Picking Up the PACE:
Loans for Residential Climate-Proofing

Aymeric Bellon	Cameron LaPoint	Francesco Mazzola	Guosong Xu
UNC Chapel-Hill	Yale SOM	ESCP Europe	Erasmus RSM

The Mortgage Market Research Conference

Federal Reserve Bank of Philadelphia

May 2024

How to accelerate green transition of housing?

- Homes are affected by **climate change adaptation and mitigation**
  - Accounted for 26% of global energy-related emissions in 2022 (IEA, 2023)
  - 1 in every 10 homes in the US was impacted by natural hazards in 2021 (CoreLogic 2022)
- Investment in green residential projects is **insufficient** (Climate Policy Initiative 2023)
  - Total global investment in mitigation alone is currently $28.7 bil./year
  - Yet, $827.1 bil./year needed to reach net zero emissions by 2050
- We study a **new class** of financial contracts which aims to reduce this investment gap
  - **Residential Property Assessed Clean Energy (PACE) loans**
  - Borrowers pay off loans through local property tax bill

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PACE loans are highly controversial

Increase in risks: Lax screening and potential predatory lending practices. Breach the priority of traditional mortgages

Efficiency: Allow financially constrained households to invest in projects that improve their home equity value

Summary of our empirical findings

- Households that appear **ex ante financially constrained** more likely to use PACE loans
- PACE loans finance projects that **significantly increase the home's value**
- **PACE loans significantly increase property tax delinquency rates**
- We find evidence of **crowdin** of traditional mortgage lending
- Simple back-of-envelope calculation combining our DiD estimates (ATT effects)

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

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Contributions & related literature

1. **Effects of climate adaptation on property/mortgage markets**

   Eichholtz et al. (2010); Goodman & Zhu (2016); Issler et al. (2019); Jaffee et al. (2019); Keys & Mulder (2020); Rose & Wei (2020); Giglio et al. (2021); CFPB (2023); Sastry et al. (2024); Millar & White (2024)

   → First cost-benefit analysis of PACE using comprehensive microdata

2. **Green investment gap**

   Fowlie et al. (2015,18); Levinson (2016); Houde & Aldy (2017); Gerarden et al. (2017); Hahn & Metcalfe (2021); Berkouwer & Dean (2022); Myers et al. (2022); Clara et al. (2022); Lu & Spaenjers (2023)

   → Highlight the role of households' financial constraints in developed country context

3. **Green financial contracts**

   Zerbib (2019); Tang & Zhang (2020); Flammer (2021); Baker et al. (2022); Kim et al. (2022)

   → We study a new type of local govt.-backed lending product

4. **Corporate environmental liens**

   Bellon (2021); Akey & Appel (2021); Ohlrogge (2022); Chen (2022)

   → We study environmental liens linked to households

Institutional Background on PACE Programs and data

Legal background on PACE contracts

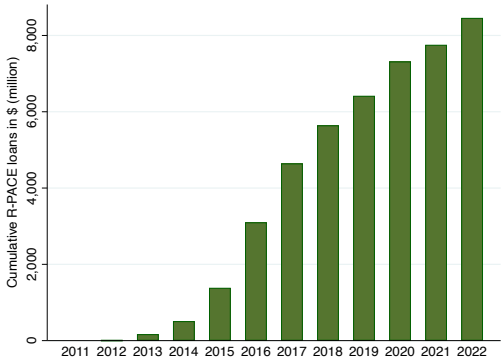
Property Assessed Clean Energy (PACE) Program

Loans for qualified energy efficient and climate-proofing home improvement projects where borrowers pay back debt through annual local property tax bill.

- Qualified uses are fairly expansive: solar panels, HVAC upgrade, **re-roofing, impact-resistant windows/doors,** generator, water conservation, etc.
- Local govt. as the loan servicer means that lien on the property is *super senior* to all other forms of debt $\implies$ dominates mortgage lender or bankruptcy claims (LaPoint 2023)
- In practice, a public-private partnership: local govt. issues bonds backed by tax payments and outsources underwriting to private lenders ("administrators")

More background | Fraud?

