UNEP FINANCE INITIATIVE

Assessing credit risk and opportunity in a changing climate: Outputs of a working group of 16 banks piloting the TCFD Recommendations

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April 2018

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Many of the environmental challenges that the world faces XSH½E]VWRXHSVIQGSPWXQEEKRGKHIXVEGEHGO to one fundamental root cause: short-termism. Financial markets can become a catalyst for action on sustainability, but for that they need to become more long-term oriented. The beauty of the TCFD framework is that it encourages organizations to consider and disclose long-term impacts. This change in perspective is what we need to achieve sustainable devel-

The collaborative effort to pilot some of the recommendations by the Task-Force on Climate-related Financial Disclosures is invaluable for advancing best practice of climate risk analysis. I am convinced that we can close data and know-how gaps over XMQ][SVOMSRKERGMEP ½RERGMEP tries as well as in research.

LI ELO EA NI

Managing Director, Environmental & Social Risk

UBS

Rabobank's participation in the UNEP FI pilot on the implementation of the recommendation of the TCFD is line with our mission of Growing a Better World Together. By partnering with leading international organizations like UN Environment we aim to make a serious contribution to tackling the challenges brought about by climate change. Assisting in the realization of the Paris0 Tyeie part 04.9 (of(ouropear)-24.6 national)129 (cmpasis.)808 y ou(ld(im(act Worwit in the(UNEP FIT)139.9 (TCFDPpilot)080.3 (W)70.1 (or)-40.1 kting GrupL. le

This report is the result of a collaboration of sixteen of the world's leading banks under the UN Environment Finance Initiative (UNEP FI) to pilot the recommendations published by the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD). Through this collaboration, banks set out to develop and test a scenario-based approach for assessing the potential impact of climate change on their corporate lending portfolios as recommended by the TCFD. As an inaugural exercise, the output of this process is LQWHQGHG WR SURYLGH D ÀUVW EXW FULWLFDO VWHS recommendations.

The TCFD recommendations urge banks to use scenario analysis to assess and disclose the "actual and potential impacts" of climate-related risks and opportunities on their business as well as how they manage them. In this framework, climate risk can be divided into two risk categories: physical risk and transition risk. To assess both sides of climate risk, the sixteen banks formed a Working Group to test the impacts of climate risk under three scenarios (representing a 1.5°C, 2°C, and 4°C global average temperature increase by the end of the century), supported by two consultancies: Oliver Wyman and its sister company Mercer on transition risk and Acclimatise on physical risk.

This report focuses on transition risk, which is associated with the transition to a low-car ERQ HFRQRP\ DQG FRQVWLWXWHV WKH ÀUVW LQ D WZ risk and physical risk assessment methodologies developed through the Working Group's collaboration.

Oliver Wyman, a leading global management consultancy and Mercer, a leader in investment management consulting, supported the development of the methodology outlined in this report. Oliver Wyman brought deep expertise in risk management and stress testing IURP WKH ÀQDQFLDO VHUYLFHV VHFWRU ZKLOH 0HUFH its framework for considering climate change investment risks and opportunities from its 2015 "Investing in a Time of Climate Change" study. Developing a widely applicable and rigorous methodology for assessing transition risk relied heavily on the active participation RI :RUNLQJ *URXS PHPEHUV· VXVWDLQDELOLW\ FUHG Participants from the sixteen banks provided input into this report and continue to pilot and UHÀQH WKH PHWKRGRORJ\ DV D UHVXOW RI WKHLU VL[

To avoid the most disruptive outcomes of climate change, nearly 200 countries have agreed—through the 2015 Paris Agreement[1]—to strengthen the global response to climate change in order to limit “the increase in the global average temperature to well below 2°C above pre-industrial levels”. To achieve this objective, a transition to a low-carbon global economy is required. From the perspective of the market, a low-carbon transition translates into a new and uncertain landscape of commercial risks and opportunities. These new risks and opportunities need to be understood, assessed, and translated into effective strategies if FRPSDQLHV DUH WR DGDSW WR EHQHÀW IURP DQG FR

7KH 7&)' UHFRPPHQGDWLRQV SURYLGH ERWK FRUSRUD consistent, high-level guidance to assessing and disclosing climate-related risks and opportunities. They require organisations to adopt a forward-looking, scenario-based approach to climate impact assessments, extending their horizons decades into the future. It is expected that implementing the recommendations will generate new sources of informa- WLRQ IRU PDUNHW DFWRUV DQG SROLF\PDNHUV LQÁXH transition to a more sustainable, low-carbon economy.

While providing high-level guidance, the TCFD has left it to the various industries to GHYHORS DQG SLORW WKH VSHFLÀF DSSURDFKHV PHW VSHFLÀF QHHGV DQG H[SRVXUHV

This report synthesizes the efforts of a Working Group of sixteen international banks convened by the UN Environment Finance Initiative (UNEP FI) and supported by Oliver Wyman to develop a methodology for assessing the risks and opportunities associated with the transition to a low-carbon economy (the "transition-related" impacts associated with climate change). As such the methodology addresses the Strategy element of the TCFD recommendations around the use of scenario analysis for forward-looking assessments of transition-related impacts.

The key aim of the methodology is to help banks assess the transition-related exposures in their corporate loan portfolios where they may have concerns about the potential policy and technology related impacts of a low-carbon transition, as well as an appetite to explore and capture the associated opportunities. It is also through their lending activities, including FRUSRUDWH SRUWIROLRV WKDW EDQNV FDQ SOD\ WKH

che co.(, including)]TJ /C2_1 1 3303>]TJ 0.005 20.1 9>ts `RUQ@UUHF\ QDC

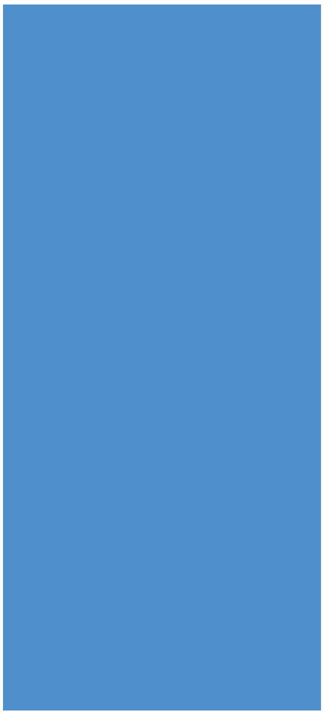
DQDO\VLV LV LQWHQGHG WR HVWLPDWH FDSLWDO QHH climate transition response, however, will evolve over decades. Analysis over this long time horizon is rather intended to assess the sensitivity of a bank's current business to plausible climate-related transition scenarios at different points in time over the extended horizon.[2] The exercise is not a precise forecast but a sensitivity analysis which can be used to inform strategic planning and portfolio composition and to ensure institutions are VXIÀFLHQWO\ FOLPDWH DZDUH.

In addition to an extended time horizon, assessing climate-related transition risk presents unique challenges IRU ÀQDQFLDO LQVWLWXWLRQV

- Limited information is available to assess how a climate transition scenario might LPSDFW WKH FUHGLWZRUWKLQHVV RI VSHFLÀF ERUUR
- Substantial coordination within organizations is required to execute an effort with VXFK VFRSH H[SHUWLVH IURP VXVWDLQDELOLW\ FUH investor relations must be brought to bear
- Finally, to be most useful and instructive for banks and the market, the methodology must be repeatable, systematic, and consistentZKLOH DOORZLQJ IRU FRP customization where data are available

To address these challenges, the methodology leverages the most relevant tools for quantifying climate-related transition risk and combines them into a holistic approach for transition risk assessmentThe methodology is anchored in analyses of particular-temper DWXUH EDVHG VFHQDULRV LQFOXGLQJ D ƒ& VFHQDUL such scenarios. It combines portfolio-level and borrower-level risk assessment.[3] As shown in Figure 0.1, a borrower-level calibration module captures nuances from the bottom up while a top-down portfolio impact assessment module extrapolates these borrower-level impacts to portfolio segments with homogeneous exposures to transition risk. As a result, only a sample of name-level analyses is required to estimate portfolio risk exposure, reducing both time and resource requirements. Note the impact of the transition scenarios can be positive, negative, or neutral depending on the sectors, the geographies, and the scenarios.

Figure 0.1: Overview of the transition risk modules



By linking the three modules, banks can address the major challenges inherent to modelling transition risk:

- Transition scenarios provide plausible views of how transition risk might evolve across sectors over the next few decades
- Borrower-level calibration allows each bank to tailor the approach and overcome a lack of empirical data to estimate changes in credit outcomes
- Portfolio impact assessment, together with the scenarios, provides a structured analytical framework that makes the approach repeatable, systematic, and consistent and helps coordinate and integrate analysis and judgment across a bank

The Working Group's piloting of this approach yielded valuable insights. In particular, the testing underscored the need for a methodology that can accommodate different scenarios and bank exposures to risk. For instance, there are multiple ways to achieve a 2°C scenario; each path can lead to vastly different sector impacts depending on the underlying scenario assumptions, such as the feasibility of wide-scale carbon capture and storage WHFKQRORJ\ &&6 6SHFLÀF VFHQDULRV PD\ SURYH PF YXOQHUDELOLWLHV)RU H[DPSOH LQ VRPH VFHQDULR rapid phase out of coal; a scenario that stresses high-carbon power generation companies may therefore not be as stressful, in the short-term, for oil and gas exploration and production counterparties. Findings like these emphasized the importance of developing a methodology compatible with different scenarios and scenario sources which will provide different views of how the future may look. While the methodology described in this report focuses on temperature-based scenarios to align with the TCFD recommendations, it can be adapted to bespoke, event-based scenarios such as a sudden policy change or a technological breakthrough. These events may lead to greater risk to the banks in the short term as banks and companies will have less time to adapt and adjust to the new environment. Broadly, as in macro-economic stress testing, banks should identify their own vulnerabilities and test various scenarios to probe them.

