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THE ECONOMICS OF NET ZERO BANKING

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The Economics of Net Zero Banking

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Abstract

Banks have voluntarily committed to align their lending portfolios with a net zero path toward a decarbonized economy. In this review, we explore the economic channels for why portfolio decarbonization might be consistent with lender profit maximization. We frame the question by positing that net zero lending may create differential value through the channels of risk and returns, where return topics span profit margins and lending book growth arguments. We then use the lens of the frame to survey the literature and speak to gaps in research knowledge. We uncover multiple roles for risk arguments influencing decarbonization. Moreover, decarbonization and green investment are tied to enhanced profitability through bank lending growth. Yet, the literature has many dots yet to connect. We suggest that future work may draw further connections between the literature in climate finance and the broader literature in banking, to enhance our understanding of the role that banks will play in the net zero transition.

1 Introduction

As of 2024, banks representing $74 trillion or 41% of global banking assets have voluntarily made net zero commitments to decarbonize their lending portfolios over time (Figure 1). A natural question is why banks would choose to take such a step – especially when banks have large lending portfolios to clients within the carbon-producing segments of the economy for a good reason. Clients in these segments often are fixed asset intensive, with cash flow and cash buffer properties that make them attractive for bank lending (Gilje, Elena, and Murphy (2020)). By contrast, potential clients in the new decarbonizing economy might be seen as riskier, with growth orientations rather than stability properties (Sautner, van Lent, Vilkov, and Zhang (2023), Sautner, Van Lent, Vilkov, and Zhang (2023)). Furthermore, the business model of banks relies on relationships forged over years and sometimes generations (Sharpe (1990),von Thadden (2004), Petersen and Rajan (1994), Berger (1995), Boot (2000), Bolton, Freixas, Gambacorta, and Mistrulli (2016)). Why would a bank voluntarily take steps that turns away from its existing lending portfolio toward one with a net zero stance?

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Our goal is to make progress on uncovering the economics of net zero banking, to understand bank motives against the above backdrop. The importance of delving into the economics of net zero for banks stems from what seems to be a surprise in both the literature and popular perceptions. The evidence points to net zero banking not being grounded in the notion of divestment. For example, Sastry, Verner, and Marquez-Ibanes (2024), Giannetti, Jasova, Loumioti, and Mendicino (2023) and Martini, Sautner, Steffen, and Theunisz (2024) find evidence that banks do not divest from high emissions firms as a reaction to net zero commitments, environmental disclosures or increased transition risk. These results from the literature translate into popular discourse around such commitments. Taking this early evidence at face value, what then does it mean for a bank to make a net zero commitment if it does not divest? The literature has focused on answering why banks would consider taking the step of moving away from carbon-heavy exposures in their lending. Rather than focusing on these questions, our objective is to put a new, broader orientation in understanding the economics of bank lending in a time of transitions, and how bank strategies and heterogeneities play into the economics of banking in a net zero economy.

We start by defining the meaning of our title, in essence defining the scope of our work. The phrase "Net Zero" in general use refers to a global emissions trajectory that limits warming to 1.5 degrees Celsius. To do so requires that the economy reach net zero by 2050, when every ton of carbon emitted is counterbalanced by carbon removal. A net zero commitment by a bank is to then adjust the emissions content of its portfolio over time to be in line with the required pathway for the global economy to meet net zero. To make their net zero commitments concrete, banks often specify a target reduction in the share of the lending portfolio used to finance carbon emissions-intensive activities ("financed emissions targets"). Banks even set different portfolio emission-reduction targets for different sectors, differentiating between oil and gas and real estate, for example. These targets can vary across banks, with some banks targetting oil and gas, and others target transport.In addition, they often also set targets to increase their financing of clean energy investments (sometimes called "sustainable finance targets").[1] The use of this term began in earnest in 2021 at the launch of the Glasgow Financial Alliance for Net Zero (GFANZ), led by Mark Carney, UN Special Envoy on Climate Action and president of Cop 26 at the time. The GFANZ alliance spans a number of different institution-types, with a banking-specific alliance referred to as the Net Zero Banking Alliance.[2] Banks making a net zero commitment are committing to aligning their portfolio allocation to be in line with a net zero trajectory.

The other part of our title is "The Economics of". Our goal is to delve into bank decision-making on the economics of their portfolio. We take the vantage that banks' net zero lending commitments emerge as an endogenous choice of the bank. Importantly, this means that bank commitments did not result from being compelled to do so by *governments*. There may be some contexts where this assumption is less valid, such as in Europe and a few other countries, where regulation (or threats of regulation) could force a net zero agenda. We also assume that banks' actions reflect an economic profit-maximizing model, rather than a model of nonpecuniary preferences or societal concerns for

[1]We note that net zero commitments are often more specific than prior commitments or alliances made by banks in the past– such statements were often broader and vaguer, and included pledges to incorporate "climate considerations" or broader environmental attributes when making lending decisions.

[2]There are now other alliances through which banks can make a net zero commitment, the main alternative to NZBA being the Science-Based Targets Initiative.

climate change being part of the banks utility function. Again, to the extent that banks do have such nonpecuniary preferences or prosocial considerations, they would serve to amplify the points that we make here (Barber, Morse, and Yasuda (2021), Kacperczyk and Peydro (2024), Oehmke and Opp (2024)). However, the focus of the review is to think about what the literature implies about the situations in which making a net zero commitment could be an *optimizing* strategy for lenders.

Another important point is that net zero commitments made by banks were not intended to evoke banks' incorporation of climate risk with regards to safety and soundness regulations. Indeed, bank risk management departments tend to be organizationally somewhat remote from the bank strategy teams making net zero commitments. Yet, remoteness is too strong a notion. The possibility of safety and soundness regulations regarding climate exposures in bank portfolios may motivate banks to adjust lending toward decarbonized portfolios, in order to manage future costs (See Jung, Santos, and Seltzer (2022) and Acharya, Berner, Engle, Jung, Stroebel, Zeng, and Zhao (2023) for a discussion of net zero and safety and soundness concerns.). Thus, we consider safety and soundness only in this capacity.

We organize our analysis of the literature around a simple value function framework of a bank's lending portfolio (subsection 2.1). We posit two key sources of value which may lead banks to endogenously choose loans which are favorable from a net zero standpoint: (1) default risk or (2) returns on lending for a given risk. In the first part of this review, we discuss recent progress on why the economics of risk may favor net zero lending, and how this may depend on the characteristics of the investment as well as the class of banks which are providing credit (subsection 2.2). Investing in decarbonization technologies is likely costly, and perhaps also risky, with borrowing firms being financially constrained and requiring external finance. Some banks may be better positioned to bear such risks.

In the second part of this review, we consider profitability motivations that do not directly pertain to risk management that may incentivize considering net zero properties of a project or firm investment (subsection 2.3). Given the potentially large financing needs of firms investing in net zero technologies, there could be important profit opportunities and growth opportunities for banks.

We conclude the review covering three additional banking net zero overlay topics, albeit in an abridged fashion (section 3). The three topics add to the motivation of banks to take net zero actions, and are thus an important linkage to consider in the overall economics. First, we consider decarbonized portfolios as a strategy for regulatory preparedness or anticipation of future policy change. Second, we highlight some recent evidence on bank's reaction functions to physical damage risk from climate weather hazards. Finally, we mention the literature as to depositor reactions to bank negative press events, to seek to understand the extent to which depository channels may be at play in net zero commitments.

In surveying the vast evidence on risk and return properties of green and brown bank finance, we laud that literature is growing as a rapid pace, but emphasize that many core aspects of risk and returns of net zero loans have yet to be studied. We outline a number of sources of heterogeneity and interaction effects that may make it important to study these questions at a borrower-bank level. In doing so, we survey and draw from a rich literature in banking that goes beyond the

energy transition, that highlights a number of key aspects that provide a lens for thinking about the economics of net zero commitments. In particular, we highlight the importance of specialization, relationship banking, scale, and market power. Such features make banking quite different from other financial intermediaries that are often studied in the climate finance literature, such as asset managers, and we argue present many opportunities for future research.

2 The Economics of Net Zero Directly in the Lending Portfolio

2.1 A Framework

To organize our thoughts, we consider bank decisions using a simple value function based exclusively on the bank's lending portfolio. We consider the financing side activities of a bank in three dimensions – commercial lending (CL), real estate (RE), and investment banking (IB). IB encompasses the lending side of investment banking, i.e., structured debt for private equity leverage, M&A finance, infrastructure finance, corporate project finance, and real asset finance.[3] We abstract from bank revenues from depository services, asset management services, and other services because of the objective herein to focus on net zero bank lending.

We assume that banks plow back all profits from lending, building a bigger stock of lending assets over time, following:

$$L_{i,t+1} = L_{it} \sum_{d \in \{CL,IB,RE\}} \left[s_{it}^{d} \times \pi\left(\rho_{it}^{d}, m_{it}^{d}\right) \right]. \tag{1}$$

Bank i creates value by lending bank assets $L_{it}s_{it}^{d}$ in each division $d \in \{$ *CL, RE, IB*$\}$, where s_{it}^{d} is the share of the lending portfolio deployed in the division, and L_{it} is the firm total lending assets. We think of s_{it}^{d} as largely a function of legacies, although current efforts and current M&A activity could impact these shares.

