

How could financial institutions manage their exposure to climate risks?

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This analysis note is the second part of three Climate Briefs on the management of climate-related transition risks by financial players.

SUMMARY FOR DECISION-MAKERS

Managing their transition risks and analysing the opportunities associated with the low-carbon transition would enable financial institutions to ensure the future performance of their portfolios in a low-carbon economy. This requires in the long run a need to incorporate a forward-looking analysis for alignment of their portfolios with a 2°C pathway into their risk management and investment decision-making processes. Such analysis would need to be based on scenarios that represent different pathways for decarbonisation of the economy, broken down into quantitative variables of financial impact of the risks and opportunity for low-carbon transition. Such climate-related variables would need to be integrated into the financial models used for the fundamental analysis of counterparties, for the evaluation of financial assets and for the management of risks.

However, certain constraints currently restrict the possibility for financial institutions to carry out such analysis for all of their outstanding investment and financing amounts: the lack of forward-looking information on companies and other counterparties; certain current features of financial models; the lack of breakdown of climate-related scenarios into financial impact variables; the information systems of financial players which need to be adapted; and the lack of training on climate-related issues for their personnel.

Nonetheless, financial institutions can start as of today to progressively roll out a certain number of preliminary actions:

- Encouraging their counterparties to issue forward-looking information on their own alignment with a 2°C pathway, for example by following initial TCFD guidelines;

- Adopting an internal stance on scenarios on which analyses are to be based, in particular “2°C” scenarios, and thinking about the objectives to be set for each business sector;
- Adapting information systems so as to be able to collect, store and aggregate new indicators and information on the climate-related issues of counterparties;
- Adapting the financial models used;
- Training all employees on the impacts of climate-related issues for the financial sector;
- Collecting and analysing the climate-related indicators already available, as detailed in the I4CE Climate Brief no. 46;
- Putting in place a governance system that will encourage climate-related issues to be taken into consideration by each internal business division.

Implementing these preliminary actions today will enable financial institutions to start to take ownership of low-carbon transition issues and to raise awareness among all their employees of the importance of climate risks and opportunities for their activities. It will also enable them to integrate climate variables into their analyzes as soon as the necessary metrics become available, and thus be able to meet the increasing demands of regulators and stakeholders.

Financial institutions must implement a forward-looking analysis of climate-related risks and opportunities

Financial institutions are, and will increasingly be, exposed to the risks relating to climate change: climate-related physical¹, transition and litigation risks, as categorised by Mark Carney² at the time of his important speech “Breaking the tragedy of the horizon - climate change and financial stability”³ given in September 2015. The following table shows a concise overview of the different types of transition risks and physical climate-related risks:

The management of either physical or transition risks by financial players is unavoidable: as shown in Figure 2⁴, either the global economy remains on a “business-as-usual” pathway - and the global average temperature will rise by more than +4°C between now and 2100 leading to a decline in the annual growth of GDP of around 2% between now and 2060 according to the OECD⁵, or the global economy aligns itself with a 2°C pathway and financial players will then be exposed to transition risks.

One possible strategy for the management of climate-related risks for financial players is to align their asset portfolios as early as possible with a 2°C pathway, as discussed in I4CE’s Climate Brief no.43.⁶ Aligning a portfolio with a 2°C pathway makes it necessary to analyse the alignment of assets in the portfolio with a given transition or decarbonisation pathway. This does not mean that all assets in the portfolio must today be “low carbon”, but that the underlying assets, no matter whether these are companies, states or other funded entities, should steer their activities and their strategy so as to follow a 2°C pathway.⁷ To be capable of making investment or financing decisions taking this criterion into account, financial players must therefore carry out forward-looking analyses based on the underlying company’s strategy with regard to the low carbon transition.

1 Physical climate-related risks correspond to financial risks linked to the economic consequences of climate change such the increase in the frequency and magnitude of extreme events or the increase in sea-level for example.

