Spatially Targeted LTV Policies and Collateral Values

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FSU-UF Critical Issues in Real Estate Symposium
University of Florida

March 9th, 2024
Motivation: regulating leverage to cool housing demand

- Housing increasingly unaffordable in major cities around the world
  - Concentrated in supply-constrained superstar cities with high amenity value

- Many types of policy experiments conducted to bring prices down
  - Taxes: transaction, capital gains, vacancy, foreign homebuyer surcharges, etc.
  - Most recent studies show transfer taxes distortionary and $P \uparrow$ through lock-in effects
  - Mortgage regulation: downpayment requirements, insurance, bank quotas/risk weights

- U.S. has conforming loan limits (CLL) which positively co-move with house prices
  - Cutoffs for whether Fannie/Freddie can buy mortgages on secondary market
  - For jumbo loans above cutoff higher required income and credit score $\implies$ rationing
  - Exceptions for certain high cost areas set by 2008 law (e.g. D.C., NYC)
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U.S. CLL formula imperfectly targets based on local $\Delta P$

$$CLL_{i,t} = \alpha \cdot \mathbb{1}\{HighCoL\}_{i,t-1} + (1 + \%\Delta HPI_{[t-1,t]} \times \overline{CLL}_{t-1}$$

- Movements in leverage limits anchored to \textit{national} housing cycle
- In practice, two ways to explicitly link to local prices:
  - Bank origination costs tied to typical home value in an area $\rightarrow$ “soft” limit, like CLL
  - Or, set required downpayment percentage by locality $\rightarrow$ “strict” limit
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What we do

### Research question

Are **spatially targeted** leverage limits preferred from an **efficiency** perspective as a way to "cool" housing markets? And how to quantify the **general equilibrium** costs?

- Study this question using a novel series of changes to strict LTV limits in Taiwan
  - Leverage policy part of Central Bank regulatory mandate (common outside U.S.)
  - **Select specific districts** to impose credit limits based on **ex ante** $\Delta P$

- Loan-level data tracking origination and performance of **all** mortgages
  - Merge with info from **administrative tax returns**, public database of geocoded home sales, and bank balance sheets
  - Larger set of outcomes than other macropru studies $\rightarrow$ financial (mispricing) + real costs

Chi, LaPoint, & Lin (2024) Spatially Targeted LTV Limits
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Chi, LaPoint, & Lin (2024) Spatially Targeted LTV Limits
Setting: sequence of LTV policy experiments in Taiwan

- Govt. concerned about $\Delta P \gg 0$ in Taipei area
- Setting features regimes lasting multiple years
  - Uncommon in literature
  - Govts. frequently tweak leverage limits post-GFC
  - Symmetric windows around reform remove seasonality in RE sales
- Test for asymmetry: several tightening events followed by loosening in 2016
Results: in what sense are these policies “successful”?

- Focus on 2014 reform: LTV drops from standard 80% to 60% for investment properties
  - Headline result: house prices decline by 5-6% in policy areas relative to nearby unregulated neighborhoods \(\Rightarrow\) price-leverage ratio elasticity between 0.75 and 1
  - No average effect on loan delinquency outcomes or borrower creditworthiness

- ↓ in origination amounts, sale prices, quoted rates for loans in treated areas
  - Driven by demand, not supply: no evidence of banks rationing credit

- But also ↓ in sales volume across price distribution relative to untreated areas
  - Small distortions in HH location choice, commuting cost ↑ for non-vacation homes
  - Spatial pricing spillovers limited to 4 km distance to policy border

- Evidence of avoidance through collateral misreporting
  - Gap between bank and govt. appraisal widens by 15% \(\Rightarrow\) observed LTV < true LTV
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Chi, LaPoint, & Lin (2024)  Spatially Targeted LTV Limits  FSU-UF Real Estate 2024
Related work on housing market regulation

- **Macroprudential regulation of housing**
  - **LTV limits:** Igan & Kang (2011); Campbell, Ramadorai, Ranish (2015); Chen et al. (2016); Armstrong, Skilling, Yao (2019); Aastveit et al. (2020); de Araujo et al. (2020); Han et al. (2021); Higgins (2021); Acharya et al. (2022); Van Bekkum et al. (2022); Bolliger et al. (2022); Eerola et al. (2022); Tzur-Ilan (2023), and many more...
  
