THE UNIVERSITY OF PENNSYLVANIA

CAPSTONE PROJECT

ALWAYS BE DISCLOSING:

SHOULD BANK SIZE PRECLUDE ELIGIBILITY FOR CLIMATE RISK DISCLOSURES?

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Abstract:

Climate risk disclosures, defined as regulatory filings by financial institutions concerning their climate-related holdings, have received significant support among policymakers for their ability to provide regulators with insights into climate finance, and also protecting the financial services sector from risks borne by climate change. However, the majority of academic research and policy proposals on this topic have called for such requirements to be broadly applied to all financial institutions, discounting the potential for climate risk, as well as the utility of climate risk disclosures, to vary among individual institutions. This study attempted to ascertain whether climate risk was disproportionately distributed among banks based on their size, and determine whether certain institutions could be exempt from climate risk disclosures where their burden of compliance outweighed the benefits from reporting their climate-related holdings. It found that small banks, particularly those under $50 billion in total assets, maintained low, and statistically insignificant amounts of risk from climate-related holdings, and if exempted, estimated climate risk disclosures to still capture over 70 percent of climate-related financial transactions as well as nearly 85 percent of consequent transitional climate risk.

Introduction:

As climate change continues its ascendence as a matter of political, economic, and social importance, public policy mitigating its effects, as well as ensuring an orderly transition towards a more sustainable future, has received increased attention from lawmakers. This particular issue is extremely complex because adequate public policy must not only address decades of inaction that have accelerated the risks associated with climate change, but profoundly recondition human behavior to remain cognizant of our collective environmental footprint. These prerequisites have prompted many nuanced debates at the intersection between climate change and economic policy because the conduct of our economy, including consumer spending, business investment, global trade, as well as government expenditures, dictate human behavior, its environmental footprint, as well as the magnitude of associated climate risks.

Accordingly, lawmakers have begun focusing on financial institutions, given their ability to provide economic support for companies and industries which perpetuate climate change, as well as the risks from such relationships on these firms, their shareholders, and the economy at-large. Climate risks to financial institutions are broadly characterized as either physical risks, via exposure to households and companies that experience extreme weather shocks, or transitional risks, via exposure to different assets which lose value over time as the economy at-large adopts more environmentally-conscious practices[1]. Lawmakers have proposed many measures to better monitor these risks among financial institutions, including capital buffers[2], stress tests[3], and even supplemental taxes however[4]; the most controversial such proposition is climate risk disclosures, which document all climate-related transactions and holdings[5].

While climate risk disclosures appear relatively innocuous, their propensity to impose a significant compliance burden on financial institutions and reveal sensitive information about individual companies, warrants additional scrutiny as to which firms should ultimately shoulder this responsibility. Some financial institutions simply have more capital and labor resources that would allow them to accumulate a greater share of climate-related holdings, thereby meriting

[1] Pointner, Wolfgang, and Doris Ritzberger-Grünwald. "Climate Change as a Risk to Financial Stability." Financial Stability Report 38 (2019): 30-45.
[2] Neisen, Martin, Benjamin Bruhn, and Dieter Lienland. "ESG Rating as Input for a Sustainability Capital Buffer." Journal of Risk Management in Financial Institutions 15, no. 1 (2021): 72-84.
[3] Battiston, Stefano, Antoine Mandel, Irene Monasterolo, Franziska Schütze, and Gabriele Visentin. "A Climate Stress-Test of the Financial System." Nature Climate Change 7, no. 4 (2017): 283-288.
[4] Campiglio, Emanuele, Yannis Dafermos, Pierre Monnin, Josh Ryan-Collins, Guido Schotten, and Misa Tanaka. "Climate Change Challenges for Central Banks and Financial Regulators." Nature Climate Change 8, no. 6 (2018): 462-468.
[5] "What is Climate Change Risk Disclosure?," Grantham Research Institute on Climate Change and the Environment, last modified May 20, 2020, https://www.lse.ac.uk/granthaminstitute/explainers/climate-change-risk-disclosure/.

periodic disclosures to regulators. By that same measure, some companies and industries have a more consequential impact on climate change, thereby meriting additional supervision regarding their financial relationships. In other words, lawmakers should strive to limit the applicability of climate risk disclosures to individual firms for whom the benefits of oversight from regulators would outweigh any potential burdens imposed.

This study will attempt to define such limitations by contrasting transitional risks among small and large banks within the United States, in order to determine whether nuanced reporting requirements could sufficiently capture climate-related risks from the financial services sector at-large while sparing certain institutions with a low-risk profile from needless regulatory oversight. While similar analyses have established the presence of such climate risks among the largest US banks, relatively none have studied, let alone compared, those risks within smaller US banks, which would make this study applicable for lawmakers when evaluating institutional eligibility for climate risk disclosures. Through a multifaceted, comprehensive statistical analysis of loan-level data among US banks over the past two decades, this study will seek to demonstrate that climate risk disclosures can be administered efficiently by estimating and exempting those financial institutions with a low predisposition to such risks.

Literature Review:

The following section provides an overview of the academic literature covering climate risks to financial institutions, as well as the utility of climate risk disclosures. Many studies have analyzed the accumulation of climate-related holdings among financial institutions however; the oldest such study is Banking on Climate Chaos, an annual report developed by an amalgam of advocacy groups which tracks financial transactions in the fossil fuels industry executed by over 60 global banks[6]. Since 2016, this report has shown a steady growth in financial transactions among the world's largest financial institutions, which slightly abated over recent months due to the onset of the global coronavirus pandemic[7]. This report also notes persistent incongruencies within global climate-related regulations has created market incentives which enable financial transactions with the fossil fuels industry to remain a profitable venture.

[6] Kirsch, Alison, Jason Opena Disterhoft, Grant Marr, Paddy McCully, Ruth Breech, Toben Dilworth, Maaike Beenes et al. "Banking on Climate Chaos 2021." (2021).
[7] Ibid.

Similar studies have examined the prevalence of physical and transitional climate risks within such global banks. A recent paper by Jung, Engle, and Berner developed a stress testing procedure for measuring transitional climate risk, known as CRISK, within global systemically-important financial institutions, measuring their expected capital shortfall after a climate stress scenario[8]. They found climate risks are directly correlated to the size of a financial institution while country-specific regulations mitigate these effects on a marginal basis. Another paper by Brownlees and Engle studied physical and transitional climate risks by developing a novel metric called SRISK, also calculated as the percentage capital shortfall of a firm conditional on a severe market decline conditional to its size, leverage, and risk, finding this metric to be most useful if consistently studying various periods within a given economic cycle[9].

Conversely, some studies have examined physical and transitional climate risks from the perspective of corporate clients. A paper by Bolton and Kacperczyk found that carbon emissions can affect cross-sectional stock returns among major US companies, and that shareholders have become much more aware of these risks given their propensity to affect company dividends[10]. As such, financial institutions servicing these companies would have to account for such risks when extending their services to them. However, another paper by Monasterolo explored shortcomings in traditional economic pricing methods which hindered the accurate incorporation of climate risks in the financial valuation and risk management of private firms[11]. Hence, while financial institutions might take steps to account for climate-related risks facing their clients, the accuracy of such actions would largely depend on the methodologies employed.

