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Climate-Related Financial Risks for Kenyan Banks

An Analysis of Loan Portfolios and GHG Emissions

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ABSTRACT

This study analyses the climate risk exposure of Kenyan banks given the greenhouse gas (GHG) emissions represented by their sectoral loan composition and their relative funding of climate risk through their loan portfolios. This is achieved by constructing two climate-relevant indices: *Emissions Exposure* (EE_i), a measure of a bank's climate risk exposure through its loan portfolio, and *Emissions Funding* (EF_i), a measure of how much of the climate risk a bank funds through its lending relative to other banks and thus a measure of climate risk importance for each bank. Results from the emissions index show that the banks, with the exception of an outlier, have fairly similar exposure to climate risk through their loan portfolio, given the GHG emissions represented by their sectoral lending. On the funding index, banks have differentiated funding of climate risk through their lending that is fairly proportional to their market shares of gross loans. Thus, larger (smaller) banks have higher (lower) funding of climate-related risk. These two complementary indices provide a first set of quantitative climate-related financial disclosures that are comparable across Kenyan banks. Secondly, the results of this analysis provide decision-useful information for the Central Bank of Kenya (CBK) and other financial regulators to formulate macroeconomic and financial policies that would seek to promote low-carbon transition via the banking industry as a key financial sub-sector. Lastly, the analysis provides a template for industry-wide assessment of climate-related risk for banks in other emerging economies and the approach used for mapping national GHG emissions to bank lending sectors is also a key contribution to the literature on quantifying climate risks for the financial sector.

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1. Introduction

> "Climate change is the Tragedy of the Horizon. We don't need an army of actuaries to tell us that the catastrophic impacts of climate change will be felt beyond the traditional horizons of most actors – imposing a cost on future generations that the current generation has no direct incentive to fix." – Carney, 2015

1 Climate change is one of the most defining issues of the century that presents a direct existential threat (Guterres, 2018). Traditionally, central bankers did not wade into the climate debate since climate change effects were long considered an externality rather than a pertinent issue within the purview of financial regulation. There has however been a shift globally as central banks and other market authorities have begun to take a keen interest in climate change and low-carbon transition.

2 The push for financial institutions and regulators to consider climate risk has mostly occurred in advanced economies. For example, the EU developed the Sustainable Finance Taxonomy and the UK Climate Financial Risk Forum, jointly established by the Prudential Regulation Authority (PRA) and the Financial Conduct Authority (FCA), recently published guidance for banks and insurers to analyse the impact of climate risks on their operations (Climate Financial Risk Forum, 2020; European Commission, 2020). In spite of the progress made in advanced markets, climate change poses a risk to financial stability in emerging economies like Kenya. Often, this risk is actually disproportionate given the materiality of the climate risk exposure relative to the low levels of greenhouse gas (GHG) emissions in many of these countries. Diffenbaugh and Burke (2019) found that global warming has increased global economic inequality between developed and developing nations by 25% since 1960 and this is associated with historical disparities in energy consumption.

3 There have been multiple industry-led initiatives that seek to explore climate risks and opportunities, including facilitating climate-relevant disclosures by financial institutions. Globally, a notable initiative has been the recommendations by the Task Force on Climate-related Financial Disclosures (TCFD). Within banking, there have been sustainability initiatives such as the Network for Greening the Financial System (NGFS),

the Sustainable Banking Network (SBN), and the Principles for Responsible Banking by the UNEP Finance Initiative (UNEP FI).

4 Given the key role of banks in allocating capital within productive sectors of the economy, it is imperative for individual banks and financial regulators like the Central Bank of Kenya (CBK) to actively contribute to climate change mitigation and adaptation for the transition to a low-carbon economy. This includes harnessing green capital and promoting low-carbon investments. Specific to Kenya, one industry initiative has been the adoption of Sustainable Finance Initiative (SFI) Guiding Principles developed by the Kenya Bankers Association (2015) to promote inclusive growth. Banks have also adopted risk management strategies in their credit appraisal processes to analyse loans using environmental, social, and governance (ESG) metrics.

5 However, there is an unexploited opportunity at the industry level to quantify climate risks attributable to GHG emissions through banks' lending activities and using such risk metrics to facilitate climate-related financial disclosures that are easily comparable across banks and that are decision-useful for climate policy and regulation. This research seeks to explore and fill this gap.

6 In this study, I analyse the exposure of Kenyan banks' lending portfolios to climate risk and their relative funding of this risk given the GHG emissions represented by their portfolios. This is achieved by constructing two climate-relevant indices for banks: an *Emissions Exposure Index* (EE_i) and an *Emissions Funding Index* (EF_i). The first, EE_i, is a measure of a bank's portfolio climate risk exposure given the GHG emissions represented by its loan portfolio through its sectoral loan composition. The second, EF_i, is a measure of the climate risk funded by a bank through its lending relative to other banks and is thus a measure of climate risk importance with regard to each bank. This approach is an adaptation of the methodology used by Monasterolo et al. (2017) to construct "GHG exposure" and "GHG holding" indices. These authors were the first to propose such complementary climate-relevant indices for financial institutions.

7 Results from my analysis of the emissions index (EE_i) show that the banks, with the exception of an outlier, have fairly similar exposure to climate risk through their loan portfolios, given the GHG emissions represented by their sectoral lending. On the funding index (EF_i), banks have differentiated funding of climate risk through their lending that is fairly proportional to their market shares of gross loans. Thus, larger (smaller) banks engage in higher (lower) funding of climate-related risk. These two complementary indices provide a first set of quantitative climate-related financial disclosures that are comparable across Kenyan banks.

8 Further, I enhance the analysis using **two forward-looking scenarios:** one being the 2030 business-as-usual (BAU) emissions forecasts and the other being a 2030 transition scenario of reducing GHG emissions by 30% relative to 2030 BAU as per the country's Nationally Determined Contribution (NDC) target. From the forward-looking analysis, banks with a high lending concentration in the manufacturing, energy, and water sectors are expected to have an increase in their risk exposure given the expected large increase in emissions in the energy sector under both the 2030 BAU scenario and the 2030 transition scenario. Overall, larger (smaller) banks will still have higher (lower) funding of climate-related risk.