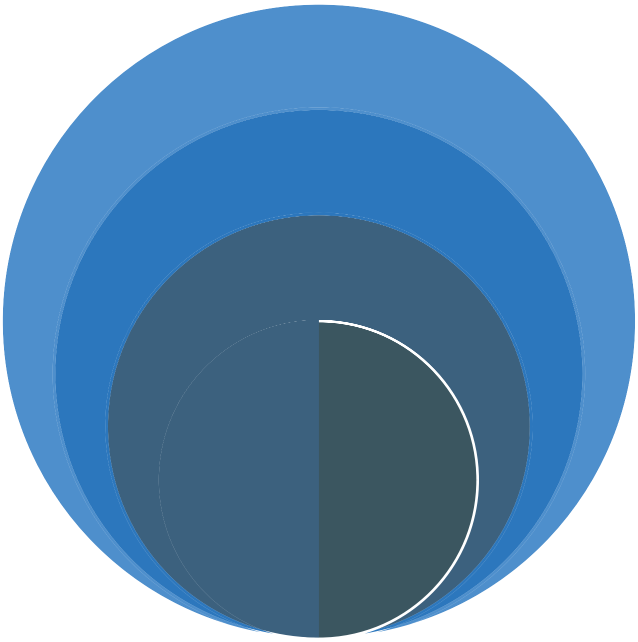
The piloting of the approach also highlighted that there is a need for further collaboration between the different stakeholders, such as banks, industry groups, and scenario modelling teams. This collaboration will help standardise approaches and practices so that results can be disclosed and compared across banks along a variety of dimensions, including sectors, geographies, and scenarios. Collaboration can also improve the assessment by creating feedback between the physical and economic scenario descriptions, and the assessments done by the banks. Increased scenario details and further granularity, for example, would improve the assessment.

A major advantage of the proposed approach is its adaptability: the methodology is extensible to multiple sectors, a variety of scenario sources, different risk factors, and timeframes 6XFK ÁH[LELOLW\ ZLOO SURYH XVHIXO -DV EDQ PHQW DV ÀQDQFLDOO\ RULHQWHG FOLPDWH VFHQDULF reporting and best practices evolve.

$V WKH ÀUVW H[HUFLVH RI LWV NLQG WKLV PHWKRGRO a foundation to build upon in future work. Implementation of TCFD recommendations will naturally require multiple phases as practices evolve and new data emerges from industry practitioners, corporates, policy makers, and climate modellers. We see a number of potential paths for further development of the approach 7KLV LQFOXGHV FUHDWLQJ ÀQDQ scenarios tailored to the vulnerabilities of the institutions, developing data and analytics for borrower-level climate risk analysis, enhancing the portfolio impact assessment methodology, and integrating transition risk assessment in the organization.

TCFD recommendations (see Figure 1.1), which aims to disclose "the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, DQG ÀQDQFLDO SODQQLQJ ZKHUH VXFK LQIRUPDWLRQ different climate-related scenarios, including a 2°C or lower scenario." A "2°C or lower scenario" lays out a trajectory "consistent with holding the increase in the global average temperature to 2°C above pre-industrial levels". The scenario analysis is expected to inform the "metrics and targets used to assess and manage climate-related risks and opportunities" (Metrics and Targets element of the TCFD recommendation in Figure 1.1)". The scenario analysis is expected to inform the "metrics and targets used to assess and manage climate-related risks and opportunities" (Metrics and Targets element of the TCFD recommendation in Figure 1.1)".

Figure 1.1: Core elements of the TCFD recommendations



ÀQDQFLDO FULVLV LQVWLWXWLRQV KDYH VSHQW \HDU management budgets to enhance their macro-economic stress testing capabilities. While we do not expect climate change risk measurement to receive the same level of singular attention at banks in the near term, we nonetheless expect that the development process will require multiple iterations, experimentation, and concerted effort across institutions to evolve a set of clear best practices. This document describes a meaningful but nonetheless initial step towards building such a best practice methodology.

1.2. HE CHALLENGE FO BANK

Despite similarities, the assessment of transition risk presents unique challenges compared to traditional risk evaluation. To develop a comprehensive methodology for assessing climate-related transition risk, banks have to overcome six key challenges.

First, limited empirical data exists to measure the strength of the climate-credit risk relationship. Banks lack historical data with which they can assess the impact of climate risk on credit losses. No long-term policy experiments have occurred at the scale WKDW ZRXOG EH UHTXLUHG IRU D ƒ& WUDQVLWLRQ policy constraints on industries, including those reliant on fossil fuels, for example, remain untested. [illegible]

Finally, conducting quality scenario analysis requires major coordination across the organization. Transition risk analysis requires a range of industry, credit risk, and sustainability experts from across the bank. In such a cross-functional exercise, ownership and governance, as well as differences in techniques and skill sets, can lead to coordination challenges. The approach should make the work required by banks manageable, with clearly

2. AN IN EG A ED APP OACH FO TRANSITION RISK ASSESSMENT

identifying the magnitude of the scenario’s impact on the creditworthiness of borrowers, incorporating quantitative and qualitative considerations. This analysis is only conducted on a subset of cases, allowing for manageable workload.

Portfolio impact assessment: The portfolio impact assessment uses a systematic and repeatable approach to extrapolate the risk assessed by other modules to the remainder of the portfolio.

the d2.1J 0path,

Portfolio impact assessment provides a structured quantitative method for combining

BO 2: Modelling transition risk: top-down or bottom-up?

Macro-economic

Additionally, guided by the TCFD recommendations, scenario sources were assessed for DYDLODELOLW\ RI WKH PRVW FULWLFDO ÀQDQFLDO
prices, emissions, investment needs, and energy demand by fuel type.

Output granularity: Though some models may cover the entire world, they do not always report the results of this analysis in a granular way. Scenario sources should also report economic and emissions results at a sector level, so that the major differences in sector relationships to risk drivers are captured. Additionally, regional or country level outputs are useful for capturing differences in transition risk across jurisdictions and levels of economic development.

Update frequency Since important socioeconomic and policy inputs into transition risk models will evolve in the real world, frequent publication of scenario model outputs is necessary. To avoid disruption or obsolescence, selected scenario models should be maintained actively by a group with a mandate to continuously[8] publish.

Based on these criteria, two publicly available, and widely referenced, scenario sources were deemed most appropriate for the purposes of this transition risk analysis exercise:

The IEA World Energy Outlook: An annual scenario analysis publication that projects carbon emissions, technology development, and energy sector trends based on current and emerging policy frameworks. The scenarios are produced using the World Energy Model, a partial equilibrium model designed to explore how energy use and production will evolve over time under alternative policy assumptions.

Integrated assessment models (IAMs): A suite of integrated energy-economy-climate PRGHOV GHYHORSHG E\ WKH VFLHQWLÀF FRPPXQLW\
between emissions, the climate outcome until 2100, and socioeconomic developments including a detailed representation of the energy and land-use systems. The scenarios generated through IAMs have been relied upon in various Intergovernmental Panel on Climate Change assessments, which is the international body for assessing the science related to climate change.

2.1.2. o o p p o po l n o

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HQW SXUSRVHV WKH EHVW ZD\ WR XVH WKHP LV WKHU
risk analysts. Scenario outputs must be translated to allow for assessment of transition risk
LQ ÀQDQFLDO WHUPV

2.1.3. B o q o mn o p and únancial risk assessment

Transition scenario models produce outputs often initially intended for policy analysis or research. As such, they describe the main dynamics that could impact sectors through policy,
WHFKQRORJ\ RU PDUNHW LPSDFWV 7R DQDO\VH WKH\
KRZHYHU WUDQVLWLRQ VFHQDULR RXWSXWV QHHG WR
model outputs can be summarized as a set of focused risk drivers that describe the major corporate performance dynamics in a transition scenario.

The main dynamics described in scenarios that have corporate performance impacts at a sector-level fall into three categories:

Policies can lead to additional costs or gains in revenue by borrowers through taxes or subsidies, impose quantity regulations that decrease demand for borrower products, or mandate capital improvements that require additional investment.

All of these policies act on a portfolio of technologies. Policies can make technologies relatively more competitive by changing their costs. Increased deployment of low-carbon technologies will help some industries and harm others, cutting into their market share. All increases in technology deployment come at a cost, requiring greater capital expenditure.

The market ÀQGV HTXLOLEULD LQ UHVSRQVH WR WUDQVL
FRPSDQLHV ÀQG ZD\V WR SDVV WKURXJK LQFUHDVHG
to price changes by modifying which products they buy. These impacts will, ultimately, affect the total emissions the economy outputs and thus the policies required to further reduce emissions in subsequent periods.

