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

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Abstract

Residential Property Assessed Clean Energy (PACE) is an innovative financing program that allows homeowners to borrow for energy efficiency or resilience upgrades and repay the loans through their property tax bills. We collect new Florida PACE loan-level data and 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 borrowers' tax delinquency rates. 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 and lowering homeowners' insurance costs.

Keywords: PACE lending, climate retrofitting, home equity loans, delinquency, liens, homeowners insurance, property taxes

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

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1 Introduction

A substantial increase in investment is required to make the housing stock both more resilient to natural disasters and more energy efficient.[1] From 2002 to 2022, homeowner spending on disaster repairs increased by about 206% in real terms (Joint Center for Housing Studies of Harvard University, 2025), while homeowner insurance costs grew 8.7% faster than the overall price level during 2018–2022 (U.S. Department of the Treasury, 2025), highlighting the growing financial burden associated with insufficient climate resilience. While the importance of investing in private adaptation and energy-efficiency improvements is well recognized, households continue to face substantial barriers in obtaining financing for such projects (Giglio et al., 2021; Lanteri and Rampini, 2023; Hovekamp and Wagner, 2023).

To overcome these barriers, several U.S. states have passed laws enabling residential Property Assessed Clean Energy (PACE) loans. PACE loans are one of the fastest-growing public lending policies in the U.S.[2] Such loans have two distinguishing 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 special assessments tacked onto their local property tax bills. 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 yielding net fiscal benefits in the form of greater property tax revenues and lower homeowners insurance costs.

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 negatively influence primary mortgage supply. PACE loans increase

[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. The PACE market has grown by 71% since 2020 alone. See Figure 1.

households' leverage and thus raise default 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 of green projects into home values. Therefore, if a PACE-financed improvement generates large enough gains in home equity values, access to PACE financing can increase lenders' mortgage recovery rates.

We 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 comprehensive sample of 77,564 PACE loans originated for home improvements across 60 Florida counties between 2015 and 2023 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 involuntary 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 (29%) and roofing repairs or reinforcements (27%), with smaller percentages attributed to modern Heating, Ventilation, and Air Conditioning (HVAC, 15%) and solar panel (8%) installations. In contrast, for non-PACE homes over the same time period, roughly half of permits 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 and measures of households' financing constraints from Data Axle.

We show that projects financed by PACE loans increase borrowers' home equity values. Specifically, repeat sales properties undergoing PACE-funded climate-proofing projects experience an average total appreciation in home sale prices of 19% to 25%. This implies that, holding fixed any time-invariant quality differences across homes, PACE projects generate average annualized capital gains net of costs of between 24% and 32%, with slightly lower returns after taking into account interest payments, permitting fees, 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. This result is not obvious, because houses with a PACE lien could attract a lower amount of potential buyers, as households cannot take out conforming mortgages on a property encumbered by a PACE lien, thus pushing prices down.

We show that the capital gains for PACE borrowers who invest in resilience measures can be rationalized by annual savings in the form of homeowners insurance premia. Using administrative data on residential insurance contracts, we find premia fall by roughly 2% following a county's adoption of PACE. Scaling up this intent-to-treat estimate by county-level PACE take-up rates and applying standard Gordon growth formulas yields discount rates of between 2.5% and 3.5%. These estimates are similar to the long-run discount rates reported by Giglio et al. (2015) and Ge et al. (2022) for real estate investments. That PACE passes through to lower insurance costs is itself an important fact given that premia have been rapidly rising in disaster-prone areas of the country in recent years.[3]

A key prediction of our conceptual framework is that PACE loan access increases households'

[3]Annual insurance premia for homeowners policies in Florida tripled between 2019 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.

default risk, as their total debt-to-income ratio is greater 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 0.3 p.p. (a 16% increase) within a year of origination. This result is not mechanical, because PACE loans could have been used as an alternative to more expensive sources of financing, such as credit card debt. Access to cheaper financing has been shown to lower households' non-debt repayment in the context of disaster lending (Collier et al., 2024a,b).

We provide 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 probe the robustness of our findings, we show that our results are similar regardless of whether we use never-treated counties (Sun and Abraham, 2021) or not-yet-treated (Callaway and Sant'Anna, 2021) 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 and insurance 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 short-term revenue losses due to household tax delinquencies from the expansion of the property tax base through capitalization into housing values translates to higher tax revenue for a county of between $335 and $895 per PACE loan-year based on prevailing effective tax rates.[4] Hence, although some PACE borrowers may be worse off from experiencing greater annual tax burdens or default costs, local governments, prospective mortgaged homebuyers, and homeowners now facing lower insurance costs in PACE counties benefit from program adoption.

Our paper contributes to several strands of literature. 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.[5] 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 context.

A defining feature of PACE is that unlike other green policy nudges, the program 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. 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,

[4]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.

[5]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).

2004). We document PACE households have lower income and wealth, fewer credit cards, and reside in properties which are smaller, 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. 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 take out 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 isolate home improvement projects motivated by disaster-proofing rather than only energy efficiency concerns. This 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). We show that the capitalization effects of PACE we uncover can be rationalized by the pass through to lower

[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.

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.[7]

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, 40 U.S. states plus Washington, D.C. 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.[8]

[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.[9] In Florida, state legislation (Chapter 163.08) has allowed local jurisdictions to record liens for PACE loans since July 2014.

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

[8]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.

[9]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.

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.[10] There are currently six administrators operating in Florida. Public-private partnerships between local governments and PACE districts are formalized via an interlocal agreement.

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 property value (as assessed by the county), except in specific cases related to energy audits. 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 annual interest rate during our sample period 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 G that such relaxed screening requirements result in PACE borrowers paying 155 basis points, on average, more than comparable HELOC borrowers.

[10]The four districts are called: Florida Green Finance Authority, Florida PACE Funding Agency (FPFA), Florida Resiliency and Energy District, and Green Corridor PACE. Of these districts, FPFA and Green Corridor are the two largest, and together they comprise 85% of the loans in our sample.

Unlike traditional financing, PACE loans are repaid through property tax payments levied as a special assessment, 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 for PACE loans facilitates such provisions.

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 to prevent fraud. We provide samples of both notices in Online Appendix B.

PACE project types. The historical purpose of PACE is to finance projects that reduce the energy consumption of the house, such as 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. We document clear complementarities between these two types of investment. Figure 2 shows a strong positive relationship between the energy efficiency and climate resilience ratings of window products sold in the U.S., which are among the most common use of PACE funds in Florida. 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.[12]

[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.

[12] This complementarity also highlights the empirical challenges with distinguishing between households' resilience versus energy efficiency motivations behind engaging in home improvement projects.

[Insert Figure 2 about here]

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 section.

First, PACE loans allow households to finance a home improvement project that could not have been funded through another loan contract or by 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. On one side, institutional frictions, such as credit scores, rigid loan-to-value rules, and fixed interest rates from a pre-existing mortgage that are lower than the current market rate, could prevent a household from refinancing their mortgage or taking out a HELOC. On the other side, PACE loans could help complete the financial contract space. PACE programs provide administrative tools ensuring that the borrower uses the funds towards a specific project completed by a reliable contractor.[13]

Second, PACE loans are senior to mortgage debt. This seniority structure means that if the lender repossesses the house, PACE liabilities are still inherited by the lender. 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 motives 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.[14]

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 of amount ℓ, to finance a project that costs ℓ and generates pecuniary value equal to 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

[13] PACE programs render 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.

[14] 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).

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.*

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.

In extension C.2 of the Online Appendix, we develop a plausible alternative mechanism where a PACE lien reduces house prices. A home with a PACE lien cannot have a mortgage loan that is securitized with Fannie Mae and Freddie Mac. Some potential buyers may not be able to buy a house with a PACE lien. As a result, a home with a PACE lien could attract fewer buyers, driving its price down. The alternative mechanism is similar to Mian et al. (2019), who show that banking deregulation leads to an increase in mortgage supply, causing higher housing prices.

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

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, 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.

In the extensions C.3 and C.4 of the Online Appendix, we consider two different mechanisms that lead to the opposite prediction for default rates. Specifically, in subsection C.3 of the Online Appendix, we assume that the alternative of a PACE loan is junior debt, such as credit card or a HELOC. If these debt contracts are more expensive than PACE loans, then relying on a PACE loan reduces households' probability of default. Several papers find support for this alternative mechanism in the context of FEMA disaster loans (Collier et al., 2024a,b). It is *ex ante* unclear whether such a conclusion also extends to PACE loans, so we empirically evaluate this possibility in Section 5.3 by showing that borrowers' property tax delinquency rates spike following PACE origination.

Moreover, in Online Appendix C.4, we assume that households behave strategically in deciding whether to repay their mortgage. Specifically, we assume that they default if the net value of their house is negative (Melzer, 2017). Within this framework, if a PACE loan finances a project that increases the value of the house, then households will have a higher home equity value, which reduces their incentive to default strategically. As a result, according to this alternative mechanism, we should observe a decrease in default rates following a PACE loan, a prediction we ultimately find is not borne out by the data.

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. The relationship is stronger for households at risk of default.*

PACE loans finance projects that improve the value of the collateral. Mortgage lenders recover a higher value from each foreclosure on 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. Moreover, households that are not at risk of default will not be affected by these forces.

4 Data Sources and Descriptive Statistics

In this section, we describe how we link loan-level data from the Florida PACE market to property sales, home characteristics, building permits, mortgages, tax liens, and local damages caused by natural hazards.

4.1 Data Sources

We use five datasets in our main analysis. The first is a representative sample of Florida PACE loans originated between 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 filings. 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) contains information on the geographic span and severity of severe weather events for Florida. Fifth, we merge in 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 for Florida by sending FOIA requests to each county and the four residential PACE districts operating in the state. For each loan, we observe the property assessor's parcel number (APN), the origination year, and the PACE district involved in underwriting.[15] A property may be associated with multiple PACE loans. Our data include 77,564 loans and 74,797 unique properties with at least one PACE loan originated in Florida since 2015, located across 60 counties. Comparing our sample size to the total number of PACE loans originated in Florida between 2014 and 2020 (Consumer Financial Protection Bureau, 2023), our sample comprises 80% of the PACE market by loan count. For our analysis, we aggregate PACE loans to the tax year of origination level for properties with multiple PACE loans to build a property-year panel dataset.

CoreLogic Data. We match the loan dataset to the CoreLogic *Owner Transfers* and Corelogic *Tax* data using the APN of each property.[16] *Owner Transfers* is a transaction-level dataset that includes information on house prices, buyers and sellers, and the use classification (e.g.,single vs. multi-family) and location of the property. It also provides details on when properties are traded. We focus on arms-length transactions of single-family and small multi-family properties

[15]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.

[16]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.

(i.e., those with two to four units).[17]

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 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 two lien events to the same underlying 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.[18] 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

[17] We identify arms-length transactions in the CoreLogic *Owner Transfers* data as those which have the internal flag PRI_CAT_CODE set to "A" among those with a price above $100, following standard practice in the literature (e.g., Allen et al., 2017). Our sample differs immaterially when we instead construct our own arms-length transaction flag by eliminating from the sample any real estate owned (REO) or foreclosure transactions, any transactions involving two family members, and any instances where the owner and seller share a surname.

[18] 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 G.

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*. 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 two purposes. First, 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.[19] Second, we use mortgage contract terms, together with any history of refinancing activity tied to a property-owner combination, to back out the implied 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 use this information to show in Online Appendix G that the super seniority of PACE keeps interest rates lower than they otherwise would be for borrowers with comparable HELOCs who have a primary mortgage they are paying down.

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. We exclude any permits attached to newly constructed homes or demolitions and then further restrict our sample of permits to those pertaining to residential applications with three or fewer separate projects attached to the same permit and to permits which have a final status of either "approved" or "completed."[20]

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

[19] 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 G.

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

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.1.

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, $Adopted_{c,t}$ is an indicator variable equal to one if county c 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.[21]

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 during our sample period 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.[22] Since both tax assessor retirements and the timing of elections for assessor positions are predetermined and unlikely to be correlated with

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

[22] 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.

local economic conditions, these findings support our identifying assumption in Section 5.4 that the timing of county-level PACE adoption is quasi-random with respect to mortgage market outcomes.

[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 to 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.

[Insert Table 2 and Figure 3 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 terms 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.

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 tax delinquencies and how PACE-financed projects 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

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.

In Online Appendix D.2, we develop a novel methodology to identify the permits backed by a PACE loan. Our resulting sample consists of a panel of 78,482 unique permits tied to 39,354 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 32,786 permits attached to 23,236 unique properties. Despite the Notice of Commencement required to 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 certain threshold amount of costs quoted by the contractor. Moreover, many counties implemented exemptions for home rebuilding following severe storms occurring during our sample period.[23]

[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 79.3% of permits approved on PACE properties within the same year of loan origination as solely pertaining to green projects.[24] Of these, the

[23]For example, Broward County (Fort Lauderdale) exempted permits related to rebuilding following Hurricane Irma in 2017.

[24]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. However, most PACE Notices of Commencement expire within one year of the loan recording date, meaning that most PACE projects will be undertaken within 12 months.

majority (56.3%) includes impact-resistant window and door installations (29.3%) and re-roofing (27.0%). For permits approved on non-PACE properties over the same time period, only 52.7% have a PACE-eligible use, and window and door permits make up only 8.8% of the total.

