addition, regulatory principles could support the consistent disclosure of clear and publicly available information by rating providers on metrics and the extent to which supplementary analysis or direct outreach with issuers is used. There should also be transparency on the extent to which rating providers over or under-weigh certain categories including for example carbon emissions and intensity, energy efficiency, investment in renewables, or forward-looking information on transition plans. These aspects will be important to clarify the weight of certain metrics, and define what drives the E pillar score.
- **Support for international co-operation between market regulators, IOSCO, IFRS and market participants (supported by international organisations and central banks) to further strengthen TCFD disclosure practices and improve granularity, reliability and interoperability of metrics with respect to climate risks and opportunities**.[1] Including through mandatory sustainability corporate reporting to support greater data reliability of Scope 1, 2 and 3 emissions and carbon intensity. International and national sustainability reporting and corporate disclosure guidance could build on the TCFD framework to improve materiality of climate transition related disclosures, and guide the development of forward looking metrics on opportunities. Guidance could also be developed to improve the consistency of data with respect to fuel-efficient expenditures, R&D, and development of new products and services. Greater assessment by central banks and international organisations of the impact of anticipated policy measures with respect to carbon emissions and elements of the TCFD framework are also warranted.
- **Strengthening transparency, assurance mechanisms and labelling of climate transition indices, funds and products** (such as green and transition bonds) so that investors fully understand products that are appropriate for transition strategies, separate from ESG and green funds, and the differences across these products in terms of transition requirements, annual pace of decarbonisation, use of transition plans, and verification mechanisms. In addition, there should be transparency on the extent to which subjective judgement is used within methodologies to create indices and funds (and in metric creation that supports this), and clarity on how methodological choices relate to financial materiality over the long-term (i.e. if responsible business conduct can improve reputation and financial standing). In addition, financial market regulators could promote greater transparency through investor education on methodologies and results of portfolio composition relative to traditional market portfolios.
- **Central banks (particularly supervisors), finance ministries and market regulators could encourage the use of science-based interim targets[2] and transparency of climate transition plans to achieve a 2 degree scenario**.[3] This could include regular assessment or verification

(where existing regulation allows) of the quality of transition plans and strategies, including the extent to which qualitative (i.e. binary metrics) or quantitative information is used in the development of E pillar scores. Guidance and principles on core metrics to assess the quality of transition plans and strategies could be an important component of this. While variations across geographies and industries may be justified, guidance should achieve high-level consistency on the prioritisation or near, medium term, and long-term global metrics. Central banks (particularly supervisors), finance ministries and market regulators should encourage disclosure of information on the scenarios[4] used for transition plans by following TCFD recommendations, as well as clear base and target years for companies underlined by science-based targets in transition plans. Such plans could be subject to verification by a trusted third party, and include engagement between investors and boards to facilitate emissions reduction strategies (including through stewardship plans). This could build on preliminary climate transition "checks" developed by a number of consulting and international bodies to help investors assess and compare plans (such as the Science Based Targets Initiative and national transition roadmaps), noting that these efforts remain at an early stage of development.