9 The fairly similar climate risk profiles of Kenyan banks means that banks face similar exposure to climate-induced risk factors given the GHG emissions represented by their

sectoral loan composition. From the funding index, the key implication is that any climate financial policies adopted by the CBK or the government that aim at low-carbon transition in the banking industry by reducing lending to high emission sectors should not target any specific banks but rather be formulated taking into consideration the proportionality of climate risk funding to the market shares of gross loans. This, in fact, would create an incentive for the CBK or government to propose market-led initiatives by banks to divert lending away from high-emissions sectors, since the banks can contribute to the transition cost in proportion to their market shares of gross loans without any particular banks being unfairly targeted or singled out.

1.1 Climate risk management framework in Kenya

10 According to the Government of Kenya (2016), Kenya is highly prone to natural disasters within the Horn of Africa with the most common hazards being drought and flooding. The impact of these hazards, already affecting millions each year, is expected to be amplified by climate change, which exacerbates the intensity and frequency of these physical risks that affect key economic sectors like agriculture.

11 Kenya's climate risk management framework is designed in alignment with the Paris Agreement that aims at holding the increase in global average temperature to well below 2 C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change (UNFCCC, 2016). However, the country still faces some key challenges in climate and disaster risk management. Firstly, climate mitigation and adaptation strategies are spread across multiple government ministries, departments, and agencies. Secondly, the climate action mandate is spread across the two levels of government, national government and devolved counties. Thirdly, climate efforts are mostly concentrated within the environmental sector and there is need for more active collaboration with stakeholders in other key sectors of the economy, such as the financial and transport sectors.

12 The latest national GHG emissions are reported in the NDC Sector Analysis Report (Government of Kenya, 2017). This is per the country's submission of Intended Nationally Determined Contributions (INDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). The NDC sector analysis identifies six sectors across which emissions are reported: energy, transport, industry, waste, forestry, and agriculture. The country's mitigation target is to abate overall GHG emissions by 30% by 2030 relative to the business-as-usual (BAU) scenario. This followed a study on the technical potential of emission abatement across all sectors.

13 The NDC goal to abate GHG emissions by 30% relative to 2030 BAU does not mean a 30% reduction of emissions equally across all six sectors given the different abatement potentials across sectors. For example, agriculture accounts for the highest contribution (40%) of national GHG emissions; however, the sector's abatement target is 4% reduction in 2030 BAU emissions. This is mostly explained by the challenge of changing practices in the agricultural sector and further complicated by the challenge of acquiring necessary data to calculate the potential and impact of mitigation options in agriculture, relative to other sectors such as energy and transport.

2. Literature review

1 Financial markets are not shielded from the ever-increasing effects of climate change. Climate change presents significant risks for financial institutions in terms of investments, lending, risk management, and insurance underwriting, with these risks having broader implications for the stability of the financial system (Global Risk Institute, 2016). Climate-related risks are typically classified into two primary channels: physical risks and transition risk. Physical risks result from climate and weather-related events which could result in large economic costs and financial losses, including asset impairment. Transition risk relates to the process of adjusting to a low-carbon economy, including losses arising from government policies, such as carbon taxes, and financial losses in high-carbon sectors resulting from rapid uptake of low-carbon new technologies (Feyen et al., 2020).

2 Responses to climate issues have tended to focus on energy policy and carbon pricing policies (International Monetary Fund, 2019), including pricing policies that not only reflect environmental costs but also co-benefits of innovation and increased productivity growth (Aghion et al., 2009). There has been a consistent push for market-based solutions to tackle climate change and facilitate low-carbon transition. Nonetheless, a number of market failures, such as the free-rider problem and imperfect information, limit effective response to climate risks. It is also recognised that fiscal policies and markets by themselves are not sufficient, justifying the use of climate-relevant financial polices (Krogstrup & Oman, 2019). Such policies are sometimes complicated by political factors because economic groups that stand to benefit from the status quo often lobby governments against policy action to correct market inefficiencies.

3 Incomplete and imperfect capital markets constitute one key market failure that makes it difficult to measure the climate risk exposure of different financial assets and to factor in this risk in asset pricing. One recommended solution to incomplete information is requiring climate-related disclosures by financial actors with the aim of improving the pricing and transparency of climate risks in financial assets. However, a key limitation in making disclosures is lack of quantifiable, relevant, and decision-useful information on climate risk exposure that is comparable among different financial actors (Monasterolo et al., 2017). In instances where information is available, there is the challenge of defining the materiality of climate risk and determining how

to incorporate climate scenario analysis as part of the disclosures (Climate Disclosures Standard Board, 2017).

4 Climate-relevant information allows for estimating climate risks and their impact on the stability of the financial system (Battiston et al., 2017). Much of the literature has built on Integrated Assessment Models (IAMs) with the Dynamic Integrated Climate-Economy (DICE) model (Nordhaus, 1992, 2014) considered a benchmark from which many modifications have followed. Nonetheless, modeling climate change risks remains a challenge given that climate change affects the economy through multiple channels interacting with each other in multiple ways (Schneider, 1997). Dietz et al. (2016) used an approach that builds on IAMs to calculate the Value at Risk (VaR) induced by climate risk while some previous literature has focused on the calculation of potential stranded assets emanating from climate risk (Meinshausen et al., 2009). Within the existing literature, there is no consensus on the best methodologies for estimating climate risks and traditional models have been insufficient to capture the climate risk associated with specific financial actors or asset classes.

5 In response to the need for climate risk assessment and quantification that facilitates relevant and decision-useful climate-related disclosures, novel approaches have been proposed on how to identify, assess, and monitor climate risks. Monasterolo et al. (2017) analysed the exposure of investors' portfolios to climate risks using a data-set of financial actors' equity holdings and loan portfolios for 17 euro-area countries in 2014 and proposed two new and complementary indices,

6 "GHG exposure" and "GHG holding". My research adapts this novel approach for climate-risk assessment of financial actors by constructing *Emissions Exposure* (EE_i) and *Emissions Funding* (EF_i) indices for Kenyan banks. The focus on the financial sector is important for three reasons: 1) it allows for assessing the direct exposures of financial actors to climate risks; 2) climate risks affect sectors in the real economy and consequently this has a direct effect on financial actors' lending or investments in these sectors (Battiston et al., 2017); and 3) the financial sector plays a key role in capital allocation within the economy and thus has a key role in accelerating the low-carbon transition.

7 Climate-related disclosure requirements facilitate market pricing that is reflective of the cost of climate risks inherent in different asset classes. Further, this transparency and associated price correction would incentivise market actors to reallocate capital from climate-risky assets to low-carbon investments within their portfolios. Thus the two climate-relevant indices that are the primary output of this study would facilitate quantitative and comparable climate-related disclosures across Kenyan banks. In effect, this study advances the objective of quantifying climate risk and its implications for systemic risk within the financial system. Quantifying climate risks is a rational pre-requisite to the designing of feasible climate finance policies (Carney, 2015; European Systemic Risk Board, 2016).

