Advancing Energy Efficiency Through Green Mortgage Backed Securities

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Abstract

Diffusion of new technology, such as green bond policies, is impacted by inefficiencies and frictions as the market navigates adoption. Using data from Fannie Mae multifamily green mortgage backed security issuances, we identify possible disconnects between pricing and benefits, as well as adoption trends. Evidence indicates that loans on properties backed by green bonds receive lower interest rates, lower debt service coverage ratios, and higher leverage ratios than their "brown" counterparts. Some of these findings represent stated program benefits, but others do not. Additionally, some benefits are observed accruing to properties which are not participating in a green MBS program, despite already qualifying for participation. Supporting evidence points to drivers of adoption and program refinements which could aid in policy maximization. Our results carry implications for both existing green bond programs as well as the diffusion of green bond policy into the broader capital markets.

Keywords: MBS, green bond, multifamily, issuance, energy efficiency, water efficiency

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1 Introduction

Green bonds, financial instruments which link proceeds to environmentally-focused efforts, are a relatively new product and with that comes the potential for market inefficiencies. The current availability of the product is thin on both the initial and secondary market, making bond pricing opaque. In 2019, new green bond issuances reached a record high of $258B USD globally, representing a more than 50% increase over 2018 yet still only 5% of the total bond market.[1] With limited market penetration comes limited market awareness, making it difficult to identify and attract assets to the programs and ensure that the programs are operating optimally.

Evidence of a linkage between environmental, social, and governance (ESG) criteria and green bond financial performance is well-documented (Friede et al., 2015). Tang and Zhang (2020) finds that equity stock prices respond positively to green bond issuance but are not driven by the related lower cost of debt, and that both institutional and stock liquidity increases after issuance, all benefiting existing shareholders. Research by the European Commission indicates pricing premiums at issuance for green bonds issued by supranational institutions and corporations but no premium for those issued by financial institutions (Fatica and Panzica, 2019). A study of Chinese green bonds indicated that credit ratings, corporate social responsibility (CSR) commitments, and environmental certifications all impact interest costs, and that green bonds with environmentally-certified assets have lower interest costs than those without such certifications (Li et al., 2020). Finally, Hachenberg and Schiereck (2018) indicates that issue size, maturity, and currency do not impact secondary market pricing differences for green bonds, but industry and ESG ratings do.

The Federal National Mortgage Association (FNMA), or Fannie Mae, was a pioneer of issuing green, agency mortgage backed securities (MBS) and remains the global leader.

[1] For more information, visit: https://www.climatebonds.net/resources/reports/2019-green-bond-market-summary

The goal of their green bond policy is to increase energy and water efficiency in the U.S. rental housing stock, resulting in increased housing affordability.[2] Such linked goals are supported by the academic literature. MacAskill et al. (2019) indicates energy efficiency subsidies can help support low and middle income housing affordability in Australia. This study provides evidence that green bonds present an opportunity to channel funds toward affordable housing. This is complemented by an analysis of techniques to advance energy efficiency within Australian housing policy and business models (Heffernan et al., 2020). Copiello (2015) finds that building energy efficiency may boost the feasibility of social housing transactions in Italy, and Femenías et al. (2018) identifies energy efficiency and renovation strategies to address affordable rental housing policy requirements in Sweden. Finally, a Dutch study indicates that affordable housing suppliers recoup their sustainable investments upon sale, as energy efficient affordable dwellings sell at a premium (Chegut et al., 2016).[3]

However, frictions exist in the market which impact both green building and green bond adoption rates. For example, some owners have environmental building certification in place which, without any additional requirements, qualifies them to receive preferential interest rates under the FNMA green bond program. Yet if owners are unfamiliar with that program, they may not report certification to their lender. Similarly, if the lender is unaware of a property's certified status, they may not recommend the green bond program to the prospective borrower.

There is also evidence of a possible mismatch in cost and benefit implications for the MBS

[2]For more information, visit: https://multifamily.fanniemae.com/financing-options/specialty-financing/green-financing/green-mission-impact

[3]In addition to affordability for tenants, environmentally-sensitive buildings are often found to have operational benefits and be lower risk investments. Existing literature identifies higher rental and occupancy rates (Eichholtz et al., 2013; Fuerst and McAllister, 2011) including multifamily rental premiums specifically (Bond and Devine, 2016), lower tenant turnover and higher tenant satisfaction (Devine and Kok, 2015), and lower utility costs (Eichholtz et al., 2019a; Clayton et al., 2020; Kats, 2010). Financing evidence indicates underwriters of commercial properties are able to observe these lower-risk features and reward them with superior loan terms (Eichholtz et al., 2019b; Devine and Yönder, 2020; An and Pivo, 2018), although Giraudet et al. (2021) finds that residential borrowers do not enjoy the same discounts for green retrofits.

issuer with respect to different programs under their green bond policy. Under the Green Building Certification program, qualification is relatively inexpensive for FNMA, both in time and financial costs, and the program offers a smaller benefit package to the borrower. Under the Green Rewards program, qualification is very time and cost intensive for FNMA, and offers a far greater benefits package to the borrower. Therefore, for the MBS issuer, the benefits are not accruing proportionally to the costs.

Such inefficiencies are common in new technology adoption. Diffusion of new technology can be hindered by market inefficiencies regarding both consumers (Newell and Siikamäki, 2013; Palmer et al., 2013) and producers (Anderson and Newell, 2004). FNMA, as the original issuer of green MBS, has only been executing their green bond policy since 2012 with the current version active since 2015. Therefore, knowledge of the product is limited for most parties in the market. This paper aims to highlight trends in the current FNMA green bond policy programs and identify informational and pricing asymmetries which may stymie greater program adoption and maximization.

Utilizing a dataset of all multifamily single-asset FNMA MBS loans issued from 2016 through 2018, we explore the relationship between various green building adoption paths and loan terms. We conduct extensive sensitivity analyses, and explore structural breaks in the sample as well as adoption drivers. Findings evidence both the advertised program benefits as well as additional loan term benefits experienced by green building-secured MBS. Such divergence in loan terms is observed with respect to use of proceeds, building size, green bond program type, and projected carbon dioxide emission reductions. We also find varying green bond program adoption patterns for large versus small buildings, and by intensity of the building's local climate. Lastly, we identify a subgroup of buildings which qualify for the green bond yet were instead funded under the traditional MBS program, bringing with it insight into how environmentally-sensitive assets are underwritten within and outside a green bond program, and a discussion of the need to enhance program visibility and uptake.

We combine our analyses into a discussion of policy implications applicable not only to FNMA as they evaluate and streamline their existing programs, but to other debt issuers - regional, national, and supranational - as they consider instituting green bond policies. Key findings point to specific approaches to encourage greater program adoption, as well as ways to prevent inefficiencies in program execution. These steps can lead to more resilient programs which can in turn more effectively shape market-wide green building adoption.

2 Data and Methodology

FNMA is a government-sponsored enterprise which securitizes mortgage loans into mortgage-backed securities (MBS). The organization's primary goal is expansion of the secondary mortgage market by providing liquidity. FNMA created their Green Mortgage Loan program to encourage the retrofitting of existing U.S. rental housing to be more energy and water efficient, and since 2017 FNMA has been the largest issuer of green bonds in the world.[4] Additionally, the organization is an important part of the US multifamily market, comprising between 14% and 40% each year since 2009. In our period of study (2016-2018), FNMA is the second largest MBS market participant, behind only its sister organization, Freddie Mac (FDMC), in market share.

FNMA offers three green multifamily mortgage incentive programs: Green Rewards; Green Building Certification; and, Healthy Housing Rewards.[5] The Green Rewards program offers preferential interest rate pricing, up to 5% additional loan proceeds, and free energy and water audits. The latter two programs offer only preferential interest rates. Healthy Housing Rewards is available only to affordable housing, has experienced limited uptake thus far, and is excluded from this study. All other loan terms available mirror those of FNMA's

[4]For more information, visit: https://www.fanniemae.com/newsroom/fannie-mae-news/multifamily-green-bond-impact-report-highlights-benefits-fannie-mae-loan-programs

[5]For more information, visit: https://multifamily.fanniemae.com/financing-options/specialty-financing/green-financing/green-financing-loans

full term sheet, including unaltered loan-to-value (LTV) and debt service coverage ratio (DSCR) requirements, despite the opportunity for additional loan proceeds under the Green Rewards program. The majority of FNMA green bond loans take the form of single-property MBS, but multi-property MBS as well as other financing tools such as real estate mortgage investment conduits (REMICs) are also eligible under the green bond policy.[6] These Green MBS programs have been available since 2015.

To qualify for Green Rewards, a property owner must commit to improving annual water and energy efficiency by 30% combined, inclusive of a minimum 15% improvement in energy efficiency. Efficiency improvements must be completed within twelve months of loan closing. The program is only available to properties which have at least twelve months of stabilized operations. Energy and water audits, funded by FNMA, are completed both pre- and post-improvements, with results available to the property owners. Program compliance is based on completion of the promised improvements within twelve months, rather than meeting the targeted efficiency goals. FNMA indicates there is no minimum investment amount required per unit, and the choice of modifications lies with the owners (i.e. they are not prescribed by FNMA). Program language suggests modifications such as upgrading appliances and HVAC (heating, ventilation, and air conditioning) equipment to more efficient models, replacing inefficient lighting, and installing photovoltaics, water-saving systems, or improved insulation. Program literature also indicates that participants may benefit from the inclusion of the projected energy and water efficiency cost savings in the underwriting of the property's net cash flow (which is one way participants may receive additional loan proceeds without a change in LTV requirements).