- **Transparency and clarification of stewardship plans of major asset managers and institutional investors in their engagement with Boards and executive management on reduction of climate intensity and net-zero targets**. This should include guidance from market supervisors to ensure that asset managers appropriately engage with transitioning firms and heighten efforts to engage with boards and facilitate assessment of the veracity of transition plans. Asset managers are expected to also disclose principles on their sustainability investment strategies such as their climate transition plans, and are encouraged to elaborate on actions when issuers do not adhere to such plans. Progress is being made in this area, but further efforts can be made to support due diligence in the tracking and assessment of tangible progress, such as through the amount and forms of resolutions to support TCFD reporting and the publication of annual transition plans, and the commitment to net-zero or tangible decarbonisation strategies.
- **Supervisory authorities should encourage pilot scenario analysis of financial institutions to assess potential losses from carbon exposures, and reflect anticipated valuation increases from opportunities through renewable energy, and new green technologies**. Currently, scenario analysis by institutions that highlight peak risk of disorderly transitions due to effective carbon pricing policies and technological breakthroughs to accelerate transitions to low-carbon economies may wish to better assess the offsetting benefits of the transition. In this respect, static scenario analysis that only assesses the impact of the stranding of assets and processes, without testing for the dynamic aspects of the transition occurring across industries, may overstate credit losses and market disruptions in bank and non-bank financial intermediation. In this respect, scenario analysis could also take into consideration policies to mitigate such impacts, to better inform financial stability and fiscal initiatives. In addition, scenario analysis can raise financial institutions' awareness and preparedness to manage climate-related risks, and support clarification as to their intention to raise the amount of capital required to withstand the level of climate risks on their balance sheets.
- **Greater assessment by policy makers on how a range of climate-related policies could better incentivise the transition.** For example, international progress to support an effective carbon price could further support financial markets in their role to channel resources efficiently to activities that reduce carbon intensity by reflecting the true cost of carbon emissions. In addition, a shift in support mechanisms from fossil fuels to renewable energy subsidies could shift operating expenses and in turn activities to support a transition. While scenario analysis exercises for the purpose of capital adequacy could potentially be useful, more holistic assessments are needed to capture upside benefits and ways that policies can support positive transitions with net benefits for markets to contribute to more sustainable economic growth.

Overall, clearer government policies, continued improvement in climate-related disclosures, interoperability of climate transition metrics, comparability of valuation methodologies, and verifiability of renewables strategies would all help strengthen valuations. In addition, while the establishment of an effective carbon price or targeted central bank measures are beyond the scope of this report, it should be acknowledged that greater policy certainty on the downside effects, such as to stranded assets, and upside effects such as regulated returns due to subsidies and incentives, could facilitate the more competitive pricing of renewables.

Importantly, more in-depth analysis is needed to assess the progress and challenges in how financial markets facilitate and are impacted by this transition to help bring about an orderly low-carbon transition. Shifting substantial amounts of capital into renewable and productive assets that can yield considerable returns over time, particularly where the economies of scale bring cost benefits. Financial markets will benefit most from policies that enhance their efficiency to intermediate, provide needed capital and liquidity, and encourage price discovery, all of such supports the transition to more resilient, low-carbon, and sustainable economies. The OECD will continue to monitor developments in OECD jurisdictions as well as through regional and international initiatives. In addition, greater empirical analysis is needed within the conceptual framework to support the identification of appropriate policies and tools to support the effective functioning of financial markets in line with an orderly transition that underpins sustainable and climate-resilient economic growth. This work will contribute to G20 and FSB roadmaps on sustainable finance and will contribute to the OECD's multi-year effort to improve ESG disclosure, data availability, metrics, and methodologies.

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Annex A. Transition Risk Glossary Acronyms

EJ/yr	Exajoules per year	$MtCO_2$	Megatonne of carbon
eq/yr	Equivalent per year	$MtCO_2$ eq	Megatonne of carbon equivalent
GHG	Greenhouse gas	TCO_2	Tonne of carbon
$GtCO_2$	Gigatonne of carbon	TEAP	Technology and Economic Assessment Panel
HCF	Hydrofluorocarbon	TWh/yr	Terawatt hours/year
HCFC	Hydrochlorofluorocarbon	UNEP	United Nations Environment Programme
IPCC	Intergovernmental Panel on Climate Change	UNFCCC	United Nations Framework Convention on Climate Change
IEA	International Energy Agency	USD/kWh	United States Dollar/Kilowatt hour

Annex B. Discussion on the estimation and financial characteristics of stranded assets