R-PACE program reached $8.5 billion in total originations by end of 2022



- 8 additional states have proposed C-PACE legislation (pacenation.org)
- R-PACE only available in California, Florida, and Missouri $\longrightarrow$ but $8.5 bil. market (2022) ▸▸ R-PACE

Datasets: overview

- **PACE loan data**
  - $>$ 16,000 property-level loans matched using the assessor's parcel number (APN)
- **CoreLogic Owner Transfers, Mortgage, and Tax data**
  - House prices, buyers and sellers, information about the use (e.g. single vs. multi-family), tax assessment, combined loan-to-value (CLTV) ratios, and location of the property
- **CoreLogic Involuntary Liens data**
  - Isolate liens placed on property due to local tax delinquency (i.e. PACE default)
- **CoreLogic Building Permits**
  - Tracks the universe of any building permit applications tied to APNs appearing in the other CoreLogic datasets Methodology
- **HMDA mortgage lending data**
  - Applicant's demographic information, lender's approval/rejection, pricing, and securitization decisions
- **SHELDUS natural hazards data**
  - Spatial Hazard Events and Losses Database for the United States (SHELDUS)

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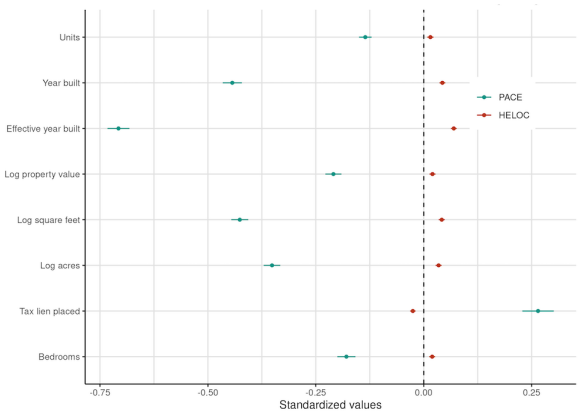
PACE Loan Takeup

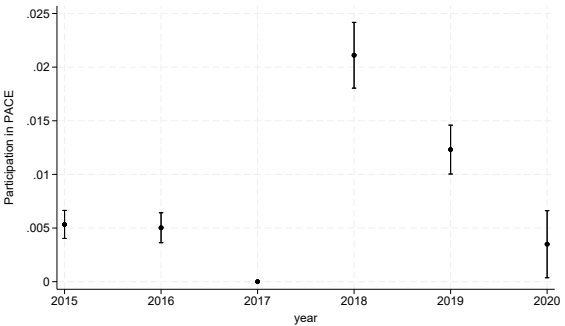
PACE properties negatively selected relative to HELOCs



- HELOCs widely available and main source of financing for HI projects in U.S. (Hurst & Stafford 2004)
- PACE properties are smaller, older, trade at lower values, and more likely to be tax-delinquent *ex ante*
  - Points to binding *ex ante* **liquidity constraints** among PACE borrowers
- Gaps close if we condition on county FEs or match PACE and HELOC borrowers on HI project type or LTV

PACE loan takeup spikes after Hurricane Irma (2017)

$$PACE_{i,c,t} = \sum_{n=2015, n\neq 2017}^{2020} \beta_n \cdot \mathbb{1}\{t = n\} \times DMG_c + \delta_t + \eta_i + \varepsilon_{i,c,t}$$

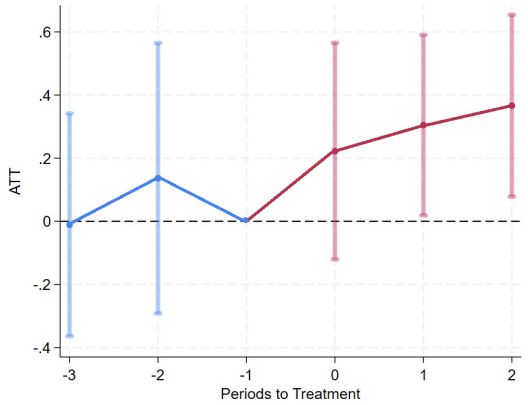


- Irma was a Category 4 hurricane causing $50 bil. in total damages across Florida
- But even before Irma, **property damages predictive of PACE adoption** ▸▸ Table
- Per capita property damages (DMG_c) based on county-level insurance payouts
- Stronger results if focus on PACE projects w/permit for windows + doors as outcome