Panel B of Figure 4 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 windows and doors dominate, with re-roofing and solar installations becoming more prevalent in recent years; 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]

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 the Callaway and Sant'Anna (2021) estimator. We estimate the event study over an unzipped panel in which the outcome is a dummy, $Permit_{i,t}$, for each parcel APN indicating permit approval in years relative to PACE loan origination.

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

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 Census tract × year fixed effects $\theta_{c,t}$. Doing so holds 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 results in that vector being absorbed by the parcel fixed effects η_i in the vast majority of cases.[25]

For each PACE-qualified project category, permitting probability spikes within a year of origination, with noticeably stronger uptake of roofing and window and door permits at 6.5 percentage points and 6.3 percentage points, respectively. 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 4 in which we focus on permits approved within the same year as PACE origination. PACE properties are 15.9 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. We estimate a 14.3 p.p. greater 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.[26]

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 property becomes more resilient to natural disasters; a lower discount rate for a resilient house increases its market value. 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

[25] Although they are potentially bad control variables, when we include lagged characteristics $\mathbf{X}_{i,t-1}$ as control variables in equation (5.1), our results hardly change.

[26] We also find that the probability of permitting within the "other" (non-PACE) category spikes by 5.1 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 (e.g., hiring a contractor and scheduling the work).

characteristics recorded by the assessors for PACE properties. We find that approximately 30% of properties with a PACE loan have a transaction record within 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 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 that 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 designate 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 DiD estimator proposed by Callaway and Sant'Anna (2021).[27] 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.[28] 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 a PACE loan is taken out. The vector of lagged 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

[27] A possible drawback of the repeat sales approach is that timing and composition of property sales are endogenous. It is not obvious in which direction this bias goes. Households in severe enough default after taking out a PACE loan may choose to sell the property to repay the debt. Alternatively, results could 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. To mitigate the concern of property flips, for each property we focus on the first transaction within a calendar year and eliminate subsequent sales. Moreover, all results are robust to restricting to 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.

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

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 house prices in a narrowly defined geography. 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 (see Panel B). 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 × 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 and Census tract × year fixed effects in columns 2 and 3, respectively. The DiD coefficient remains positive and statistically significant. PACE borrowers may internalize 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 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 performed 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. Therefore, 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 period, which may bias our estimates. For instance, selection issues may be due to flipper behavior specific to COVID-induced migration. 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 in 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.[29] The coefficient remains statistically significant, but is only half as large as the previous column's.

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 5-digit zip code × year fixed effects to allow the estimator to converge. Column 4 shows the results of the specification without property controls. Across the different specifications, the coefficients remain positive and statistically significant, indicating a strong capitalization effect of PACE.

[29] Property characteristics are not available for all properties in CoreLogic data. 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).

Next, we add the PACE loan amount at origination as a control 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.[30] 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 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 smaller extent than gains in transaction values.[31]

[Insert Table 4 about here]

Figure 7 displays results from estimating dynamic event study 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]

[30] 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.

[31] 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. Property tax assessed value and increment limits are widespread across the U.S. (Horton et al., 2024).

Individual returns. Considering the coefficient reported in column 6 of Table 4, which conditions on property characteristics and restricts to PACE permits, the average PACE property experiences sale price appreciation that is $(\exp(0.225) - 1) \approx 25\%$ greater than the average property not yet receiving a PACE loan. To make sense of the economic magnitude, given an average sale price of roughly $312,000 (see Table 2), the total capitalization effect is $\$78,324 = 25\% \times \$312,000$, or 2.9x 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 in 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.[32] The average holding period for home sellers who received a PACE loan is 3.8 years, implying a realized net capital gain of $32\% = (2.9)^{1/3.8} - 1$ on an annualized basis.[33]

The analogous net capital gain calculation is 2.8% if we include all projects – even those without a climate-proofing permit attached to the loan (column 5 of Table 4). This makes sense given that smaller dollar value projects are more likely to be exempt from local permit filing requirements, and that energy efficiency or storm-hardening projects positively capitalize lower utility bills and insurance premia. Consistent with this interpretation, we show in Section 6.1 that PACE adoption leads to lower homeowners insurance premia, and that these cash flow savings can rationalize the observed capital gains with implied discount rates of similar magnitude to those estimated in the literature on climate change investments.

The above ROI calculations do not include PACE loan origination fees in the denominator. We do not directly 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

[32]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.

[33]Adding in interest payments at the average APR of 7.31% in our sample yields a gross equity multiple of 2.7x, and a slightly lower net capital gain of 30%.

through the annual tax payment (Snaith, 2023). Recomputing our ROI with fees imposed at the implied maximum 4% rate (≈ \$1,100 in fees) still results in a 2.9x 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 comparable to the 30% premium relative to the aggregate stock market calculated by Giacoletti and Westrupp (2018), who study the remodeling and sale behavior of house flippers in Los Angeles County.[34]

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-by-owner combination 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 only infrequently recorded in the CoreLogic *Involuntary Liens* data. We define delinquency at the property-by-owner level using the name(s) recorded on the title for assessment purposes matched

[34] If we instead control for the project's scale using the point estimate in column 7 of Table 4, the ROI is 2.2x, and the net capital gain is 23%, or 21% after adjusting for interest payments in the numerator.

to the name(s) listed on the lien flag.[35] $PACE_{i,t}$ is a dummy variable equal to one if i has had a PACE lien placed as of year t and zero otherwise. The estimation sample underlying equation (5.3) is an unzipped panel of property-owners, meaning we set $Delinquent_{i,t} = 0$ as long as the property has never had a tax lien recorded as of year t within the same ownership spell.

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), Census block group, 5-digit zip code, and tax code area (TCA) levels. 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 compare tax delinquencies of properties with a PACE loan (treated group) to those that have not yet received a PACE loan (control group). Table 5 reports results from estimating pooled and event study versions of equation (5.3). Across all specifications, we observe a jump in the probability of delinquency within the first tax year of PACE origination.[36] The period $t = 0$ estimates correspond to an additional 0.2 to 0.3 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 table shows that there are no pre-trends in local tax

[35] 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.

[36] We lose some statistical significance in the specifications with controls for property characteristics. This is due to many missing values for property characteristics in the CoreLogic *Tax* data and the fact that equation (5.3) is a linear probability model, resulting in fitted values outside the [0,1] support.

delinquency probability before PACE origination for a property-owner combination.[37] These are economically significant changes in delinquency rates; our preferred estimate obtained from column 8 of Table 5, which accounts for tax jurisdiction-specific shocks over time, represents a 16% increase in tax delinquency in $t = 0$ relative to $t = -1$.[38]

[Insert Table 5 about here]

5.4 Effects of PACE on *Ex Ante* Mortgage Lending

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. 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 mortgage lending is:

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

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 $PACE_{c,t}$, a dummy equal to one for any year t following formal legal enactment of PACE in county c and zero otherwise. The vector $\mathbf{X}_{i,c,t}$ includes applicant characteristics such as

[37] We follow the convention in our pricing regressions of restricting to pre-COVID PACE borrower cohorts and restrict the post-period time window to two years after loan origination due to the fact that our *Involuntary Liens* data end in 2022.

[38] In unreported results, we find the spike in delinquency is driven mainly by borrowers in more rural Census tracts and those experiencing *ex ante* greater damages from severe storms. Moreover, when we split our sample based on whether PACE borrowers have a primary home mortgage, we find that the delinquency results are entirely driven by borrowers who did not use a mortgage to buy their home. This indicates that lack of an escrow account, which entails automatic payment of property tax bills, is a likely cause of the observed spike in tax delinquency around PACE origination.

dummy variables indicating the loan-to-income ratio, whether there are co-applicants, ethnicity, and gender. 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. This assumption is supported by the predictive regressions of Table 1.

Table 6 examines the effect of PACE access on mortgage approval rates. The dependent variable is an indicator variable equal to one if a mortgage is approved, and zero otherwise. Column 1 shows a positive, statistically significant effect of PACE access on mortgage approval rates, indicating increased mortgage supply in PACE-enabled counties. Column 2 focuses on refinancing applications, showing a 1.6 p.p. increase in loan approvals, implying PACE enhances credit supply for both new and existing homeowners. Panel A of Figure 8 shows that mortgage approval rates for purchases and refinancing significantly rise post-PACE adoption; the 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 quantitatively consistent with average takeup rates of PACE loans among eligible single-family homeowners.

[Insert Table 6 about here]

Across all specifications, the $\widehat{\beta}_n$ coefficients show no pre-trend and are statistically insignificant, bolstering our assumption that mortgage approval rates would have trended similarly between PACE and non-PACE counties if the program had not been enacted. 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 8 shows that the treatment effect is increasing over time, consistent with more households acquiring PACE loans as the program becomes more established in a county. The time path of the $\widehat{\beta}_n$ obtained from the dynamic version of (5.4) supports the latter channel. The magnitude of the increase in approvals matches the average five-year county-level PACE program participation rate of 1.5% for owner-occupied homes that we calculate in Section 6.1.

[Insert Figure 8 about here]

We explore heterogeneity in borrower risk profiles for post-PACE mortgage originations. Our framework in Online Appendix C predicts that any 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 LTI are more likely to default on their mortgage following a negative income shock (Ganong and Noel, 2023). We compare each applicant's LTI ratio with the median LTI 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 6 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. Finally, Panel B of Figure 8 shows that differential pre-trends between the two groups is not driving the results.

We explore mortgage securitization decisions in column 5 of Table 6. 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 national 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 8 shows that PACE adoption increases private-label securitization, with positive and statistically significant coefficient estimates of the intent-to-treat (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 6 and in Panel D of Figure 8. To do so, we re-estimate 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, implying PACE motivates lenders to charge higher interest rates due to higher default probabilities (as shown in Section 5.3). Taken together, our evidence points to lower expected losses given default for lenders due to higher collateral values, while in the case of non-default, lenders expect to receive more on-time mortgage payments.

6 Discussion of Cost-Benefit Implications

In this section, we use our estimates for capitalization effects and tax delinquency to highlight spillovers of PACE to homeowners insurance premia and local property tax revenues.

6.1 Pass Through to Homeowners Insurance Premia

We analyze the impact of PACE adoption on the homeowners' insurance market. The purpose of this exercise is to show that the magnitude of house price capitalization of PACE-financed projects can be rationalized by the payoffs these projects generate. While the full stream of cash flows from PACE projects is generally unobservable, we focus on one prominent investment type financed through PACE: the installation of impact-resistant windows. Our focus is motivated by Florida Statutes §627.0629, which requires insurers to provide premium discounts and credits to homeowners undertaking wind damage mitigation measures, including the installation of impact-resistant windows. Under a reasonable set of assumptions, we can recover the savings generated by PACE projects.

To estimate the potential savings in terms of lower homeowners insurance premia, we use administrative data from Florida's Quarterly and Supplemental Reporting System (QUASR). The QUASR data provide insurer–county–year observations on residential insurance premia and insurers' total coverage exposure from 2009 to 2024, although we focus on the pre-COVID period to the sample for our pricing estimates in Table 4.[39] For identification, we exploit the

[39] The QUASR data have been extensively used in the literature on the Florida homeowners insurance market. See Eastman et al. (2024) and Sastry et al. (2024) for recent applications.

staggered timing of PACE adoption, following the same estimator and design used in our analysis of mortgage markets in Section 5.4. In particular, we estimate difference-in-differences specifications of the form:

$$\log(Premium_{c,t}) = \alpha + \beta \cdot PACE_{c,t} + \theta_c + \delta_t + \gamma' \cdot \mathbf{X_{c,t-1}} + \varepsilon_{c,t} \tag{6.1}$$

We regress log annual premia at the county level on an indicator $PACE_{c,t}$ for whether county c has an active PACE program as of year t. Using the Sun and Abraham (2021) estimator, the control group consists of counties which never formally adopted a PACE program. The vector of lagged county demographic controls $\mathbf{X_{c,t-1}}$ accounts for unconditional average differences between PACE adopter vs. non-adopter counties along the statistically significant dimensions reported in columns 1 and 2 of Table 1. Such differences in Table 1 largely disappear after conditioning on year δ_t and county θ_c fixed effects.

Table 7 reports the estimates for the drop in homeowners insurance premia due to county-level PACE adoption. Average insurance premia decline by between 1.1% and 3.5%, depending on the choice of DiD estimator and sample period, but the effect remains robustly negative and of similar a magnitude regardless of whether we restrict to wind-only policies, include county-level demographic controls, or exclude contracts underwritten by the state-run insurer of last resort, Citizens Property Insurance Corporation (Citizens). For our preferred estimate in column 6 using the Sun and Abraham (2021) estimator and restricting to wind-only policies pre-COVID, the average annual dollar value savings are 1.8% $\times$ \$1,755 = \$31.24.[40] This is an intent-to-treat effect because it does not distinguish between PACE borrowers and non-borrowers.