Understanding exactly how reserves should be interpreted as to their role as stranded assets and measurement from a corporate finance perspective (i.e. as liabilities and interaction with other types of stranded assets) will also be important in understanding how these will be dealt with in the context of carbon transition (see Section 2 and 3 of this report). From a financial perspective, accountants have measures to deal with the impairment of assets (e.g. IAS 16) which seek to ensure that a companies' assets are not carried at more than their recoverable amount. If the current estimates of losses are correct however, and extend over multiple business cycles, then there is a much higher likelihood that global markets are able to absorb these losses over time. Indeed, the climate transition is already contributing to defaults associated with stranded assets, for example in the coal industry. Yet, investors have been able to absorb trillions of USD losses during brief acute crises (though contributing to financial stability risks) but have absorbed these losses more efficiently over time. For example, credit losses in banks and other financial institutions exceeded USD 4 trillion in the aftermath of the Global Financial Crisis (IMF, 2009), and European banks have since written off over USD 600 billion of Non-Performing Loans over the past five years (EBA, 2020).

Assessing the extent to which these losses may materialise is more complicated. Currently estimates on stranded assets are calculated based on losses incurred in the event that oil and other carbon based forms of energy have to be written off, and are left in the ground. However, companies are valued on net current value and future expected profit, with a tangential connection to reserves. This may skew calculations on the prospective value of losses related to stranded assets throughout a climate transition, in which estimates may use output as a lose proxy for valuations (despite value added being used). Therefore further consideration may be needed to fully understand the interaction between fossil fuel reserves, mitigation costs, corporate valuations and therefore stranded assets. In addition, in-depth analysis as to other cost channels related to stranded assets may be warranted to understand the extent to which the financial sector is able to absorb these losses and associated costs throughout the chain. While stranded assets will exhibit debt and liabilities mark downs, similarly to traditional credit losses such as Non-Performing Loans (NPLs), there are a number of characteristics that may differentiate stranded assets in terms of how financial markets may be able to absorb associated loss in the event of write-off. These include potential concentration risks, and financial recovery characteristics:

- First, stranded assets will likely have high concentration risks. Which means that the investors and institutions that will likely own stranded assets (i.e. focus on a number of sectors), may likely be concentrated to holdings between a relatively small number of investors. This may be less so for banks and financial institutions, yet compared to NPLs which are held across a wide range of sectors and financial institutions, this will likely be lesser for stranded assets. For example, in Canada in 2018, the top 25 shareholders of the fossil fuel sector represented a total holding of 42% of the market (Carroll and Huijzer, 2018). The majority of these shareholders were foreign

private corporations (16%), as well as asset management and investment funds (15%). This only represents the equity holdings of companies in an industry with the potential for high stranded assets, yet it illustrates that part of losses could be concentrated among a small number of investors, independent of credit losses.

- Second, the same companies that will likely hold stranded assets, may also be the same companies that are bearing the brunt of investment in the carbon transition (e.g. in big greenfield energy investments). If this is the case, any losses incurred to these companies will impact vital investment needed to help adapt to a carbon transition. Using the example of Canada again, the largest investors in renewable energy companies and projects are expected to be asset management and investment funds, combined with venture capital firms. Little information is available to assess the extent to which these represent the same strata of the first category of investors, yet further analysis into this could be warranted.
- Third, NPLs will likely have some form of recovery, whereas with a stranded asset, the asset itself has the potential to become obsolete – which could represent a more significant haircut than the liabilities on an NPL (Daniel, Christine and Jacqueline, 2012). In this sense, the stranded portion of the carbon-related assess (either reserves or machinery and equipment that use fossil fuels) can be compared to the present value of the loss-given-default of an NPL.

Annex C. Assumptions for the estimation of stock prices for selected industries

The analysis on companies pertaining to the different industries in the document includes predefined assumptions related to average market growth rates and is not trying to forecast the stock price of the companies analysed, but is comparing the possible stock price of companies if they were to grow at historical average market growth rates in the future.

The results can also depend on different factors, which are outside the scope of the current analysis. The information and publications are not intended to be and do not constitute financial advice, investment advice, trading advice or any other advice or recommendation of any sort.