2 Mark Carney is currently Governor of the Bank of England, Chairman of the Financial Stability Board (FSB) (international economic grouping set up and appointed by the G20, bringing together 26 national financial authorities and several international organisations and financed mainly by the Bank for International Settlements) and First Vice-Chair of the European Systemic Risk Board (institution in charge of macro-prudential regulation of the financial system within the European Union for the purpose of contributing to the prevention of systemic risk).

3 Speech made by Mark Carney on 29 September 2015 at Lloyd’s in London. Speech available at this link: <http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx>

4 Bruegel Policy Brief, Financial risks and opportunities in the time of climate change, D. Schoenmaker and R. van Tilburg, April 2016 http://bruegel.org/wp-content/uploads/2016/04/pb-2016_02.pdf

5 OECD (2016), The economic consequences of climate change, OECD Publications, Paris DOI: 10.1787/9789264235410-en

6 Why should financial actors align their portfolios with a low-carbon pathway to manage transition risks? <http://www.i4ce.org/download/three-notes-on-the-management-of-climate-related-risks-by-financial-actors/>

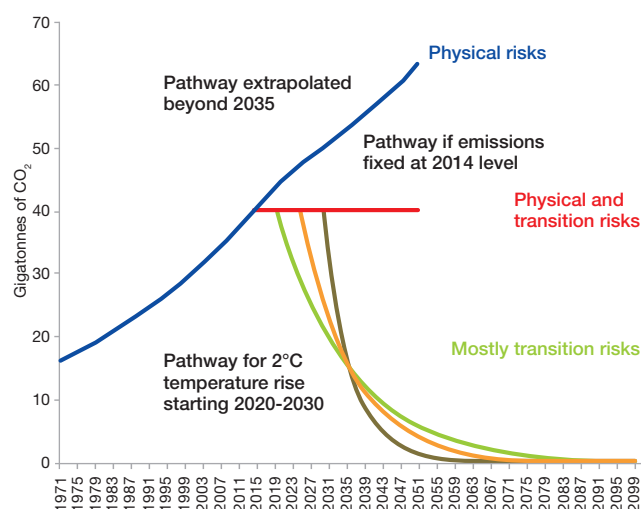
7 For more details on what I4CE considers to be an asset and portfolio aligned with a 2°C pathway, see Climate Brief no.44. <http://www.i4ce.org/download/three-notes-on-the-management-of-climate-related-risks-by-financial-actors/>

FIGURE 1: TYPOLOGY OF TRANSITION AND PHYSICAL CLIMATE-RELATED RISKS

TRANSITION RISKS	
Policy and legal	Market
<ul style="list-style-type: none"> Increased pricing of GHG emissions Enhanced emissions-reporting obligations Mandates on and regulation of existing products and services Exposure to litigation 	<ul style="list-style-type: none"> Changing customer behavior Uncertainty in market signals Increased cost of raw materials
Technology	Reputation
<ul style="list-style-type: none"> Substitution of existing products and services with lower-emissions options Unsuccessful investment in new technologies Upfront costs to transition to lower emissions technology 	<ul style="list-style-type: none"> Shift in consumer preferences Stigmatization of sector Increased stakeholder concern or negative stakeholder feedback
PHYSICAL RISKS	
Acute	
Increased severity of extreme weather events such as cyclones and floods. <i>(causing damages to facilities, reduction or disruption in production capacity...)</i>	
Chronic	
<ul style="list-style-type: none"> Changes in precipitation patterns and extreme variability in weather patterns Rising average temperatures Rising sea levels <i>(causing damages to facilities, increased operating costs, impacts to workforce management and planning...)</i>	

