Picking Up the PACE: Loans for Residential Climate-Proofing*

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Abstract

Residential Property Assessed Clean Energy (PACE) loans allow homeowners to fund investments in green residential projects through their property tax payments. We collect new PACE loan-level data and develop a novel approach to recover households' home improvement investment decisions from permit descriptions. PACE projects are capitalized into home values, but expansions of the property tax base are partially offset by an uptick in tax delinquency rates among borrowers. Lenders in PACE-enabled counties expand mortgage credit access, indicating improved recovery values despite a PACE lien's super seniority. Overall, PACE adoption increases local fiscal income while improving climate-proofing of the housing stock.

Keywords: PACE lending, property taxes, green retrofitting, home equity loans, delinquency, liens, securitization

JEL classifications: G21, G51, Q54, R21, R28

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1 Introduction

Making houses energy efficient is crucial for transitioning to a net-zero economy.[1] However, there are significant barriers to financing energy efficiency improvements (Giglio et al., 2021; Lanteri and Rampini, 2023). To help households finance such projects, several US states have passed laws enabling residential Property Assessed Clean Energy (PACE) loans. PACE is one of the fastest-growing public lending policies in the US.[2] Such loans have two characterizing features. First, eligible projects are limited to energy efficiency and/or climate resiliency improvements, such as solar panels or hurricane-resistant windows. Second, borrowers pay off PACE loans through their local property tax bill. In this paper, we provide the first micro-level empirical evidence of how housing and mortgage markets respond to PACE adoption. We show that PACE loans relax households' financial constraints without crowding out for-purchase or refinancing mortgages, while bringing net fiscal benefits to local governments in the form of greater property tax revenues.

There is substantial disagreement among market participants and policymakers about the merits of PACE financing. We use a stylized model to summarize the economic arguments of the debate and generate empirically testable predictions. On the positive side, PACE loans can relax homeowners' financial constraints. Local governments can finance such green projects, because a super seniority clause protects them from losses if borrowers default. Conversely, the presence of a PACE lien can influence primary mortgage supply. PACE loans increase households' leverage and thus raise bankruptcy risk, thereby encouraging lenders to reduce *ex ante* mortgage supply. At the same time, the collateral value of a mortgage may increase due to the capitalization effect of green projects into home values. Therefore, if a PACE-financed improvement generates high

[1] In 2022, the operations of buildings and accounted for 26% of global energy-related emissions; residences alone accounted for 16% of emissions (International Energy Agency, 2023). Annual investment in carbon-reducing retrofits would have to increase thirty-fold to reduce CO2 emissions in the residential sector by enough to achieve the goals set out by the 2016 Paris Agreement (Buchner et al., 2023).

[2] The residential PACE program reached \$9.1 billion in total loan dollars originated by the end of 2023, growing from \$1.4 billion in 2015. See Figure 1.

value, access to PACE financing can increase the mortgage recovery rate.

We then bring these empirical predictions to the data. We construct a new dataset where we observe the economic outcomes of PACE investments at the property owner level. We collect a sample of 55,519 PACE loans originated for home improvements located across 40 Florida counties by sending Freedom of Information Act (FOIA) requests to each county in Florida and to coalitions of PACE lenders. We then link each PACE loan to property-level data from the CoreLogic database. The CoreLogic data allow us to observe household outcomes, such as housing transactions, home equity-secured loans, building permit filings, property tax delinquency, and other liens, such as bankruptcy judgments.

We develop a novel approach to observe households' home improvement investment decisions. Specifically, we parse the text in memos attached to permit applications to classify projects permitted around the time of PACE loan origination into broad categories which are eligible for PACE financing. The largest fraction of PACE permits are for impact-resistant window and door installations (28%) and roofing repairs or reinforcements (26%), with smaller percentages attributed to modern Heating, Ventilation, and Air Conditioning (HVAC, 15%) and solar panel (9%) installations. In contrast, for non-PACE residential permits over the same time period, over half fall outside these four categories of projects explicitly eligible for PACE financing. This strong first-stage effect of PACE origination on green home improvements – together with coordinated paperwork required from contractors, lenders, and borrowers to finalize a PACE contract – indicates that fraudulent use of PACE funds is not widespread and would be difficult to achieve in practice.

A particular advantage of having detailed microdata is that we can leverage the staggered rollout of PACE across Florida counties and households over our sample period. We deploy a battery of modern difference-in-differences (DiD) estimators for staggered treatment to account for the fact that the treatment and control groups do not remain stable over time. We compare early to late PACE borrowers via Callaway and Sant'Anna

(2021)'s estimator, which, with the inclusion of neighborhood-specific time trends, helps us hold fixed the relative subprimeness of the PACE borrower pool. To bolster the validity of this research design, we show that properties of early vs. late cohorts of PACE borrowers are statistically and economically similar in terms of *ex ante* tax delinquency rates and observable characteristics that proxy for property quality.

We show that the projects financed by PACE loans increase borrowers' home equity value. Specifically, repeat sales properties undergoing PACE-funded home improvement projects experience an average total appreciation in home sale prices of 20%. This implies that, holding fixed any time-invariant quality differences across homes, PACE projects generate an average annualized capital gain for sellers of 24%, with only slightly lower returns after taking into account discounting, permitting fees, loan origination fees, and growth in households' property tax bills over time. Our estimates are comparable to the returns to home improvement projects calculated by Giacoletti and Westrupp (2018), who study the remodeling and sale behavior of house flippers in Los Angeles. We find the returns to PACE projects vary across permit type, with positive capitalization effects coming from both energy efficiency and climate-proofing projects. The returns to PACE projects also lie within the confidence intervals of hedonic valuations we estimate from sales occurring after non-PACE green home projects completed during our sample period.

One important prediction of our conceptual framework is that PACE loan access increases households' default risk, as their total debt-to-income ratio is higher than if they only retained a primary mortgage. We show that households taking out a PACE loan are more likely to be ever-delinquent on their property tax bills by 1 p.p. (a 20% increase) within a year of origination, relative to HELOC borrowers with properties featuring similar physical characteristics. However, these delinquencies are transitory in nature. Using tax lien sale records, we find that PACE properties are as likely as non-PACE properties to be in severe enough default to have a tax lien sold at auction, with no PACE property being tax foreclosed.

Finally, we find evidence that mortgage lenders increase their credit supply in response to PACE. Using loan application data from the Home Mortgage Disclosure Act (HMDA), we find that PACE adoption in a PACE county results in a 1.3 p.p. higher approval rate for first lien home purchase and refinance loans, representing a 1.5% increase in loan approvals. The interpretation of this result through the lens of our conceptual framework is that increased home values due to investment in PACE-qualified projects improve lenders' recovery values, leading to greater mortgage credit supply. Indeed, we find a stronger positive credit expansion effect for high-risk borrowers, driven by mortgage lenders increasing their approval rates for private-label securitized loans to this group.

To probe the robustness of these findings, we show that our results are similar regardless of whether we use never-treated counties (Sun and Abraham, 2021) or not-yet-treated (de Chaisemartin and D'Haultfœuille, 2020) counties as the control group. Importantly, we show that the *timing* of counties' formal PACE adoption is uncorrelated with a variety of local conditions, including household income, employment, racial demographics, municipal debt-to-revenue ratios, natural disaster declarations, and political vote shares. Turnover in the assessor's office negatively predicts PACE adoption in a county-year, mediated by cases in which residents have stronger surveyed concerns about climate change risks. Since both tax assessor retirements and the timing of elections for assessor positions are predetermined and unlikely to be correlated with local economic conditions, these findings support our identifying assumption of quasi-random timing of PACE passage with respect to mortgage market outcomes.

We combine our empirical estimates via back-of-the-envelope calculations to determine the desirability of adopting PACE from the perspective of local governments. Subtracting our estimate of revenue losses due to household tax delinquencies from the expansion of the property tax base through capitalization into housing values translates to higher per capita tax revenue for a county of between \$267 and \$623 per PACE loan-year based on prevailing effective tax rates.[3] Hence, although some PACE borrowers may be worse off from experiencing greater annual tax burdens or bankruptcy costs, local governments and prospective mortgaged homebuyers in PACE counties benefit from program adoption.

By focusing on households rather than firms, our paper extends the literature studying debt contracts which aim to improve energy efficiency and climate resilience. Examples of financial contracts targeting corporate sustainable investment include corporate green bonds (Zerbib, 2019; Tang and Zhang, 2020; Flammer, 2021; Baker et al., 2022b), sustainability-linked bank loans (Kim et al., 2022), and blended financing structures (Flammer et al., 2023). We depart from this literature by studying a new class of loan contracts, namely PACE loans, which represent a public-private partnership in providing contractual solutions that are instead targeted to households for green residential investment.

We build on research documenting the energy efficiency gap, as described in Gerarden et al. (2017) and Jaffee et al. (2019), and on public policies put in place to reduce it.[4] Several papers document low participation in residential energy efficiency programs despite the environmental benefits and positive private returns (Fowlie et al., 2015, 2018). A key factor that affects household participation in environmental retrofit projects is credit constraints (Berkouwer and Dean, 2022), which we also document but in the context of disaster-prone areas in a developed country.

A defining feature of PACE is that unlike other green policy nudges, it operates through relaxed screening standards rather than by subsidizing credit, as PACE lenders are not allowed to screen applicants on the basis of their credit score. Indeed, we find PACE households have lower income and wealth, and reside in properties which are smaller,

[3]We assume that 100% of the tax delinquencies are paid by the local government. This is a strong assumption, as PACE loans can be backed by municipal bond issues purchased by private investors (e.g. insurance companies), which attenuates our finding of a positive fiscal effect.

[4]Previous papers examine the role of efficiency standards (Hausman and Joskow, 1982; Clara et al., 2022), building energy codes (Jacobsen and Kotchen, 2013; Levinson, 2016), energy subsidies (Fowlie et al., 2015; Houde and Aldy, 2017; Fowlie et al., 2018; Hahn and Metcalfe, 2021), appliance rebate programs (Davis et al., 2014), as well as certification and labeling (Eichholtz et al., 2010; Myers et al., 2022; Lu and Spaenjers, 2023).

older, and have lower assessed values than HELOC households in the same neighborhoods. Relative to work on the energy efficiency gap, our paper provides the first empirical evidence that residential PACE loan programs broaden household access to borrowing for green property retrofits, especially for individuals facing *ex ante* binding financing constraints. Relaxing financing constraints, in turn, improves the value of real estate assets, leading to further expansions in household borrowing capacity (Favara and Imbs, 2015; Zevelev, 2020; Mazzola, 2024).

Our findings provide the first policy evaluation of local PACE programs with estimates on both the costs and benefits side. Our work provides an empirical microfoundation for the macroeconomic modeling simulations of commercial PACE loans in Rose and Wei (2020) by combining data covering the major stakeholders: governments, PACE borrowers, non-PACE homeowners, and lenders.[5] We also provide a large-scale analysis of PACE loans, thus establishing the external validity of Goodman and Zhu (2016), who examine sale prices for a subsample of 773 California houses with a PACE lien, and Kirkpatrick and Bennear (2014), who study the early stages of solar adoption via PACE in California between 2008 and 2010. [6] Millar and White (2024) observe a slowdown in county-level house price growth when counties roll out residential PACE programs. We show that this result cannot be driven by houses with a PACE lien, as we instead observe an increase in prices for such properties sold after their owners takeout a PACE loan.

The results of our paper generally align with those in the literature on the capitalization of green investments into house prices (Dastrup et al., 2012; Aydin et al., 2020; Gillingham and Watten, 2024). A distinguishing feature of our analysis is that we leverage granular data on building permits that allow us to document home improvement projects motivated by disaster-proofing rather than only energy efficiency concerns. This

[5]There are major structural differences between our setting and that in Rose and Wei (2020). First, Rose and Wei (2020) are concerned with the California commercial PACE program while our focus is on residential environmental retrofits. Second, we examine household participation and tax revenue implications, rather than the general equilibrium effects of the PACE program on local economies.

[6]Other related work includes Eichholtz et al. (2010) and Jaffee et al. (2019), who study the energy performance of commercial real estate, whereas we examine the residential property market.

is important given recent evidence that insurance markets in regions like coastal Florida are unraveling due to insurers exiting (Sastry et al., 2024), resulting in home and flood insurance premia rapidly rising in areas where PACE loans are also prevalent (Keys and Mulder, 2020, 2024).[7] At least a portion of the capitalization effects of PACE we uncover are due to pass-through to lower homeowners insurance costs, as Florida law requires insurers to provide discounts or credits to homeowners who take steps to strengthen their properties against wind damage.[8]

Finally, our paper adds to the economics and finance literature on environmental liability by studying a new class of liens that applies to households instead of firms. Most papers in this literature have studied the impact of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) liens on firm investment and borrowing decisions (Akey and Appel, 2021; Bellon, 2021; Chen, 2022). Our paper complements this literature by studying liens that back a different set of projects, namely resilience and energy efficiency investments in residential property.

2 Background on PACE Programs

General background. Over the last two decades, 38 states in the U.S. have passed legislation enabling PACE to provide financing for energy efficiency upgrades and disaster resiliency improvements for property owners. While most PACE programs focus on commercial properties, PACE financing is also available to residential property owners in California and Florida. Based on data provided by PACE Nation, Panel A of Figure 1 shows that the aggregate size of the residential PACE loan market has sharply increased since its introduction around 2010. By the end of 2023, the total amount of residential PACE financing reached approximately $9.1 billion.[9]

[7] Annual insurance premia for homeowners policies in Florida tripled between 2018 and 2023, increasing annually by 42% in 2023 alone (Bloomberg, 2024). Keys and Mulder (2024) document that this run-up in insurance costs was largely driven by pass through of reinsurance costs to high disaster risk areas.

[8] See the Homeowner's Insurance Wind Mitigation Discount Law (Section 627.0629 of the Florida Statutes): https://www.flsenate.gov/laws/statutes/2012/627.0629.

[9] The total size of the residential PACE market includes loans originated in Missouri, which adopted PACE in 2021 and repealed its PACE program in August 2024.

[Insert Figure 1 about here]

We focus on the Florida residential PACE program, for which we obtain a detailed sample of loans from two of the largest coalitions of PACE lenders, combined with public records received via FOIA requests submitted to each of Florida's 67 counties.[10] In Florida, state legislation (Chapter 163.08) has regulated PACE loans since July 2014. The Act refers to Chapter 2008-227, Laws of Florida, which outlines the role of PACE in the state's comprehensive plan to reduce reliance on energy-intensive carbon emissions and increase the energy efficiency and conservation of all end-use sectors. Given this goal, the Florida legislature has recognized a "compelling state interest" to provide additional financial means for property owners to undertake energy improvement and hurricane-hardening projects attached to their homes.

County-level adoption. Panel B of Figure 1 provides a map of counties classified by the current status of their residential PACE legislation. The figure highlights the prevalence of PACE programs across Florida, with most counties having enabled PACE financing at some point, except for a handful in the panhandle region. In 2011, Miami-Dade became the first Florida county to launch the program. The pace of adoption increased between 2015 and 2018, and by the close of 2020, the majority of large Florida counties implemented the program. Florida counties with PACE currently partner with four districts, each of which represents a coalition of administrators who screen loan applicants on behalf of the municipality. There are currently six administrators operating in Florida.

PACE loan procedures. Online Appendix A contains a detailed institutional description of PACE, which we summarize here. Homeowners are eligible for PACE loans regardless of their credit score, provided they have fulfilled all debt and tax obligations in the last three years prior to applying. PACE loans offer up to 100% financing for qualifying home improvements, with the loan amount generally capped at 20% of the appraised

[10]Relative to the Florida PACE program, the California PACE program has faced multiple statewide legal challenges and additions to consumer protection regulation, making it difficult to determine precise treatment statuses.

property value (as assessed by the county), except in specific cases. For the single-family homes in our estimation sample, the most common loan term is 20 years, with an average origination amount of approximately $30,000 and an average fixed interest rate of around 7%. Under state guidelines, lenders can perform hard credit inquiries to determine applicants' payment histories but do not use credit scores to determine eligibility or pricing. We calculate in Online Appendix H that such relaxed screening requirements result in PACE borrowers paying 155 basis points, on average, more than comparable HELOC borrowers.

Unlike traditional financing, PACE loans are repaid through property tax payments, which are attached to the property rather than the borrower.[11] This makes PACE loans "super senior" to other claims, such as mortgage liens, because delinquent property tax payments – including those with PACE assessments – take priority over other lienholders. Importantly, mortgage lenders cannot legally enforce covenants regarding the homeowner's decision to take out a PACE loan; for instance, they cannot demand early payment of the mortgage principal if a PACE loan is obtained. However, due to the super senior status of PACE liens, borrowers may be required by lenders or future buyers to pay off the PACE loan in full before refinancing or selling the property (Cox, 2011). The absence of prepayment penalties in a PACE loan facilitates such an operation.

Residential PACE loans are available for single-family homes, condos, vacant residential land, and small multi-family buildings. Prospective PACE borrowers can apply either directly through a district or administrator (the underwriter) or indirectly via a registered contractor. Once a loan is underwritten, the district forwards the loan terms to the local tax assessor, who generates a Notice of Assessment, which is also sent to the borrower as a loan disclosure form. In many records offices, clerks attach to the loan contract a Notice of Commencement on the improvement resulting from the building permit, helping prevent fraud.

[11] These PACE payments are based on a fixed interest rate determined at the time of loan origination, and they fully amortize the loan, similar to a standard fixed-rate mortgage.

[Insert Figure 2 about here]

PACE project types. The historical purpose of PACE is to finance projects that reduce the energy consumption of the house, such energy-efficient window installations. PACE-approved projects also include investments that improve the resistance of the house to natural disasters, such as impact-resistant windows. In Figure 2, we show a strong positive relationship between the energy efficiency and climate resilience ratings of window products sold in the U.S. Making a house more resistant to natural disasters can lead to lower energy consumption. This relationship is consistent with diffuse technical progress rendering home improvements using recent products more efficient on multiple dimensions. The example of windows, which are among the most common use of PACE funds in Florida, also highlights the empirical challenges with distinguishing between households' resilience versus energy efficiency motivations behind engaging in home improvement projects.

3 Conceptual Framework

We present a simple model in Online Appendix C that serves as a roadmap for our empirical tests. We summarize the economic intuition in this subsection. We build the framework on several features. First, PACE loans are senior to mortgage debt. This seniority structure means that if the lender repossesses the house, then PACE liabilities are inherited by the lender. Second, PACE loans allow households to finance a home improvement project that could not have been funded through another loan contract or a mortgage refinancing. While we do not fully microfound this hypothesis to keep the model tractable, we describe multiple reasons for why this assumption is realistic in Online Appendix C. In short, institutional frictions, such as credit scores, rigid loan-to-value rules, and fixed interest rates from a pre-existing mortgage that is lower than the current market rate, can prevent a household from refinancing their mortgage or taking out a HELOC. A unique feature of PACE loans is that they provides contractual tools ensuring that the household uses the funds towards a specific project completed by a reliable contractor, which improves the collateral's value.[12] Third, without loss of generality, we assume that households default on their mortgage because of an exogenous negative income shock, consistent with the fact that pure strategic default motivates are not a salient feature of the data. Households are strategic only to the extent that if they default, they do not repay their PACE and mortgage loans.[13]

The model consists of two periods. A representative household borrows money to buy a house in period 1. In period 2, the household takes out a PACE loan ℓ, to finance a project that costs ℓ and generates a pecuniary value of ΔH. The net present value of the project financed by a PACE loan is thus $\Delta H - \ell$, and we assume that this quantity is positive. Finally, at the end of the period 2, the household receives an income shock. The magnitude of the income shock is randomly generated. If the household is unable to pay back the PACE loan and/or the mortgage, then the household defaults and enters foreclosure. The lending market is competitive. Mortgage lenders offer a mortgage contract to the representative household so that their profit is zero. Mortgage lenders are more patient than the representative household. We assume a rational expectations equilibrium.

These assumptions yield the following predictions:

Prediction 1: *PACE financing increases a home's market value.*

Intuition: PACE loans finance projects that improve the value of the house. We assume that they have a positive net present value and that the equilibrium is rational. As a result, the value of the project is perfectly capitalized into house prices.

Prediction 2: *PACE loans increase the probability of households defaulting.*

Intuition: The representative household defaults if their income is below their total debt obligation. Taking out a PACE loan increases the household's total debt obligation,

[12] PACE programs make contracts more perfect by curating a list of approved contractors to implement the project and requiring underwriters, contractors, and tax assessor's offices to file documents certifying that work has begun on the financed project, which limits the scope for fraudulent uses of funds.

[13] While we assume the income shock is exogenous, we could easily interpret this exogenous income shock as being correlated with a drop in house prices, which would generate empirical predictions consistent with "double-trigger" models of default (Ganong and Noel, 2023).

which mechanically increases the probability of default. Importantly, projects financed by a PACE loan are attached to the house and thus illiquid. This feature of PACE loans rules out situations where households deleverage by selling the project that the PACE loan finances.

Prediction 3: *The supply of mortgage loans increases if PACE loans lead to house price appreciation and if the increase in default rates is sufficiently small.*

Intuition: PACE loans finance projects that improve the value of the collateral. Mortgage lenders recover a higher value from each foreclosure of a PACE property, as the PACE loan generates positive net present value. At the same time, there is an increase in mortgage default due to higher combined debt-to-income ratios, which reduces lenders' profits. In the event that default rates only negligibly rise, lenders' profits will grow. A competitive lending market then implies that in equilibrium greater profits from improved recovery values will lead to entry, and thus, an expanded supply of mortgage lending.

The remainder of the paper tests these three intertwined predictions. Specifically, we present evidence for these mechanisms by showing that PACE liabilities generate sizable house price appreciation (Section 5.2), lead to increased property tax delinquency rates (Section 5.3), and lead to greater *ex ante* mortgage credit supply based on lenders' approval rates of new loan applications (Section 5.4).

4 Data Sources and Descriptive Statistics

In this section, we describe how we link loan-level data from the Florida PACE market to property characteristics, building permits, mortgages, tax liens, and local damages caused by natural hazards. We compare property and borrower characteristics for PACE loans vs. closed-end home equity lines of credit (HELOCs), where the latter is the most similar alternative home equity loan contract typically used by borrowers to finance home improvement projects (Canner et al., 1998; Hurst and Stafford, 2004).

4.1 Data Sources

We use five datasets in our main analysis. The first is informational on residential Florida PACE loans originated 2015 and 2023. The second is the suite of products from CoreLogic that we merge together to obtain detailed information on deeds transactions, bankruptcy and tax liens, and permit information. The third dataset is loan applications and approvals from the Home Mortgage Disclosure Act (HMDA) covering private lending. Fourth, the Spatial Hazard Events and Losses Database for the United States (SHELDUS) consists of information on the geographic span and severity of severe weather events for Florida. Fifth, information on households' income, wealth, age, and the number of available credit lines, imputed from marketing research data provided by Data Axle. As HMDA, SHELDUS, and Data Axle have been widely used in previous research, we relegate descriptions of these databases to Online Appendix F.

PACE loan data. We obtain loan-level data originated in Florida by sending FOIA requests to each county in Florida and the four PACE districts. For each loan, we observe the property assessor's parcel number (APN) and the origination year. A property may be associated with multiple PACE loans. The data include 47,445 unique properties with at least one PACE loan originated in Florida since 2015, located across 40 counties. For our analysis, we aggregate PACE loans to the origination year level for properties with multiple PACE loans to build a property-year panel dataset.[14]

CoreLogic Data. We match the loan dataset to the CoreLogic *Owner Transfers* and Corelogic *Tax* data using the APN of each property.[15] *Owner Transfers* is a transaction-level dataset that includes information on house prices, buyers and sellers, and information about the use (e.g. single vs. multi-family) and location of the property. It

[14]There are no centralized official providers of data on PACE-financed investments. Administrators report loans into coalitions, called PACE districts or agencies, on a voluntary basis. Since PACE loans are implicitly backed by property tax revenues and municipal bond issues, counties and local courts retain basic information about the existence of PACE liens. However, complete information about loan contract terms is not part of the public record in most counties.