While both physical and transitional climate risks to financial institutions can be observed from many different perspectives, the academic literature has found some agreement as to how such risks can best be monitored. A paper by Ens and Johnston examined a plethora of scenario analyses employed by central banks on the subject of climate risk, finding it critical for financial institutions to take stock of direct and indirect emissions from private companies, as well as their respective costs[12]. They also stressed the importance of including all potential liabilities in the calculation of institutional climate risk in order to gage the most accurate metrics. Another paper

[8] Jung, Hyeyoon, Robert F. Engle, and Richard Berner. "Climate Stress Testing." FRB of New York Staff Report 977 (2021).
[9] Brownlees, Christian, and Robert F. Engle. "SRISK: A Conditional Capital Shortfall Measure of Systemic Risk." The Review of Financial Studies 30, no. 1 (2017): 48-79.
[10] Ibid.
[11] Monasterolo, Irene. "Climate Change and the Financial System." Annual Review of Resource Economics 12 (2020): 299-320.
[12] Ens, Erik, and Craig Johnston. Scenario Analysis and the Economic and Financial Risks from Climate Change. No. 2020-3. Bank of Canada Staff Discussion Paper, 2020.

by Baudino and Svoronos analyzing pilot stress test programs by independent European Central Banks found that greater data availability, and synchronized methodological specifications, for all reporting financial institutions could allow regulators to gage the magnitude of physical and transitional climate risks to the financial services sector at-large[13].

Unfortunately, as mentioned previously, many of these studies have solely focused on the largest US and/or global financial institutions when examining climate risk. This is an obvious flaw within the current academic literature, considering such firms comprise less than 5 percent of financial institutions in the United States as well as less than 1 percent of financial institutions globally, but nonetheless understandable[14]. Many small financial institutions are not subject to the same reporting requirements as their larger counterparts, making data availability an issue. In addition, many aspects of the empirical methods employed when analyzing climate risk among large financial institutions are just not applicable to their smaller counterparts given differences in their portfolios, clientele, and geographic distribution. Hence, this study will attempt to bridge this difference by analyzing climate risk among small and large financial institutions using the same metrics, contributing a vital perspective to the current body of academic literature.

Description of the Data:

This study uses syndicated loan data from the Loan Pricing Corporation (LPC) DealScan database, which is managed by Thompson Reuters, and compiled by the Wharton Research and Data Services (WRDS). While principally concerning loans, the dataset comprises a multitude of financial transactions supported by banks, credit unions, other depository institutions, as well as non-depository financial institutions around the world. First, this dataset was limited to financial transactions reported between 2000 and 2020, using the date when such deals became "active", defined as when the lender formally transferred capital to the borrower. Second, this dataset was limited to banks headquartered in the United States, including only those institutions within Bank Holding Companies (BHCs) that are registered with the Federal Deposit Insurance Corporation (FDIC) as banks. Third, this dataset was further limited to corporate borrowers within industries with above-average carbon emissions. This step was accomplished by utilizing a Department of

[13] Baudino, Patrizia, and Jean-Philippe Svoronos. Tech. Stress-Testing Banks for Climate Change – A Comparison of Practices. Bank of International Settlements, July 2021. https://www.bis.org/fsi/publ/insights34.pdf.
[14] Marc Labonte and David W. Perkins, "Over the Line: Asset Thresholds in Bank Regulation" (Congressional Research Service, May 3, 2021), https://sgp.fas.org/crs/misc/R46779.pdf.

Commerce study which tabulated the average carbon emissions of every industry featured within the North American Industry Classification System (NAICS)[15], identifying those industries with carbon emissions above the average level of all private, non-farm industries, and matching them with borrowers' NAICS codes within the LPC DealScan dataset.

Supplemental institutional data was collected using quarterly FDIC call reports, including total assets, liabilities, as well as various income and debt metrics. All of the remaining US banks within the LPC DealScan dataset were divided into five peer groups based on total assets within a given quarter, ranging from those under $1 billion in total assets to those over $100 billion in total assets. Between 2000 and 2020, the final dataset consisted of 49,866 financial transactions among 632 individual banks, roughly averaging 2,500 such transactions per year. While the final dataset contains a small percentage of financial transactions as per the aforementioned criterion, absent complete loan-level data which banks are not legally obligated to disclose, it sufficiently serves its purpose of providing a basis for comparison between banks across the spectrum. Each peer group comprised roughly one-quarter of banks, with similar geographic diversification as well. In terms of diversification among corporate clients, roughly 10 percent of borrowers were directly focused on fossil fuels, a typical metric for climate-related financial transactions within similar studies such as Achraya et. al.[16] as well as Jung, Engle, and Berner[17], while the remaining 90 percent were from other sectors, demonstrating the utility in using a comprehensive approach via average carbon emissions to define climate-related financial transactions.

Quantitative Analysis:

A cursory analysis of the truncated dataset yielded several important insights. First, while climate-related financial transactions among the largest banks have declined precipitously over the past ten years, they remain an outlier when compared against all other smaller peers. Figure 1 below depicts the number of climate-related financial transactions for each peer group of banks over the past two decades. While large banks over $100 billion in total assets generally increased their financial transactions with corporate clients in carbon-intensive industries over the past two decades, those of all other peer groups declined within the same timeframe. Furthermore, while

[15] Henry, David, Beethika Khan, and Sandra Cooke-Hull. "US Carbon Dioxide Emissions and Intensities over Time: A Detailed Accounting of Industries, Government and Households." (2010).
[16] Acharya, Viral V., and Stephen G. Ryan. "Banks' Financial Reporting and Financial System Stability." Journal of Accounting Research 54, no. 2 (2016): 277-340.
[17] Jung, Hyeyoon, Robert F. Engle, and Richard Berner. "Climate Stress Testing." FRB of New York Staff Report 977 (2021).

large banks over $100 billion in total assets sponsored nearly 900 such climate-related financial transactions by the conclusion of the second decade, all other peer groups undertook less than 300 transactions, suggestive of a burgeoning monopoly within this segment of the market.

Insert Figure 1 here.

Second, annunciating this latter point, climate-related finances, which could be subject to physical and transitional risks, are overwhelmingly retained by the largest banks with over $100 billion in total assets. Figure 2 below compares the percentage of dollars allocated to corporate clients within carbon-intensive industries by bank peer group, demonstrating the rapid pace by which banks over $100 billion in total assets have consolidated their services to this segment of the market. Conversely, small banks under $1 billion in total assets, as well as those between $1 billion and $10 billion in total assets, once comprised over half of all financial transactions with such clients but saw this share reduced over the past two decades to a collective 15 percent. This suggests that smaller banks, either voluntarily or by some persuasion, have significantly reduced their services to corporate clients within carbon-intensive industries.

Insert Figure 2 here.

Third, such climate-related financial transactions have steadily grown larger over the past two decades, a potential driver behind the decreasing share of small banks within this segment of the market. Figure 3 below charts the average financial transaction with a corporate client within a carbon-intensive industry, adjusted for inflation using 2019 dollars, as well as the first and third corresponding quartiles. Over the past two decades, the average financial transaction undertaken by any bank tripled from $200,000 to over $600,000 while the variance in individual transactions has also significantly increased by over $500,000 per year. These observations suggest smaller banks, on average, have become less capable of accommodating the typical corporate client in a carbon-intensive industry, which could be due to greater demands from corporate clients given higher costs of business, increased supervisory or regulatory costs facing financial institutions, as well as potential reputational costs from the perceived association with a controversial customer.

Insert Figure 3 here.

This preliminary analysis provides robust evidence of smaller financial institutions being less vulnerable to climate risks given their limited exposure, echoing similar studies which have hypothesized the largest such firms to originate near 80 percent of all syndicated climate-related loans. While small banks once rivaled large banks as viable servicers for corporate clients within carbon-intensive industries, recent trends prove consolidation in favor of the latter. This could be driven by a variety of political, financial, even social factors which have either encouraged small banks to disengage from this segment of the market, or prompted corporate clients from carbon-intensive industries to view large banks as more efficient servicers based on their needs. These observations indicate that small banks probably have less vulnerabilities to report via climate risk disclosures, and further indicate a limited value for regulators in terms of meaningful supervision of these institutions as well as the financial services sector at-large.