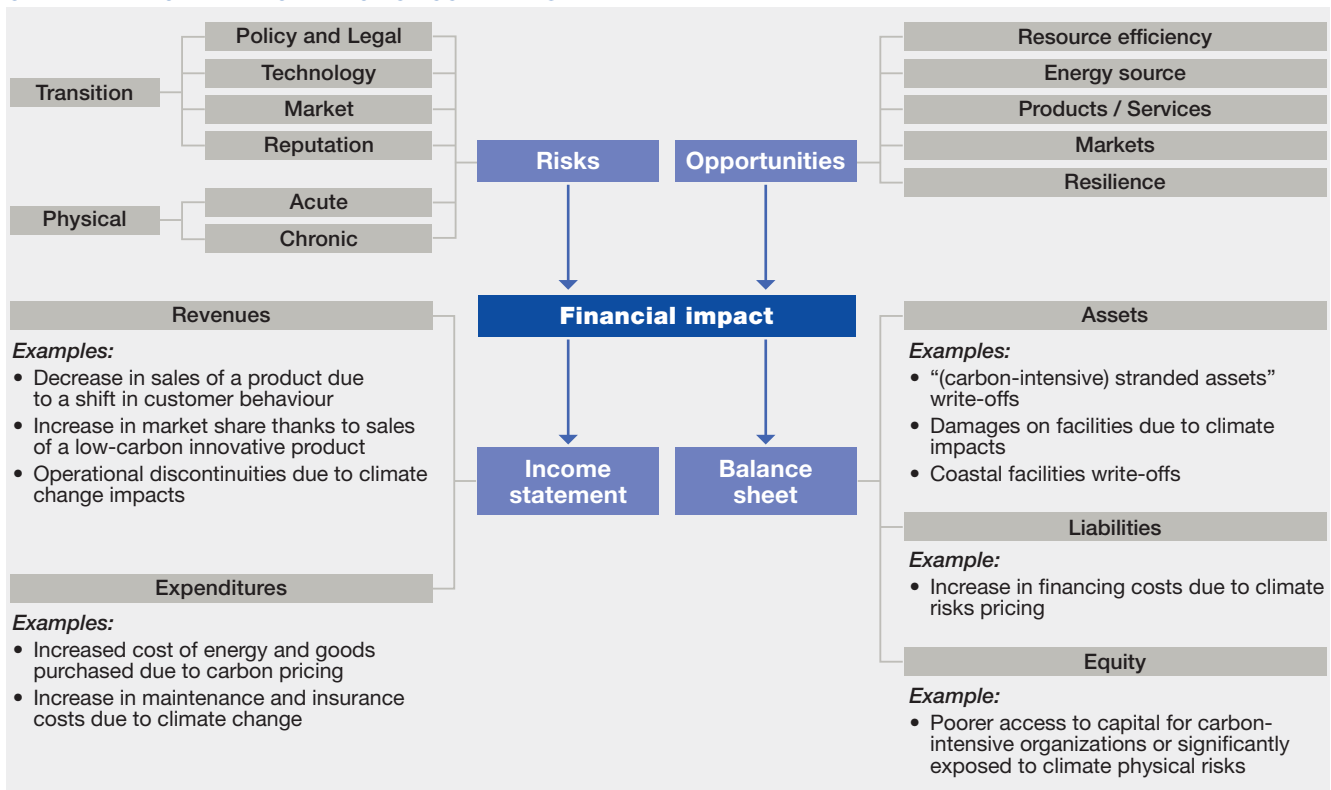
Source: I4CE, adapted from the TCFD report, Recommendations of the Task Force on Climate-related Financial Disclosure, December 2016.

FIGURE 2: CLIMATE-RELATED RISKS IN LINE WITH GHG EMISSION PATHWAYS



Source: Schoenmaker and van Tilburg (2016), adapted from UK Prudential Regulation Authority (2015).

FIGURE 3: EXAMPLES OF THE IMPACTS OF CLIMATE-RELATED RISKS AND OPPORTUNITIES ON THE FINANCIAL PERFORMANCE OF COMPANIES



Source: TCFD, Recommendations of the Task Force on Climate-related Financial Disclosures, December 2016, with examples of financial impacts added by I4CE.

Furthermore, the TCFD (Task Force on Climate-related Financial Disclosures)⁸, a working group launched by the Financial Stability Board in December 2015, recommends that the financial players, like other businesses, should carry out forward-looking analyses based on scenario analysis including a 2°C scenario, in its final report made public in December 2016. More specifically, the report recommends carrying out an analysis of risks and opportunities for the financial performance of companies under different scenarios, including a 2°C scenario.⁹ The TCFD also recommends that even if such analysis may initially be carried out on a qualitative basis, it should become increasingly quantitative and clearly present assumptions made in the scenarios used.