[15]CoreLogic recently renamed their legacy *Deeds* data product to *Owner Transfers*. The structure of the two datasets is the same, except the latter now has the unified panel identifier, a "CLIP," which can be linked across CoreLogic datasets to construct a property-level panel.

also provides details on when properties are traded. We focus on arms-length transactions of single-family and small multi-family properties (i.e. those with two to four units). To eliminate the impact of extreme outliers, we winsorize transaction values at the 1st and 99th percentiles.[16]

To obtain observable property characteristics, such as location and physical structure (size, bedrooms, age, etc.), we merge CoreLogic *Owner Transfers* to CoreLogic *Tax* using the CLIP id, which is the concatenation of the APN, parcel sequence number, and geolocation. CoreLogic *Tax* contains the tax assessment record for each property, including properties which are ultimately exempt from paying property tax. This allows us to continuously track valuations and recorded improvements to the property for both PACE and non-PACE properties. An advantage to studying the Florida PACE market is that properties in Florida are revalued by the local assessor each year. This is in contrast to many other states which feature long intervals between mass reappraisal of the property stock (e.g. every two years in Missouri).

We also obtain tax and bankruptcy lien data from CoreLogic's *Involuntary Liens* database. We calculate tax delinquency rates by pooling together all local tax liens, including property tax liens and liens placed for overdue user or impact fees, which might include sewer, trash, or public utilities fees. *Involuntary Liens* also contains information on liens resulting from bankruptcy judgments, although these are far more rare occurrences. A bankruptcy lien is placed on an asset after a personal bankruptcy declaration goes through the courts. In contrast, under property tax law, a tax lien is active on the property if its owner is in arrears on their tax bill at least one day after the due date for the prior tax year's liability (LaPoint, 2023).

One limitation to the *Involuntary Liens* dataset is that it is not possible to construct a lien-level panel, since there is no way to link to two lien events to the same underlying

[16] We identify arms-length transactions in the CoreLogic *Owner Transfers* data as those which have the internal flag PRI_CAT_CODE set to "A," indicating arms-length transfers. Our sample differs immaterially when we instead construct our own arms-length transaction flag by eliminating from the sample any REO or foreclosure transactions, any transactions involving two family members, and any instances where the owner and seller share a surname.

delinquency spell. This means that we cannot track the performance of PACE liens or the severity of a delinquency event by accounting for when the lien is removed from the property.[17] For this reason, we define delinquency as an absorbing state, meaning in our analysis we consider a property to be "delinquent" in a given year if while under the same ownership it has ever had a tax lien placed on it.

We merge in information on any for-purchase mortgage, refinancing, and home equity loans or lines of credit from CoreLogic *Mortgage*.[18] CoreLogic *Mortgage* reports the loan amounts, recording dates, contract details such as the loan maturity, rate type (fixed vs. floating), and lender and borrower names. We use the CoreLogic *Mortgage* data for three purposes. First, for some of our difference-in-differences analyses, we compare outcomes for properties with PACE loans to the outside option of financing via home equity lines of credit (HELOCs), which are the most common source of non-PACE financing for home improvement investments. In what follows, we define HELOCs as fixed rate home equity loans; our definition consists of nearly 99% of traditional, non-PACE home equity loans and conditions on any differential household preferences for fixed vs. floating rate debt.[19]

Second, we use CoreLogic *Mortgage* to compute combined loan-to-value (CLTV) ratios. This allows us to adjust for selection across the PACE and HELOC segments of the home equity loan market by matching the two borrower types on the basis of their equity stake in the property.[20] Third, we use mortgage contract terms, together with any history of refinancing activity tied to a property-owner combination, to back out the implied

[17]In FOIA requesting PACE records from individual counties participating in the program, we find that local governments usually do not separately log property tax payments towards the "normal" tax liability and the portion that goes towards amortizing the PACE loan. In some cases, information on the amortization schedule is available from the local court system which records details on the loan contract at the time of origination and termination. We discuss how we compile the payment data obtained through these FOIA requests in Online Appendix H.

[18]The legacy version of CoreLogic *Deeds* used to contain much of the information which is now contained in the more detailed, but separate CoreLogic *Mortgage* dataset.

[19]We do not include cash-out refinancing loans in this definition due to the fact that such loans combine rate refinancing with equity extraction, whereas PACE loans are a pure equity extraction. Cash-out refinancing loans are also less likely to be used for home improvement projects (Hurst and Stafford, 2004), which is the purpose of our treatment group of PACE loans.

[20]Generally, HELOCs have higher LTVs than PACE loans, but this is partially a function of the maximum principal drawdown limit set by the lender for the former. We compare LTVs for closed-end HELOCs and PACE loans in Online Appendix H.

mortgage amortization schedule. Beyond relying on rough proxies for the presence of escrow such as tenure in the house, this allows us to determine whether an individual would likely have an escrow account in place at the time they take out a PACE loan. We show in Section 5.3 that the spike in delinquency rates we observe following PACE loan origination is entirely driven by homeowners without an escrow account, or those who have remained in the house throughout our full sample period, pointing to the lack of salience of the property tax amongst long-time homeowners (Cabral and Hoxby, 2012).

The final component in our CoreLogic database is *Building Permits*, which tracks the universe of any building permit applications tied to APNs appearing in the other CoreLogic datasets. We merge in the set of building permits tied to PACE and non-PACE properties using the CLIP id. *Permits* includes the text description of the work tied to each permit application, the quoted costs of the work stipulated by the contractor on file, and the identities of the contractor and applicant.[21] We restrict our sample of permits to those pertaining to residential applications with three or fewer separate projects attached to the same permit, to those not pertaining to newly constructed homes, and to permits which have a final status of either "approved" or "completed."[22]

Crucially, the memo attached to each application provides information that allows us to isolate permitted projects with a PACE-approved use. Using standard string parsing methods, we divide up the permits into five mutually exclusive categories: HVAC, Roofing, Solar, Windows and Doors, and Other. Other includes any non-PACE home improvement projects such as interior remodelings, kitchen renovations, property expansions, and landscaping. We are careful to separate solar installations (Solar) which happen to be on the roof from roof repairs and reroofing (Roofing). We present the full list of keywords and methods we use to categorize permits in Online Appendix D.

[21]Depending on the application format in a jurisdiction, the text description of the project reflects either information reported by the applicant or by the town clerk filing the permit application.

[22]For some counties, there is no meaningful distinction between the two, as the contractor is not always required to confirm with the town planning office that the work has been completed.

4.2 Descriptive Statistics on PACE Adoption

We investigate what factors explain counties' introduction of PACE programs in Table 1. We run linear probability models where the dependent variable, $Adopted_{j,t}$ is an indicator variable equal to one if a county adopts PACE in a given year. We find that counties with lower unemployment rates, more pronounced climate concerns, and those experiencing more (lagged) natural disasters are more likely to introduce PACE programs. However, the predictive power of most economic, demographic, or political factors is only significant in the cross section; when we include county and year fixed effects (in columns 3 through 5), most of these factors do not significantly predict PACE adoption.[23]

What then is driving the seemingly random variation in county-level timing of PACE program adoption? We hand-collect information on changeovers in the leadership of each local tax assessor's office in Florida and find a correlation of the timing of PACE introduction with assessor turnover. In columns 2 and 4, we include a term that interacts local climate concerns from the Yale Program on Climate Change Communication Surveys with an *Assessor turnover* indicator, which flags cases where a new county assessor has entered the office.

On average, counties with new assessors are less likely to adopt PACE in the changeover year. However, we find a significantly positive estimate of the interaction term, suggesting that the (new) assessor's climate stance may drive PACE adoption in that county, especially since tax collectors are elected officials in Florida.[24] Since both tax assessor retirements and the timing of elections for assessor positions are predetermined and unlikely to be correlated with local economic conditions, these findings support our identifying assumption in the mortgage market analysis of Section 5.4 that the timing of county-level PACE adoption is quasi-random.

[23]Online Appendix I further shows that local governments' financial conditions, such as their debt-to-revenue, liquid assets, and debt service coverage, do not drive PACE adoption.

[24]Similarly, Baldauf et al. (2020) use the Yale Program on Climate Change surveys to document that individuals in climate change believer neighborhoods negatively capitalize sea level rise forecasts into house prices.

[Insert Table 1 about here]

Table 2 presents descriptive statistics for the key house characteristics and private lending variables we use in the empirical analysis. To thoroughly assess the characteristics of properties with a PACE loan, we also compare properties financed through PACE with those financed through HELOCs. A HELOC is a plausible alternative to a PACE loan, since both instruments carry low origination fees relative to alternative equity extraction products like cash-out refinancing options, and HELOCs are commonly used to fund home improvement projects.[25]

[Insert Table 2 about here]

Figure 3 conducts a balance test for *ex ante* characteristics of properties with an attached PACE loan vis-à-vis those with a HELOC. Properties with a PACE loan are smaller than properties with a HELOC, both in terns of total square feet and number of bedrooms. PACE properties consist of fewer residential units (i.e. they are more likely to be single-family homes). Moreover, properties with a PACE loan are significantly older, have lower market assessed values, and are more likely to have a prior history of tax delinquency. Households attached to PACE properties are younger, have lower imputed income and wealth levels, and fewer open credit lines prior to origination. These average differences between PACE and HELOC properties are quantitatively similar even after conditioning on the Census tract location. Overall, this evidence is consistent with the view that PACE loans provide credit to relatively financially constrained households, compared to borrowers taking out HELOC loans which carry lower rates, on average.

[Insert Figure 3 about here]

[25]HELOCs and closed-end home equity loans are also tax-advantaged in that interest paid on the credit line balance can be deducted from the borrower's taxable income. During tax years 2018–2025, HELOC interest is tax-deductible if the proceeds are used to "buy, build, or substantially improve the residence." For years prior to 2018, HELOC interest is generally tax-deductible regardless of the use of funds. See IRS Publication 936 Home Mortgage Interest Deduction.

5 Main Empirical Results

We present our main empirical results in this section. We analyze at the loan level how access to PACE financing corresponds to building permit activity. Next, we show the impact of PACE loans on loan delinquencies and how the projects they back are capitalized into home sale prices. Finally, we show that counties formally enabling PACE districts to originate loans does not result in mortgage credit rationing.

5.1 PACE Borrowers' Building Permit Decisions

To obtain PACE financing borrowers are required to state on the application their intended use of funds (e.g. asphalt shingle roofs, as in the sample contract in Online Appendix A), and the town clerk attaches a notice of commencement to the loan disclosure. However, our loan-level data from lender districts and counties do not consistently report the home improvement project type, leading us to use permits from CoreLogic matched to the parcel to obtain this information.[26] Examining homeowners' permitting decisions around the time of PACE loan origination is important for two reasons. One is to rule out systemic fraud – that is, cases where borrowers take out a PACE loan for a qualified green project only to instead use the proceeds exclusively towards other uses. The second is that we can gauge the timing of home improvement investments to guide our interpretation in Section 5.2 of the capitalization effects of PACE into home prices.

One challenge we face is that multiple projects can be filed under the same permit application, leading to instances in which the permit filing describes both PACE-eligible and PACE-ineligible projects. Households might lump different projects together under the same contractor given fixed costs (e.g., receiving a quote and scheduling the job) leading to complementarity between PACE investments and non-PACE investments and other sources of home improvement financing, whether internal (cash) or external

[26] Much of the information from the scanned copies of notices of commencement we obtained from the counties matches the permit information from CoreLogic. This includes the name and address of the registered contractor executing the project.

(HELOCs). Over half of permits on PACE loan properties feature multiple projects.[27] To address this measurement problem, we impose several restrictions on our sample of building permits:

(i) We restrict to properties listed on the permit application with a land use of either single-family, condominium, or small multi-family with fewer than four units.

(ii) We parse the text of the clerk's memo for each permit application to classify permits into five major categories: HVAC, Roofing, Solar, Windows and Doors, and Other. These categories reflect the vast majority of projects attached to PACE loans (Consumer Financial Protection Bureau, 2023). We then drop permits for which the categories are not mutually exclusive (e.g., the memo mentions undertaking a solar panel installation *and* window replacement). This results in us dropping only 6% of permits. We present in Online Appendix D the full list of keywords we text mine to define these categories.

(iii) We drop instances of duplicate permits, where duplicates are defined as a permit with the same effective date, issued in the same jurisdiction to the same APN with the same permit project type.[28] Such duplicates arise due to instances of incorrect recording, or in a small number of cases, because properties receive multiple PACE loans with a common project attached to each lending contract.

After applying these restrictions, our resulting sample consists of a panel of 52,651 unique permits tied to 26,434 distinct PACE properties. If we subset to permits filed within a year of a PACE loan being originated on the property, we obtain a subsample of 25,268 permits attached to 17,640 unique properties. Despite the Notice of Commencement required to

[27]We show in Section 5.4 that there is a negative effect on demand (i.e. applications) for home improvement loans at the Census tract level following a county's enrollment into PACE. However, PACE likely acts as a substitute for HELOCs for relatively small permit values, but as a complementary source of financing for larger jobs.

[28]Permit project type is a variable field created by CoreLogic, and there are almost 1,900 unique project types listed in our sample of PACE loans. Therefore, our definition of duplicate permits is fairly stringent.

execute a PACE contract, not all PACE loans match to a building permit in the CoreLogic data. This is because counties differ in how they exempt projects from permit filing, either by exempting certain project categories or exempting projects below a quoted cost obtained from a contractor. Moreover, many counties implemented exemptions for home rebuilding following severe storms occurring during our sample period.[29]

[Insert Figure 4 about here]

Figure 4 illustrates that the composition of permits issued to owners of properties with a PACE loan is strongly stilted towards projects with a clear PACE-qualified home improvement. Over our full sample period (Panel A), we classify 77.0% of permits approved on PACE properties within the same year of loan origination as green projects.[30] Of these, the majority (53.6%) includes impact-resistant window and door installations (27.9%) and re-roofing (25.8%). For permits approved on non-PACE properties over the same time period, only 48.1% have a PACE-eligible use, and hurricane-proof permits make up only 27.5% of the total. Panel B shows how this decomposition of permit types attached to PACE vs. non-PACE properties evolves over time as more counties adopt the program. In the early stages of counties' PACE adoption, permits for roofing dominate, with window and door installations becoming more prevalent in recent years and solar becoming less common; by contrast, for non-PACE properties there is virtually no variation in the breakdown of permit types over time. Figure 4 thus provides initial evidence of a clear first stage effect of PACE borrowing on green home investments.

[Insert Figure 5 about here]

[29]For example, Broward County (Fort Lauderdale) exempted permits related to rebuilding following Hurricane Irma in 2017: https://www.broward.org/Building/BuildingPermits/Pages/Permit-Changes-for-Hurricane-Irma-Repairs.aspx.

[30]Varying the length of the time window around PACE origination yields intuitive results. As we shorten the window around origination, the fraction of permits classified as "other" declines almost linearly. There is no consistent timeline for filing a permit relative to applying for a PACE loan, and in many towns retroactive permitting carries limited or no fines and fees.

In Figure 5 we run event studies in which the outcome is an approved permit for a specific project type and compare properties with PACE loans to those without PACE loans but with a history of permitted projects using Callaway and Sant'Anna (2021) estimator. We estimate the event study over an unzipped panel in which we have a dummy $Permit_{i,t}$ for each parcel APN indicating permit approval in a time t relative to PACE loan origination.

$$Permit_{i,t} = \sum_{t=-3,t\neq-1}^{+3} \beta_t \cdot PACE_{i,t} + \eta_i + \theta_{z,t} + \varepsilon_{i,t} \tag{5.1}$$

Following Roth (2024), we estimate equation (5.1) in long-differences for the pre-PACE and post-PACE coefficients, so that we can visually interpret pre-trends on the $\widehat{\beta}_t$ coefficients relative to the reference period $t = -1$. We follow this convention throughout the paper for research designs where we apply the Callaway and Sant'Anna (2021) estimator. In all event study specifications in Figure 5, we include 5-digit zip code $\times$ year fixed effects $\theta_{z,t}$. Doing so helps us hold fixed features of the locality such as the stringency of rules set by the town building code division, which might affect whether borrowers decide to apply for a permit or whether the town approves the project. Note that we do not include a vector of property characteristics, because the property's size and physical structure might be altered by permitted activities. Including characteristics $\mathbf{X}_{i,t-k}$ recorded from the property's assessment history as of k years ago would result in that vector being absorbed by the parcel fixed effects η_i.[31]

For each PACE-qualified project category, the permitting probability increases by between 2 p.p. and 4 p.p. within a year of origination, with noticeably stronger uptake of roofing and window and door permits. PACE borrowers are less likely to permit in the years prior to and directly following PACE takeup. The presence of a negative pre-trend is consistent with PACE properties being negatively selected due to financing constraints borrowers face. This observed timing helps validate our approach to constructing Figure

[31] Still, even though they are potentially bad control variables, when we include lagged characteristics $\mathbf{X}_{i,t-1}$ on the RHS of (5.1), our results hardly change.

4 in which we focus on permits approved within the same year as PACE origination. PACE properties are 10.8 p.p. more likely to have any PACE-eligible project (i.e. one of the four types pictured in Figure 5) permitted in the year of loan origination than control projects not associated with a PACE loan.[32] We also find that the probability of permitting within the "other" (non-PACE) category spikes by 1.4 p.p. within a year of origination. This points to the complementarity of PACE and non-PACE projects given fixed costs of home improvement investment decisions.

5.2 Capitalization of PACE Loans into House Prices

Counties introduce PACE programs primarily to stimulate investment in residential energy efficiency and climate resiliency. These investments might be capitalized into higher house prices for at least three non-mutually exclusive reasons. First, projects financed by a PACE loan can reduce user costs associated with homeownership, such as utility bills or insurance premia. Second, the future value of the house might be less uncertain if the house becomes more resilient to natural disasters.[33] Third, homeowners may derive non-pecuniary benefits from living in a house that is more energy efficient if they have taste-based reasons for engaging in green retrofits.

To evaluate the effect of PACE financing on house prices, we use transaction data for houses that received a PACE loan over a period of 9 years around each PACE loan from CoreLogic *Owner Transfers*, which we merge with CoreLogic *Tax* to obtain a history of physical characteristics recorded by the assessors for PACE properties. We find that 44% of properties with a PACE loan have a transaction record in this timespan. Because household demand for PACE loans is endogenous, comparing market prices for homes of PACE borrowers to those of houses unattached to PACE loans could be problematic. Our balance test in Figure 3 points to PACE properties being negatively selected relative to the counterfactual of HELOC properties. However, even if we were to control for these

[32] We uncover a 2.9 p.p. higher probability of permitting for a PACE-eligible project within a year of origination if we instead estimate equation (5.1), again via the Callaway and Sant'Anna (2021) estimator, but using not-yet PACE borrowers as the control group for current PACE borrowers.

[33] A house whose value is more certain would have a higher price through a discount rate channel.

differences along observable quality dimensions, PACE-financed properties may also be of unobservably lower quality, which would bias upward estimates in pricing regressions where we compare sales of properties with PACE financing to those which never obtained PACE financing.

To minimize this form of selection bias, we adopt a within-treatment group comparison approach. Specifically, we restrict our sample of house transactions to properties with a PACE loan. For each treated unit (i.e., a property with a current PACE loan), we set not-yet-treated units (i.e., properties that will receive a PACE loan in subsequent years) as the control group. We estimate the average treatment effect on the treated (ATT) using OLS as well as the estimator proposed by Callaway and Sant'Anna (2021).[34] Our regression equation takes the following form:

$$\log(Price_{i,t}) = \beta \cdot PACE_{i,t} + \gamma' \cdot \mathbf{X}_{i,t-1} + \theta_{g,t} + \delta_m + \varepsilon_{i,t} \tag{5.2}$$

where the dependent variable $\log(Price_{i,t})$ is the log transaction price of property i in year t. The main independent variable $PACE_{i,t}$ is an indicator equal to one for transactions occurring in year t after property i receives a PACE loan and zero for transactions before PACE loan is taken out. The vector of pre-PACE property characteristics $\mathbf{X}_{i,t-1}$ includes log square footage (winsorized at the 1st and 99th percentiles), bins for the number of bedrooms and bathrooms, and property age proxied by years built in 10-year bins, which we add only in robustness checks to avoid losing statistical power from the limited sample size. Additionally, we include dummies for PACE-financed permit types (HVAC, solar panel, windows, or roof), and geography (county, 5-digit zip code, or tract) × year fixed effects, $\theta_{g,t}$, to control for common factors such as local economic prospects that affect

[34] A possible drawback of the repeat sales approach is that timing and composition of property sales are endogenous. For instance, results might be driven by property "flippers." Specifically, institutional investors might buy up properties and then use PACE to get cheap credit relative to the credit lines they might use to do bulk renovations on a portfolio of properties. All results of Table 3 are robust to the owner-occupier or single-family property samples (not shown for brevity), suggesting that endogenous selection and behavior of institutional investors in the single-family market are not major concerns in our setting.

house prices in a narrowly defined geography.[35] The month-of-year dummies δ_m account for seasonality in housing transactions which leads to sellers earning higher capital gains when they sell in summer months. This phenomenon is pronounced even in tropical markets like Florida (Ngai and Tenreyro, 2014).

Figure 6 supports the notion that comparing early vs. later cohorts of PACE properties helps hold fixed the relative subprimeness of the PACE borrower pool. Even without conditioning on geographic fixed effects (Panel A), different annual PACE cohorts have similar incomes, wealth and credit access, and are statistically no more or less likely to have a prior history of tax delinquency, as indicated by a tax lien previously ever being placed on the property as of the year before origination; the standardized sample means for each cohort further shrink towards zero when we compare cohorts of PACE properties within the same Census tract. To the extent that some differences between the earliest and latest cohorts' properties remain, notably on the size and age dimensions, we include these observable characteristics as controls in pricing regression (5.2).

[Insert Figure 6 about here]

We first report OLS results in Table 3 from estimating equation (5.2). Column 1 of Table 3 includes county $\times$ year fixed effects. The coefficient is positive and statistically significant, suggesting that after PACE-financed retrofitting, properties are sold at a significant premium. Next, we add 5-digit zip code or Census tract $\times$ year fixed effects in columns 2 and 3. The coefficient remains positive and statistically significant. PACE borrowers may internalize the future home equity value increases and as a result of that decide to do other renovations on the house (wealth effect). To address these potential issues, we report results from specifications controlling for cumulative permitting activity *ex ante* ($t = -6$ to $t = -2$) in column 4, as well as *ex post* ($t = +2$ to $t = +6$) in column 5 of Table 3. The coefficient of interest is still positive and statistically significant

[35] Our results are nearly identical if we instead redefine the outcome variable as log price per square foot.

at the 1% level, although slightly lower in magnitude. This is consistent with the fact that returns to green projects may be over-estimated if one does not control for multiple renovations done on the home (Gillingham and Watten, 2024). Finally, the specification in column 6 adds four triple interaction terms combining the difference-in-differences (DiD) interaction with each type of permit that PACE finances. The triple DiD coefficients are all positive, and statistical significance is present in three (windows, HVAC, and solar) out of four project types, relative to the "other" reference category. Specific features of the investments or adaptability of the properties generate heterogeneous capitalization effects, and house price appreciation comes from climate resiliency (roof and windows) and energy efficiency (HVAC and solar) improvements, both of which lower the user cost of homeownership.

[Insert Table 3 about here]

Robustness tests. The time window of our main repeat sales sample includes the COVID-19 pandemic which may bias the estimates. In fact, selection issues may be due to specific flipper behavior during COVID. Therefore, we study the pricing effects of PACE loans splitting the sample of sales by transaction dates. Columns 1 and 2 of Table 4 focus on transactions occurring after, and before, March 2020 respectively. In both cases, the DiD coefficients are positive and statistically significant. The coefficient in the pre-COVID sample (column 2) is economically larger, possibly reflecting less contamination from strategic selling behavior. Therefore, we keep the pre-March 2020 sample for the rest of the specifications of Table 4. Column 3 adds property controls, which include bins of the number of bedrooms and bathrooms, log of square footage, and deciles of property age.[36] The coefficient remains statistically significant, but its magnitude halves with respect to the one in the previous column.