To receive preferential interest rate pricing under the Green Building Certification pro-

[6]Quarterly, FNMA takes some single-property MBS and resecuritizes them into Green REMIC deals in which a specific tranche in a larger deal is backed by green financing. This treatment does not impact the terms of the underlying loans. While REMIC issuance give us a setting to examine pricing, the relatively short time series and infrequency of issuance make pricing studies of limited use at present.

gram, a building must be certified under one of the FNMA-approved green buildings certification programs. FNMA reviews its list of approved programs annually to ensure completeness and compliance with their goal of advancing water and energy efficiency. While the list includes more than ten programs (each with multiple schemes), the most commonly utilized programs include the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program, the U.S. Environmental Protection Agency's Energy Star program, and the Green Building Initiative's Green Globes program.

There is a relationship between the recent growth of the Green MBS programs and the "carveout" offered by the FNMA conservator, the Federal Housing Finance Agency (FHFA). Although both FNMA and FDMC have been under conservatorship since September 2008, it was not until 2014 that FHFA began capping the amount of multifamily loans that FNMA and FDMC were allowed to purchase in a given year. In both 2018 and 2019, the cap was $35 billion annually.[7] In 2016, FHFA began allowing the agencies to exclude eligible green properties from counting against the lending cap. Although FNMA had instated various green lending policies in earlier years, this carveout marked the beginning of rapid growth in their green multifamily lending.[8] Regulators and policy makers expressed concern that FNMA's and FDMC's roles in the multifamily housing market were growing too rapidly, driven at least in part by the green carveout. FHFA documented that the enterprise share of new multifamily originations increased from approximately 36% in 2015 to 49% in 2017, with FNMA and FDMC experienced 41% more growth than the overall multifamily market during that time. Based on these trends, on September 13, 2019, FHFA released a new policy that ended the carveout for green programs, effective October 1, 2019.[9] In place of

[7]For more information, visit: https://www.fanniemae.com/portal/media/corporate-news/2019/multifamily-volumes-6818.html

[8]Green loans were not the only type of lending granted a carveout; a myriad of affordable housing initiatives were also exempt from this lending limit. For example, FNMA and FDMC did combined business of approximately $140 billion in 2018, while their combined cap was only $70 billion.

[9]Carveouts for affordable housing remain in place and qualifications for affordable programs have been expanded. For more information, visit: https://www.fhfa.gov/Media/PublicAffairs/Pages/FHFA-Revises-

the green carveout, FHFA has increased the lending cap to $100 billion each for Fannie and Freddie for the five quarter period from Q4 2019 to the end of Q4 2020. For FNMA, this is roughly equivalent to its most recent five quarters of total business. Moving forward, green initiatives will be considered part of regular business for FNMA and FDMC. Therefore, it is important to evaluate the effectiveness of the programs, as green initiatives must now be considered alongside other lending opportunities in competing for business.

To form the sample, we first take the universe of multifamily FNMA MBS that were originated between 2016 and 2018 (obs=13,717).[10] In this period FNMA issued a total of $51.5B in Green MBS, as compared to $130.4B in conventional or cooperative backed bonds. We then limit our sample to only single asset deals (obs=13,485). Finally, we exclude all cooperative housing, military housing, and affordable housing deals from our sample, as these types of financing are highly specialized, leaving us with a final sample of 10,677 securities, of which 2,657 are participants in a FNMA Green MBS program. When we limit our analysis to securities that have non-missing values for key variables related to underwriting and property characteristics (e.g. LTV ratios, interest rate at issuance, occupancy rate at issuance, and date property was built) we have 8,370 observations, with approximately one-quarter of that sample participating in Green MBS, and the remainder of the sample non-participants ("Brown" MBS). (Insert Figure 2 about here) Figure 2 maps the location of continental U.S. properties securing single-asset FNMA MBS during the 2016 through 2018 sample period. The green markers indicate properties participating in FNMA Green MBS programs, and the brown markers indicate properties securing Brown MBS. Visual inspection indicates the spatial distribution of the Green MBS closely follows that of the full MBS pool.[11] This

Multifamily-Loan-Purchase-Caps-for-Fannie-Mae-and-Freddie-Mac.aspx

[10]There is FNMA issuance of Green Rewards securities in 2015, but only a handful of these deals are single-asset securities, and the total dollar volume of issuance was only $0.2B, so we exclude 2015 from our analysis. We stop the analysis at the end of the year 2018, as new higher qualification standards in energy usage reduction for Green Rewards were implemented in 2019. All FNMA MBS are underwritten initially as single-asset instruments. They may later be re-packaged into multi-asset securities, but that occurs after the scope of our analysis.

[11]Similar analysis was completed comparing the location of Green MBS to all commercial properties

provides an indication that the program is not exclusively adopted in certain markets, but is penetrating all existing FNMA MBS markets. Figure 1 confirms this, highlighting FNMA Green MBS adoption rates by state. During the sample period, every state which experiences FNMA MBS issuance activity (i.e. all but three states) also experiences FNMA Green MBS issuance activity. The proportion of MBS activity which falls under the FNMA Green MBS programs scales up to 65%, confirming the depth of program penetration.

(Insert Figure 1 about here)

Table 1 provides summary statistics on FNMA MBS included in the sample. Column (1) provides average values for all MBS. Columns (2) and (3) break the sample into all loans that participate in a FNMA Green MBS program and those that do not, respectively. Column (2) is broken into the two observed streams: Green Building Certification (Column (4)) and Green Rewards (Column (5)). Column (6) examines a third definition of green properties: those that qualify for participation under the Green Building Certification stream but are not participating in the FNMA green mortgage incentive program.

(Insert Table 1 about here)

Panel A indicates that over one-quarter of the 8,370 observed MBS are participating in one of the FNMA green bond incentive programs, highlighting significant uptake. Of these, the vast majority have pursued the Green Rewards path (24% of the total). While approximately 3% of the sample pursued the Green Building Certification stream, an additional 1.6% of the sample also possessed the certification required to participate in the program but did not pursue the incentive program.

Panel B provides loan details by subsample. Here we observe evidence indicating that buildings which obtain green building certification (Columns (4) and (6)) tend to be larger (i.e. have more units), with larger loan amounts and monthly debt service. Additionally, there is early evidence of lower interest rates associated with loans secured by these proper-

certified under the examined rating schemes, and the two groups also follow similar spatial distribution.

ties. The Column (6) properties, which are eligible for the Green Building Certification program incentives but do not participate, prove to be substantially larger in terms of building units and loan size, and are almost exclusively associated with a fixed rate loan. Additionally, their debt service coverage ratio exceeds a factor of two, while all other sample analyses indicate coverage of approximately 1.7 to 1.8. This indicates that the loans associated with the non-participating yet qualified properties are unique amongst the sample, which may point to why they are not enrolled in the Green MBS program despite their eligibility. Research by FNMA into this unique subsample could prove insightful, particularly with respect to how to attract such lower risk loans into the FNMA portfolio. Panel C provides property details and loan categorization information, which is available for a slightly smaller sample. Here, the new construction nature of green building certified assets shines through, with a notable difference in average year constructed. FNMA MBS are most commonly refinance loans, however Green Rewards loans are predominantly associated with purchase loans.

2.1 Methodology

We estimate a series of regression models to analyze the underwriting and issuance characteristics of the universe of multifamily single-asset MBS originated between 2016 and 2018. First, we investigate the drivers of loan terms including interest rate, loan amount per unit (measured in thousands of dollars), debt service coverage ratio (DSCR) and loan-to-value (LTV) at issuance on these bonds. Interest rate is of particular interest because a reduction in interest rate is one of the benefits explicitly touted for all versions of the FNMA Green MBS programs.[12] Conversely, the program specifies there are no special underwriting allowances regarding LTV, although there is language that allows for additional loan proceeds to be provided to Green Rewards participants to pay for efficiency upgrades. Using the OLS

[12]Interest rates are represented by bond coupon rate. We don't observe yield information from the market as most transactions are private placement and the secondary market for FNMA green bonds is very limited.

specification in Equation 1, we isolate the impact of being a participant in the green bond program (*Green Bond (d)*) on each specified loan term, while controlling for a host of loan features (*Loan*) and property characteristics (*Property*) that may also impact the issuance interest rate.

$$Y_i = \beta_0 + \beta_1 GreenBond_i + \beta_2 Loan_i + \beta_3 Property_i + \varphi_{fe} + \epsilon \tag{1}$$

Loan characteristics include loan term (in months), type (amortization schedule, and fixed versus adjustable rate mortgages), purpose (refinance or supplemental as opposed to baseline purpose: purchase), and loan amount (expressed as loan balance per unit at the time of origination). Property characteristics include the occupancy rate of the building, number of units, the year of property construction, value of the building at loan origination (expressed in millions of dollars), and a categorical building quality measure.[13] All models include servicer, state, and year of origination fixed effects to capture unobservable variation. We also use models similar to Equation 1 to estimate the projected CO2 offset identified by the borrower at the time of origination under the Green Rewards program. *CO2AvoidUni* is expressed as the estimated projection of carbon dioxide emissions avoided annually in metric tons, divided by the number of units in the property, as a result of the efficiency improvements undertaken through the Green Rewards program.