[Insert Table 7 about here]

Online Appendix I offers additional tests to validate the robustness of our findings on insurance premia. Figure I.1 in Online Appendix I plots the dynamic event study to rule out that the decline in premia follows pre-existing trends. Additional tests based on an exposure shift-share design at the county-insurer level support the view that endogenous sorting of insurance companies along the dimension of PACE access does not drive our results. Figure I.2 provides

[40]The estimates hardly change if we estimate the exact same specification as in column 6 of Table 7 but instead use the Callaway and Sant'Anna (2021) estimator which leverages only the variation that comes from the within-treated group due to staggered timing. If we do so, the estimated drop in premia is 2.0%.

suggestive evidence that county-level PACE adoption helps mitigate market unraveling, since access to PACE lowers growth in the county-level market share of Citizens.

We can now relate the cash flow savings from reduced homeowners insurance premia to our estimated capitalization effects using a standard Gordon growth formula applied to an infinitely-lived asset (a house in this case). The long-run discount rate would then be equal to $r = \Delta Premium/\Delta P$. For our estimated 1.8% county-level decline in wind policy premia from column 6 of Table 7, scaled by the 1.5% average county-level takeup rate of PACE loans (as a fraction of owner-occupied single-family homes), we obtain annual premium savings of $\Delta Premium = \$2{,}083$ for PACE borrowers. Comparing this number to the average price increase upon sale of $\Delta P = \$78{,}725$ for PACE-funded climate-proofing projects based on Table 4 yields a discount rate of 2.7%. The implied discount rate increases to 3.5% if we instead use $\Delta P = \$60{,}413$ which conditions on the scale of the project (column of Table 4). These discount rate estimates are in line with the 2.6% rate reported by Giglio et al. (2015) for leasehold contracts and the 2.7% rate computed by Ge et al. (2022) for flood insurance costs.

If homeowners have rational expectations about future increases in their annual insurance costs, then the incremental pro-rated savings due to inflation will also be capitalized into house prices. Suppose homeowners assume annual insurance premium savings from a climate-proofing PACE project grow at a constant rate consistent with historical inflation in premia during the pre-COVID period from 2015 to 2019: 3.9% average year-on-year growth for wind damage policies in the QUASR data. This is a conservative assumption to the extent that average premia have dramatically increased in Florida since 2019, tripling between 2019 and 2023 by some estimates (Bloomberg, 2024). Applying this inflation factor yields a long-run discount rate of 6.7%, keeping all other parameters of the problem the same.

Some of the capitalization may be due to the energy savings of climate-proofing projects; that is, a new roof or set of windows can improve the efficiency of air conditioning (Figure 2). Including energy savings and accounting for inflation in utilities costs would imply slightly greater discount rates. All estimates in Table 4 control for any other permitted projects on the house, so our measure of ΔP is purged of any valuation increases due to broad-based home renovations. Finally, because we need to condition on a sale to estimate ΔP, our sample of PACE properties in Table 4 is concentrated in counties with greater takeup rates, lowering the local average treatment effect (LATE) on premium savings. The takeup rate reweighted in proportion to each county's number of observations included in our house price DiD is 5.0%, leading to initial annual premium savings of $626 and an inflation-adjusted discount rate of 4.8%. Overall, these calculations support the external validity of our research design to determine the capitalization effects of PACE projects into house prices.

6.2 Local Property Tax Revenues

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:

$$\Delta R_{t,t+1} = \underbrace{\tau_{t+1}}_{\text{effective tax rate}} \times \Big(\underbrace{\Delta P_{t,t+1}}_{\text{capitalization effect}} - \underbrace{\Delta D_{t,t+1} \cdot P_t}_{\text{revenue lost from delinquency}} \Big) \tag{6.2}$$

where $\Delta R_{t,t+1}$ is the change in local property tax revenue. The first term in (6.2) 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. This is a short-run revenue calculation to the extent that local governments always eventually recover back taxes through the tax lien auction or foreclosure process, with a lag of up to one year in Florida (LaPoint, 2023).[41] 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 (6.2) using our ATT estimates from Section 5.2 and 5.3, we calculate an average net tax benefit of between $335 and $895 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),

[41] In submitting FOIA requests for PACE loan records, we also asked each county for a list of liens sold at auction and final lien statuses for all PACE properties which end up in delinquency. We uncovered no record of a PACE property entering tax foreclosure. The non-existence of tax foreclosure off of a PACE lien is consistent with research conducted for investors in California PACE bonds (Kroll Bond Rating Agency, 2018). Hence, the tax revenue losses from PACE are likely close to zero for the county in the long-run.

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 $1.15\% \times (\$30,000 - 0.003 \times \$312,000) = \$335$ at the lower end, and $361 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 $1.15\% \times (\$78,700 - 0.003 \times \$312,000) = \$895$, or $965 if we feed in a 1.24% average ETR. $312,000 represents the average property sales price in our estimation sample. We use the two-year change in the ever-delinquency rate of 0.3 p.p. from our difference-in-differences estimates of Table 5 in this calculation.

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 assume 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 (Zimring and Fuller, 2010). 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). Third, PACE loans finance projects that reduce 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.[42]

Although understanding the local fiscal drivers of PACE loan adoption is important, there are other features that could explain why governments may not want to have PACE in place,

[42] 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.

which we abstract from in this paper. In particular, we abstract from the impact of PACE loans on consumers' welfare. Such a dimension is critical to the larger policy debate about whether to put a PACE program in place – a debate which continues in the Florida state court system. For instance, the state of Missouri cited "limited consumer protections" and "troubling consumer protection issues" in its decision to repeal PACE loans for residential real estate. These concerns about consumers' welfare are exacerbated by the fact that PACE loans were exempt from Regulation Z (Truth In Lending Act) protections prior to December 2024. The inclusion of any financial products secured by property tax liens, including PACE loans, aims to guarantee consumers access to clear and transparent disclosure of key loan terms as with home mortgages since the Global Financial Crisis. More research linking PACE loans to borrowers' credit histories is needed to understand the full impact of PACE programs on consumer welfare.

7 Conclusion

PACE loans represent an innovative and rapidly growing set of financial contracts which allow homeowners to fund investments in green residential projects through special assessments on their annual property tax bill, without directly screening on the applicant's credit score. We offer the first evidence of the impact of PACE loans on household-level outcomes. We develop a new approach to classify households' investments in energy efficiency and resiliency projects and build a new loan-level dataset based on public records linked to property tax, transaction, and completed building permits. We present three main results using these new data.

First, PACE-financed properties experience a significant increase in market value compared to otherwise similar properties that have not yet received a PACE loan. The average house price appreciation exceeds twice the amount of the PACE loan, implying annualized net capital gains between 20% and 30% for borrowers who sell their home with a PACE-permitted project attached. However, borrowers engaging in smaller dollar value projects which are not typically permitted realize weaker returns. We show that the capitalization of climate-proofing projects into house prices can be rationalized by declines in homeowners insurance premia in areas adopting PACE, conditional on individual loan takeup rates. Second, tax delinquency rates increase by 0.3 percentage points after PACE borrowers take out a loan. 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 home's collateral value.

Overall, combining our estimates via a simple cost-benefit analysis implies that the net short-run fiscal benefit to local tax offices amounts to $900 per borrower per year. Our results together suggest PACE programs are an effective policy for closing the residential green investment gap and mitigating unraveling of the homeowners' insurance market in areas like coastal Florida that are prone to severe natural disasters. 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 financial constraints – but without leading to an unraveling of mortgage markets.

While we believe that understanding the local fiscal drivers of PACE adoption is important, our paper is silent about the impact of PACE loans on overall consumer welfare, on the aggregate reduction in carbon emissions, or local job creation and non-residential physical capital investment. Our paper does not examine the long-term effects of resiliency measures, which could incentivize continued residence in high-risk disaster areas. Nonetheless, we believe our estimates remain informative, as resilience investments will necessarily need to increase across all regions of the United States, regardless of households' potential migration decisions (First Street Foundation, 2025). Ultimately, as new data become available, more work is needed to understand the complete welfare impacts of residential PACE programs for homeowners and local economies.

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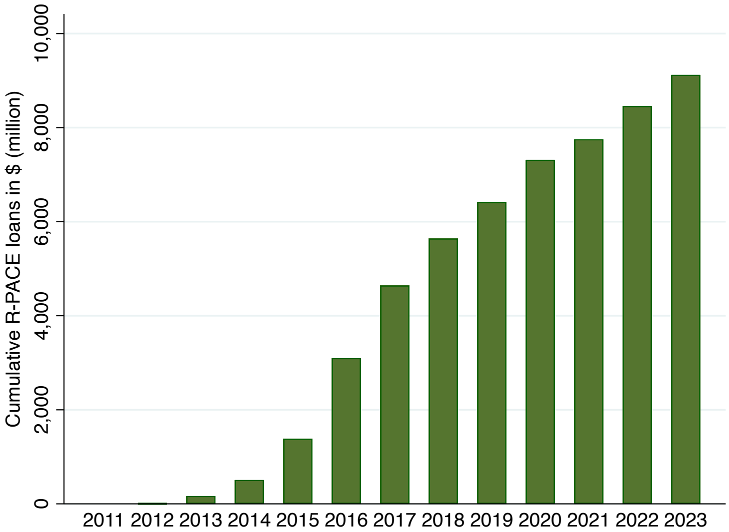
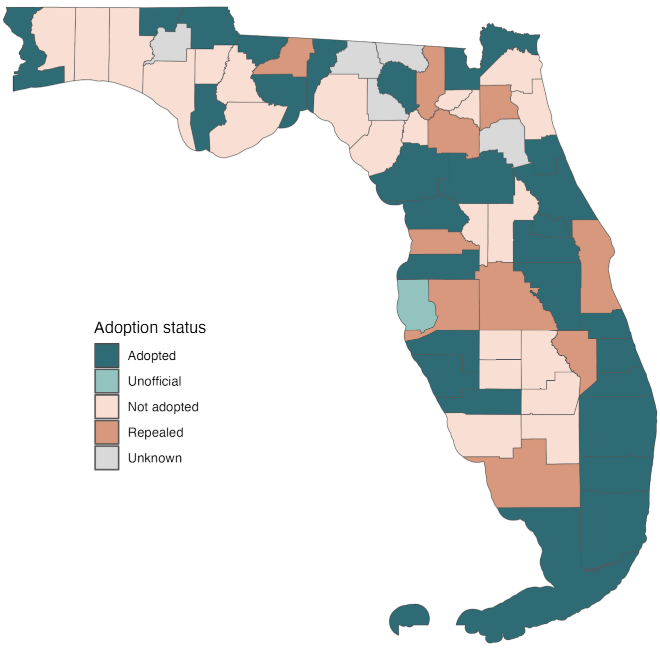
FIGURE 1. PACE Program Size and County-Level Adoption in Florida

A. Total Amount of PACE Loans Originated



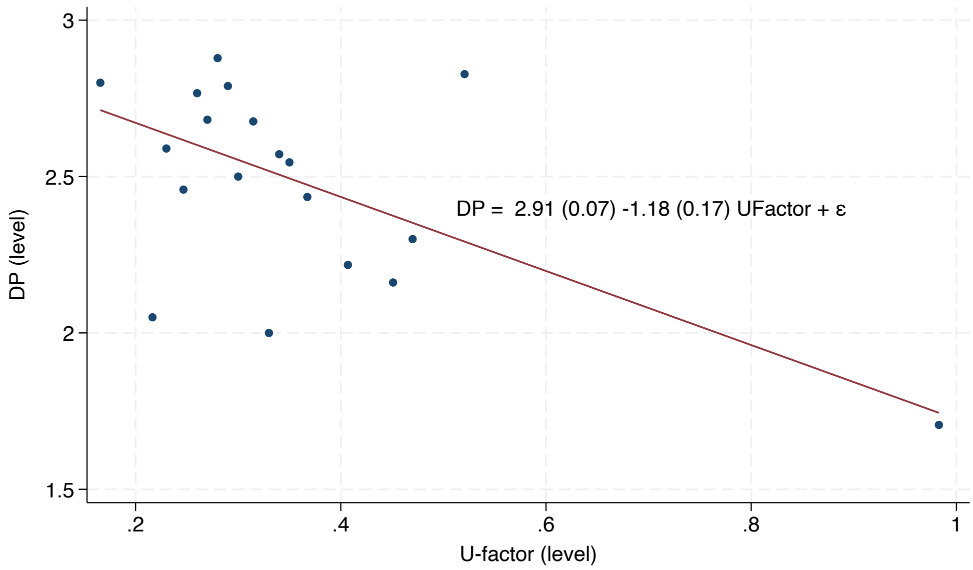
B. County-Level Adoption of Florida Residential PACE Programs