Finally, in France, Article 173 of the Law relating to the Energy Transition for Green Growth (*Loi relative à la transition énergétique pour la croissance verte*, LTECV) requires institutional investors to present in their annual report the resources implemented in order to contribute to compliance with the international objective of limiting global warming, in respect of indicative targets defined in line with the national low carbon strategy.

⁸ Task Force on Climate-related Financial Disclosures, Recommendations of the Task Force on Climate-related Disclosures, December 14, 2016.

⁹ According to the TCFD in this report, a 2°C scenario presents a pathway for deployment of an energy system and a pathway for emissions in line with the objective of limiting the increase in global average temperature to 2°C above the pre-industrial average. The TCFD does not recommend any specific scenario, but presents a number of them in its technical supplement on the use of scenario analysis.

For all these reasons, it is necessary for financial institutions to carry out a forward-looking analysis of their portfolio’s alignment with a 2°C pathway and to measure the risks and opportunities that the underlying assets in their portfolio will present in a low-carbon transition scenario. Indeed, certain activities that are very profitable today will see their performance tail off in a low-carbon economy, while new activities and new markets will develop, which will improve the financial performance of companies that are capable of seizing such opportunities. The best performing financial portfolios will therefore be those that have been able to harness these new risks and opportunities. Figure 3 gives examples of the potential financial impacts of climate-related risks and opportunities on companies.

A vision for the integration of forward-looking climate analysis inside financial institutions

The forward-looking analysis of a portfolio’s alignment with a 2°C pathway would enable financial institutions to manage their transition risks and guarantee the financial performance of their asset management products - provided such analysis was incorporated into investment decision and risk management processes. This forward-looking analysis should be applied to all financing and investment lines managed by the financial institution, above and beyond portfolios dedicated to the funding of energy transition.

Structural elements of a forward-looking analysis

A forward-looking analysis of alignment with a 2°C pathway should be based on several scenarios in order to identify the potential impacts of low-carbon transition on the financial performance of the businesses and other underlying assets being studied. In practice, the low-carbon transition has implicit, and significant, uncertainties in terms of the political, macroeconomic and sectoral instruments that will be used for its implementation. This uncertainty is what is at the core of transition risks. At the political level, the regulatory and fiscal provisions to be deployed with a view to ensuring compliance with the undertakings of the Paris Agreement remain partly undecided at this stage.¹⁰ At the macroeconomic level, most of the uncertainty hinges on the relative level of the efforts exerted by the energy sector for a decarbonisation of the energy mix and carbon efficiency efforts to be consented by all the other economic sectors. At the sectoral level, uncertainties relate to the magnitude and time horizon of technological breakthroughs and market transformations that will take place during the low carbon transition.

A forward-looking analysis therefore should be based a minima on a scenario corresponding to the implementation of actions necessary to achieve a 2°C pathway, as well as a scenario corresponding to a less ambitious pathway. This less-ambitious scenario, however, would need to incorporate higher parameters for physical climate-related risks, as recommended in the TCFD report and its technical supplement on the use of scenario analysis.¹¹ Such scenarios could be based on macroeconomic scenarios developed

¹⁰ In order to ensure the fulfilment of undertakings made in the context of the Paris Agreement in the shape of "Nationally Determined Contributions" or "NDCs", the introduction of new regulatory and fiscal measures is expected from the governments over the next few years. These potential additional measures could take the shape of the introduction of a carbon tax, a tightening of the energy efficiency standards on certain products, new public incentives on certain low-carbon activities, etc. At European level, the details of the EU ETS reform are still under discussion for example.