2.2 Endogenous Adoption Drivers

Causal and omitted variable bias issues can plague efforts to measure environmentally-sustainable asset impact (Margolis et al., 2009). An elevated consumer demand for environmentally-sustainable assets may create a local ideology which could increase the demand for such assets regardless of the presence of or benefits associated with a green bond incentive program. We

[13]Value of the building is sales price for purchase transactions and appraised market value for refinance transactions.

attempt to measure the impact of such local demographic, economic, and climate factors on adoption of the FNMA Green MBS programs. By estimating the logistic model outlined in Equation 2, we investigate the probability of security i's participation in a FNMA green bond program (G=1).

$$Pr(G_i = 1) = F(\beta_1 Density_i + \beta_2 DegreeDays_i + \beta_3 Education_i + \beta_4 Loan_i + \beta_5 Property_i + \varphi_{fe} + \epsilon) \tag{2}$$

In addition to controlling for the previously-described loan and property characteristics as well as fixed effects, we measure the impact of several variables which may shape a geography's propensity to demand environmental investments. Specifically, we include a contemporaneous measure of climate intensity to proxy for the relative extremity of the climate in which the building is situated.[14] We use the metric of total degree days (heating degree days plus cooling degree days divided by 1,000). This data is collected from the NOAA and the National Centers for Environmental Information, and the number of degree days is measured as the total observed in the year of loan origination. We use this metric as a proxy for potential demand for green building. Specifically, the number of degree days measures the deviation of the local temperature from an ambient temperature of 65 degrees Fahrenheit. Heating degree days measure the absolute deviation below this standard and cooling degree days measure the absolute deviation above the standard. Summed together, they can serve as a proxy for local need for heating and air-conditioning services, respectively. The larger the number of degree days, the more costly an inefficient heating or cooling system may prove. Therefore, properties in areas with larger needs for heating or air-conditioning due to the local climate will benefit more from either energy efficient building practices in new buildings (Green Building Certification program) or retrofitting existing buildings (Green Rewards program).

[14]Results are robust to including lagged total degree days.

Additionally, we include population density, measured in thousands of residents by zip code, which teases out a possible urban versus rural mindset regarding environmental commitment.[15] Finally, we use share of the population within a zip code with a 4-year college degree or higher as a proxy for education. These demographic data are taken from the U.S. Census and American Community Survey.

3 Results and Discussion

We begin our analysis by examining the loan terms associated with FNMA MBS, identifying impacts of participation in the Green Rewards and Green Buildings Certification programs, as well as impacts on loans eligible to participate in, but not enrolled in, the the Green Building Certification program. As identified in the Data section, the majority of these treated loans fall under the Green Rewards program, so we will center our attention on those results, with secondary focus given to loans secured by green building certified properties, both participating and not participating in the FNMA Green MBS program.

(Insert Table 2 about here)

The promise of a lower interest rate is the shared benefit of all FNMA Green MBS programs, and Column (1) of Table 2 indicates that MBS participating in the green bond programs receive a statistically and economically significant lower interest rate than traditional MBS. Column (2) breaks this impact down by type of green commitment. Results indicate that not only those participating in the FNMA green bond programs but also those which have obtained green building certification and do not participate in the program are granted lower interest rates. This is consistent with the literature indicating that green buildings are lower risk properties, and are underwritten as such (Devine and Yönder, 2020; Eichholtz et al., 2019b; An and Pivo, 2018). Interestingly, while all categories reflect an

[15] We also proxy urban location using the concentration of electric car charging stations near each property and find similar results due to high correlation with population density.

interest rate discount, the magnitude is approximately twice as large for the Green Rewards program loans as for the categories associated with green building certification.

Columns (3) and (4) examine the impact on initial debt amount per unit and DSCR, respectively. Debt findings indicate that loans associated with green properties take on less debt per residential unit. DSCR analysis proves informative only for properties participating in the Green Building Certification program, indicating such loans are associated with lower DSCRs. Both of these findings provide further evidence of green buildings being underwritten as lower risk investments.

Table 3 explores the loan to value ratios (LTVs) associated with FNMA MBS. Column (1) includes (and controls for) all loans types, including interest only, amortizing, balloons, and all combinations thereof. Regression results indicate that both FNMA Green MBS program paths are associated with higher LTVs than their non-green counterpart loans, after controlling for loan terms, loan, type, loan use, and asset quality. With strong statistical significance, Green Rewards MBS are associated with an additional 4.1% in LTV, which is not indicated as a feature of the program. The Green Rewards documentation specifies that while additional loan proceeds may be available to Green Rewards participants, LTV guidelines are not impacted. Should those funds be available due to increase efficiency of the improvements, then that reflects operating statement savings which lead to higher net operating income and therefore higher asset value. In that case, the added costs from efficiency improvements should be offset by the added value, resulting in a largely unaffected LTV. this does not appear to be the case. Similar findings are present for FNMA MBS under the Green Building Certification program. Lack of statistical significance prevents insight into the MBS secured by green building certified properties which do not participate in the FNMA green MBS program.

(Insert Table 3 about here)

Columns (2), (3), and (4) re-estimate the same model for three loan type subsamples:

amortizing/balloon; interest only/amortizing/balloon; and, interest only/balloon, respectively. In all cases, the results perpetuate, with the largest LTV increases associated with the Column (2) subsample for amortizing balloon loans. Taken together, Table 3 indicates that MBS financed under green bond programs are associated with LTVs that are 2% to 10% higher than their traditional MBS counterparts. This is not a stated outcome or goal of the FNMA green MBS program, and implications of it are discussed further in the Discussion Section.

3.1 Robustness Tests

The above analyses may be biased in terms of sample composition and modeling. To address such issues, we test our sample and results for such biases. Table 4 provides a robustness test on Table 2 by excluding variables described in Panel C of Table 1. By doing this, the sample size increases, as does the magnitude of most reported variables by a slight amount. However, the general results remain unaffected.

Additionally, we examine if there are differences in our previous models if we divide our sample by various LTV cutoffs. From Table 1, we know that the Brown MBS sample has a lower average LTV at origination than MBS secured by green properties. We divide our sample by above- and below-mean LTV loans, and find no significant difference in the four groups' outcomes relative to the full sample results. Examination of LTV sample distribution identifies clusters of observations at 50%, 60% and 70% LTVs. We repeat this exercise, this time using these high density points of the distribution as cutoffs, and find qualitatively similar results.[16]

(Insert Table 4 about here)

[16]Results suppressed to conserve space.

3.2 Subsample Analyses

Restricting the sample to single-asset MBS could create a bias toward larger properties, as smaller properties would more likely be grouped together into multi-property MBS in order to reach certain MBS size thresholds. An examination of the Brown FNMA MBS and Green FNMA MBS samples indicates that buildings with less than 50 units represents just under 5% of both samples. Therefore, their exclusion represents a relatively small and equally weighted subset of both the total MBS activity and the Green MBS activity.

(Insert Figure 3 about here)

However, an examination of program participation rates for large versus small buildings indicates differing adoption activity. Figure 3 presents the adoption rates for green building technology for the smallest and largest building quartiles of the sample, based on unit count. Results indicate that approximately one-third of the largest buildings pursue some form of green building technology, while the same holds true for only about one-eighth of the smallest buildings. Further, most green building activity in the smallest quartile of buildings is through the Green Rewards program, and there are nearly no buildings that qualify for the Green Building Certification program but are not participating. Given these notable sample variations by building size, we examined the previous regression analyses for these small and large building subsamples.

Table 5 recreates three analyses examining the impacts of green building technology adoption on interest rate, LTV, and DSCR for the small and large building subsamples. Columns (1) and (2) re-estimate the findings from Table 2, Column (2) for the largest and smallest buildings, respectively. Comparison amongst those results indicates that while green building certification is associated with interest rate decreases in the full sample, there is no evidence of that relationship for the largest and smallest properties. This is interesting given that the highest concentration of certified properties is in the largest building quartile, and interest rate reduction is a stated benefit of all FNMA Green MBS programs. Green

Rewards program participation holds its strong statistical significance for both large and small subsamples, and the largest interest rate decrease is offered to the smallest properties.

(Insert Table 5 about here)

Columns (3) and (4) recreate the LTV impact analysis shown for the full sample in Table 3, Column (1). Interestingly, the full sample analysis presents a picture of relatively equal treatment for green bond programs, yet when the largest and smallest building quartiles are broken apart, the results vary distinctly. For Green Building Certification program participants, large buildings are associated with about 1% less of an LTV premium (over Brown MBS) than their small building counterparts (3.8% versus 4.8%). Yet an exaggerated version of the opposite effect is observed for Green Rewards participants: large buildings experiencing double the LTV premium of small buildings (6.0% versus 2.9% higher LTV than Brown MBS). Additionally, here we observe the first statistically significant evidence of an LTV premium for non-participating green-certified buildings, and it is substantial: a 6.7% higher LTV than small building Brown MBS. The notable take away from the LTV subsample analysis is the increased variance in the treatment of the largest and smallest green buildings in the sample, both inside and outside the FNMA green bond programs. These outliers in size also appear to be the outliers in garnering underwriting benefits.