Regression Analysis:

Although such observations contribute to the notion that small banks should, at the very least, be subjected to different supervisory standards from their larger counterparts on the matter of climate risk, they do not sufficiently demonstrate their imperviousness to adverse financial consequences from their continued relationships with corporate clients within carbon-intensive industries. Even while accounting for a minor segment of this market, small banks could still be afflicted by adverse shocks to climate-related assets within their existing portfolios, accelerating the potential risk of insufficient institutional safety and soundness, which, if observed by many individual institutions, could pose just as much danger to the greater financial services sector as if the same case were to affect one or two large banks. Hence, the next part of this analysis will examine whether the existing financial relationships of small banks with corporate clients within carbon-intensive industries pose significant risks that, by themselves, warrant further regulatory supervision, as well as contrasting such risks with those of large banks.

First, a rudimentary model is utilized to isolate the effects of climate-related transactions, referred to as CLIMractions, on core bank capital, defined as liquid institutional finances which all banks are required to maintain at any given point in time. The dependent variable within this model, Tier-One (Core) Capital, consists of common equity as well as noncumulative perpetual

preferred stock and minority interests in consolidated subsidiaries less goodwill as well as other intangible assets[18]. The three independent variables within this model consist of Assets, a dollar-value of total bank assets less the estimated dollar value of its CLIMractions, Liabilities, which is similarly a dollar-value of total bank liabilities, and CLIMractions. A logarithmic transformation is applied to each variable for the model to gage a simple percentage change effect between Tier-One (Core) Capital, and the independent variables. Data for CLIMractions was retrieved from the truncated dataset discussed in the previous section while annual Tier-One (Core) Capital, Assets, and Liabilities data was obtained from quarterly call reports administered by the FDIC. The model employed two-way fixed effects for bank and year, thus enabling the recognition of institution or time-specific trends, and their impact on Tier-One (Core) Capital. A summary of all variables employed within this model is shown in Table 1 below.

Insert Table 1 here.

As per Table 2, Assets and Liabilities, as expected, imposes a significant effect on Tier-One (Core) Capital amongst small banks and large banks alike. Both are endogenous variables whose values fluctuate based on the particular bank and year. Conversely, CLIMractions only exerts a highly significant effect on the Tier-One (Core) Capital of large banks, equivalent to all other Assets and Liabilities. Among small banks up to $50 billion in total assets, CLIMractions does not even impose a moderate or marginal effect on their Tier-One (Core) Capital, suggesting these institutions are either better capitalized to mitigate risks from climate-related transactions within their portfolios, or that such transactions are not even major risks in the first place. These results are even more noteworthy given the inclusion of bank- and time-specific fixed effects which enabled the model to control for CLIMractions emanating from the portfolios of different individual institutions, as well as within different quarters throughout the past two decades. In other words, the model shows a consistent lack of risk within CLIMractions among small banks under $50 billion in total assets. The complete regression results are shown below in Table 1, including the model specifications, coefficients as well as t-values (italicized). $CoreCapital_{it}$ represents the Tier-1 (Core) Capital of bank i at year t while $ln(\beta_1 CLIMRactions_{it})$ denotes the

[18] "Definition of Capital in Basel III - Executive Summary," Bank for International Settlements, last modified June 27, 2019, https://www.bis.org/fsi/fsisummaries/defcap_b3.htm.

natural log of CLIMractions of bank i at year t. $ln(\beta_2 Assets_{it})$ and $ln(\beta_3 Liabilities_{it})$ each represent the respective Assets and Liabilities of a bank, which are logarithmically transformed while, μ_{it} represents the idiosyncratic errors in both i and t not addressed by the model.

Insert Table 2 here.

According to the regression results, a one percent increase in CLIMractions could yield between a 0.001, among larger banks, to 0.01, among smaller banks, percent decrease in Tier-One (Core) Capital. While such effects might appear counterintuitive, small banks retain fewer total assets therefore, all individual holdings within their portfolio have a more pronounced effect on their Tier-One (Core) Capital. Furthermore, the results suggest the CLIMraction coefficient is negatively correlated with bank size. In other words, a percentage increase in CLIMractions will engender a decrease in Tier-One (Core) Capital therefore; institutions with a greater share of CLIMractions are more vulnerable to increased risk. Given the rudimentary nature of this model, there is a possibility that these results could be influenced by omitted variable bias, including other segments of institutional lending, or general macroeconomic conditions, both of which will be explored in greater detail. Yet, these results suggest that increased CLIMractions lead to a statistically significant decrease in Tier-One (Core Capital) among large banks that is not present in small banks. This not only means that larger banks pose a greater risk to the financial services sector at-large given their climate-related transactions, but also pose a greater risk to themselves arising from these particular holdings.

To explore the evolution of this risk, annual CLIMraction betas, denoting the percent change in Tier-One (Core) Capital, were calculated for each peer group of banks. These betas were calculated utilizing a modified version of the rudimentary model that did not include fixed effects for bank or time. As per Figure 4 below, banks under $50 billion in total assets exhibited some variation in the effect of transitional risk via climate-related financial transactions on their Tier-One (Core) Capital yet it did not prove to substantially change over the past two decades. Conversely, the transitional risk from climate-related financial transactions of large banks over $50 billion in total assets grew substantially, as indicated by its increasingly negative effect on their Tier-One (Core) Capital. This is likely correlated with their progressive monopolization of

financial transactions within carbon-intensive industries, but may also be related to unobserved risks as well, emanating from such corporate clients themselves.

Insert Figure 4 here.

Finally, a secondary model was employed to further explore the impact of CLIMractions on core bank capital in a more realistic environment. Using a dynamic autoregressive distributed lag (ARDL) framework, this model examines the effects of CLIMractions, as well as the velocity of CLIMractions, defined as the marginal effect of every additional CLIMraction, on Tier-One (Core) Capital, with a key assumption that past bank- and time-specific factors influence future such factors. In addition, there are four groups of supplemental independent variables included within the model. The first group contains several financial instruments which comprise the bulk of revenue for banks, including deposits, net loans and leases, and securities. The second group contains income and expense measures, providing further insight to institutions' financial health, including total interest income, total interest expenses, total non-interest income, and total non-interest expenses. The third group encompasses two performance ratios, return on assets (ROA) and return on equity (ROE), which provide additional insight to institutions' operational capacity as well as efficacy, while the final group comprises several macroeconomic variables including gross domestic product (GDP), consumer price index (CPI), the unemployment rate, as well as a dummy variable for recession, to capture external operating conditions that affect all institutions of all sizes. Internal bank data was collected from the quarterly FDIC call reports, while external macroeconomic data was aggregated and collected from the St. Louis Federal Reserve Bank. A summary of all variables employed within this model is shown in Table 3 below.

Insert Table 3 here.

According to the regression results in Table 4 below, CLIMractions imposes a significant effect on Tier-One (Core) Capital for large banks above $50 billion in total assets. This effect is higher across all bank peer groups, ranging from 0.01 to 0.02, though only significant for large banks, suggesting that when accounting for additional internal and external conditions, thereby mimicking a realistic scenario, the transitional risks associated with CLIMractions is higher. The

regression results are also indicative of increased negative returns from additional CLIMractions as shown by the negative coefficient for the velocity of CLIMractions. For those banks over $50 billion in total assets, this means that every additional percentage of climate-related transactions could further stress core institutional capital by another one percent. Furthermore, these losses can be exacerbated by adverse macroeconomic conditions, as shown by significant, albeit weak, negative coefficients for GDP, the unemployment rate, and recession dummy. Conversely, the CLIMractions of small banks under $50 billion in total assets exhibited a weak response to these same variables, further suggesting a lack of risk from their present climate-related holdings. The complete regression results are shown below in Table 2, including the model specifications, coefficients as well as t-values (italicized). As in the first regression, $CoreCapital_{it}$ represents the Tier-1 (Core) Capital of bank i at year t while $ln(\beta_1 CLIMRactions_{it})$ denotes the natural log of CLIMractions of bank i at year t. $\beta_2 CLIMRactions_{it}^2$ is the velocity of every additional CLIMraction on Tier-1 (Core) Capital of each bank i at year t, while $\sum_{j=1}^{j} \beta_3 FI_{it}$, $\sum_{j=1}^{j} \beta_4 IE_{it}$. $\sum_{j=1}^{j} \beta_5 PR_{it}$, and $\sum_{j=2}^{k} \beta_6 MC_{it}$ represent a multivariate vector containing additional independent variables classified as Financial Instruments, Income and Expenses, Performance and Conditions Ratios, and Macroeconomic Conditions, respectively. Finally, μ_{it} represents the idiosyncratic errors in both i and t not addressed by the model. Tier-One (Core) Capital is regressed on its own lag of one year, and one year lags for all independent variables except for macroeconomic conditions, which are lagged by two years since these are more long-term trends.