8 To my knowledge, this is the first research in Kenya and across African markets that provides a set of quantitative and comparable climate-related disclosures for banks that directly links the sectoral composition of bank lending portfolios to national GHG emissions to establish the climate risk exposure represented by banks' portfolios and their relative funding of the climate risk through their lending. The findings provide decision-useful information for the CBK and the government on climate-related financial risk and has implications for climate financial policies that would seek to

promote financial stability and facilitate smooth transition to a low-carbon economy. Further, this analysis provides a template for other emerging economies for the assessment of banking portfolios for climate-related financial risk using the two indices.

3. Data and stylised facts

3.1 Bank data

1 Kenyan banks' financial data are obtained from three sources: CBK Banking Annual Supervision reports and respective banks' annual financial reports and investor presentations. My analysis uses 2018 lending data reported by banks, or 2017 data where 2018 data on sectoral loan composition is missing. Relative to the economy, the banking sub-sector assets accounted for 49.51% of Kenya's nominal GDP.

2 The CBK report provides the gross loans amounts for each bank and the industry gross loans across 11 lending sectors in the economy (Table 1). Overall, the industry value of gross loans in 2018 was KES 2,483.5 billion (Central Bank of Kenya, 2018), with the highest lending being to personal loans (26.6%) and the lowest to mining and quarrying (0.5%). There are four sectors with at least 5% of industry gross loans: trade (19.1%), real estate (15.2%), manufacturing (13.0%), and transport and communication (6.6%).

Table 1: Banking industry gross loans by sector, 2018

Lending Sector	Industry Share
Personal	26.6%
Trade	19.1%
Real estate	15.1%
Manufacturing	13.0%
Transport and communication	6.6%
Energy and water	4.4%
Building and construction	4.1%

Financial services	3.9%
Agriculture	3.6%
Tourism, restaurants, and hotels	2.9%
Mining and quarrying	0.5%
Total	100%

3 The analysis focuses on the banks' lending portfolios because the breakdown of other banking assets by sector categories that can be directly mapped to GHG emissions is not available. Nonetheless, Kenya's banking industry assets are mostly loans, so this analysis is appropriate. In 2018, loans and advances accounted for 52% of the banking industry balance sheet, followed by government securities (27%). Investments and other assets are a small 9% and the residual is made up of cash, placements, and balances at the CBK (Central Bank of Kenya, 2018).

Sample of banks

4 Kenya had 40 registered banks in 2018, excluding two banks in receivership and one under statutory management. Of these, 13 are listed on the Nairobi Securities Exchange (NSE), and 12 of these are local banks and one is a cross-listing of Rwanda's Bank of Kigali. The analysis uses a sample of 12 banks; this includes 11 listed Kenyan banks (all listed banks except HF Group) and Family Bank which, although not listed, accounted for 2% of industry gross loans. HF Group is omitted from the sample since it is primarily a property and mortgage lending bank and thus has no comparable sectoral breakdown in its reporting. The sample of banks used accounts for 82% of gross loans and I deem this satisfactorily representative of the Kenyan banking industry (Table 2).

Table 2: Market shares of industry gross loans, 2018

Bank	Market share
1 KCB	0.17
2 Coop	0.10
3 Equity	0.09
4 Barclays*	0.08
5 CFC Stanbic	0.06
6 DTB	0.06
7 I&M	0.06
8 SCB	0.05

9 CBA**	0.05
10 NIC**	0.05
11 NBK***	0.03
12 Family	0.02
Other banks	0.18
Total	1.00

*Barclays has since rebranded to Absa Kenya
**CBA and NIC have since merged to form NCBA Bank
***NBK has since been acquired by KCB Bank

Sectoral loan composition

5 Although the CBK reports provide gross loans amounts for each sector at industry level and gross loans amounts for each bank, they do not provide the sectoral breakdown at bank level. Bank-level sectoral loan composition is necessary for the analysis of climate risk exposure by sector across banks. For this, I use sectoral lending breakdown as reported in individual banks' annual financial reports or investor presentations. Some banks report the actual gross loans advanced to each sector in Kenyan shillings while some (e.g., Equity Bank) report the percentage of lending shares across the sectors from which actual gross loan amounts can be estimated.

6 However, a discrepancy in reporting makes the gross loans amounts not immediately comparable across banks: banks do not report gross loans across similar sector categories, hence there is no standardised reporting of sectoral loan composition. For example, while Coop Bank reports lending across 10 sectors (the same as the 11 sectors in the CBK report but without mining and quarrying loans), Barclays Bank (now Absa Kenya) reports gross loans across 6 sectors: manufacturing; wholesale and retail trade; transport and communication; agriculture; private individuals; and others. The difference in sectoral reporting of gross loans across banks requires standardising the reporting across banks.

7 In standardising the sectoral reporting, I make a number of adjustments:

"Manufacturing, energy, and water" sector: CBK publishes distinct gross loans advanced to the manufacturing sector and to the energy and water sector. Since many banks aggregate loans to these sectors, I aggregate bank-level loans to either of these sectors to one sector category.

"Real estate, building, and construction" sector: CBK publishes distinct gross loans advanced to the real estate sector and to the building and construction sector. Since many banks aggregate loans to these sectors, I aggregate bank-level loans to either of these sectors to one sector category.

"Personal loans" sector: Where a bank reports gross loans advanced to "others" but has no distinct personal/consumer loans, these loans advanced to "others" are treated as personal loans. This applies to CFC Stanbic, I&M Bank, NIC Bank, and Family Bank. I decided on this treatment after consulting Kenyan bankers working in credit departments; these loans are mostly personal loans to their customers whose use is not reported like loans to any of the specified sectors. All other banks

have distinct personal loan categories. However, these are not similar to loans to "other services".

8 After standardisation of sectoral reporting across banks, there are nine distinct sector categories for each bank. Each of these sectors can be mapped directly to the CBK reporting and the output of the standardisation accounts for 96% of the gross loans in the sample. The remaining 4% belongs to loans to "other services" which could not be mapped directly to any of the 11 distinct sectors as reported by the CBK. Table 3 shows the standardised sectoral loan composition. Column A is the composition at industry level while Column B is that of the sample.