The following basic assumptions have been applied to calculate the estimated price for each company in figures 16, 26 and 34, based on data from Refinitiv:

Revenue growth rate: past 5 years average for the industry at a global level.

Operating Margin: past 5 years average for the industry at a global level.

Sales to capital ratio: past 5 years average for the industry at a global level.

Risk-free rate: 1.25% (Current 10Y US bond yield)

Cost of capital: Company specific based on Refinitiv data

Effective tax rate: 20%

Marginal tax rate: 25%

NOTES

[1] See Bolton et al. (2021) and Hsu et al. (2020) for US market; Alessi et al. (2021) for European market.

[2] See In et al. (2019) for the US; Batten et al. (2016) for European market.

[3] Events like the Paris Agreement, where there is an intensification of regulations to reduce carbon emissions, can generate a rise in transition risk but a potential reduction in physical risk.

[4] The authors create two lists of unique terms from transition risk and physical risk documents weighting each term according to their term frequency-inverse document frequency (tf-idf) and obtaining vocabularies ranked by term relevance. See further details in Bua et al. (2021).

[5] Developed in line with Engle et al. (2020).

[6] The authors do an analogous study to investigate the effect of physical risk shocks.

[7] From the period surrounding the Paris Agreement and before the outbreak of COVID-19. Equity returns are aggregated into "brown" and "green" portfolios constructed according to several metrics of climate risk exposure (GHG emission levels, GHG emission intensity, Environmental (E) score, Environmental, Social and Government (ESG) score) and NACE sectors.

[8] Lewis (2014) simulation based on the stringent constraint of limiting GHG-emissions to 450ppm of CO2 equivalent in the atmosphere.

[9] Abu Dhabi Investment Authority, Kuwait Investment Authority, the New Zealand Superannuation Fund, Norges Bank Investment Management, Saudi Arabia's Public Investment Fund, and the Qatar Investment Authority.

[10] This summarises comments made by US SEC Commissioner Allison Herren Lee, Jan 30, 2020, "Modernizing" Regulation S-K: Ignoring the Elephant in the Room.

[11] An extreme event is one in which weather, climate, or environmental conditions—such as temperature, precipitation, drought, or flooding—rank above a threshold value near the upper or lower ends of the range of historical measurements.

[12] Climate transition risks include: risks posed by policies aimed at decreasing greenhouse gas (GHG) emissions to meet the 2 degree target by the end of the century (e.g. carbon prices); legal risks arising as a function of climate litigation (e.g. in the context of climate damages), and; technology risks that relate to the uncertainty in technological development and deployment (presenting both risks and opportunities for financial market actors).

[13] See Speech by Mark Carney, Breaking the tragedy of the horizon – climate change and financial stability, then Governor of the Bank of England and Chairman of the Financial Stability Board, at Lloyd's of London, London, 29 September 2015.

[14] Stranded assets can be broadly defined as assets that suffer an unanticipated or premature write-downs, devaluations, or conversion to liabilities (Caldecott, Howarth, and McSharry, 2013).

[15] The term “carbon” is used in a variety of ways when talking about greenhouse gas emissions. In this case “carbon” is used as shorthand referring to CO2, or greenhouse gases in general, and to express CO2 emissions in terms of the amount of carbon in the CO2.

[16] In addition, a number of sources take into consideration the use of negative emissions technologies (NETs) that could help mitigate the cumulative impact of carbon emissions, giving some flexibility to achieve the 2 degree target by 2030. For example, the Climate Policy Initiative estimate that the widespread use of negative emissions technologies has the potential to extend the 2050 carbon budget by 11-13% in a scenario in which there is a 50-80% probability of meeting the 2 degree target.

[17] This does not discount the fact that mispricing of externalities associated with carbon reflects market failures, which in turn affects market pricing where fossil fuels contribute to asset valuations or profits. Efficient markets are able to transmit new information unlocked by better climate reporting at the company and national levels (e.g. through central banks, other authorities, and industry bodies) to help investors make informed decisions about how to price transitions.