These lending assets perform according to an expected return function π. The return on a lending portfolio is a function of ρ_{it}^{d}, the default probability, and m_{it}^{d}, other attributes of profitability or growth from the current year set of lending. These attributes include pricing mechanisms (market power or scale/cost efficiencies) and lending volume growth mechanisms (specialization, follow-on growth opportunities). Default and return attributes reflect both legacy characteristics and current bank efforts.

The firm's objective is to maximize firm value as recursive value function of returns on lending assets turned into future lending assets:

$$\underset{s_{i1}^{\cdot},\rho_{i1}^{\cdot},m_{i1}^{\cdot}}{V_{i1}} = L_{i0}\left(-1 + \sum_{d \in CL,IB,RE} \left[s_{i1}^{d} \times \pi\left(\rho_{i1}^{d}, m_{i1}^{d}\right) \right] \right) + \underset{s_{i2}^{\cdot},\rho_{i2}^{\cdot},m_{i2}^{\cdot} | s_{i1}^{\cdot},\rho_{i1}^{\cdot},m_{i1}^{\cdot}}{\arg\max} \beta V_{i2}. \tag{2}$$

We use this framework to explore dimensions of how the economics of net zero banking could enter bank valuation. In particular, we present evidence of the effect of decarbonizing lending portfolio

[3] We are going to focus on lending assets, but we can embed revenues from transaction fees in investment banking transaction services and the deployment of assets being the deployment of human capital toward IB activities.

on bank valuation through channels of (i) default probabilities ρ and (ii) return attributes m, which can be further broken down into two components: profitability from enhanced pricing and lending growth.

We consider how these channels of bank valuation interact with other known features of banking, including but not limited to: specialization, relationship banking, and competition. In going through these channels, we will highlight existing work on how the channel interacts with these features of banking, as well as point out gaps in the literature which could be important for future research.

Before delving into the literature, it is important to put a caveat on our understanding of any single bank's positioning toward net zero lending. A challenge deserving a special mention is the possibility that net zero commitments are a form of greenwashing. In settings without regulation (subsection 3.1), lender net zero commitments and public statements are voluntary. Some researchers and many advocates in the public domain may deem net zero statements by banks to be cheap talk, because of opacity and limited accountability mechanisms (Crawford and Sobel (1982)). In this vein, Giannetti et al. (2023) find that banks with more public-facing discussion of the environment also lend more to polluting sectors, suggesting that banks' communication of net zero activities may not match their confidential lending activities. [4] Additionally, Sastry et al. (2024) find that banks with a net zero commitment have similar lending behavior to those without one.

Yet, some may view the word greenwashing to be too strong in this setting. A key challenge which identifying greenwashing is that, in the short run, it may be indistinguishable with financing transition investments made by polluting firms that only pay off or lower emissions over the long-term. That means that such financing may not show up in year-over-year emissions improvements. This mechanism aligns more with stewardship and lending to overcome frictions, such as short-termism to long term value opportunities, as in Blickle, Morse, and Sastry (2024). In addition, as we lay out in the coming pages, banks have differing relative positioning, where the economics of net zero lending give them comparative advantages. These comparative advantages may not be similar across banks. In these frames, a question then is whether there may be a divergence between which lenders choose to publicly signal a net zero commitment and which lenders have genuine comparative advantages in identifying profitable net zero opportunities. This use of the net zero language may, reasonably, not be sufficient for net zero advocates, but is a more nuanced depiction of banks serving a net zero agenda. In either case, an easy interpretation of the setting is that space exists for improvements in data, both in short-term emissions reductions and in long-term decarbonizing investment, so that researchers can better measure lender net zero action.

2.2 Default Risk

The first mechanism in our framework is risk. Banks may choose to strive toward net zero in lending because of the economics of risk. We can understand bank incorporation of decarbonzing

[4] Similarly, in corporate domains, Aldy, Bolton, Halem, Kacperczyk, and Orszag (2023) find a significant increase in climate public dialogue across corporate communications, but that this seldom is associated with real emissions reductions. Likewise, Darendeli, Law, and Shen (2022) develop a measure of green investment in human capital, and show that it has a limited relationship to rating agency environmental scores of firms.

("green") and carbon-intensive ("brown") risk in terms of two mechanisms – interest rate pricing and rationing. Rationing reflects the bank practice of rationing lending when risk gets above a hurdle rate. This rationing can happen because of reasons of payments-induced distress, adverse selection, and moral hazard. Rationing may also happen because of reasons of compliance with current or future safety and soundness or capital regulations, a point to which we return later.

In this subsection, we provide a brief survey of the nascent but developing literate on the risks in green and brown lending. We start with a bit of nomenclature and thoughts on the literature development.

A phrase often used is "transition risk". Transition risk in our specific context is the risk to lending portfolios because clients face costs from the transition to a clean energy economy (Krueger, Sautner, and Starks (2020)). These costs of the transition, which include policy effects, consumer sentiment, weather shocks, shifting supply lines, stranded assets, and others, can cause client firm distress, leading to default. Yet, the underlying tensions of net zero lending may pull risk assessment in opposing directions for banks. On the one hand, bank clients' exposure to stranded assets, green regulations, and carbon-emitting sectors may mean greater risk for bank lending portfolios. On the other hand, newer, more innovative technologies of the decarbonizing economy may be reflective of more unproven technologies and therefore implying higher risk profiles. We see this tension being played out in research, with more research needed to bring these pictures together through mechanisms potentially identifiable in microdata (see, for example, Kim, Olson, and Phan (2023)).

As the literature develops, more work on dynamics may be important. For example, the dynamics of profitability and innovation may play out in a way that makes ascribing risk properties as being unstable over time. That is, it is possible that transition can be very risky in the short-run and have lower risk in the long run (Kumar and Purnanandam (2023)). In this vein, Bellon, LaPoint, Mazzola, and Xu (2024) show that a federal program to promote decarbonization in real estate (PACE) did lead to increased delinquency of mortgages in the short-term on such loans, but led to a long-term improvement in the resiliency of the housing stock, which was subsequently positively capitalized into house prices. To the extent that lower carbon alternatives continue to be developed and adopted over time, we expect further research to shed light on how these business models and inherent risks may differ and evolve over time.

Finally, we have found little research on the role of divisional risk across banks. In our framework, we intentionally draw attention to the possibility that the implementations and heterogeneities of net zero lending across banks reflect legacy comparative advantages and efforts in divisional focus. Some banks may have a greater share of their portfolio in real estate, which may focus on real-estate related net zero opportunities. Other banks might specialize in investment banking and structured debt activity. In such cases, these banks may be exposed to risks from the green economy in innovation, but may have volume incentives from expanding lending opportunities in the transition economy. This subject is taken up by Blickle et al. (2024), but this may just be the tip of the iceberg on this topic.

2.2.1 Pricing Risk and Cost of Capital Studies

Evidence regarding the pricing of banks' total transition risk typically starts with measuring the carbon intensity of borrowers receiving bank financing, and then considers how banks price those exposures (Sautner et al. (2023), Jung et al. (2022)). The question being asked is: what is the transition risk exposure of portfolio firms, and how do banks price those risks or otherwise manage them? In this vein, Delis, Greiff, Iosifidi, and Ongena (2024) gather new data on corporate fossil fuel reserves and study the pricing of stranded asset risk in syndicated loans. They find that banks price added climate risk in the loan rate charged to their client fossil fuel firms. Martini et al. (2024) find that bank equity returns are related to the returns of a stranded asset index, reflecting the extent to the banks' exposure to their clients' transition risk.

Much evidence on carbon emissions as priced risk comes from papers taking the vantage of a firm, the flip-side of the bank risk. Looking at the firm side, Gormsen, Huber, and Oh (2024) find that green firms have an estimated 1 percentage point lower *perceived* cost of debt finance than brown firms. However, this result is time dependent, with the green firm cost of capital becoming negative only after the 2015 Paris agreement suggesting that the transition risk may only be the policy aspect being priced. Yet, transition risks may be self-reinforcing toward green lower cost of capital in that their study points to some large energy firms applying lower costs of capital to their decarbonzied economy divisions relative to their carbon intensive ones.

Evidence from the bond markets provides a similar glimpse of transition risk pricing. Liu and Lin (2023) find that carbon risk is priced in the cost of capital in municipal bonds, with similar results for sea-level rise in Painter (2020) and Goldsmith-Pinkham, Gustafson, Lewis, and Schwert (2023) [5] Results are similar for corporate bond pricing to firms, with Seltzer, Starks, and Zhu (2022) finding that firms with poorer environmental ratings or higher carbon emissions tend to have both lower bond ratings and higher yield spreads, which gets exacerbated in the post-Paris agreement period. Others like Faralli and Ruggiero (2023) look at the risk models of rating agencies, and find that after 2015, there is a positive correlation between Moody's expected default estimates (EDF) and firm's emission levels, as well as other estimates of transition risk. Ehlers, Packer, and de Greiff (2022) finds that there is a loan risk premium related to direct carbon emissions in syndicated lending, though indirect emissions are not priced.