Costs and Benefits for Local Governments

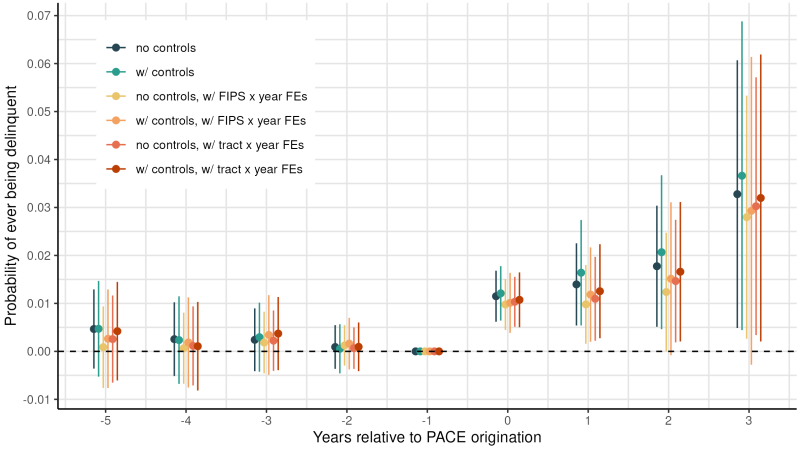
Strong capitalization effect of PACE into house prices

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



- Implies large headline ROI of $\approx$ 2x
  - 35% $\uparrow$ in price relative to loan amount
    ⏩ Without controls
- Add in origination costs, permit fees, and discounted change in tax bill
  - Permit fees typically very small, vary by town ($100 – $200)
  - Average origination fees $\approx$ $1,300 (CFPB 2023)

Delinquency ↑ by 1 p.p. (12%) within year of origination



- Effect grows over time due to ever-delinquency flag (2.5 p.p., or 30% ↑ within 3 years)
  - Similar trajectory if use property or property × owner combo as the panel unit

Combining our estimates $\Longrightarrow$ PACE expands tax base

- Simple back-of-envelope calculation combining our DiD estimates

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

- Even after netting out delinquencies, **revenues grow by $694 per PACE loan-year** in counties participating in program
  - Similar ΔP if instead use market assessed values (tax base revalued each year in FL)
  - ATT effects: evidence from HMDA consistent with positive pecuniary externalities
- Again, **lower-bound** estimate of the increase in revenue because...
  - This is without accounting for spillovers to local employment or non-PACE investments
  - We don't value the pecuniary benefit of reduced environmental externalities
  - Some delinquency costs are partially borne by municipal bond investors
  - Measure ΔD using an "ever-delinquent" flag, but some loans are performing

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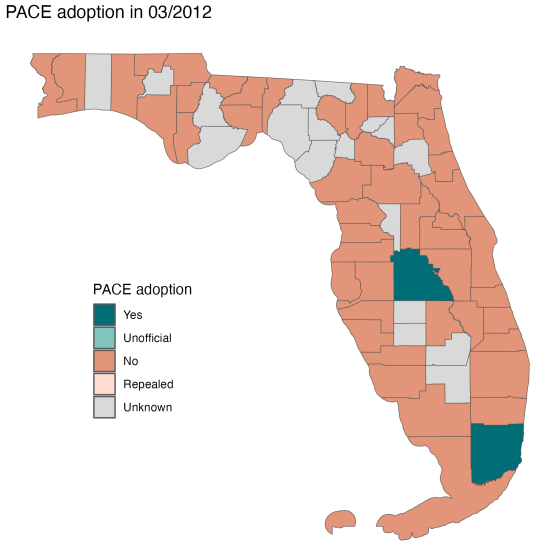
Does PACE loan adoption crowdout other forms of mortgage credit?

How might mortgage lenders respond to PACE?

- Simple conceptual framework where lenders make underwriting decisions with vs. w/o PACE availability to mortgage borrowers
  - HH makes downpayment and buys house in $t = 1$ and then repay or default in $t = 2$
  - The lending market is competitive
- Crowdout: reduce mortgage supply due to loss given default ↑
  - PACE super seniority diminishes the recovery value of the morgage
  - CDTI ratio higher w/PACE, leading to more defaults on mortgage (Ganong & Noel 2023)
- **Crowdin:** collateral recovery value becomes higher, not lower if PACE loans are used to finance projects with $\Delta P >> 0$
  - LGD might decline if projects generate new cash flows (e.g. energy savings or lower HO insurance premia) that are capitalized into house prices
- Ultimately an empirical question which force dominates!