[36]Property characteristics are not available for all properties in CoreLogic data. Therefore, the sample size is reduced. To directly compare our results across specifications, we maintain the same sample composition in the specification with (column 2) and without property controls (column 3).

To address heterogeneous effects by origination year cohort, we adopt Callaway and Sant'Anna (2021)'s estimator for the results reported in the remaining columns, replacing Census tract × year fixed effects with zip code × year fixed effects to enhance estimation convergence. Column 4 shows the results of the specification without property controls. The coefficient is positive and statistically significant. It remains similar in magnitude and largely significant in column 5 as well, where we add property controls. In column 6, we focus on property transactions that have some permits recorded and that we classify under energy efficiency (HVAC or solar panel) or climate proofing (roof or windows) categories filed at the time of PACE loan origination. The results are statistically significant and double in magnitude, suggesting most of the value increase is not coming from projects that have unclassified permits, which are either low dollar value projects and thus exempt from permit filing, or otherwise coupled with a PACE ineligible project.

Next, we add PACE loan amount to the main specification with property controls. Doing so helps account for the fact that we do not directly observe the quantity of installations attached to a permit (e.g., the number of solar permits installed on a roof). The sample size shrinks substantially due to missing information on loan values, but the main coefficient of interest remains positive, large, and statistically significant. For completeness, in column 8 we run a specification on the (log) annual tax assessed values using a parcel-year panel data structure.[37] Using tax assessed values as the outcome serves two purposes. It allows us to overcome the selection inherent in repeat sales, while addressing the concern that any home equity gains realized by the homeowner may be mostly offset by increases in property tax bills caused by the PACE-funded improvements. PACE projects are capitalized into the property tax base by 1.7% – to a much lesser degree

[37]Tax assessed value refers to the combined value of the parcel's land including improvement values as provided by the county or local taxing/assessment authority and measured prior to the application of any tax exemptions or appeals. As we do for market prices, we winsorize assessed values at the 1st and 99th percentiles.

than transaction prices.[38]

[Insert Table 4 about here]

Our DiD event study approach identifies the plausibly causal effect of PACE financing under the assumption that house prices of treated and not-yet-treated properties would have followed parallel trends in the absence of receiving a PACE loan. Although this assumption cannot be directly tested, to get a clearer view of how the point estimates evolve over the term of the PACE loan, we include a set of lead and lag indicators around the loan origination year. Figure 7 reports the DiD from estimating dynamic versions of equation (5.2) in columns 4 to 7 of Table 4. In all cases, pre-period coefficients show that the average difference in transaction prices between a comparable non-PACE property and a not-yet PACE property is small and statistically insignificant. In contrast, the post-PACE coefficients are positive and statistically significant at the 1% level. This evidence supports the parallel trends assumption underlying our identification strategy. The economic magnitudes are similar across estimates produced in the specification with and without controls (blue and red coefficients), as well as across samples of properties with explicitly PACE-eligible permits issued within a year of origination, and conditional on loan value at origination (green and orange coefficients, respectively).

[Insert Figure 7 about here]

Individual returns. Considering the coefficient reported in Table 4 estimated with Callaway and Sant'Anna (2021)'s estimator, conditioning on property characteristics and restricting to climate-proofing permits in column 6, the average PACE property experiences sale price appreciation that is $(\exp(0.18) - 1) \approx 19.7\%$ greater than the

[38] The relatively low capitalization into assessed values is consistent with provisions of the Florida Save Our Homes Amendment of 1995, which limits annual increases in the assessed value of homesteaded properties to 3% or the change in the National Consumer Price Index (CPI), whichever is less. In unreported results, we find quantitatively similar results using the repeat sales sample but with tax assessed values as the outcome variable.

average property not yet with a PACE loan. To make sense of the economic magnitude, given an average sale price of roughly \$313,000 (see Table 2), the total capitalization effect is $\$61,661 = 19.7\% \times \$313,000$, or 2.3x the average value of the loan origination amount of \$27,000 in this subsample. Our pricing estimates effectively scale down the returns by the loan-to-cost ratio by controlling for other non-PACE permitted projects conducted on the property, suggesting that the treatment effect is economically sizeable and not driven by other home renovations.[39] The average holding period for home sellers who received a PACE loan is 3.8 years, implying a realized net capital gain of $(2.3)^{1/3.8} = 24\%$ on an annualized basis. The analogous net capital gain calculation is 8% if we include all projects – even those without a climate-proofing permit attached to the loan (column 5). This makes sense given that smaller dollar value projects are more likely to be exempt from local permit filing requirements, and that explicitly energy efficiency or storm-hardening projects capitalize lower utility bills and insurance premia.

The above ROI calculation does not include PACE loan origination fees in the denominator. We do not observe fees attached to our sample of loans. The Consumer Financial Protection Bureau (2023) tabulates average fees equal to 5% of the loan origination amount in their sample of four districts, including two districts from Florida. Origination fees not rolled into the loan principal include two potential sources of fees: the tax assessor's office and property appraisers contracted by the underwriter. In Florida, a statewide cap of 2% on each type of fee applies to all counties, and such fees are typically not paid upfront but linearly amortized through the annual tax payment (Snaith, 2023). Recomputing our ROI with fees imposed at the implied maximum 4% rate ($\approx$ \$1,200 in fees) results in a 2.1x multiple. Our individual return estimates are therefore comparable, but slightly larger than the 20% annualized abnormal capital gains relative to comparable REIT index funds, and slightly under the 30% premium relative to the aggregate stock

[39]Computing the loan-to-cost ratio directly using the *Building Permits* data is complicated by the fact that the quoted costs and the permit filing fees are available for only roughly half of our sample of PACE loans with a permit attached. Further, the quoted project cost at the time a permit is filed may not reflect the true cost of undertaking the project to the extent that additional materials and contractor labor may be required to complete the job.

market, calculated by Giacoletti and Westrupp (2018), who study the remodeling and sale behavior of house flippers in Los Angeles County.

In sum, our findings are broadly consistent with the policy goal of capitalizing environmental retrofitting into house prices through increased credit access. When combined with the fact that most PACE loans are taken up by households facing *ex ante* tighter financing constraints, we highlight an important benefit to incumbent homeowners and local governments in the form of increased home equity values enabled by publicly-backed financing programs that facilitate closing of the residential green investment gap.

5.3 The Effect of PACE Loans on Borrower Delinquency

The preceding analysis highlights a statistically significant and substantial premium in market values for PACE-financed houses. But a major critique of the residential PACE program is that repayments through property taxes could lead to increased tax delinquency. This concern is particularly relevant given that a large fraction of PACE loans are extended to lower-income and credit-constrained households, who may struggle to afford the property tax increases (Wong, 2024) or face greater difficulties in understanding the contract terms when signing the loan agreement (Agarwal et al., 2009; Lusardi and Mitchell, 2014). The average annual non-*ad valorem* payment of \$2,831.79 towards a PACE loan balance represents a 79% increase in the total combined property tax bill for the average borrower in Florida.

In this section, we assess the impact of PACE loans on tax delinquency. Our regression specification is similar to equation (5.2), but with the dependent variable now capturing local property tax delinquency at the property level:

$$Delinquent_{i,t} = \beta \cdot PACE_{i,t} + \gamma' \cdot \mathbf{X}_{i,t-1} + \eta_i + \theta_{g,t} + \varepsilon_{i,t} \tag{5.3}$$

where the outcome variable $Delinquent_{i,t}$ equals one in cases where property i has ever had a local tax lien involuntarily placed on it as of year t, indicating delinquency. We measure delinquency as an absorbing state, since lien removals are not systematically recorded in the CoreLogic *Involuntary Liens* data. Our results remain materially unchanged if we instead examine delinquency at the property-by-owner level, using the name(s) recorded on the title for assessment purposes matched to the name(s) listed on the lien flag.[40] $PACE_{i,t}$ is a dummy variable equal to one if property i has a PACE lien in year t and zero otherwise. The estimation sample underlying equation (5.3) is an unzipped panel of properties, meaning we set $Delinquent_{i,t} = 0$ as long as the property has never had a tax lien recorded as of year t.

We estimate different variations on this equation by including or excluding the vector $\mathbf{X}_{i,t-1}$ of property characteristics as control variables, as described in Section 5.2. We also run separate specifications with neighborhood $\times$ year fixed effects $\theta_{g,t}$ at different levels of geographic granularity, including the Census tract (defined according to 2010 decennial Census boundaries), county FIPS, 5-digit zip code levels, and tax code area (TCA). Including TCA fixed effects conditions on both a common statutory property tax rate and access to any amenities financed through the local property tax base (Amornsiripanitch, 2023). One can think of a TCA as a small neighborhood defined by the intersection of tax jurisdictional boundaries (e.g., the intersection of a school district and tax assessor's neighborhood), which allows us to isolate the behavioral aspects of PACE loan default from secular local increases in default rates due to increases in local tax burdens faced by all homeowners. Our results are largely impervious to the choice of geographic unit defining the neighborhood $\times$ time fixed effects $\theta_{g,t}$.

As with the house price analysis in the preceding subsection, we estimate equation (5.3) using the Callaway and Sant'Anna (2021) estimator. To avoid bias stemming from selection into PACE borrowing, we continue to compare tax delinquencies of properties with a PACE loan (treated group) to those that have not yet received a PACE loan

[40] Using the property-by-owner combination as the unit of analysis rather than individual properties helps isolate cases where a property may have been in arrears on its taxes, after which the previous owner sold the property, extinguishing the initial lien, and then the new owner who became a PACE borrower subsequently defaulted on their property tax bill.

(control group). Figure 8 Panel A plots the results from the event study. Across all specifications, we observe an abrupt jump in the probability of delinquency within the first tax year of PACE origination. The period $t = 0$ estimates are all statistically significant at the 1% level and correspond to an additional 1 percentage point increase in the probability of being tax delinquent within the same tax year after the household takes up a PACE loan. Moreover, the figure shows that (i) there are no pre-trends in local tax delinquency probability before PACE origination for the property; and (ii) the estimated ATT increases over time due to our definition of $Delinquency_{i,t}$ as an absorbing state – or what is called an "ever-delinquent" flag in the literature.

[Insert Figure 8 about here]

To probe the robustness and mechanism underlying these results, we construct an alternative control group consisting of properties with HELOC-financed retrofitting projects. We isolate HELOC loans associated with a permit issued within 6 months of origination and use those loans as the control group to re-estimate equation (5.3). As with the previous analysis, in Panel B of Figure 8 we find that following a PACE lien, tax delinquencies again increase significantly within the same tax year of origination. Since in this comparison the control units comprise properties with similar retrofits financed by HELOCs, the treatment effect is driven by PACE liens rather than undertaking the project itself. Therefore, our results support the view that PACE program adoption could lead to higher tax default rates.

How quantitatively important are these PACE-driven delinquency rates for the collection of property tax revenues? Answering this question is key to determining the net fiscal costs local governments incur by enacting PACE within their jurisdiction. Our baseline effect obtained from comparing current vs. not-yet PACE borrowers in Panel A of Figure 8 represents a 12% increase in tax delinquency in $t = 0$ relative to $t = -1$. The same effect for the HELOC vs. PACE borrower comparison in Panel B represents a

20% increase relative to the baseline $t = -1$ gap in delinquency rates between the typical (home improvement) HELOC and PACE borrower.

For our HELOC vs. PACE event study, we find a 2.5 p.p. increase in delinquency probabilities within three years of treatment ($t = 2$ full tax years post-PACE); this forms an upper bound estimate of the effect of PACE on tax default.[41] In Section 6, we combine our estimates for the property-level capitalization and delinquency effects of PACE to show that even using our upper bound estimate of a 2.5 p.p. uptick in delinquency rates – and assuming no partial default on the tax bill – PACE generates net fiscal gains for adoptor counties.

5.4 Mortgage Lending: *Ex Ante* Effects

Prediction 3 of our conceptual framework states that positive capitalization effect of PACE loans should translate into *ex ante* increases in mortgage supply. In this subsection we empirically determine how credit supply of primary mortgages reacts to introducing PACE programs at the county level.

We draw on borrower application-level HMDA data from 2010 up to and including 2019, harmonizing lender ID systems across HMDA vintages through the Woodstock Institute's Crosswalk file.[42] We isolate credit supply movements by focusing on loan approval decisions. We exclude cases in which the applicant withdrew their application, or the file was closed due to incompleteness. To avoid confounding effects of policies applied to secondary mortgage loans, we restrict the sample to mortgage applications for houses to be occupied as a principal dwelling, which includes both single-family and 2-to-4-unit homes.

Our regression equation for estimating the effects of county-level PACE adoption on

[41] We cautiously interpret our event study point estimates at horizons $t > 2$, as PACE is a relatively new program amongst the largest counties in our sample where the bulk of PACE loans occur, and our *Involuntary Liens* data end in 2022. The point estimates at $t > 2$ are identified off of a subset of borrowers located in early adoptor counties.

[42] The Woodstock Institute's Crosswalk File is accessible from https://woodstockinst.org/blog/hmda-lei-converter/.

mortgage lending is:

$$Lending_{i,l,c,t} = \beta \cdot PACE\ adoption_{c,t} + \gamma' \cdot \mathbf{X}_{i,c,t} + \alpha_c + \delta_t + \eta_l + \varepsilon_{i,l,c,t} \tag{5.4}$$

where the dependent variable $Lending_{i,l,c,t}$ measures lending decisions, such as lender l's approval, pricing, or securitization rates for borrower i in county c of year t. The variable of interest is $PACE\ adoption_{c,t}$, a dummy variable that equals one for county c in year t following formal legal enactment of PACE and zero otherwise. The vector $\mathbf{X}_{i,c,t}$ includes borrower characteristics such as dummy variables indicating the loan-to-income ratio, whether there are co-applicants, ethnicity, and gender. Finally, we include geography (e.g., Census tract) fixed effects, α_c, lender fixed effects, η_l, and year fixed effects, δ_t, to account for unobservable differences across regions, among lenders, and over time. We are mainly interested in β, which captures the effect of PACE access on mortgage lending decisions. The identifying assumption underlying this research design is that in the absence of any PACE programs, mortgage markets in counties that passed PACE legislation early would have evolved similarly to markets in counties that passed PACE legislation later.

We start by examining the effect of PACE access on the mortgage approval rate. The dependent variable is an indicator variable that equals one if a mortgage is approved, and zero otherwise. A positive estimate of β would indicate a positive effect of PACE programs on lenders' willingness to originate mortgages. In contrast, a negative β would suggest borrowers' access to PACE crowds-out private lending.

[Insert Table 5 about here]

We present results in Table 5. Column 1 shows a positive, statistically significant coefficient when controlling for Census tract, lender, and year fixed effects, as well as borrower and loan characteristics, indicating increased mortgage lending in PACE-enabled counties. Column 2 focuses on refinancing applications, showing a 1.6

p.p. increase in loan approvals, suggesting PACE enhances credit supply for both new and existing homeowners.

Panel A of Figure 9 shows that mortgage approval rates for purchases and refinancing significantly rise post-PACE adoption; coefficients are positive and significant only after adoption. This translates to a 1.3 p.p. higher approval rate for first-lien home purchases—a 1.5% increase from $t = -1$, which is economically meaningful.

In all specifications, $\widehat{\beta}_n$ coefficients show no pre-trend and are statistically insignificant, supporting our assumption that mortgage approval rates would have trended similarly between PACE and non-PACE counties if the program had not been enacted.[43]

[Insert Figure 9 about here]

Taken together, the preceding evidence supports the interpretation that households respond to PACE in a county, that PACE loans complement private primary mortgage lending and increase lenders' expected returns by accelerating environmental retrofitting and house price appreciation. Two channels can explain these findings. One explanation is that when an improved PACE property is sold, banks are more likely to extend credit to the borrower for purchasing a new, nearby property, due to the increased proceeds the borrower receives from the sale. The second explanation is that the adoption of the PACE program expands *expected* climate-proofing investment, prompting banks to be more willing to lend regardless of the number of actual PACE-financed properties in a given county (i.e., an anticipation effect).

There are reasons to believe that an anticipation effect exists, because we observe an immediate effect on bank lending at $t = 1$ (i.e. in the first year after program adoption), when PACE takeup and transaction volume for PACE-improved properties is low. On the other hand, Figure 9 shows that the treatment effect is increasing over time, consistent

[43]Online Appendix presents several robustness tests using the stacked DiD approach proposed by Cengiz et al. (2019) and Baker et al. (2022a), or replacing our news-based treatment dates with the year the first PACE loan appears in the tax roll data we received through Freedom of Information Act (FOIA) requests submitted to each county.

with more households taking advantage of the program by acquiring PACE loans over time. The time path of the $\widehat{\beta}_n$ obtained from the dynamic version of (5.4) supports the first explanation.

To shed light on the mechanism of (actual or expected) house value appreciation underlying our private lending results, we explore heterogeneity in borrower risk profiles for post-PACE mortgage originations. Our framework in Online Appendix C predicts that the positive effect on mortgage approvals is more pronounced for borrowers exhibiting greater *ex ante* risk of default. Unfortunately, lenders do not report into HMDA standard measures of credit risk (e.g., FICO scores). To capture borrower risk, we use the applicant's loan-to-income (LTI) ratio. Our choice of LTI as a proxy for risk is guided by the fact that households with a higher loan-to-income ratio are more likely to default on their mortgage following a negative income shock. We compare each applicant's LTI ratio with the median LTI value within a Census tract. If an applicant's LTI is above the median value in a given Census tract, we classify that applicant as high-risk. Similarly, low-risk applicants are those with a below-median LTI value. We then estimate equation (5.4) for high- and low-risk applicants separately. Columns 3 and 4 of Table 5 show the results of this sample split exercise. The coefficient in column 3 (high-LTI) is almost three times as large as the one in column 4 (low-LTI applicants). This evidence suggests the PACE effect on lending is most pronounced for high-risk borrowers.

Panel B of Figure 9 shows a clear divergence in approval rates for the two groups of applicants over the post-adoption period. We find that the ITT effect on mortgage approvals is driven by the high-risk group (red points) as the estimates of β are both statistically and economically larger than those for the low-risk group (black points). This points to lenders reallocating mortgages after PACE introduction towards borrowers who appear *ex ante* riskier. Our proposed mechanism is that green installations increase the collateral value of homes, which is consistent with our tests in Section 5.2 documenting the positive impact of PACE loan take-up on house values.

Next, in column 5 of Table 5 we explore mortgage securitization decisions after PACE passage to help resolve the puzzle that credit supply expands despite the negative effect of the super seniority of property tax liens on the liquidity of mortgages in the secondary market. We estimate similar regressions to those specified in equation (5.4) and replace the dependent variable with dummies for securitization decisions. Specifically, we focus on private-label securitization, such as banks or non-bank financial companies, vis-à-vis securitization by the government sponsored enterprises (GSEs). The coefficient in column 5 is positive and statistically significant, suggesting a shift to private securitization after PACE is adopted in a county. This result is consistent with the ban on PACE-lien securitization imposed by Fannie Mae and Freddie Mac in July 2010 after the state of California formally passed its PACE legislation. Panel C of Figure 9 shows that PACE adoption increases private-label securitization, with positive and statistically significant coefficient estimates of the ITT effect on approvals for the years following PACE implementation in a county. Lenders substitute towards private-label securitization to circumvent the GSE ban on purchases of PACE-levered mortgages.

Finally, we study the effect of PACE on lenders' pricing decisions by focusing on home purchase loans in column 6 of Table 5 and in Panel D of Figure 9. The DiD coefficient of a regression is estimated following equation (5.4) by replacing the outcome variable with the mortgage rate (APR) at origination. The coefficient is positive and significant at the 5% level. This suggests PACE motivates lenders to charge higher interest rates due to a higher probability of tax default (as shown in Section 5.3). Taken together, our evidence points to a lower expected loss given default for lenders due to higher collateral values, while in the case of non-default, lenders expects to receive more on-time mortgage payments.

6 Discussion of Local Cost-Benefit Implications

By contrasting the benefits of capitalizing PACE loans into house prices with the potential costs of increasing delinquency rates, the evidence presented above highlights the tension surrounding the introduction of PACE programs, as raised by policymakers and regulators. We perform a simple back-of-the-envelope calculation to assess the direct net benefit (cost) of PACE from the perspective of the local tax office:

$$\Delta R_{t,t+1} = \underbrace{\tau_{t+1}}_{\text{effective tax rate}} \times (\underbrace{\Delta P_{t,t+1}}_{\text{capitalization effect}} - \underbrace{\Delta D_{t,t+1} \cdot P_t}_{\text{revenue lost from delinquency}}) \tag{6.1}$$

where $\Delta R_{t,t+1}$ is the change in local property tax revenue. The first term in (6.1) represents the benefit of PACE, which is the positive change in revenues due to the average increase in home values. We subtract from the capitalization effect revenues lost from an uptick in the delinquency rate $\Delta D_{t,t+1}$ on the prior year's tax bill. We suppress the county subscript, although, in principle, both the local effective tax rate $\tau_{j,t+1}$ and the ATT effect could vary by jurisdiction.

Evaluating equation (6.1) using our ATT estimates from Section 5.2 and 5.3, we derive an estimated net tax benefit of between \$267 and \$623 per borrower-year. To calculate effective tax rates $\tau_{j,t+1}$, we follow the methods of Horton et al. (2024). Since our estimates of the capitalization effects of PACE are in terms of market prices, we use an effective tax rate (ETR), which is equal to the tax bill divided by the sale price. In contrast, a statutory tax rate is the tax bill divided by the tax-assessed value. We use the pre-COVID period overlapping with our PACE loan sample (2015–2019) to calculate tax rates to avoid any mis-measurement related to tax assessments being delayed by the pandemic. We find the average Florida county levies a 1.15% ETR; if we instead drop extreme transaction values at the 1% tails of the distribution, the average ETR is 1.24%.

Based on our estimates in Section 5.2 and Section 5.3 and ETRs across Florida counties, the direct net effect on local tax income is $1.15\% \times (\$31,000 - 0.025 \times \$313,000) = \$267$ at the lower end, and \$287 for our upper-bound estimate of the average effective tax rate if we use the pre-COVID estimation sample and CSDID estimator (column 5 of Table 4). The analogous fiscal gains if we further restrict to capitalization due to climate-proofing projects (column 6 of Table 4) are $1.15\% \times (\$62,000 - 0.025 \times \$313,000) = \$623$, or

$672 if we feed in a 1.24% average ETR. $313,000 represents the average property sales price in our estimation sample. We use the three-year change in the ever-delinquency rate of 2.5 p.p. from the HELOC vs. PACE difference-in-differences estimates of Figure 8 in this calculation. Using the uptick in delinquency rates implied by the HELOC vs. PACE borrower comparison instead of the early vs. late PACE research design leads to more conservative estimates of the net fiscal gain.

There are at least three reasons to believe that our estimates offer lower bounds on the fiscal benefit of PACE programs to local governments. First, we rely on the strong assumption that 100% of the fiscal costs induced by tax delinquencies are paid by the local government. In reality, many PACE loans are backed by private investors, who would at least partially absorb tax losses in the case of default. Second, we do not directly model the spillover effect of PACE programs on the local economy, including potential job creation and related investment spending. Research on the macroeconomic benefits of PACE in California suggests that a $4 million increase in PACE financing leads to a $10 million increase in local gross output (Rose and Wei, 2020). Therefore, on average, local governments are likely to benefit from program adoption and face strong incentives to enroll if the property tax base is a sufficiently large fraction of revenues. Third, PACE loans finance projects that aim at reducing negative externalities. We do not quantify the pecuniary value of the potential reduction in negative externalities, such as carbon emissions, or mitigation of unraveling home insurance markets, attributable to the projects financed by PACE loans.[44]

7 Conclusion

This paper offers the first systematic evidence on the tradeoffs of the PACE program to assess its effectiveness towards improving the resilience and energy efficiency of the housing capital stock in the face of climate change. We develop a new approach to classify households' green home improvement investments and build a new loan-level dataset

[44]If PACE projects increase households' disposable income by reducing the user costs of homeownership, then this may, in turn, lower the probability of tax default in the future.

linked to property tax, transaction, and permit records to present three main results.