Risk factor pathways are a way to interpret these economic scenario impacts in corporate
ÀQDQFLDO WHUPV (DFK ULVN IDFWRU SDWKZD\ LV D G
scenario compared to a baseline or reference scenario, in this case a 4°C scenario, where only current policies are expected to continue. As such, risk factor pathways were developed from scenario outputs with the intention of meeting several criteria. They must:

(QDEOH D ÀQDQFLDO LQWHUSUHWDWLRQ Risk factor FRUSRU
SDWKZD\V VKRXOG LQGLFDWH ÀQDQFLDO ORVV RU JD
and geography that is intuitive and based on analysis of the scenario.

Allow common comparisons across sectors. To achieve consistency, the structure of the risk factors should be applicable to multiple economic sectors (though the
VSHFLÀF YDOXHV WKH\ WDNH DUH H[SHFWHG WR GLII
common risk drivers, differing risk analysis frameworks would have to be developed for different sectors.

Apply to multiple scenarios fr00C0005u6004C>12. 1 Tf 0.050 0 Tce64lel.851 0 Td [(: T)20

Based on these starting principles, four risk factor pathways were developed at the VHFWRU JHRJUDSK\ OHYHO WR HQF[9]RPSDVV PDMRU GUL

Incremental direct emissions cost, or the increased costs of emitting CO_2 and other greenhouse gases relative to a baseline scenario. In transition scenario models, increased costs are driven by the amount of emissions per period, and the associated carbon-equivalent price. In the real world, these increased costs might be levied as a direct tax on emitters, or through cap-and-trade.

Incremental indirect emissions cost, or the increased costs of production inputs relative to a baseline scenario. During a low-carbon transition, carbon-intensive fuels will increase in price due to pass-through of direct emissions costs. Increased fuel costs will directly impact sectors that use carbon-intensive fuels for economic activity. Increased fuel costs can be further passed on through downstream goods, indirectly incurring subsequent cost increases. Scenario models usually only report increases in fuel prices, but analysis can identify increases of other intermediate goods costs used in production down the chain.[10]

Incremental low-carbon capital expenditure, or the increased costs associated with the need for capital investment to transition to a low-carbon economy. In scenarios, capi- WDO H[SHQGLWXUH LQFUHDVHV WR HQVXUH VXIÀFLHQ LQ VXEVHTXHQW SHULRGV &DSLWDO H[SHQGLWXUH I mandates assumed by the scenario.

Change in revenue, or changes in price and consumer demand. As costs increases, an increasing proportion of costs may be expected to be passed on to consumers. Consumers, in turn, will respond to increased prices by decreasing their demand for certain goods and increasing their demand for others, leading to a change in revenue.

Together, the combined risk factor pathways provide a picture that is meaningful for assessing probability of default for corporates exposed to these risk factors. Each risk factor has DQ LPSDFW RQ ERUURZHUV· FDVK ÁRZ DQG WKH VXP R IXWXUH FDVK ÁRZV PLJKW FKDQJH GXH WR FOLPDWH W directly linked to the borrower's ability to pay off debt without adversely impacting future ÀQDQFLDO SHUIRUPDQFH ([FHVV FDVK FDQ EH DOORFDW probability that a borrower will default by failing to pay back a loan. Note however that, even after combining output variables, the resulting risk factor pathways are still based on economic PRGHOV DQG DUH WKXV DQ LPSHUIHFW SUR[\ IRU ERUU 7KH\ VKRXOG EH LQWHUSUHWHG DV D VXPPDU\ RI WKH V

Risk factor pathways provide a picture of transition risk that can be interpreted at a glance. For example, Figure 2.3 shows how risk factor pathways evolve in the European Union's oil and gas sector under a 2°C transition scenario in the REMIND model, an integrated assessment model developed by the Potsdam Institute for Climate Impact Research (PIK). In this case, one expects both oil and gas, as fossil fuels, to experience risk increases.

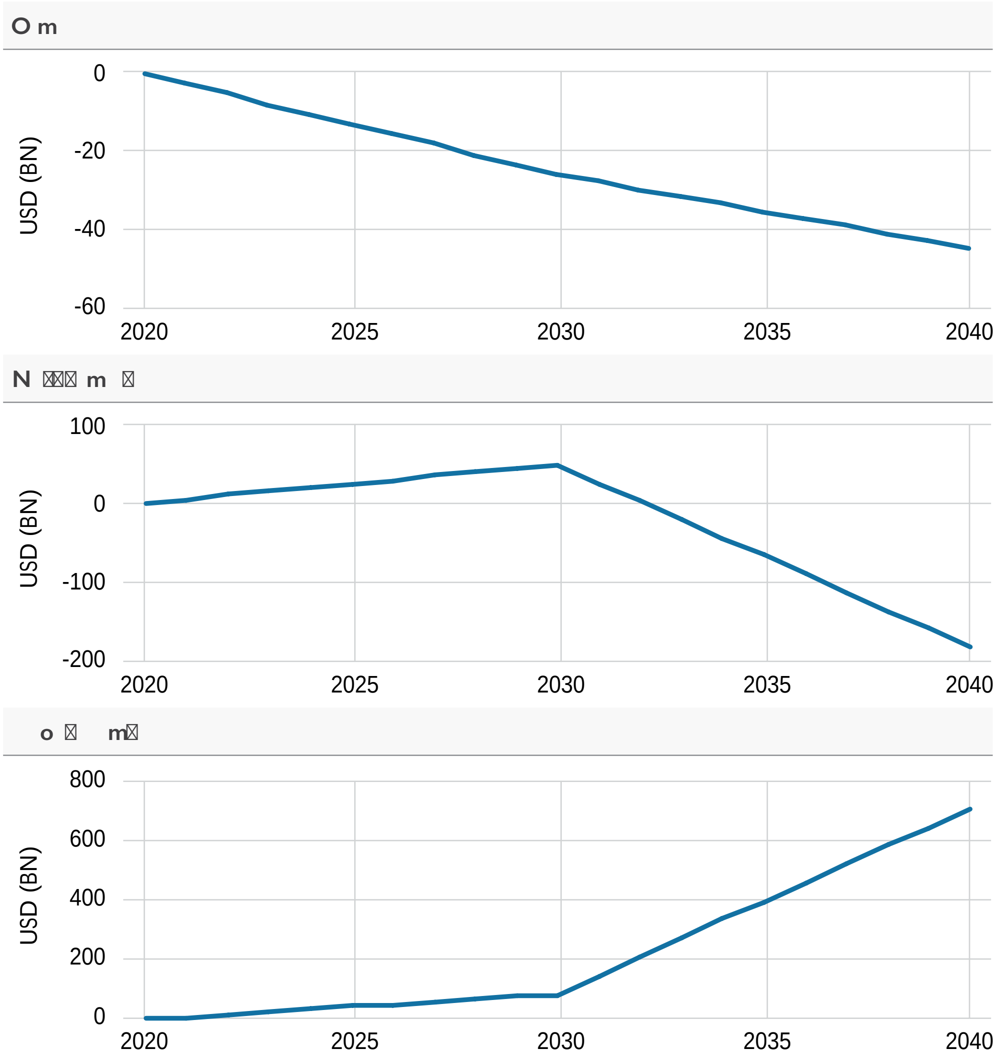
'XULQJ WKH SLORW VHFWRU GHÀQLWLRQV ZHUH GHYHORSH RI YDULDEOH UHSRUWLQJ SURYLGHG E\ WKH WUDQVLWLRQ of fourteen high-level sectors for use in the pilot: energy, oil and gas, oil, gas, coal, electricity, agriculture and forestry, crops, forestry, livestock, renewables, transportation, industrial processes, and residential and commercial buildings. An additional layer of "segment" granularity for risk DQDO\VLV LV GHÀQHG DQG FXVWRPL]HG E\ EDQNV DV IXUW JHRJUDSKLHV ZHUH GHÀQHG

10 For example, using input-output models to project the change in other intermediate good prices based on a pass-through of fuel prices.

Figure 2.3: European Union oil and gas risk factor pathways from the REMIND model 2°C scenario

Such “snapshots” of sector risk can be derived for all sectors and geographies covered in the transition scenario models.[12] Figure 2.5 shows one such example for Asia.

Figure 2.5: Asia combined oil and gas risk factor pathways, REMIND 2°C scenario



: Potsdam Institute for Climate Impact Research; Oliver Wyman analysis

Box 3: Translating scenarios from two of the world's leading transition scenario models

From PIK (REMIND) and IIASA (MESSAGEix-GLOBIOM)

13 Read more about the IAMC at www.globalchange.umd.edu/iamc/

At present, scenario models only provide transition risk outputs at a sector level. Banks, however, are interested in understanding differences in scenario impacts within sectors where there are major variations in borrower characteristics. Understanding risk is perhaps even more important at a more granular segment level within a sector, where groups of companies share homogeneous exposures to transition risk drivers.

7R EULQJ VHFWRU OHYHO ULVN GRZQ WR WKH VHJPHQW relative sensitiv- ities of segments to each transition risk driver. Relative sensitivities specify the impact of transition risk drivers on one segment relative to others. For electric utilities, for example, FRDO ÀUHG SRZHU SODQWV ZLOO KDYH D KLJKHU VHQV to direct emissions cost than a nuclear or renewables-focused generation company. In some sectors, where there are winners and losers, relative sensitivities must also identify the direc- tion of impact relative to the sector as a whole. For example, electric vehicle producers may see an increase in revenue even though car manufacturers as a whole may see a decline.