¹¹ Task Force on Climate-related Financial Disclosure, Technical supplement – the use of scenario analysis, December 14, 2016.

by recognised organisations that would be itemised with quantitative variables selected by the financial institution in line with its expectations. By way of illustration, such variables could be the level of a carbon price, or the impact of a technological breakthrough on the market. Guidelines to help the breakdown of climate-related scenarios into quantitative variables of the financial impacts of transition risks are for example proposed by the TCFD,¹¹ as well as by the Energy Transition Risks & Opportunities (ET Risk) research project.¹²

The low-carbon transition scenarios developed in this manner would then need to be incorporated into existing investment decision and risk management processes so as to make it possible to measure the impact of low-carbon transition on the performance of the companies financed.

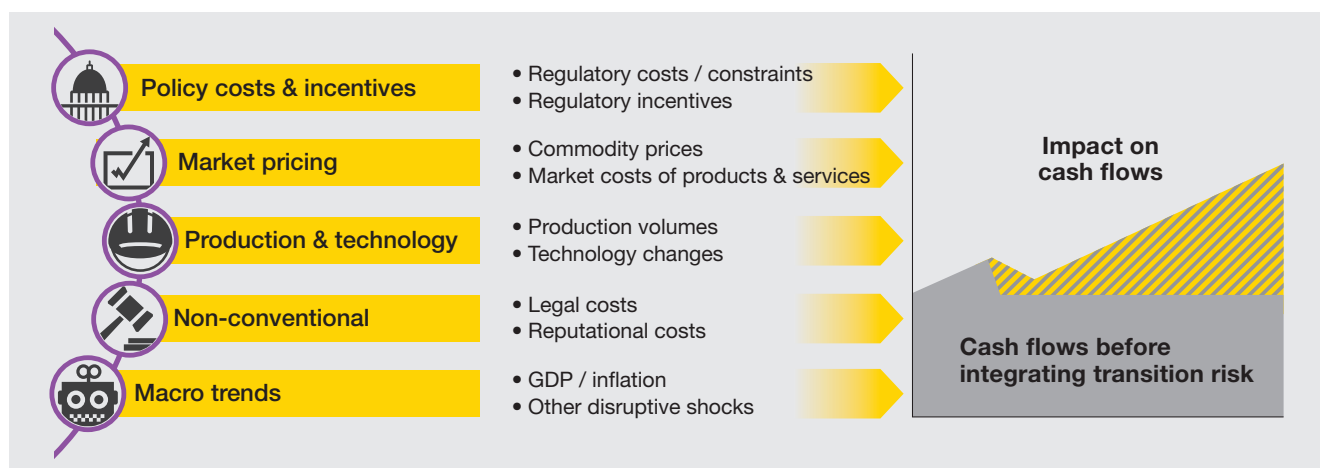
Integration of forward-looking climate-related analysis into the investment decision or financing processes

The investment decision or financing process depends on the business lines within a financial institution. Nevertheless, across all financial business lines, it involves anticipating the future financial performance of a company or underlying organisation, or the ability to repay in the case of the personal loans segment, and deducing from this either the future ability to repay, or the resale of a financial security. This "fundamental analysis" is carried out by the account managers ("front office") directly, by the research department inside the financial institution, or even by ratings agencies or other financial intermediaries.

Whatever the business line and the investment or financing decision process, a scenario analysis combining the effects of transition policies and the physical impacts of

¹² "Transition Risk Toolbox" report, December 2016, available at the following link: http://2degrees-investing.org/IMG/pdf/2ii_et_toolbox_v0.pdf. Members of the ET Risk research consortium include: 2°C investing initiative, I4CE, University of Oxford, Carbon Tracker Initiative, CO-Firm, Kepler-Chevreux, S&P Global. The aim of this 3-year research programme is to develop a framework for analysis of transition risks suited to listed financial securities.

FIGURE 4: DEVELOPING PARAMETERS AND VARIABLES ON TRANSITION RISKS



Source: 2°C Investing Initiative for the ET Risks consortium Transition Risk Toolbox, December 2016.

climate change must therefore be incorporated directly into the “fundamental analysis” of underlying assets. Indeed, climate-related risks and opportunities will have a direct impact on the future financial performance of underlying assets, since they impact earnings like they do projected expenditures, as explained in the following diagram.