An important piece of evidence, providing a twist to the story, however, comes from Beyene et al. (2024) , who study a spread of transition risk pricing between the bond and bank pricing of climate risk. In their evidence, firms face heightened transition risk-induced cost of capital facing bond holders relative to banks. The interpretation may be, with more evidence needed, that banks do a better job of mitigating transition risk through stewardship. Contrary to this line of thinking, Degryse, Goncharenko, Theunisz, and Vadasz (2023) find that after 2015, banks specializing in green finance offer cheaper loans to firms in the decarbonizing economy, but banks not specializing in green do not price green versus brown client firms deferentially, all else equal.

[5] For those interested in the transition risks explicitly related to "stranded assets," those assets that lose profitability when climate risks materialize or ambitious climate policy is adopted, might consider Delis et al. (2024) ,Atanasova and Schwartz (2019), and Beyene, Delis, and Ongena (2024). Also see Giglio, Kelly, and Stroebel (2021), Bolton and Kacperczyk (2021), and for further evidence and references more generally on the question of the cost of capital.

Another reason that net zero portfolios could have different risk properties could relate to fundamentals about business models or technologies. Even a cursory comparison suggests there may be significant differences between incumbent technologies and lower carbon alternatives, such as fixed costs, capacity, capital intensity, maturity, and regulation differences (Best (2017), Andonov and Rauh (2024)). One obvious point is that lower carbon technologies tend to be newer and more innovative. There is an established literature in private equity and venture capital that considers to what extent investment in startup innovation or new technologies exhibits different risk and return properties (Kaplan and Schoar (2005), Korteweg and Sorensen (2017)), which can carry over to thinking about investment in climate-related technologies (Kumar (2024)). Additionally, Bena, Bian, and Tang (2024) finds that lower carbon solutions in the transport sector carry more risk due to rapid innovations in battery development and the risk of technological obsolescence. Similarly, Sastry et al. (2024) study the financing of renewables projects, and find that banks with a net zero commitment charge higher interest rates and have higher collateralization levels than banks without one. As another example, Ginglinger and Moreau (2023) find that firms with more climate exposures tend to take on more leverage. On the other hand, Chiu, Hsu, Li, and Tong (2024) find that firms with higher green ratings also tend to file more green patents and have more profitability over the longer term. We expect that future evidence will provide more information about how the fundamentals emerging from the changing landscape of technologies impacts firms' risk profiles.

Further research on these fronts might delve into pinning down the mechanisms of cost of capital results. For example, do cost of capital differences for green versus brown projects provided by banks and other fixed income providers reflect an added cost due to transition risk? If so, what kind of transitions risks are driving pricing? Are these risks systematic across banks? Also unclear is whether backstop effects (too important to fail effects) are undermining the price of credit risk.

2.2.2 Bank Heterogeneities in Managing Risk

The discussion above focused on general risk properties of net zero portfolios compared to other portfolios. In banking, however, informational frictions may play an important role, with banks potentially having an information advantage in the course of screening and monitoring loans (Diamond (1984)). The literature has identified a number of reasons for why banks may vary in their ability to assess risk across different projects. One important source of heterogeneity comes from specialization. Paravisini, Rappaport, and Schnabl (2023) studies export lending and find that banks are highly specialized in particular exporting markets and countries, with strong persistence in specialization over time. In a similar vein, Blickle, Parlatore, and Saunders (2023) use confidential administrative bank data to study lenders' specialization in different industries. They show that a loan made by a bank that is more specialized in the borrower's industry is less likely to become non-performing than if the loan is provided by a less specialized bank.

A complementary but distinct point is that banks often have extended relationships with borrowers, which can confer an advantage in the acquisition of soft information relative to new banks that do not have a relationship with that borrower (Petersen and Rajan (1994), Degryse and Ongena (2005)). Zhou, Caldecott, Hoepner, and Wang (2022) find evidence of such informational advantages in the Chinese context. Studying a change in China's green credit policy, they find that

Chinese state-owned banks were better able to evaluate credit risk of green lending than city and regional banks which have more informational asymmetries and less expertise.

There is also a small but interesting literature thinking about the interaction of lender specialization and borrower industries in the climate context specifically. Degryse et al. (2023) find that green banks provide cheaper loans to green firms in the post 2015 period, but do not find evidence of such a premium in loans made by other types of banks to green firms. On the flip side, Erten and Ongena (2024) studies President Trump's withdrawal from the global Paris agreement, and find that banks reduce environmental risk pricing in "browner" states where local beliefs are broadly less concerned with climate change. We will come back to specialization and relationship banking in subsection 2.3 when discussing how profitability and informational rents also depend on these channels.

2.2.3 Rationing Risk: Divestiture

While one approach to managing transition risks may be adjusting pricing, another complementary approach comes from the rationing of credit – either decreasing portfolio exposures to carbon-intensive firms or divesting altogether (Edmans, Levit, and Schneemeier (2024)). If bank exposures are calculated based on the portfolio weight of firms exposed to transition risk, then a natural way to decrease this exposure is to tilt away or divest from such firms (Jung et al. (2022)). While conceptually straightforward, the question about whether banks are actually divesting has been challenging to identify empirically, with mixed results across papers and contexts. The econometric challenge comes from separately identifying shifts in credit supply (i.e. divestment) from broader shifts in credit demand, which can vary at the sector, industry, or even firm level. This literature draws heavily on the bank lending channel literature to tease apart supply and demand explanations of changes in credit (Khwaja and Mian (2008)).

To evaluate divestment, some papers have taken a single-sector approach, focusing on a single particularly polluting sector, and comparing banks based on some measure of their likelihood to divest. For example, Green and Vallee (2024) find that lenders with more stringent internal environmental policies are divesting from coal in their syndicated lending portfolios. In contrast, Haushalter, Henry, and Iliev (2023) finds limited evidence of divestment from mountaintop removal coal projects when focusing on banks that have specific policies to limit lending to this particular type of highly polluting production technology. While the average bank did not reduce their lending to such projects, they find that larger banks were more likely to reduce their mountaintop removal coal loans than other banks.

Others have taken a broader approach by looking across multiple sectors, but then classifying firms as either "brown" or "green" depending on their industry code, their reported emissions, or based on where the fit with respect to lender decarbonization targets. In this space, Kacperczyk and Peydro (2024) find evidence that lenders who pledge to make a net zero commitment through SBTi reduce lending to brown companies in the syndicated lending market, with limited effects of such divestment on firm carbon emissions. On the other hand, Giannetti et al. (2023) examine administrative data from Europe that encompasses banks' overall portfolios, and do not find any evidence that lenders with more discussions of the environment in their disclosures actually divest

from browner companies. Sastry et al. (2024) study banks that have made a net zero pledge, and shows that there is significant variation across net zero lenders in which sectors they target for portfolio decarbonization, and find little evidence that lenders divest to meet these targets thus far.

2.2.4 Divestment versus Stewardship and the Objective of Emissions

An alternative to divestment is often referred to as "engagement", where banks can seek to reduce firm emissions through stewardship and retaining relationships. The literature that looks at divestment versus engagement focuses on which is more effective in leading to lower emissions as an objective function. Although that might seem a different objective from our agenda of the economics of net zero lending, the two may be highly correlated, since many of the risks we describe come from the carbon economy. On the one hand, Hong and Kacperczyk (2009) find that that divestment from sin stocks in equity markets can lead to meaningful cost of capital reductions for target firms, suggesting that divestment can create pecuniary incentives for the targeted firms. On the other hand, Broccardo, Hart, and Zingales (2022) show that the costs and benefits of stewardship relative to divestment toward the aim of reduced emissions in an equity market context depends on the quantity of socially responsible capital. Similar results are obtained in Berk and van Binsbergen (2021) for equity markets. We posit that these mechanisms may play out differently in the banking context, which may not need the mechanism of social capital and may have different tradeoffs between divestment and stewardship relative to equity markets.

Toward this aim, some evidence is beginning to emerge. One approach to measuring engagement is to measure what happens to emissions released by firms that are impacted by bank financing choices. Green and Vallee (2024) find that coal firms are negatively affected in access and cost of finance, and that the the coal power plants owned by firms targeted for divestment exhibit a higher probability of being retired, implying lower emissions. This may provide a basis for the effectiveness of divestment in the lending context, since they find that bank financing is not perfectly substitutable, an interesting divergence perhaps from equity financing .

However, much evidence goes against divestment as a mechanism to influence total macroeconomic financing of the carbon economy. For example, Sachdeva, Silva, Slutzky, and Xu (2022) exploit a policy where the US. Department of Justice forced a subset of banks to divest from firms with high levels of money laundering and fraud. They find that divested firms could easily substitute and borrow from other non-targeted banks on similar lending terms. Kacperczyk and Peydro (2024) find that although carbon-intensive firms do borrow less from climate-aligned banks than other ones, there is no effect on their carbon emissions. Sastry et al. (2024) similarly find that borrowers of net zero banks do not differentially reduce their verified EU ETS emissions relative to borrowers from other types of banks. Of course, it is possible that the full effect of the divestment movement on carbon emissions may have not yet materialized.