Entry of R-PACE lending in Florida: 2012 – 2023



- County-level staggered DiD design for mortgage/insurance market outcomes
  - Adoption dates from news sources, LexisNexis, and official loan records
- Local govt. PACE adoption in a year is uncorrelated with...
  - Population size, racial demographics
  - Household income, unemployment, college education
  - Democratic voting share
- PACE adoption is predicted by natural disaster declarations but **timing within county is not** Table

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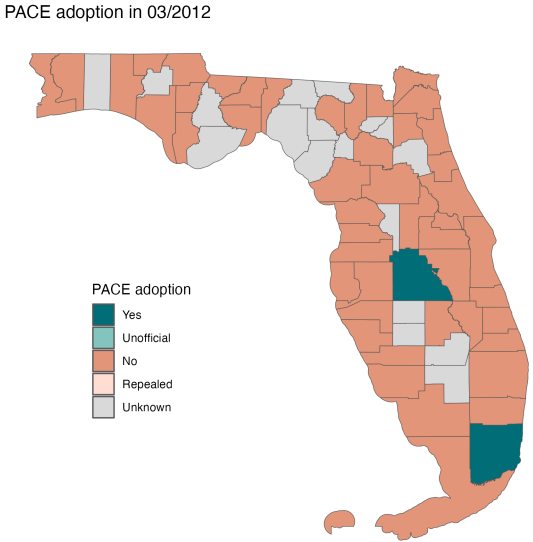

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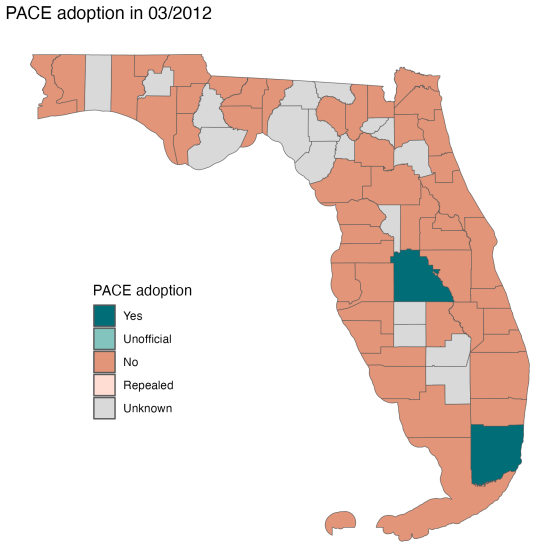

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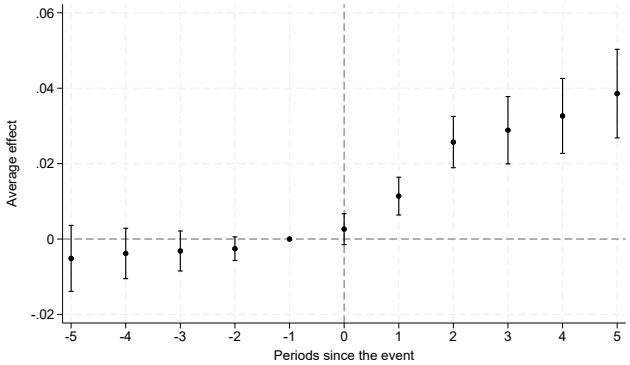
Credit supply expands due to improved collateral values

$$Lending_{i,c,t} = \beta \cdot PACE\ adoption_{c,t} + \gamma \cdot \mathbf{X}_{i,c,t} + \alpha_c + \delta_t + \varepsilon_{i,c,t}$$



- Using DiD estimators with county-level staggered adoption (Cengiz et al. 2019; Sun & Abraham 2021; Baker et al. 2022)

Conclusion

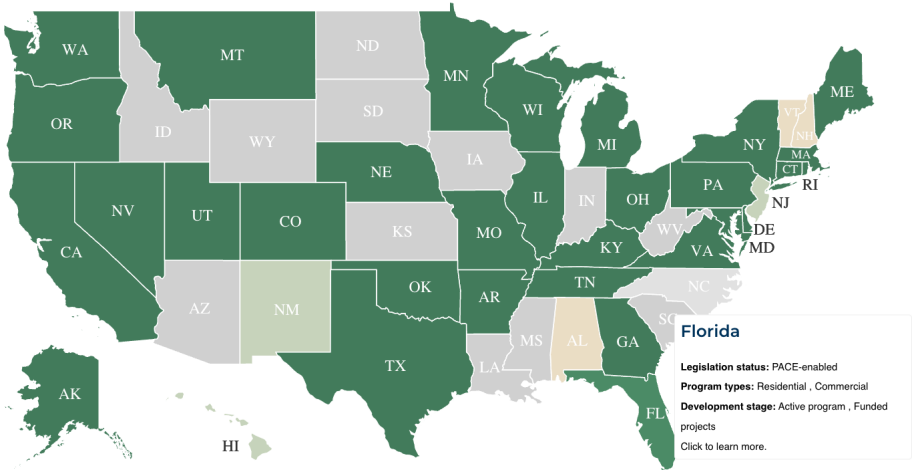
Conclusion: PACE does more good than harm