First, PACE-financed properties experience a significant increase in market value compared to otherwise similar properties that have not yet received a PACE loan. On average, the appreciation in house prices is greater than twice the amount of the PACE loan, implying an annualized net capital gain of 24% for borrowers who subsequently sell their home. Second, we show that tax delinquency rates increase by 1 to 2.5 percentage points after PACE borrowers take out the loan. This effect is driven by older property owners without an escrow account for whom property tax bills are less salient. Third, we find no evidence supporting the concern that PACE financing crowds out private mortgage lending. In fact, private mortgage approvals increase in counties that have opted into the PACE program, consistent with our evidence that PACE-financed retrofits enhance the property's collateral value.

These three results are consistent with a stylized model where PACE loans reduce households' financial constraints. Lenders are more willing to grant a PACE loan than a traditional home improvement loan because they are exposed to little potential loss in the event of default. Houses with projects featuring greater net present values trade at higher sale prices. As a result, PACE loans lead to improved collateral recovery values, raising lenders' profits and encouraging *ex ante* mortgage supply through market entry.

Our results together suggest PACE loans are an effective financial innovation towards closing the residential green investment gap. The local government backing of PACE loans through the property tax base helps solve the market failure of under-investment in NPV-positive, climate-resilient home improvement projects – due, in part, to the presence of *ex ante* liquidity constraints – but without leading to an unraveling of mortgage markets. While we do not assess other impacts on housing costs, such as energy or insurance savings, or potential positive externalities of PACE, such as local physical capital investment and job creation (which we leave for future research), a simple cost-benefit analysis based on our estimates indicates that the net fiscal benefit to local tax offices amounts to roughly \$600 per borrower per year. As more data on household-level cash flows becomes available, future research will highlight the spillover effects of PACE programs to the user costs of homeownership.

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TABLE 1. Determinants of PACE Adoption at the County Level

Dep. variable: PACE Adopted	(1)	(2)	(3)	(4)	(5)
Population	-0.019	-0.002	-0.430	-0.034	0.519
	(0.069)	(0.070)	(1.022)	(0.994)	(1.353)
Household median income	0.786**	0.544	-0.177	-0.170	0.074
	(0.346)	(0.392)	(0.343)	(0.334)	(0.425)
% Bachelor's degree or higher	-1.890**	-1.810**	1.663	1.300	1.597
	(0.783)	(0.773)	(1.312)	(1.218)	(1.385)
% Black	0.915	1.981	0.886	0.636	-1.255
	(2.487)	(2.350)	(2.647)	(2.560)	(4.137)
% Latino	1.232	1.960	-2.123	-1.269	-5.482
	(2.167)	(2.051)	(7.169)	(6.792)	(8.669)
% White	0.791	2.030	-5.302	-1.909	-5.828
	(2.168)	(2.022)	(4.788)	(5.036)	(6.861)
Unemployment rate	-4.182***	-3.856***	-0.566	-0.886	-0.389
	(1.435)	(1.243)	(1.233)	(1.226)	(1.345)
Municipal debt/Revenue	0.019	-0.005	-0.012	-0.018	0.008
	(0.038)	(0.039)	(0.028)	(0.026)	(0.024)
Democratic leaning	1.304**	0.488	-0.778	-1.100	-1.586
	(0.637)	(0.589)	(1.120)	(1.020)	(1.327)
Neighbor PACE	0.043	-0.060	0.046	0.026	-0.017
	(0.103)	(0.097)	(0.085)	(0.087)	(0.079)
#Declared natural disasters	0.130***	0.094***	-0.019	-0.026	-0.034
	(0.025)	(0.027)	(0.028)	(0.029)	(0.039)
Abnormal property damage	-0.000	-0.000	-0.000	-0.000	-0.001
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Climate concerns		0.038***		0.021	0.029
		(0.012)		(0.019)	(0.022)
Assessor turnover		-0.009		-1.232**	-1.322*
		(0.731)		(0.525)	(0.709)
Assessor turnover × Climate concerns		-0.000		0.023**	0.024*
		(0.013)		(0.010)	(0.013)
Sample	All	All	All	All	Pre-2020
Observations	466	466	466	466	344
R-squared	0.340	0.385	0.708	0.724	0.689
County FE	No	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes

Note: This table examines whether a county's economic, political, or demographic conditions predict the adoption of PACE programs. The dependent variable is an indicator equal to one ($Adopted_{j,t}$) if a county j has adopted PACE in that year t. Columns 3 and 5 include county fixed effects and year fixed effects. Standard errors are reported in parentheses and clustered at the county level. County population is from the Census; the fraction of Black, Latino, and White population, household median income, education attainment, and unemployment rate are from the American Community Survey; county-level debt-to-revenue ratio is from Willamette University's Government Finance Database, which is based on the Census Annual Survey of State and Local Government Finances; Democratic leaning comes from Florida Department of State's Election Reporting System and measures the county-level voting share for the Democratic presidential candidate in the most recent presidential elections; Neighbor PACE is a dummy variable equal to one if one or several neighboring counties have an effective PACE program in year t; "climate concerns" measures the percentage of people in a county who are worried about global warming, as indicated by the Yale Program on Climate Change Communication surveys (Howe et al., 2015; Marlon et al., 2022); Assessor turnover is a dummy which turns on when a new county appraiser assumed the position in that year; # Declared natural disasters come from FEMA and measures the number of natural disasters in year $t-1$; Abnormal property damage, as reported by SHELDUS, is defined as deviations in property damage caused by natural hazards (on a per capita basis) in $t-1$ from their historical means (i.e., from 1960 to 2008). $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

TABLE 2. Summary Statistics for House Price and Lending Samples

	N	Mean	Std. Dev.	p5	p95
Panel A: House Price Analysis (CoreLogic-PACE matched repeat sales sample)					
Sale amount$_{i,t}$	20,947	313,435	178,773	103,000	625,000
log(Price)$_{i,t}$	20,947	12.51	0.55	11.54	13.35
log(AssessValue)$_{i,t}$	20,941	11.90	0.66	10.78	12.89
HVAC$_{i,t}$	20,947	0.075	0.26	0	1
Solar$_{i,t}$	20,947	0.040	0.20	0	0
Roof$_{i,t}$	20,947	0.11	0.31	0	1
Windows$_{i,t}$	20,947	0.14	0.35	0	1
Ex-ante Permits$_{i,t}$	20,947	0.45	1.01	0	2
Ex-post Permits$_{i,t}$	20,947	0.10	0.43	0	1
Bedrooms$_{i,t}$	17,912	2.97	0.89	2	4
Bathrooms$_{i,t}$	18,493	2.08	1.55	1	3
log(square footage)$_{i,t}$	20,685	7.37	0.35	6.82	7.98
Age deciles$_{i,t}$	20,682	5.44	2.90	1	10
Panel B: Mortgage Lending Analysis (HMDA sample)					
Approval$_{i,l,c,t}$	2,137,224	0.842	0.364	0	1
PACE$_{i,c,t}$	2,582,095	0.427	0.495	0	1
Private securitization$_{i,c,t}$	1,818,279	0.328	0.469	0	1
Rate spread$_{i,c,t}$	625,475	0.945	1.712	-0.19	2.25

Note: This table reports the summary statistics of the key variables used in the house price analysis (Panel A) and in the mortgage lending analysis (Panel B).

TABLE 3. OLS Estimates for PACE Loan Effects on House Prices

Dep. variable: log(Price)	(1)	(2)	(3)	(4)	(5)	(6)
$PACE_{i,t}$	0.047***	0.040***	0.041***	0.047***	0.039***	0.027***
	(0.008)	(0.006)	(0.004)	(0.004)	(0.003)	(0.006)
$PACE_{i,t} \times Roof_i$						0.0202
						(0.017)
$PACE_{i,t} \times Windows_i$						0.024**
						(0.010)
$PACE_{i,t} \times HVAC_i$						0.024**
						(0.010)
$PACE_{i,t} \times Solar_i$						0.059**
						(0.027)
Observations	20,947	20,947	20,947	20,947	20,947	20,947
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
County × Year FE	Yes	No	No	No	No	No
Zip code × Year FE	No	Yes	No	No	No	No
Census Tract × Year FE	No	No	Yes	Yes	Yes	Yes
Ex-ante Permits	No	No	No	Yes	Yes	Yes
Ex-post Permits	No	No	No	No	Yes	Yes
Mean Dep. Var.	12.422	12.422	12.422	12.422	12.422	12.422

Note: This table presents the DiD regression coefficient estimates using the OLS estimator. The dependent variable in each column is the log sale price of a property. Treatment is a PACE loan attached to the property, and the control group is composed of not-yet-treated properties. Coefficients in columns 4 to 6 are estimated in regressions controlling for the cumulative number of permits in the 6 to 2 years before PACE loan origination (*ex ante*), while those in columns 5 and 6 add also the cumulative number of permits filed in the 2 to 6 years after PACE loan origination (*ex post*). All specifications include permit type dummies according to our classification scheme described in Online Appendix D, which are interacted one-by-one with the $PACE_{i,t}$ variable in column 6. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

TABLE 4. Robustness: ATT Estimates for PACE Loan Effects on House Prices and Pre-Exemption Tax Assessed Values

Dep. variable:	log(Price)							log(TaxValue)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$PACE_{i,t}$	0.031***	0.040***	0.016***	0.095***	0.091***	0.180***	0.184***	0.017***
	(0.008)	(0.006)	(0.004)	(0.013)	(0.034)	(0.050)	(0.061)	(0.003)
Pre-/Post-COVID	Post	Pre	Pre	Pre	Pre	Pre	Pre	Pre
Loan sample	All	All	All	All	All	Permitted	LoanAmt	All
Estimator	OLS	OLS	OLS	CSDID	CSDID	CSDID	CSDID	CSDID
Observations	7,835	10,767	10,767	16,436	16,436	7,387	4,707	104,841
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Property Controls	No	No	Yes	No	Yes	No	Yes	Yes
Census Tract × Year FE	Yes	Yes	Yes	No	No	No	No	No
Zip code × Year FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	12.740	12.287	12.287	12.287	12.287	12.312	12.420	12.066

Note: This table presents the treatment effects on the treated (ATT) regression coefficient estimates using OLS (columns 1-3) or Callaway and Sant'Anna (2021)'s estimator (column 4-8) aggregated using group-time average. In reporting Callaway and Sant'Anna (2021)'s estimates, we follow Roth (2024) and use long-differences for the pre-treatment and post-treatment coefficients to better interpret pre-trends relative to the reference period $t = -1$. The dependent variable in columns 1-7 is the log sale price of a property, while in column 8 is the tax assessed value of the land. Treatment is a PACE loan attached to the property, and the control group is composed of not-yet-treated properties. Coefficients in columns 1, 2, 4, and 6 are estimated in regressions without property controls. Those in columns 3, 5, 7, and 8 includes property controls (bins for number of bedrooms and of bathrooms, log of floor space, age deciles dummies). We winsorize floor space at the 1st and 99th percentiles. The sample in column 1 includes property sales whose transactions took place after March 2020, samples in column 2 to 7 before March 2020, and in column 8 before the 2020 property tax year. All specifications include *ex ante* and *ex post* permitting activities as well as permit type dummies according to our classification scheme described in Online Appendix D. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

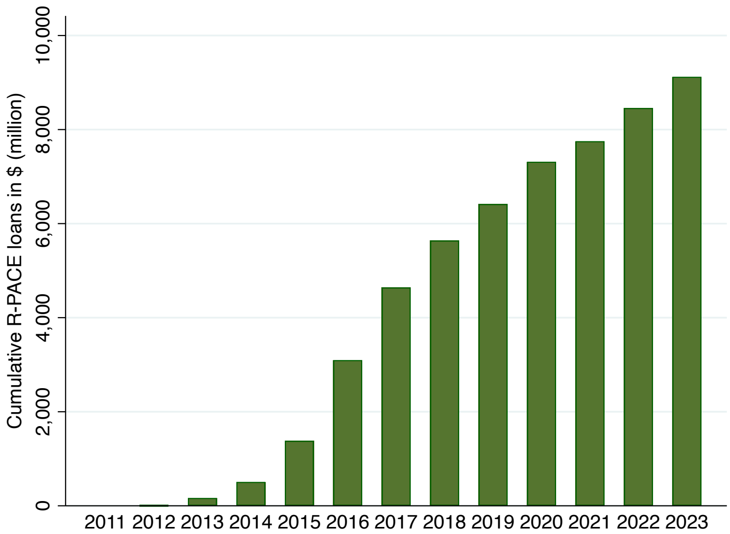
TABLE 5. Impact of PACE Adoption on Mortgage Credit Outcomes

Dep. variable:	Approval				PriSec	RateSpread
	(1)	(2)	(3)	(4)	(5)	(6)
PACE adoption$_{c,t}$	0.013***	0.016***	0.021***	0.008***	0.010***	0.016*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.009)
Loan type	Purchase	Refinancing	Purchase	Purchase	Purchase	Purchase
Borrower Sample:	All	All	High-risk	Low-risk	All	All
Observations	2,136,429	1,705,797	1,037,778	1,098,026	1,817,657	624,855
R-squared	0.086	0.178	0.090	0.089	0.523	0.153
Census tract FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Lender FE	Yes	Yes	Yes	Yes	Yes	Yes
Borrower Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.843	0.843	0.836	0.874	0.328	0.945

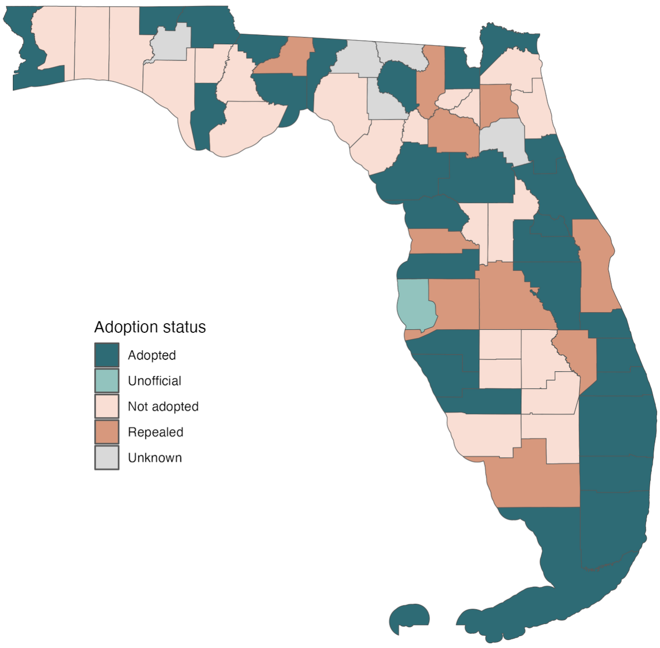
Note: This table reports the impact of county-level PACE adoption on mortgage application acceptance, securitization and pricing (interest rate) decisions (supply). We restrict the sample to mortgage applications for one-to-four-family houses intended to be occupied as a principal dwelling. The outcome variables are the dummy variable $Approval_{i,l,c,t}$ taking value one if lender l approves mortgage application i for a house in county c in year t (columns 1 to 4); $PriSec_{i,l,c,t}$, a dummy variable taking value 1 if the mortgage loan is sold to private investors via securitization within the year of origination, and zero otherwise (rejected, or GSE-securitized) (column 5); $RateSpread_{i,l,c,t}$, the interest rate on originated loans (column 6). $PACE\ adoption_{c,t}$ is a dummy variable that takes the value one if county c has introduced R-PACE in year t, and zero otherwise. Borrower controls include the loan-to-income ratio, ethnicity, gender, and presence of co-applicant. The samples in columns 3 and 4 consist of applicants with above tract-median LTI (high risk) and below tract-median LTI (low risk), respectively. We produce each estimate by taking a pooled difference in means via Sun and Abraham (2021)'s estimator. Robust standard errors clustered at the county level in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

FIGURE 1. PACE Program Size and County-Level Adoption in Florida

A. Total Amount of PACE Loans Originated



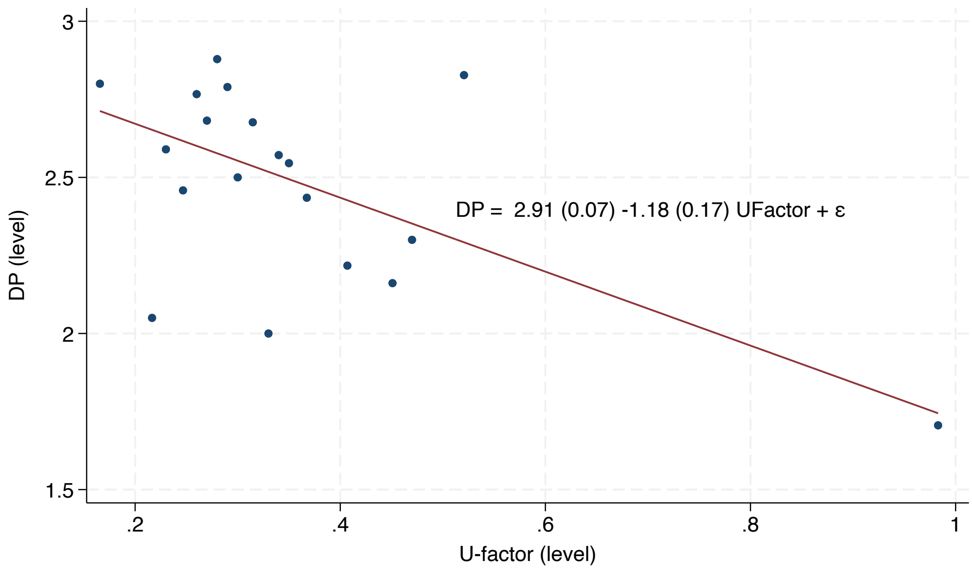
B. County-Level Adoption of Florida Residential PACE Programs



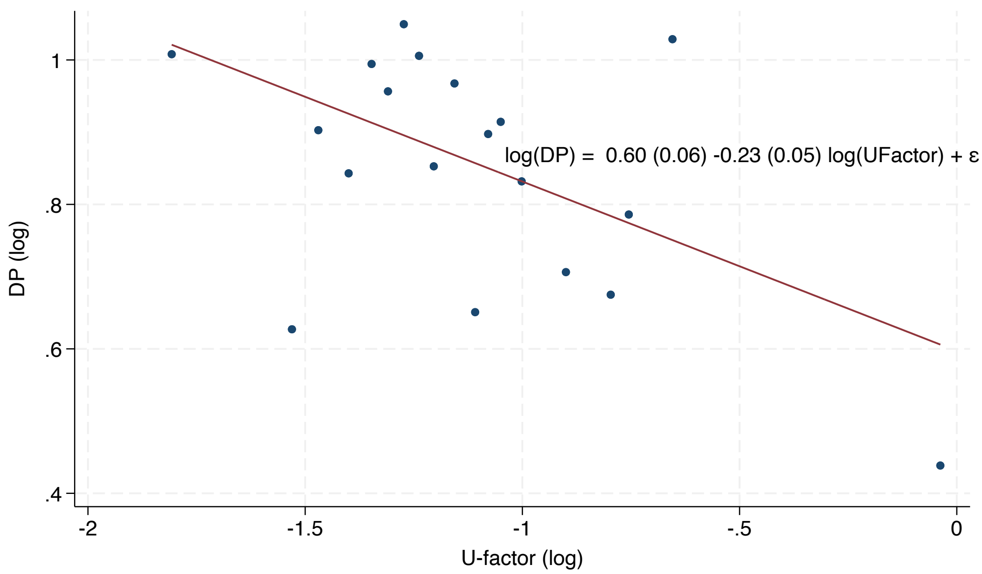
Note: Panel A plots the cumulative amount of loans (in millions of nominal U.S. dollars) originated from the residential PACE programs between 2011 and 2023. Residential PACE programs are available in California, Florida, and Missouri. Source: https://www.pacenation.org/pace-market-data/. Panel B provides a map of Florida counties that have adopted residential PACE programs as of December 2023. We classify counties into five categories: "Adopted" if PACE is adopted and currently enabled; "Unofficial" if there is no official adoption of PACE but PACE lenders have originated loans to properties in that county; "Not adopted" if PACE has not yet been adopted; "Repealed" if the county adopted PACE at one point but lenders withdrew due to legal challenges; "Unknown" if adoption information is not yet available and we have no record of PACE loans originated in those counties.

FIGURE 2. Relationship between Window Product DP Ratings and U-Factors

A. Relationship in Levels



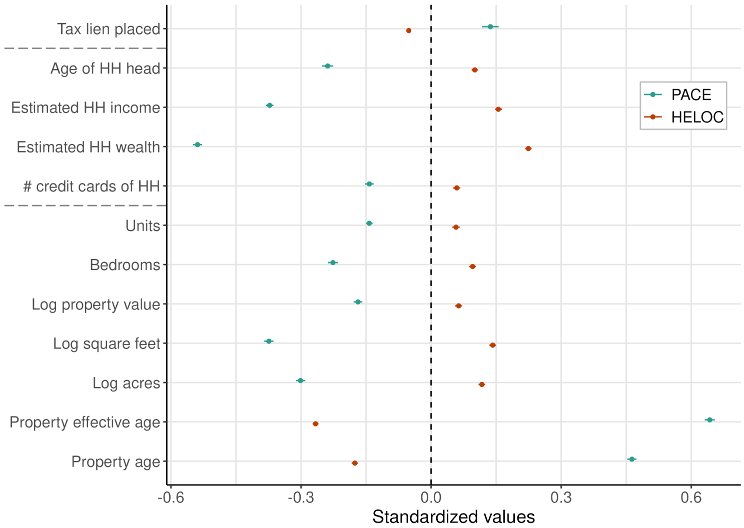
B. Relationship in Logs



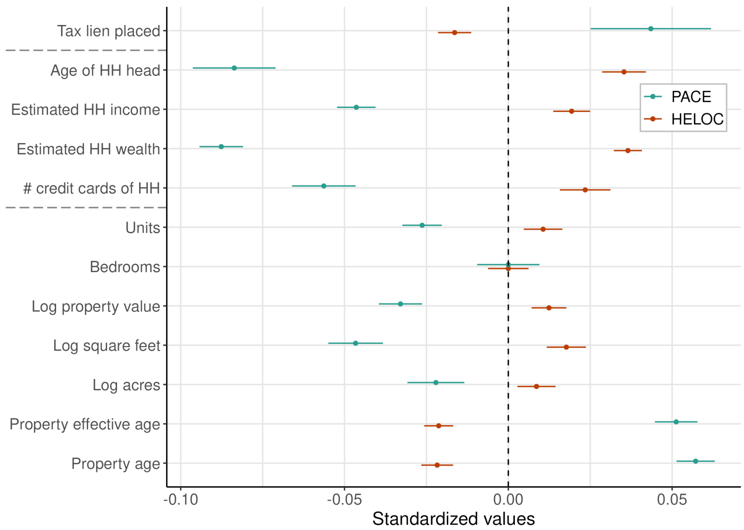
Note: This graph shows the relationship between the Design Pressure (DP) ratings and the U-Factor of window products using data from 500 window models currently sold in the United States. We sort the windows into 20 equally-sized bins using `binscatter`. The U-Factor measures how well the window insulates. The lower the U-Factor, the better the window insulates the house. U-factor ranges from 0.20 to 1.20. The DP rating measures the load created by wind that a door can withstand. Windows with higher DP ratings are more resistant to high-velocity wind. Panel A shows the relationship in levels, while Panel B shows the relationship in logs.