More broadly, Hartzmark and Shue (2023) argue divestment in lending or equity markets can unintentionally incentivize investing in polluting technologies if firms are financially constrained because decarbonization is more costly and polluting. They suggest that engagement may be a more effective approach for mitigating emissions. Relatedly, both De Haas, Martin, Muuls, and Schweiger (2024) and Xu and Kim (2021) provide evidence that more financially constrained firms are less

likely to invest in decarbonization and reducing pollution. Cohen, Gurun, and Nguyen (2024) points out that historically, firms in the energy sector that would likely be excluded using an "ESG" screen tended to be first-movers in producing higher quality, green innovation. They suggest that an unintended consequence of divestment from energy sector firms could be to limit the financing of green innovation. Similarly Srivastava, Bloom, Bunn, Mizen, Thwaites, and Yotzov (2024) find that high energy-intensity firms in the UK expect to make more climate-related investments into energy efficiency.

Under what contexts might stewardship be more effective than divestment in generating a macroeconomic impact on economy-wide carbon emissions? More work clearly needs to delve into the mechanisms of stewardship to understand potential for the channels. While divestment is relatively easy to measure using lending flows, engagement or stewardship is much more difficult, because it often involves data on financing specific projects or plants rather than specific firms. In addition, it is broadly known that firm-level measures of emissions are often voluntarily reported by very few firms, leading to challenges with both selection into disclosure as well as limited power for statistical tests Aswani, Raghunandan, and Rajgopal (2023). [6] Moreover, the effects of either divestment or engagement may require longer time periods to assess, since decarbonizing investments are often longer-maturity or in a growth stage.

One avenue for stewardship is relationship or specialist banking that can perhaps unwind short-termism frictions toward decarbonized economy opportunities. This is the argument of Blickle et al. (2024), who study the ability of bank finance to unlock growth opportunities for lending to finance decarbonzing investments. We return to this mechanism later, in studying the economics of net zero lending coming from growth of the lending book incentives.

2.3 Non-Risk Drivers of Net Zero Lending

The framework in subsection 2.1 posits that lender profitability depends on both default risk ρ, as well as lending returns m. We now turn to returns, considering two channels through which net zero portfolios may exhibit different return properties than carbon-intensive ones, separately from default risk considerations. We introduce these channels as questions. First, are banks able to price decarbonizing economy loans at a higher margin, potentially because of the competitive landscape? Second, are banks able to enjoy more lending volume multiplier effects, either in current unlocking of opportunities or in the multiplying of a green project lending into greater future volume for the lending book?

2.3.1 Price Margins and Bank Specialization: A Quick Landscape

The first non-risk channel through which net zero lending may lead to different lending returns is through pricing, in particular, through price margins. Outside of the climate finance context, it is clear that banks vary as to the focus of their products, business models, geographies, and industries. It is reasonable to believe that these choices are endogeneously chosen by the bank and reflect a number of considerations, including comparative advantage, economies of scale and scope, costs

[6] These challenges become compounded when using modeled emissions, which can be subject to measurement error and are based on models estimated on voluntarily reported data.

and benefits of diversification, informational asymmetries, and market power. Although banking is ubiquitous, this does not mean that bank pricing of loans is purely competitive.

Evidence supports the idea that banks can capture rents for a number of reasons. These include (1) information asymmetries and relationship lending (e.g., Sharpe (1990), von Thadden (2004), Degryse and Van Cayseele (2000),Blickle, Brunnermeier, and Luck (2019), Mazet-Sonilhac and Mésonnier (2022)), (2) sector expertise and specialization (Blickle, Parlatore, and Saunders (2023), Blickle, He, Huang, and Parlatore (2024), Paravisini, Rappaport, and Schnabl (2023), Duquerroy, Mazet-Sonilhac, Mésonnier, and Paravisini1 (2022)) or (3) competition (e.g., Boot and Thakor (2000), Ongena, Pinoli, Rossi, and Scopelliti (2020)), to name a few. Across this literature, authors find that rents to expertise and information generally exist, and these rents are split depending on the context, with some rents kept by the bank as market power pricing and some rents returned to the client borrower.

2.3.2 Bank Competition and Pricing in the Economics of Net Zero Lending

Only a few direct pieces evidence yet exists on the possibility that returns to specialization, information, or relationships accrue to banks in net zero lending. For example, Degryse et al. (2023) find that green banks offer better pricing terms to green firms, suggesting that there are match-specific effects between banks and firms. The sector-specific loan pricing implied by the work of Paravisini et al. (2023) or Blickle et al. (2023) can likely be extend to gain an understanding of bank expertise in net zero sectors. More is to be done on this front.

However, evidence is beginning to emerge on bank relationship and specialization advantages in the net zero context through the competitive landscape. For example, Sastry et al. (2024) shows that banks making a net zero commitment differ in which sectors they choose to target for decarbonization, with targets more likely to be set in the sectors where banks' ex-ante lending shares are higher. Zhou et al. (2022) shows strong evidence of the effect of climate policy expertise, with state-owned lenders having improved green project selection than city and regional lenders, who are one step removed from opportunities emerging from central planning. Klee, Morse, and Shin (2023) finds that electrical vehicles have a lower interest rate than gas engine alternatives, but only when the loan is made by a captive (manufacturer-based) lenders, not for outside bank and nonbank lenders. Finally, in the physical risks context, Kim et al. (2023) find significant heterogeneity across banks with varying levels of expertise, with banks informed as to the climate hazard risk being much more likely to reduce lending to riskier borrowers but less likely to adapt when local competition is higher, all else equal. They also find strategic complementarities between banks in how they adapt to climate hazard risks, whereby banks are more likely to adapt in markets where competitors are also more likely to do so.

An important consideration is to what extent bank credit is special, and how much it complements or substitutes with other sources of borrowing. Evidence suggests that banks face increased competition from nonbanks in a number of lending markets, including from shadow banks and fintech lenders in the mortgage market (Buchak, Matvos, Piskorski, and Seru (2018), Donaldson, Piacentino, and Thankor (2021)), from private credit to corporates (Fang, Ivashina, and Lerner (2015), Aramonte (2020)), as well as from bond markets (Becker and Ivashina (2014)). Such

competition would put strains on banks to be able to extract market power pricing. Yet, how might this vary according to a bank's net zero stance?

In the climate context, one might start by considering the green bond market as competition. However, such markets are small in scale relative to bank lending (Flammer (2021)). Irrespective, most green bonds are underwritten by net zero banks, so green credit and green bonds may not be substitutes per se (Fatica, Panzica, and Rancan (2021), Flammer (2021)).[7] This is consistent with the literature on universal banking, which suggests that banks seek to utilize the benefits of client-specific relationship across a range of their services and products (e.g. Puri (1996)). Evidence that the financing of fossil fuel extraction (and in particular stranded fossil assets) being unique to bank finance, with frictions to substitution to bond finance is found in Beyene et al. (2024). Similarly, Green and Vallee (2024) find that the reduction in bank credit to coal production is not offset by increased substitution to bonds or equity issuance.

Broadly, the literature suggests it is difficult to offset lost bank financing with other sources of credit. However, this statement is not without exceptions. For example, Ongena et al. (2020) find that firms which were previously unlisted but then allowed to obtain capital market financing through listing "minibonds" substituted away from bank financing. Likewise, the relationship between the equity markets and banking matter, a location-specific context. For example, Bolton, Halem, and Kacperczyk (2022) find that carbon transition risk pricing differs across markets, with more internalization in Europe rather than the United States, as well as differences between debt and equity. Although not directly studying the competitive pressures of net zero financing directly, this evidence suggests new lines of research on this front are needed. Indeed, Demirguc-Kunt, Feyen, and Levine (2013) compare bank-based and market-based financial systems and show that both grow together, with different channels through which financing affects growth. Taken together, it is likely that "green finance" will look different depending on the nature of the financial market. More bank-centric markets like Europe may have different patterns than more capital-centric markets like the United States. Much more evidence may need to emerge before the competitive advantage of net zero lending is well understood.

2.3.3 Lending Book Growth Opportunities in the Economics of Net Zero Lending

The second channel whereby decarbonized lending might cause different returns to the bank lending portfolio, unrelated to default risk, is through volume of lending growth. Banks might decide in favor of net zero lending portfolio simply because it is their opportunity to grow their lending book, thus scaling bank profits over time with volume growth. In some sense, lending book growth opportunities is the inverse of divestment. In the prior section, we considered the economics of risk causing firms to divest. The mechanism we have in mind here is not one of scaling back on risk, but of scaling up growth prospects.

Evidence as to profitable growth opportunities in the decarbonizing economy are found broadly in the literature. A full listing of such research is beyond our scope, but emerging evidence comes from a variety of growth modes, including green new hiring (e.g., Darendeli et al. (2022)), green revenues and products (e.g., Kruse, Mohnen, Sato, and Pope (2020), Chiu et al. (2024)), green

[7] See Climate Bonds Initiative.

strategy (e.g., Cauthorn, Drempetic, Hoepner, Klein, and Morse (2024)) and green innovation (e.g., Sautner et al. (2023), Bolton, Kacperczyk, and Wiedemann (2024)). Conversely, it could be that lending portfolios focused on the carbon economy see a longer horizon scaling back of loan volume relative to lending books focused on decarbonizing economy efforts.