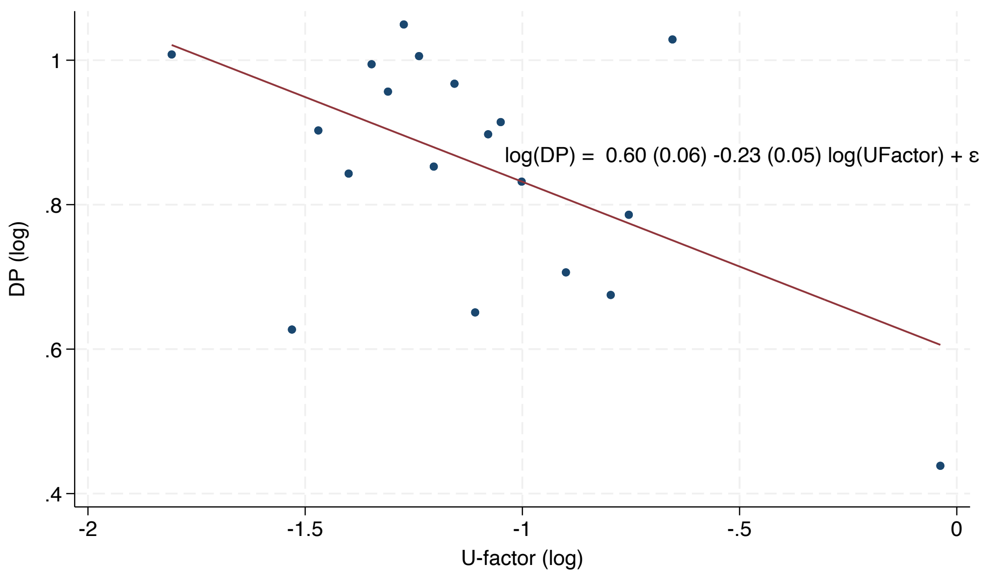
Note: Panel A plots the cumulative amount of loans (in millions of nominal U.S. dollars) originated from the residential PACE programs between 2011 and 2023. Residential PACE programs are available in California, Florida, and Missouri. Source: https://www.pacenation.org/pace-market-data/. Panel B provides 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



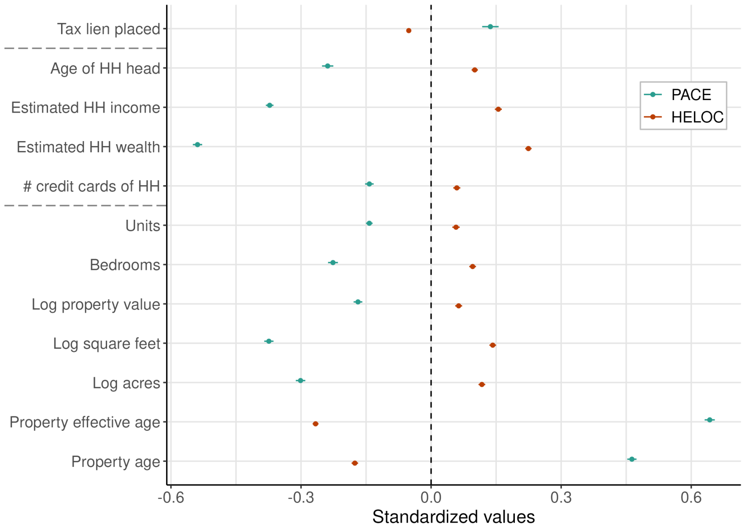
B. Relationship in Logs



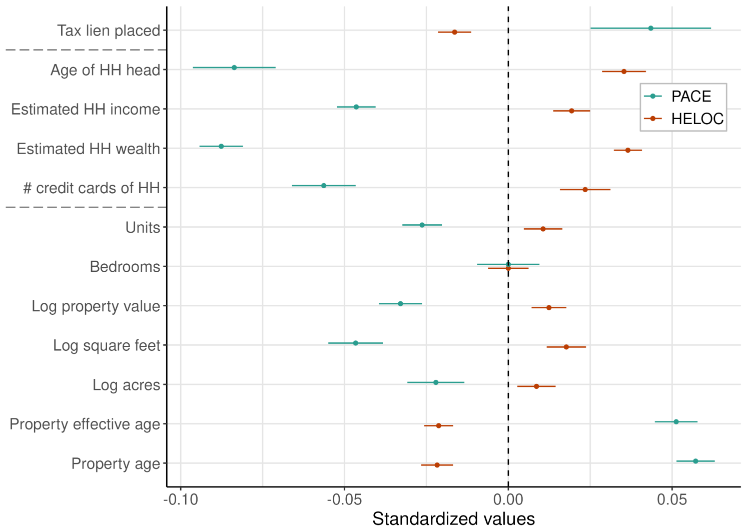
Note: This graph shows the relationship between the Design Pressure (DP) ratings and the U-Factor of window products using data from 500 window models currently sold in the United States. We sort the windows into 20 equally-sized bins using `binscatter`. The U-Factor measures how well the window insulates. 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. See Online Appendix E for details on how we collected the data displayed in this figure.

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

A. Unconditional Balance Test



B. Conditioning on Census Tract Fixed Effects

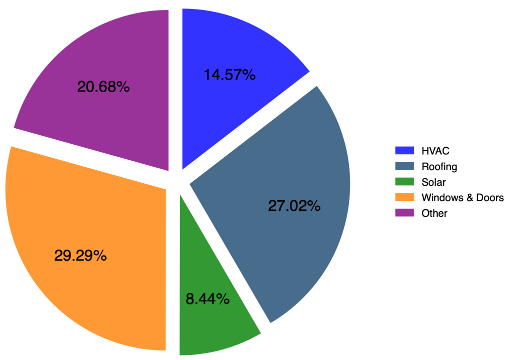


Note: This graph compares characteristics for homes with a PACE loan and properties with a closed-end (i.e., fixed interest rate) home equity line of credit (HELOC). To conduct this comparison, we use variables as of the year prior to loan origination for each type of loan product. Log property value 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.

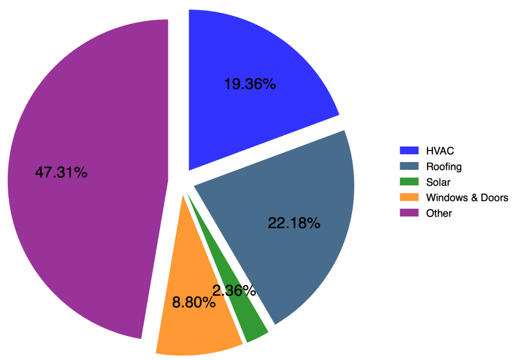
FIGURE 4. Composition of Permitted Home Improvement Projects

A. Permit Types Pooled over Sample Period

Permits on PACE Properties

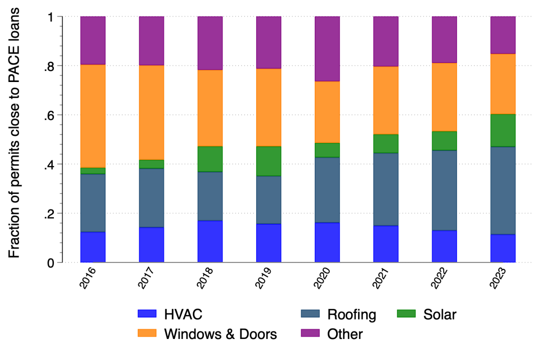


All Non-PACE Florida Residential Permits

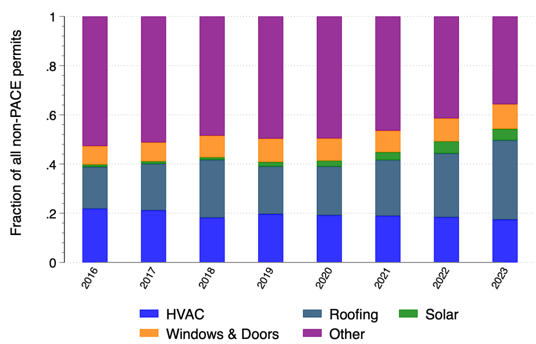


B. Evolution of Permit Type Activity Over Time

Permits on PACE Properties



All Non-PACE Florida Residential Permits

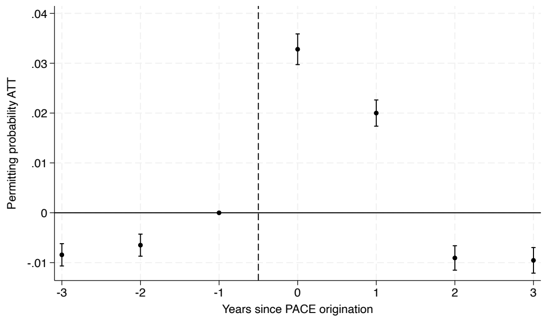


Note: We classify building permits tied to residential properties with a PACE loan by string parsing the description of the home improvement project filed with the town clerk as part of the permit application. The five mutually exclusive categories are: HVAC, roofing, solar, windows and doors, and other. 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, tax years 2016 – 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. We restrict the sample to permits on residential properties, excluding newly constructed units and teardowns of existing units. See text for further details on the CoreLogic building permits data and Online Appendix D for how we sort permits into these categories.

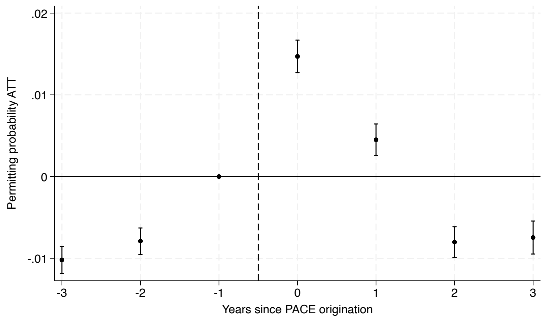
FIGURE 5. Dynamic Event Studies: Building Permits Issued around PACE Origination

A. Energy-Efficient Projects

HVAC Permits

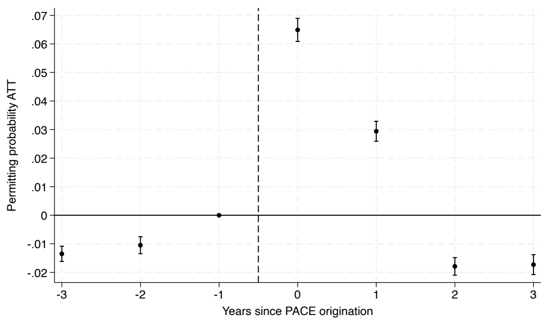


Solar Panel Installation Permits

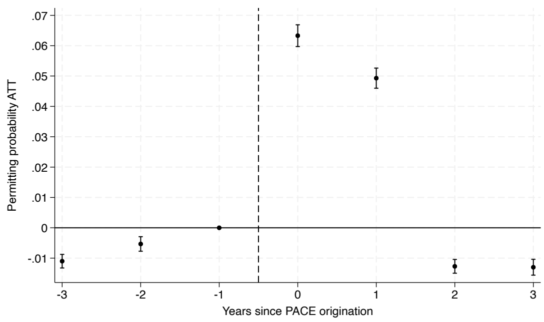


B. Disaster-Proofing Projects

Roofing Permits



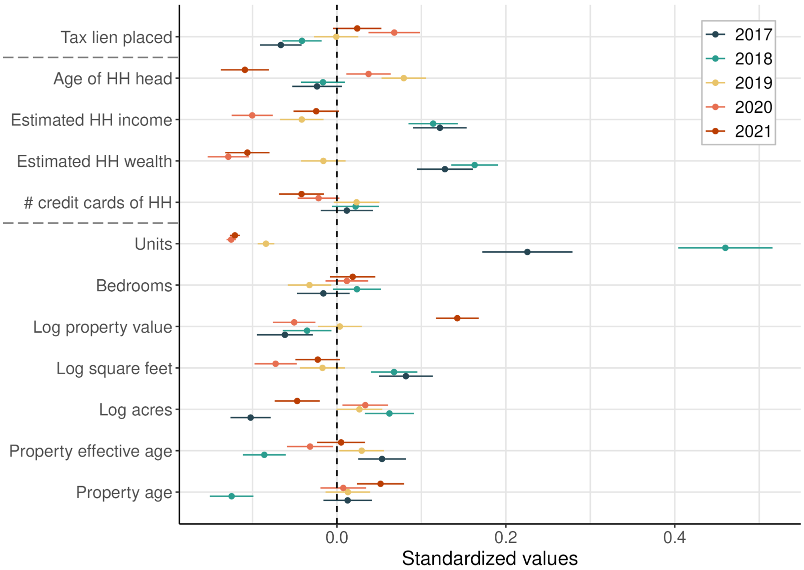
Window & Door Permits



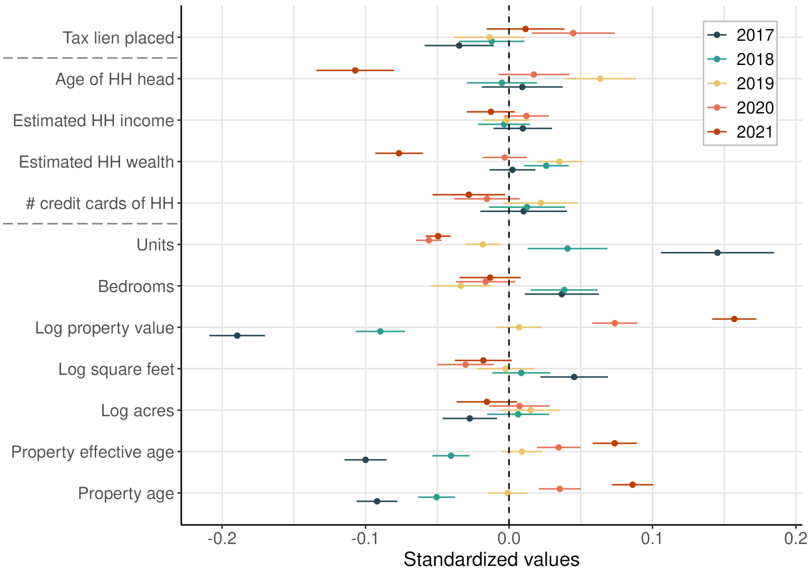
Note: This figure presents the aggregated group-time average treatment effects on the treated (ATT) event study coefficient estimates using Callaway and Sant'Anna (2021)'s estimator in which properties with non-PACE permits serve as the control group. Following Roth (2024), we use long-differences for 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 Census tract $\times$ 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 Online Appendix D for how we sort permits into these categories. We restrict the sample to permits on residential properties, excluding newly constructed units and teardowns of existing units. 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