FIGURE 3. Balance Test: Household and Property Characteristics for PACE Loans vs. Open-End HELOCs

A. Unconditional Balance Test



B. Conditioning on Census Tract Fixed Effects

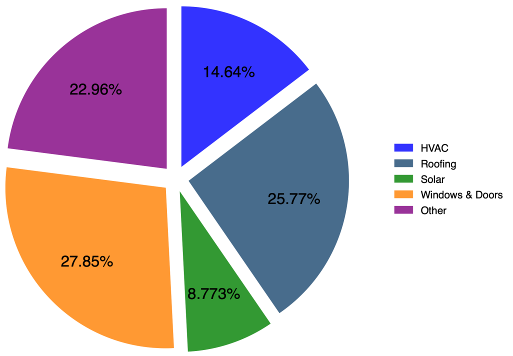


Note: This graph compares characteristics for homes with a PACE loan and properties with a closed-end (i.e. fixed interest rate) home equity line of credit (HELOC). To conduct this comparison, we use variables as of the year prior to loan origination for each type of loan product. Log property value refers to log real property values, deflated using CPI-U. Panel A compares unconditional means, while Panel B compares mean characteristics within each Census tract. The x-axis in each panel is the z-score for each variable. Property-level variables come from the CoreLogic suite of datasets; properties with a PACE loan are smaller, older, and trade at a lower price than properties with a HELOC. PACE properties are also more likely to have a prior history of tax delinquency, as indicated by a tax lien previously ever being placed on the property as of the year before loan origination. Household-level variables from Data Axle include estimated income, wealth, and the number of credit cards as of the year prior to origination. To match the household-level information from Data Axle to our matched sample of property-loans from CoreLogic, we focus on single-family homes where there is a unique mapping to a CoreLogic address to account for cases where Data Axle fails to purge records of previous residents at an address. We winsorize continuous variables at the 1st and 99th percentiles before computing sample means.

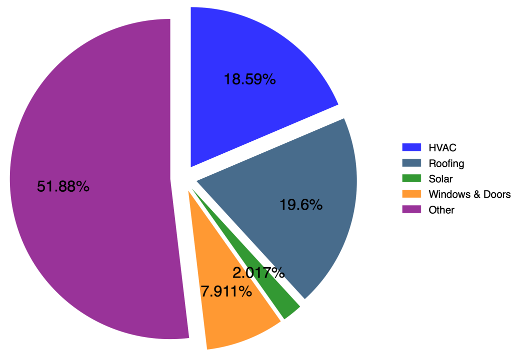
FIGURE 4. Composition of Permitted Home Improvement Projects

A. Permit Types Pooled over Sample Period, 2015 – 2023

Permits on PACE Properties

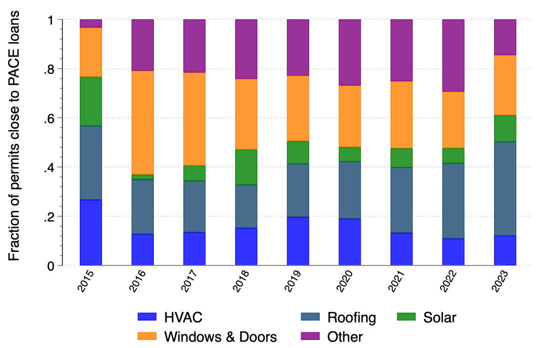


All Non-PACE Florida Residential Permits

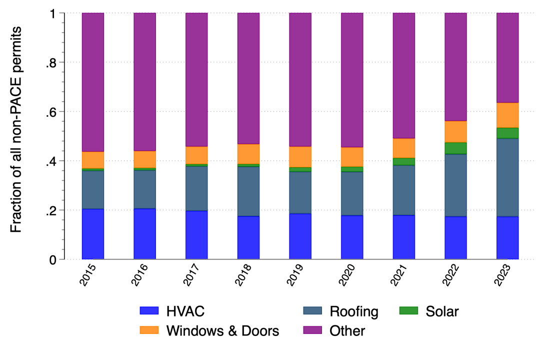


B. Evolution of Permit Type Activity over Time

Permits on PACE Properties



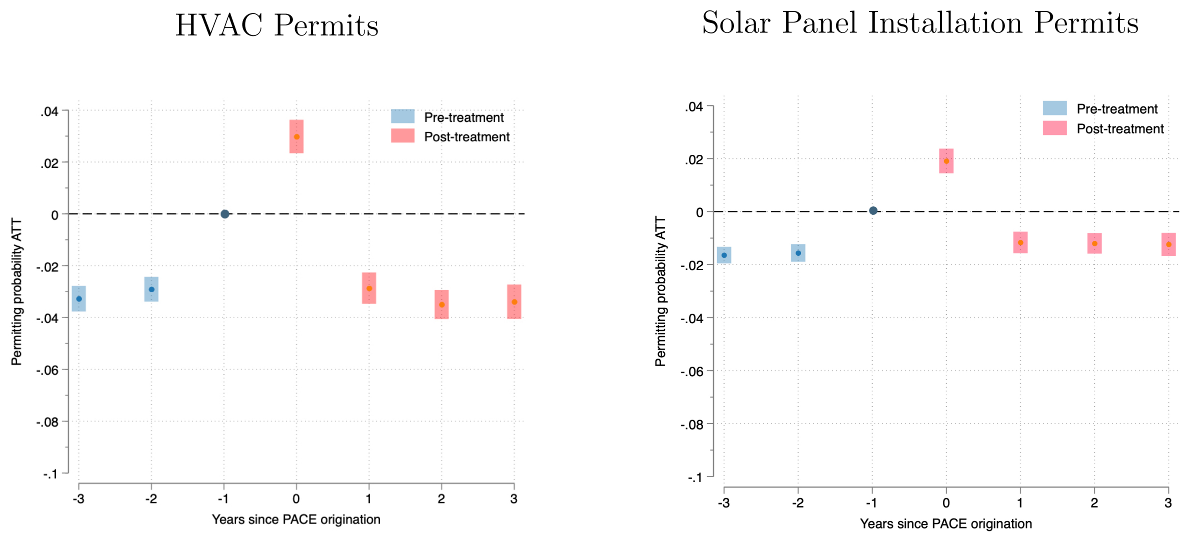
All Non-PACE Florida Residential Permits



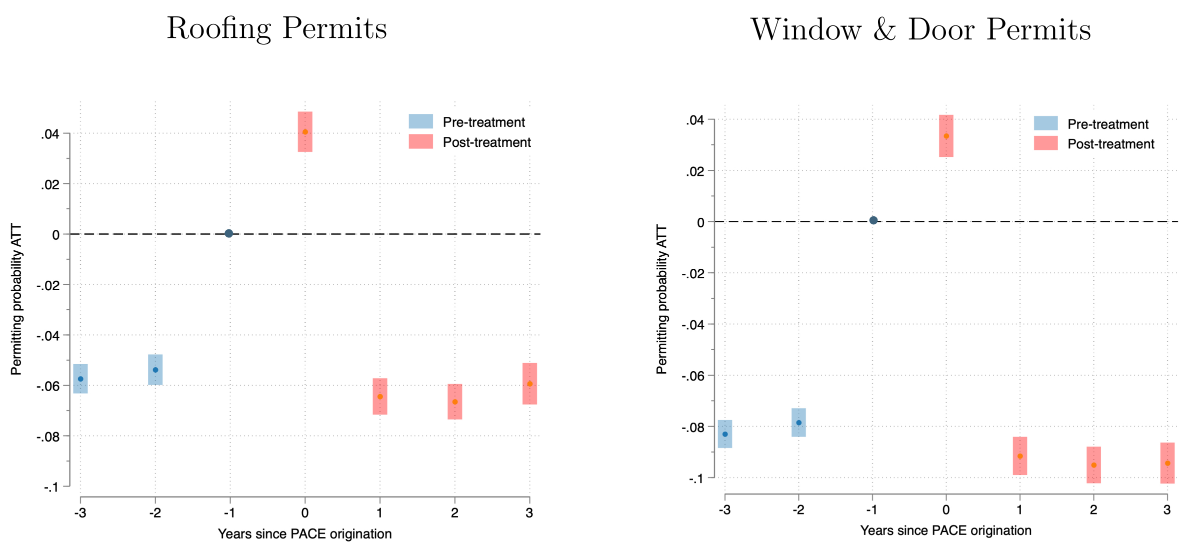
Note: We classify building permits tied to residential properties with a PACE loan by string parsing the description of the home improvement project filed with the town clerk as part of the permit application. The five mutually exclusive categories are: HVAC, roofing, solar, windows and doors, and other. We define roofing as replacing the roof of the house, which distinguishes permits involving solar panel installations on the roof. "Other" includes any permits which would not qualify for PACE based on the project description, such as kitchen or other cosmetic renovations. Panel A shows the breakdown of permits into these categories over the full sample time period, 2015 – 2023 for only residential PACE properties (left) and for all single-family homes in Florida (right). Panel B. shows how the proportions of permits evolve over the sample period. For permits associated with a PACE property, we tabulate only for permits issued with an effective date within the same year of loan origination. See text for further details on the CoreLogic building permits data and how we sort permits into these categories.

FIGURE 5. Dynamic Event Studies: Building Permits Issued around PACE Origination

A. Energy-Efficient Projects



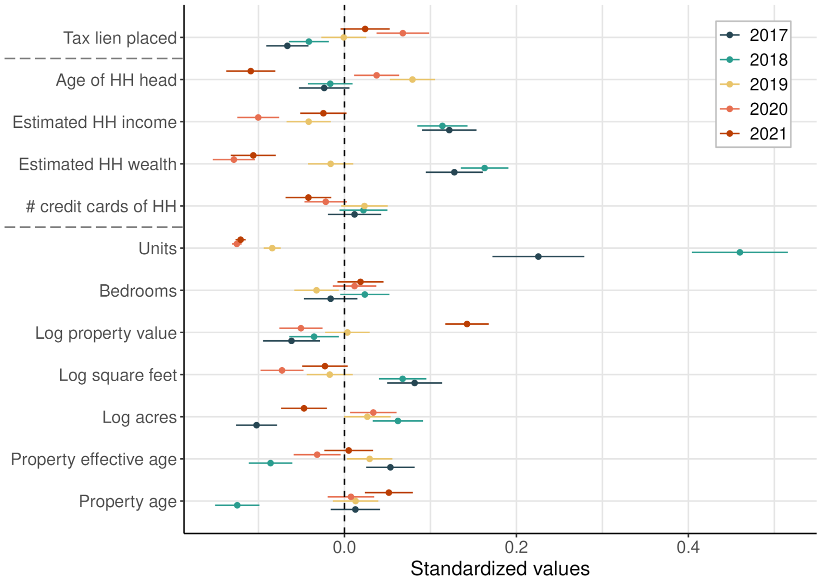
B. Disaster-Proofing Projects



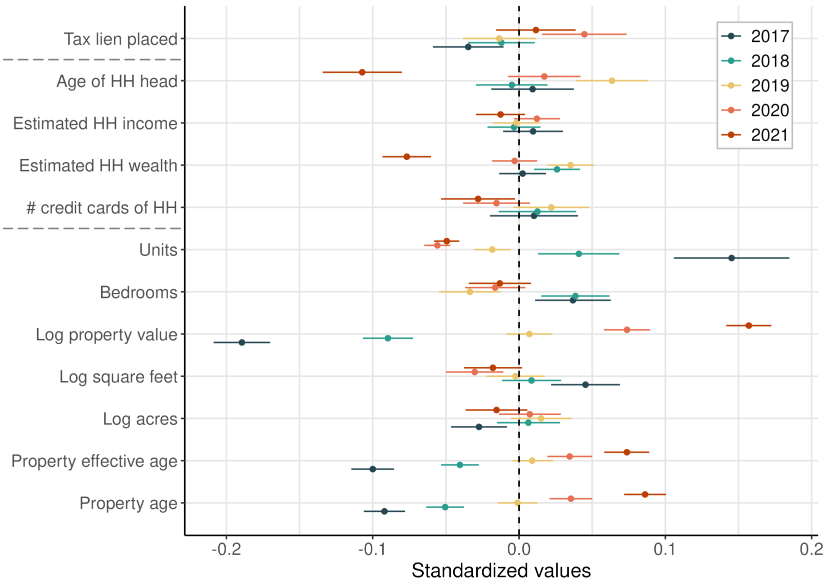
Note: This figure presents the aggregated group-time average treatment effects on the treated (ATT) event study coefficient estimates using Callaway and Sant'Anna (2021)'s estimator in which properties with non-PACE permits serve as the control group. Following Roth (2024), we use long-differences for the pre-treatment and post-treatment coefficients, so that we can easily interpret pre-trends relative to the reference period $t = -1$. The dependent variable in each graph is an indicator equal to one if within t years of receiving a PACE loan a permit is issued within one of four climate-adaptation categories. Panel A displays results for the energy-efficient adaptations (HVAC and solar), while Panel B shows results for disaster-proofing adaptations (roofing and window and door installations). Each regression includes a full set of 5-digit zip code $\times$ year fixed effects. Time on the x-axis is measured in years relative to PACE loan origination ($t = 0$). See text for further details on the CoreLogic building permits data and how we sort permits into these categories. We restrict the sample to permits on residential properties. Bars indicate 95% confidence intervals with standard errors clustered at the property (APN) level and obtained through wild bootstrap with 1,000 replications.

FIGURE 6. Balance Test: Comparing Early vs. Late Cohorts of PACE Borrowers

A. Unconditional Balance Test

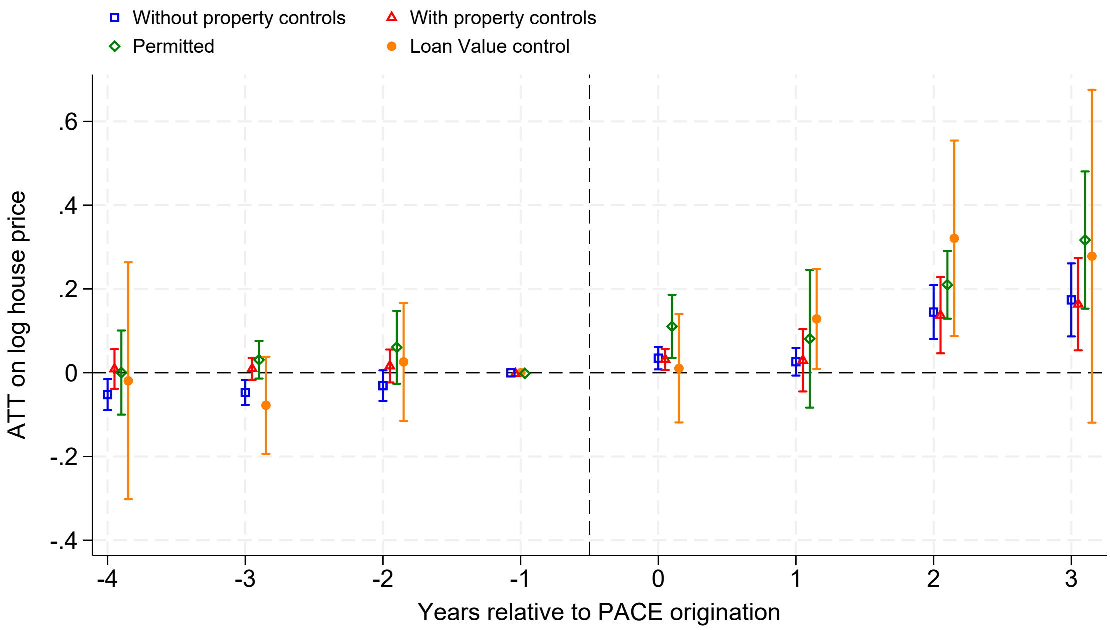


B. Conditioning on Census Tract Fixed Effects



Note: This graph compares characteristics for homes attached to different tax year cohorts of PACE borrowers. To conduct this comparison, we use variables as of the year prior to loan origination for each borrower cohort. Log property value refers to log real property values, deflated using CPI-U. Panel A compares unconditional means, while Panel B compares mean characteristics within each Census tract. The x-axis in each panel is the z-score for each variable. Different annual PACE cohort properties are no more or less likely to have a prior history of tax delinquency, as indicated by a tax lien previously ever being placed on the property as of the year before loan origination. Household-level variables from Data Axle include estimated income, wealth, and the number of credit cards as of the year prior to origination. To match the household-level information from Data Axle to our matched sample of property-loans from CoreLogic, we focus on single-family homes where there is a unique mapping to a CoreLogic address to account for cases where Data Axle fails to purge records of previous residents at an address. We winsorize continuous variables at the 1st and 99th percentiles before computing sample means.

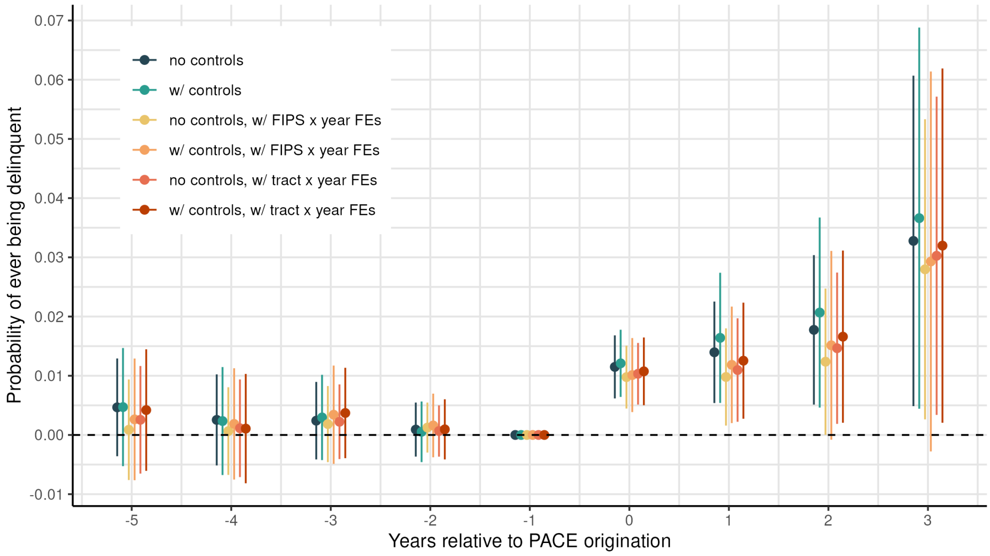
FIGURE 7. Dynamic Event Studies: Capitalization of PACE Lending into House Prices



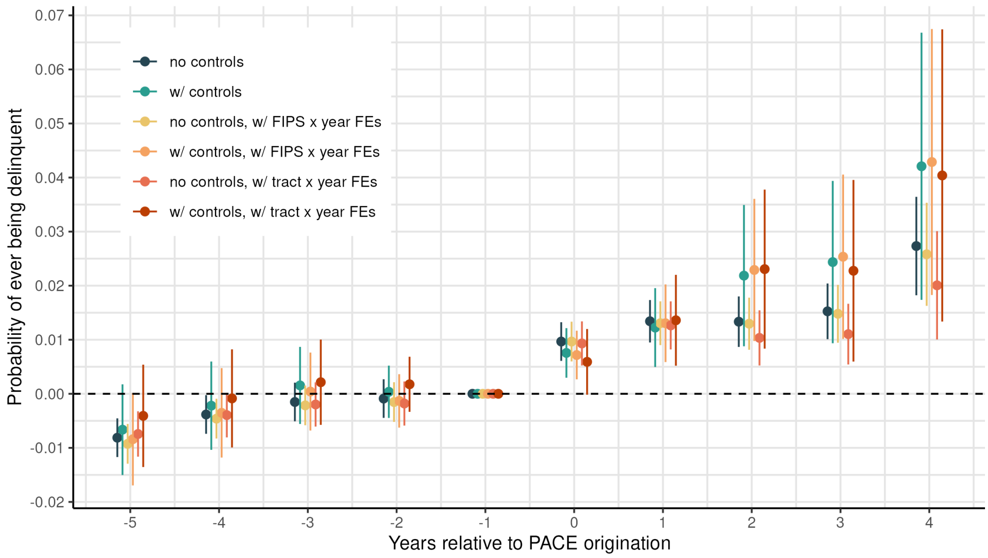
Note: This figure plots the Average Treatment Effects on the Treated (ATT) from event study specifications estimated via Callaway and Sant'Anna (2021)'s estimator with home transaction prices winsorized at the 1st and 99th percentiles as the outcome variable. Following Roth (2024), we use long-differences for the pre-treatment and post-treatment coefficients, so that we can easily interpret pre-trends relative to the reference period $t = -1$. The dependent variable is the logarithm of the sale amount of a property transaction. We restrict our sample to repeat sales of residential properties which both receive a PACE loan at some point during our sample period, 2015 – 2023. All specifications include month and 5-digit zip code × year fixed effects, permits during PACE origination ($t = -1$ to $t = +1$), and *ex ante* ($t = -6$ to $t = -2$) and *ex post* count ($t = +2$ to $t = +6$) of non-PACE permits. The specification with property controls includes winsorized log square footage, bins for number of bedrooms and bathrooms, and deciles of property age. The "permitted" specification restricts the sample to PACE projects with a climate-proofing permit filed within a year of origination. The "loan value control" specification adds to the vector of controls the loan origination amount to account for different quantity scales of the funded project. Time on the x-axis is measured in years relative to PACE loan origination ($t = 0$). Bars indicate 95% confidence intervals with standard errors clustered by county.

FIGURE 8. Dynamic Event Studies: PACE Origination and Property Tax Delinquency

A. Comparing Early to Late PACE Borrowers



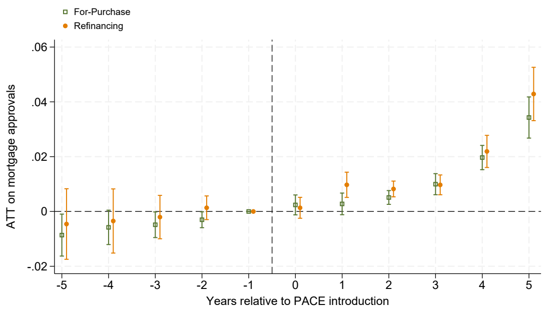
B. Comparing PACE Borrowers to HELOC Borrowers



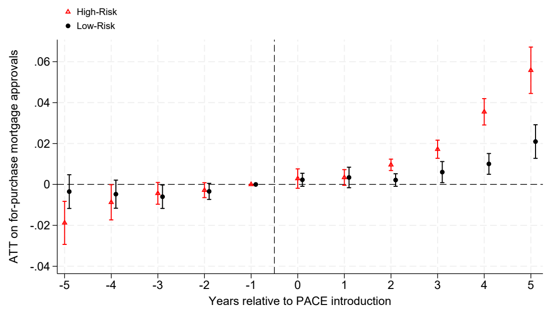
Note: This figure plots local property tax delinquency probabilities for PACE borrowers around the year of loan origination. The outcome is a dummy equal to one if the property has ever been delinquent as of that point in time. In Panel A, we compare early PACE borrowers to late (i.e. not-yet-treated) PACE borrowers using Callaway and Sant'Anna (2021)'s estimator. Following Roth (2024), we use long-differences for the pre-treatment and post-treatment coefficients, so that we can easily interpret pre-trends relative to the reference period $t = -1$. In Panel B, we compare PACE borrowers to HELOC borrowers. Since the never-treated and not-yet-treated control groups are not well-defined for the comparison of PACE to HELOC borrowers, for the treatment/control split in Panel B, we instead use the stacked difference-in-differences estimator proposed by Cengiz et al. (2019). Specifications with property controls include winsorized log square footage, bins for number of bedrooms and bathrooms, and deciles of property age. In some specifications, we include county FIPS $\times$ year fixed effects. For specifications with tract $\times$ year fixed effects, we impose boundaries according to the 2010 decennial Census. In each graph, we estimate the event study specification over an unzipped annual panel of tax delinquency statuses for each single-family property in our sample. Bars indicate 95% confidence intervals obtained from standard errors clustered by property APN.