How do these opportunity-oriented volume incentives interact with banks' strategies and their cross-sectional heterogeneities? An important channel to mention is the signal effect of making a net zero commitment. It could be the case that public signals reflect bank beliefs about their comparative advantage in renewables lending, or projections about volume growth in the area.[8] However, it could also be the case that banks public signals could reflect other pecuniary and nonpecuniary benefits that do not reflect true lending activity (Crawford and Sobel (1982), Giannetti et al. (2023)).

A starting place in this nascent literature is the finding of Martini et al. (2024). These authors measure banks' exposures to climate transition via the carbon footprint of their syndicated loan portfolios and find that the driver of bank's lower transition risk over time is a increase in more lending to low emission borrowers. Kacperczyk and Peydro (2024) suggest a similar mechanism, where lenders reallocate portfolios towards green firms and away from brown firms. This green opportunity lending is in lieu of providing loans to brown firms to invest in decarbonization. Sastry et al. (2024) also find that a broad cross-section of banks have increased their financing of renewables power generation using the vehicle of project finance.

These findings suggest that it is green firms which provide the opportunity for net zero lending and are the source of volume-incentivized building of net zero lending books. This punchline may be only part of the story, however.

2.3.4 Short-Termism and Lending Book Growth

Blickle et al. (2024) introduce a model and evidence that bank financing of net zero with a volume incentive can enable firms to overcome short-termism and invest in value-maximizing opportunities. A robust literature provides evidence that firms may prefer short term stock performance, at the expense of firm real investment into projects creating optimal valuation. The reasons causing short-termist equilibria stem from short-termist shareholder incentives from trading or holdings preferences (e.g., Graham, Harvey, and Rajgopal (2005), Cremers, Pareek, and Sautner (2020), Bushee (2001), Dow, Han, and Sangiorgi (2024), Fried and Wang (2018)) or from short-termist lenders (e.g. Bird, Ertan, Karolyi, and Ruchti (2021)). In many to most of these causes, the mechanism is the nature or structure of CEO compensation or other agency relationships between CEOs and shareholders (e.g. Bolton, Scheinkman, and Xiong (2006), Almeida, Ersahin, Fos, Irani, and Kronlund (Almeida et al.), Thakor (2020)).

A number of policy makers have posited that short-termism in financial markets could be an important reason behind limited investment in net zero projects that are likely to pay off over the longer-term. This argument was made perhaps most famously in a 2015 speech by then head of the financial stability board Mark Carney, where he argued "the catastrophic impacts of climate change

[8] Cauthorn et al. (2024) show that firms do green economy signaling in the context of corporate (rather than bank) strategy for a transition versus status quo agenda.

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."[9]

While this view is influential among policymakers, there are only a handful of papers which study whether this line of thinking extends to the finance of decarbonization setting. In the equity markets context, Starks, Venkat, and Zhu (2023) shows that institutional investors with longer-term investment horizons tend to be more likely to hold ESG portfolios. A recent paper by Kumar and Purnanandam (2023) use regional adoption of a cap-and-trade scheme as shocks to energy firms and find that utility market-to-book ratios increased even though utility profitability in the short-term declined. They argue that the increase in value comes from increased demand by institutional investors with a longer-term orientation.

Gormsen et al. (2024) examine firms' self-disclosed cost of capital in public communications and earnings calls, and find that prior to 2016, firms had a higher perceived cost of capital for sustainable projects, but that this flipped after 2016 to green investing being perceived as having a lower cost of capital. They show that similar trends also hold for firms' self-reported hurdle rates. Blickle et al. (2024) show that this cost of capital evidence on short-termism also holds for decarbonizing investment. These authors find a role for both short-termism and fixed costs in limiting transition investment, with an important interaction effect that comes from whether borrowers are connected to specialized banks.Blickle et al. (2024) tie their evidence to a theoretical framework whereby profit-oriented bank lenders have an incentive to providing financing for long-horizon decarbonizing investments precisely because it allows them to generate profits that can be further reinvested in future lending. This role for banks is especially relevant where short-termism (in the investor base) is more pronounced, in firms needing high capital intensity investment, and where bank-borrower specialization are linked by sector expertise.

There is room for far more research in understanding what role, if any, short-termism may play in the propensity of the banking sector to support firm investments in the net zero economy.

2.3.5 Financing Constraints

Another volume mechanism toward the economics of net zero lending is through the relaxing of financial constraints a la Hennessy and Whited (2007). Perhaps brown firms do not invest in net zero technologies because of financial constraints, yet a differentiated net zero assessment by banks, building off the transition risk or profit margin specialization arguments, might lead to new, profitable volume opportunities. These opportunities would be in firms previously at their financial constraint. Note that this aspect of the economics of net zero lending requires not just the volume growth arguments, but some specialization that may arise with the creating of a net zero team (or net zero commitment incentives) within a bank.

The evidence points to the role of financial constraints in hindering green investment. For example, Xu and Kim (2021) study a setting of firms trading off abatement costs and legal liability to possible environmental damage and find that when firms are financially constrained (using natural experiments), a relaxing of financial constraints results in lower pollution emissions. Likewise De Haas et al. (2024) show that firms in locations characterized by financial constraints and firms

[9]See Bank of England, "Breaking the tragedy of the horizon", 2015.

with bankers who face deleveraging in a financial crisis operate industrial facilities with higher-emitting producing techniques, all else equal. These studies characterize the equilibrium on non-investment.

From a building a lending book perspective, however, the question of how banks can gain profitable volume is only yet beginning to be studied, but also builds on much of the previous evidence on risk, profit margins, growth opportunities, and short-termism. Yet, if banks are able to specialize, appealing to any of these arguments that enable them to overcome financial constraints, these studies suggest that the impact on the environmental pollution might be large. Indeed, this is the focus of the work of Bustamante and Zucchi (2024), who model how financing access interacts with green technologies. These authors offer an array of possible choices for a brown firm to decarbonize – abatement, slow adoption of green technology, or more radical investment in green innovation. A key theoretical finding, applicable here, is that green innovation may be less affected by financial constraints, depending on the payoff structure of the innovation. Yet, the adoption of net zero technologies over time is very affected by constraints in their model.

The nature of whether abatement, adoption, or innovation dominate in the needs for reaching net zero as a society is beyond our scope (e.g., see Cohen et al. (2024), Ye (2023), Bustamante and Zucchi (2023), Kogan, Papanikolaou, Seru, and Stoffman (2017), Bolton et al. (2024)) among many others). Yet, learnings from future research on the iteration of financing constraints with green adoption and innovation financing needs will surely be critical for making progress on achieving net zero, both from a bank and from a society perspective.

3 Additional Banking and Net Zero Topics

Our topic overlaps with three other climate banking topics, which we will touch on now but are not our central focus. Each of these topics intertwines with net zero lending motivations.

3.1 Bank Net Zero Portfolios as Regulatory Preparedness

Banking is a highly regulated activity across most jurisdictions. For lenders, there is always a backdrop of what type of regulation they may face. This statement certainly holds true in the context of net zero and transition risk, where both indirect and direct policies may influence the economics of net zero banking.

Indirectly, many policies could impact banks through their borrowing firms, such as the adoption of a carbon price or regulation over net zero emissions pathways. In practice, countries have already begun enacting such policies to mitigate climate change and reduce carbon emissions. Among the most well-known are policies to place a price on carbon, such as the EU ETS, the California Cap-and-Trade policy, or the Canadian Carbon Tax. Another important policy came in 2015 with the adoption of the Global Paris agreement, where countries set net zero targets and commitments to reduce emissions in line with nationally-determined contributions (NDCs). Directly, policies could impact banks through such mechanisms as green capital requirements, green disclosure, or climate modeling in safety and soundness deliberations. Bank-specific policies or those being considered

include the UK transition plan task force, the European Green Asset Ratio disclosure, China's green credit policy.

Given this regulatory backdrop, a natural question is how banks will optimally adjust their lending in response to actual regulation or the threat of regulation. While net zero commitments by banks are not directly a safety and soundness policy, such commitments will of course be influenced by the broader policy environment. Stated another way, given the large changes in public policy over the last decade, adopting a net zero stance toward a bank's portfolios can be thought of as a strategy to prepare for anticipated policy and regulatory changes. It is beyond our scope to review the literature concerning the wide suite of climate-related policies that interact with bank regulatory setting and climate modeling of risks. The literature has examined a wide suite of policy changes that interact with banks' motivations to favor or disfavor net zero lending. We review a subset of these papers here to bring out the larger point that effects vary considerably depending on the policy being considered and broader regulatory environment.

We begin with two recent theoretical papers that highlight the interaction between carbon pricing, green capital requirements, and green finance and bringing out the arguments that bank regulation and the global transition could be interlinked through net zero lending. Oehmke and Opp (2022) show that green capital requirements can be good from a transition risk management standpoint, but it can have perverse effects when used to substitute for a carbon tax, potentially crowding out marginal lending to clean firms. Similarly Pedersen (2023) suggests that green finance is at best an imperfect perfect substitute for enacting a global carbon price that equals the social cost of carbon, due in part to cost of capital channels and the existence of stranded assets.