Table 3: Standardised reporting of sectoral loan composition, 2018

	A	**B**
	Industry (CBK Report)	**Sample (Banks' Reports)**
Personal	26.6%	29.8%
Agriculture	3.7%	4.2%
Mining and quarrying	0.4%	0.1%
Manufacturing, energy, and water	17.5%	14.7%
Real estate, building, and construction	19.3%	18.0%
Wholesale and retail trade	19.1%	15.2%
Tourism, restaurants, and hotels	2.9%	1.9%
Transport and communication	6.6%	7.4%
Financial services	3.9%	4.3%
Other services		4%
Total	**100%**	**100%**

9 The two columns are consistent and the small discrepancies are explained by 1) the fact that the sample uses 12 banks (accounting for 82% of industry gross loans) and 2) the 4% residual of loans to "other services" within the sample. I proceed to use these sector categories for the analysis and Table 4 summarises the sectoral loan composition employed (extracted from column B of Table 3).

Table 4: Sectoral loan composition of sampled banks, 2018

Lending sector	Sector Share
Personal	29.8%

Agriculture	4.2%
Mining and quarrying	0.1%
Manufacturing, energy, and water	14.7%
Real estate, building, and construction	18.0%
Wholesale and retail trade	15.2%
Tourism, restaurants, and hotels	1.9%
Transport and communication	7.4%
Financial services	4.3%
Other services	4.5%
Total	100%

3.2 Emissions data

10 The analysis uses the 2015 GHG emissions data as reported in the NDC Sector Analysis Report (Government of Kenya, 2017). Total national GHG emissions in 2015 were 80 metric tonnes of carbon dioxide equivalent (MtCO2e) as shown in Table 5. There is no more recent data and the emissions data for the subsequent years are forecast estimates. The NDC target is abating GHG emissions by 30% relative to the 2030 BAU scenario. The BAU forecast for 2030 is 143 MtCO2e.

Table 5: Kenya GHG emissions by sector, 2000–2030

	Baseline Emissions (MtCO2e)						
Sector	2000	2005	2010	2015	2020e	2025e	2030e
Agriculture	23	26	30	32	34	36	39
Electricity generation	1	1	1	1	12	24	42
LULUCF*	21	18	21	26	25	23	22
Transportation	4	4	7	9	12	16	21
Energy demand	5	5	6	7	8	9	10
Industrial processes	1	1	2	3	4	5	6
Waste	1	2	2	2	3	3	4

Total	55	57	70	80	98	115	143

*Land use, land-use change, and forestry
Note: Where the totals do not add up, this is due to rounding errors

11 Table 6 is an extract of the sectoral contribution to the national emissions in 2015.

Table 6: Kenya GHG emissions by sector, 2015 (baseline)

Emission Sector	Emissions (MtCO2e)	Sector %
Agriculture	32	40%
Electricity generation	1	1%
LULUCF	26	33%
Transportation	9	11%
Energy demand	7	9%
Industrial processes	3	4%
Waste	2	3%
Total	80	100%

12 Agriculture is the biggest contributor to Kenya's GHG emissions (40%), followed by the land use, land-use change, and forestry (LULUCF) sector (32%), largely as a result of deforestation. Transport is the third largest contributor (11%).

3.3 Bank-level sectoral measures – W_{ij} and M_{ij}

13 I define two measures of interest in each bank's lending portfolio: 1) the share of each bank's loan portfolio to each sector, W_{ij}, and 2) the market share of each bank in each lending sector, M_{ij}. These two measures are adopted from Monasterolo et al. (2017) who defined sectoral measures in constructing "GHG exposure" and "GHG holding" indices for portfolios of equity holdings and loans in the euro area.

The share of each bank's loan portfolio allocated to each sector, M_{ij}

14 Let GL_{ij} denote the gross loans by each bank i to each economic sector j. Also, let the share of emissions attributable to each sector be denoted by S_j.

15 W_{ij}, being the share of each bank's loan portfolio to each sector can be calculated as:

$$W_{ij} = \frac{GL_{ij}}{\sum_k GL_{ik}} \quad (1)$$

where the index k runs over the set of all sectors and where $\Sigma W_{ij} = 1$ for each bank.

For example, if Bank A lends to only two sectors, 40% to sector 1 and 60% to sector 2, then W_{A1}=0.4 and W_{A2}=0.6.

From this preliminary analysis, Table 7 below reports the values of W_{ij} for the banks across the sectors. The highest financial exposures are seen mostly in four sectors: personal loans; real estate, building, and construction; manufacturing, energy, and water; and wholesale and retail trade. This is seen across most of the banks including the top three banks in market share of gross loans (KCB, Coop, and Equity). The lowest financial exposure is seen in the mining and quarrying sector, with only I&M bank reporting loans to this sector within the sample.

Table 7: Share of each bank's loan portfolio to each sector, W_{ij}

Bank Lending Sector	KCB	Equity	Coop	Barclays*	CBA**	SCB	CFC Stanbic	DTB	I&M	NIC**	NBK***	Family
Personal	0.36	0.25	0.40	0.61	0.36	0.53	0.06	0.05	0.06	0.18	0.00 †	0.40
Agriculture	0.03	0.03	0.02	0.05	0.03	0.03	0.16	0.03	0.03	0.05	0.02	0.06
Mining and quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Manufacturing, energy, and water	0.14	0.10	0.10	0.14	0.17	0.22	0.20	0.12	0.24	0.24	0.07	0.01
Real estate, building, and construction	0.25	0.25	0.14	0.00	0.06	0.01	0.35	0.29	0.26	0.00	0.22	0.07
Wholesale and retail trade	0.08	0.23	0.15	0.16	0.08	0.15	0.12	0.17	0.21	0.16	0.20	0.37
Tourism, restaurants, and hotels	0.03	0.04	0.01	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
Transport and communication	0.05	0.09	0.09	0.03	0.06	0.05	0.11	0.07	0.05	0.19	0.07	0.08
Financial services	0.06	0.00	0.10	0.00	0.00	0.00	0.00	0.18	0.01	0.05	0.00	0.00
Other services	0.00	0.00	0.00	0.00	0.24	0.01	0.00	0.00	0.13	0.13	0.42 †	0.01
Sum of W_{ij}	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

*Barclays has since rebranded to Absa Kenya

**CBA and NIC have since merged to form NCBA Bank

***NBK has since been acquired by KCB Bank

†NBK did not report any personal loans category in its sectoral breakdown but these are likely included in "other services" (reported as *Business Services* in the financials) that account for 42% of the bank's loans

The market share of each bank in each lending sector, M_{ij}

Again, GL_{ij} denotes the gross loans by each bank to each economic sector, S_j is the share of emissions attributable to each sector, and W_{ij} is the share of each bank's loan portfolio to each sector.