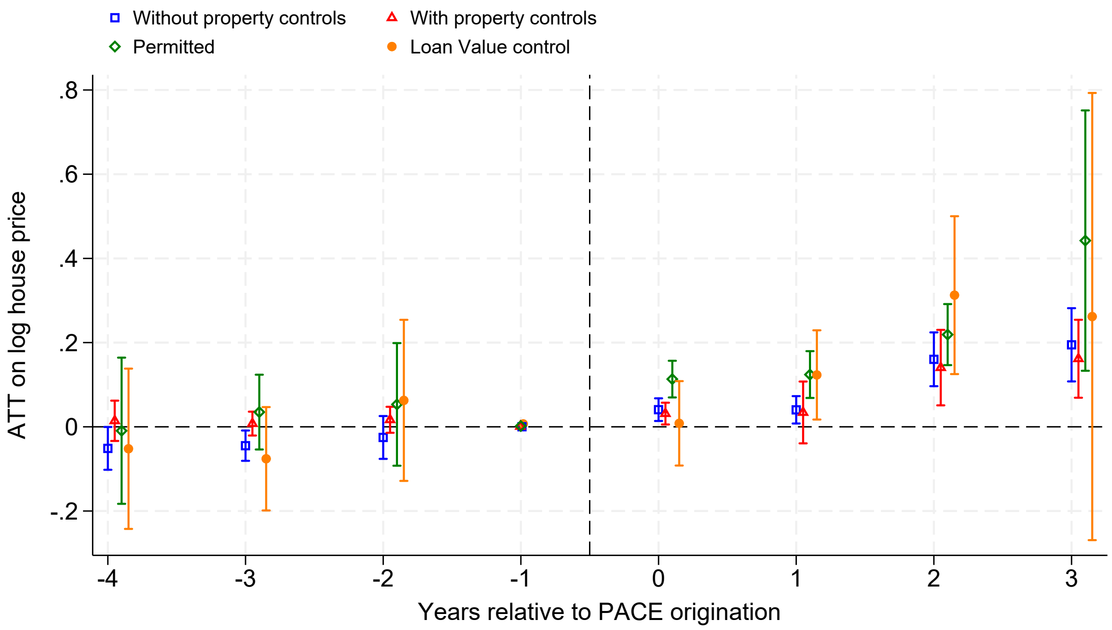


B. Conditioning on Census Tract Fixed Effects



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.

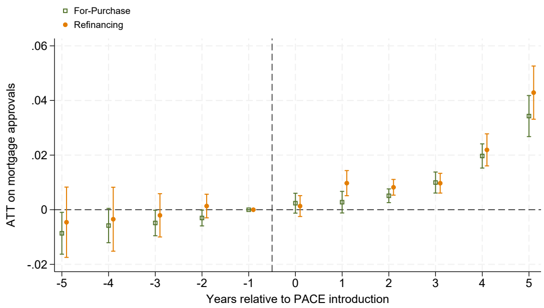
FIGURE 7. Dynamic Event Studies: Capitalization of PACE Lending into House Prices



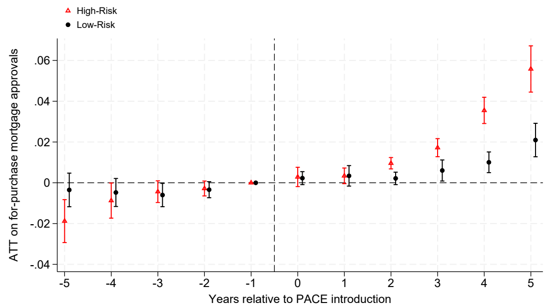
Note: This figure plots the Average Treatment Effects on the Treated (ATT) from event study specifications estimated via Callaway and Sant'Anna (2021)'s estimator with home transaction prices winsorized at the 1st and 99th percentiles as the outcome variable. Following Roth (2024), we use long-differences 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 log 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 lagged 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. Event Study: Lenders' Responses for First Lien Mortgage Applications

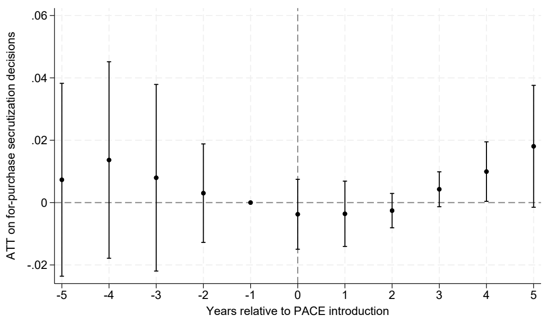
A. Approval Rates on For-Purchase and Refinancing Mortgages



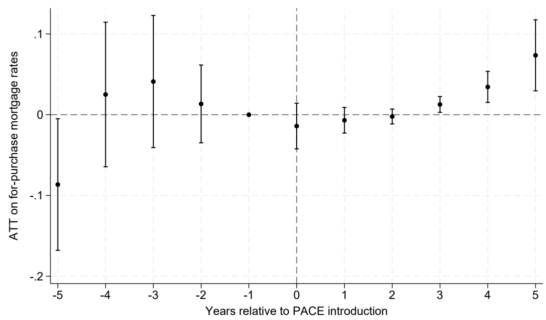
B. Approval Rates on For-Purchase Mortgages by Borrower LTI



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.

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 ($Adopted_{c,t}$) if a county c 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 annual American Community Survey estimates; 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$_{i,t}$	20,946	311,857	180,350	100,000	625,000
log(Price)$_{i,t}$	20,946	12.50	0.55	11.52	13.35
log(AssessValue)$_{i,t}$	104,841	12.10	0.55	11.12	12.92
HVAC$_{i,t}$	20,946	0.08	0.26	0	1
Solar$_{i,t}$	20,946	0.04	0.20	0	0
Roof$_{i,t}$	20,946	0.11	0.31	0	1
Windows$_{i,t}$	20,946	0.14	0.35	0	1
Ex-ante Permits$_{i,t}$	20,946	0.45	1.01	0	2
Ex-post Permits$_{i,t}$	20,946	0.10	0.43	0	1
Bedrooms$_{i,t}$	17,911	2.97	0.89	2	4
Bathrooms$_{i,t}$	18,492	2.08	1.55	1	3
log(square footage)$_{i,t}$	20,684	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	0.84	0.36	0	1
PACE$_{i,c,t}$	2,582,095	0.43	0.50	0	1
Private securitization$_{i,c,t}$	1,818,279	0.33	0.47	0	1
Rate spread$_{i,c,t}$	625,475	0.95	1.71	-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)
$PACE_{i,t}$	0.052***	0.044***	0.045***	0.052***	0.043***	0.031***
	(0.008)	(0.006)	(0.004)	(0.003)	(0.003)	(0.005)
$PACE_{i,t} \times Roof_i$						0.016
						(0.016)
$PACE_{i,t} \times Windows_i$						0.029**
						(0.013)
$PACE_{i,t} \times HVAC_i$						0.022**
						(0.010)
$PACE_{i,t} \times Solar_i$						0.055*
						(0.027)
Observations	20,946	20,454	20,946	20,946	20,946	20,946
R-squared	0.219	0.457	0.459	0.465	0.466	0.466
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.1, which are interacted one-by-one with the $PACE_{i,t}$ variable in column 6. Robust standard errors clustered by property APN in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

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)
$PACE_{i,t}$	0.035***	0.046***	0.015***	0.109***	0.092***	0.225***	0.177**	0.017***
	(0.007)	(0.006)	(0.004)	(0.015)	(0.031)	(0.044)	(0.081)	(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	7,814	10,555	10,555	16,453	16,453	6,723	4,712	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	No	Yes	Yes	Yes	Yes	Yes
Ex ante Permits	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ex post Permits	Yes	Yes	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 averages. 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.1. Robust standard errors clustered by property APN in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

TABLE 5. Estimates for PACE Loan Effects on Property Tax Delinquency

Dep. variable: $Delinquent_{i,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$PACE_i(t=-3)$	−0.0003	0.0036**		0.0015	0.0017	0.0003	0.0016	
	(0.0017)	(0.0018)		(0.0019)	(0.0018)	(0.0021)	(0.0019)	
$PACE_i(t=-2)$	−0.0000	0.0016		−0.0002	0.0002	0.0005	−0.0004	
	(0.0012)	(0.0013)		(0.0010)	(0.0009)	(0.0010)	(0.0009)	
$PACE_i(t=0)$	0.0031***	0.0023**		0.0026**	0.0024**	0.0021*	0.0030***	
	(0.0010)	(0.0011)		(0.0011)	(0.0011)	(0.0012)	(0.0012)	
$PACE_i(t=+1)$	0.0029**	0.0014		0.0042*	0.0042*	0.0038	0.0043**	
	(0.0011)	(0.0013)		(0.0022)	(0.0022)	(0.0024)	(0.0022)	
$PACE_{i,t}$			0.0033***					0.0034***
			(0.0014)					(0.0013)
Pre-/Post-COVID	Pre	Pre	Pre	Pre	Pre	Pre	Pre	Pre
Loan Sample	All	All	All	All	All	All	All	All
Estimator	OLS	OLS	OLS	CSDID	CSDID	CSDID	CSDID	CSDID
Observations	73,031	73,031	73,031	73,031	73,031	55,160	73,031	73,031
Property (APN) FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Property Controls	No	No	No	No	No	Yes	No	No
Census Tract × Year FE	No	No	No	Yes	No	No	No	No
Block Group × Year FE	No	No	No	No	Yes	Yes	No	No
TCA × Year FE	No	Yes	Yes	No	No	No	Yes	Yes
Mean Dep. Var.	0.0176	0.0176	0.0176	0.0185	0.0185	0.0199	0.0185	0.0185

Note: This table presents the treatment effects on the treated (ATT) regression coefficient estimates for property tax delinquency as the outcome using OLS (columns 1-3) or Callaway and Sant'Anna (2021)'s estimator and comparing early to late PACE borrowers (column 4-8), according to (5.3). Column 3 uses pre-PACE vs. post-PACE differences to compute a pooled ATT, including both treated and never-treated property-by-owner combinations. Column 8 computes pooled ATTs using group-time averages. We restrict the sample to pre-March 2020 cohorts of PACE borrowers to match the estimation sample of our pricing regressions. The outcome in each column is a dummy equal to one if the property-owner combination has ever been delinquent on their property tax bill, as indicated by a local tax lien placed on the property during the owner's tenure in the house. Following Roth (2024), in columns using the CSDID estimator, 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 $t = -1$. Specifications with property controls include lagged winsorized log square footage, bins for number of bedrooms and bathrooms, and deciles of property age, all interacted with year dummies. For specifications with tract × year or block group × year fixed effects, we impose boundaries according to the 2010 decennial Census. Tax code area (TCA) × year fixed effects hold fixed changes specific to tax jurisdictions (e.g., a change in school tax rates). We estimate the regression over an unzipped annual panel of tax delinquency statuses for each single-family property-owner combination in our sample. Robust standard errors clustered by property APN in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

TABLE 6. Impact of PACE Adoption on Mortgage Credit Outcomes

Dep. variable:	Approval				PriSec	RateSpread
	(1)	(2)	(3)	(4)	(5)	(6)
$PACE_{c,t}$	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). $PACE_{c,t}$ 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. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

TABLE 7. Homeowners Insurance Premia Effects of County-Level PACE Adoption

Dep. variable: log($Premium_{c,t}$)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PACE	-0.031**	-0.032**	-0.028***	-0.017*	-0.034***	-0.018**	-0.017*	-0.011**
	(0.012)	(0.013)	(0.010)	(0.009)	(0.012)	(0.009)	(0.009)	(0.005)
Time Period	Full	Full	Full	Full	Full	Pre-COVID	Pre-COVID	Pre-2018
Policies	All	All	All	All	Wind	Wind	All	Wind
Private/Public	All	All	All	All	All	All	All	Private
Estimator	SA	SA	BJS	Stacked	SA	SA	SA	SA
Observations	680	303	674	4,638	680	481	481	357
County controls	No	Yes	No	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	7.469	7.425	7.465	7.426	7.469	7.365	7.365	7.354

Note: This table presents results from estimating the county-year difference-in-differences specification in equation (6.1). The dependent variable in each column is the log property insurance premium for owner-occupied homes, collapsed to the county-year level. PACE is a dummy variable that takes the value of one if county c has adopted PACE in year t, and zero otherwise. In some columns we take average premia for policies which only cover wind-related damages. In the final column we include only contracts from private insurers, excluding contracts underwritten by Citizens Property Insurance Corporation. Column 3 uses the Borusyak et al. (2024) estimator which includes both the never-treated and not-yet treated sets of counties in the control group; column 4 uses the stacked event study estimator (Baker et al., 2022a). In all other columns we use the Sun and Abraham (2021) [SA] estimator. In column 2 we include lagged county-level controls include population, proportion of Black, proportion of Hispanic, proportion of population with a Bachelor's degree or higher, unemployment rate (all from the one-year American Community Survey estimates), and abnormal property damage caused by natural disasters, as reported by SHELDUS. These control variables account possible selection into treatment status, as suggested by the results in Table 1. The final three columns restrict to the sample to the pre-COVID or pre-2018 period. Using the pre-2018 period avoids coverage issues in the QUASR data (see Online Appendix I for a discussion). See Section 4.2 for a detailed discussion of factors influencing PACE adoption at the county level in Florida. In each regression, we weight observations by their lagged county-level population. Robust standard errors clustered at the county level in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

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 on PACE

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 most counties, 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 G, 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 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

[1] We find evidence of loose enforcement of the eligibility 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.