Columns (5) and (6) recreate the DSCR analysis originally completed for the full sample in Table 2, Column (4). Within the smallest buildings subsample analysis in Column (6) we see that certified properties (both inside and outside the green bond program) are associated with lower DSCRs than results reported in the full sample analysis. Additionally, Column (5) indicates that the largest properties are awarded lower DSCRs under the Green Rewards program, whereas the full sample analysis proved uninformative.

The purpose of the loan may also create bias with the results, particularly with respect to the pursuit of FNMA Green MBS programs. While many of the approved green building certification programs focus on operations, some are directed toward design and construction.

Therefore, uptake of the Green Building Certification program may be more likely associated with more recently constructed buildings and, therefore, purchase rather than refinance loans. Similarly, the Green Rewards program targets capital expenditures focused on increasing building efficiency. The undertaking of these expenditures is more likely to occur at the time of a purchase rather than in the middle of an investor's holding period. To explore this, Table 6 examines the relationship between interest rate at issuance and FNMA MBS secured by green buildings, subsampled by loan purpose.

(Insert Table 6 about here)

Table 6, Columns (1) and (2) mirror the analysis in Table 2, Column (1), this time restricted to loans for purchase and refinance reasons, respectively. Results indicate that participation in one of the FNMA green bond programs results in an interest rate decrease for both loan purposes, but that the rate decrease is about one-third larger for refinance loans. Columns (3) and (4) mirror Table 2, Column (2), breaking out the green bond programs, and evaluating loans which could participate under the Green Building Certification program but do not. These results also indicate that larger rate decreases are awarded to refinance loans than purchase loans in every form of green commitment, and that the largest benefits fall to the Green Rewards program (as is observed in the full sample). Exploring why superior loan terms are extended to some green bond participants outside the stated program benefits, such as to refinance loan versus purchase loans, may help the issuer improve program execution; this will be discussed further in the Discussion section.

3.3 Uptake Analysis

Uptake of the FNMA green bond programs may be impacted by a variety of forces, shaping both how loans are underwritten and which borrowers adopt the programs. We explore three related questions. First, Chang and Devine (2019) identifies the importance of each owner's awareness of green technology as it impacts the magnitude of market wide adoption.

For example, in the case of MBS, if a servicer has no experience with green bonds, they are much less likely to pursue the FNMA Green MBS programs. To explore this, we examine the participation of servicers in the FNMA green bond programs. We find that of 26 servicers observed in our dataset, all but two participate in FNMA Green MBS programs, and these two servicers represent less than 1% of the total sample. However, we do find a high servicer concentration in the MBS with green building certifications that do not participate in the FNMA green program. Among the 184 MBS in that subgroup, 116 (63%) are associated with one servicer, with the remaining 37% spread across twelve other servicers. Therefore, green bond program adoption may be enhanced through improved communication of the available programs to the servicers; this will be discussed further in the Discussion and Policy Implications section.

Second, in the Green Rewards program, borrowers must commit to enacting energy and/or water efficiency modifications to the property securing the loan. The improvement of energy efficiency is important not only to promote green policy goals and improve operating costs, but is also important from the perspective of loan performance. Recent evidence by Mathew et al. (2021) demonstrates that the risk of default is higher when energy costs are high relative to net operating income. While the goal of the program is primarily framed as resource efficiency, applicants must also estimate the projected offset carbon emissions associated with planned efficiency improvements. These improvements must be completed within the first twelve months of the loan, but failure to comply has no stated penalty. Such a setup creates the opportunity for a costless signal from the perspective borrower to the underwriter, raising the question: does the possibility of greenwashing impact loan terms?

(Insert Table 7 about here)

Table 7 explores this question by looking at the stated commitment to reduce future CO2 emissions by borrowers in the Green Rewards program. The sample is restricted to only loans participating in the Green Rewards program and Brown MBS. The four columns

measure the impact of this promised decrease in carbon emissions on interest rate, LTV, debt per unit, and DSCR. Results indicate that loan packages which promise to avoid more carbon emissions are associated with elevated LTVs and debt levels per building unit, after controlling for loan and property characteristics and the previously-described fixed effects; there is no evidence of a relationship with interest rate or DSCR.[17] Observed higher debt levels and LTVs are not necessarily surprising as the Green Rewards program does indicate that additional funds may be available to the borrower to support the targeted efficiency improvements. However, as with other presented evidence of higher LTVs, attention should be paid to possible increased levels of risk exposure associated with the non-binding promise by borrowers to enact extensive efficiency improvements. This is particularly true given there is no evidence of statistically different interest rates from projected carbon emissions reduction, and lower interest rates are one of the stated benefits of the Green Rewards program. This may indicate that the interest rate benefit is calculated free from impact by the promise of future avoided carbon emissions, but such promises may be shaping underwriter's decisions regarding debt and LTV.

Third, we examine drivers of program uptake, studying the impact of assets being situated in geographic areas which may inordinately demand environmentally-sensitive investment. Using Equation 2 and the variables described in the Endogenous Adoption Drivers subsection, Table 8 reports results examining the likelihood that a FNMA multifamily loan will be secured by a green building.

(Insert Table 8 about here)

In Table 8, Columns (1) and (3) include all green building certified properties as well as those participating in the Green Rewards program, and Columns (2) and (4) remove the certified but non-participating loans from the sample, strictly comparing FNMA Green MBS

[17]Although we do not find any evidence that the commitment to CO2 emission reduction reduces the DSCR at origination, Mathew et al. (2021) finds evidence that the higher energy costs reflected through a reduction in DSCRs are associated with a higher risk of default.

to their Brown MBS sister loans. Columns (1) and (2) report baseline logit results including the loan and property variables, as well as fixed effects variables, found in all other analysis. Results indicate that green building-secured loans are more likely to carry less debt per unit and be associated with a purchase rather than a refinance, yet roughly comparable in size, value, and age. Columns (3) and (4) add in the variables capturing a geographic area's propensity to be green. The property and loan variables largely retain their economic and statistical significance. We find limited evidence for the effect of demographic variables on the propensity for a green building to secure a loan; education is marginally significant in both specifications and population density is insignificant. The most convincing external driver of propensity to participate in green building programs is climate intensity. For every 1,000 degree days observed in the year of loan origination (sample mean=5,712 degree days) we estimate an approximate 5% increase in the probability of participation in green building activity.

3.4 Discussion

Results from statistical and non-parametric analyses point to several interesting insights. These topics are worth consideration by debt issuers as they address aspects of effective formulation and execution of green bond policies.

First, there is relatively limited uptake of FNMA Green MBS by smaller properties (as compared to larger properties). This is unsurprising as the marginal cost of undertaking the program requirements is larger for smaller properties than for larger ones. Seeking any form of environmental improvement incurs a level of cost, in time and dollars. For a larger investor, that cost can be spread over more units and staff, benefiting from economies of scale. With respect to the Green Rewards program, the improvements to reach a minimum 30% decrease in energy or water consumption must occur within a twelve-month horizon. Meeting this requirement in a building with few rather than many units can be much more

difficult. Capital improvements are often first made to units as they turn over, prior to approaching existing tenants for entry into occupied units (a more complicated task). For example, if a building turns over ten percent of units on average each year, then comparing a small 50 unit and large 500 unit building means easy access to complete the targeted efficiency improvements in five versus 50 units, respectively. Larger buildings also often have more common area in which the landlord can improve efficiency with less tenant coordination. Therefore, should MBS issuers wish to more actively incentivize small asset owners to participate in their green bond programs, they may wish to tailor a program to address the above complications. Possible allowances could include relaxed compliance timelines (allowing longer than twelve-month horizons with stepped efficiency goals), and education or support programs related to execution of efficiency techniques.

Second, analysis indicated that FNMA Green MBS are associated with higher LTVs than their Brown MBS counterparts, all other things equal. This result is highly statistically significant for the Green Rewards MBS, which is interesting as that program's documentation specifies that, despite additional loan proceeds being a possible benefit, there is no alteration in the LTV terms available. This finding does not imply that that FNMA is lending past the organization's LTV guidelines. The Green Rewards MBS participants may simply be requesting higher LTVs than the Brown MBS, while all loans are situated within the LTV guidelines. Interestingly, a similar result is found in Table 7, indicating that a marginally larger non-binding commitment to avoid more carbon emissions through Green Rewards efficiency improvements is associated with higher LTVs as well. These results uncover a possible area of underwriting bias which should be carefully explored by debt issuers, especially in light of the program benefits of higher loan proceeds without higher LTV allowances and the possibility of greenwashing impacting underwriter perceptions.

Third, uptake of green building technology within FNMA MBS differs notably, and for logical reasons. Of the three categories of environmentally-sensitive properties we study,

Green Rewards MBS is overwhelmingly the most common (27% of the sample versus 3% and 1.6% for green building certified properties within and outside the FNMA green bond program, respectively). The popularity of Green Rewards is likely attributable to the relatively large benefits package that comes with participation: free energy and water audits (before and after efficiency improvements); preferential interest rates; and, the possibility of additional loan proceeds. Further, one of the largest observed interest rate benefits is associated with Green Rewards refinance loans, achieving more than a quarter point rate decrease on average. On the contrary, obtaining green building certification can be a costly and time-consuming activity for a building owner, and offers only preferential interest rates under the FNMA green bond program. Therefore, when the market observes both program options, they are incentivized to choose Green Rewards. As Green Rewards both costs FNMA more, in time and money (as they fund the energy and water audit), and may expose the organization to lower market pricing on their MBS due to costlier loan terms (preferential interest rates, additional loan proceeds, and evidence of higher LTVs), there is a disconnect between the costs and benefits of the two FNMA Green MBS programs. In the future, debt issuers should carefully consider the relative costs and benefits of various green bond policies, with attention given to how uptake of programs may differ depending on the mix of offerings.