FIGURE 9. Event Study: Lenders' Responses for First Lien Mortgage Applications

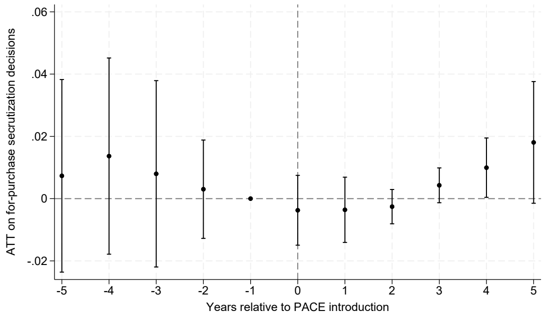
A. Approval Rates on For-Purchase and Refinancing Mortgages



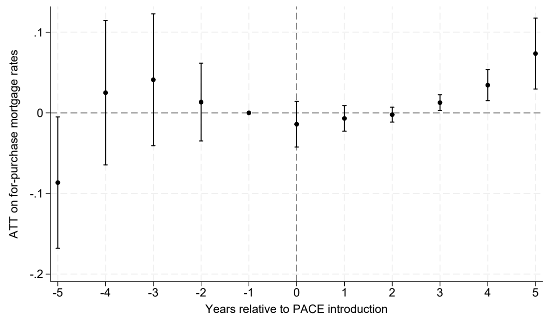
B. Approval Rates on For-Purchase Mortgages by Borrower LTI



C. Private Securitization Rates on For-Purchase Mortgages



D. Interest Rates on For-Purchase Mortgages



Note: The graph plots the dynamic coefficient estimates of regression equation (5.4) using Sun and Abraham (2021)'s estimator for different mortgage market outcome variables. In each panel, time on the x-axis is years relative to the county's introduction of the PACE program. Panel A examines approval rates on for-purchase and refinancing mortgages, which is a proxy for lenders' credit supply response. Panel B repeats the exercise but splitting for-purchase mortgage approvals by whether the loan application is above (high-risk) vs. below (low-risk) the median loan-to-income (LTI) ratio in the borrower's Census tract. Panel C uses a dummy for whether an approved loan is subsequently private-label securitized. Panel D examines the interest rate (APR) on approved for-purchase mortgages at origination. We restrict to the pre-2020 period in the HMDA data for our analysis to define treatment as an absorbing status given the COVID-19 shock to Florida real estate markets and legal challenges to PACE in some formerly treated counties in recent years.

Online Appendix to

Picking Up the PACE: Loans for Residential Climate-Proofing

by Aymeric Bellon (UNC-Chapel Hill), Cameron LaPoint (Yale SOM), Francesco Mazzola (ESCP Business School), and Guosong Xu (Rotterdam School of Management)

Contents

A Additional Institutional Background

This section provides additional institutional background on PACE loans in Florida.

Legal implementation of PACE. To generate the map in Figure 1 and assign treatment date cutoffs, we track the progress of PACE adoption across all 67 Florida counties using a combination of local news stories about the entry of PACE districts, cross-referenced with LexisNexis links to the local property tax code and, whenever possible, by obtaining the dated list of PACE liens recorded with each county's tax assessor's office or the circuit court clerk, whichever is the applicable records custodian. For each county, the first PACE lien ever recorded occurs within the same year of statutory adoption. Most of our outcome variables come from local tax records or the public version of HMDA and are thus available at annual frequency, and so it makes no difference in our analysis whether we use the statutory adoption date or first year a PACE loan appears on the tax roll as the treatment time cutoff.

This process also allows us to account for cases where PACE is in flux in a county due to legal challenges. In our main difference-in-differences analyses, we consider county-level PACE adoption to be an absorbing state even if there is a city or town within the parent county which attempts to nullify PACE. 10 counties have experienced such legal challenges, but all of them have continued recording new PACE liens, indicating that, from the lender's perspective, there is continued legal ambiguity about which level of government has the ultimate authority to enable PACE. Our results are robust to simply excluding contentious PACE liens in these defector jurisdictions.

Eligibility and rules. All homeowners are eligible for PACE loans, regardless of their credit score, as long as (i) the homeowner has paid all their property taxes and has not been delinquent over the preceding three years; (ii) there are no involuntary liens attached to the property, such as those imposed as a result of a bankruptcy court order; (iii) there are no notices of default or other property-based debt delinquency for the last three years; and (iv) the homeowner is the borrower for all mortgage debt secured by the property [5 F.S. Chapter 163.08(2)(b)(9)].[1] Policymakers contend that the unique design of PACE loans makes financing available to homeowners who are unable to obtain credit through traditional channels, such as home equity lines of credit (HELOCs), or to those who resist making investments due to the concern that they will have to repay the full loan amount when the property is sold or refinanced (Cox, 2011).

In Online Appendix H, we compare contract terms for a subset of PACE loans for which we observe interest rates and origination amounts to those of HELOCs used towards home improvement projects within the same geographic area. Annual interest rates charged on fixed-rate HELOCs are at least 155 basis points lower than rates charged on PACE loans of similar dollar amounts, and this spread remains conditional on loan-to-value, Census tract, and the existence of a primary mortgage balance. This fact, together with the

[1] We find evidence of loose enforcement of the eligiblity requirement that PACE borrowers not have a record of property tax delinquency in the three years preceding origination. Figure 3 shows that PACE properties are far more likely to have a recent local tax lien, despite there being no such requirement in place for HELOC borrowers. The loose enforcement of this provision could be due to the difficulty administrators face in determining the prior tax delinquency status of a property owner, especially in jurisdictions where such records are not digitized.

deferred payment schedules often offered with HELOC contracts, suggests that in the absence of financing constraints or concerns about maintaining a higher credit score, consumers would strictly prefer a fixed-rate, closed-end HELOC to a PACE loan.

PACE loans provide qualifying home improvements with up to 100% financing. Under CS/HB 7179, which established the PACE program in Florida in 2010, the total PACE loan amount is limited to 20% of the (market) appraised property value assessed by the county unless mortgage lenders with a lien on the property consent to higher LTV loans.[2] However, home improvements that show through an energy audit that the annual energy savings equal or exceed the annual repayment amount are not subject to this limit. As a result of this rule, we show in Online Appendix H that the mean PACE LTV is 10%, compared to 18% for a comparable home improvement HELOC, with 97% of PACE loans having an LTV below the 20% statutory threshold.

Unlike other forms of financing, PACE credit is repaid in the form of property tax payments, and these payments are attached to the property rather than the borrower. Delinquent property tax payments with the PACE assessment take priority over other lienholders, such as a mortgage lender, making PACE loans super senior to other claims to the property used as collateral. Importantly, mortgage lenders cannot legally enforce a covenant related to a homeowner's decision to use a PACE loan. For example, they cannot demand payment in anticipation of the principal amount of the mortgage if the debtor obtains a PACE loan.

Single-family homes, condos, vacant residential land, and small multi-family buildings are all eligible for residential PACE loans. In our sample of PACE loans with permits, 95% are single-family homes, 4% are condos, and the remaining 1% are multi-family properties with less than ten units. Properties also qualify for residential PACE loans if they start out with a non-residential land use and convert to residential through construction.[3]

Application process. Prospective PACE borrowers can apply directly through the website of a district or administrator (the lender) or indirectly through a registered contractor.[4] If initiated through a contractor, the contractor forwards the quoted cost for the home improvement project and any permit information to the PACE lender operating in that area. Unlike traditional consumer credit products, under state guidelines lenders do not use credit scores to determine eligibility, which leads to lax screening compared to other home equity lines. However, lenders do perform a hard credit inquiry to determine whether the applicant satisfies the eligibility criteria, including whether they have a recent history of mortgage delinquency or bankruptcy.[5]

[2] The full text of the law establishing Florida PACE can be found here: https://www.flsenate.gov/Session/Bill/2010/7179.

[3] Most counties offering residential PACE (R-PACE) also partner with districts and administrators specializing in commercial PACE (C-PACE) loans. The structure of C-PACE is very similar to R-PACE in that the owners pay back the loan through the local property tax assessment. Yet, since commercial properties are typically much greater in value there are multiple contributors to the capital stack. Hence, many PACE administrators specialize in either R-PACE or C-PACE loans.

[4] See, for example, the application tool from Florida PACE Funding Agency, one of the four districts: https://floridapace.gov/apply/.

[5] See, for instance, the PACE FAQs compiled by Palm Beach County's Office of Resilience: https://discover.pbcgov.org/resilience/pages/pace-frequently-asked-questions.aspx.

At the time of origination, the district involved in underwriting the loan sends the loan terms to the local tax assessor, who then generates a Notice of Assessment. The borrower is then CC'ed on this notice, which serves as a loan disclosure form. In many records offices, clerks attach to the loan contract a Notice of Commencement on the improvement resulting from the building permit, which mitigates the scope for fraud. Without this paper trail, borrowers might otherwise attempt to take out a PACE loan by listing an eligible project, but then use the funds for some other purpose. We show in Section 5.1 that the vast majority of PACE borrowers apply funds towards permitted projects within four major categories: HVAC, roofing, solar, and window and door upgrades.

Loan repayment. A defining feature of PACE is that the loans are government-backed. This means that the borrower repays through their annual local property tax assessment. Annual local property tax payments are based on an interest rate fixed at origination, and the payments fully amortize the loan, just like with a standard fixed-rate mortgage. For our estimation sample of single-family homes, the most common loan term is 20 years, the average origination amount is around $30,000, and the average fixed interest rate is approximately 7%. This would imply an annual tax payment of $2,831.79 towards the PACE loan balance.[6] Local tax assessors separately itemize the PACE loan payment amount in each annual tax bill as a non-*ad valorem* assessment – in contrast to the property tax itself which is *ad valorem*. However, the *ad valorem* and non-*ad valorem* components are lumped together into a single tax liability. This means that if a primary mortgage lender requires the PACE borrower to submit a monthly payment into an escrow account, the total monthly mortgage payment will increase to cover the resulting increase in property taxes.

There are no prepayment penalties attached to PACE loans. Due to the super seniority of the PACE lien, lenders can require that borrowers pay off the PACE loan in full before refinancing or selling the property. In the event a borrower is overdue on their property tax bill, and thus becomes delinquent on the PACE loan, the only way they can remove the lien is by redeeming the tax debt. Because they follow the property (*in rem*) and not the individual (*in personam*), local tax liens cannot be discharged through personal bankruptcy (LaPoint, 2023).[7] Hence, since the ultimate penalty for severe delinquency is tax foreclosure or forced sale of the property, strategic default motives are limited for PACE borrowers. We show in Online Appendix H that the super seniority of PACE loans acts as a shield against higher interest rates when there is a pre-existing mortgage in place.

In Online Appendix B we offer examples of official PACE documents attached to recorded loans in Florida. We obtain these documents directly from local tax authorities, and they form the basis for the merged property-loan-level data we use in our empirical analysis of the program.

[6] It is straightforward to compute the implied annual payment in Excel as $PMT(0.07, 20, -30000) =$ $2,831.79, where 20 is the loan term in years. Other common loan terms are 5, 10, 15, 25, and 30 years. The average interest rates rise and fall with overall economic conditions, with rates in 2023 averaging closer to 8%. There is no explicit index rate but the rates track 10-year Treasuries, just like a fixed-rate mortgage.

[7] Tax liens cannot be discharged unless the house is abandoned. Moreover, only property tax debts that are at least one year old can be discharged through personal bankruptcy, and even then, only if the household declares bankruptcy before a tax auction occurs.

PACE project types. The primary and historical purpose of PACE is to finance projects that reduce the energy consumption of the house, such as the installation of more energy-efficient windows. PACE-approved projects also include investments that improve the resistance of the house to natural disasters, such as impact-resistant windows. In Figure 2, we show a strong positive relationship between the energy efficiency and climate resilience of home improvement projects. To do so, we collect data on 500 window products. We describe the data collection process in Online Appendix E. There is a strong negative correlation between the Design Pressure (DP) rating and U-Factor for window products. The U-Factor measures how well the window insulates the house. The lower the U-Factor, the better insulation the window provides. The DP rating measures the load created by wind that a door can withstand. Windows with high DP ratings are more resistant to high-velocity wind. We document a strong relationship between the two indicators. Specifically, a 1% increase in a window's U-Factor is associated with a 0.23% decrease in that product's DP rating.

Overall, making a house more resistant to natural disasters can lead to lower energy consumption. This relationship is consistent with diffuse technical progress that makes home improvements using recent products more efficient on multiple dimensions. The example of windows, which are among the most common use of PACE funds in Florida, also highlights the challenges with distinguishing between households' resilience versus energy efficiency motivations behind engaging in home improvement projects.

B Sample PACE Loan Documents

In this appendix, we offer examples of recorded PACE loan contracts and accompanying documents, including local property tax bill stubs and home improvement permit filings. Some jurisdictions – mostly less-populated ones – do not maintain digitized records of PACE assessments. For such counties, our FOIA requests for information on PACE loans tied to property APNs yielded a combination of PDF scans of the "Notice of Assessment" (Figure B.1) confirming the loan details and the "Notice of Commencement" (Figure B.2) confirming the improvement being financed by the PACE loan. The document fields and formatting are standard across all Florida counties. As discussed in Section 2, the Notice of Commencement renders it difficult for the borrower to apply PACE funds towards consumption of goods or services other than the project listed on the assessment notice.

The format of property tax bills is also standard across counties, although the particular line items comprising the total local tax bill will vary due to overlapping sub-county jurisdictions (i.e. the tax code area described in Section 5.3) and the existence of any non-*ad valorem* assessments specific to the property (like a PACE loan). For instance, in the sample tax bill pictured in Figure B.3, the borrower received a PACE loan from the Green Corridor PACE District operating in the county, and this annual payment towards the loan balance represents about one-third of the property owner's overall property tax bill. Property owners are responsible for paying both *ad valorem* and non-*ad valorem* tax bills according to the same calendar schedule, meaning that failing to pay the full balance due for a tax year (payment deadline of March 31st in Florida). The March 31st payment deadline for the preceding tax year's liability also means that depending on the month of origination, some PACE borrowers can effectively defer any payment on the loan for over a year. The maximum length of time between PACE loan origination and the due date for payment on that loan is 16 months if the loan is originated on December 1st.

Figure B.1. Sample PACE Contract and Property Lien Recording

GADSDEN COUNTY NICHOLAS THOMAS
Instrument: 230005183 Recorded: 07/17/2023 1:47 PM

OFFICIAL RECORDS: 1 of 4
Book: 937 Page: 241

Recording Fee: $35.50

This instrument prepared by and executed by a public office of the Florida PACE Funding Agency and after recording return to:
Home Run Financing
750 University Ave #140
Los Gatos, CA 95032

SPACE ABOVE THIS LINE RESERVED FOR RECORDER'S USE

NOTICE OF ASSESSMENT

GADSDEN

THIS NOTICE OF ASSESSMENT ("Notice") provides a summary memorandum of a Financing Agreement entered into by and between the FLORIDA PACE FUNDING AGENCY (the "Agency") and the record owner(s) of the Assessed Property (the "Property Owner"), both as described hereinafter. This Notice is executed pursuant to such Financing Agreement in substantially the form appended to Agency Resolution #2016-0809-3, a certified copy of which is recorded in the Official Records at 160008599; a Final Judgment, a certified copy of which is recorded at 140007031; a Final judgment, a certified copy of which is recorded at 220010257; all in the Public Records of GADSDEN, Florida, and all of the terms and provisions thereof are incorporated herein by reference. Agency has levied and imposed a non-ad valorem assessment as a lien of equal dignity to taxes and assessments, and as more particularly described herein and in such Financing Agreement, on the Assessed Property in conformance with Section 163.08, Florida Statutes (the "Supplemental Act").

1. Property Owner: [redacted]
2. Assessed Property: See Legal Description in Attachment I. OR 873 P 138 OR 579 P 1338 OR
3. Street Address of Assessed Property: 388 Charlie Harris Loop, Quincy FL 32352
4. Property Appraiser Parcel Identification Number: 2-17-3N-3W-0000-00244-0100
5. Qualifying Improvements:
   Energy Efficiency Improvement:
   Roof - Asphalt Shingle
6. Financed Amount (pursuant to the Financing Agreement; this amount may be reduced WITH SUCH REDUCED AMOUNT REFLECTED IN A SUPPLEMENTAL NOTICE OF ASSESSMENT): $22,777.37
7. Interest Rate (to be applied to the principal amount of the Financed Amount): 9.99%
8. Assessment Installment (pursuant to the Financing Agreement; this amount may be reduced WITH SUCH REDUCED AMOUNT REFLECTED IN A SUPPLEMENTAL NOTICE OF ASSESSMENT): $2,992.92
9. Period of years (number of Annual Payments): 15 years
10. The Annual Payment of the Assessment will appear on the same bill as for property taxes, and will include the Assessment Installment, plus any annual costs of administration and charges associated with the Assessment, annual collection costs, and annual charges required by the local property appraiser and tax collector.
11. The Assessment is NOT due on sale or transfer of the Assessed Property. Payoff and release

Notice of Assessment ES
Application ID No.: 5293401
County: GADSDEN
Generated on: July 06, 2023

information may be obtained by contacting the Florida PACE Funding Agency at: www.floridapace.gov or Home Run Financing, 750 University Ave #140,Los Gatos, CA 95032; Telephone: (844) 873-7223; Email operations@homerunfinancing.com; Websites: www.homerunfinancing.com and www.floridapace.gov.

12. NOTE: Prepayment information must be requested ten (10) business days prior to any prepayment. Prepayments must be in immediately available funds.
13. Suggested ALTA, Schedule B exclusion to coverage for title insurance professionals: *"Non-ad valorem assessment, which by its term is not due upon sale, evidenced by notice recorded in Official Record Book____, at Page____."*
14. The following caveat is intended to be supplemental, constructive notice provided in writing to any prospective purchaser as required by the Supplemental Act. So long as the Assessment provided for hereunder has an unpaid balance, at or before the time Property Owner enters into a contract to sell the Assessed Property, the Property Owner gives any prospective purchaser by law a written disclosure statement in the following form:

QUALIFYING IMPROVEMENTS FOR ENERGY EFFICIENCY, RENEWABLE ENERGY, OR WIND RESISTANCE - The property being purchased is located within the jurisdiction of a local government that has placed an assessment on the property pursuant to s. 163.08, Florida Statutes. The assessment is for a qualifying improvement to the property relating to energy efficiency, renewable energy, or wind resistance, and is not based on the value of the property. You are encouraged to contact the county property appraiser's office to learn more about this and other assessments that may be provided by law.

THE DECLARATIONS, ACKNOWLEDGMENTS AND AGREEMENTS CONTAINED AND INCORPORATED HEREIN SHALL RUN WITH THE LAND DESCRIBED HEREIN AND SHALL BE BINDING ON THE PROPERTY OWNER (INCLUDING ALL PERSONS OR ENTITIES OF ANY KIND), AND ANY AND ALL SUCCESSORS IN INTEREST. BY TAKING SUCH TITLE, PERSONS OR ENTITIES WHO ARE SUCCESSOR SHALL BE DEEMED TO HAVE CONSENTED AND AGREED TO THE PROVISIONS OF THIS NOTICE AND THE REFERENCED FINANCING AGREEMENT TO THE SAME EXTENT AS IF THEY HAD EXECUTED IT AND BY TAKING SUCH TITLE, SUCH PERSONS OR ENTITIES SHALL BE ESTOPPED FROM CONTESTING, IN COURT OR OTHERWISE, THE VALIDITY, LEGALITY AND ENFORCEABILITY OF THIS AGREEMENT.

OFFICIAL RECORDS: 2 of 4
Book: 937 Page: 242

Figure B.2. Sample Notice of Improvement Commencement for PACE Loan

GADSDEN COUNTY NICHOLAS THOMAS
Instrument: 230004789 Recorded: 06/30/2023 8:41 AM

OFFICIAL RECORDS: 1 of 1
Book: 936 Page: 705

Recording Fee: $10.00

NOTICE OF COMMENCEMENT

The undersigned hereby gives notice that improvements will be made to certain real property, and in accordance with Chapter 713. Florida Statutes, the following information is provided in this Notice of Commencement.

1. Description of Property
   Legal Description Lot 1 / Block 2-17-3N-3W-0000-00244-0100 / Pin 2-17-3N-3W-0000-00244-0100
   Street Address 388 Charlie Harris loop City Quincy FL. Zip 32351
2. General description of improvement RE-Roofing (Remove + Replace Shingles)
3. Owner information
   A. Name [redacted]
   B. Address 388 Charlie Harris loop City Quincy St FL Zip 32351
   C. Interest in Property
   D. Name & Address of Fee Simple Title Holder (Other than Owner)
4. Contractor Name and Address
   Kevin Krueger 8934 Western Way Jacksonville Fl 32256
5. Surety Name

   ~~Bond amount~~ $ $19,500
6. Lender's Name and Address

7. Person within the State of Florida designated by owner upon whom notices or other documents may be served as provided in Section 713.13(1)(a)7 of the Florida Statutes.

8. In addition to self, the Owner designates the following person to receive a copy of the Lienor's Notice as provided in Section 713.13(1)(b) of the Florida Statues. Give name and address.

9. Expiration date of Notice of Commencement. The expiration date is one (1) year from the date of recording unless a different date is specified.

Signature of Owner/ Agent: [signature]

This foregoing instrument was acknowledged, sworn to and subscribed before me this 30th day of June, 2023.

PREPARED BY:

State of: Florida

County of: Gadsden

Notary Signature [signature]

Printed Name: Allison Owens

Known personally/ /ID shown: GA DL

Corey Andrew Jaramillo
\+ physically present.

Notary Seal

ALLISON OWENS
MY COMMISSION # HH 100966
EXPIRES: March 4, 2025
Bonded Thru Notary Public Underwriters

Figure B.3. Sample Property Tax Bill after PACE Loan Originated

Sam C. Steele C.F.C.
Monroe County Tax Collector

Monroe County 2019 Paid Individual Tax Certif

NOTICE OF AD VALOREM TAXES AND NON-AD VALOREM ASSESSMENTS

ACCOUNT NUMBER	ESCROW CODE	MILLAGE CODE	PROPERTY ID #
1610844		500K	1610844

MUST PAY BY CASH, CREDIT CARD OR CERTIFIED FUNDS

[redacted]
205 Pirates Dr
Key Largo, FL 33037-2323

NEW OWNER DUP BILL MAILED

00494680000000326139
205 PIRATES Dr

BK 13 LT 14 AND 15 PIRATES COVE PB3-18 KEY LARGO OR502-826 OR672-82D/C OR1170-621AFF OR1170-622 OR117

Paid 06/22/2020 $7,106.47
Receipt # 116-19-00001470
Paid By CORELOGIC

AD VALOREM TAXES

TAXING AUTHORITY	TELEPHONE	ASSESSED VALUE	EXEMPTION AMT	TAXABLE VALUE	MILLAGE RATE	TAXES LEVIED
SCHOOL STATE LAW	305-293-1400	401,428	0	401,428	1.5550	624.22
SCHOOL LOCAL BOARD	305-293-1400	401,428	0	401,428	1.7880	717.75
GENERAL FUND	305-292-4473	401,428	0	401,428	0.7697	308.98
F&F LAW ENFORCE JAIL	305-292-7017	401,428	0	401,428	1.7747	712.41
HEALTH CLINIC	305-296-4886	401,428	0	401,428	0.0437	17.54
GENERAL PURPOSE	305-292-4473	401,428	0	401,428	0.1725	69.25
MOSQUITO CONTROL	305-292-7190	401,428	0	401,428	0.4508	180.96
M C LOCAL ROAD PATROI	305-292-7017	401,428	0	401,428	0.3484	139.86
SFWM DIST	800-432-2045	401,428	0	401,428	0.1152	46.24
OKEECHOBEE BASIN	800-432-2045	401,428	0	401,428	0.1246	50.02
EVERGLADES CONST PR.	800-432-2045	401,428	0	401,428	0.0397	15.94
K L FIRE RESC & EMERG I	305-743-6586	401,428	0	401,428	1.0000	401.43
				AD VALOREM TAXES:	8.1823	$3,284.60

BILL EXPRESS
SCAN TO PAY ONLINE!