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 G 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]

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

[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.

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 G 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.

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.

Tax implications It is important to highlight that PACE loans do not offer any significant tax advantages compared to traditional mortgage refinancing or a HELOC credit, as only the interest portion of the PACE payment is potentially deductible. To claim such a deduction,

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[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.

households have to itemize their deductions and not take the standard deduction. Moreover, the total amount of mortgage debt, including PACE assessments that can be deducted, cannot exceed $750,000 for joint filers and $375,000 for single filers.

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 in late November. This long lag time between the funds being disbursed and the first payment could contribute to the uptick in tax delinquency within a year of origination that we observe in Section 5.3 if the lag reduces the salience of the increased tax burden (Cabral and Hoxby, 2012).

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 Certi

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 Baseline framework

C.1.1 What Market Frictions Does PACE Mitigate?

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,

[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.

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.

C.1.2 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 with a value of I. The project increases the value of the house by $\Delta H(I)$, with $\Delta H'(I) > 0$ and $\Delta H''(I) < 0$. 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. Without loss of generality, we assume that the project is entirely financed with a PACE loan, so that $I = \ell$. 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:

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

[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.

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, $\Delta H(\ell) - \ell > 0$.

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:

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

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

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.1.3 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: There exist a $\Delta H^* > 0$, such that if $\Delta H'(\ell) > \Delta H^*$, then a marginal increase in the project through PACE financing increases the supply of mortgage.

Intuition/proof: If $\Delta H(\ell)$ increases sufficiently when ℓ 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 ($\beta < \delta$).

Finally, notice that this relationship only holds when households' income can be lower enough for them to default. In case households always have enough income to repay their debt ($\underline{R} > D + \ell$), then mortgage supplies are locally independent of their PACE loans and the payoffs of PACE loans ($\Delta H(\ell)$).

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.

C.2 Model Variation 1: PACE Loans Reduce Liquidity of the House

In this model extension, we repeat our baseline conceptual framework, except now we assume that, in cases of default, lenders liquidate a house with a price haircut that is a function of the amount of outstanding PACE debt attached to the house: $H(\ell) < 0$ with $H'(\ell) < 0$ and $H''(\ell) > 0$. The reasoning for this assumption is that houses with a PACE lien will field fewer potential buyers because potential buyers face frictions when seeking mortgages to purchase the house. Indeed, current regulation prohibits the selling to a public GSE of a mortgage of a house with a PACE lien. The bank could use some cash to prepay the PACE lien before putting a house on the market, but cash can be costly to find and has an opportunity cost.

With this new framework, households' utility remains the same, but the profit function of the bank becomes slightly different:

$$\Pi(A, D) = \underbrace{-(H_0 - A)}_{\text{Loan amount}}$$

$$+ \underbrace{\delta \int_{\underline{R}}^{D+l} H(l) + \Delta H(l) - l \;\; dF(R_2)}_{\text{Expected profit if borrower defaults}} \; \delta \underbrace{\int_{D+l}^{\bar{R}} D \;\; dF(R_2)}_{\text{Expected profit if the borrower does not default}}$$

We make the same assumption for $f(\cdot)$ that we did in the baseline model: we assume that $f(\cdot)$ comes from a uniform distribution and (optimized) repayment amount D^* is between $[\underline{R}, \overline{R}]$. We can derive the following proposition:

Proposition 3: There exists a $\Delta H^{**} > \Delta H^*$, such that if $\Delta H'(\ell) > \Delta H^{**}$, then a marginal increase in the project through PACE financing increases the supply of mortgages.

Intuition/proof: The key driver of lenders' supply is the fact that PACE loans allow households to finance projects that increase the value of the house. Houses with these projects have a higher collateral value. Under the exit liquidity friction in this extension, PACE projects need to generate a greater increase in collateral value than before to increase the profit of lenders and offset the liquidity cost imposed by the PACE lien.

Notice that having liquidity frictions to sell a house with a PACE lien does not change the result regarding the probability of default, so the same result as **Proposition 2** applies here.

C.3 Model Variation 2: Costly Alternative Financing Methods

We replicate the baseline model, but add the presence of junior debt. Specifically, households can borrow B_u of junior debt or ℓ in the form of a PACE loan to finance their project I, so that $I = B_u + \ell$. Unsecured (or junior) interest rates are equal to: $r_u > 0$, while PACE interest rates are $r_p > 0$. B_u denotes junior debt, which can be thought of as HELOC or credit card obligations. As a result, it does not affect the PACE lender's recovery rate. We assume that exogenous institutional constraints, such as credit score limits, pin down the value of B_u. We also assume that if the borrower cannot repay the unsecured debt, then they file for bankruptcy and default on their mortgage. Using the fact that $I - \ell = B_u$, we can write the household's utility function as follows:

$$U(A,D) = -\underbrace{A}_{\text{down payment}} + \underbrace{\beta \int_{\underline{R}}^{D+r_u\cdot P_I - r_u\cdot\ell + r_p\cdot\ell} R_2 \ \ dF(R_2)}_{\text{Expected utility if default}}$$

$$\underbrace{+\beta\int_{r_u\cdot P_I - r_u\cdot\ell + r_p\cdot\ell}^{\bar{R}} R_2 - D - r_u\cdot P_I + r_u\cdot\ell - r_p\cdot\ell \ \ dF(R_2)}_{\text{Expected utility if no default}}$$

The lender's profit function then becomes:

$$\Pi(A,D) = \underbrace{-(H_0 - A)}_{\text{Loan amount}} + \underbrace{\delta\int_{\underline{R}}^{D+r_u\cdot P_I - r_u\cdot\ell + r_p\cdot\ell} H + \Delta H(l) - r_p\cdot\ell \ \ dF(R_2)}_{\text{Expected profit if borrower defaults}}$$

$$\underbrace{\delta \int_{D+r_u\cdot P_I - r_u\cdot\ell + r_p\cdot\ell}^{\bar{R}} D \ \ dF(R_2)}_{\text{Expected profit if the borrower does not default}}$$

We make the same assumption for $f(\cdot)$ that we did in the baseline model: we assume that $f(\cdot)$ comes from a uniform distribution and (optimized) repayment amount D^* is between $[\underline{R}, \overline{R}]$. We also assume that the total investment I is fixed to understand how the substitution pattern between junior and PACE debt affects households' default and lenders' mortgage supply. We can derive the following proposition:

Proposition 4: There exists a PACE interest rate r^*, such that if $r_P < r^*$, then a marginal increase in PACE lending leads to an increase in mortgage supply.

Intuition/proof: Because we assumed that the amount of investment is fixed, an increase in PACE lending leads to a decrease in junior debt. If households substitute junior debt by using more PACE debt, then this has two different effects on lenders' profits. First, lenders experience a haircut on the collateral value, as mortgage debt is paid first in case of bankruptcy or severe default. Second, it can change households' probability of default. If junior debt is more expensive than PACE debt, then the replaced PACE debt will lead to lower mandatory repayments, thus decreasing the probability of filing for bankruptcy and increasing the lender's profit even more. If the latter effect is strong enough, then as lenders have zero profit and are more patient, any increase in their profit translates into an increase in their mortgage supply.

Proposition 5: A marginal increase in PACE lending decreases the probability of default if $r_p < r_u$

Intuition/proof: Because we assumed that the amount of investment is fixed, if households use more PACE debt instead of junior debt, and if PACE debt is less expensive, then they are less likely to file for bankruptcy.

C.4 Model Variation 3: Strategic Default

In this subsection, we explore the predictions generated by a default choice triggered by strategic motivations.

As in the previous setting, the model has two periods. In the first period $t = 1$, a representative household buys a house that has a price H_0. The household has total income equal to R. They make a deposit of A at time 0 and take out a mortgage $H_0 - A$ that specifies the repayment amount D. The household discount rate is equal to β.

In the second period $t = 2$, the household takes out a PACE loan to finance an eligible house improvement project with a value of I. For simplicity, we assume that the project is paid with zero cash and that there is no interest payment in the PACE loan, so the value of the project is equal to the value of the PACE loan that requires total repayment ℓ. Without loss of generality, the entire home improvement project is financed through a PACE loan, so that $I = \ell$. The project increases the household's personal utility derived from living in the house by $\Delta U(\ell)$, but also changes the value of the house by $\Delta H(\ell)$, such that $\Delta H'(\ell) > 0$, $\Delta H''(\ell) < 0$, $\Delta U'(\ell) > 0$ and $\Delta U''(\ell) < 0$. For simplicity, we assume that the payoffs of the home improvement project are non-stochastic and that the project is always undertaken by the household. Just after taking out the PACE loan, the household strategically decides to repay their mortgage given the house value in time $t = 2$.

Specifically, $\widetilde{H_1}$ denotes the house price in period two. This price is a random variable that follows a well-defined probability distribution $F(\cdot)$. The household exercises their strategic default option under some conditions; they will not repay their mortgage if their current equity in the house $\widetilde{H} + \Delta H(\ell) - D$ is below the utility cost to default $(-S - \Delta U(\ell))$. The term $-S - \Delta U(\ell)$ represents the personal cost of defaulting for households. It includes the utility cost of losing access to the home improvement project, $\Delta U(\ell)$, and the utility cost of strategically defaulting, $-S$. As a result, the household will default if: $\widetilde{H} + \Delta H(\ell) - D - l < -S - \Delta U(\ell)$. PACE loans have an ambiguous impact on strategic default incentives, which depends on the non-pecuniary value of the project that is financed, namely $\Delta U(\ell)$, and the pecuniary value directly capitalized into home values house, $\Delta H(\ell)$, with respect to the cost of the project ℓ.

The household's utility function is then equal to:

$$U(A, D) = \underbrace{R}_{\text{Income}} - \underbrace{A}_{\text{down payment}} + \underbrace{\beta \int_{\underline{H}}^{D-S-\Delta U(\ell)-\Delta H(\ell)+\ell} -S - \Delta U(\ell) \ dF}_{\text{Expected utility if (strategic) default}}$$

$$+\underbrace{\beta \int_{D-S-\Delta U(\ell)-\Delta H(\ell)+\ell}^{\bar{H}} H + \Delta H(\ell) + \Delta U(l) - D - \ell \ dF}_{\text{Expected utility if no (strategic) default}}$$

As before, we assume lenders are more patient than borrowers. Lenders' discount rate satisfies $1 > \delta > \beta > 0$ to create gain for trade. As a result, lenders' profit function is the following:

$$\Pi(A,D) = \underbrace{-(H_0 - A)}_{\text{Loan amount}} + \underbrace{\delta \int_{\underline{H}}^{D-S-\Delta U(\ell)-\Delta H(l)+\ell} H + \Delta H(\ell) - \ell \;\; dF}_{\text{Expected profit if borrower defaults}}$$

$$\underbrace{\delta \quad \int_{D-S-\Delta U(\ell)-\Delta H(\ell)+\ell}^{\bar{H}} D \;\; dF}_{\text{Expected profit if the borrower does not default}}$$

PACE loans have an ambiguous effect on lenders' profit. Both the default region and the loss given default decrease with the project's NPV: $\Delta H(l) - l$. Lenders are not able to directly monetize the non-pecuniary value of the project for the household when they foreclose on the property. However, this non-pecuniary value helps lenders by limiting incentives for the household to strategically default.

Lending markets are competitive, so lenders have zero rent: $\Pi(A,D) = 0$. The representative household maximizes his utility under the constraint of lenders' zero profit condition. Defining the default boundary as $B = D - S - \Delta U(\ell) - \Delta H(\ell) + \ell$, we obtain the following FOC:

$$\underbrace{\beta \int_B^{\bar{H}} dF + \beta \Delta U(\ell) \cdot f(B)}_{\text{Marginal utility cost of a higher debt repayment}} \qquad = \underbrace{-\delta.(S + \Delta U(\ell)) \cdot f(B) + \delta \int_B^{\bar{H}} dF}_{\text{Margin savings in the downpayment}}$$

This first order condition characterizes a key tradeoff. Increasing the debt value increases households' utility by decreasing the downpayment, but decreases future payoffs. The optimal downpayment, set competitively by lenders, is a function of households' non-pecuniary benefit associated with the PACE project, as well as the NPV of the PACE project.

We make the same assumptions as in the previous model regarding the distribution of the shock. Specifically, we assume that $f(\cdot)$ comes from a uniform distribution and (optimized) repayment amount D^* is between $[\underline{H}, \overline{H}]$. Given the previous first-order condition, we can derive the following two propositions:

Proposition 6: If $\Delta H'(\ell) + \frac{\beta}{(\beta-\delta)} \Delta U'(\ell) > 1$, then an increase in investment financed through a PACE loan leads to a higher supply of mortgages.