Insert Table 4 here.

Altogether, these regression analyses suggest transitional risks emanating from climate-related financial transactions are primarily concentrated among large banks with over $50 billion in total assets. In both regressions, CLIMractions amongst small banks under $50 billion in total assets did not appear to exert a statistically significant effect on Tier-One (Core) Capital. When controlling for fixed effects, and examining this relationship in the context of other institutional and macroeconomic variables, this suggests that CLIMractions require additional capital be held at-risk, or excluded from the liquid operating capital a bank maintains. This could be due to the nature of the industry or corporate clients themselves, whereby such capital takes longer to come

back to the bank in terms of profit. When examined in conjunction with the quantitative analyses covered within the previous section, this means transitional risks from climate-related financial transactions among small banks do not pose as serious of a threat to the stability of the greater financial services sector, nor to their own solvency as individual institutions. Using a simplified and realistic model, transitional climate risks were estimated to have an insignificant effect on small banks under $50 billion in total assets, with a risk factor which has generally remained stagnant over the past two decades. Therefore, holding small banks accountable to the same standards of stringency as large banks in terms of climate risk disclosures appears to have little merit from a supervisory standpoint given these substantial, size-based differences. These results further question the need for any standardized climate risk disclosures among small banks given the lack of significant, estimated risk to report.

Cost-Culpability Analysis:

The analyses clearly suggest a disparate distribution of transitional climate risks among banks which is heavily skewed in favor of larger institutions. Hence, if all banks were subjected to climate risk disclosures, some institutions might have little to report, or their activities, if any, might not be as consequential to broader supervisory objectives such as financial stability hence; the resources expended to comply with such policies might outweigh benefits from compliance itself, and vice versa. Given these uneven dynamics, the final analysis within this study focuses on the construction of a cost-culpability metric which provides some comparison between the costs encumbered by a bank when subject to climate risk disclosures, and their culpability from harboring actual risk. Such a metric could be valuable to regulators when determining whether certain institutions could be exempted from such requirements based on inherent preconditions which would lower their expected risk profile.

Studies have consistently demonstrated the presence of significant economies of scale in terms of regulatory compliance among banks based on their total asset size[19]. Larger institutions have more resources available to comply with new financial regulations, such as manpower and technology, as well as greater capital to facilitate additional investments within these areas in the name of regulatory compliance. Furthermore, as a bank acquires these resources, they face lower long-term costs via regulatory compliance because of efficiencies derived from their scale, such

[19] Mester, Loretta J. "Scale Economies in Banking and Financial Regulatory Reform." The Region 24, no. 3 (2010): 10-13.

as the ability to reassign many employees with the requisite technical skills or repurpose existing technologies which only require periodic maintenance. Small banks do not possess such luxuries due to their scale, and have been shown to face significantly higher compliance costs nearly three or four times that of their larger peers.

According to the Conference of State Bank Supervisors (CSBS), compliance expenses as a percentage of noninterest expenses were nearly 10 percent for the smallest banks, but just over 5 percent for the largest banks[20]. Similarly, a study by the Federal Reserve Bank of Minneapolis quantifying the impact of additional regulation on institutional profitability stratified by bank size found nearly 60 percent of institutions which would become unprofitable due to additional compliance expenditures were in the smallest peer group of banks studied, or those below $100 million in total assets[21]. Furthermore, according to analyses from the Baker Institute, while large banks over $10 billion in total assets devote more dollars to compliance expenditures, they still do not imbue much of an impact on their overall finances compared to institutions with under $10 billion in total assets, reflecting a major disadvantage to the latter[22].

The "cost" component of the cost-culpability ratio is derived from compliance cost data published in the CSBS study, which aggregated such metrics, directly reported by banks via an annual survey, amongst five peer groups ranging from those under $100 million in total assets and those between $1 billion and $10 billion in total assets[23]. Furthermore, they deconstruct this metric of compliance costs by various subcategories of expenditures, including personnel, data processing, accounting, consulting, and legal services, all reported by banks as a percentage of their non-interest income[24]. Using an elementary linear forecasting technique, compliance costs for each of these subgroups are estimated for larger banks in this study not covered by the CSBS analysis, averaged for each peer group. Finally, upon adjusting for inflation, multiplying these estimates by the total dollar amount of compliance costs in 2021, and dividing the value for each peer group by the total compliance costs spent by all banks, the ratio numerator, or peer group's share of total compliance costs, is created.

[20] Dahl, Drew, Jim Fuchs, Andrew Meyer, and Michelle Neely. "Compliance Costs, Economies of Scale and Compliance Performance: Evidence from a Survey of Community Banks." Federal Reserve Bank of St. Louis, April (2018).
[21] Feldman, Ron, Ken Heinecke, and Jason Schmidt. "Quantifying the Costs of Additional Regulation on Community Banks." Economic Policy Paper 13, no. 3 (2013).
[22] Hogan, Thomas L., and Scott Burns. "Has Dodd–Frank Affected Bank Expenses?." Journal of Regulatory Economics 55, no. 2 (2019): 214-236.
[23] Dahl, Drew, Jim Fuchs, Andrew Meyer, and Michelle Neely. "Compliance Costs, Economies of Scale and Compliance Performance: Evidence from a Survey of Community Banks." Federal Reserve Bank of St. Louis, April (2018).
[24] Ibid.

The "culpability" metric of the cost-culpability ratio follows a similar structure however, since these values are derived from the CLIMraction betas calculated in the previous section, their construction is arguably simpler. The annual peer group betas graphed within Figure 4 were multiplied by annual Tier-One (Core) Capital for each bank within the dataset, thus providing an estimate of total institutional capital at-risk. As with the cost metrics, after adjusting for inflation, aggregating capital at-risk per peer group, and dividing these values by the total capital at-risk among all banks, the ratio denominator, or peer group's share of transitional climate risk to the banking industry at-large, is created. The cost-culpability ratio provides an estimate of whether the costs of compliance with climate risk disclosures are matched or surpassed by the benefits of transitional climate risk reported. A ratio below 1 suggests compliance costs are superseded by the benefits of climate risk disclosures whereas a ratio below 1 suggests compliance costs are not exceeded by the benefits of climate risk disclosures. To estimate the "disparity" or inequality between cost and culpability, a percent change value is calculated using the ratio and 1, which would symbolizes a perfectly equitable relationship.

According to the results shown in Figure 5 below, climate risk disclosures amongst small banks under $10 billion in total assets would likely not have much value for financial regulators, but would be financially demanding for these institutions given their share of overall compliance costs. Conversely, climate risk disclosures amongst large banks over $10 billion would be much more valuable to financial regulators, with the benefits exceeding compliance costs facing these individual institutions. The difference in average disparity between institutions under $1 billion that would incur more individual costs than provide collective benefit, and those institutions over $100 billion that would provide more collective benefit than incur more individual costs, came to nearly 50 percent. Hence, this analysis demonstrates value in restricting climate risk disclosures to the largest banks, thus saving small banks from an unnecessary financial hassle.