M_{ij}, being the market share of each bank in each lending sector can be calculated as:

$$M_{ij} = \frac{GL_{ij}}{\sum_k GL_{kj}} \quad (2)$$

21 where the index k runs over the set of all banks and where $\Sigma M_{ij} = 1$ for each sector.

22 For example, if Banks A and B are the only banks that lend to sector 2, accounting for 45% and 55% of loans to that sector respectively, then $M_{A2} = 0.45$ and $M_{B2} = 0.55$.

23 From the preliminary data analysis, Table 8 reports the values of M_{ij} for the banks across the sectors. The market shares in each sector do not add up to 1 since some market share in each sector is held by non-sampled banks. As expected, large banks have dominant market shares in the different sectors with KCB Bank having the largest market share in three sectors: personal; manufacturing, energy, and water; and real estate, building, and construction.

Table 8: Market share of each bank's loan portfolio in each sector, M_{ij}

Bank Lending Sector	KCB	Equity	Coop	Barclays*	CBA**	SCB	CFC Stanbic	DTB	I&M	NIC**	NBK***	Family
Personal	0.24	0.09	0.15	0.17	0.06	0.11	0.01	0.01	0.01	0.03	0.00 †	0.03
Agriculture	0.14	0.08	0.05	0.11	0.04	0.04	0.27	0.06	0.04	0.07	0.01	0.03
Mining and quarrying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Manufacturing, energy, and water	0.14	0.05	0.06	0.06	0.05	0.07	0.07	0.04	0.08	0.07	0.01	0.00
Real estate, building, and construction	0.23	0.12	0.08	0.00	0.01	0.00	0.11	0.09	0.08	0.00	0.03	0.01
Wholesale and retail trade	0.07	0.11	0.08	0.06	0.02	0.04	0.04	0.05	0.06	0.04	0.03	0.04
Tourism, restaurants, and hotels	0.18	0.13	0.03	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Transport and communication	0.13	0.13	0.14	0.04	0.04	0.04	0.10	0.06	0.04	0.14	0.03	0.02
Financial services	0.27	0.00	0.27	0.00	0.00	0.00	0.01	0.29	0.02	0.06	0.00	0.00
Other services	0.00	0.00	0.00	0.00	0.31	0.02	0.00	0.00	0.20	0.17	0.30†	0.00

*Barclays has since rebranded to Absa Kenya

**CBA and NIC have since merged to form NCBA Bank

***NBK has since been acquired by KCB Bank

†NBK did not report any personal loans category in its sectoral breakdown but these are likely included in "other services" (reported as *Business Services* in the financials)

3.4 Mapping of emissions to bank lending sectors

24 Having obtained bank-level measures, the next step is to map the bank lending sectors to the GHG emissions reported by the Ministry of Environment and Natural Resources. This is necessary since the emissions reporting sectors are not similar to the lending sectors and there is no national reporting of emissions by categories equivalent to the lending sectors. The mapping of GHG emissions to bank lending sectors is a key

contribution of this study to the literature on climate financial risk in Kenya and other emerging economies.

25 For the mapping of GHG emissions to bank lending sectors, I considered two treatments:

1. **One-to-one sectoral mapping:** This is for lending sectors than can be directly mapped one-to-one to any of the emission reporting sectors. Four sectors qualify: agriculture; transport; electricity generation; and industrial processes. Collectively, they account for 45 MtCO2e (56% of emissions).
2. **GDP-weighted emission mapping:** For the remaining 44% of emissions, I allocated them to the other lending sectors based on each sector's contribution to GDP; i.e. allocation of emissions to each sector is based on each of the sector's percentage contribution to national output. Data on sectoral contribution to GDP is obtained from the CBK reports and corroborated with data from the Kenya National Bureau of Statistics (KNBS). Historically, emissions have been strongly correlated with economic activity. Cohen et al. (2018) found that, while key developed economies show signs of the decoupling of emissions and output trends, in emerging economies there is still a strong upward trend in emissions that is matched by an upward output trend.

26 Table 9 shows the mapping of the lending sectors to the six emission categories.

Table 9: Mapping of GHG emissions to bank lending sectors

GHG Emission Sector	Bank Lending Sector	Emissions %
- Agriculture	- Agriculture	40%
- Transportation	- Transportation and communication	11%
(*2 sectors combined*) Electricity generation Industrial processes	- Manufacturing, energy, and water	5%
(3 sectors combined) LULUCF* Energy demand Water	Combined emissions split across 7 sectors by GDP contribution weighting: Personal Mining and quarrying Real estate, building, and construction Wholesale and retail trade Tourism, restaurants, and hotels Financial services Other services	44%
	Total	100%

*Land use, land-use change, and forestry

27 It is worth noting that energy demand as an emission sector relates to national energy demand at all levels (household, industrial, and commercial) and thus is not be erroneously directly mapped to the manufacturing, energy, and water sector.

28 Table 10 provides emissions weights of each banking sector based on the mapping.

Table 10: GHG emission contributions by lending sector, 2018

Sector	Emissions %
Personal	6%
Agriculture*	40%
Mining and quarrying	1%
Manufacturing, energy, and water*	5%
Real Estate, building, and construction	12%
Wholesale and retail trade	7%
Tourism, restaurants, and hotels	1%
Transport and communication*	11%
Financial services	6%
Other economic activities	11%
Total	100%

*These sectors were mapped directly to their respective emission sectors. The other sectors' emissions contributions were determined from GDP-weighting as seen in Table 9

29 "Other economic activities" in the emissions mapping refers to GDP-weighted emissions from economic activities not directly linked to any of the distinct bank lending sectors. These include the following economic activities captured in the GDP reporting by KNBS: public administration; professional, administration, and social services; education; health; and other services. Most of these are public services and it is reasonable that there are national emissions from public and social services not linked to the sectors under CBK reporting.

30 Table 11 below replicates GHG emissions by sector with the total national emissions rescaled across all bank lending sectors without the "other economic activities" category. The redistribution keeps the relative weights across all the bank lending sectors and thus does not distort the analysis.

Table 11: GHG emission contributions by sector (rescaled emissions=100%)

Sector	Emissions %

Personal	7%
Agriculture*	45%
Mining and quarrying	1%
Manufacturing, energy, and water*	6%
Real estate, building, and construction	13%
Wholesale and retail trade	8%
Tourism, restaurants, and hotels	1%
Transport and communication*	13%
Financial services	6%
Total	100%

*These sectors were mapped directly to their respective emission sectors. The other sectors' emissions contributions were determined from GDP-weighting as seen in Table 9.