[18] For example, innovations in photovoltaic technology have led to an 80% fall in the cost of renewable energy from some power generators; see OECD (2018), A Chain Reaction: Disruptive Innovation in the Electricity Sector.

[19] Issues related to energy consumption, such as by consumers who use fossil fuels for homes, transportation, and as inputs to products they consume, has not been covered in this piece. It is an important issue that merits separate consideration.

[20] While a number of climate-related definitions of stranded assets have been proposed, this report uses that of Caldecott, Howarth, and McSharry (2013). The IEA defines stranded assets as ‘those investments which have already been made but which, at some time prior to the end of their economic life (as assumed at the investment decision point), are no longer able to earn an economic return’ (IEA 2013). The Carbon Tracker Initiative also use this definition of economic loss, but says they are a ‘result of changes in the market and regulatory environment associated with the transition to a low-carbon economy’ (Carbon Tracker Initiative, n.d.). The Generation Foundation (2013) defines a stranded asset ‘as an asset which loses economic value well ahead of its anticipated useful life, whether that is a result of changes in legislation, regulation, market forces, disruptive innovation, societal norms, or environmental shocks’ (Generation Foundation 2013).

[21] Caldecott et al. (2017) argue that the stranding of assets might occur for a much wider set of reasons and can be related to much broader environmental challenges than global warming. Including changes in the natural resource landscape (e.g. scarcity of phosphate or shale gas abundance), in social norms or social tipping and consumer behaviour (e.g. Greta Thunberg) and in litigation (e.g. carbon liability) and changing statutory interpretations (e.g. fiduciary duty or disclosure requirements) that can lead to stranded assets.

[22] The 2 degree scenario (66%) set out by the IEA implies less than 10 Gt net CO2 emissions (non-land use), less than 8 GtCO2 eq/yr methane emissions and around 3 GtCO2 eq/yr of nitrous oxide emissions by 2050, with 0 Gt net CO2 emissions by 2060.

[23] In the event of a disorderly transition, the value of these costs will increase significantly given the increase in net present value. However, should this occur in an orderly transition in which costs of decommissioning are supported by the government in the form of tax supports or write-offs, and/ or offset with new investment in renewables, companies may be able to recover some losses with a more limited impact on financial markets.

[24] Decommissioning refers to the suite of processes involved in withdrawing a facility from service at the end of its life; its deconstruction and dismantling; and the removal of components for reuse, remanufacturing, recycling, storage and/or disposal.

[25] The OECD estimates that the carbon pricing gap was 76.5% in 2018, representing EUR 30 per tonne of CO2. By the current rate of gap narrowing, carbon prices will only meet real costs in 2095 (OECD, 2018).

[26] While stigmatisation and reputational risks can be separate from transition risks, in this context they are discussed in the event of companies ability and willingness to transition.

[27] In the US alone, state and local governments have filed more than a dozen lawsuits under various tort theories, including state common law public nuisance claims, to recover climate-change related expenses from energy industry defendants (CFTC, 2020).

[28] The levelised cost of energy (LCOE), or levelised cost of electricity, is a measure of the average net present cost of electricity generation for a generating plant over its lifetime. The LCOE is calculated as the ratio between all the discounted costs over the lifetime of an electricity generating plant divided by a discounted sum of the actual energy amounts delivered.

[29] For example, see: Seto, K.C. and Dhakal, S., 2014. Chapter 12: Human Settlements, Infrastructure, and Spatial Planning. In Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, et al. (eds.). Cambridge University Press, Cambridge, UK, and New York. Available at: http://www.mitigation2014.org. For a contrary perspective, see, for example, Alcott, H. and Greenstone, M., 2012. Is There an Energy Efficiency Gap? The Journal of Economic Perspectives, 26 (1).

[30] Fossil fuel power-generating assets are also exposed to this risk, as fossil fuels have to be purchased as inputs.