Insert Figure 5 here.

Given these results, two final analyses are performed to gauge the potential efficacy of an exemption from climate risk disclosures for banks under $50 billion in total assets. According to the left chart in Figure 6, financial regulators would still maintain access to over 70 percent of all CLIMraction dollars through climate risk disclosures. This means that financial regulators would

be able to have a highly sufficient understanding of which banks are financing which companies, as well as the total amount of dollars subject to potential climate-related risk. Furthermore, as per the right chart in Figure 6, these dollars would consistently account for nearly 85 percent of total transitional climate risk among individual banks. This means the exclusion of small banks from climate risk disclosures would not jeopardize broader financial stability goals as they pertain to institutional climate risk. Together, these charts indicate that small banks can be excluded from mandatory climate risk disclosures, while enabling financial regulators to capture the majority of individual, and collective risk from the larger banks still subject to these requirements.

Insert Figure 6 here.

Limitations:

The analyses performed within this study provide reliable empirical evidence to suggest transitional climate risk is unevenly distributed amongst banks of different sizes therefore, the utility derived from climate risk disclosures would vary depending upon the reporting institution. However, there are some limitations which should be acknowledged, and could provide the basis for additional research in this field. First, the LPC DealScan dataset is constructed using data that is voluntarily submitted by banks, many of which are driven by the incentive to publicly promote their footprint to appear attractive to investors. While this dataset consistently covered about 60 percent of all U.S. banks[25], it excluded many smaller institutions which would not have such a motivation given their local focus. This is a major limitation within many similar studies which analyze climate-related financial transactions by banks – since there is no mandatory system by which all institutions are required to report such holdings, researchers must estimate, or depend upon voluntary data, to estimate the prevalence of risk or benefits of climate risk disclosures. In addition, while the analysis was able to capture nearly 80 to 90 percent of banks in the larger peer groups, this percentage declined considerably to only capturing about 40 percent of banks in the smaller institutions, even if all peer groups had a roughly similar amount of observations[26].

[25] "FDIC Consolidated Reports of Condition and Income" 2000 - 2021
[26] Ibid.

A similar limitation arises within the coverage of corporate clients in carbon-intensive industries. Since many small banks do not have a similar motivation as their larger counterparts to voluntarily submit corporate lending data, this analysis might also inadvertently overlook the relationships between small banks and small corporate clients in climate-intensive industries. In addition, this could particularly distort the estimates of inherent transitional climate risks to small banks whose portfolios are heavily dependent upon these smaller corporate clients. This is also a difficult issue to address, as these borrowers are often overlooked because their carbon footprint is much lower compared to multinational corporations[27]. A third limitation not pertaining to the raw dataset can be found within the cost-culpability ratio itself. The culpability denominator is predicated upon comparing the transitional climate risk of the individual bank compared to that of all other institutions in the banking industry that, as previously explained, may insufficiently address whether small banks possess inherent risks from their climate-related holdings, even if they might not pose a threat to the broader banking industry. This issue requires some ingenuity, which is why this study employed several regressions to examine the inherent risk of transitional climate risk to banks, and other studies have used similar methods to confirm this relationship.

Conclusion:

While a controversial matter of public policy, climate change has exhibited few signs of receding as a global issue with immense political, economic, and social ramifications. Financial institutions have emerged as critical players within this debate, given their status as propagators of climate change through financing corporate clients with a significant environmental footprint, as well as potential champions to its resolution by revisiting their financial relationships through a lense of broader, social responsibility. These dynamics have popularized the concept of climate risk disclosures, which would require that financial institutions report all such holdings to their prudential regulators, yet existing proposals exhibit little regard, or even acknowledgment, of the uneven distribution of climate risk, as well as the consequent costs and utility to be obtained if such requirements were applied equally to all firms.

[27] Berners-Lee, M., Howard, D.C., Moss, J., Kaivanto, K. and Scott, W.A., 2011. Greenhouse Gas Footprinting for Small Businesses—The use of input–output data. Science of the Total Environment, 409(5), pp.883-891.

This study attempted to determine whether climate risk disclosures could be enacted with some exemptions predicated upon the propensity of certain institutions to have a disproportionate lack of exposure to transitional climate risk, both as individual institutions, and in relation to the broader banking industry at-large. This study determined small banks under $50 billion in total assets have significantly decreased their financial relationships with corporate clients in carbon-intensive industries, while such holdings which remain in their portfolios pose insufficient risk to their capitalization and solvency. Furthermore, it estimated regulators could still capture over 70 percent of all dollars devoted to financial transactions with corporate clients in carbon-intensive industries, as well as nearly 85 percent of total transitional climate risk, if they were to create an exemption for banks with under $50 billion in total assets.

Minimizing burdens while maximizing benefits is a core tenant in financial regulation, as well as public rulemaking in general. This principle has not been acknowledged within ongoing discussions of climate risk disclosures, stemming from a lack of data, especially for small banks whose local focus reduces their need to provide such details, as well as a general focus among policymakers, researchers, and other experts towards the largest banks as well as their corporate clients which often account for the lion's share of the global environmental footprint. While this study is one of the first to tackle the question of climate risk disclosures as they pertain to small financial institutions, it cannot be the last, especially as financial regulators proceed to develop a framework and adopt a final rule. By ensuring financial institutions with the greatest culpability incur the greatest costs, climate risk disclosures can be a critical tool in the fight against climate change, while engendering nominal disruption to the broader ecosystem of financial services.