- **We show that local government-backed loans can help close the investment gap in green residential projects $\longrightarrow$ revenues $\uparrow$ by $694 per loan-year**
- **Mechanism:** lowering screening standards without subsidizing credit helps relax households' **financing constraints**
  - PACE borrowers are negatively selected compared to HELOC borrowers for home improvement projects
  - Uptick in delinquency rates quantitatively small relative to capitalization into home values
- Super seniority of the tax lien does not lead to crowdout of traditional mortgage credit, since recovery value of collateral $\uparrow$

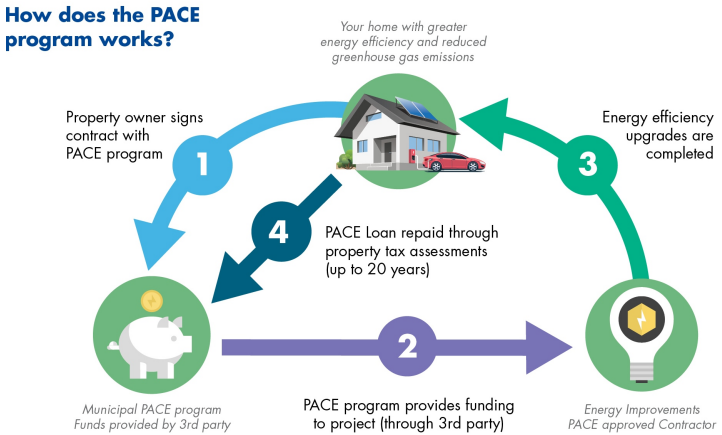
THANK YOU!

Appendix

PACE loans offered in 30 states + D.C. and growing



How PACE works in practice



Source: City of Miami Beach.

Back

How do borrowers obtain PACE financing?

- **Two application methods:**
  1. Apply directly through district or lender's website
  2. Work with registered contractor on home improvement project, and contractor forwards your application to district operating in that area

- **Screening process:**
  - Lender may perform a hard credit inquiry but cannot use FICO score in approval decision
  - Credit inquiry used to uncover DTI, payment delinquency, and bankruptcy history
  - PACE loan cannot exceed 10% of income, and property CLTV $\leq 100\%$

- **At origination:**
  - Notice of assessment lists the loan terms $\longrightarrow$ filed with town clerk (borrower CC'ed)
  - Notice of commencement attached to loan details the home improvement project $\Longrightarrow$ difficult to commit fraud using loan proceeds towards unqualified 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 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 / Alt 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 [redacted]
   A. Name
   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

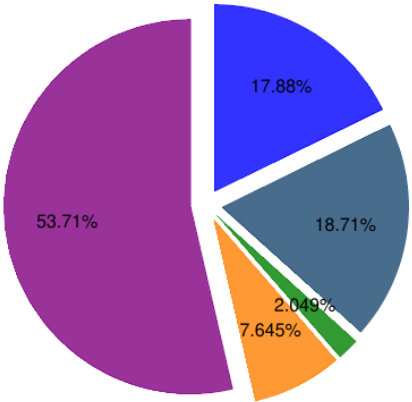
   Kevin Krueger 8934 Western Way Jacksonville FL 32256

5. Surety Name

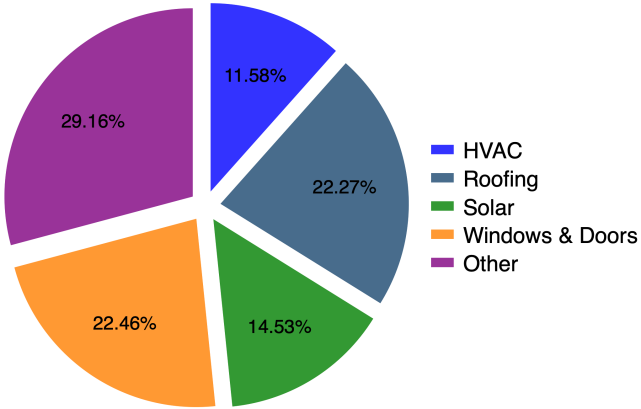
   ~~Bond amount~~ $ $19,500

PACE loans mainly used for hurricane proofing in FL

All FL Residential Permits



Permits Tied to FL R-PACE Properties



Source: Bellon, LaPoint, Mazzola, Xu (2024): "Picking Up the PACE: Loans for Residential Climate-Proofing"