While relative sensitivities provide constraints on the relative relationships of a segment to D SDUWLFXODU WUDQVLWLRQ ULVN GULYHU WKH\ GR driver's impact on the segment. In the case of electric utilities, one need only identify that FRDO ÀUHG SRZHU SODQWV DUH ZRUVH RII LQ WHUPV counterparts when setting relative sensitivities; one does not need to know by how much. The magnitude of these differences, expressed as a calibrated sensitivity, is always identi- ÀHG WKURXJK ERUURZHU OHYHO FDOLEUDWLRQ DV GH

2.2. BO O E -LE EL CALIB A ION

Outputs from transition scenarios cannot be directly translated into impacts on the credit- ZRUWKLQHVV RI ERUURZHUV 8QGHU D VSHFLÀF VFHQD is impacted by a number of drivers, both quantitative (such as emission costs) and qualita- tive (such as adaptability to the new environment).

While the scenarios provide a high-level view on some of these

Figure 2.6: Adjusting rating factors for unregulated power generation utilities using scenario variables

W M Q T P M ½ IHPIR E Q TXRVIE X M Z I

Probability of Default (PD) is the probability of a borrower defaulting over a one-year time period.

Loss Given Default (LGD) is the percentage of an exposure a bank expects to lose if a default occurs. Loss given default is ultimately a function of the value and type of collateral a borrower puts up to back a loan.

Exposure at Default ($' LV WKH H[SHFWHG DPRXQW RI ÀQDQF to the borrower at the time of default, taking into account interest and principal payments. Exposure at Default is usually expressed as a dollar amount and varies based on the lending terms offered to the borrower.

The methodology described in the remainder of this section focuses primarily-on assessing the evolution of PD under different transition scenarios. The assessment of LGD LV H[SHFWHG WR EH VHFWRU VSHFLÀF UHTXLULQJ FX collateral backing a particular loan, and is discussed in Section 2.3.3. EAD is assumed to remain constant for the purposes of this analysis, allowing the results to be interpreted as an assessment of the sensitivity of the current portfolio to transition risk.

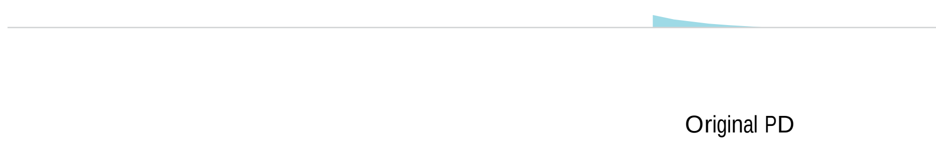
2.3.2. Assessing probability of default (PD)

2YHU WKH SDVW GHFDGHV EDQNV KDYH GHYHORSHG D assess exposure of their portfolios to credit risk. These existing frameworks can be lever DJHG ZLWK PRGLÀFDWLRQ WR DVVHVV WUDQVLWLRQ L

A Merton-like framework is used to theoretically ground the calculation of transition-related PD impacts. Originally developed in the 1970’s by Robert Merton, the Merton model for VWUXFWXUDO FUHGLW ULVN LV RIWHQ XVHG ZLWKLQ À borrower defaulting[14]. Banks, brokerages, and investors around the world have historically leveraged this model in their credit analytics.

7KH IUDPHZRUN UHODWHV 3' WR WKH OLNHOLKRRG WK EHORZ D WKUHVKROG YDOXH VSHFLÀHG E\ WKH YDOXH WKH ÀUP·V IXWXUH DVVHW YDOXHV LV WKHUHIRUH FUX EXWLRQ RI IXWXUH ÀUP DVVHW YDOXHV LV ZLGHQHG WKURXJK D FKDQJH LQ PHDQ WKH 3' LV DIIHFWHG 7K assess transition risks.

Figure 2.8: Illustration of the adjusted Merton framework for climate risk



,Q WKH SURSRVHG IUDPHZRUN D ORZ FDUERQ WUDQV values in response to the introduction of additional systemic risk related to transition risk. With idiosyncratic and other systemic factors remaining unchanged,[15] an increase or decrease in PD can be measured at a given point-in-time based on a shift in the distribution of asset values. This methodology adapts the Merton framework to assess PD impacts as a shift in the distribution of asset values; Figure 2.8 illustrates an adverse impact. This shift is determined by a combination of the risk factor pathways, sensitivities, and calibration points. 7KH PRGLÀHG HTXDWLRQ LV H[SUHVVHG LQ (TXDWLRQ

Equation 2.9: Model calibration equation

$$PD \mid \quad \Phi[\Phi \quad (PD \quad) \quad \frac{1}{\alpha} \sum_{r} (\quad f \,)]$$

$IWHU GHWHUPLQLQJ WKH PDJQLWXGH RI VHFWRU LPS
calibration points. Experts qualitatively evaluate relative sensitivities to provide a relative

A po o q m qq p

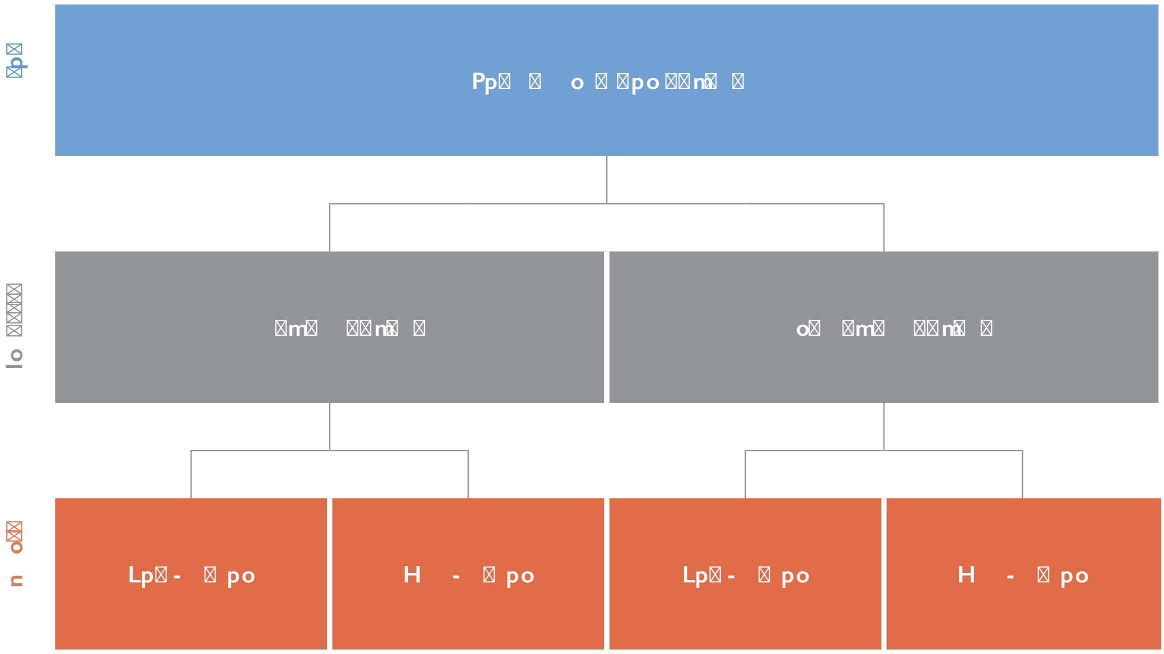
The purpose of the proposed methodology is to provide a systematic, consistent, and repeatable approach for assessment of transition risk in corporate lending. The method ology offers a consistent structure for translating expert insights into transition impacts RQ ERUURZHUV E\ JURXQGLQJ WKDW MXGJPHQW LQ W

3. OPE A IONALI ING HE APP OACH: LESSONS LEARNED FROM BANK PILOTING

7KH GHYHORSPHQW RI WKH PHWKRGRORJ\ EHQHÀWHG
the Working Group, who continue to test and implement the approach. These pilots are being conducted on banks' own portfolios in the sector groups selected for this study, spanning oil and gas, electric utilities (power generation), metals and mining, transportation, and DJULFXOWXUH DQG IRUHVWU\ 7KH SLORWLQJ SURFHVV
incorporated into the methodology.

7R ODXQFK WKHVH SLORWV EDQNV ZHUH SURYLGHG VF

Figure 3.1: Segmentation scheme for the power generation utilities sector



7KH VHFWRU LV ÀUVW VSOLW EHWZHHQ UHJXODWHG
Regulated utilities are able to pass costs through to the consumers and are therefore less exposed to transition risk. The revenue of unregulated utilities, on the other hand, is largely determined by market forces. Unregulated and regulated utilities are expected to react differently to a transition scenario.

Furthermore, banks segmented unregulated and regulated utilities by the energy mix of each utility. The higher the carbon dependency of a utility, the more transition risk it will encounter as it will have to choose between investing in low-carbon generation capacity or bear the emissions cost burden.