Fourth, green bond policy authors should consider how their programs may shape green building technology adoption, and how geographic-specific drivers may shape green bond program adoption. Green bond policy advances green building technology adoption, both directly through the buildings securing Green MBS, and indirectly through spillover effects, including increased knowledge of green building technology within the real estate industry and mass commercialization of the related products. However, visual inspection (being able to physically see changes) is an unlikely path for increased adoption under the Green Rewards program. This is because energy and water efficiency improvements are relatively unobservable, visually, compared to other green improvements such as a green roof, bike

racks, solar chimney, etc. Therefore, debt issuers wishing to leverage their green bond policies for the greatest market adoption may want to consider how to publicize the commitment at the building site. Green building certification programs already do this with building plaques and signage, and a similar signal may help increase visibility around participation in green bonds, and therefore aid in adoption. Additionally, we find evidence that properties located in areas with more intense building heating or cooling demands are more likely to participate in green building programs, suggesting specific geographic areas could be targeted for green bond policy adoption.

Finally, evidence of properties that qualify for the FNMA Green Building Certification MBS program but do not participate highlights information asymmetry present in the market. Properties that qualify are not being enrolled into a program that would guarantee them preferential interest rates with no added cost, as they have already met the program requirements. This may be occurring because owners aren't aware of the program at the time of loan commitment. It is less likely that it is because lenders do not know the buildings are certified, as we observe that green building certified properties are often associated with lower interest rates even when they are not enrolled in the program. To decrease this asymmetry, there needs to be better communication of green bond program availability to underwriters, servicers, and potential borrowers. For FNMA, this may attract more large properties and loans which traditionally have not considered FNMA MBS for financing needs. The Green MBS program incentives could render the FNMA financing packages more competitive, especially for buildings which already have green building certification in place. Taken together, these actions may increase the green bond program footprint, ensure all green building pricing benefits are accruing under the green bond programs, and decrease the average overhead cost of executing the Green MBS programs.

4 Conclusion and Policy Implications

FNMA instituted its first green bond policy in 2012 and has since offered a variety of program iterations. We study the single-asset multifamily MBS which qualify under two of the current green bond program paths: Green Rewards and Green Building Certification. Examining FNMA MBS issuance from 2016-2018, we gain insight into underwriting trends and inefficiencies impacting the program. Since FNMA is the current market leader in issuance of Green MBS, the continued growth and success of this program is key to the overall growth of this product segment in the multifamily market.

All FNMA MBS secured by green multifamily properties experience underwriting benefits at the time of MBS issuance, including both those participating in FNMA green bond programs, and those that do not. This indicates that underwriters are incorporating the green building certification signal into the underwriting of property risk, which is consistent with the existing literature on green buildings and financial risk. In addition to preferential interest rates, in most cases FNMA Green MBS also received higher LTVs. While this is also consistent with the literature, it is not a stated benefit of the program.

Subsample analysis indicates differing impacts on loan terms for the largest and smallest buildings, and for those associated with a purchase versus a refinance. A look into what is driving adoption of these programs indicates that underwriters may be bias by borrower promises of greater carbon emission offsets (offering larger LTVs), and that buildings in areas of greater climate intensity are more likely to participate in green bond programs.

Limitations to this research are largely rooted in the newness of the program. Most importantly, we are unable to observe the performance improvements of the Green MBS buildings. This is particularly key for properties participating in the Green Rewards program, as they have a twelve-month period to achieve their committed energy and water efficiency improvements. Once sufficient data is available and accessible, analysis will allow researchers

to observe if the initial targets are achieved, and which approaches prove most effective. Further, it will allow for examination of the secondary market pricing response to Green MBS offerings as well as any secondary pricing changes as operational efficiency data becomes available.

The results of this research carry important insights not just for FNMA, but also for all debt issuers (regional, national, or supranational) as they consider instituting a green bond policy. Evidence indicates adoption can be aided by tailoring programs for smaller buildings, increasing transparency into a building's participation in the green bond program, targeting geographies with extreme climates, and ensuring education of the program offerings to many stakeholders such as underwriters, servicers, and potential borrowers. Finally, issuers should pay close attention to matching costs and benefits of green bond program offerings, both for their organization and participating borrowers, to ensure adoption aggregates proportionately preventing undue risk exposure and supporting the long-term success of green bonds.

Percent of FNMA MBS Issuance Amount that is Green, By State

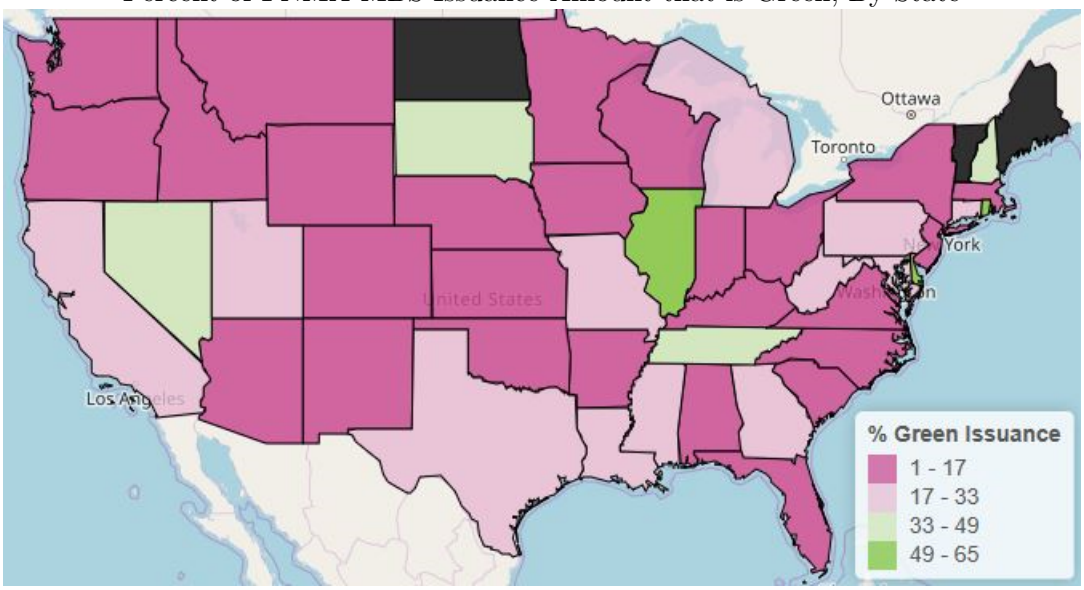

Figure 1: This figure depicts the percentage of total FNMA multifamily MBS issuance from 2016 through 2018 that participated in either the FNMA Green Rewards or Green Building Certification programs, by state. Participation rates are observed up to 65% of the total FNMA MBS new issuance amount in dollars. Every state that had FNMA multifamily issuance during that time period had some level of participation in the Green MBS program; states in black had no FNMA MBS issuance during that period. Lower adoption levels are shown in pink, and higher adoption levels are shown in green.

FNMA Green and Non-Green MBS Property Locations

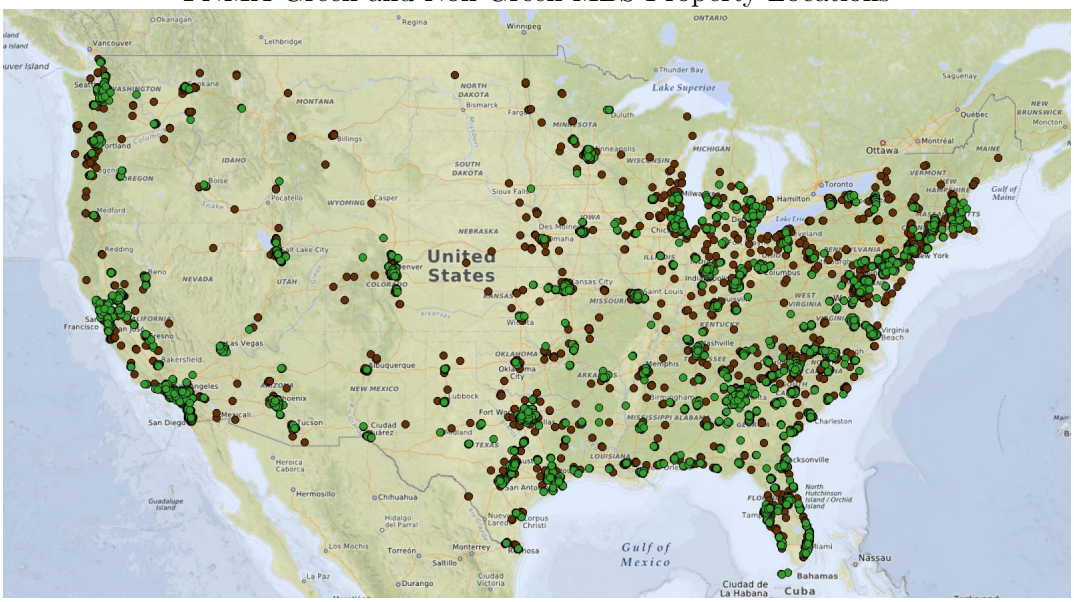

Figure 2: This figure depicts the location of all properties securing single-asset multifamily FNMA MBS, situated within the continental U.S., during the 2016 through 2018 sample period. The green markers indicate properties participating in the FNMA Green MBS programs, and the brown markers indicate properties securing traditional MBS.