4. Indices analysis

1 The standardised reporting of banks' lending, key sectoral measures already analysed across banks, and GHG emissions mapped to sectoral lending is all the necessary information for the main analysis of interest: construction of two climate-relevant indices, *Emissions Exposure Index* (EE_i) and *Emissions Funding Index* (EF_i) for each bank *i*.

4.1 Definition of the indices

4.1.1 Emissions Exposure Index (EE_i)

2 This is a measure of a bank's portfolio climate risk exposure. The index answers the question "How much is each bank exposed to climate risk through its sectoral loan composition, given the GHG emissions represented by its loan portfolio?"

3 Recall that GL_{ij} denotes the gross loans by each bank i to each economic sector j and S_j is the share of emissions attributable to each sector. Also, we defined W_{ij} as the share of each bank's loan portfolio to each sector, such that $W_{ij} = \frac{GL_{ij}}{\sum_k GL_{ik}}$ where the index *k* runs over the set of all sectors and where $\Sigma W_{ij} = 1$ for each bank.

4 The *Emissions Exposure Index* (EE_i) is the sum of the relative exposures of each bank *i* across all economic sectors *j* weighted by the relative share of emissions attributable to each sector S_j, that is:

EEi = Σ_jSjWij (3)

5 For example, assume Bank A has its entire lending concentrated on agriculture ($W_{A,AGR} = 1$) and Bank B directs its lending entirely to financial services ($W_{B,FIN} = 1$); since the share of emissions in the agriculture sector is higher than in financial services, i.e. $S_{AGR} > S_{FIN}$, then $EE_A > EE_B$ in this case.

6 Thus, EE_i captures the GHG emissions intensity of the loan portfolio of each bank according to the emission shares represented by its sectoral loan composition.

4.1.2 Emissions Funding Index (EF_i)

7 This is a measure of the climate risk funded by the bank's lending portfolio. The index answers the question "*How much of the climate risk attributed to GHG emissions does each bank fund through its lending relative to other banks?*"

8 Again, GL_{ij} denotes the gross loans by each bank i to each economic sector j and S_j is the share of emissions attributable to each sector. In addition to W_{ij}, we also defined M_{ij} as the market share of each bank in each sector, such that $M_{ij} = \frac{GL_{ij}}{\sum_k GL_{kj}}$ where the index *k* runs over the set of all banks and where $\Sigma M_{ij} = 1$ for each sector.

9 The *Emissions Funding Index* (EF_i) is the sum of the market shares of each bank *i* across all economic sectors *j* weighted by the relative share of emissions attributable to each sector S_j, that is:

$EFi = \Sigma_j SjMij$ (4)

10 $\Sigma EF_i = 1$ across all banks.

11 For example, assume there are only two Banks, A and B, that lend entirely to the transport sector with market shares of 40% and 60% respectively ($M_{A,TRAN} = 0.4$, $M_{B,TRAN} = 0.6$); since the share of transport sector emissions S_{TRAN} is the same for both banks, the difference in market shares means $EF_A < EF_B$ as Bank B funds a larger proportion of emissions.

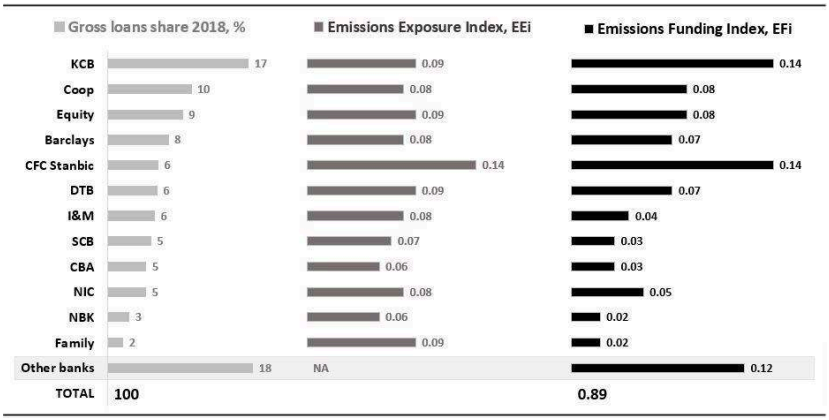
12 Thus, EF_i captures the relative funding of climate risk and is a measure of climate risk importance of each bank, given the emissions funded by its lending relative to other banks.

13 As noted by Monasterolo et al. (2017) in their novel development of climate-relevant indices for the euro area, these two indices are complementary and help capture two very important aspects of climate risk for Kenyan banks: the climate risk exposure represented by banks' portfolios and their relative funding of the climate risk through their lending. No such related indices have been constructed for banks in any other emerging economies in Africa. Further, no available research on climate-related disclosures for banks has mapped GHG emissions to lending sectors using the hybrid approach applied in this study.

4.2 Results and interpretation

14 Figure 1 below reports the values of EE_i and EF_i calculated for each bank across all sectors.

Figure 1: Results of EE_i and EF_i analysis



Note: Barclays has since rebranded to Absa Kenya; CBA and NIC have since merged to form NCBA Bank; NBK has since been acquired by KCB Bank

Emissions Exposure Index, EE_i

15 From the main results in Figure 1 above, all banks except one have EE_i values around a narrow range of 0.06–0.09. Given the index definition, this means that the banks have a fairly similar exposure to GHG emissions based on their sectoral lending composition. CFC Stanbic has a relatively higher EE_i of 0.14. As the sample is representative of the industry, this implies a fairly similar concentration of climate risk exposure across Kenyan banks given their sectoral loan composition. The relatively higher exposure by CFC Stanbic can be explained by the high concentration of its loan portfolio in the high-emission agriculture and real estate sectors as seen in Table 7 (collectively accounting for 51% of the bank's gross loans).

16 The key finding from the Emissions Exposure Index (EE_i) analysis can be summed up as follows: *Kenyan banks, with the exception of one outlier, have fairly similar exposure to climate risk through their loan portfolios, given the GHG emissions represented by their sectoral lending.*

Emissions Funding Index, EF_i

17 From the main results in Figure 1, there is a differentiation in the values of EF_i across the banks which is fairly proportional to their market share of gross loans. Given the index definition, this means that the banks have differentiated funding of climate risk through their lending that is fairly proportional to their market shares. CFC Stanbic has a high emissions funding relative to its size (EF_i of 16% similar to the biggest bank KCB) and this can be explained by its relatively high climate risk exposure EE_i seen earlier. The differentiation of emissions funding that mimics market shares is not unexpected given that banks have a fairly similar concentration of exposure as concluded from the EE_i analysis. Thus, bigger (smaller) banks have higher (lower) funding of climate risk.