Back

Permit probability spikes around PACE origination

$$\text{Permit}_{i,t} = \sum_{t=-3, t\neq -1}^{+3} \beta_t \cdot PACE_{i,t} + \eta_i + \theta_{z,t} + \varepsilon_{i,t}$$

	Windows/Doors	Roofing	HVAC	Solar
$t = -3$	-0.012^{***}	-0.016^{***}	-0.016^{***}	-0.012^{***}
$t = -2$	-0.013^{***}	-0.016^{***}	-0.016^{***}	-0.011^{***}
$t = 0$	0.016^{***}	0.026^{***}	0.019^{***}	0.020^{***}
$t = 1$	-0.027^{***}	-0.030^{***}	-0.035^{***}	-0.023^{***}
$t = 2$	-0.032^{***}	-0.037^{***}	-0.040^{***}	-0.028^{***}
$t = 3$	-0.028^{***}	-0.039^{***}	-0.040^{***}	-0.028^{***}
Estimator	CSDID	CSDID	CSDID	CSDID
Property FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
5-digit zip code × year FEs	✓	✓	✓	✓
# clusters	604	604	604	604
N	177,745	177,745	177,745	177,745

- Compare early to late PACE borrowers using Callaway & Sant'Anna (2021)
- Timing: we define $t = 0$ to be within one year (± 6 months) of origination ▸ Graph
  - Retroactive permitting possible without penalty in most FL towns
  - Notice of commencement has a one-year expiration date
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  - Some of the permits in "other" category may be small green projects below permit exemption thresholds

Permit probability spikes around PACE origination

$$\text{Permit}_{i,t} = \sum_{t=-3, t\neq -1}^{+3} \beta_t \cdot PACE_{i,t} + \eta_i + \theta_{z,t} + \varepsilon_{i,t}$$

	Windows/Doors	Roofing	HVAC	Solar
$t = -3$	-0.012^{***}	-0.016^{***}	-0.016^{***}	-0.012^{***}
$t = -2$	-0.013^{***}	-0.016^{***}	-0.016^{***}	-0.011^{***}
$t = 0$	0.016^{***}	0.026^{***}	0.019^{***}	0.020^{***}
$t = 1$	-0.027^{***}	-0.030^{***}	-0.035^{***}	-0.023^{***}
$t = 2$	-0.032^{***}	-0.037^{***}	-0.040^{***}	-0.028^{***}
$t = 3$	-0.028^{***}	-0.039^{***}	-0.040^{***}	-0.028^{***}
Estimator	CSDID	CSDID	CSDID	CSDID
Property FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
5-digit zip code × year FEs	✓	✓	✓	✓
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Summary stats for house price and lending samples

	N	Mean	Std. Dev.	p5	p95
	Panel A: House Price Analysis (CoreLogic-PACE Repeat Sales)				
$SaleAmount_{i,t}$	2,858	322,011.5	170,957.6	120,000	659,000
$\log(Price)_{i,t}$	2,858	12.55	0.52	11.70	13.40
$Bedrooms_{i,t}$	2,858	3.02	0.83	2	4
$\log(squarefootage)_{i,t}$	2,858	9.04	0.81	7.74	10.78
$AgeDec_{i,t}$	2,858	5.24	2.87	1	10
	Panel B: Private Lending Analysis (HMDA)				
$Approval_{i,c,t}$	1,575,159	0.828	2.851	1	10
$PACE_{i,c,t}$	1,829,045	0.266	0.442	0	1
$PriSec_{i,c,t}$	1,021,842	0.414	0.493	0	1
$GSEsec_{i,c,t}$	1,021,842	0.586	0.493	0	1

What predicts counties' PACE adoption decisions?