FNMA Green MBS Program Participation for Smallest and Largest Buildings

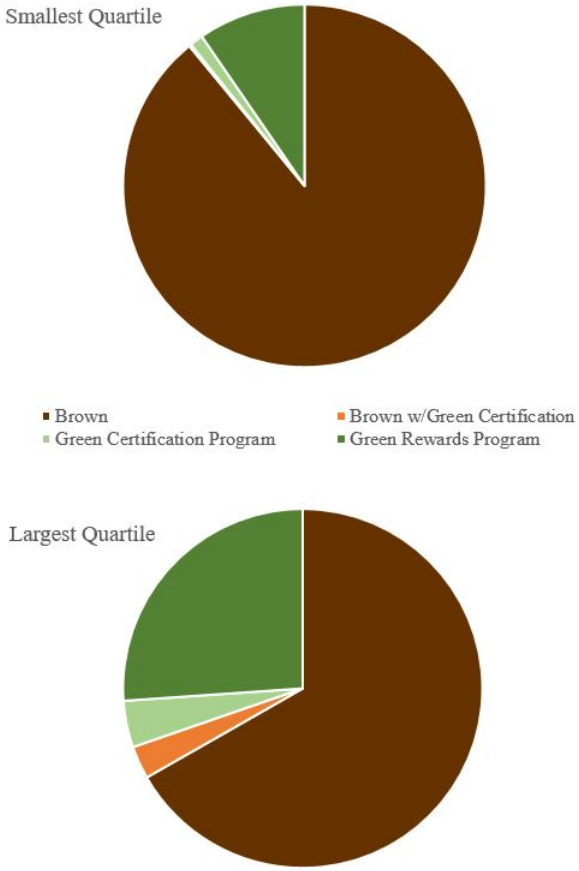

Figure 3: This figure depicts the percentage of buildings in the possible four program states for the smallest building (top) and largest building (bottom) quartiles. Buildings were sorted based on the number of apartment units, then grouped into quartiles. Each pie chart is broken into the four possible program states: those participating in the Green Rewards program (dark green); those participating in the Green Building Certification program (light green); those not participating in either program yet which qualify for the Green Building Certification program (orange); and, those neither participating nor qualified (brown).

	(1) All	(2) Green	(3) Non-Green	(4) Green Certification	(5) Green Rewards	(6) Non-participant with Certification
Panel A: Sample Composition						
Green Bond (d)	0.27					
Green Certification (d)	0.03					
Green Rewards (d)	0.24					
Non-participant with Certification (d)	0.02					
Panel B: Loan Variables						
Interest Rate at Issuance	4.36	4.35	4.37	4.08	4.37	4.12
Loan Term (months)	127	132	125	127	133	107
Loan amount (millions)	18.63	20.93	17.80	35.05	19.51	45.42
DSCR	1.80	1.76	1.82	1.73	1.76	2.17
Monthly debt service/unit	1,095	409	1,342	587	393	1,270
Occupancy Rate	93.64	93.52	93.68	93.91	93.48	93.43
Building Size: Number of Units	201	228	191	221	228	306
LTV	0.61	0.68	0.58	0.65	0.68	0.64
Adjustable Rate (d)	0.10	0.06	0.12	0.10	0.05	0.03
N	8884	2373	6511	217	2156	143
Panel C: Property Condition, Loan Purpose and Loan Type Variables						
Property Condition						
Year Property Built	1986	1985	1987	2008	1982	2004
Excellent Condition (d)	0.15	0.10	0.17	0.53	0.05	0.61
Fair/Poor Condition (d)	0.05	0.02	0.06	0.01	0.02	0.00
Good Condition (d)	0.31	0.19	0.36	0.20	0.19	0.15
Unknown Condition (d)	0.49	0.69	0.41	0.26	0.73	0.24
Loan Purpose						
Purchase Loan (d)	0.39	0.52	0.33	0.32	0.55	0.40
Refinance Loan (d)	0.58	0.47	0.62	0.66	0.45	0.58
Supplemental Loan (d)	0.04	0.01	0.04	0.02	0.01	0.02
Loan Type						
Amortizing/Balloon (d)	0.27	0.11	0.34	0.14	0.11	0.16
Interest Only/Amortizing/Balloon (d)	0.52	0.69	0.46	0.66	0.69	0.31
Interest Only/Balloon (d)	0.18	0.20	0.18	0.20	0.20	0.53
Fully Amortizing (d)	0.02	0.01	0.03	0.00	0.01	0.00
N	8370	2351	6019	217	2134	45

"All" refers to the full sample of loan observations with non-missing values for all variables. "Green" refers to all loans in the Green Rewards or Green Certification programs. "Green Certification" and "Green Rewards" contain observations from loans that participate in each program, respectively. "Non-participant with certification" refers to observations with a green certification that would make them eligible for the Green Rewards program, but do not receive financing under the Green Rewards or Green Certification programs. All values reported in this table are averages. All variables labeled with "(d)" are 0/1 dummy variables

Table 1: Summary Statistics

	(1) Rate	(2) Rate	(3) Debt per Unit	(4) DSCR
Green Bond (d)	-0.19288***			
	(0.00828)			
Brown with Green Certification		-0.09667***	-1.83100**	-0.00009
		(0.03468)	(0.92967)	(0.05997)
Green Certification Program		-0.11895***	-3.87940***	-0.11511***
		(0.01989)	(0.40200)	(0.02534)
Green Rewards Program		-0.20057***	-1.86457***	-0.01945
		(0.00865)	(0.18039)	(0.01195)
Loan Term (months)	0.00093***	0.00094***	0.00106	-0.00006
	(0.00017)	(0.00017)	(0.00181)	(0.00017)
Number of Units	-0.00032***	-0.00031***	-0.01200***	0.00052***
	(0.00004)	(0.00004)	(0.00094)	(0.00006)
Occupancy Rate (%)	-0.00308***	-0.00318***	-0.35760***	-0.00337**
	(0.00096)	(0.00097)	(0.04676)	(0.00144)
Property Value ($ Millions)	-0.00103***	-0.00103***	0.00826***	-0.00215***
	(0.00023)	(0.00024)	(0.00309)	(0.00023)
Adjustable Rate (d)	-0.91542***	-0.91598***	4.35461***	0.05677***
	(0.01164)	(0.01164)	(0.48807)	(0.01501)
Year Property Built	-0.00117***	-0.00122***	0.03015***	-0.00127***
	(0.00019)	(0.00019)	(0.00437)	(0.00023)
Amortizing/Balloon	-0.18429***	-0.18254***	1.38743**	-0.15098**
	(0.05248)	(0.05242)	(0.54045)	(0.06439)
Interest Only/Amortizing/Balloon	-0.29892***	-0.29800***	1.49055***	0.09966
	(0.05198)	(0.05193)	(0.50868)	(0.06221)
Interest Only/Balloon	0.13333	0.13803	-1.18529	0.42904**
	(0.12759)	(0.12838)	(0.87557)	(0.18649)
Fair/Poor	0.05843**	0.06039***	-2.95306***	-0.05415**
	(0.02305)	(0.02308)	(0.44276)	(0.02681)
Good	0.00369	0.00637	-2.52146***	0.04289***
	(0.01318)	(0.01331)	(0.44140)	(0.01541)
Unknown	-0.05617***	-0.05478***	-5.46725***	0.06260***
	(0.01409)	(0.01421)	(0.45777)	(0.01564)
Refinance	0.01965**	0.01645*	-1.62355***	0.11125***
	(0.00900)	(0.00904)	(0.27986)	(0.01057)
Supplemental	0.81631***	0.81155***	-4.12599***	0.20264***
	(0.02817)	(0.02815)	(0.37153)	(0.02805)
Loan Balance per Unit ($100Ks)	-0.00291***	-0.00289***		
	(0.00028)	(0.00028)		
Constant	6.09928***	6.20062***	-22.29770**	4.65934***
	(0.42379)	(0.42450)	(9.91533)	(0.51547)
Observations	9223	9223	9222	9222
R^2	0.679	0.679	0.292	0.311

Note: All models are estimated using OLS with standard errors robust to heteroskedasticity.The omitted category for green participation is "Brown," the omitted category for loan type is "Fully amortizing," the omitted category for building condition is "Excellent," and the omitted category for loan purpose is "Purchase." Debt per unit is expressed in thousands of dollars at origination. Fixed effects for property location (state), servicer, and year of origination are included in the model, but omitted from this table.