Developing the segmentation scheme across banks yielded two conclusions:

7KH ÀQDO VHJPHQWDWLRQ VFKHPH PD\ GLIIHU E\ LQV

The segmentation process is iterative

6HJPHQWDWLRQ VKRXOG UHÁHFW ERWK KRPRJHQHRXV
GULYHUV DQG D PDWHULDO SRUWIROLR H[SRVXUH 6L
risk appetite, underwriting strategy, and geographic and sectoral distributions, full standard-
L]DWLRQ RI VHJPHQW GHÀQLWLRQV FRXOG DG-YHUVHO
geneous and material risk analysis. With a fully standardized segmentation scheme, some
EDQNV PD\ ÀQG WKHPVHOYHV RYHU VHJPHQWLQJ LQ D
rower bottom-up assessment using very granular segments. Further segmentation would
OHDG WR LPPDWHULDO H[SRVXUHV DQG RYHUH[WHQG
ca0055>-e00510043>-88004F0tionfferusing v

segmentation schemes as more data became available or the experts garnered a better under-
standing of how segments might respond. In general, bank experts may wish to explore
YDULRXV ZD\V RI DVVHVVLQJ WKHLU SRUWIROLRV WKU

'HÀQLQJ VHFWRU VHJPHQWV LV QRW D OLQHDU SURFH

Relative sensitivities can be associated with sector characteristics that do not widely vary across scenarios. Thus, for example, sensitivity to emissions costs could be based on the current carbon-intensity of emissions. Low-carbon capital expenditure could be assessed based on the need to invest in or replace capital to reduce carbon emissions. Sensitivities to revenue could be assessed by examining price elasticities or cross-elasticities of demand.

Bank experts can choose to supplement their knowledge with external studies or reports

3.1.3. D n o o p p -m m m poqp o

During calibration, bank experts translate the transition scenario into PD impacts on a subset of segment borrowers. The output from this analysis is a series of calibration points, which quantify the scenario's impact on borrowers' PDs at given periods relative to through-the-cycle PDs.

&DOLEUDWLRQ LV WKH PRVW LPSRUWDQW VWHS IRU RE
VFHQDULR LPSDFWV EXW LW LV DOVR WKH PRVW VHQV
section provides the general guidelines for conducting a calibration analysis. The second section shares some key insights from credit risk analysts piloting this process.

q mp qm ppl

Three steps are necessary to conduct borrower-level calibration:

1. Selecting representative borrower cases
2. Contextualizing the scenario impact on borrowers
3. Translating scenario changes into PD changes

Selecting representative borrower cases

To calibrate borrower-level impacts, banks need to assess the scenario's impact on the PDs of "representative" borrowers. Since borrower cases are used to extrapolate to segment impacts, selecting representative cases is critical for avoiding sample bias. Two criteria are particularly important:

Representative of potential climate-related impacts: Within segments, sector experts should ide3 (t)10 (4n[mer)-28 (thr no)12.9 uaincesvis.

• Pl0 `p@ ` O@ pÀ ðÀ pð|0LW ¿O0 €V RDO ÀUXG§HQXUDWLRQP @
generatioe"
exosuarrrepresentatisampding(biaeedtow)13.4 (w)13.7 ardn wvrestlimatg(segment ris.:)]TJ /S

sources can help shore up gaps in these indicators, as well as identify impacts at a more granular level of analysis.

Since transition scenario models currently output high-level sector variables, additional information may be needed to supplement bank experts' understanding of low-carbon transition impacts at a borrower and segment level. Relevant transition literature can come in the form of other scenarios with the same temperature target, CO_2 price, or ex-post analyses of scenario or historical impacts at the segment or borrower-level.

As an example, Table 3.2 provides an illustration of select supplementary scenario sources in the oil and gas sector.

Table 3.2: Select external study selections in the oil and gas sector

SEGMENT	ESTIMATED METRIC	EFE ENCE AN I ION SCENARIO METRIC	KEY DYNAMICS CAP ED	REFERENCE STUDY
O m o	Mid-range incremental cost of carbon tax to oil sands producers	USD 30 CO_2e/tonne (currently planned carbon tax)	Cost	Special Report: What does the carbon tax mean for the Canadian oil sands?[17]
		USD 50 CO_2e/tonne (potential future carbon tax)	Cost	
Oil reúneries	(IGPMRI MR VIKMSREP TVS½X margins (Singapore)	USD 14 CO_2e/tonne carbon tax	4VS½XEFMPMX]	Singapore to become more eco-friendly with carbon tax[18]
O m	Estimated unburnable proven and probable VIWIVZIW GSQTER] WTIGM½G data available)	IEA 450 scenario through 2050	Revenue	Oil & carbon revisited: Value at risk from "unburnable" reserves[19]
Oil reúneries	Reduction in BAU capital investment in E&P GSQTER] WTIGM½G HEXE available)	IEA 450 scenario through 2035	Capital expenditure	2 degrees of separation: Transition risk for oil and gas in a low-carbon world[20]

When analysing supplemental literature that differs from the scenario's risk factor pathways, experts should most heavily weight sources that are compatible with the transition scenario. Experts should be aware that many policy and technology combinations can be assumed in a 2°C scenario, across a number of economic environments. The timing and magnitude of transition impacts often differs substantially by scenario source. Information used from supplemental sources with different implied transition risk factors should therefore be applied carefully to avoid inconsistencies in results. Supplementary information that is consistent with the scenario should be given greater emphasis by experts. For example, experts might identify supplementary sources with similar socioeconomic developments, policy instruments, and temperature or emissions targets as the transition scenario under examination.

17 www.td.com/document/PDF/economics/special/Canadian/Span2Cksham7 080.5 (emphascn 9sf Tw -

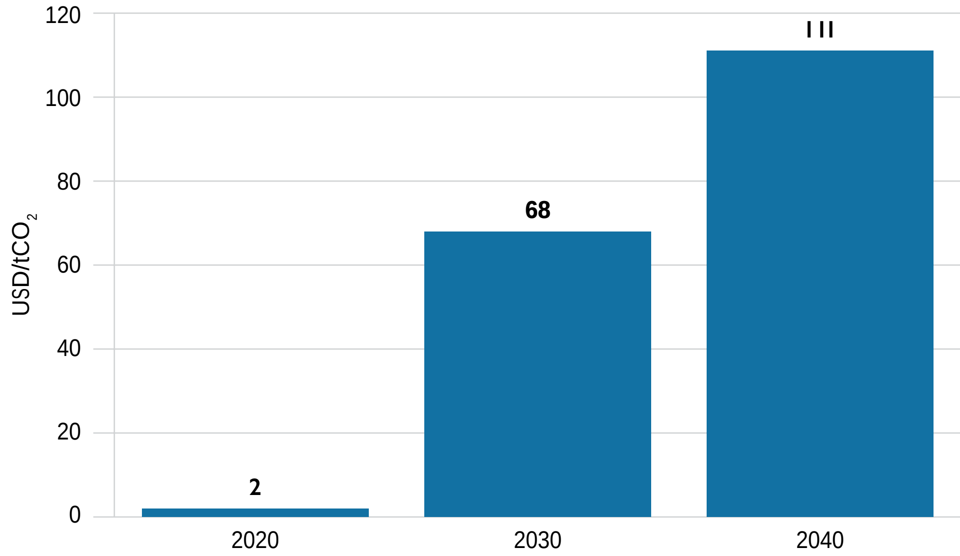
Translating scenarios into probability of default

Armed with an understanding of the impact of the scenario on a segment, experts then translate the scenario into an impact on a borrower's probability of default (PD) or credit rating.

Experts may conduct this assessment using quantitative or qualitative means, or a mix of both methods. Regardless of the method chosen, however, expert judgement will be required to sense-checkFay.exper99 scn /GS0 gs ,.3 i

3.2.

Figure 3.3: Carbon prices in the REMIND CD-LINKS 2°C scenario, all regions

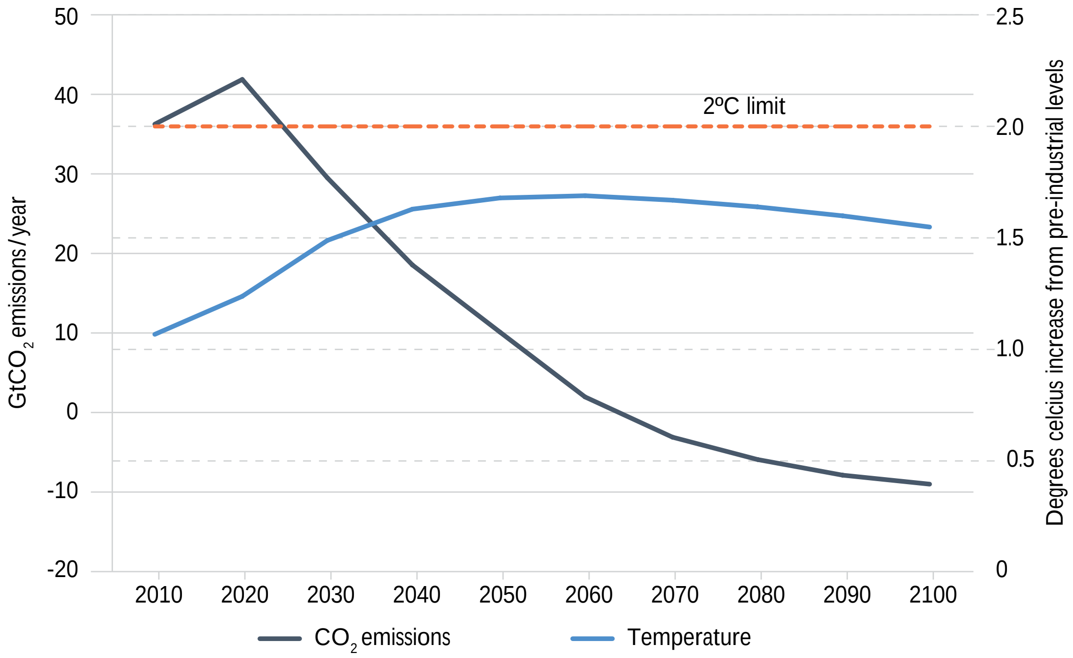


Assumed availability of carbon sequestration options, including reverse emissions (i.e. reduction of atmospheric CO_2 by afforestation or bioenergy combined with carbon capture and sequestration (CCS)), increase the permissible emissions from fossil fuels and thus reduce

p p popn mpqn o

Overall, the REMIND CD-LINKS scenarios occur in a “middle-of-the-road” world, where social, economic, and technological trends do not shift markedly from patterns of the recent past.