WWW.MONROETAXCOLLECTOR.COM
GET BILLS BY EMAIL

NON-AD VALOREM ASSESSMENTS

LEVYING AUTHORITY	TELEPHONE	UNITS	AMOUNT
MO CO SOLID WASTE	305-295-4323	1.000	402.00
KEY LARGO WASTEWATER #4	305-451-4019	0.000	340.23
GREEN CORRIDOR PACE	866-807-6864	1.000	2,198.84
NON-AD VALOREM ASSESSMENTS:			$2,941.07

TOTAL COMBINED TAXES AND ASSESSMENTS:
$6,225.67

C Details on Conceptual Framework

In this appendix, we formalize the theory underlying the conceptual framework described in Section 3.

C.1 What Market Frictions Does PACE Solve?

It is important to understand why PACE loans are unique and which market frictions they are correcting. The first question is whether PACE loans are redundant contracts that could have been substituted with *existing* contracts provided by private intermediaries, such as traditional mortgage cash-out refinancing options or a HELOC. Conditional on PACE loans not being redundant, the second question is why no *novel* private solution can offer a financing option for green home improvement projects.

Regarding the first question, PACE loans provide financing to households that cannot refinance their mortgage or obtain a HELOC. Mortgage lenders rely heavily on credit scores when screening applicants for a mortgage or a HELOC. In contrast, obtaining a PACE loan does not depend on credit scores; in principle, anyone who has not been delinquent on a loan or property taxes for the last three years qualifies for a PACE loan.[8] There are two reasons why a PACE loan can be offered in a sustainable manner to households with poor credit scores. First, it creates a debt claim that is super senior and, thus, less risky than a traditional mortgage. Second, PACE financing is available for a set of qualified projects, which potentially increases the value of the house.[9]

Even for people with high credit scores, cash-out refinancing or HELOCs may not be attractive. Households need to have enough equity in the house, and if this is the case, the new LTV ratio after any equity extractions must be below 80% for the borrower to avoid paying mortgage insurance. Moreover, refinancing a fixed-rate mortgage means that the rate could reset upward, increasing borrowing costs even conditional on the borrower's LTV. Debt service could increase if mortgage interest rates increase over the period since the original mortgage was originated. Interest rates increased steadily between 2015 and 2019, and again during the recovery from the COVID-19 pandemic, covering the bulk of our sample period.

Regarding the second question, in the absence of market imperfections, all projects that increase the value of a house in excess of the project's cost should be financed. In practice, however, lenders face several frictions that prevent such financing from happening. Asymmetric information and imperfect contracting render it costly for a lender to (i) commit the household to use the money for specific home improvement projects, and (ii) source contractors who can correctly implement the home improvement projects. For instance, if a new roof is improperly installed, it may result in further damages to the house in the event of a severe storm event. PACE loans make contracts more complete. PACE programs solve these two frictions by curating a list of approved contractors to implement the project and requiring underwriters, contractors, and tax

[8]See our discussion of eligibility and rules in Section 2 for more details on the minimum set of qualifications PACE applicants must satisfy.

[9]We provide empirical evidence in Section 5.4 that traditional mortgage lenders recognize the capitalization of these projects into home collateral values, and reduced losses given default, by increasing loan approval rates in response to counties' PACE adoption.

assessor's offices to file documents certifying that work has begun on the financed project, which limits the scope for fraudulent uses of funds.

C.2 Theoretical Model

Framework. The model has two periods. In the first period $t = 1$, a representative household buys a house at price H_0. The household makes a deposit of A at time 0 and takes out a mortgage $H_0 - A$ with repayment amount D. The household discount factor is equal to β.

In the second period, $t = 2$, the household takes out a PACE loan to finance an eligible house improvement project. The project increases the value of the house by ΔH. Moreover, the value of the house in the second period is equal to H, which is not necessarily equal to H_0. The PACE loan requires a repayment of ℓ. At time $t = 2$, the household receives an income equal to $\widetilde{R}_2$. Income received in period $t = 2$ is random and follows well-defined probability distribution $f(\cdot)$. [10] The household defaults if total income falls below total liabilities, namely $D + \ell$, and the lender then recoups losses by foreclosing on the house. As a result, the household will default if: $\widetilde{R}_2 < D+\ell$. Borrowing through PACE increases the probability of bankruptcy for households because the total repayment amount is higher.

The household's utility function across the two periods is then equal to the following:

$$U(A,D) = \underbrace{-A}_{\text{down payment}} + \underbrace{\beta \int_{\underline{R}}^{D+\ell} \widetilde{R}_2 \;\; dF(\widetilde{R}_2)}_{\text{Expected utility if default}}$$

$$\underbrace{+\beta \int_{D+\ell}^{\overline{R}} \widetilde{R}_2 - D - \ell \;\; dF(\widetilde{R}_2)}_{\text{Expected utility if no default}}$$

An important friction is that PACE loan finances projects that, taken in isolation, are *illiquid*. The inability to keep the house and sell the PACE-backed project implies that the household cannot simply sell the PACE-financed project following a negative income shock. An important statistic is the net present value of the PACE financed project, that is, how much the house value appreciates, net of its discounted costs, if the PACE project is realized.

We assume lenders are more patient than borrowers. Lenders' discount factor satisfies $0 < \beta < \delta < 1$ to allow for gains from trade. As a result, lenders' profit function is given by:

[10] In reality, $\widetilde{R}_2$ could be affected by projects funded by PACE loans. For instance, installing solar panels allows the homeowner to sell electricity to the grid, increasing $\widetilde{R}_2$; similarly, installing impact-resistant windows might lower homeowners insurance premia by preventing damages from severe storms, thereby increasing households' disposable income. Without loss of generality, we assume that these potential income gains have a long-term impact and are thus mainly captured through the house price gains we document.

$$\Pi(A,D) = \underbrace{-(H_0 - A)}_{\text{Loan amount}} + \underbrace{\delta \int_{\underline{R}}^{D+\ell} H + \Delta H - \ell \; dF(\widetilde{R}_2)}_{\text{Expected profit if borrower defaults}} + \underbrace{\delta \int_{D+\ell}^{\overline{R}} D \;\; dF(\widetilde{R}_2)}_{\text{Expected profit if borrower does not default}}$$

PACE loans have an ambiguous effect on lenders' profit. The household's default region widens when a PACE loan is undertaken. However, the recovery value can be higher if the PACE loan increases the home's value, $\Delta H - \ell > 0$.

Lending markets are competitive, so lenders have zero rent: $\Pi(A,D) = 0$. The representative household maximizes his utility subject to the zero profit condition. We obtain the following first-order condition:

$$\underbrace{\beta \int_{D+\ell}^{\overline{R}} dF(\widetilde{R}_2) - \beta(D+\ell)f(D+\ell)}_{\text{Marginal NPV cost of more debt repayment}} =$$

$$\underbrace{\delta(H + \Delta U - \ell)f(D+\ell) + \delta \int_{D+\ell}^{\overline{R}} dF(\widetilde{R}_2) - \delta D f(D+\ell)}_{\text{Marginal NPV benefit of lower downpayment}}$$

This first-order condition characterizes a key tradeoff. Marginally increasing debt outstanding is costly for the household because it increases future debt repayment in non-defaulting states. It also weakly increases the probability of default. However, an increase in mortgage debt carries a utility benefit because it decreases the necessary downpayment. The extent to which the downpayment amount is reduced depends on the participation constraint of lenders. Downpayments will be reduced by more if the collateral recovery value of lenders is higher, which depends on the net present value of the PACE-financed project.

C.3 Model Predictions

Comparative statics depend on $f(\cdot)$, which we do not observe. To make the results more tractable and without loss of generality, we assume that $f(\cdot)$ comes from a uniform distribution and (optimized) repayment amount D^* is between $[\underline{R}, \overline{R}]$. Given the previous first-order condition, we can derive the following propositions:

Proposition 1: The supply of mortgage lending D is increasing in the payoffs of PACE loans (ΔH) but decreasing in the loan amount ℓ of the PACE contract.

Intuition/proof: If ΔH increases, then the recovery value of lenders in the event of default increases, reducing the risk of a short sale in which the value of the house falls below the outstanding debt. As lenders make zero profit, they have to increase the probability of default by increasing D in order not to make any profit. Increasing D also increases households' utility, as they are more impatient ($\beta < \delta$). With a uniform distribution $f(\cdot)$, the second order condition becomes $\beta < \delta$ and the optimal D can be expressed as an increasing function of (ΔH) and a decreasing function of ℓ.

Proposition 2: The probability of default is weakly higher with a PACE loan.

Intuition/proof: The default boundaries are determined by $D + \ell$, which increases with ℓ.

D Classifying Building Permit Activity

We describe in this appendix how we classify building permits into categories of PACE eligible vs. ineligible projects by parsing the text string attached as a memo to permit filings with the town clerk's office. Before listing the steps in our algorithm, we begin by noting that CoreLogic pre-classifies permit applications in their *Building Permits* data into broad categories. We choose not to use these pre-populated permit project types for two reasons. First, each permit in the CoreLogic data can have up to three project types listed. For example, a permit might have its CoreLogic-generated project types listed as "Demolition," "HVAC," and "Mechanical Work," but the text of the permit memo reads "Air conditioning change out." Classifying this as a demolition in the traditional sense would lead to an erroneous classification of this permit as an "other," non-PACE use. When we instead work directly with the memo text, our methods classify this observation as an HVAC permit. Second, the CoreLogic project types are missing for one-third of observations, requiring us to rely on other data fields to determine the type of work being done on the house.

We adopt an iterative approach which leverages the pre-classification of memos by CoreLogic and the full text string. We focus on the classifying permits into five categories – four broad categories of projects eligible for PACE financing under Florida state law: solar, HVAC, windows and doors, and roofing – and a catch-all "other" category combining all PACE ineligible home improvements. We can also separate our categories into finer subcategories such as "impact" for window installation permits with modern impact-resistant technology, as summarized by the Design Pressure (DP) ratings in Figure 2, but the memos are frequently so terse that information about the features of the product being installed is left unstated.

1. We first isolate permits tied to single-family homes by creating a flag based on the state land use description. We use the keywords: "SFR," "SINGLE FAMILY," "TOWNHOUSE," "TOWNHOME," "SINGLE FAM," "DUPLEX," "MULTIPLE SFR'S," "SINGFAM - COOP." Similarly, we create a flag for condominiums and small multi-family properties with less than four units to include in our sample. In cases where the state land use description is missing, we search for similar keywords in the county's land use description for that permit and code the flag using that field. The intersection of these three flags accounts for 71% of the permits matched to PACE properties. This means properties which were *ex ante* single-family and small multi-family residences receiving a PACE loan account for 71% of permits tied to PACE properties.[11]

[11] Since owners may simultaneously opt to convert the property from an income-generating to owner-occupied use while engaging in green home improvement projects financed through PACE, it is possible we exclude some residential permits from our sample. However, information about the work and the property itself is recorded on permits on an *ex ante* basis, so we do not attempt to track down properties which conform to this scenario.

2. Next, we use the pre-classifications provided by CoreLogic to sort the permits into 13 broad types using the keywords listed in quotes:

   - Type 1 (interior remodel): "Bathroom Remodel," "Multi-Room Remodel," "Kitchen Remodel"
   - Type 2 (exterior remodel): "Fences," "Patios," "Siding," "Signage"
   - Type 3 (HVAC): "HVAC," "Mechanical Work"[12]
   - Type 4 (plumbing): "Plumbing," "Sewer Laterals"
   - Type 5 (roofing): "Roofing"
   - Type 6 (solar): "Solar Installation"
   - Type 7 (electrical): "Electrical Work"
   - Type 8 (doors and windows): "Doors and Windows"
   - Type 9 (construction): "Demolition," "New Construction"
   - Type 10 (add ons): "Pool and Spa Construction," "Mobile Homes," "Home Addition," "Garage Construction," "Docks," "Decks and Porches"
   - Type 11 (paving, concrete, landscapes): "Flatwork Concrete," "Paving, Driveways, and Sidewalks," "Landscale," "Foundations," "Excavation and Grading," "Retaining Walls"
   - Type 12 (new residential): "Residential"
   - Type 13 (commercial): "Commercial," "Commercial Renovation"

   We code a permit as belonging to any of these types as long as one of the three CoreLogic pre-classifications satisfies the keyword criteria. Therefore, a permit may belong to, at most, three of the 13 types listed. The 13 types perfectly span the set of possible keywords CoreLogic provides for our sample of Florida permits.

3. We then collapse the 13 types in the previous step into one of the possible major categories of PACE projects. We count a permit as belonging to the HVAC category if any of its three CoreLogic codes falls into Type 3, to the roofing category if Type 5, to the solar category if Type 6, to the windows and doors category if Type 8. A permit is "other" if it falls into any of the other twelve types. At this stage, a permit can therefore fall into multiple categories.

4. We further refine our five categories by parsing the memo in the text string to account for missing values in the CoreLogic fields. In this step we also code permits which were previously coded as belonging to the roofing category to solar if they mention both roof and solar panel installations. For instance, we code the permit as roof if it mentions "shingle," and the permit as solar if it mentions "cell" or "photovoltaic." See our replication file for the full set of keywords used in this step.

[12] The mechanical work tag is used by CoreLogic to refer to heating and cooling or climate control installation. Other types of mechanical work fall into the electrical category in Type 7.

5. At this stage, approximately 3% of permits do not belong to one of our five parent categories, because they are either missing CoreLogic's pre-classifications or are missing a memo. We further move permits from the "other" category to one of the four PACE categories if the contractor's listed permit work type shares any of the keywords we applied to the memo field in the previous step.

6. Finally, we drop permits in which the final status reads as terminated ("canceled," "rejected," "revoked," "suspended," "triage," "withdrawn") or permits which never progressed beyond the application stage ("applied," "filed," or "plancheck"). Roughly 12% of permits are either terminated or incomplete, although most of these permits do not occur within the 12 months of PACE loan origination for that property. A PACE loan will be cancelled if the borrower does not follow through with the permitted work within the 12-month period since origination, and the borrower is liable for any interest already accrued on the non-*ad valorem* assessment. We also drop duplicate filing entries sharing an APN, contractor's listed permit work type, permit effective date, and the municipality.

This algorithm results in the classification of PACE and non-PACE permits in Figure 4. Under our scheme, 94% of permits matched to a PACE loan fall into a mutually exclusive category. Our results are nearly identical regardless of whether we drop the 6% of permits corresponding to multiple possible uses of PACE funds.

E Data on Window Resiliency and Energy Efficiency

The U-Factor data is collected from the NFRC (National Fenestration Rating Council).[13] The design pressure (DP) rating is discretized into three categories: low, average, and high. There is no central database to collect the DP rating. As a result, we adopt a multi-step approach:

1. We first research the rating from the NFRC Search Directory, the respective website of the product, and any other sources. When a rating is available, we assign "low" if the rating is between 0% and 40% of the total grade, "average" if this percentage is between 40.1% and 59.9%, and "high" if this percentage is between 60% and 100%.

2. Second, we look at specific text descriptions. For instance, if the window is "Hurricane Certified/Resistant," we assign it to the high DP rating category.

3. Third, we look at the materials used to construct the window. A window made out of triple-paned glass is far more hurricane-resistant than a window made out of tempered single-paned glass. If the window being analyzed has a grid, it is generally less resistant to hurricanes than windows without a grid. Grids create additional seams and joints, which can be weak points in the structure during high-impact events like hurricanes. Moreover, we consider whether the window was made out of a specific material that affects the rating score. For example, fiberglass vs. argon

[13] Source: https://search.nfrc.org/search/searchdefault.aspx

windows receive different scores. We confirm our own evaluation of the data using ChatGPT, by specifically asking ChatGPT for a DP rating based on the material and structure of the windows.

F Description of Supplemental Datasets

HMDA mortgage lending data. We use the Home Mortgage Disclosure Act (HMDA) data for our analysis of the mortgage market effects of PACE adoption in Section 5.4.[14] We focus on 2010-2020 HMDA datasets, and use the FFIEC mapping files to harmonize lenders' names pre-2017 with those from 2018 onwards.[15] The choice of ending our sample period in 2020 is justified by the fact that county-level COVID-related effects may bias the estimates. Further, a wave of repeals and legal challenges to Florida PACE occurred in the post-2020 period which makes it difficult to interpret the nature of a county's treatment status when the legality of PACE is in flux. Our results are qualitatively similar, though weaker, when including post-2020 data.

The public HMDA data is a repeated cross-sectional dataset covering nearly the universe of mortgage applications in the U.S. For each applicant, we observe applicant demographic information – including their gender, income, and co-applicant status – as well as the lender's acceptance/rejection, pricing, and securitization decisions. Our ability to separate out lenders' acceptance decisions for each borrower application allows us to tease out whether the super seniority of PACE loans incentivizes lenders to stop offering primary mortgages in counties where the local government has enabled PACE. Contrary to this hypothesis, we find in Section 4.4 that lenders increase their approval rate of for-purchase and refinancing mortgages.

SHELDUS natural hazards data. We rely on the Spatial Hazard Events and Losses Database for the United States (SHELDUS) to examine the determinants of counties' enactment of PACE ordinances. We download the complete hazard-level data extract covering all Florida counties from 2010 onward. The database contains most natural disasters, such as thunderstorms, hurricanes, floods, wildfires, and tornadoes. It reports the date of the natural hazard event, the affected counties, and various measures of direct losses caused by the event based on insurance claim payouts (indemnities). We capture *ex ante* risk exposure to natural disasters by calculating the value (in real 2021 dollars) of average property damages at the county level between 1960 and 2021. This variable ranks counties based on their historical exposure to natural disasters. Under rational expectations, this measure should be monotonically increasing in the expected probability of natural disaster risks at the county level.

Data Axle Consumer Database. We use household-level information from consumer research firm Data Axle (formerly ReferenceUSA) to obtain snapshots of households' income, wealth, and credit access prior to PACE or home equity loan origination. Data Axle imputes this information using proprietary models feeding in data based on the

[14] Note that because PACE lenders offer specialized non-mortgage loan products, they are not required to report PACE loans into HMDA. We confirmed that the coalitions of lenders (districts) or the lenders themselves (administrators) originating Florida PACE loans do not appear in HMDA during our sample time period.

[15] See here https://ffiec.cfpb.gov/documentation/faq/identifiers-faq.

consumption patterns of households located at an address and those of surrounding addresses, along with income statistics from the U.S. Census Bureau and self-reported survey data. According to Data Axle, the model has also been validated against both IRS and Census income information.

Because observations in Data Axle are at the household-quarter level, we take several steps to match the records to the CoreLogic data which track properties. We merge about 60% of observations in the PACE sample to unique locations in the Data Axle. For this merge, we match coordinates rounded to 4 decimals, 4-digit zip code identifiers and years. We check these merges by requiring that the house numbers across the two datasets line up, and if the house number is missing, then we impose a constraint that the street names have a string distance of less than 0.5. This excludes extremely few matches (less than 2%), indicating the merge is quite precise.

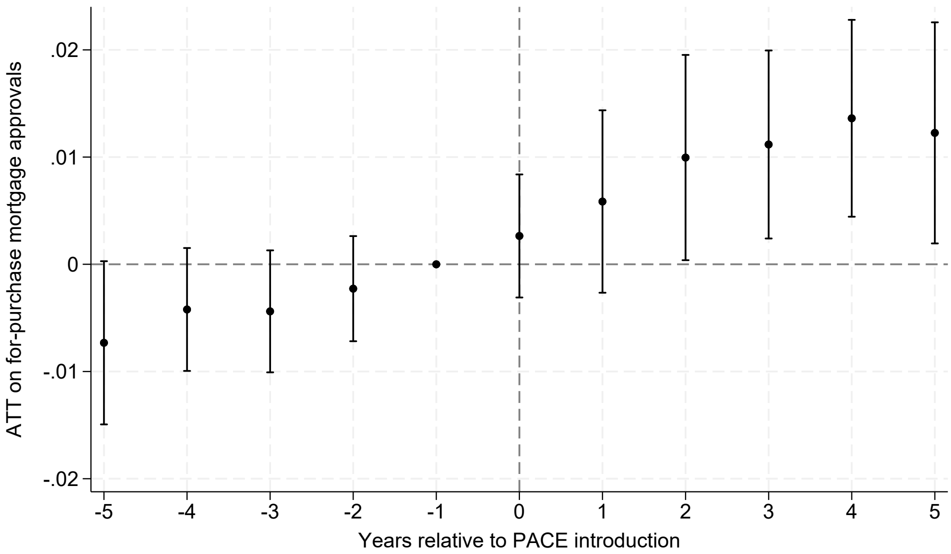
However, while we can merge 60% to unique locations in Data Axle, many of these locations contain multiple households. In cases where the address corresponds to multiple units, we can additionally match on the unit number if this is populated. In the remaining cases, we restrict to owner-occupied addresses where Data Axle only has a single household on file as being in residence. These two restrictions reduce the match rate between Data Axle and our CoreLogic sample to about 31%.

Since household records are only updated sporadically, owing to the relativey low match rate described above, we use Data Axle only to form proxies for *ex ante* financing constraints, rather than using the data source to examine the evolution of households' financial health following PACE. For a unit with loan origination in t, we assign the last Data Axle observation from the preceding year $t-1$. PACE households have income and wealth over 0.5 standard deviations lower than HELOC households, and have a 0.2 standard deviations lower number of credit cards. At the same time, early vs. later cohorts of PACE borrowers are statistically identical along these dimensions, justifying our use of the not-yet-treated as a control group to help hold fixed the relative subprimeness of the PACE borrower pool in our analysis of the capitalization effects of PACE projects into house prices.

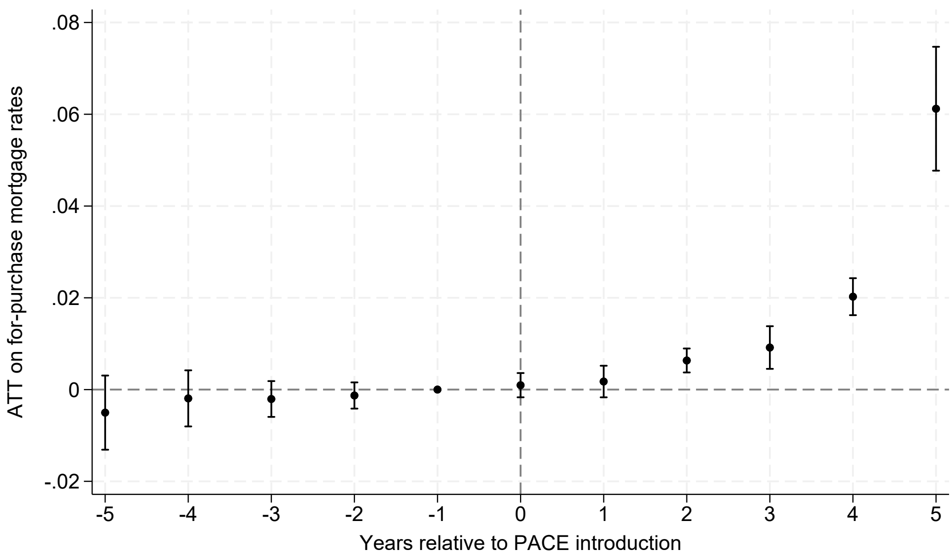
G Robustness Checks of *Ex Ante* Lending Analysis

Figure G.1. Event Study: Lenders' Credit Supply Response for First Lien Home Purchase Mortgages

A. Stacked DiD



B. Tax year-based treatment dates



Note: Panel A plots the coefficient estimates using the "stacked" difference-in-differences approach of Cengiz et al. (2019) which adds stacked cohort fixed effects to the regression equation (5.4). In Panel B, coefficients are estimated using the Callaway and Sant'Anna (2021)'s estimator, and treatment timing is defined as the year when the first PACE loan is recorded in by county tax assessors. Time on the x-axis is years relative to the county's introduction of the PACE program.