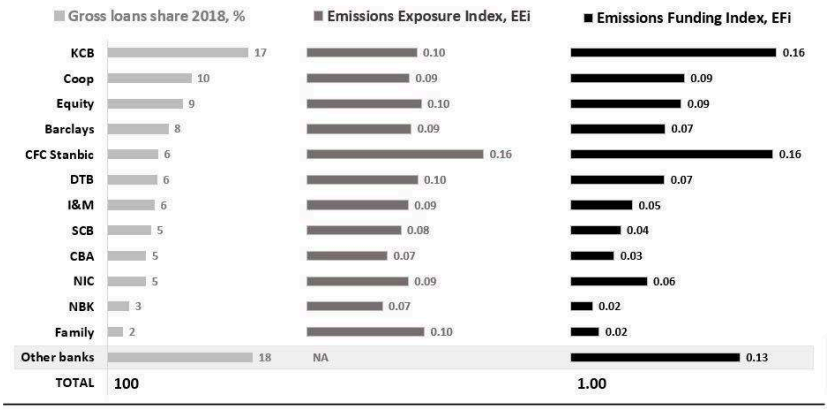
18 The key finding from the *Emissions Funding Index* (EF_i) analysis can be summed up as follows: *Kenyan banks, with the exception of one outlier, have differentiated funding of climate risk attributed to their loan portfolios that is fairly proportional to their market shares of gross loans, and this is expected given the similarity in their similar exposure profiles.*

Rescaling emissions funding to 100%

19 From the main results in Figure 1, values of EF_i add up to 0.89, i.e. the funding of sectoral emissions through the banks' loan portfolios add up to 89% of emissions attributed to the sectors collectively. This is because there are emissions within the economy that are not directly linked to any of the bank lending sectors. These are mostly the "other economic activities" identified in the GDP reporting that are not directly linked to any of the distinct lending sectors. They include economic activities in the following GDP categories: public administration; professional, administration and social services; education; health; and other services.

20 The calculation of EE_i and EF_i is repeated this time rescaling the emissions sectoral contribution such that the lending sectors account for 100% of emissions funding within the banking industry. Figure 2 uses the rescaled emissions, i.e. $\Sigma EF_i = 1$ to report the values of EE_i and EF_i. As the relative weighting of emissions across sectors is unchanged, the interpretation and conclusion is the same as in Figure 1: *Kenyan banks, with the exception of one outlier, have differentiated funding of climate risk attributed to their loan portfolios that is fairly proportional to their market shares of gross loans.*

Figure 2: Results of EE_i and EF_i analysis (rescaled emissions=100%)



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21 From Figure 2, the non-sampled banks account for 13% of emissions funding implying that the sample of banks representing 82% of industry gross loans account for 87% of emissions holdings.

4.3 Forward-looking scenario analysis

22 The values of EE_i and EF_i are known for each bank, together with the respective interpretation of the two indices for the banking industry. To enhance the analysis, I am interested in a forward-looking view of the expected values of the indices in 2030. This helps enable a futuristic view of the climate risk exposure across the banks. Two scenarios are of interest:

- a business-as-usual (BAU) scenario that uses the emissions forecasts for 2030;
- a transition scenario of abating emissions by 30% relative to 2030 BAU.

23 For both scenarios, I repeat the analysis of EE_i and EF_i using the BAU emissions forecasts and the transition scenario 30% emissions reduction target as shown in column 1 and column 2 respectively in Table 12 below. For both cases, the futuristic view is determined with regard to the emissions (and not the sectoral loan composition), and thus we use the current sectoral loan composition for each bank but with the 2030 emissions forecasts for each scenario.

Table 12: GHG emissions forecasts in 2030 – BAU and transition scenarios

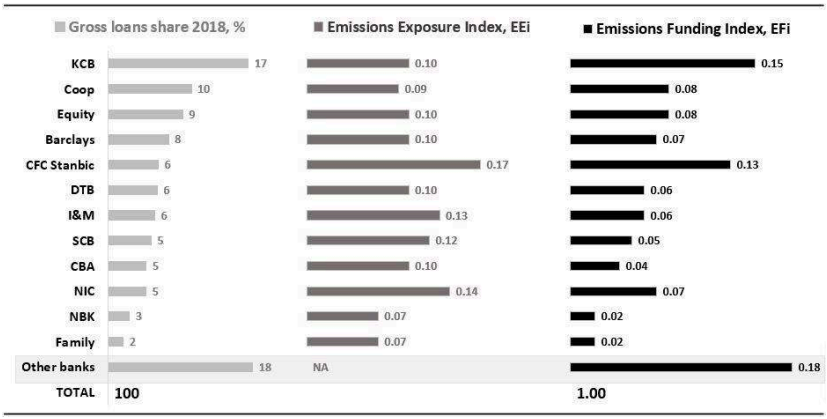
Sector	GHG Emissions Forecasts, 2030		
	Current Baseline (2015)	Baseline Scenario (BAU)	Transition Scenario (30% reduction)
Agriculture	32	39	36
Electricity generation	1	42	32
LULUCF	26	22	2
Transportation	9	21	18
Energy demand	7	10	4
Industrial processes	3	6	5
Waste	2	4	4
Total	80	143*	100*
Emissions reduction			*30%*

*The values in the rows add up to 144 and 101 respectively due to rounding.