Figure 3.5: Global average temperature and carbon dioxide emissions in the REMIND CD-LINKS 2°C scenario

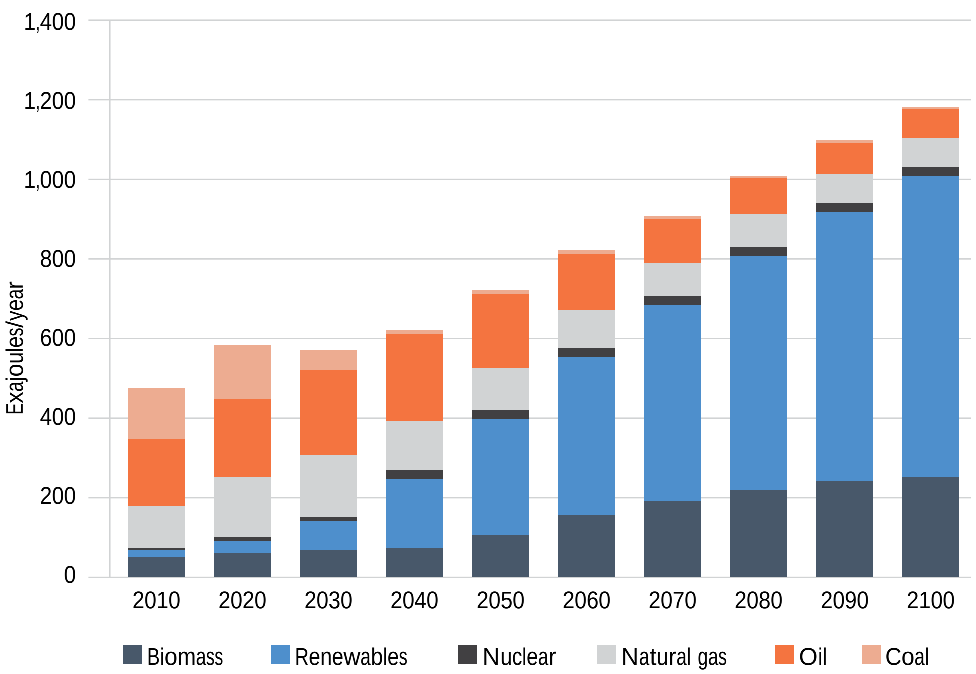


p : Potsdam Institute for Climate Impact Research

Energy mix

The energy sector mix shifts rapidly in the 2°C scenario, as the world transitions away from fossil fuels and to renewable technologies. Figure 3.6 shows the projected change in global primary energy supply throughout the century.

Figure 3.6: Global primary energy mix in the REMIND CD-LINKS 2°C scenario, using the direct equivalent accounting method



Evaluating segment sensitivities involves the qualitative assessment of a segment's expo-
W Y X S Y M W E G T X E S X L [V E I] P W E X S M L W I G E X S [L S P B L I X E F F P S M [H I R X M ½ I W
sensitivity of each segment to each risk factor:

Table 3.3: Segment sensitivity to risk factor

SEGMENTS	RISK FACTOR PATHWAYS			
	DI EC EMISSIONS CO	INDI EC EMISSIONS CO	LO -CA BON CAPE	E EN E

* applies to the US, not to the EU

Probability of Default (PD) calibration [E W R H I V X E [G V R H M S W J ½ G X S Y R H I V
stand how the transition scenario will impact the credit standing of the entities assessed. The output from this analysis is a set of calibration points, which identify the impact on utilities' through-the-cycle PDs in a particular period relative to their 2017 baseline PDs. Barclays' approach consisted of a bottom-up, quantitative-based stress test supported by qualitative assumptions where required.

Five representative utility cases were selected for each segment and region based on the following factors: materiality of exposure, granular generation mix, and geographic location. Each utility case underwent a 'static stress test' where no transition response was registered as well as an "adaptive stress test" to capture possible transition response. These stress
W G I R E W M S W R E R G W I S P V Q E X L G X M R M X S M Q W I X E G E X V R M G E K W
¾ S [W R H F E P E R G I W L I I X

The assumes no capital expenditure (capex) requirement to change
K I R I V E X M S R H I ¾ I G X W R Y I E G W S W Y X Q T X E S R W G S W E Q M W W M S R W
that apply as of 2030/2040 compared to the 2017 baseline. In addition, carbon intensive utilities' total power supply has been subjected to a haircut according to reliance on fossil
J Y I P M ¾ I G X L H R K W T P E S G W Q Q R I X R I V E G X E M T S E R G R L X] V S M X H I V W Y T T P]
curve (i.e. declining ability to address demand on the market in an economic way).

The q V I ¾ I G X W R Y I E G W S W Y X Q X L E M X S T E P S W J
on the 2017 baseline and assumes overnight capex requirements (with adequate learning discount rates applied) to change utilities' generation mix to get closer to or match the assumed regional generation mix in 2030/2040. This capex then builds into debt.
8 L I G E T V I ¾ I G X W L W I J X Y M X R L H R W X G E F F E G W M X Y Q R S R K [G S E P
S M E P R H Y G P M E M V [K E ½ W S H Y X G Y E X T E I X L V I K M Q R M E R K M Z I E V M M M
any additional capacity requirement catered via renewable sources.

Portfolio calibration was achieved by extrapolating to the wider portfolio the PD calibration results using the Portfolio Assessment Tool designed by Oliver Wyman. The tool relies
S R H E X E S Y V G R E W G I R E G S R S H W X ½ S R H X L 4 S X W H E W Q X M X Y X I þÿÁÀ 0

Based on two key credit metrics (funds from operations to debt, and debt to EBITDA), four different stressed through-the-cycle PDs (TTC PDs) have been calculated: 2030 static, 2030 adaptive, 2040 static, and 2040 adaptive. For each year, the average of the static and [illegible] calibration points in the calibration of the entire portfolio. The observed results appear reasonable, despite the stress tests' use of conservative assumptions.

[illegible] age portfolio PD is 2.2x greater in the US and 2.3x greater in the EU relative to baseline. However, given the majority of the utilities are investment grade, stressed average PDs result in a portfolio that remains largely in the investment grade or high non-investment grade credit categories.

Barclays believes that the initial results of this experimental assessment could be further [illegible] a lack of or inconsistent entity data and disclosure, reliance on relatively few credit metrics, low visibility on capital structures going forward, and the absence of assumptions on potential government subsidies as well as capacity payments. Where applicable, the case study incorporated a "most conservative view" that included fully debt-funded overnight capex

BANK #2 CASE STUDY:
METALS & MINING

To pilot a scenario-based assessment of transition risk, one Bank brought together relevant modellers, analysts, and credit professionals. The various teams were drawn together from XLIWMMTEVEXI

Table 3.6: Segment sensitivity to risk factor

[illegible] 1	[illegible] 2	[illegible] 3
Investment Grade (IG)	**[illegible]-IG**	**[illegible]-IG**
BBB- [illegible]	**BBB- [illegible] BB**	**B [illegible] BB**

Tier 1: No change from current PDs for the predicted 2030/2040 PDs for groups BBB- and above ([illegible]). This segment is considered to have high resilience to climate change.

Figure 4.1: Average annual world investment by sector for a 2°C transition

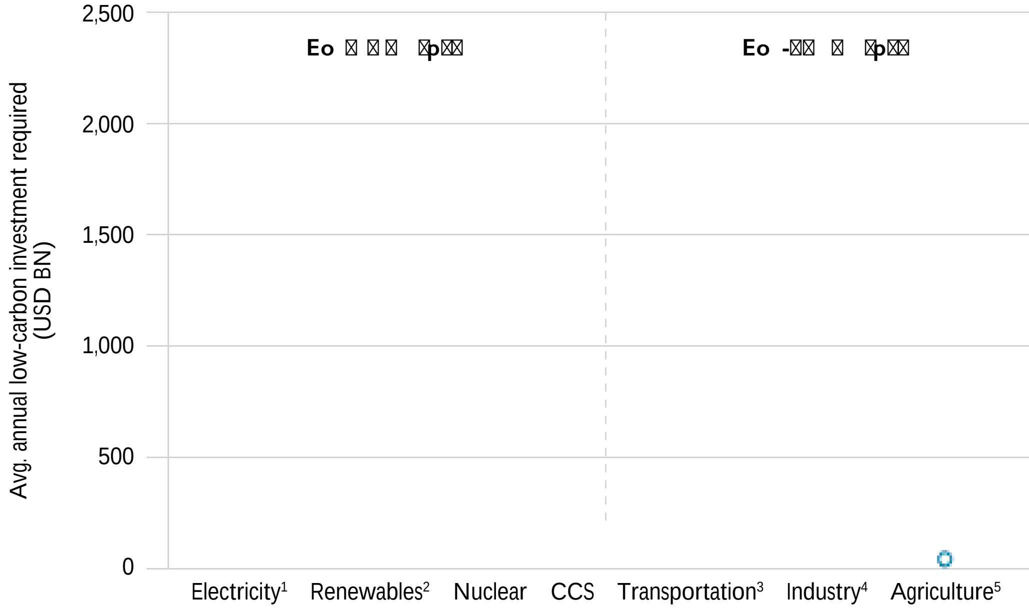


Figure 4.2: Global average annual energy investments by category from 2016 to 2050 according to six global IAMs run in the CD-LINKS project.