	(1) PACEAdopted	(2) PACEAdopted	(3) PACEAdopted	(4) PACEAdopted	(5) PACEAdopted	(6) PACEAdopted
Population	-0.046	-0.054	-0.042	-0.408	-0.600	-0.744
	(0.066)	(0.071)	(0.074)	(0.959)	(0.983)	(0.950)
Household median income	0.633**	0.740**	0.562	-0.225	-0.168	-0.195
	(0.304)	(0.326)	(0.372)	(0.344)	(0.360)	(0.372)
Fraction w/ bachelor degree or higher	-1.688**	-1.846**	-1.686**	1.281	1.822	1.748
	(0.687)	(0.732)	(0.773)	(1.273)	(1.242)	(1.214)
Black fraction of population	0.547	0.530	0.757	-0.566	0.369	0.700
	(2.276)	(2.451)	(2.463)	(2.599)	(2.612)	(2.616)
Latino fraction of population	0.807	0.870	1.086	-1.705	-4.362	-5.403
	(1.974)	(2.105)	(2.131)	(5.755)	(6.905)	(7.189)
White fraction of population	0.311	0.365	0.664	-4.517	-6.596	-7.086
	(2.021)	(2.160)	(2.191)	(3.852)	(4.677)	(4.736)
Unemployment rate	-4.840***	-4.413***	-5.124***	-0.785	-0.282	-0.326
	(1.030)	(1.250)	(1.451)	(1.138)	(1.245)	(1.426)
Democratic leaning	1.248**	1.473**	1.451**	-0.648	-0.913	-0.895
	(0.600)	(0.662)	(0.690)	(1.102)	(1.142)	(1.211)
#Declared natural disasters	0.064***			-0.003		
	(0.022)			(0.030)		
#Declared natural disasters L1		0.135***			-0.015	
		(0.027)			(0.029)	
#Declared natural disasters L2			0.122***			0.001
			(0.037)			(0.029)
Observations	504	466	430	504	466	430
R-squared	0.322	0.325	0.286	0.693	0.705	0.713
County FE	No	No	No	Yes	Yes	Yes
Year FE	No	No	No	Yes	Yes	Yes

Back

Keyword classification for home improvement permits

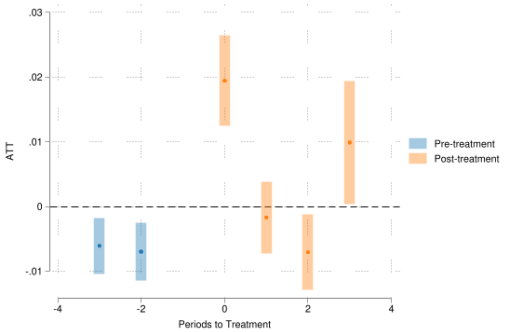
- Use CoreLogic Building Permits to identify types of projects
  - Focus on permit applications, but dates, but subset to completed permits
  - Each permit can have multiple projects listed (up to 3)
  - Focus on SFHs, no teardowns, no new construction

- Parse strings from town clerk's memo to sort permits into 5 mutually exclusive types:
  - Windows and doors: windows, doors, impact, etc.
  - Roofing: roof, shingle, asphalt, etc.
  - HVAC: cool, heat, air conditioning, AC, HVAC, duct, etc.
  - Solar: photovoltaic, cell, solar, generator, etc.
  - Other: any other permits with no explicitly mentioned PACE-qualified project