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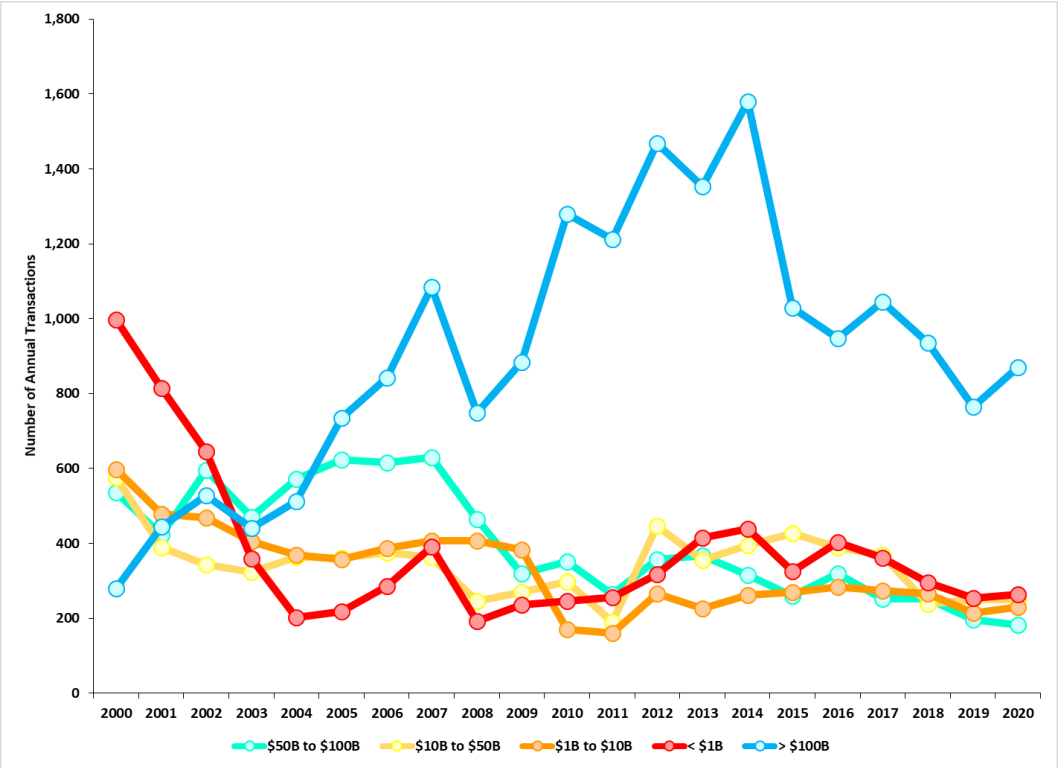
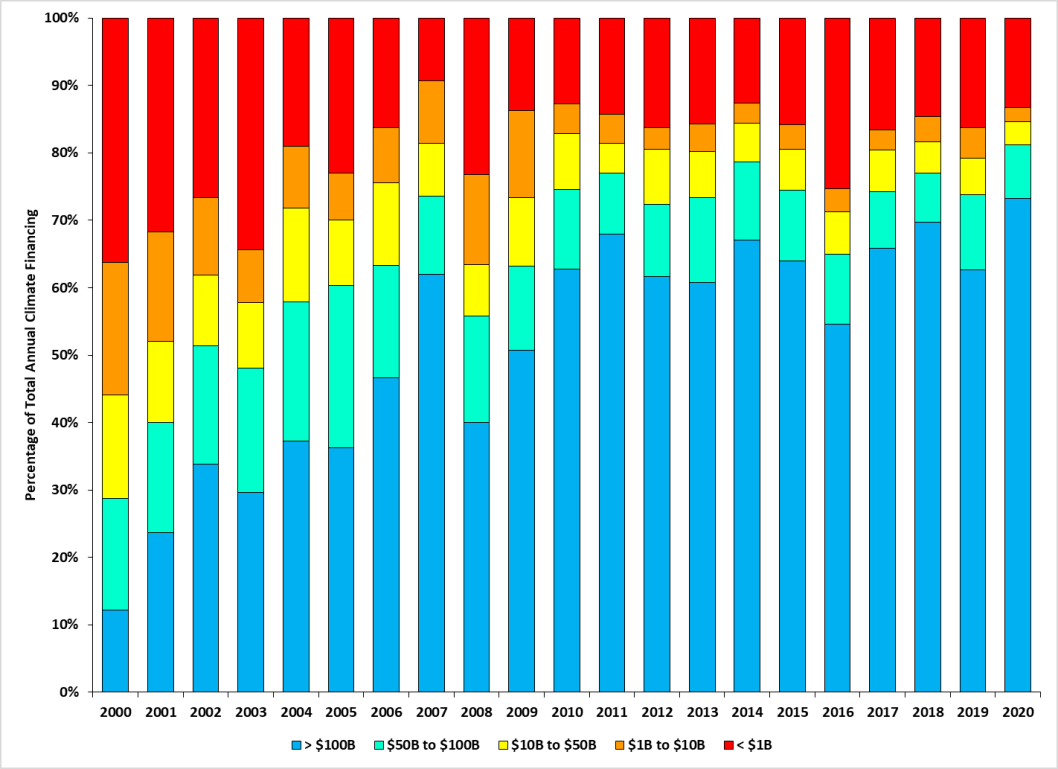
Appendix

Figure 1: Number of Annual Financial Transactions with Corporate Clients in Carbon-Intensive Industries by Bank Peer Group



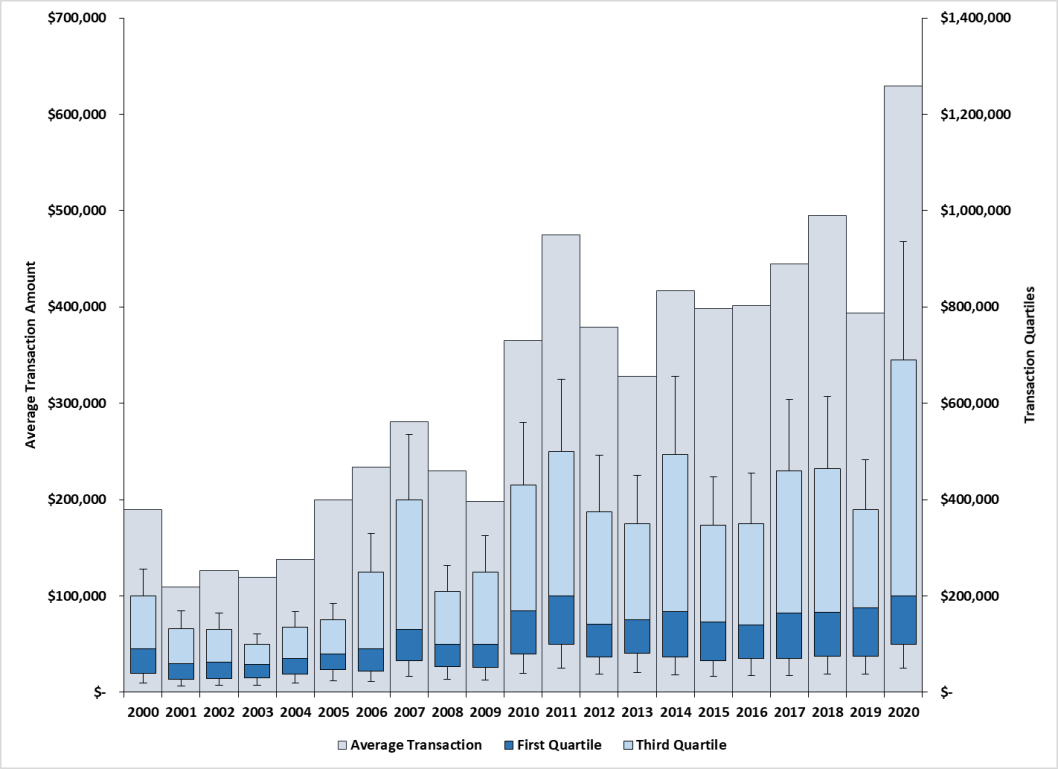
Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation

Figure 2: Percentage of Climate-Related Financial Transactions with Corporate Clients in Carbon-Intensive Industries by Bank Peer Group



Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation

Figure 3: Annual Financial Transaction Costs when Servicing Corporate Clients within Carbon-Intensive Industries



Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation

Table 1: Simple Model Variable Descriptions

Type	Variable	Source	Description
Dependent Variable	Tier-One (Core) Capital	FDIC	Common equity plus noncumulative perpetual preferred stock and minority interests in consolidated subsidiaries less goodwill as well as other intangible assets. Logarithmically transformed.
Independent Variables	CLIMractions	LPC DealScan	Total value of climate-related transactions per year by bank. Logarithmically transformed.
	Assets	FDIC	Sum of all assets owned by the institution including cash, loans, securities, bank premises and other assets. Logarithmically transformed.
	Liabilities	FDIC	Deposits and other borrowings, subordinated notes and debentures, limited-life preferred stock and related surplus, trading account liabilities and mortgage indebtedness. Logarithmically transformed.