To enable climate-related issues to be taken into account in the fundamental analysis, existing valuation models must be complemented by “climate-related” variables representing key risks and opportunities - physical or transition - in line with the sectors.

This purely quantitative aspect of a forward-looking climate-related analysis may also be complemented by a qualitative strategic-focused alignment with a 2°C pathway. This should be done for one of two reasons: 1. efficient management of climate-related risks through an early alignment with the pathway; or 2. impact-focused contribution to the financing of the low-carbon transition by the financial institution. Such proactive coordination at the financing or investment portfolio level may be carried out via the integration of 2°C alignment objectives in the financial institution’s strategy.

Integration of forward-looking climate-related analysis into the risk management processes

Risk management within financial institutions is typically carried out by a department separate from front-line business units directly involved in investment decisions. Risk management by financial establishments (banks and insurers) is regulated and supervised by national central banks and supervisory authorities, as guarantors of the financial system’s stability, and the appointment of which was made explicit following the financial crisis of 2008-2010.

Changes in financial regulations and national supervision practices are harmonised at world level by the Basel Committee, which brings together the representatives of central banks and prudential authorities from twenty six countries. One of the pillars of banking regulation in respect of risks focuses on prudential rules, and in particular an equity capital requirement calculated on the basis of the risks to which the bank is exposed. In the calculation of equity capital requirement, credit risks are considered to be the exposure weighted on the level of counterparty risk and credit risk on assets. In order to calculate this risk-weighted exposure, European banks have for the most part chosen to develop their own in-house models for rating credit and counterparty risks on their assets, in preference to a flat-rate calculation of equity capital requirement.¹³

These models are constructed in accordance with guidelines laid down by financial regulations and must be validated by the supervisory authority to be able to be used in order to

¹³ The relevance of using in-house models is currently the subject of discussions in the context of finalising the Basel III Agreements and the start of discussions on Basel IV. It is possible that the use of in-house models in the context of prudential regulation will be significantly restricted over the next few years.

substantiate compliance with prudential regulations. The vast majority of European banks have chosen to develop in-house models in order to monitor their exposure to risks.

For the integration of climate-related risks into the assessment of their exposure to risks by financial institutions and the supervisory authority, it is important to add climate-related risk parameters to the existing in-house models, as well as to the standard models for assessment of the exposure to risks. This may be achieved in two different ways: either by creating a new risk category corresponding to climate-related risks in prudential regulations, or by incorporating climate-related risk parameters into the assessment of existing risk categories, as defined in the context of the Basel agreements: market risk, interest rate risk, liquidity risk, counterparty risk, credit risk and operational risk. In both cases it is necessary to “translate” the climate-related risks assessed by the macroeconomic models into variables that can be integrated into the financial models for risk management. These variables will need to reflect the risks and opportunities associated with both the low carbon transition and the economic effects of climate change.

This work to define climate-related variables suited to financial risk models is in progress, particularly in the context of research projects such as the ET Risk consortium. In the coming months and years, defining these variables will necessitate collaboration between climate research centres, financial institutions and regulators.

Incorporating climate-related risks into the in-house risk management models will enable the financial institutions to assess their exposure to climate-related risks, in the case of a specific risk category, or to assess the impact of climate-related risks on their general risk level. Financial institutions will thus be able to put a hedging policy in place on these risks, or an investment and financing policy making it possible to limit their exposure to climate-related risks. This assessment will also allow the supervisory authority to measure the financial system’s overall exposure to financial risks. If the threat to the financial system’s stability represented by climate-related risks is confirmed, the supervisory authority may for example intervene via financial regulations so as to limit the exposure.

The current constraints and limits to the integration of a climate-related scenario analysis in valuation and financial risk models

There exists today a number of constraints and limits within the financial system that will need to be overcome in order to achieve the objective of integrating a forward-looking climate-related analysis into the financing decision and risk management processes. Four of these limits are discussed here.