4.3.1 2030 business-as-usual scenario

24 Figure 3 below reports the values of EE_i and EF_i using the 2030 BAU emissions forecasts.

Figure 3: Results of EE_i and EF_i analysis – 2030 BAU scenario



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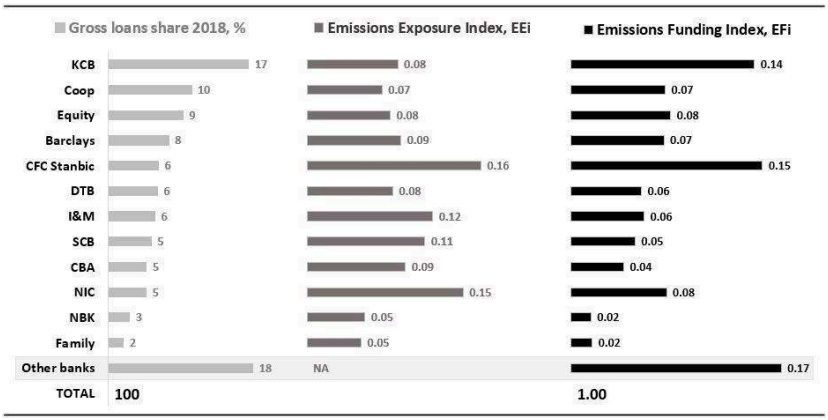
25 From the results in Figure 3 above using 2030 BAU emissions forecasts, most EE_i values are still within a narrow range, 0.07–0.12 with CFC Stanbic still as the outlier. In addition, there is one more result of interest: there is an emissions exposure spike for I&M Bank and NIC Bank (which is now merged with CBA Bank to form NCBA). This EE_i spike is explained by high lending exposure to the manufacturing, energy, and water sector (24% sector share by each of the two banks). The energy sector is forecast to have the highest increase in emissions by 2030, with a 12-fold increase from 4 MtCO2e in 2015 to 47 MtCO2e in 2030 (see Table 12), accounting for 63% of the increase in emissions over the 15-year period. This significant increase in the risk exposure of the two banks with a high concentration in lending to the manufacturing, energy, and water sector is associated with a small increase in the funding risk EF_i. Overall, EF_i results are still consistent with the earlier finding that larger (smaller) banks have higher (lower) funding of climate risk.

4.3.2. 2030 transition scenario

26 The transition scenario is expected to have an effect on the values of the indices in 2030 given the increase in expected emissions but also the fact that different sectors have different abatement potential and thus this affects S_j, the relative share of emissions attributable to each sector in 2030. Like with the BAU scenario, I use the current sectoral loan composition for each bank but with the 2030 emissions forecasts with the 30% abatement target scenario. Figure 4 below reports the values of EE_i and EF_i using the 2030 transition scenario

Figure 4: Results of EE_i and EF_i analysis – 2030 transition scenario



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27 From the results in Figure 4 above using 2030 transition emissions forecasts, most EE_i values are still within a range, 0.05–0.11 with CFC Stanbic still as the outlier. In addition, just like in the 2030 BAU scenario, there is an emissions exposure spike for I&M Bank and NIC Bank (which is now merged with CBA Bank to form NCBA). This spike is still explained by the high lending exposure to the manufacturing, energy, and water sector, which has expected a significant increase in emission levels. While there is a 21% drop in the sector's forecast emissions from 47 MtCO2e to 36 MtCO2e under the 2030 reduction targets, the latter still represents a significant increase in emissions from 4 MtCO2e in 2015. For contrast, the LULUCF sector has a forecast 93% emissions reduction from 26 MtCO2e in 2015 to 2 MtCO2e under the 2030 transition scenario. Thus, these two banks that have a high concentration in lending to the manufacturing, energy, and water sector are still expected to have a significant increase in risk exposure with an associated small increase in the funding risk. Overall, like with the 2030 BAU scenario, the EF_i results are still consistent with the earlier finding that larger (smaller) banks have higher (lower) funding of climate-related risk.

5. Implications of the results

1 From the baseline and forward-looking analysis, we have seen three key results:

1. ***Emissions Exposure Index* (EE_i):** Kenyan banks, with the exception of an outlier, have fairly similar exposure to climate risk through their loan portfolios, given the GHG emissions represented by their sectoral lending.
2. ***Emissions Funding Index* (EF_i):** Kenyan banks, with the exception of an outlier, have differentiated funding of climate risk attributed to their loan portfolios that is fairly proportional to their market shares of gross loans, and this is expected given the similarity in exposure profiles. Larger (smaller) banks will have higher (lower) funding of climate-related risk.
3. **Forward-looking analysis:** Banks with a high concentration in lending to the manufacturing, energy, and water sector are expected to have an increase in their risk exposure given the expected large increase in emissions in the energy sector under both the 2030 BAU scenario and the 2030 transition scenario. Overall, larger (smaller) banks will still have higher (lower) funding of climate-related risk.

2 The fairly similar climate risk profiles of the Kenyan banks means that banks face similar exposure to climate-induced risk factors given the GHG emissions represented by their sectoral loan composition. From the funding index, the key implication is that any climate financial policies proposed by the CBK or the government that aim to achieve low-carbon transition in the banking industry by reducing lending to high emission sectors should not target any specific banks but be formulated taking into consideration the proportionality of climate risk funding to the market shares of gross loans. This, in fact, would create an incentive for the CBK or government to propose market-led initiatives by banks to divert lending away from high-emissions sectors, because the banks can contribute to the transition cost in proportion to their market shares of gross loans without any particular banks being targeted or singled out.

3 Another policy implication from the expected increase in emissions in the manufacturing, energy, and water sector is that the country's energy transition will be central in shaping the country's low-carbon transition and reducing the associated climate-related risk posed to the stability of the financial system. Thus the country's energy policy, which seeks to further reduce fossil electricity generation to more

sustainable renewable energy, sources should be expedited to cut back on emissions in 2030 and thus reduce climate-related risk.

6. Conclusion

1 This study has provided an analysis of two climate-relevant indices as a first set of quantitative climate-related financial disclosures that are comparable across Kenyan banks. Secondly, this study provides decision-useful information for the CBK and other financial regulators to formulate macroeconomic and financial policies that would seek to promote low-carbon transition via the banking industry as a key financial sub-sector. Further, this analysis provides a template for industrywide assessment of climate-related risk for banks in other emerging economies and the approach used for mapping national GHG emissions to bank lending sectors is also a key contribution to the literature on quantifying climate risks for the financial sector.

2 This analysis could be replicated using standardised bank-level sectoral loan composition data in the possession of the CBK. As discussed, banks do not report gross loans across similar sector categories and this study initially standardised the sectoral reporting across the banks satisfactorily. However, replication of these results using data held by the CBK would validate these results and in essence provide a first set of comparable and decision-useful climate-related financial disclosures for Kenya's banking industry. This could further be adapted and replicated across other countries where sectoral lending data and sectoral emissions data are available. The main limitation of this study is that both bank lending and GHG emissions are reported at the sectoral level. For example, there could be huge lending to a high-emissions sector (e.g. agriculture or transport) but with the loans funding business activities with fairly low contribution to emissions in the sector. To establish a more accurate linkage between sectoral lending portfolios and GHG emissions in this case, we would need both sets of data at a more fine-grained sub-sector level.

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