On the empirical side, a number of papers have explored bank portfolio reallocation as reactive to large-scale climate policy changes. A first set of papers look at the 2015 Paris Climate Agreement, which represents a shock to broader beliefs that countries may adopt policy in order to meet their climate pledges. Reghezza, Altunbas, Marques-Ibanez, Rodriguez d'Acri, and Spaggiari (2022) find that European banks reallocated credit away from polluting firms relative to less polluting firms after the 2015 Paris Agreement. The effects were stronger for well-capitalized banks, suggesting an interaction between transition risk and capital regulation. Likewise, in studying Turkish banks reaction to the 2015 Paris agreement, Aslan, Bulut, Cepni, and Yilmaz (2022) find that they reduced credit to provinces with more pollution.

A second set of papers consider carbon pricing. Ivanov, Kruttli, and Watugala (2023) look at California's adoption of a cap-and-trade policy, and find that banks respond quickly, with affected firms experiencing a contraction in credit through shorter loan maturities, reduced access to permanent forms of bank financing, and higher interest rates. Similarly, Laeven and Popov (2023) examine the effect of the introduction of a carbon tax on lending to fossil fuel companies in the syndicated lending market. They find that banks decrease their lending to fossil fuels in the country where the carbon tax is enacted, and increase their lending to fossil fuels in foreign countries without the carbon tax, suggesting a type of carbon leakage through the banking system where banks reallocate their emissions-intensive lending to countries with weaker environmental regulation and bank supervision.

A final set of papers in our abridged review of the growing climate policy-bank reaction literature study financial disclosure and regulation. Mésonnier and Nguyen (2022) consider a French law that

required carbon disclosures from many institutional investors including pension funds, insurers, and asset managers, but not banks. The authors find that treated investors reduce their fossil fuel financing relative to the untreated ones. Similarly, Miguel, Pedraza, and Ruiz-Ortega (2024) study a Brazilian regulation that forced banks to consider environmental risks in their capital assessments, and find that treated banks rationed credit to polluting sectors. However, the portfolio reallocation did little to curtail firm emissions, because firms were able to substitute to borrowing from smaller banks. Bellon (2021) studies changes in lender liability for toxic releases of borrowing firms and finds significant reduction in pollution, which is likely brought about by a borrowing cost channel.

There is a small literature which thinks about the political economy of net zero commitments, in the sense that private net zero commitments may influence government incentives to adopt climate-related policy. Acharya, Engle, and Wang (2024) argue that corporate net zero commitments can help remedy a coordination failure that emerges when government policy is constrained and large private actors can internalize carbon and innovation externalities. An alternate point of view is that private net zero commitments can take pressure off the public sector to enact policy (Kim, Macey, and Underhill (2023)). There are contexts when government policy pushes against decarbonization while private firms prioritize it, such as in Darmouni and Zhang (2023) who show the surprising result that government owners of coal plants are *less* likely than private firms to retire or scale down emission-intensive coal plants. From the point of view of the economics of net zero banking, it is not clear to what extent these dynamics improve our understanding of the economic actions of value-oriented banks as lenders. Whether connections exist is a topic for future consideration.

3.2 Weather-Related Physical Impact Risk

The next climate banking topic largely omitted from our study is the robust literature on the direct weather-related physical impacts of climate change on banks via a geography channel. Climate-induced weather events have a negative impact on lending portfolio performance as a whole (Berger, Curti, Lazaryan, and Mihov, 2023), and specifically for commercial lending (Correa, He, Herpfer, and Lel (2023)) and real estate lending (Issler, Stanton, Vergara-Alert, and Wallace (2024), Biswas, Hossain, and David (2023)). This exposure is mitigated, especially in the real estate markets, by the role of the government agencies (Ouazad and Kahn (2021), LaCour-Little, Pavlov, and Wachter (2023)), government flood insurance (Sastry (2024)), and private homeowners insurance (Sastry, Sen, and Tenekedjievia (2024)). Interestingly, banks also find some offsetting effects in new volume opportunities in recovery lending (Koetter, Noth, and Rehbein, 2020). Yet, on net, banks update, pulling away from exposed geographies (Aslan et al. (2022)) and companies ((Cortés and Strahan, 2017)).

For our purposes, however, a bank's exposure to the geography of weather risk, especially through the real estate portfolio, may have little direct correlation to the economics of why a bank might choose to strive for a decarbonizing net zero lending portfolio, unless the geography is correlated to sector risk. This could occur if, for example, carbon-intensive firms are also exposed to physical risks (e.g. Huang and Kahn (2023)). We leave this topic for others to explore. That said, in a broad sense, physical risks from climate change and transition risks from the adoption of climate policy are likely to be negatively correlated. This is because the less policy that is adopted

to reduce emissions, the more likely there will be extreme physical effects from a changing climate. We therefore focus our discussion of physical risks on what it may imply about the profitability of net zero lending, leaving other components aside.

3.3 Deposits and Net Zero Banking Demand

The final climate banking topic that we largely omit relates to deposits. It could be that some banks promote greenness in order to attract depositors. The literature on depositor preference for net zero actions (or lack of fossil fuel financing) by banks tends to focus on loyalty when brown behavior comes to light. For example, Homanen (2022) and Mazet-Sonilhac and Mésonnier (2022) study depositor reactions to, respectively, oil pipeline financing news and NGO campaigns targeting poor net zero reputation. In both cases, depositors react to brown behavior information by pulling back deposits, but with what might be considered quite small impact (Mazet-Sonilhac and Mésonnier, 2022), likely due to personal costs of changing banking relationships. This deposit side of the bank balance sheet is understudied in the literature. Yet, the evidence on depositor loyalty does suggest that such demand-driven effects for net zero banking is unlikely to be the dominant driver of bank's wanting to make commitments to net zero.

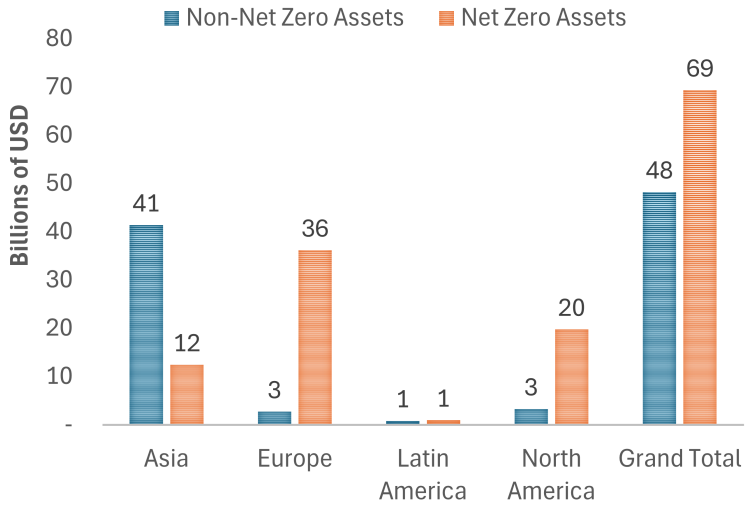
4 Conclusion

As the risks from climate change continue to become more salient in public perception, banks will likely play an important role in financing investments that help to decarbonize the global economy. In this review, we consider the various reasons why banks may find it profitable to do so, and consider evidence that supports or negates these ideas. We start with a simple framework of the bank's lending portfolio that posits two important sources of value that may differentiate low carbon investments from carbon-intensive ones: (1) default risk, and (2) returns through pricing or loan volume growth. We then draw heavily from the broader literature on banking to isolate to what extent there may be comparative advantages or rents that enable some banks to excel at such lending relative to other banks or other sources of financing. Throughout our review of the literature, we also argue that there are significant opportunities for future research that deepen our understanding of the channels through which banks influence the global transition to low carbon, net zero economy.

Tables and Figures

Figure 1: Top 100 Global Banks Total Assets

This figure shows the top 100 global banks by assets, grouped by region and by whether the bank has made a net zero commitment through the Net Zero Banking Alliance (NZBA). Data on top 100 banks and assets is obtained from S&P Global Research (Jimenea, Wu, and Terris (2024)). Data on NZBA membership is obtained from their website.



References

Acharya, V., R. Engle, and O. Wang (2024). Strategic commitments to decarbonize: The role of large firms, common ownership, and governments.

Acharya, V. V., R. Berner, R. Engle, H. Jung, J. Stroebel, X. Zeng, and Y. Zhao (2023). Climate stress testing. *Annual Review of Financial Economics 15*, 291–326.

Aldy, J. E., P. Bolton, Z. Halem, M. Kacperczyk, and P. Orszag (2023). Show tell: An analysis of corporate climate messaging and its financial impacts. *SSRN Working Paper No. 4418347*.

Almeida, H., N. Ersahin, V. Fos, R. M. Irani, and M. Kronlund. How Do Short-Term Incentives Affect Long-Term Productivity? *Working Paper*.

Andonov, A. and J. Rauh (2024). The shifting finance of electricity generation. *NBER Working Paper w32733*.

Aramonte, S. (2020, March). Private credit: recent developments and long-term trends. *BIS Quarterly Review*.

Aslan, C., E. Bulut, O. Cepni, and M. H. Yilmaz (2022). Does climate change affect bank lending behavior? *Economics Letters 220*, 110859.

Aswani, J., A. Raghunandan, and S. Rajgopal (2023, 04). Are Carbon Emissions Associated with Stock Returns?*. *Review of Finance 28*(1), 75–106.

Atanasova, C. and E. S. Schwartz (2019). Stranded fossil fuel reserves and firm value. *NBER Working Paper w26497*.