Intuition: Suppose that ℓ increases marginally. Then, $\Delta H(\ell)$ is higher, so households have lower incentives to strategically default on their mortgage when the price of the house drops. Mortgage companies have a higher recovery value in case of default if $\Delta H(\ell)$ increases. The nonpecuniary value of the home $\Delta U(\ell)$ increases, so households are less likely to strategically default. However, a countervailing force is that if ℓ increases, then this makes strategic default more likely, because the total repayment amount increases. If the effect of an increase of ℓ on $H(\ell)$ and $U(\ell)$ is high enough, then the latter effect is muted, and total mortgage supply increases, as mortgage companies do not make a profit.

Proposition 7: If the project has positive marginal NPV value for the household, namely $\Delta U'(\ell) + \Delta H'(\ell) > 1$, then a marginal increase in PACE lending leads to a lower probability of default.

Intuition: A higher PACE loan allows households to build equity in the house and derive non-pecuniary flow utility from their property. This increase in the value of the house discourages strategic default when the value of the house drops for exogenous reasons.

D Building Permit Methodology

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.

D.1 Classifying Building Permit Activity

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 rely solely 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 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 73% 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 73% 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.

5. At this stage, approximately 2% 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.

[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.

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, 95% of permits matched to a PACE loan fall into a mutually exclusive category. Our results are nearly identical regardless of whether we drop the 5% of permits corresponding to multiple possible uses of PACE funds.

D.2 Identifying permits backed by PACE loans

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 (HELOCs). 49% of permits on PACE loan properties feature multiple projects.[13] 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. We drop any permits referring to a new construction or solely to a demolition based on the CoreLogic types.

(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 5% of permits. We present in Online Appendix D.1 lists 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.[14] 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.

[13] In unreported results using the HMDA data, we find 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.

[14] 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.

E Data on Window Resiliency and Energy Efficiency

The U-Factor data is collected from the NFRC (National Fenestration Rating Council).[15] 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 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.[16] We focus on 2010-2020 HMDA datasets, and use the FFIEC mapping files to harmonize lenders' names pre-2017 with those from 2018 onwards.[17] 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

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

[16] 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.

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

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 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 relatively 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 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.

G.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.[18] 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.[19] We therefore view this subsample of loans as representative of the statewide PACE market.

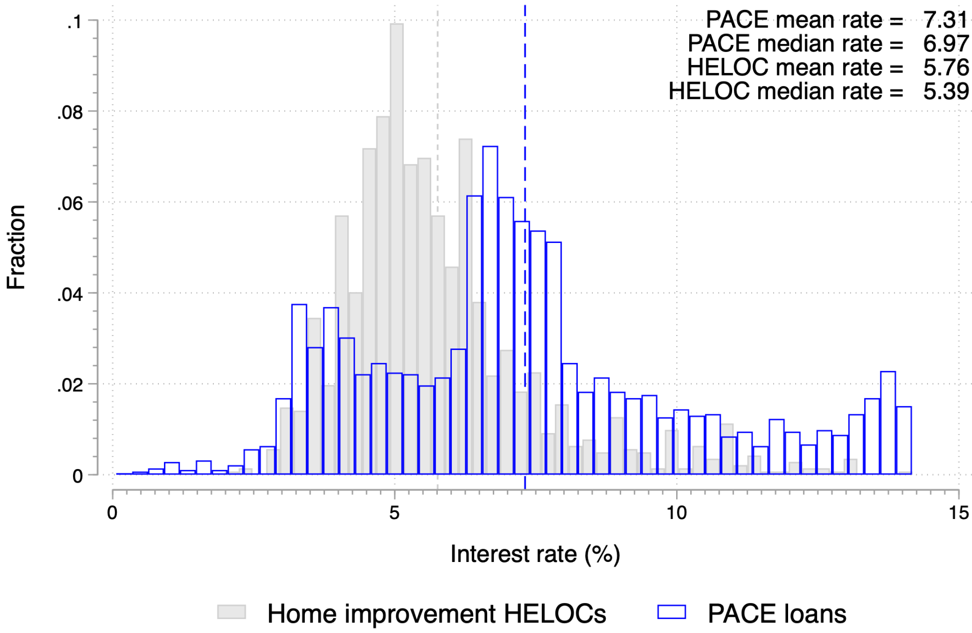
Since PACE loans are fixed-rate term loans, to back out the interest rate we require the origination amount, the required annual payment, and the loan term. We do not observe the loan term, but PACE loans are only originated with 5, 10, 15, 20, 25, or 30-year term lengths. We therefore compute a vector 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, 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

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

[19] 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 G.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 G 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.

multiple loans recorded as a single PACE assessment or nearly full prepayment in the initial tax year; PACE loans do not carry prepayment penalties.[20]

Figure G.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 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

[20] 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%.

greater than for the average fixed-rate home improvement HELOC loan.[21] 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.[22] 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.

A potential additional advantage to taking out a HELOC is that the interest is tax deductible if the funds are used towards a home improvement project on an owner-occupied residence. The IRS has not issued specific guidance pertaining to the tax treatment of PACE loans, although some legal firms have advised that PACE loan interest is tax deductible. Further, payments made towards amortizing a PACE loan do not qualify for the state and local tax (SALT) deduction, as SALT only pertains to *ad valorem* property taxes.

To provide an upper bound on the possible after-tax wedge between HELOC and PACE interest rates, suppose that HELOC interest payments are tax deductible while PACE interest payments are not or are generally not known to be by borrowers. According to the NBER TAXSIM model, the average marginal income tax rate in 2021 was 23.25%.[23] This means the after-tax rate spread for a PACE loan relative to a home improvement HELOC implied by the distributions in Figure G.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.[24] Applying this itemization probability to the calculation results in a spread of 168 basis points.

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

Table G.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:

$$r_{i,c,t} = \alpha + \beta \cdot PACE_{i,c,t} + \sum_{m=1}^{M} LTVbin_{i,c,t} + PrimaryMtg_{i,c,t} + \gamma_c + \delta_t + \varepsilon_{i,c,t} \tag{G.1}$$

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

[21] 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.

[22] 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.

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

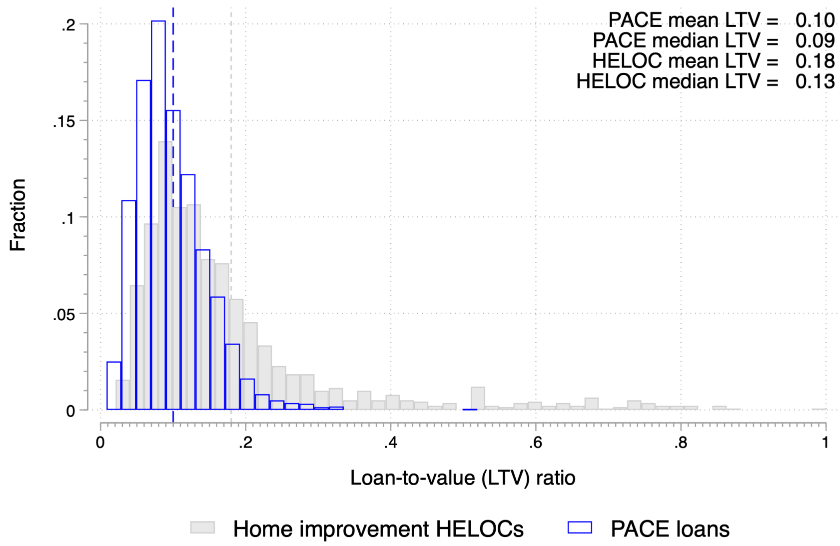
[24] See analysis by the Tax Policy Center: https://www.taxpolicycenter.org/briefing-book/what-are-itemized-deductions-and-who-claims-them.

Table G.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 (G.1) and (G.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 (G.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 G.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.

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 G.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.[25] 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 (G.1) by adding an interaction of $PACE_{i,c,t}$ with $PrimaryMtg_{i,c,t}$:

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

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 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 G.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 (G.2).

[25] 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.

H Do Counties' Finances Predict PACE Program Adoption?

Table H.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.

I Additional Results for Homeowners Insurance Market

This appendix presents robustness checks and additional results on homeowners insurance market outcomes in support of our Section 6.1 calculations of the potential capitalization of premia into house prices.

I.1 QUASR Florida Homeowners Insurance Data

We submitted a FOIA request to the Florida Office of Insurance Regulation (FLOIR) to obtain a complete history of quarterly data on homeowners insurance policies. Our data span 2009Q1 to 2024Q2 and are aggregated to the insurer-county-quarter level so that the records can be disseminated to the public.[26] In what follows, we collapse the data to the annual frequency to avoid any seasonality in insurance policy underwriting and to match the frequency of our results on insurance markets to the annual frequency of our PACE and property tax data used in the main analysis. An example of an observational unit in our analysis would then be the average premium charged on all residential homeowners insurance policies in Miami-Dade County in 2010Q1 underwritten by Citizens Property Insurance Corporation, the Florida state-run insurer of last resort.

The underlying source of these data are quarterly commercial and residential property insurance reports submitted to the FLOIR via their Quarterly and Supplemental Reporting System (QUASR).[27] Insurers doing business in Florida are required to comply with data

[26] Quarterly market reports from FLOIR aggregated to the company level can be found here: `https://floir.com/tools-and-data/residential-market-share-reports`.

[27] Custom reports based on QUASR data can be downloaded in non-batch format here: `https://apps.fldfs.com/QSRNG/Reports/ReportCriteria.aspx`.

Table H.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 ($Adopted_{c,t}$) if a county c 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. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

provision according to Florida Statutes §624.424(10). The QUASR data have been used extensively in the literature on the Florida homeowners insurance market. For recent examples, see Eastman et al. (2024) who examine the pass through of premia to house prices and Sastry et al. (2024) who show underpriced GSE mortgage risk leads to insurance market unraveling. A known issue with the QUASR data is that coverage has deteriorated over time, with a sharp drop in the number of total premia (as determined by regulatory filings) missing post-2018 due to insurers successfully petitioning for filing exemptions related to trade secrets (Sastry et al., 2024). To account for this, we check robustness of our specifications to restricting our sample to the period from 2009 to 2018. Doing so also avoids the post-2020 period during which the legal status of PACE was in flux for several Florida counties.

I.2 Event Study Results for County-Level Insurance Premia

We evaluate the parallel trends assumption inherent in the difference-in-differences (DiD) specification (6.1) by estimating a dynamic version of the form:

$$\log(Premium_{c,t}) = \sum_{t=-3,t\neq-1}^{+5} \beta_t \cdot PACE_{c,t} + \theta_c + \gamma' \cdot \mathbf{X_{c,t-1}} + \varepsilon_{c,t} \tag{I.1}$$

where as in the main analysis of Section 6.1, we regress log annual premia at the county level on an indicator $PACE_{c,t}$ for whether county c has an active PACE program as of year t. Using the Sun and Abraham (2021) estimator, the control group consists of counties which never formally adopted a PACE program. This estimator produces a conservative estimate of the pass through to insurance premia to the extent that some of the counties in the control group contain PACE administrators without an active interlocal agreement. The majority of such cases occur after a 2023 legal challenge mounted by Leon County resulting in a ruling that PACE administrators could do business across the entire state without an interlocal agreement.[28] For this reason, our baseline specifications in Table 7 which restrict to the pre-COVID period eliminate this potential source of contamination bias. The vector of lagged county demographic controls $\mathbf{X_{c,t-1}}$ is informed by unconditional average differences between PACE adopter vs. non-adopter counties along the statistically significant dimensions reported in columns 1 and 2 of Table 1. However, such differences in Table 1 largely disappear after conditioning on year δ_t and θ_c fixed effects.

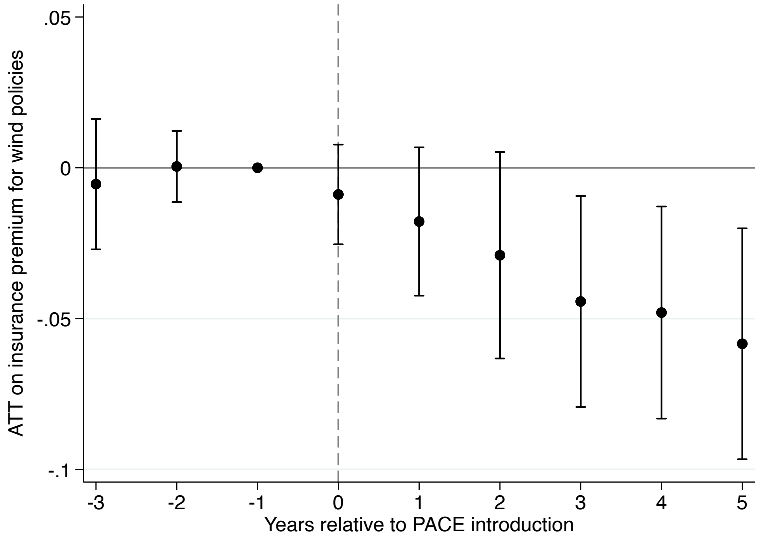
Figure I.1 shows no visual evidence of a differential movements in insurance premia for wind-damage policies prior to PACE introduction. We focus on wind-damage policies given the evidence in Section 5.2 that climate-proofing projects drive house price capitalization of PACE and Florida Statutes §627.0629 requiring insurers to provide discounts and credits to homeowners who invest in wind damage mitigation measures. Further, the observed negative effect on premia grows over time, consistent PACE takeup rates growing steadily in the years since households gain access to the loans.