Total Annual Investment in Renewable Energy, Nuclear Energy, and Energy Efficiency from 2010–2050 under a 2°C scenario

Developing

Ind

Additional uses of scenarios for opportunities assessment are also possible. Identifying the incremental investment required to meet more rigorous mitigation targets, for example, will help determine the sensitivity of sector investment demand to transition ambitions. Comparison of scenarios across various transition timeframes could surface market timing considerations.

Analysing scenarios, however, only gets banks part of the way toward developing an actionable strategy to capture transition-related opportunities. Some of these limitations are data-related. Scenario comparisons can be imprecise, limited by inconsistencies in sector and J H R J U D S K L F G H À Q L W L R Q V 0 D Q \ R X W S X W V R I V F H Q D U L

Most importantly, such scenarios ultimately have limited utility for answering the most pressing bank questions in setting a low-carbon investment strategy. Namely, most scenarios can neither tell banks what segments and industries within a sector will require more investment in a low-carbon transition, or which future is likely to materialize. Scenarios offer a start ing, order of magnitude assessment of sector-level investment needs, but further analysis is required to make this information useful.

Figure 4.3: Market opportunities assessment – Scorecard (illustrative)

D I E	E AL A ION C I E IA	G IDING Q E ION	INDICA O	EXAMPLE ASSESSMENT
Ppm n q	Will future policies have a meaningful impact on the segment's potential market? **H** – High positive impact on segment's potential market **M** – Moderate positive impact on segment's potential market **L** – Low or adverse impact on segment's potential market	Is the segment's industry likely to be adversely affected by carbon costs?	Industry carbon intensity	
		Is the segment's industry likely to FI E XEVKIX SJ WTIGM½GI VIKYPEXMSRW I KIJ½GMIRG] SV IQMWWMSRW GET regulations?	Policy announcements Country strategic plans	
		Is the segment likely to receive subsidies?		
		Does the segment export to other geographies where policies might expand markets?	Export data Export country policies	
opm po o m q pn o	Will the segment's product be a competitive solution to transition challenges? **H** – Highly competitive solution **M** – Moderate increases in demand **L** – Low increase or decline in demand	Does the segment produce a product or technology that could substitute for adversely impacted technologies?	Market and product analysis	
		Do other low carbon segments compete directly with this segment?	Market technology scan	
		Is the product's market likely to become highly fragmented, or consolidated by particular players?	Market concentration Intellectual property and patents	
		Is the segment cost competitive with carbon-intensive alternatives?	Cost and/or price differentials	

p : Oliver Wyman

The above assessment guide helps point out potentially attractive segments. For example, an analysis of the Wind Independent Power Producer (IPP) segment in India might reveal promising features. Using the questions above, banks might identify the potential for further policy-related disruption in the electricity sector based on emerging policies like the "Generation Based Incentive Mechanism". Wind IPP companies in India could offer a highly cost-competitive solution with government support. Market fragmentation might make VHOHFWLQJ SDUWLFXODU ZLQQHUV GLIÀFXOW KRZHYH

4.2. IDENTIFYING BANK CAPABILITIES

Yet market size is not enough to make opportunities actionable; banks also need to consider their ability to capture those markets. To gain a deeper understanding of which segments are actually within an institution's grasp, banks require an individualized assessment of their own capabilities.

A second scorecard, focused on bank capabilities, accompanies segment-level market assessment. This scorecard should focus on the three major drivers of banks' potential market share: the competitive landscape, their risk appetite, and their operational capacity. An H[DPSOH VFRUHFDUG ZKLFK LGHQWLÀHV SRWHQWLDO questions for analysis is shown in Figure 4.4.

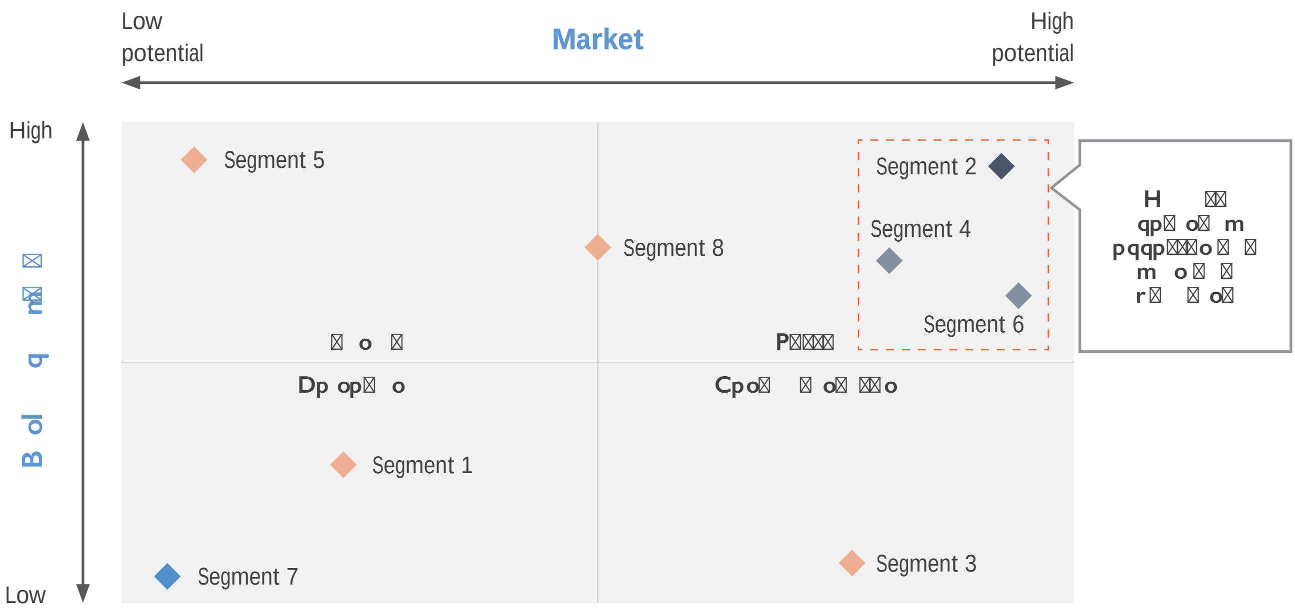
Figure 4.4: Bank capabilities assessment – Scorecard (illustrative)

D I E	E AL A ION C I E IA	G IDING Q E ION	INDICA O	EXAMPLE ASSESSMENT
Cpn q ⌧⌧⌧ mo ⌧ q	Is the bank in a strong position in the segment relative to other players in the market? H – Bank is competitively positioned to be a market leader M – Bank is positioned to keep pace with others in the industry L ¯ &ERO JEGIW WMKRM½GERX challenges to competing with others in the market	What is the bank market share in the segment? How fragmented is the market within the segment? How mobile is the competitor structure (e.g. newcomers)?	Market share vs. competition Competitive research	
⌧ qq ⌧⌧	-W XLI WIKQIRX´W VMWO TVS½PI aligned with the bank's risk appetite? H – Segment is in strongly aligned with bank objectives M – Segment is loosely aligned with bank objectives L – Segment is misaligned with bank objectives	What is the expected evolution of XLI VMWO TVS½PI (i.e. the probability of default) of the segment? -W XLI JYXYVI WIKQIRX VMWO TVS½PI aligned with the bank's risk appetite?	Segment historical performance Transition risk analysis Risk appetite statement	
Oq ⌧ ⌧po m q ⌧⌧	Does the bank have the tools and expertise to act on the segment opportunity? H – Bank has currently available internal resources and experts M – Bank does not have currently available resources, but predicts the ability to acquire necessary resources L – Bank does not currently have nor will be able to acquire necessary resources	Is the bank active in parts of the investment ecosystem adjacent to the segment? Does the bank have talent capacity to onboard new clients in the segment? Does the bank have specialized expertise among RMs, investment team to cover the segment? Does the bank have excess ½RERGMEP GETEGMX] XS I\XIRH GETMXEP to others in the segment? (SIW XLI FERO LEZI E WYJ½GMIRXP] advanced and functional data environment to assess and serve the segment?	Review of bank capabilities Size of investment team	

p⌧⌧ : Oliver Wyman

Banks can also use this comparison to create a two-dimensional chart comparing market opportunities and bank capabilities across two axes. Plotting results of the segment analysis can help to provide high-level guidance on bank strategic action as shown in Figure 4.6.

Figure 4.6: Illustrative snapshot analysis of bank capabilities and market assessment



$V VHHQ LQ WKLV ÀJXUH UHVXOWV IURP WKH VFRUHFD For segments that both excel in their market potential and bank's ability to capture them, shown in the upper right quadrant, banks might choose intentional pursuit or increased investment. For segments that lag in capabilities, but show good market potential, banks will likely weigh carefully the need for internal investments to make market opportunities feasi ble. Conversely, where bank capabilities are substantial, but the market shows currently low potential of developing, a strategy of watching and waiting to determine how the market plays out, or even staged divestment, may be prudent. Finally, where both capabilities and market potential are low, banks may choose the status-quo.

This strategic analysis should be seen as the beginning of a broader discussion. It provides structure to a strategic discussion around expansion in a low-carbon world, either by lending to the winners of the low-carbon transition or by helping clients adapt to the low-carbon economy. But it is only the starting point for deeper bank due diligence and strategic planning.