[31] This notion is called the 'Porter Hypothesis'. See Porter and van der Linde (1995), Toward a new conception of the environmental-competitiveness relationship, Journal of Economic Perspectives, Vol. 9.

[32] A recent paper by Ralph De Haas and Alexander Popov, argues that capital markets (and in particular equity markets) may even be superior to banks in incentivising climate-supporting investment, https://www.ecb.europa.eu/pub/economicresearch/resbull/2019/html/ecb.rb191127~79fa1d3b70.en.html

[33] See FT Article, 10th August 2019, ESG investing sparks race in tech and hiring at asset managers, https://www.ft.com/content/247f4034-4280-318a-9900-87608a575ede

[34] McKinsey, 2021, "The big choices for oil and gas in navigating the energy transition"

[35] The analysis includes predefined assumptions related to market growth rates and is not trying to forecast the stock price of the companies analysed. The results can also depend on different factors, which are outside the scope of the current analysis. See annex C for more information.

[36] Estimates by Oil Change International (2016) and Carbon Tracker (2016) with input information from the International Energy Agency (2013), McGlade & Elkins (2015) and International Project for Sustainable Energy Paths (cited as Krause et al, 1989).

[37] Estimates by International Energy Agency (2013), McGlade & Elkins (2015) and International Project for Sustainable Energy Paths (cited as Krause et al, 1989).

[38] See for example, among others, *TOGETHER 2025+ Volkswagen Group Strategy (available at https://www.volkswagenag.com/en/sustainability/reporting.html)* and the *Sixth Toyota Environmental Action Plan* (available at https://global.toyota/en/sustainability/report/er/)

[39] In their Transition Plans, almost all of the majors auto companies declare that, on average,CO2 emissions from Scope 1 and 2 have fallen by more than 35% per vehicle since 2010 (OECD staff calculations).

[40] Resources include energy, water, waste and solvents. Base year for the calculation: 2010 (OECD staff calculation). Source: *Auto Companies Environmental Reports*.

[41] Analysis, based on data availability, conducted on the following companies: *Toyota*, *BMW*, *Volkswagen Group*, *General Motor*. Source: *Auto Companies Environmental Reports*.

[42] See *the European Commission Policy* at https://ec.europa.eu/clima/policies/transport/vehicles/regulation_en.

[43] In 2009, in the wake of the financial crisis, when bank credit became inaccessible, publicly listed non-financial companies raised a record USD 511 billion in new equity through the stock market. This pattern seemed to repeat itself during the 2020 pandemic, when already listed non-financial companies raised a record of USD 626 billion in new equity, of which electric vehicle manufacturers benefited. See OECD (2021), The Future of Corporate Governance in Capital Markets Following the COVID-19 Crisis, Corporate Governance, OECD Publishing, Paris, https://doi.org/10.1787/efb2013c-en.

[44] See a discussion on some manufacturer processes in Financial Times (2021), Forget COP26 boasts — decarbonising takes thousands of tiny, boring steps', https://www.ft.com/content/1bca616e-3398-4599-8019-8cd688364d9e

[45] See The *Wolkswagen Annual report*, available at *https://annualreport2019.volkswagenag.com/groupmanagement-report/results-of-operations-financial-position-and-net-assets/net-assets.html*

[46] See BMW *Investor Relation,* available at *https://www.bmwgroup.com/en/investor-relations.html*

[47] For further comparison see for example: for Toyota, *https://global.toyota/en/ir/* ; for General Motors, *https://investor.gm.com/*

[48] See McKinsey Report on the automotive perspective at *https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/disruptive-trends-that-will-transform-the-auto-industry/de-DE*

[49] See *Kepler Cheuvreux Transition Research 360, Climate Change Scenario Risk and Opportunities*

[50] The analysis includes predefined assumptions related to market growth rates and is not trying to forecast the stock price of the companies analysed. The results can also depend on different factors, which are outside the scope of the current analysis.