Forward-looking information on underlying assets is still very limited

In order to be able to analyse the future performance and exposure to transition risks of underlying companies in their financing and investment portfolios in the light of the low-carbon transition issues, financial institutions need to have access to forward-looking information on the strategy, investments and future activities of these companies. This information is not widely available at present for a number of reasons:

- in contrast to accounting data, this information is not at present required by the authorities¹⁴;
- some of this information relating to strategy is considered to be sensitive and confidential by the companies;
- publishing information on climate-related risks and alignment with the low-carbon transition requires an exercise of forward-looking analysis to be carried out which is often not currently done by a majority of companies.

This is the reason why the Financial Stability Board (FSB) suggested starting with a task force in charge of drawing up recommendations on the information that companies should be publishing in association with climate-related issues. These recommendations have been available since December 2016.^{15 16}

For the financial system to be capable of taking the climate-related risks and opportunities of their portfolios into consideration, it is therefore essential that the companies in all sectors take into account the recommendations formulated by the TCFD, and in particular:

- analyse their strategy in the light of the low carbon transition scenario and in particular of a 2°C scenario;
- measure the financial impact of climate-related risks and opportunities, on their earnings by activity as well as on their expenditures;
- define objectives for alignment with a 2°C pathway and specify the resources implemented for achieving such objectives;
- incorporate this information into their annual reports.

The financial models used at present limit the ability to integrate climate-related risk parameters

The financial models currently used by the financial institutions and supervisory authorities present two major constraints that limit their ability to integrate climate-related risks and opportunities.

Firstly, these models, and in particular the risk management

models, are for the most part based on historical data projected into the future. However the low-carbon transition will cause a long-term change to the global economy, and past financial performances and risks will no longer be relevant for analysing future financial performance. These models therefore present a limited ability to analyse financial performance in a context of transition towards a new economic model.

Secondly, as highlighted by Mark Carney, there is a “tragedy of the horizon”.¹⁷ Financial models are constructed over short time horizon (2 to 3 years for monetary policies and 10 years for financial stability stress tests, from 5 to 15 years for valuation models or a maximum of 25 to 30 years for credit analyses). This near-term focus makes it somewhat difficult to take the economic consequences of climate change into account - since the climate-related models typically present data on impacts to a horizon of 2035, 2055, or 2100 - when it is necessary to take action today to succeed in limiting the future significant impacts of climate change.

Carrying out an analysis of risks and financial performance in the long term also raises the question of how to take an organisation’s ability to adapt to changes in the physical world and markets into account. Companies will be able to review their strategy and their exposure to climate-related risks, with margins for manoeuvre and time frames that will vary in line with activities, type of organisation and quality of governance.

Operational constraints must be overcome within the financial institutions

Apart from the issues of data and financial models, financial institutions must also push beyond operational limitations in order to be able to incorporate climate-related forward-looking analyses into their financing decision and risk management processes.

The information systems of financial institutions will need to be adapted so as to be capable of managing the climate-related data and indicators from their underlying assets. Indeed the information systems of financial institutions are not currently organised to be capable of collecting and aggregating such data.

Moreover, in general today among financial institutions, there is a lack of awareness and of technical skills with regard to the risks and opportunities associated with climate change, whether in reference to transition risks or opportunities or to physical risks. Therefore, all personnel of financial institutions responsible for the collection, analysis and use of climate-related data will need training on the implications of climate-related risks and opportunities, in order to be in a position to ask for relevant information and to understand the results of analyses that have been carried out. Such in-house training may be complemented by internal or external “technical” support services, capable of answering

¹⁴ One exception: in France, article 173 of the 2015 Law relating to the Energy Transition for Green Growth makes it compulsory for listed companies to disclose in their annual report the financial risks associated with the effects of climate change and the measures taken to reduce them. This provision is applicable as of the financial year that ended on 31 December 2016.

¹⁵ Task Force on Climate-related Financial Disclosures, Recommendations of the Task Force on Climate-related Disclosures, December 14, 2016.

¹⁶ A summary of the response from I4CE to the consultation on the TCFD report is available here: <http://www.i4ce.org/apports-recommandations-tcfd-debat-risques-climat/>

¹⁷ Mark Carney, “Breaking the tragedy of the horizon – climate change and financial stability”, 29 September 2015. <http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx>

questions from operatives and pointing them towards good sources of information or data when necessary.