Barber, B., A. Morse, and A. Yasuda (2021). Impact investing. *Journal of Financial Economics 139*.

Becker, B. and V. Ivashina (2014). Cyclicality of credit supply: Firm level evidence. *Journal of Monetary Economics 62*, 76–93.

Bellon, A. (2021). Fresh start or fresh water: The impact of environmental lender liability. *SSRN Working Paper No. 3877378*.

Bellon, A., C. LaPoint, F. Mazzola, and G. Xu (2024). Picking up the pace: Loans for residential climate-proofing. *SSRN Working Paper No. 4800611*.

Bena, J., B. Bian, and H. Tang (2024). Financing the global shift to electric mobility. *SSRN Working Paper No. 4526150*.

Berger, A. N., . U. G. F. (1995). Relationship lending and lines of credit in small firm finance. *The Journal of Business 68*(3).

Berger, A., F. Curti, N. Lazaryan, and R. A. Mihov, Atanas amd Roman (2023). Climate risks in the US banking sector: Evidence from operational losses and extreme storms . *Working Paper*.

Berk, J. and J. H. van Binsbergen (2021). The impact of impact investing. *SSRN Working Paper 3909166*.

Best, R. (2017). Switching towards coal or renewable energy? the effects of financial capital on energy transitions. *Energy Economics 63*, 75–83.

Beyene, W., M. Delis, and S. Ongena (2024). Too-big-to-strand? bond versus bank financing in the transition to a low-carbon economy. *Swiss Finance Institute Research Paper No. 24-43*.

Bird, A., A. Ertan, S. A. Karolyi, and T. G. Ruchti (2021, 09). Short-Termism Spillovers from the Financial Industry. *The Review of Financial Studies 35*(7), 3467–3524.

Biswas, S., M. Hossain, and Z. David (2023). California wildfires, property damage, and mortgage repayment. *Federal Reserve Bank of Philadelphia Working Paper No. 23-05*.

Blickle, K., M. Brunnermeier, and S. Luck (2019). Micro-evidence from a system-wide financial meltdown: The german crisis of 1931. *Working paper*.

Blickle, K., Z. He, J. Huang, and C. Parlatore (2024). Information-Based Pricing in Specialized Lending. *Working paper*.

Blickle, K., A. Morse, and P. Sastry (2024). Specialized Banks Solve Corporate Short-termism: Evidence from Transition Investment. *Working Paper*.

Blickle, K., C. Parlatore, and A. Saunders (2023). Specialization in Banking. *Working paper*.

Bolton, P., X. Freixas, L. Gambacorta, and P. E. Mistrulli (2016, 06). Relationship and Transaction Lending in a Crisis. *The Review of Financial Studies 29*(10), 2643–2676.

Bolton, P., Z. Halem, and M. Kacperczyk (2022). The financial cost of carbon. *SSRN Working Paper No. 4094399*.

Bolton, P. and M. Kacperczyk (2021). Do investors care about carbon risk? *Journal of Financial Economics 142*.

Bolton, P., M. Kacperczyk, and M. Wiedemann (2024). The co2 question:technical progress and the climate crisis. *Working Paper*.

Bolton, P., J. Scheinkman, and W. Xiong (2006). Executive Compensation and Short-Termist Behaviour in Speculative Markets. *Journal of Finance 73*, 577–610.

Boot, A. W. (2000). Relationship banking: What do we know? *Journal of Financial Intermediation 9*(1), 7–25.

Boot, A. W. A. and A. V. Thakor (2000). Can relationship banking survive competition? *The Journal of Finance 55*(2), 679–713.

Broccardo, E., O. Hart, and L. Zingales (2022). Exit versus voice. *Journal of Political Economy 130*(12), 3101–3145.

Buchak, G., G. Matvos, T. Piskorski, and A. Seru (2018). Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics 130*(3), 453–483.

Bushee, B. J. (2001). Do institutional investors prefer near-term earnings over long-run value? *Contemporary Accounting Research 18*(2), 207–246.

Bustamante, M. C. and F. Zucchi (2023). Innovation, industry equilibrium, and discount rates. *Working Paper*.

Bustamante, M. C. and F. Zucchi (2024). Financially Constrained Carbon Management. *Working Paper*.

Cauthorn, T., S. Drempetic, A. G. Hoepner, C. Klein, and A. Morse (2024). Climate transition vs status quo: Evidence from latent corporate strategies. *Working Paper*.

Chiu, W.-C., P.-H. Hsu, K. Li, and J. T. Tong (2024). Environmental scandals and green products. *Working Paper*.

Cohen, L., U. G. Gurun, and Q. Nguyen (2024). The esg - innovation disconnect: Evidence from green patenting. *Working Paper*.

Correa, R., A. He, C. Herpfer, and U. Lel (2023). The Rising Tide Lifts Some Interest Rates: Climate Change, Natural Disasters and Loan Pricing. *Working Paper*.

Cortés, K. R. and P. E. Strahan (2017). Tracing out capital flows: How financially integrated banks respond to natural disasters. *Journal of Financial Economics 125*(1), 182–199.

Crawford, V. P. and J. Sobel (1982). Strategic information transmission. *Econometrica 50*(6), 1431–1451.

Cremers, M., A. Pareek, and Z. Sautner (2020). Short-term investors, long-term investments, and firm value: Evidence from russell 2000 index inclusions. *Management Science 66*(10), 4535–4551.

Darendeli, A., K. K. F. Law, and M. Shen (2022, September). Green new hiring. *Review of Accounting Studies 27*(3), 986–1037.

Darmouni, O. and Y. Zhang (2023). Brown capital (re)allocation. *SSRN Working Paper No. 4796331*.

De Haas, R., R. Martin, M. Muuls, and H. Schweiger (2024). Managerial and financial barriers to the green transition. *Management Science Forthcoming*.

Degryse, H., R. Goncharenko, C. Theunisz, and T. Vadasz (2023). When green meets green. *Journal of Corporate Finance 78*, 102355.

Degryse, H. and S. Ongena (2005). Distance, lending relationships, and competition. *The Journal of Finance 60*(1), 231–266.

Degryse, H. and P. Van Cayseele (2000). Relationship lending within a bank-based system: Evidence from european small business data. *Journal of Financial Intermediation 9*(1), 90–109.

Delis, M. D., K. d. Greiff, M. Iosifidi, and S. Ongena (2024). Being stranded with fossil fuel reserves? climate policy risk and the pricing of bank loans. *Financial Markets, Institutions & Instruments 33*(3), 239–265.

Demirguc-Kunt, A., E. Feyen, and R. Levine (2013). The evolving importance of banks and securities markets. *The World Bank Economic Review 27*(3).

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *Review of Economic Studies 51*.

Donaldson, J., G. Piacentino, and A. Thankor (2021). Intermediation variety. *The Journal of Finance 76*(6), 3103–3152.

Dow, J., J. Han, and F. Sangiorgi (2024). The short-termism trap: Catering to informed investors with limited horizons. *Swedish House of Finance Research Paper No. 21-24*.

Duquerroy, A., C. Mazet-Sonilhac, J.-S. Mésonnier, and D. Paravisini1 (2022). Bank Local Specialization. *Working paper*.

Edmans, A., D. Levit, and J. Schneemeier (2024). Socially responsible divestment. *SSRN Working Paper No. 4093518*.

Ehlers, T., F. Packer, and K. de Greiff (2022). The pricing of carbon risk in syndicated loans: Which risks are priced and why? *Journal of Banking and Finance*.

Erten, I. and S. Ongena (2024). Do Banks Price Environmental Risk? Only When Local Beliefs are Binding! *Swiss Finance Institute Research Paper Series*.

Fang, L., V. Ivashina, and J. Lerner (2015). The disintermediation of financial markets: Direct investing in private equity. *Journal of Financial Economics 116*(1), 160–178.

Faralli, M. and F. Ruggiero (2023). The rise of climate risks: Evidence on firms' expected default frequencies. *SSRN Working Paper No. 4144802*.

Fatica, S., R. Panzica, and M. Rancan (2021). The pricing of green bonds: Are financial institutions special? *Journal of Financial Stability 54*, 100873.

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics 142*(2), 499–516.

Fried, J. M. and C. C. Y. Wang (2018, 12). Short-Termism and Capital Flows. *The Review of Corporate Finance Studies 8*(1), 207–233.

Giannetti, M., M. Jasova, M. Loumioti, and C. Mendicino (2023). "glossy green" banks: The disconnect between environmental disclosures and lending activities. *Working Paper*.

Giglio, S., B. Kelly, and J. Stroebel (2021). Climate finance. *Annual Review of Financial Economics 13*, 15–36.

Gilje, E., L. Elena, and D. Murphy (2020). Drilling and debt. *Journal of Finance 75*, 1287–1325.

Ginglinger, E. and Q. Moreau (2023). Climate risk and capital structure. *Management Science 69*(12), 7492–7516.

Goldsmith-Pinkham, P., M. T. Gustafson, R. C. Lewis, and M. Schwert (2023, 05). Sea-Level Rise Exposure and Municipal Bond Yields. *The Review of Financial Studies 36*(11), 4588–4635.