  - **Other constraints [D(P)TI, quotas, risk weights, taxes, etc.]:** Kuttner & Shim (2016); Cerutti, Claessens, Laeven (2017); DeFusco & Paciorek (2017); DeFusco, Johnson, Mondragon (2020); Benetton (2021); Deng et al. (2021); Hu (2022); Chi, LaPoint, Lin (2023)

- **Evidence of relationship between credit supply and house price growth**
  
  - Mian & Sufi (2011,22); Favara & Imbs (2015); Loutskina & Strahan (2015); Cerutti, Dagher, Dell’Ariccia (2017); Fuster & Zafar (2021); Greenwald & Guren (2021); Blickle (2022)

- **Adverse outcomes of lender-borrower collusion**
  
  - **Collateral misreporting:** Ben-David (2011); Agarwal, Ben-David, Yao (2015); Garmaise (2015); Piskorski, Seru, Witkin (2015); Griffin (2021); Kruger & Maturana (2021)
  
  - **Credit screening standards:** Keys et al. (2010); Purnanandam (2011); Ambrose, Conklin, Yoshida (2016); Griffin & Maturana (2016a,b); Mian & Sufi (2017)
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What’s new here...

1. Spatially targeted nature of a national leverage policy $\rightarrow$ spillovers
2. Measure collateral revaluation by comparing loans to administrative appraisals
3. Setting features tightening and loosening of LTV limits, multiple years without successive reforms $\rightarrow$ remove seasonality + GE effects
4. Ability to identify banks $\rightarrow$ trace out what happens to profits + portfolio shifts
Background & Data
Mortgage market in Taiwan: a quick primer

- **Private bank lending market is ≈ 100% floating rate mortgage contracts**
  - Standard contract type resets rate each year ("tracker mortgage")
  - Small # of adjustable rate mortgages (ARMs) w/initial period where rate fixed
  - Indexed to bank-specific 1 or 2-year CD rate = weighted avg. of Treasury rates

- Fixed rate mortgages (FRMs) only offered on special govt. loans issued by public banks

- **Like U.S., standard pre-reform LTV is 80%, for similar reasons**
  - Banks explicitly set a maximum LTV they are willing to originate (private insurance)
  - Prepayment penalties, and no points rolled into closing costs

- LTV policies we study apply uniformly to traditional banks (90%) and shadow banking sector (10%) \(\implies\) no avoidance through shopping across lender types
Spatial targeting clearly based on *ex ante* $\Delta P$

$$\log p_{i \in g, q} = \delta^g_q + \gamma^g_b + \beta^{g'} \cdot X_{i \in g, t} + \varepsilon_{i \in g, q} \rightarrow \tilde{P}^g_q = \exp(\hat{\delta}^g_q)$$
Clear first stage: LTV ratios bunch around limits

- Treatment group varies over time according to:
  - First vs. second mortgages
  - Neighborhoods selected by central govt.
  - Very high-end properties (>1.3 mil. USD)

- All restrictions lifted in March 2016 except for high-end homes
  $\rightarrow$ test for symmetry

- We will show that due to changes in LTV limit formula, 2014 had biggest effects

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<th>Control</th>
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Data infrastructure

- **Complete set of mortgage originations from ROC Central Bank (2009-21)**
  - Contract characteristics at origination + track loan performance over time
  - Info on borrowers: occupation, income, age, permanent address

- **Merge with database of market prices and rents from public records**
  - Compiled + geocoded in our other paper on transfer taxes (Chi, LaPoint, Lin 2023)

- **Universe of personal tax records from Ministry of Finance (2006-16)**
  - Already linked with wealth estimates, property and deed tax assessments
  - Cannot merge directly with loan registry, but can merge with public property records

- **Bank balance sheet data from TEJ+ and DealScan**
  - Link branch information to scraped addresses → track (re)allocation of loans within bank

Chi, LaPoint, & Lin (2024)
**Empirical research designs to identify policy effects**

1. **Matched DiD (à la Abadie & Imbens 2011)**
   - Match on observables to identify second mortgagors which would have asked for higher LTV but could not due to policy limits
   - Identifies very localized treatment on treated effect