Macroeconomic climate-related risk models must be translated into microeconomic models and variables suited to financial models

A final constraint for the operational implementation of climate-related scenario analyses lies in the limited availability of microeconomic scenarios on physical and transition climate-related impacts, and also in the lack of availability of climate-related risk transmission models for sectoral value chains and the broader financial system.

To carry out a systematic quantitative analysis of the climate-related impacts on the financial performance of companies, it is necessary to break down existing macroeconomic scenarios into geographical, sectoral, sub-sectoral and per technology scenarios. Furthermore, the assumptions of these scenarios must be presented in a transparent manner so that companies can modify them to suit their own needs. This work is in progress within various research centres and initiatives, among which can be mentioned the “Deep Decarbonization Pathways Project” (DDPP)¹⁸, and the Energy Transition Risks & Opportunities (ET Risk) research project.¹⁹

Another area of research not yet sufficiently explored concerns the analysis of climate-related risk transmission channels. Companies are subject to direct impacts of the effects of climate change and transition, but also indirect impacts. These indirect impacts represent the impacts on their value chain which have repercussions on their own financial performance. For example, the introduction of a high carbon price for energy producers will result in higher energy selling prices, and therefore higher energy costs for the company. Depending on the negotiation abilities of each player within a value chain, they will be more or less better placed to pass on the financial impacts to other players, upstream or downstream. In order to accurately assess an organisation’s exposure to climate-related risks, it would therefore be useful to know the potential dynamics of repercussions from the financial impacts inside the main value chains concerned. In this context, it is particularly important to carry out such an analysis of the climate-related risk transmission channels within the financial sector so as to confirm that climate-related risks do indeed represent a systemic risk and could threaten the stability of the global financial system.

Nonetheless, such additional economic research requirements must not prevent companies and financial institutions from beginning to analyse the impacts of climate-related risks and opportunities on their strategy: indeed, even when sufficiently detailed quantitative scenarios are not yet available, it is already possible to carry out qualitative analyses, as recommended by the TCFD.

In parallel with the necessary research efforts, financial institutions should begin to take climate-related issues into account as of today

The whole financial sector will be impacted by the economic effects of two incremental and partially opposed changes under way: those connected with the impacts of climate change and those connected with low-carbon transition. These economic effects will be significant and may be of a systemic nature. The financial sector therefore has every interest in taking climate-related issues into account in its strategy and risk management in order to guarantee its stability and the future financial performance of the various financial players. Private as well as public financial institutions should therefore progressively incorporate a forward-looking and quantitative analysis for alignment of their portfolios with a 2°C pathway into their decision and risk management processes. To do this, climate-related variables would need to be integrated into the financial models used for the fundamental analysis of underlying companies, for the evaluation of financial securities and for the management of risks.

As discussed in this note, several operational limitations need to be overcome in order to enable the integration of a forward-looking analysis for alignment with a 2°C pathway in the financial models. Such limitations may be overcome in the short term via additional research and development efforts on the breaking down of climate-related and transition scenarios into variables that are consistent with the financial models. In the medium term, the perspectives opened up by Fintech technologies, and in particular Robot Finance tools, in terms of ability to manage and analyse an extremely large quantity of data, should be explored in order to facilitate the consideration of multiple climate-related variables and data in financial models.

Lastly, financial institutions can already begin to improve their consideration of climate-related issues in all their activities, above and beyond their portfolios dedicated to the financing of energy transition. Indeed, some financial institutions have already started a few years ago to work on initiatives in that direction. Some indicators and databases are already available and make it possible to give preliminary indications to financial players on their climate-related issues. Climate Brief no. 46 explores the analyses of climate-related issues that it is possible, and desirable, for financial players to carry out right away.

¹⁸ For further information on the Deep Decarbonization Pathways Project, see: <http://deepdecarbonization.org/>

¹⁹ See footnote 12 for more information on this research programme.

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