Gormsen, N. J., K. Huber, and S. S. Oh (2024). Climate capitalists. *Working Paper*.

Graham, J., C. Harvey, and S. Rajgopal (2005). The Economic Implications of Corporate Financial Reporting. *Journal of Accounting and Economics 40*, 3–73.

Green, D. and B. Vallee (2024). Measurement and Effects of Bank Exit Policies. *Working Paper*.

Hartzmark, S. M. and K. Shue (2023). Counterproductive impact investing: The impact elasticity of brown and green firms. *Available at SSRN 4359282*.

Haushalter, D., J. J. Henry, and P. Iliev (2023). Can Banks Save Mountains? *The Review of Corporate Finance Studies*.

Hennessy, C. A. and T. M. Whited (2007). How costly is external financing? evidence from a structural estimation. *The Journal of Finance 62*(4), 1705–1745.

Homanen, M. (2022). Active Depositors. *Journal of Banking and Finance 136*.

Hong, H. and M. Kacperczyk (2009). The price of sin: The effects of social norms on markets. *Journal of Financial Economics 93*(1), 15–36.

Huang, R. and M. E. Kahn (2023). U.s electric utility adaptation to natural disasters shocks and green power mandates. *NBER Working Paper No. w30583*.

Issler, P., R. Stanton, C. Vergara-Alert, and N. Wallace (2024). Housing and mortgage markets with climate risk: Evidence from california wildfires. *SSRN Working Paper No. 3511843*.

Ivanov, I. T., M. S. Kruttli, and S. W. Watugala (2023, 12). Banking on Carbon: Corporate Lending and Cap-and-Trade Policy. *The Review of Financial Studies 37*(5), 1640–1684.

Jimenea, A., J. Wu, and H. Terris (2024). The world's largest banks by assets, 2024. *S&P Global Research*.

Jung, N., J. Santos, and L. Seltzer (2022). U.s. banks' exposures to climate transition risks. *FRB of New York Staff Report No. 1058*.

Kacperczyk, M. and J.-L. Peydro (2024). Carbon emissions and the bank-lending channel. *Working Paper*.

Kaplan, S. and A. Schoar (2005). Private equity performance: Returns, persistence and capital flows. *Journal of Finance 60*, 1791–1823.

Khwaja, A. I. and A. Mian (2008). Tracing the impact of bank liquidity shocks: Evidence from an emerging market. *American Economic Review 98*(4), 1413–1442.

Kim, D., L. M. Olson, and T. Phan (2023). Bank Competition and Strategic Adaptation to Climate Change. *Working paper*.

Kim, H., J. Macey, and K. Underhill (2023). Does esg crowd out support for government regulation? *University of Chicago Coase-Sandor Institute for Law Economics Research Paper No. 983*.

Klee, E., A. Morse, and C. Shin (2023). Auto finance in the electric vehicle transition. *SSRN Working Paper No. 4642783*.

Koetter, M., F. Noth, and O. Rehbein (2020). Borrowers under water! rare disasters, regional banks, and recovery lending. *Journal of Financial Intermediation 43*, 100811.

Kogan, L., D. Papanikolaou, A. Seru, and N. Stoffman (2017, 03). Technological Innovation, Resource Allocation, and Growth*. *The Quarterly Journal of Economics 132*(2), 665–712.

Korteweg, A. and M. Sorensen (2017). Skill and luck in private equity performance. *Journal of Financial Economics 124*, 535–562.

Krueger, P., Z. Sautner, and L. T. Starks (2020). The importance of climate risks for institutional investors. *The Review of Financial Studies 33*(3), 1067–1111.

Kruse, T., M. Mohnen, M. Sato, and P. Pope (2020, 01). Green revenues, profitability and market valuation: Evidence from a global firm level dataset. *Working Paper*.

Kumar, M. (2024). Getting dirty before you get clean: Institutional investment in fossil fuels and the green transition. *SSRN Working Paper w32733*.

Kumar, M. and A. Purnanandam (2023). Carbon emissions and shareholder value: Causal evidence from the u.s. power utilities. *Working Paper*.

LaCour-Little, M., A. Pavlov, and S. Wachter (2023, 09). Adverse Selection and Climate Risk: A Response to Ouazad and Kahn (2022). *The Review of Financial Studies 37*(6), 1831–1847.

Laeven, L. and A. Popov (2023). Carbon taxes and the geography of fossil lending. *Journal of International Economics 144*, 103797.

Liu, H. and C. Lin (2023). Climate change news risk and corporate bond returns in china. *Finance Research Letters 58*, 104526.

Martini, F., Z. Sautner, S. Steffen, and C. Theunisz (2024). Climate transition risks of banks. *Working Paper*.

Mazet-Sonilhac, C. and J.-S. Mésonnier (2022). Some Don't Like It Hot: Bank Depositors and NGO Campaigns Against Fossil Fuels. *Banque de France Working Paper*, 323–336.

Miguel, F., A. Pedraza, and C. Ruiz-Ortega (2024). Climate-change regulations: Bank lending and real effects. *Journal of Financial Stability 70*, 101212.

Mésonnier, J.-S. and B. Nguyen (2022). Showing off cleaner hands: mandatory climate-related disclosure by financial institutions and the financing of fossil energy. *Banque de France Working Paper*, 323–336.

Oehmke, M. and M. Opp (2022). Green capital requirements. *Swedish House of Finance Research Paper No. 22-16*.

Oehmke, M. and M. Opp (2024). A theory of socially responsible investment. *Review of Economic Studies (forthcoming)*.

Ongena, S., S. Pinoli, P. Rossi, and A. Scopelliti (2020). Bank credit and market-based finance for corporations: the effects of minibond issuances. *Working Paper*.

Ouazad, A. and M. E. Kahn (2021, 11). Mortgage Finance and Climate Change: Securitization Dynamics in the Aftermath of Natural Disasters. *The Review of Financial Studies 35*(8), 3617–3665.

Painter, M. (2020). An inconvenient cost: The effects of climate change on municipal bonds. *Journal of Financial Economics 135*(2), 468–482.

Paravisini, D., V. Rappaport, and P. Schnabl (2023). Specialization in Bank Lending: Evidence from Exporting Firms. *Journal of Finance 78*(4), 2049–2085.

Pedersen, L. (2023). Carbon pricing versus green finance. *SSRN Working Paper No. 4382360*.

Petersen, M. A. and R. G. Rajan (1994). The benefits of lending relationships: Evidence from small business data. *The Journal of Finance 49*(1), 3–37.

Puri, M. (1996). Commercial banks in investment banking conflict of interest or certification role? *Journal of Financial Economics 40*(3), 373–401.

Reghezza, A., Y. Altunbas, D. Marques-Ibanez, C. Rodriguez d'Acri, and M. Spaggiari (2022). Do banks fuel climate change?,. *Journal of Financial Stability*.

Sachdeva, K., A. F. Silva, P. Slutzky, and B. Xu (2022). Defunding controversial industries: Can targeted credit rationing choke firms? *Available at SSRN*.

Sastry, P. (2024). Who bears flood risk? evidence from mortgage markets in florida. *SSRN Working Paper No. 4306291*.

Sastry, P., I. Sen, and A.-M. Tenekedjievia (2024). When insurers exit: Climate losses, fragile insurers, and mortgage markets. *SSRN Working Paper No. 4674279*.

Sastry, P., E. Verner, and D. Marquez-Ibanes (2024). Business as usual: Bank net zero commitments, lending, and engagement. *NBER Working Paper No. w32402*.

Sautner, Z., L. Van Lent, G. Vilkov, and R. Zhang (2023). Firm-level climate change exposure. *Journal of Finance 78*, 1449–1498.

Sautner, Z., L. van Lent, G. Vilkov, and R. Zhang (2023). Pricing climate change exposure. *Management Science 69*(12), 7540–7561.

Seltzer, L., L. Starks, and Q. Zhu (2022). Climate regulatory risk and corporate bonds,. *NBER Working Paper No. w29994*.

Sharpe, S. A. (1990). Asymmetric information, bank lending, and implicit contracts: A stylized model of customer relationships. *The Journal of Finance 45*(4), 1069 – 1087.

Srivastava, P., N. Bloom, P. Bunn, P. Mizen, G. Thwaites, and I. Yotzov (2024). Firm climate investment: A glass half-full. *NBER Working Paper No. w33081*.

Starks, L., P. Venkat, and Q. Zhu (2023). Corporate esg profiles and investor horizons. *SSRN Working Paper No. 3049943*.

Thakor, R. T. (2020, 09). Short-termism, Managerial Talent, and Firm Value. *The Review of Corporate Finance Studies 10*(3), 473–512.

von Thadden, E.-L. (2004). Asymmetric information, bank lending and implicit contracts: the winner's curse. *Finance Research Letters 1*(1), 11–23.

Xu, Q. and T. Kim (2021, 05). Financial Constraints and Corporate Environmental Policies. *The Review of Financial Studies 35*(2), 576–635.

Ye, Z. (2023). Bank divestment and green innovation. *Available at SSRN 4324996*.

Zhou, X., B. Caldecott, A. Hoepner, and Y. Wang (2022). Bank green lending and credit risk: an empirical analysis of china's green credit policy. *Business Strategy and the Environment 31*(4), 1623–1640.