Table 2: Impact of CLIMractions on Bank Tier-One (Core) Capital - Simple Model

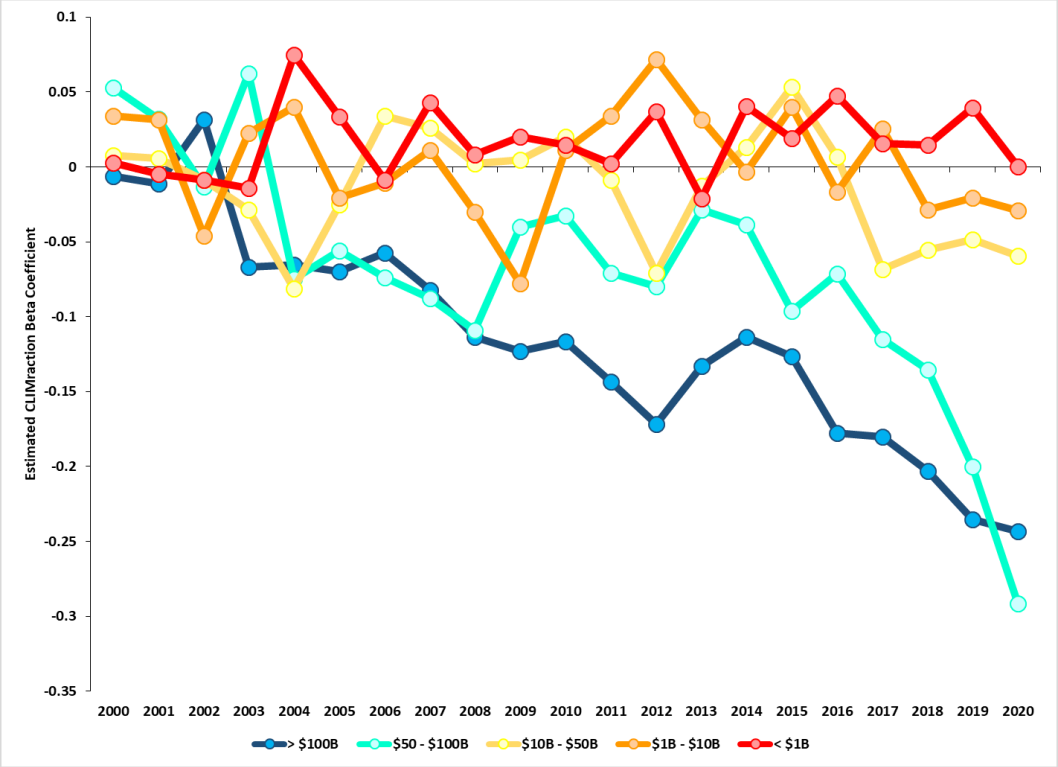
$$CoreCapital_{it} = \alpha + ln(\beta_1 CLIMRactions_{it}) + ln(\beta_2 Assets_{it}) + ln(\beta_3 Liabilities_{it}) + \mu_{it}$$

	> $100B	**$50B - $100B**	**$10B - $50B**	**$1B - $10B**	**< $1B**
Log Assets	0.148*** 0.034	0.124*** 0.018	0.150*** 0.030	0.097*** 0.025	0.227*** 0.032
Log Liabilities	0.723*** 0.030	0.592*** 0.059	0.923*** 0.020	0.878*** 0.020	0.718*** 0.031
Log CLIMractions	-0.001*** 0.011	-0.001*** 0.016	-0.009 0.008	0.011 0.007	0.010 0.007
# of Observations	254	187	690	925	772
R-Squared	0.9425	0.9348	0.8319	0.8301	0.8702
Adjusted R-Squared	0.9365	0.9211	0.8258	0.8256	0.8679
Time FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes

* = 90% Confidence
** = 95% Confidence
*** = 99% Confidence

Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation

Figure 4: Evolution of CLIMraction Beta Coefficients from 2000 to 2020 by Bank Peer Group



Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation

Table 3: Complex Model Variable Descriptions

Type	Variable	Source	Description
Dependent Variable	Tier-One (Core) Capital	FDIC	Common equity plus noncumulative perpetual preferred stock and minority interests in consolidated subsidiaries less goodwill as well as other intangible assets. Logarithmically transformed.
CLIMractions	CLIMractions	LPC DealScan	Total value of climate-related transactions per year by bank. Logarithmically transformed.
	CLIMractions^2	LPC DealScan	Total value of climate-related transactions per year by bank squared. Logarithmically transformed.
Financial Instruments	Total Securities	FDIC	The sum of held-to-maturity securities at amortized cost, available-for-sale debt securities and equity securities. Logarithmically transformed.
	Net Loans & Leases	FDIC	Total loans and lease financing receivables minus unearned income and loan loss allowances. Logarithmically transformed.
	Total Deposits	FDIC	The sum of all deposits including demand deposits, money market deposits, other savings deposits, time deposits and deposits in foreign offices. Logarithmically transformed.
Income & Expenses	Total Interest Income	FDIC	Sum of income on loans and leases, plus investment income, interest on interest bearing bank balances, interest on federal funds sold and interest on trading account assets. Logarithmically transformed.
	Total Interest Expense	FDIC	Total interest expenses. Logarithmically transformed.
	Total Noninterest Income	FDIC	Income from fiduciary activities, service charges on deposit accounts in domestic offices, trading gains and fees from foreign exchange transactions, other foreign transaction gains, and fees from trading assets and liabilities. Logarithmically transformed.
	Total Noninterest Expense	FDIC	Salaries and employee benefits, expenses of premises and fixed assets, and other noninterest expenses. Logarithmically transformed.
	Additional Noninterest Income	FDIC	Includes: Investment banking, advisory, brokerage, and underwriting; venture capital revenue; net Servicing fees; net securitization income; insurance commission fees and income; net gains on loan sales; as well as net gains on real estate. Logarithmically transformed.
Performance & Condition Ratios	Return on Assets (ROA)	FDIC	Net income after taxes and extraordinary items as a percent of average total assets. Cubically transformed.
	Return on Equity (ROE)	FDIC	Annualized bank net income as a percent of average total equity on a consolidated basis. Cubically transformed.
Macroeconomic Indicators	Gross Domestic Product (GDP)	FRB St. Louis/BEA	Gross domestic product (GDP), the featured measure of U.S. output, is the market value of the goods and services produced by labor and property located in the United States. Logarithmically transformed.
	Consumer Price Index (CPI)	FRB St. Louis/OECD	CPI is a measure of the average monthly change in the price for goods and services paid by urban consumers between any two time periods.
	Unemployment Rate	FRB St. Louis/BLS	The unemployment rate represents the number of unemployed as a percentage of the labor force. Logarithmically transformed.
	Recession Dummy	FRB St. Louis/NBER	Dummy variable identifying quarters during which a recession took place according to assessment by the NBER.

Table 4: Impact of CLIMractions on Bank Tier-One (Core) Capital - Complex Model

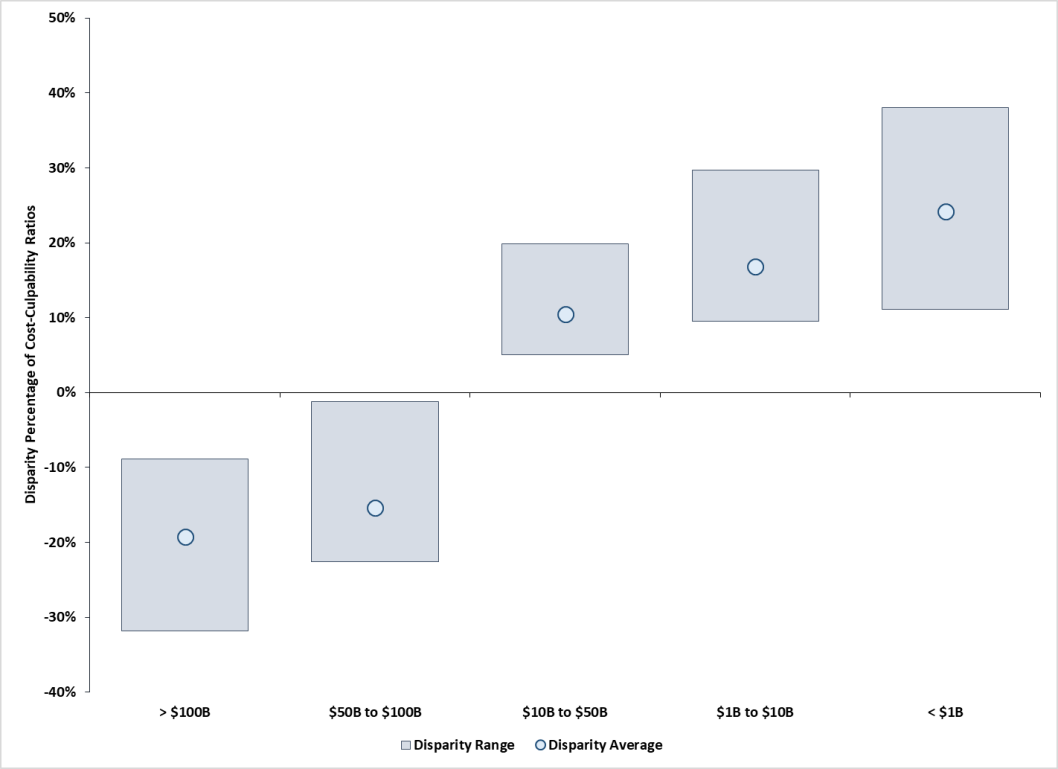
$$CoreCapital_{it} = \alpha + ln(\beta_1 CLIMRactions_{it}) + ln(\beta_2 CLIMRactions_{it}^2) + \sum_{j=1}^{j} \beta_3 FI_{it} + \sum_{j=1}^{j} \beta_4 IE_{it} + \sum_{j=1}^{j} \beta_5 PR_{it} + \sum_{j=2}^{k} \beta_6 MC_{it} + \mu_{it}$$