2. **Border discontinuity designs (Dell & Olken 2020; Méndez & Van Patten 2022)**
   - Examine how outcomes vary around borders formed by spatial LTV policy
   - One of few applications of border diff-in-disc design in financial intermediation literature

3. **Branch-level DiD using exposure based on loan portfolio, bank exposure**
   - Shift-share: parent banks and their branches face differential exposure to reform depending on where their loan originations were historically concentrated
   - No laws against inter-regional banking to finance home purchases
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Matched Diff-in-Diff Approach
Matched diff-in-diff implementation

- Fill in “missing” homebuyers who would have taken out (second) mortgage w/LTV above the limit according to following steps...

1. Exclude individuals with an LTV ratio before policy that is far from cap
2. Match borrower who chose loan slightly below the cap post-reform to nearest pre-reform borrower in same district according to $X_{i,t}$ (age, income, educ.)
3. **Control group** chooses same LTV ratio before and after policy, but slightly below cap
4. **Treatment group** chooses to be above the LTV cutoff before the policy

$$\text{ATT} = \left( \text{After} - \text{Before} \right)_{\text{treated}} - \left( \text{After} - \text{Before} \right)_{\text{control}}$$

5. Run regression on matched sample to account for other sources of observed heterogeneity

- Caveat: we have to match on location, which limits # of potential borrower matches, so some differences in income remain between treatment/control group
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**Borrower characteristics before vs. after matching**

### A. December 2010 reform

<table>
<thead>
<tr>
<th></th>
<th>Unmatched</th>
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<td>Post-reform</td>
<td>t-stat</td>
<td>Pre-reform</td>
<td>Post-reform</td>
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<tr>
<td><strong>Annual income</strong></td>
<td>607.66</td>
<td>743.97</td>
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<td><strong>Years of education</strong></td>
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<td>2.05</td>
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<tr>
<td><strong>Birth year</strong></td>
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<td>1968.81</td>
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### B. June 2014 reform

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<tr>
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<td>Post-reform</td>
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<td><strong>Annual income</strong></td>
<td>504.99</td>
<td>650.43</td>
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<td>625.44</td>
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<td><strong>Years of education</strong></td>
<td>14.59</td>
<td>14.73</td>
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<tr>
<td><strong>Birth year</strong></td>
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<td>1971.95</td>
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</table>
2010 matched diff-in-diff $\Rightarrow$ smaller, shorter loans, $P \downarrow$

<table>
<thead>
<tr>
<th>ATT</th>
<th>log(loan $$)</th>
<th>log(psm)</th>
<th>interest rate (%)</th>
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<tbody>
<tr>
<td></td>
<td>−0.130***</td>
<td>−0.128***</td>
<td>−0.092*</td>
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<tr>
<td></td>
<td>(0.044)</td>
<td>(0.048)</td>
<td>(0.049)</td>
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<tr>
<td></td>
<td>−0.104**</td>
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<td>(0.031)</td>
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<tr>
<td>District &amp; bank</td>
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- Compare 61-65% LTV to 55-59% LTV in symmetric window around each reform
- Similar point estimates if use tighter range, but wide CIs
- Some neg. effect on maturity: substitution to shorter loans to lock in teaser rates
2014 MATCHED DIFF-IN-DIFF $\implies$ SMALLER LOANS, $P \downarrow$, $r \downarrow$

<table>
<thead>
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<th>log(loan $$$)</th>
<th>log(psm)</th>
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<tr>
<td></td>
<td>$-0.110^{**}$</td>
<td>$-0.230^{***}$</td>
<td>$-0.148^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.087)</td>
<td>(0.050)</td>
</tr>
<tr>
<td></td>
<td>$-0.096^{*}$</td>
<td>$-0.195^{**}$</td>
<td>$-0.190^{***}$</td>
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<tr>
<td></td>
<td>(0.058)</td>
<td>(0.089)</td>
<td>(0.057)</td>
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**Matched variables:**