7KH WUDQVLWLRQ WR D ORZ FDUERQ HFRQRP\ ZLOO Z lending opportunities. Under a transition scenario, some markets will even more rapidly expand than forecasted at present. Leading banks may choose to position themselves to QRW RQO\ OLH DW WKH FXWWLQJ HGJH RI WKDW FKDQJ to certain segments. Additionally, banks can play an instrumental role in helping their long-term clients, especially from the carbon-intensive industries, adapt to the new environment. The approach to assessing opportunities suggested in this chapter could provide a launching point for those discussions.

5. F E DI EC ION : DEVELOPING THE NEXT GENERATION OF TRANSITION RISK ANALYSIS

7KLV WUDQVLWLRQ ULVN PHWKRGRORJ\ LV HQYLVLRQH process of creating best practice transition scenario risk analysis. It provides a foundation for transition risk analysis by outlining a systematic, consistent, and repeatable framework, while collaboration with modellers could also yield a richer set of scenario-based policy and technology stressors that banks could use to examine their individual vulnerabilities to transition risk. For instance, banks could run short- term, event-based scenarios such as a sudden policy change or a technological breakthrough or an overshoot scenario, in which CO2 concentrations or temperatures temporarily exceed target levels before being reduced, leaving less time for companies to adapt.

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The borrower-level calibration exercise is a time-intensive but important component of the transition risk methodology; it also has the greatest potential for further enhancement. Such

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The methodology outlined in this document provides for scenario-based assessment of WUDQVLWLRQ ULVN +RZHYHU LQVWLWXWLRQV QHHG V SURSHUO\ PDQDJH WUDQVLWLRQ ULVNV $V FOLPDWH U their broader incorporation into a range of business management and risk management SURFHVVHV DW ÀQDQFLDO LQVWLWXWLRQV :KLOH VSH RQ SDUWLFXODU SURÀOHV SRWHQWLDO H[DPSOHV RI I

- Integration across other risk measurement processes including physical risk
- (PEHGGLQJ LQWR ULVN LGHQWLÀFDWLRQ SURFHVVHV
- Incorporation of climate risk considerations in underwriting and credit rating processes
- Consideration of climate-related limits and exposure monitoring
- Climate risk-related portfolio management and structuring
- Consideration within business planning and strategic planning

* * *

These ideas for enhancements point to a future where transition risk analysis becomes mainstream as a cornerstone of the risk analyst's toolkit. Through this project, banks have built the foundations of this future, where rigorous tools and approaches are brought together and applied to the challenge of transition risk assessment; and where transition risk is elevated as a strategic concern. To build on these foundations, senior engagement from the organizations will be required: climate risk will need to become a bank-wide, senior management and board-level priority.

COMING SOON FROM ACCLIMATISE:
AN APPROACH FOR ASSESSING PHYSICAL CLIMATE-RELATED RISKS AND OPPORTUNITIES

B A mn

lo p po

Regardless of the success and rate at which global greenhouse gas emissions are controlled some man-made climate change is locked into the earth's climate system over coming decades, and changes are already underway. Physical risk, one of the two pillars of climate-related risk addressed by the TCFD, is the risk resulting from climate variability, extreme events, and longer-term shifts in climate patterns which are already underway. For EDQNV SK\VLFDO ULVNV FRXOG PDQLIHVW LQ D YDULH cial health of their borrowers, and the credit risk in their lending portfolios.

Climate change can also present opportunities for the clients to which banks lend. Some clients will need additional investment to undertake actions that increase their climate resilience. This, in turn, leads to lending opportunities for banks. Further, an expanding and global market is developing for climate-related products and services, and companies, such as engineering and technology providers, are identifying opportunities to capitalise on the shifting market trends. For banks, this can translate into opportunities to do more business.

To support banks to consider the physical risks and opportunities of climate change to their loan portfolios, a sector-based methodology is being developed and tested with the sixteen banks involved in the pilot project. This section provides an outlook of the methodology, with full details being published in a report focused on physical risk and opportunity in summer 2018.

The assessment of sectors' and companies' performance, incorporating changing climate risk exposures at the level of banks' portfolios, is novel and innovative. As such, the pilot SURMHFW KDV LGHQWLÀHG DUHDV IRU IXUWKHU GHYH with the TCFD recommendations. These include, amongst others:

- %DQNV· ODFN RI ORFDWLRQ VSHFLÀF GDWD RQ WKHL
- A lack of published research linking climate change impacts on sectors to borrower ÀQDQFLDO SHUIRUPDQFH DQG FRPSDQ\ FUHGLW ULVN

p o q mp q p p q m l o pqqp o

The impacts of a changing climate will affect commercial and retail borrowers. Many economic sectors and businesses face a changing risk landscape, from Small and Medium Enterprises (SMEs) to multi-national corporations. The degree to which any sector is vulnerable to climate change depends on its level of climate sensitivity. Four sectors were chosen to pilot the physical risk methodology, due to their high climate sensitivity and materiality within banks' lending portfolios. These sectors are characterised by their reliance on physical assets, complex value chains or natural assets. Table 6.1 presents the sectors and sub-sectors included in the pilot project, along with a summary of key physical risks facing borrowers in these sectors. In the physical risk methodology, these risks are framed in terms RI SRWHQWLDO ÀQDQFLDO LPSDFWV RQ ERUURZHUV D in banks' lending portfolios.

Table 6.1: Sectors covered by the methodology and the key physical risk banks' borrowers in these sectors may face

EC O	B EC O	KEY PHYSICAL RISKS
Eo	Oil and gas	Physical damage and downtime from extreme events (e.g. tropical cyclones impacting offshore assets) Changes in production/output from incremental changes in climate (e.g. rising XIQTIVEXYVIW GEYWMRK PSWW SJ SYXTYX JVSQ 0MUYM VI½RIVMIW
	Power utilities (power generation, power transmission)	4L]WMGEP HEQEKI ERH HS[RXMQI [illegible] transmissions lines) Changes in production/output from incremental changes in climate (e.g. changing rainfall patterns affecting hydropower generation) and extreme events (e.g. drought impacting the availability of cooling water for thermal power production)
oqp	Infrastructure (ports)	Physical damage and downtime from extreme events (e.g. storm surge impacting port infrastructure) Changes in production/output from incremental changes in climate (e.g. climate-driven GLERKIW MR EKVMGYPXYVEP TVSHYGXMSR ERH GSRWIU
A m	Crop production Animal husbandry Forestry/timber production	Changes in production/output from incremental changes in climate (e.g. warmer temperatures, changing rainfall patterns affecting crop yields) and extreme events (e.g. extreme temperatures impacting livestock)
m	Retail mortgages Commercial property	4L]WMGEP HEQEKI ERH GLERKI MR TVST [illegible] JVSG affecting homes)

K pn qpo o p q m l n p pm

[illegible]

K pn qpo o p q mpqqp o n p

The TCFD reports describe “climate-related opportunity” as “the potential positive impacts related to climate change on an organization.” At present, there are no agreed methodologies for identifying and assessing opportunities arising from, and in response to, the physical impacts of a changing climate. Working with the sixteen banks, the pilot project is developing a framework for assessing these opportunities and their potential impact on lending portfolios.

A taxonomy of climate-related opportunities can assist banks in understanding the potential investment needs of their clients, and the role of banks in providing invest ment for climate resilience. This is not an area which has been extensively researched and WKHUH DUH YHU\ IHZ SXEOLVKHG H[DPSOHV ZKLFK VSH services sector. The pilot project is developing a taxonomy of opportunities relevant to banks.

Market analysis data for banks exploring the demand and timescale for capital driven by the impacts of a changing climate is not readily available. Most of the available analysis has been published by international development banks and development partners, or by governments in national and sectoral climate change risk assessments and adaptation plans. In the pilot project, the framework explores how such information can be used to assess opportunities, although the limitations will require banks to rely on judge ments and assumptions.

Capital requirements to meet the challenges of a changing climate will vary across VHFWRUV DQG ZLOO EH LQÁXHQFHG E\ JOREDO UHJLR and by policy and regulatory drivers. The framework recognizes the variations and uncer tainties in these factors, and the need for banks to assess future impacts on their business by sectors and markets, rather than at an aggregated, business or economy-wide level.

2SSRUWXQLWLHV ZLOO GHSHQG RQ EDQNV· .VSHFLÀF JHQHULF WRS GRZQ DQDO\VLV RI RSSRUWXQLWLHV ZL of each bank and the bank’s own assessment of the scale and value of these opportunities. The framework assists banks in identifying those opportunities, which should be evaluated consistent with their internal strategies and procedures. Assessment of the opportunities VKRXOG LQFRUSRUDWH WKH YLHZV RI VHFWRUDO H[SH respond to changes in market conditions.

GENERATING THE RISK FACTOR PATHWAYS

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Table 7.2: Risk factor pathways calculations

As can be seen in Figure 5.2, the transition risk models provide a comprehensive cover DJH RI WKH HQHUJ\ VHFWRU +RZHYHU IRU HQG XVH D relevant variables were provided by the models during the pilot project, especially with regards to low-carbon investment and revenue. In these cases, additional assumptions were made based on external sources. Assumptions were derived from foremost sources of data (including IPCC Annex 1 emissions, the Food and Agriculture Organization of the United Nation's international prices, UNFCCC Investment and Financial Flows, and the IEA World

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