	> **$100B**	**$50B - $100B**	**$10B - $50B**	**$1B - $10B**	< **$1B**
Climate Assets					
Log CLIMractions	-0.0102*** -4.987	-0.0195*** -5.793	-0.0155* -3.923	-0.0191 -0.058	-0.0286 -0.0823
Log CLIMractions²	-0.0090*** 3.434	-0.0081*** 3.372	-0.0036 -1.338	-0.0270 -0.259	0.0547 0.321
Financial Instruments					
Deposits	0.0108 0.354	-0.1185*** -7.197	0.0366*** 2.712	-0.1022*** -3.415	0.2984*** 3.267
Net Loans & Leases	-0.0611*** -5.570	-0.0255*** -4.136	0.0028 0.349	0.0046 0.167	-0.3647*** -4.068
Securities	0.0145*** 3.538	0.0230*** 9.253	0.0030 0.570	0.0470*** 4.201	-0.0268 -1.356
Income & Expenses					
Total Interest Income	0.0730*** 3.791	0.0771*** 7.108	-0.0768*** -4.425	-0.0183 -0.375	-0.0023 -0.023
Total Interest Expenses	-0.3016** -2.543	-0.5112*** -7.956	-0.1646* -1.745	-0.5227** -2.153	-1.2177*** -2.952
Total Noninterest Income	0.0393*** 3.801	0.0332*** 5.615	-0.0321** -2.568	0.1175*** 3.698	0.2401*** 3.301
Total Noninterest Expenses	-0.0892*** -2.951	-0.0274* -1.737	0.1673*** 5.426	-0.2185** 2.364	-0.4475*** -3.010
Performance Ratios					
Return on Assets (ROA)	0.0017 1.091	0.0040 1.617	0.0329*** 5.069	-0.0225 -0.944	-0.1044* -1.813
Return on Equity (ROE)	0.0000 0.064	0.0001 1.576	-0.0001 -0.546	-0.0001 -1.377	0.0092 1.235
Macroeconomic Conditions					
Gross Domestic Product (GDP)	0.0020*** -0.200	0.0106** -2.062	-0.0243*** -2.586	-0.0396** -1.254	-0.0644* -1.284
Core Consumer Price Index (CPI)	-0.0000* -0.438	-0.0000* -1.707	-0.0000 -1.243	0.0000 0.398	-0.0000 -0.453
Unemployment Rate	-0.0006*** 1.146	-0.0006** 2.137	-0.0007 -1.489	-0.0014 -0.905	-0.0027 -1.074
Recession	-0.0870*** -2.963	-0.1578*** -9.119	-0.1585*** -4.348	-0.1016** -0.859	-0.0285** -0.147
Observations	254	187	690	925	772
R-Squared	0.892	0.871	0.909	0.835	0.837
Adjusted R-Squared	0.882	0.869	0.894	0.819	0.807

* = 90% Confidence
** = 95% Confidence
*** = 99% Confidence

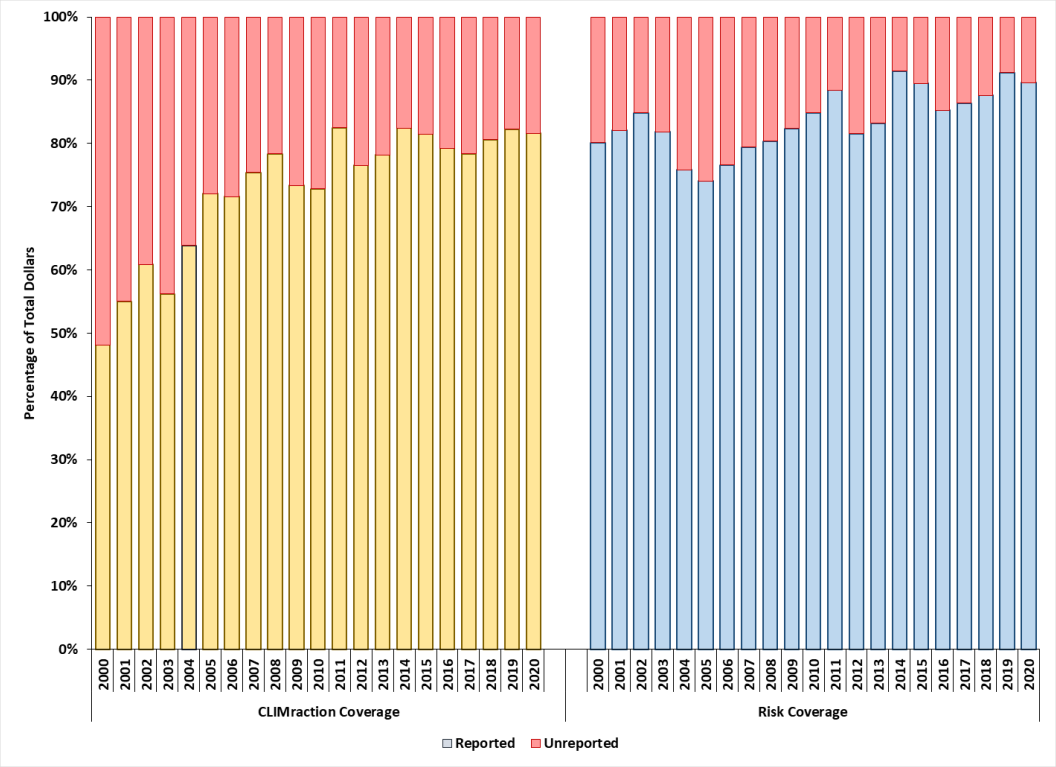
Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation, Federal Reserve Bank of St. Louis, U.S. Bureau of Labor Statistics, Bureau of Economic Analysis, Organisation for Economic Co-operation and Development, National Bureau of Economic Research

Figure 5: Disparity in Cost of Compliance with Climate Risk Disclosures and Culpability via Transitional Climate Risk by Bank Peer Group



Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation, Conference of State Bank Supervisors

Figure 6: Estimated Coverage of Financial Transactions with Corporate Clients in Carbon-Intensive Industries, and Consequent Transitional Climate Risk if Banks Under $50 Billion in Assets were Exempt from Providing Climate Risk Disclosures



Sources: Thompson/Reuters, Wharton Research and Data Services, Federal Deposit Insurance Corporation, Conference of State Bank Supervisors