I.3 Results Using Insurers' Exposure to PACE Counties

One possible threat to identification of the causal effect of PACE program adoption is that insurers may expand their policy issuance in a county in response to PACE adoption, perceiving

[28]The Leon County Circuit Court ruling has now been appealed up to the Supreme Court of Florida: https://acis.flcourts.gov/portal/court/68f021c4-6a44-4735-9a76-5360b2e8af13/case/0566c652-8d36-4e9a-9b67-b999013d4bb1.

Figure I.1. Event Study: County-Level PACE Adoption Effects on Homeowners Insurance Premia



Note: This figure plots the Average Treatment Effects on the Treated (ATT) from event study specifications as in (I.1), estimated via the Sun and Abraham (2021) estimator. The dependent variable is the log annual home insurance premium for wind-damage policies on owner-occupied residences at the county level. We weight observations by their lagged county-level population. Time on the x-axis is measured in years relative to PACE program adoption ($t = 0$). We use dates that official PACE ordinances or the first interlocal agreements are enacted to assign treatment timing. To compute average county-level premia, we collapse the data after first isolating contracts which only offer protection against damages from wind. Bars indicate 95% confidence intervals with standard errors clustered by county.

such contracts as becoming relatively safer because homeowners now have access to financing for home-hardening investments. To alleviate this concern, we employ a shift-share design by fixing insurers' county exposure to its initial level in 2009, the year before passage of Florida Statute §163.08 authorizing local PACE programs. For example, suppose that in 2009, insurer A operates in Brevard and Miami-Dade Counties with exposure values of \$30k and \$70k in total contract face values (i.e., the total insured values), respectively. By 2012, insurer A increases its exposure in Miami-Dade to \$80k while maintaining \$30k in Brevard. In 2012, Miami-Dade County has enacted PACE. We calculate insurer A's 2012 PACE exposure share as 70% (= 70/100) using its initial 2009 exposure before PACE adoption as the vector of "shares," and the staggered adoption of PACE across Florida counties as the "shifters."

This logic motivates the following regression estimated at the insurer-year level:

$$\begin{aligned}\log(Premium_{i,c,t}) = \alpha + \beta_1 \cdot PACE_{c,t} \times ExposureShare_{i,c,t} + \beta_2 \cdot PACE_{c,t} \\ + \beta_3 \cdot ExposureShare_{i,c,t} + \gamma' \cdot \mathbf{X_{c,t-1}} + \epsilon_{i,c,t}\end{aligned} \tag{I.2}$$

where $log(Premium)_{i,c,t}$ is the log annual insurance premium for contracts underwritten by insurer i in county c. $PACE_{c,t}$ is a dummy variable equal to one if county c has adopted PACE in year t, and zero otherwise. We interact $PACE_{c,t}$ with $ExposureShare_{i,c,t}$, which measures insurer i's 2009 share of dollar value exposure to all PACE counties with an ordinance as of year t. In some specifications, we also experiment with including insurer $\times$ year fixed effects or replacing the time-varying, lagged county demographic controls $\mathbf{X_{c,t-1}}$ with county $\times$ year fixed effects to account for county-specific time trends in the homeowners insurance market.

Table I.1 reports the results from estimating (I.2), showing a robust effect of PACE adoption on negative pass through into insurance premia from the estimated coefficient of interest ($\beta_1 < 0$). This effect qualitatively holds regardless of whether we use OLS, a stacked DiD estimator (Baker et al., 2022a), or the Sun and Abraham (2021) estimator to account heterogeneous treatment effects by cohort of adoption. We also observe a similar, slightly attenuated effect if we restrict the estimation sample to contracts only insuring against wind-based damages to the property (columns 7 to 9). Based on our preferred specification in column 6 which uses the Sun and Abraham (2021) estimator and includes all policies in the sample, a one standard deviation increase in an insurer's exposure to PACE counties generates a 4.7% decrease in annual insurance premia after PACE adoption.[29]

I.4 Effects on Local Market Share of State-Run Insurer (Citizens)

The preceding evidence shows that PACE adoption passes through to lower insurance premia at the county level, the insurer-county level, and at an individual level, as suggested by house price capitalization. Based on Table 7, pass through occurs for both the private and public homeowners insurance market segments. Since its creation in 2002, Citizens Property Insurance Corporation (Citizens for short) acts as the state-run insurer-of-last-resort, offering contracts to Florida homeowners who otherwise cannot obtain a policy from the private market. Citizens periodically engages in a "Depopulation Program" when its market share rises, which most recently occurred after Hurricane Ian in 2022 (Citizens Property Insurance Corporation, 2024).

A natural question arises of whether the home-hardening projects that PACE loans finance help homeowners remain in the private segment of the market. This can occur either because homeowners are less likely to be dropped by their insurer or because they are not priced out of the private market. Homeowners are eligible for Citizens coverage if all private insurer quotes are more than 20% higher than Citizens' comparable coverage premium.[30] We show in Table 7 that the pass through of PACE to premia is of a similar magnitude across Citizens and non-Citizens policies, indicating that any drop in Citizens' market share is more likely due to PACE preventing unraveling from insurers exiting the market altogether, dropping policies, or refusing policies for PACE customers who are currently enrolled with Citizens.

Since Citizens' market share is volatile both at the county level and in aggregate over our sample time period, and thus likely non-stationary, we use the year-on-year county-level growth rate in the market share as our outcome variable and re-estimate equations (6.1) and (I.1). In Figure I.2. Consistent with the hypothesis that PACE helps prevent insurance market unraveling, we find a negative effect in Table I.2 on the local growth rate of Citizens' market share; this effect is robust across a range of staggered DiD estimators which permute the definition of the control group to incorporate difference combinations of never-adopter and not-yet-adopter counties. Comparing PACE counties to non-PACE counties, the average PACE adoption event results in a 37.5 percentage point drop in the market share growth rate. We find no clear evidence of a pre-trend in local market shares, supporting our interpretation based on Table 1 and hat selection of counties into PACE is not driven by historical claims payouts from property damages.

[29]Given that the standard deviation of $ExposureShare$ is 0.333 and the standard deviation of $\log(Premium)$ is 0.567, the calculation is $\exp(0.333 \times 0.078/0.567) = 0.0469$.

[30]See discussion of the Citizens 20% rule in the context of the Depopulation Program here: https://www.citizensfla.com/-/new-rules-for-citizens-depopulation-program.

Table I.1. Insurer Exposure Share Design: PACE Adoption Effects on Insurance Pricing

Dep. variable: log($Premium_{i,c,t}$)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$PACE_{c,t} \times ExposureShare_{i,c,t}$	-0.078***	-0.098***	-0.081***	-0.084***	-0.041***	-0.078***	-0.048*	-0.027*	-0.047*
	(0.021)	(0.024)	(0.026)	(0.024)	(0.014)	(0.025)	(0.025)	(0.014)	(0.025)
$ExposureShare_{i,c,t}$	0.182***	0.215***	0.186***		-0.065***	0.177***	0.130***	-0.058***	0.123***
	(0.045)	(0.046)	(0.046)		(0.013)	(0.046)	(0.047)	(0.013)	(0.047)
$PACE_{c,t}$	0.020	0.027**							
	(0.012)	(0.013)							
Population		0.050							
		(0.196)							
% Black		0.425							
		(0.798)							
% Hispanic		0.716							
		(0.760)							
Unemployment rate		-0.157							
		(0.232)							
% Bachelor's degree or higher		0.114							
		(0.208)							
Abnormal property damage		-0.000							
		(0.000)							
Sample	All	All	All	All	All	All	Wind	Wind	Wind
Estimator	OLS	OLS	OLS	OLS	Stacked	SA	OLS	Stacked	SA
Observations	40,535	22,977	40,535	40,514	254,876	40,535	39,880	251,859	39,880
R-squared	0.765	0.773	0.767	0.803	0.638	0.767	0.806	0.685	0.806
Insurer FE	Yes	Yes	Yes	–	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	–	–	–	–	–	–	–
County FE	Yes	Yes	–	–	–	–	–	–	–
County × Year FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Insurer × Year FE	No	No	No	Yes	No	No	No	No	No

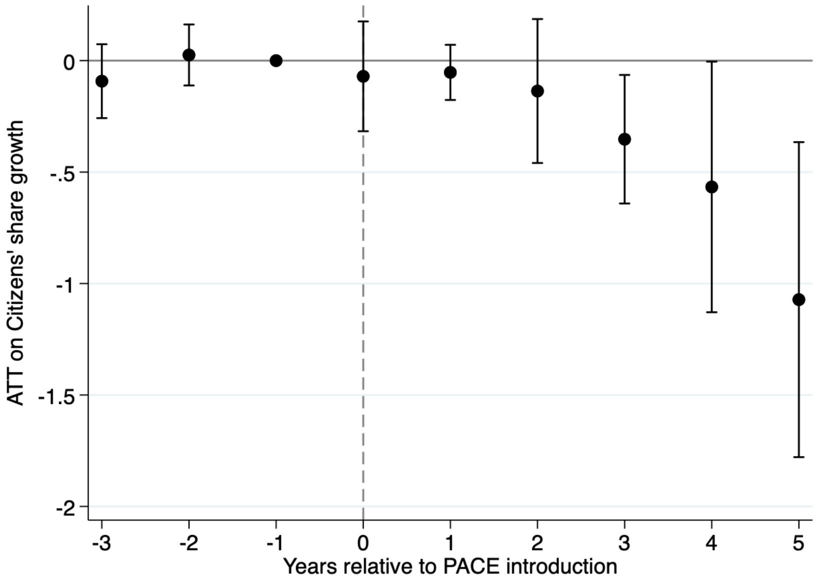
Note: This table presents results from estimating exposure share difference-in-differences regressions according to (I.2). The dependent variable in each column is the log annual home insurance premium for owner-occupied residences at the insurer-county level. PACE is a dummy variable that takes the value of one if county c has adopted PACE in year t, and zero otherwise. *ExposureShare* measures the percentage of insurer i's dollar exposure to PACE counties in year t; we fix the vector of insurers' county-level exposure shares to the baseline year of 2009 prior to the statewide enactment of PACE in Florida. We use dates that official PACE ordinances or the first interlocal agreements are enacted to assign treatment timing across counties. Columns 1 through 4 report OLS regressions; columns 5 and 8 use the stacked event study estimator (Baker et al., 2022a); columns 6 and 9 use the Sun and Abraham (2021) [SA] estimator. In columns 7 through 9 we restrict the sample to policies covering wind damages only. In column 2, the lagged county-level controls include population, proportion of Black, proportion of Hispanic, proportion of population with a Bachelor's degree or higher, unemployment rate (all from the one-year American Community Survey estimates), and abnormal property damage caused by natural disasters, as reported by SHELDUS. Robust standard errors clustered at the insurer-year level in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

Table I.2. PACE Adoption Effects on Citizens' Local Market Share

	(1)	(2)	(3)	(4)	(5)
PACE	-0.177*	-0.375***	-0.407***	-0.314**	-0.359**
	(0.094)	(0.114)	(0.076)	(0.130)	(0.157)
Estimator	Stacked	SA	BJS	Stacked	SA
Observations	4,295	675	669	1,183	303
County controls	No	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes

Note: This table presents the county-year level difference-in-differences regressions of the form in (6.1). Instead of insurance premia, the dependent variable is now the growth in county-level market share of the public insurance provider, Citizens Property Insurance Corporation. PACE is a dummy variable that takes the value of one if county c has adopted PACE in year t, and zero otherwise. Columns 1 and 4 use the stacked event study estimator (Baker et al., 2022a); columns 2 and 4 use the Sun and Abraham (2021) [SA] estimator, and column 3 uses the Borusyak et al. (2024) [BJS] estimator which includes both the never-treated and not-yet treated sets of counties in the control group. Lagged county-level controls in columns 4 and 5 include population, proportion of Black, proportion of Hispanic, proportion of population with a Bachelor's degree or higher, unemployment rate (all from the one-year American Community Survey estimates), and abnormal property damage caused by natural disasters, as reported by SHELDUS. We weight observations by their lagged county-level population. We use dates that official PACE ordinances or the first interlocal agreements are enacted to assign treatment timing. Robust standard errors (in parentheses) are clustered at the county level. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

Figure I.2. Event Study: County-Level PACE Adoption Effects on Citizens Property Insurance Corporation's Local Market Share



Note: This figure plots the Average Treatment Effects on the Treated (ATT) from event study specifications as in (I.1), estimated via the Sun and Abraham (2021) estimator. Instead of insurance premia, the dependent variable is now the growth in county-level market share of the public insurance provider, Citizens Property Insurance Corporation. We weight observations by their lagged county-level population. Time on the x-axis is measured in years relative to PACE program adoption ($t = 0$). We use dates that official PACE ordinances or the first interlocal agreements are enacted to assign treatment timing. Bars indicate 95% confidence intervals with standard errors clustered by county.