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- Compared to 2010 reform, much stronger effects on prices and interest rates
- *Ex ante* riskiness of loans changed due to **closing of misreporting loophole**
- Lenders pass through decreased cost of insuring the loan to consumers
**No effect on loan delinquency outcomes in either reform**

\[
\text{Delinquent}_{i,t} = \alpha + \beta_1 \cdot Post_t + \beta_2 \cdot Post_t \times \mathbb{1}\{LTV > 60\%\}_j + \beta_3 \cdot Income_i \times Post_t \\
+ \beta_4 \cdot Income_i \times \mathbb{1}\{LTV > 60\%\}_j + \beta_5 \cdot Income_i \times Post_t \times \mathbb{1}\{LTV > 60\%\}_j + \psi(i,j) + \varepsilon(i,j),t
\]

- Estimate regression on matched sample with matched borrower pair FE's \(\psi(i,j)\)

- Take matched sample of loans around each reform and track performance over the **full** time sample (\(\approx 5\) years on average), **controlling for maturity**

- For both reforms we find...
  - No evidence of change in delinquency (30-day, 30-60 day, 90+ day) or frequency of lenders writing off the loan (charge-offs)
  - No heterogeneity in delinquency within an income bin or by mortgage DTI
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Robustness checks for matched DiD strategy

1. **Alternative LTV bandwidths**: results robust for main outcomes, although standard errors blow up for \( \leq \pm 3 \% \) windows around 60% LTV

2. Similar results for prices and loan quantity within a standard loan maturity
   - 51.9% of mortgages have 20-year amortization period, and 34.5% are 30-year loans
   - Due to power issues check with more expansive bandwidth \( > \pm 4 \% \)

3. Delinquency results at different horizons and by ex ante bank risk
   - No average effect on loan delinquency or charge-off rates
   - Use parent bank ROE as a proxy for ex ante riskiness measure (Meiselman, Nagel, Purnanandam 2023)
   - Banks with high ex ante ROE have higher systematic tail risk exposure during the crisis
   - Post-reform reduction in ever-delinquent probability if higher bank ROE
   - \( \Rightarrow \) may be some gains on the systemic risk side to spatial targeting
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Border Diff-in-Disc Approach
**Border “diff-in-disc” design to capture market effects**

\[ Y_{i,d,t} = \gamma \cdot \left( LTVCap_{i,d} \times \text{Post}_{d,t} \right) + f(\text{lat}_i, \text{lon}_i) + g(\text{DTrain}_i) + \beta' \cdot X_{i,d,t} + \xi_d + \delta_t + \sum_{s=1}^{N} \phi_s^i + \varepsilon_{i,d,t} \]

- Compare two properties with same distance + characteristics and compare outcomes pre vs. post LTV tightening
- Extend to border “diff-in-diff-in-disc” comparing the newly treated region to the previously treated one (blue) \( \rightarrow \text{Post}_{d,t} \)
- Reduced demand from investors for houses in treated regions \( \implies \gamma < 0 \) on prices
  - Banks might respond by offering more attractive loan terms
  - Loan outcomes: rate (margin), maturity, delinquency, assessed value
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Prices ↓ for properties in leverage-restricted areas

- 5% drop in house prices as cross into LTV regulation area
  - Complements matched DiD results by controlling for prop. + neighborhood characteristics
    - Age, size, building material, commuting costs, high-rise
    - Census demographics + slope/elevation/temperature
  - Robust to choice of bandwidth (x-axis) and conservative standard error bands (Conley)

Details 2012 placebo Table
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### Graph

![Graph showing the log price pre vs. post difference between 2014 LTV-restricted vs. unrestricted districts](chart)

**Details**

- 2012 placebo
- Table

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<th>Distance to LTV policy border (km)</th>
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- Robust to choice of bandwidth (x-axis) and conservative standard error bands (Conley)
**No Pre-Trends on Dynamic Diff-in-Disc Effects**

**A. June 2014 LTV Tightening**

- Select symmetric windows around reform to avoid policy overlap + seasonality effects
- Robust to quadratic lat/lon function

**B. June 2012 Reform (Placebo)**

Chi, LaPoint, & Lin (2024)  
Spatially Targeted LTV Limits  
FSU-UF Real Estate 2024
Prices do not recover in regulated areas after repeal

A. Robustness to bandwidth

- Prolonged period of leverage constraints neg. altered investors’ $E[\Delta P]$
- Consistent with experimental evidence (Fuster & Zafar 2016, 2021)