Table 2: Baseline Results

	(1) LTV-all	(2) LTV-AmortBalloon	(3) LTV-IOAmortBalloon	(4) LTV-IOBalloon
Brown with Green Certification	0.02840	0.06034	0.07250***	-0.01721
	(0.01787)	(0.05074)	(0.01662)	(0.03097)
Green Certification Program	0.03992***	0.08041**	0.03358***	0.03887*
	(0.00909)	(0.04022)	(0.00840)	(0.02175)
Green Rewards Program	0.04138***	0.09675***	0.02283***	0.05720***
	(0.00382)	(0.01232)	(0.00401)	(0.00870)
Loan Term (months)	0.00065***	0.00213***	0.00011*	0.00044**
	(0.00007)	(0.00018)	(0.00006)	(0.00018)
Number of Units	-0.00004*	-0.00021***	0.00011***	0.00010**
	(0.00002)	(0.00006)	(0.00002)	(0.00005)
Property Value ($ Millions)	-0.00046***	-0.00135***	-0.00126***	-0.00044***
	(0.00010)	(0.00035)	(0.00014)	(0.00014)
Adjustable Rate (d)	0.01069*	0.14459***	-0.00566	-0.03202**
	(0.00598)	(0.01799)	(0.00572)	(0.01599)
Fair/Poor	-0.01442	-0.04230*	-0.00326	0.01611
	(0.01087)	(0.02160)	(0.00888)	(0.04285)
Good	-0.01232*	-0.03128**	-0.00491	0.00936
	(0.00649)	(0.01396)	(0.00656)	(0.01480)
Unknown	0.01979***	-0.00781	-0.00121	0.06433***
	(0.00719)	(0.01517)	(0.00770)	(0.01603)
Amortizing/Balloon	0.15167***			
	(0.01993)			
Interest Only/Amortizing/Balloon	0.25361***			
	(0.01990)			
Interest Only/Balloon	0.26306***			
	(0.04966)			
Refinance	-0.04788***	-0.03063*	-0.05491***	-0.02597**
	(0.00412)	(0.01668)	(0.00396)	(0.01073)
Supplemental	-0.41639***	-0.33334***	-0.52628***	-0.38082***
	(0.00923)	(0.01989)	(0.02130)	(0.02712)
Occupancy Rate (%)	0.00102*	0.00105	0.00142**	0.00021
	(0.00057)	(0.00127)	(0.00057)	(0.00150)
Year Property Built	0.00024***	0.00024	0.00014*	0.00104***
	(0.00008)	(0.00017)	(0.00008)	(0.00021)
Constant	-0.19610	0.09107	0.39032	-1.75397***
	(0.17113)	(0.38440)	(0.37281)	(0.44779)
Observations	8369	2295	4379	1522
R^2	0.456	0.491	0.379	0.285

Note: All models are estimated using OLS with standard errors robust to heteroskedasticity.The omitted category for green participation is "Brown," the omitted category for loan type is "Fully amortizing," the omitted category for building condition is "Excellent," and the omitted category for loan purpose is "Purchase." Fixed effects for property location (state), servicer, and year of origination are included in the model, but omitted from this table.

Table 3: Baseline Results-LTV

	(1) Rate	(2) Debt per Unit	(3) DSCR	(4) LTV
Brown with Green Certification	-0.09831***	-1.52272*	-0.00945	0.02874
	(0.03511)	(0.86955)	(0.05872)	(0.01931)
Green Certification Program	-0.13605***	-3.03555***	-0.09360***	0.05671***
	(0.01970)	(0.36950)	(0.02665)	(0.00907)
Green Rewards Program	-0.22797***	-2.16868***	0.02113*	0.06237***
	(0.00855)	(0.18288)	(0.01200)	(0.00402)
Loan Term (months)	0.00120***	-0.00428***	0.00033**	0.00039***
	(0.00012)	(0.00118)	(0.00014)	(0.00005)
Number of Units	-0.00031***	-0.01285***	0.00055***	-0.00003
	(0.00004)	(0.00093)	(0.00006)	(0.00002)
Occupancy Rate (%)	-0.00343***	-0.37701***	-0.00251*	0.00123**
	(0.00098)	(0.04801)	(0.00146)	(0.00059)
Property Value ($ Millions)	-0.00099***	0.01978***	-0.00215***	-0.00044***
	(0.00023)	(0.00301)	(0.00023)	(0.00010)
Adjustable Rate (d)	-0.92448***	4.46557***	0.08402***	0.01530**
	(0.01170)	(0.49613)	(0.01550)	(0.00598)
Year Property Built	-0.00136***	0.04178***	-0.00110***	0.00038***
	(0.00019)	(0.00440)	(0.00023)	(0.00008)
Refinance	0.04794***	-1.46210***	0.05330***	-0.07397***
	(0.00878)	(0.30040)	(0.01050)	(0.00413)
Supplemental	0.90433***	-3.41967***	0.05825**	-0.49139***
	(0.02636)	(0.38169)	(0.02722)	(0.00796)
Loan Balance per Unit ($100Ks)	-0.00256***			
	(0.00026)			
Constant	6.69353***	-46.22809***	4.50538***	-0.26782
	(0.40022)	(9.78063)	(0.48896)	(0.16649)
Observations	9223	9222	9222	8369
R^2	0.670	0.273	0.280	0.396

Note: All models are estimated using OLS. Models correspond to baseline models in Table 2, but exclude property condition and loan amortization type variables that constrict sample size in the baseline results. Results are similar when Brown with Green Certification properties are excluded. The omitted category for green participation is "Brown" and the omitted category for loan purpose is "Purchase." Debt per unit is expressed in thousands of dollars at origination. Fixed effects for property location (state), servicer, and year of origination are included in the model, but omitted from this table.

Table 4: Baseline Results-Robustness

	(1) Rate Big Buildings	(2) Rate Small Buildings	(3) LTV Big Buildings	(4) LTV Small Buildings	(5) DSCR Big Buildings	(6) DSCR Small Buildings
Brown with Green Certification	-0.07566	-0.04128	-0.02531	0.06723***	0.16110	-0.18772***
	(0.07093)	(0.08954)	(0.03158)	(0.01442)	(0.09882)	(0.06970)
Green Certification Program	-0.03426	-0.05622	0.03781**	0.04790***	-0.07075	-0.16788***
	(0.03214)	(0.04358)	(0.01812)	(0.01768)	(0.05103)	(0.05085)
Green Rewards Program	-0.17587***	-0.23029***	0.06018***	0.02882***	-0.07363***	-0.01683
	(0.01655)	(0.02164)	(0.00815)	(0.00918)	(0.02189)	(0.03065)
Loan Term (months)	0.00005	0.00191***	0.00092***	0.00014*	0.00034	-0.00010
	(0.00028)	(0.00022)	(0.00015)	(0.00008)	(0.00034)	(0.00024)
Loan Balance per Unit ($100Ks)	-0.03363***	-0.00277***			-0.01533***	0.00079
	(0.00493)	(0.00048)			(0.00392)	(0.00055)
Number of Units	-0.00010	0.00366***	0.00006**	-0.00008	0.00017*	0.00188***
	(0.00007)	(0.00041)	(0.00003)	(0.00017)	(0.00009)	(0.00047)
Property Value ($ Millions)	-0.00086***	-0.01139***	-0.00051***	-0.00093*	-0.00138***	-0.00499***
	(0.00026)	(0.00136)	(0.00013)	(0.00054)	(0.00028)	(0.00150)
Adjustable Rate (d)	-0.93958***	-0.78560***	0.00750	0.01717	-0.02861	0.12089***
	(0.01849)	(0.02706)	(0.01107)	(0.01174)	(0.02258)	(0.03619)
Fair/Poor	0.11329**	0.01069	-0.00663	-0.02102	-0.05142	-0.04117
	(0.04619)	(0.05283)	(0.02050)	(0.02271)	(0.04660)	(0.05906)
Good	0.02965	-0.03593	-0.00346	-0.02251*	0.02304	0.07798**
	(0.02474)	(0.02656)	(0.01127)	(0.01189)	(0.02771)	(0.03174)
Unknown	-0.02657	-0.11022***	0.03952***	-0.00089	0.03785	0.11027***
	(0.02706)	(0.03036)	(0.01382)	(0.01345)	(0.03176)	(0.03356)
Amortizing/Balloon	-0.05712	-0.00859	0.12070*	0.06854***	0.04035	-0.18898**
	(0.17800)	(0.06233)	(0.06601)	(0.02166)	(0.17192)	(0.07335)
Interest Only/Amortizing/Balloon	-0.23360	-0.07426	0.29222***	0.09335***	0.25275	0.05608
	(0.17625)	(0.06202)	(0.06577)	(0.02184)	(0.16372)	(0.07230)
Interest Only/Balloon	0.40112	0.32836**	-0.28796	0.38714***	0.60252	0.69819***
	(0.49617)	(0.15242)	(0.18445)	(0.05179)	(0.55487)	(0.20037)
Refinance	0.04805***	-0.07546***	-0.02620***	-0.04415***	0.08662***	0.08562***
	(0.01606)	(0.02231)	(0.00930)	(0.00788)	(0.01908)	(0.02204)
Supplemental	0.80895***	0.67678***	-0.35617***	-0.43954***	0.12635**	0.17957***
	(0.05260)	(0.06907)	(0.01952)	(0.02166)	(0.05560)	(0.04211)
Occupancy Rate (%)	-0.00221	-0.00181	-0.00011	0.00319***	-0.00105	-0.00499*
	(0.00273)	(0.00151)	(0.00145)	(0.00100)	(0.00282)	(0.00255)
Year Property Built	-0.00197***	-0.00030	0.00054**	0.00016*	-0.00321***	-0.00011
	(0.00057)	(0.00026)	(0.00026)	(0.00009)	(0.00070)	(0.00031)
Constant	7.21826***	4.15162***	-0.25073	-0.29854	8.36146***	2.20495***
	(1.25705)	(0.53946)	(0.55570)	(0.21401)	(1.53112)	(0.69235)
Observations	2357	2310	2166	2023	2357	2310
R^2	0.722	0.694	0.498	0.541	0.296	0.424

Note: All models are estimated using OLS with standard errors robust to heteroskedasticity.The omitted category for green participation is "Brown," the omitted category for loan type is "Fully amortizing," the omitted category for building condition is "Excellent," and the omitted category for loan purpose is "Purchase." Debt per unit is expressed in thousands of dollars at origination. Fixed effects for property location (state), servicer, and year of origination are included in the model, but omitted from this table.