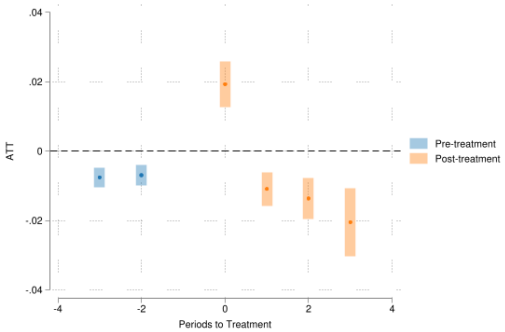
Back

Permitting spikes around PACE origination

HVAC Permits



Solar Panel Installation Permits

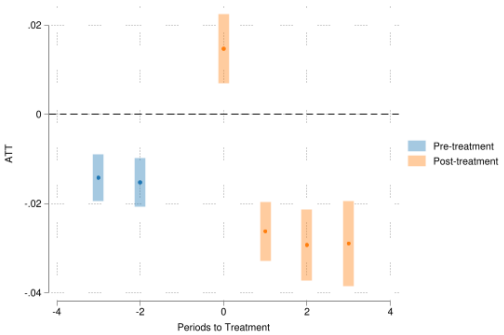


- Clear jump in permitting probability of 2 p.p. for energy efficiency projects

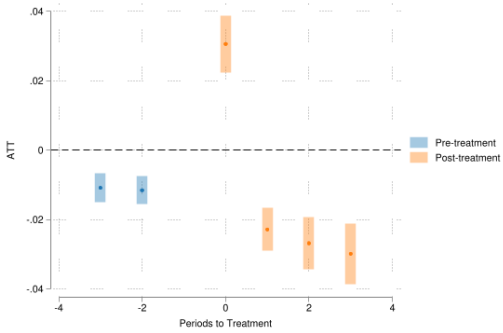
back

Permitting spikes around PACE origination

Roofing Permits



Window & Door Permits

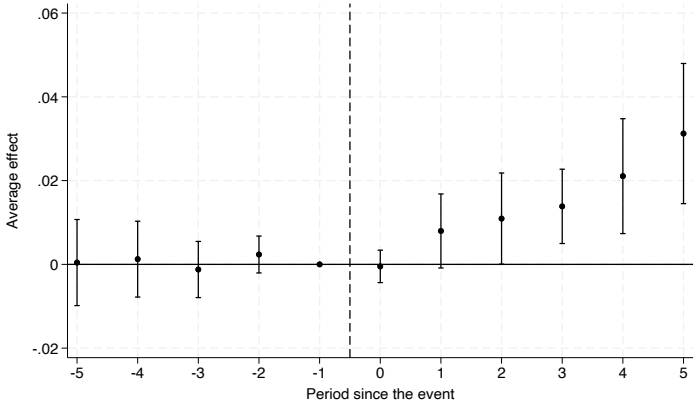


- Clear jump in permitting probability of 2 p.p. for disaster-proofing projects

	(1) $PACE_{i,j,t}$	(2) $PACE_{i,j,t}$	(3) $PACE_{i,j,t}$	(4) $PACE_{i,j,t}$
Post Irma$_{i,t}$ × DMG$_j$	0.013***			
	(0.001)			
1 year after Irma × DMG$_j$		0.018***		
		(0.001)		
2 years after Irma × DMG$_j$		0.009***		
		(0.001)		
3 years after Irma × DMG$_j$		0.000		
		(0.001)		
Post Irma$_{i,t}$ × Irma$_j > 0$			0.070***	
			(0.005)	
1 year after Irma × Irma$_j > 0$				0.099***
				(0.007)
2 years after Irma × Irma$_j > 0$				0.038***
				(0.005)
3 years after Irma × Irma$_j > 0$				-0.007
				(0.007)
Observations	78,432	78,432	78,432	78,432
R-squared	0.17	0.17	0.17	0.17
Property FE	x	x	x	x
Year FE$_t$	x	x	x	x

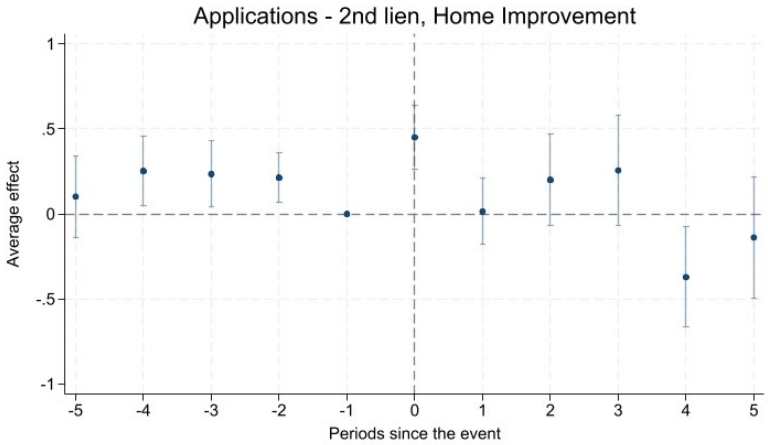
Back

Credit supply also expands for refinancings



- $\Longrightarrow$ PACE expands credit supply to both new and existing mortgage borrowers

Null effect on home improvement loan applications



- Borrowers use HELOCs to "top-up" PACE funding but also demand is lower to extent HELOCs are substitutable contracts

Covariate-unadjusted pricing results

Dep. variable: $\log(Price_{i,t})$	**Panel A: without property controls**			
	ATT	SE	95% Confidence Bands	
Pre-PACE	0.111***	0.028	0.055	0.166
Post-PACE	0.187***	0.030	0.128	0.246
$t = -3$	0.179***	0.038	0.105	0.253
$t = -2$	0.043	0.031	-0.019	0.104
$t = 0$	0.119***	0.038	0.045	0.192
$t = 1$	0.407***	0.045	0.319	0.495
$t = 2$	0.035	0.051	-0.064	0.134

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