H Comparing PACE to HELOC Loan Contracts

In this appendix we compare PACE to private home improvement loans on the basis of the interest rates charged, loan-to-value (LTV) ratios, and the role of combined LTV in the loan pricing.

H.1 Distribution of PACE vs. HELOC Interest Rates

The main alternative consumer debt product to a PACE loan is a home equity line of credit (HELOC) used towards a home improvement project. In this appendix we compare loan contract features for Florida PACE loans vs. home improvement loans to highlight the tradeoffs consumers face in choosing one or the other. We find that HELOCs carry interest rates which are, on average, 155 basis points lower than those charged on comparable PACE loans. This fact, together with the deferred payment schedules often offered with HELOC contracts, suggests that in the absence of financing constraints or concerns about maintaining a higher credit score, consumers would strictly prefer a fixed-rate, closed-end HELOC to a PACE loan.

An empirical challenge we face is that we do not directly observe key contract features for PACE loans such as the interest rate or loan amortization term. We compile our PACE loan dataset by submitting public records requests to counties and PACE districts. Contract features comprising private information cannot be disclosed through Freedom of Information Act (FOIA) requests. However, for a sample of 4,190 PACE loans originated in Broward County, we observe both the origination amount and can scrape for each of these loans the history of annual property tax payments towards amortizing the PACE assessment, separate from any payments made towards normal *ad valorem* assessments.[16] Broward County contains Fort Lauderdale and is located in the Miami metropolitan area. Broward is the second largest county in Florida by 2022 population, and 48% of loans in our overall PACE sample are originated there.[17] We therefore view this subsample of loans as representative of the statewide PACE market.

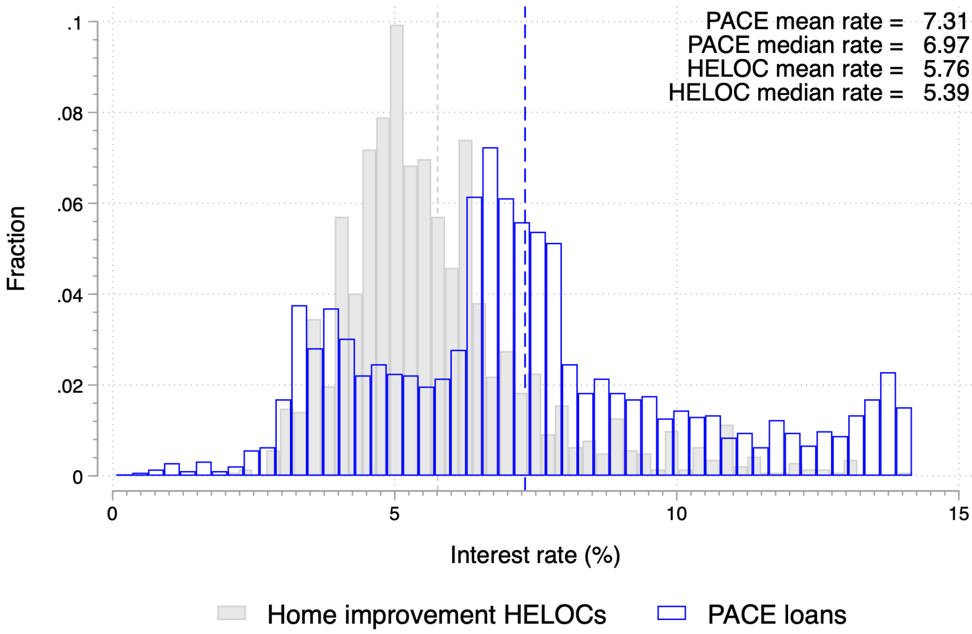
Since PACE loans are fixed-rate term loans, to back out the interest rate we require the origination amount, the required annual payment, and the loan term. We do not observe the loan term, but PACE loans are only originated with 5, 10, 15, 20, 25, or 30-year term lengths. We therefore compute a vector of possible interest rates for each loan corresponding to these possible 5-year term bins and average the rates across the bins to compare to the distribution of HELOC interest rates. For each of the loans in our sample, there is no interest rate which can generate the observed amortization schedule at a 5-year horizon, indicating that 5-year PACE loans are not originated in Broward County.

We assign a fixed required payment amount to each loan based on the first annual payment made on the loan. In some cases the annual payments can differ year to year by small amounts due to administrative fees levied by the county for maintaining records of the PACE assessment. Since such fees are capped at 2% of the loan payment in Florida,

[16] We scrape these records from the Broward County website: https://county-taxes.net/broward/property-tax.

[17] For in-depth population and demographic breakdowns by Florida county, see: https://www.bebr.ufl.edu/wp-content/uploads/2022/12/estimates_2022.pdf.

Figure H.1. Distribution of Interest Rates for PACE and Home Improvement Loans: Broward County (2018 – 2022)



Note: The figure plots the distribution of interest rates for PACE loans and fixed-rate home equity lines of credit (HELOCs) used towards home improvement originated in Broward County (Miami-Fort Lauderdale), Florida between 2018 and 2022. We filter the HMDA data to include fully amortizing, closed-end home improvement equity loans; the interest rate variable in HMDA is only available starting in 2018. We compute interest rates for PACE loans using the methods outlined in the Online Appendix H text. The interest rate definition is an APR, since in both loan samples any (unobserved) origination fees are loaded into the principal. We restrict the sample to loans with origination amounts under $100,000, which is above the 99th percentile of loan amount for a PACE loan and above the 90th percentile of loan amount for a second lien home improvement HELOC. Origination amounts in excess of $100,000 for HELOCs are likely to pertain to multi-family construction projects or major non-green renovations, which are not allowable uses of funds under the PACE program.

linearly amortized over the loan term, we keep the initial year's payment as the fixed required payment as long as the "drift" in payments across years is within this tolerance. We drop any loans for which we compute an average interest rate of over 16% in any of the 5-year term buckets, as such cases likely feature multiple loans recorded as a single PACE assessment or nearly full prepayment in the initial tax year; PACE loans do not carry prepayment penalties.[18]

Figure H.1 plots the interest rate distributions across the two loan markets for Broward County, focusing on loans originated between 2018 and 2022. We use this sample time period because interest rates are not available prior to 2018 for HELOCs in the HMDA data. One drawback to the HMDA dataset is that property-level information is sufficiently redacted for confidentiality reasons that we cannot isolate the type of home improvement

[18] The sample of PACE loans for California and Florida used by Consumer Financial Protection Bureau (2023) overlaps with our sample and features a maximum annualized interest rate of 10%.

projects as we can with properties which can be matched to CoreLogic *Building Permits* dataset. We thus restrict to loan amounts below $100,000 to render it more likely that the home improvements being conducted with HELOCs do not involve larger multi-family properties. We use only HELOCs tied to properties classified as "single-family" on the loan application.

Under these sample restrictions, the average interest rate on a PACE loan is 155 basis points greater than for the average fixed-rate home improvement HELOC loan.[19] Our average PACE interest rate of 7.3% is close to the average 7.6% interest rate reported by Consumer Financial Protection Bureau (2023) in their sample of loans which covers both California and Florida. The most common loan term for closed-end HELOC loans in Florida is 30 years, but 10-year, 15-year, 20-year, and 30-year terms are also common.[20] If we compare the mean 30-year HELOC interest rate to the mean interest rate for a PACE loan assuming a 30-year amortization term, then the average spread widens to 416 basis points. Most of the spread between PACE and HELOC interest rates is concentrated at the long end of the yield curve.

An additional advantage to taking out a HELOC is that the interest is tax deductible if the funds are used towards a home improvement project. According to the NBER TAXSIM model, the average marginal income tax rate in 2021 was 23.25%.[21] This means the after-tax rate spread for a PACE loan relative to a home improvement HELOC implied by the distributions in Figure H.1 is $0.0731 - (1 - 0.2325) \times 0.0576 = 289$ basis points. This is an extreme upper bound on the rate spread to the extent that it assumes 100% of all PACE borrowers would itemize if they instead took out a HELOC, an assumption unlikely to be true given that in recent years only about 10% of federal income tax filers choose to itemize.[22] Applying this itemization probability to the calculation results in a spread of 168 basis points.

H.2 What Determines the Rate Spread on PACE Loans?

Table H.1 shows that the basis point spread we uncover for PACE loans relative to home improvement HELOCs remains even within loan-to-value (LTV) bins, years, and Census tracts. In particular, we estimate regressions of the following form:

$$r_{i,c,t} = \alpha + \beta \cdot PACE_{i,c,t} + \sum_{m=1}^{M} LTVbin_{i,c,t} + PrimaryMtg_{i,c,t} + \gamma_c + \delta_t + \varepsilon_{i,c,t} \quad \text{(H.1)}$$

[19]For mortgages with monthly amortization schedule, the rate at origination does not correspond to an annual interest rate. If we assume all HELOCs are paid monthly, then the equivalent average annualized interest rate is $(1 + .0576/12)^{12} - 1 = 5.91\%$, meaning the spread with a PACE loan would narrow only by 15 basis points to 140 basis points.

[20]Conditional on loan term, the distribution of interest rates at origination is similar for closed-end and open-end home improvement HELOCs. For instance, in our Broward County sample, open-end lines have a starting average rate of 5.91%, while closed-end lines carry a rate of 5.23%, or a 69 basis point spread. This suggests most open-end HELOC borrowers immediately exercise their maximum drawdown option, and banks price the loan as if it were effectively a closed-end line.

[21]See https://taxsim.nber.org/marginal-tax-rates/af84n.html for historical marginal income tax rates generated by the NBER TAXSIM model.

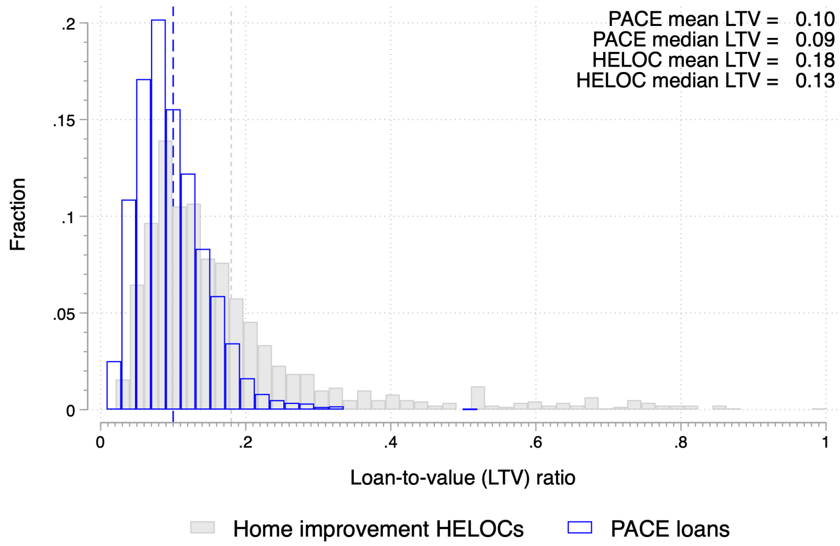
[22]See analysis by the Tax Policy Center: https://www.taxpolicycenter.org/briefing-book/what-are-itemized-deductions-and-who-claims-them.

Table H.1. Interest Rate Spread for PACE Loans vs. HELOCs

Dep. variable: % interest rate ($r_{i,c,t}$)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$PACE$	2.096***	0.746***	0.791***	0.584***	1.533***	1.268***	0.587***	1.052***	0.824***	1.834***
	(0.093)	(0.100)	(0.102)	(0.103)	(0.131)	(0.140)	(0.095)	(0.127)	(0.193)	(0.212)
$PrimaryMtg$			0.304***	0.307***	1.044***	0.992***	0.297***	0.706***	0.233***	2.029***
			(0.070)	(0.068)	(0.107)	(0.123)	(0.064)	(0.089)	(0.079)	(0.277)
$PACE \times PrimaryMtg$					−0.946***	−0.863***		−0.576***		−1.932***
					(0.136)	(0.145)		(0.118)		(0.288)
Sample	Closed	Closed	Closed	Closed	Closed	Closed	Both	Both	30-year	30-year
Origination year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LTVbins	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Census tract FEs	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
p-value on seniority	–	–	–	–	0.244	0.104	–	0.233	–	0.103
N	6,290	6,271	6,222	6,185	6,222	6,185	7,342	7,342	4,736	4,736
Adj. R^2	0.170	0.310	0.314	0.379	0.318	0.381	0.354	0.356	0.516	0.520

Note: The table reports results from estimating specifications of the form in equation (H.1) and (H.2) using our sample of PACE loans and home improvement HELOCs originated in Broward County over the period 2018 to 2022. Columns (1) through (6) use the set of closed-end HELOCs as a comparison group for PACE loans, while columns (7) and (8) include both closed-end and open-end HELOCs. The final two columns compare 30-year interest rates charged on PACE loans to 30-year, closed-end HELOCs. *LTVbins* corresponds to dummies for LTV deciles, with the bottom decile (1%-5% LTV) omitted as the reference category. p-value on seniority refers to the p-value on the test of $\beta_2 + \beta_3 = 0$ in equation (H.2), which tests for whether there is no differential effect of having a mortgage on PACE interest rates. To determine the existence of a pre-existing mortgage for PACE borrowers, we merge to the CoreLogic *Tax* and CoreLogic *Mortgage* data based on the property APN and fuzzy string match names between the ownership record on the tax roll and the most recent mortgage transaction on the property, hand-checking any observations with a similarity score between 20% and 70% to rule out false-negative matches. Robust standard errors clustered at the Census tract level in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

Figure H.2. Distribution of Loan-to-Value (LTV) Ratios for PACE and Home Improvement Loans: Broward County (2018 – 2022)



Note: The figure plots the distribution of loan-to-value (LTV) ratios for PACE loans and fixed-rate home equity lines of credit (HELOCs) used towards home improvement originated in Broward County (Miami-Fort Lauderdale), Florida between 2018 and 2022. We filter the HMDA data to include fully amortizing, closed-end home improvement equity loans. We compute LTV ratios for the HELOC as the ratio of the loan amount at origination to the property value reported on the application. For PACE loans, the LTV is defined as the loan amount, divided by the market assessed value in the year prior to origination. We restrict the sample to loans with origination amounts under $100,000, which is above the 99th percentile of loan amount for a PACE loan and above the 90th percentile of loan amount for a second lien home improvement HELOC. Origination amounts in excess of $100,000 for HELOCs are likely to pertain to multi-family construction projects or major non-green renovations, which are not allowable uses of funds under the PACE program.

where $r_{i,c,t}$ is the interest rate at origination charged on loan i originated in year t and attached to property located in Census tract c. The dummy $PACE_{i,c,t}$ indicates that the loan is a PACE loan, which means β corresponds to the rate spread for a PACE loan vs. a comparable HELOC. Given that greater leverage influences rates through higher default probabilities, we include a set of M LTV bin dummies to hold fixed the loan amount relative to the property's market assessed value in $t-1$. While assessed values are generally an imperfect measure of a home's market value, in Florida the assessment ratio of market assessed values to recent sale prices is usually over 90%, indicating that the assessor's value is a reasonable proxy for the appraisal that would be attached to a mortgage loan application.

We plot the distribution of LTVs for PACE and our sample of comparable HELOCs from HMDA in Figure H.2. By state statute, the total PACE loan amount is limited to 20% of the county's assessed market value of the property unless mortgage lenders with a lien on the property consent to higher LTV loans or an energy audit documents that the annual energy savings equal or exceed the annual repayment amount [4 F.S. Chapter 163.08(2)(b)(12)(a)]. As a result of this rule, the average PACE LTV is 10%, compared to 18% for a comparable home improvement HELOC, and 97% of PACE loans have an LTV below the 20% statutory threshold. Since our pricing results in Section 5.2 indicate, across a range of specifications, that PACE properties sold after home improvement appreciate in excess of 10%, the average PACE borrower can sell their property and pay off the remaining loan balance even if they are unable to make payments through other resources. Together, these facts explain why severe property tax default resulting in tax foreclosure is so far non-existent for Florida PACE.

Conditioning on origination year, the basis point spread is 210 points. The spread drops to 75 basis points once we account for variation due to LTV, and drops further to 58 basis points after adding Census tract fixed effects. The spread increases only slightly to 59 basis points when we include open-end HELOCs in the comparison group sample in columns (7) and (8), and the spread widens to 82 basis points if we restrict the sample to interest rates on 30-year loan terms in columns (9) and (10).

We match each PACE loan to the homeowner's history of mortgage transactions on that property. We then code a dummy $PrimaryMtg_{i,c,t}$ as equal to one if the owner is still paying off a primary mortgage at the time of PACE loan origination. Thus, we set $PrimaryMtg_{i,c,t} = 1$ if the mortgage loan term > number of years that have passed since the mortgage origination year up until the PACE origination year. Accounting for the existence of a primary mortgage helps proxy for the combined LTV (CLTV). For our sample of HELOCs in HMDA we directly observe combined LTV at the time of the loan application. For PACE loans, isolating CLTV involves tracking the balance of mortgage loans over time until the year of PACE origination. Doing so is complicated by the fact that the CoreLogic data do not systematically report interest rates for mortgages and do not provide the loan performance history. For HELOCs in the HMDA data, we set $PrimaryMtg_{i,c,t} = 1$ if the HELOC has second lien status. 63% of PACE loans have a primary mortgage attached to the property, compared to 54% of our sample of home improvement HELOCs.[23] Column (3) shows that having a primary mortgage is associated with a 30 basis point increase in home equity loan interest rates, averaging across both HELOCs and PACE loans.

Since PACE loans are super senior to other claims on home equity, the existence of a prior mortgage, holding fixed LTV, should not influence interest rates charged on PACE loans, but should influence rates charged on HELOCs which lack this super seniority property. To test that hypothesis, we augment equation (H.1) by adding an interaction of $PACE_{i,c,t}$ with $PrimaryMtg_{i,c,t}$:

$$\begin{aligned} r_{i,c,t} &= \alpha + \beta_1 \cdot PACE_{i,c,t} + \beta_2 \cdot PrimaryMtg_{i,c,t} \\ &+ \beta_3 \cdot \Big(PACE_{i,c,t} \times PrimaryMtg_{i,c,t}\Big) + \sum_{m=1}^{M} LTVbin_{i,c,t} + \gamma_c + \delta_t + \varepsilon_{i,c,t} \end{aligned} \tag{H.2}$$

Under the super seniority hypothesis, we would expect $\beta_2 > 0$ and $\beta_3 < 0$, with the two coefficients being of equal magnitude. The reason is that in the event of default, a HELOC lender would be in a second lien position but the local government as the ultimate PACE

[23] Consumer Financial Protection Bureau (2023) reports that 70.8% of borrowers in their pooled sample of PACE loans across California and Florida have a pre-existing mortgage.

lender would not. In contrast, the local government need not worry about receiving the full amount due if the proceeds from sale of the home are not enough to cover the combined amount of debt because they can directly sell tax liens to recoup any losses, or eventually move to foreclose. Our evidence in Table H.1. is consistent with the super seniority of PACE loans offering a shield against higher interest rates for home improvement debt when there is a pre-existing mortgage in place; we fail to reject the null that $\beta_2 + \beta_3 = 0$ in equation (H.2).

I Do Counties' Finances Predict PACE Program Adoption?

Table I.1 extends the analysis in Table 1 concerning county-level determinants of PACE program adoption. We include an extensive set of county financial accounting variables to study whether local governments' finances affect PACE program adoption and/or mediate the role of the tax assessor's office. Municipal finance variables include county-level (total) debt, tax revenue, expenditures, interest payments, and holdings of cash and securities. We scale these variables by total revenue. The data come from Willamette University's Government Finance Database and are based on the Census Annual Survey of State and Local Government Finances. In each regression, represented as a separate column in the table, the dependent variable equals one if a county has adopted PACE in a given year, and zero otherwise.

We find that a county's financial condition does not predict PACE adoption in the specifications where we control for county and year fixed effects (columns 3–5). This evidence supports the idea that local governments' financial incentives are not the driving factor behind program implementation. As in Table 1, we find that newly elected tax assessors are more likely to pass a PACE program in counties where residents' climate concerns are high, as measured by the Yale Program on Climate Change Communication surveys. Since both tax assessor retirements and the timing of elections for assessor positions are predetermined and unlikely to be correlated with local economic conditions, these findings support our identifying assumption in the mortgage market analysis of Section 5.4 that the timing of county-level PACE adoption is quasi-random.

Table I.1. Do Municipal Finances Predict PACE Adoption?

Dep. variable: PACE Adopted	(1)	(2)	(3)	(4)	(5)
County financial variables:					
Debt/Revenue	-0.124	-0.164*	-0.057	-0.100	-0.185
	(0.105)	(0.087)	(0.100)	(0.092)	(0.161)
Tax revenue	0.702	0.845*	0.759	0.399	0.572
	(0.477)	(0.456)	(0.671)	(0.627)	(0.698)
Expenditure ratio	-0.127	-0.097	-0.155	-0.030	-0.121
	(0.239)	(0.197)	(0.294)	(0.291)	(0.310)
Interest payment/Revenue	-0.088	0.844	0.356	0.364	-0.141
	(1.774)	(1.432)	(1.856)	(1.841)	(1.303)
Cash/Revenue	0.178	0.159	0.048	0.080	0.222
	(0.127)	(0.115)	(0.105)	(0.102)	(0.162)
Other county-level factors:					
Population	0.040	0.071	-0.439	-0.049	0.307
	(0.073)	(0.077)	(1.042)	(1.016)	(1.497)
Household median income	0.706**	0.473	-0.150	-0.160	0.128
	(0.307)	(0.351)	(0.359)	(0.349)	(0.426)
% Bachelor degree or higher	-1.819**	-1.834**	1.587	1.221	1.516
	(0.817)	(0.752)	(1.268)	(1.199)	(1.384)
% Black	1.591	2.721	0.979	0.770	-0.766
	(2.383)	(2.089)	(2.601)	(2.483)	(3.903)
% Latino	1.883	2.467	-1.851	-1.337	-5.250
	(2.122)	(1.838)	(7.239)	(6.776)	(8.902)
% White	1.109	2.386	-5.016	-1.810	-6.304
	(1.982)	(1.696)	(4.787)	(4.993)	(7.037)
Unemployment rate	-4.239***	-3.764***	-0.653	-0.977	-0.484
	(1.424)	(1.249)	(1.223)	(1.222)	(1.356)
Democratic leaning	0.710	-0.132	-0.779	-1.033	-1.768
	(0.761)	(0.681)	(1.129)	(1.014)	(1.209)
Neighbor PACE	0.026	-0.066	0.033	0.015	-0.027
	(0.092)	(0.086)	(0.085)	(0.087)	(0.081)
#Declared natural disasters	0.125***	0.084***	-0.019	-0.023	-0.032
	(0.025)	(0.029)	(0.028)	(0.029)	(0.039)
Abnormal property damage	0.000	0.000	-0.000	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Climate concerns		0.044***		0.021	0.029
		(0.011)		(0.019)	(0.022)
Assessor turnover		0.355		-1.253**	-1.322*
		(0.619)		(0.519)	(0.699)
Assessor turnover × Climate concerns		-0.007		0.023**	0.024*
		(0.011)		(0.010)	(0.013)
Sample	All	All	All	All	Pre-2020
Observations	466	466	466	466	344
R-squared	0.376	0.425	0.711	0.725	0.693
County FE	No	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes

Note: This table examines whether a county's government finances, economic, political, or demographic conditions predict the adoption of PACE programs. The dependent variable is an indicator equal to one ($Adopted_{j,t}$) if a county j has adopted PACE in that year t. Standard errors are reported in parentheses and clustered at the county level. County financial accounting data come from Willamette University's Government Finance Database. Variable definitions appear in Table 1. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.