[51] The WACC is a financial metric used to calculate a firm's cost of capital in which each category of capital is proportionately weighted. Typically all sources of capital including equity stock, preferred stock and debt are included in the calculation.

[52] The analysis includes predefined assumptions related to market growth rates and is not trying to forecast the stock price of the companies analysed. The results can also depend on different factors, which are outside the scope of the current analysis.

[53] These by no means represent the full array of projects, practices and tools being utilised in financial markets, yet to provide useful examples for policymakers, this report selects a number with accessible data to analyse relevant characteristics.

[54] Japan Financial Services Agency (FSA), and Ministry of Environment (MoE) are observers of the study group.

[55] See FSA (2020) Basic Guidelines on Climate Transition Finance, compiled by FSA, METI, and BoE.

[56] See ICMA (2020) Climate Transition Finance Handbook.

[57] See FSA (2021) Report by the Expert Panel on Sustainable Finance, published by Expert Panel on Sustainable Finance.

[58] See Tokyo Stock Exchange (2021) Revised Japan's Corporate Governance Code.

[59] Such as the Climate Bond Standards.

[60] For more information on environmental and climate-related corporate disclosure, see Boffo, R., C. Marshall and R. Patalano (2020), "ESG Investing: Environmental Pillar Scoring and Reporting", OECD Paris, www.oecd.org/finance/esg-investing-environmental-pillar-scoring-and-reporting.pdf

[61] ESG rating providers can range from stand-alone entities to arms of larger index providers or credit rating agencies that rank companies according to specific ESG criteria.

[62] See for example Goldstein, I., Jiang H., and Ng D., "Investor flows and fragility in corporate bond funds", *Journal of Financial Economics*, 126, 2017, pp. 592-613

[63] See De Haas, R., and Popov, A. (2019), "Finance and carbon emissions", ECB Working Paper No 2318; and Financial Integration and Structure in the Euro Area, European Central Bank, Frankfurt am Main, March 2020.

[64] OECD estimation using Refinitiv ESG data, 2019.

[65] For an analysis of the rationale, see Visco (2019). An account of the challenges and opportunities of the climate transition and sustainable finance from a central bank perspective is given by Bernardini, Faiella, Lavecchia, Mistretta, Natoli (2021).

[66] Market neutrality implies that central bank's portfolio choices should interfere as little as possible with market resource allocation, except insofar as monetary policy dictates (Signorini, 2020).

[67] Carbon intensity at corporate level (measured as the ratio between greenhouse gases emissions and sales) was chosen as the target variable on the basis of a study of the construction of financially-efficient ESG portfolios carried out through machine learning techniques (Lanza, Bernardini and Faiella, 2020).

[68] The portfolio of corporate bonds denominated in EUR is managed in-house, while that of bonds denominated in USD has been outsourced to external asset managers. Both portfolios track ESG benchmarks. Investments in green bonds started in 2019 through the underwriting of the shares of an

investment fund managed by the Bank for International Settlements that invests in USD-denominated green bonds mostly issued by supranational institutions. Subsequently, green investments have been extended with purchases of green bonds denominated in various currencies and issued by governments, public agencies and supranational institutions.

[69] For a recent review, see Bernardini, Faiella, Lavecchia, Mistretta, Natoli (2021) and a companion box in this volume.

[70] The opinions expressed in the two papers are those of the authors alone and should not be attributed to the Bank of Italy or the Eurosystem.

[71] Bernardini E., Di Giampaolo J., Faiella I. and Poli R. (2019), "The impact of carbon risk on stock returns: evidence from the European electric utilities", *Journal of Sustainable Finance & Investment*, 11:1, 1-26, DOI: 10.1080/20430795.2019.1569445.

[72] Lanza A., Bernardini E. and Faiella I. (2020), "Mind the gap! Machine learning, ESG metrics and sustainable investment", Occasional Papers No. 561, Banca d'Italia.

[73] However, the certification of the projects does not necessarily mean that benefits like CO2 emission reductions have been quantified.