Table 5: Results by Building Size

	(1) Rate-Purchase	(2) Rate-Refinance	(3) Rate-Purchase	(4) Rate-Refinance
Green Bond (d)	-0.18686***	-0.24642***		
	(0.01277)	(0.01205)		
Brown with Green Certification			0.00271	-0.17041***
			(0.06453)	(0.04481)
Green Certification Program			-0.09862***	-0.16885***
			(0.03381)	(0.02522)
Green Rewards Program			-0.19620***	-0.25940***
			(0.01303)	(0.01273)
Loan Term (months)	0.00284***	0.00136***	0.00284***	0.00136***
	(0.00022)	(0.00013)	(0.00022)	(0.00013)
Loan Balance per Unit ($100Ks)	-0.00218***	-0.00377***	-0.00217***	-0.00371***
	(0.00034)	(0.00049)	(0.00034)	(0.00049)
Number of Units	-0.00031***	-0.00015**	-0.00031***	-0.00015**
	(0.00009)	(0.00006)	(0.00009)	(0.00006)
Occupancy Rate (%)	-0.00250*	-0.00435***	-0.00261*	-0.00433***
	(0.00143)	(0.00138)	(0.00143)	(0.00139)
Property Value ($ Millions)	-0.00222***	-0.00215***	-0.00225***	-0.00215***
	(0.00062)	(0.00028)	(0.00066)	(0.00028)
Adjustable Rate (d)	-0.88542***	-0.92709***	-0.88601***	-0.92913***
	(0.01558)	(0.01802)	(0.01556)	(0.01805)
Year Property Built	-0.00258***	-0.00064**	-0.00269***	-0.00067***
	(0.00036)	(0.00025)	(0.00036)	(0.00025)
Fair/Poor	0.10493***	0.05944*	0.10495***	0.06307*
	(0.03349)	(0.03442)	(0.03335)	(0.03452)
Good	0.03292	0.00876	0.03505*	0.01292
	(0.02025)	(0.01871)	(0.02010)	(0.01897)
Unknown	0.01319	-0.14078***	0.01448	-0.13761***
	(0.02168)	(0.02031)	(0.02151)	(0.02068)
Constant	9.25986***	5.62372***	9.47696***	5.68234***
	(0.72792)	(0.53484)	(0.73070)	(0.53515)
Observations	3630	5298	3630	5298
R^2	0.721	0.542	0.721	0.543

Note: All models are estimated using OLS with standard errors robust to heteroskedasticity. The omitted category for green participation is "Brown" and the omitted category for building condition is "Excellent." Debt per unit is expressed in thousands of dollars at origination. Fixed effects for property location (state), servicer, and year of origination are included in the model, but omitted from this table.

Table 6: Loan Purpose- Purchase Loan vs. Refinance Loan

	(1) Initial Interest Rate	(2) LTV	(3) Debt per Unit	(4) DSCR
Co2AvoidUnit	-0.00502	0.00837***	0.68137***	0.00820
	(0.00384)	(0.00293)	(0.06136)	(0.00584)
Number of Units	-0.00029***	0.00007***	-0.00139***	0.00037***
	(0.00007)	(0.00002)	(0.00028)	(0.00008)
Loan Term (months)	0.00181***	-0.00014	-0.00250***	-0.00005
	(0.00023)	(0.00009)	(0.00057)	(0.00038)
Occupancy Rate (%)	-0.00373*	0.00145*	-0.01284	-0.00058
	(0.00205)	(0.00075)	(0.00956)	(0.00334)
Property Value ($ Millions)	-0.00073*	-0.00066***	0.00723***	-0.00175***
	(0.00039)	(0.00014)	(0.00219)	(0.00037)
Adjustable Rate (d)	-0.82833***	-0.00975	-0.06716	0.08259**
	(0.02647)	(0.01038)	(0.12412)	(0.03574)
Fair/Poor	-0.01043	-0.02750	-0.24430**	0.03994
	(0.04643)	(0.02215)	(0.11649)	(0.06903)
Good	-0.01831	-0.01053	-0.10772	0.08985***
	(0.02672)	(0.01329)	(0.06726)	(0.03474)
Unknown	0.02570	-0.01539	-0.18561**	0.12735***
	(0.02682)	(0.01368)	(0.07419)	(0.03577)
Amortizing/Balloon	-0.09694	0.05641	-0.67725***	-0.41398*
	(0.13361)	(0.04985)	(0.19525)	(0.24238)
Interest Only/Amortizing/Balloon	-0.09165	0.10667**	-0.48231***	-0.13867
	(0.13185)	(0.04908)	(0.18132)	(0.23961)
Interest Only/Balloon	-0.04796	0.54794***	1.65249***	0.04443
	(0.19812)	(0.08586)	(0.58449)	(0.49918)
Refinance	-0.00353	-0.05995***	0.02152	0.14151***
	(0.01245)	(0.00501)	(0.04227)	(0.01773)
Supplemental	0.82972***	-0.47118***	-1.42304***	0.11940
	(0.08186)	(0.03444)	(0.34255)	(0.09962)
Year Property Built	-0.00213***	-0.00013	-0.00007	-0.00088*
	(0.00038)	(0.00015)	(0.00178)	(0.00050)
Constant	7.62368***	0.30489	1.57874	4.22804***
	(0.79894)	(0.30502)	(3.68058)	(1.14412)
Observations	2325	2230	2325	2325
R^2	0.748	0.495	0.759	0.417

Note: Co2 Avoided per Unit is the projected annual carbon dioxide emissions avoided in metric tons at loan origination divided by the number of building units. Debt per unit is expressed in thousands of dollars at origination. All models are estimated using OLS with heteroskadasticity robust standard errors. Only properties that participate in Green Rewards, and thus are required to report on Co2 emission savings projections, are included in this model. All models include issuance year, servicer, loan purpose, and state fixed effects. The omitted category for green participation is "Brown," the omitted category for loan type is "Fully amortizing," the omitted category for building condition is "Excellent," and the omitted category for loan purpose is "Purchase."

Table 7: Impact of Projected Co2 Emissions Avoided on Origination

	(1) Green	(2) Green Robust	(3) Green-Additional Vars	(4) Green Robust-Additional Vars
Population Density (1000s)			-0.00055	-0.00038
			(0.00107)	(0.00107)
Heating and Cooling Degree Days (1000s)			0.05291***	0.05087***
			(0.01810)	(0.01821)
% 4-Year College+			0.00207*	0.00207*
			(0.00119)	(0.00119)
Loan Balance per Unit ($100Ks)	-0.01552***	-0.01547***	-0.01482***	-0.01476***
	(0.00203)	(0.00203)	(0.00208)	(0.00208)
Number of Units	0.00046***	0.00045***	0.00045***	0.00044***
	(0.00004)	(0.00004)	(0.00005)	(0.00005)
Loan Term (months)	0.00039***	0.00039***	0.00038***	0.00039***
	(0.00009)	(0.00009)	(0.00009)	(0.00009)
Occupancy Rate (%)	0.00014	0.00010	0.00107	0.00103
	(0.00130)	(0.00132)	(0.00138)	(0.00140)
Property Value ($ Millions)	-0.00048**	-0.00039*	-0.00051**	-0.00043*
	(0.00022)	(0.00022)	(0.00025)	(0.00025)
Year Property Built	-0.00115***	-0.00114***	-0.00119***	-0.00116***
	(0.00021)	(0.00021)	(0.00023)	(0.00023)
Fair/Poor	-0.10979***	-0.11305***	-0.11679***	-0.12038***
	(0.02322)	(0.02343)	(0.02422)	(0.02440)
Good	-0.04781***	-0.05167***	-0.05521***	-0.05891***
	(0.01591)	(0.01607)	(0.01680)	(0.01694)
Unknown	0.04063***	0.03735**	0.03826**	0.03531**
	(0.01570)	(0.01588)	(0.01668)	(0.01684)
Refinance	-0.13929***	-0.14097***	-0.13773***	-0.13955***
	(0.01042)	(0.01050)	(0.01096)	(0.01105)
Supplemental	-0.29882***	-0.30116***	-0.30871***	-0.31136***
	(0.01512)	(0.01525)	(0.01519)	(0.01533)
Observations	9189	9133	8523	8467
R^2	0.2244	0.2448	0.2411	0.2417

Note: Outcome is 1 if property is part of a green building program, 0 otherwise. Green Robust excludes Brown loans with prior green credentials from the model. All models are estimated with logistic regression. All models include issuance year, servicer, loan purpose, and state fixed effects. Average marginal effects presented for logistic regressions. The omitted category for green participation is "Brown," the omitted category for loan type is "Fully amortizing," the omitted category for building condition is "Excellent," and the omitted category for loan purpose is "Purchase." Debt per unit expressed in thousands of dollars at origination.

Table 8: Propensity to be Green

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