[74] The constituents of certain ETFs and some indices are not always available. This is relevant to the 'unpacked' network discussed in the subsequent paragraphs (and affects 4 % of the fund-to-fund exposures).

[75] The data source is the firm's regulatory filings or, where not available, an estimate based on either past filings or the firm's relative position in its industry (Refinitiv, 2019). A total of 81 % of equity and corporate bond holdings are associated with emissions data.

[76] There are two generally accepted types of climate risk: physical risk and transition risk. Physical risk relates to either event-driven (e.g. floods) or longer-term (e.g. sustained higher temperatures) developments that either cause direct damage to organisations' assets or indirectly affect their operating environment (e.g. supply chains). Transition risk relates to the financial and reputational risks faced by legal entities as part of the extensive policy, legal, technological and market changes that arise to address the efforts required to mitigate and adapt to climate change. See TCFD (2017) for further discussion.

[77] Including biofuels, biomass and waste, energy smart technologies, wind, solar and other clean energy projects as defined by Bloomberg New Energy Finance. See BNEF (2019), Financing the Low-Carbon Future: A Private Sector View on Mobilising Climate Finance.

[78] The Net Zero Asset Managers Initiative is a group of international asset managers committed to supporting the goal of net zero greenhouse gas emissions by 2050 or sooner, in line with global efforts to limit warming to 1.5 degrees Celsius; and to supporting investing aligned with net zero emissions by 2050 or sooner.

[79] Mésonnier J.S, Nguyen B. Showing off cleaner hands: mandatory climate-related disclosure by financial institutions and the financing of fossil energy, *Banque de France Working Paper Series n° 800*, January 2021.

[80] Proceeds from these bonds are earmarked for green projects but are backed by the issuer's entire balance sheet.

[81] The Green Bond Principles have four core components: (i) use of proceeds; (ii) process for project evaluation and selection; (iii) management of proceeds; and (iv) reporting. See ICMA (2018) Green Bond Principles Voluntary Process Guidelines for Issuing Green Bonds.

[82] The green bond market has developed around the idea of flat pricing - where the bond price is the same as ordinary bonds. Prices are flat because the credit profile of green bonds is the same as other vanilla bonds from the same issuer. Therefore, green bonds are pari pasu to vanilla issuance.

[83] See R. Vermeulen et al (2018): An energy transition risk stress test for the financial system of the Netherlands, Occasional Study 16(7), De Nederlandsche Bank.

[84] The NGFS scenarios are available here: https://www.ngfs.net/en/publications/ngfs-climate-scenarios.

[85] See Hebbink, G., L. Berkvens, M. Bun, H. van Kerkhoff, J. Koistinen, G. Schotten and A. Stokman (2018), The price of transition: an analysis of the economic consequences of CO2 taxation, DNB Occasional Studies 16(8).

[86] NACE is the industry standard classification system used in the European Union, see: Statistical Classification of Economic Activities in the European Community, Rev. 2 (2008) (NACE Rev. 2).

[87] See De Nederlandsche Bank (2020) Annual Report, Annex 1 Climate-related Financial Disclosure.

[1] The TCFD's Proposed Guidance on Climate-related Metrics, Targets, and Transition Plans, published for consultation in June and July 2021, illustrates the importance of the need for better transparency, harmonisation and precision of key metrics related to transition plans.

[2] Targets are considered 'science-based' if they are in line with what the latest internally agreed climate science deems necessary to meet the goals of the Paris Climate Agreement – limiting global warming to well-below 2°C above pre-industrial levels and pursuing efforts to limit warming to 1.5 degrees.

[3] This is of particular importance when applied to the ICMA bond recommendations.

[4] The Sectoral Decarbonisation Approach (SDA) refers to a scientifically-informed method for companies to set GHG reduction targets necessary to stay within a 2 or 1.5 degree temperature rise above preindustrial levels.

www.oecd.org/finance