B. Dynamic border diff-in-disc effects

Chi, LaPoint, & Lin (2024)  Spatially Targeted LTV Limits
FSU-UF Real Estate 2024
A. Spillover by Donut Hole Radius

- Spillover effects limited to within $\leq 4$ km of policy border $\rightarrow$ commuting costs
- Reject null that entire DiD pricing effect in treated areas is due to spillovers
**Additional results for border analysis**

1. Results hold for each reform if use faraway never-treated districts as control group

2. Heterogeneous effects on prices by *ex ante* neighborhood average income
   - Price declines concentrated in higher-income areas subject to LTV limits
   - Properties in 10% more affluent districts experience 1% greater decline in $P$

3. Similar effects for district-level sales volume
   - Overall home sales volume declines by 26% in 2014 regulated districts relative to faraway unregulated districts

4. Sharper discontinuity at the border if use city-level boundaries
   - Spatial targeting might be improved by defining boundaries according to banks' mortgage markets

Chi, LaPoint, & Lin (2024)  Spatially Targeted LTV Limits  FSU-UF Real Estate 2024
Collateral Misreporting Channel
Isolating collateral misreporting

- **Appraisal gap** = (log) difference between bank’s appraised collateral value and most recent local property tax appraisal value for house $i$

$$\text{Gap}_{i,b,d,t} = \log(A_{i,b,d,t} - A_{i,d,t}^*)$$  \hspace{1cm} (2)

- For land transactions, $A^*$ publicly observable
- For buildings, compute $A^*$ based on AVM (hedonic) fitted value
- Houses appraised every 3 years for building property tax

- Include appraisal drift function $D(t, t^*)$: bank may simply move their collateral appraisal in lockstep with reval announced by tax authority

- Using change in loan-to-price (LTP) ratios would overestimate amount of misreporting
  - Since $\Delta P < 0$ due to regulation, then even if no misreporting $\Delta LTP > 0$
Isolating collateral misreporting

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Triple diff shows large inc. in collateral misreporting

\[
\begin{align*}
\text{Gap}_{i,b,d,t} &= \alpha + \gamma_1 \cdot \text{Post}_t + \gamma_2 \cdot \text{LTV}_{\text{District},i,d} + \gamma_3 \cdot \left( \text{Post}_t \times \text{LTV}_{\text{District},i,d} \right) \\
&\quad + \gamma_4 \cdot \text{2nd Mrtg}_i + \gamma_5 \cdot \left( \text{Post}_t \times \text{2nd Mrtg}_i \right) + \gamma_6 \cdot \left( \text{LTV}_{\text{District},i,d} \times \text{2nd Mrtg}_i \right) \\
&\quad + \gamma_7 \cdot \left( \text{Post}_t \times \text{LTV}_{\text{District},i,d} \times \text{2nd Mrtg}_i \right) + \mathcal{D}(t,t^*) + \theta' \cdot \mathbf{X}_{i,t} + \beta' \cdot \mathbf{X}_{b,t-1} + \eta_b + \xi_d + \delta_t + \varepsilon_{i,d,b,t}
\end{align*}
\]

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N 41,015 40,123 29,648 29,283
Adj. \( R^2 \) 0.56 0.55 0.62 0.61

Note: Full set of interaction terms suppressed for space.

- ATT: Gap ↑ by \( \approx 15\% \) ($2.3k) relative to average of $15.5k gap for 2nd+ mortgages under the 2010 regime with the loophole
- Since market prices depend on lagged appraisals, collateral inflation creates persistent mispricing in regulated neighborhoods
**Triple diff shows large inc. in collateral misreporting**

\[ \text{Gap}_{i,b,d,t} = \alpha + \gamma_1 \cdot \text{Post}_t + \gamma_2 \cdot \text{LTV}_{\text{District,}_i,d} + \gamma_3 \cdot \left( \text{Post}_t \times \text{LTV}_{\text{District,}_i,d} \right) + \gamma_4 \cdot \text{2nd}_\text{Mrtg}_i + \gamma_5 \cdot \left( \text{Post}_t \times \text{2nd}_\text{Mrtg}_i \right) + \gamma_6 \cdot \left( \text{LTV}_{\text{District,}_i,d} \times \text{2nd}_\text{Mrtg}_i \right) + \gamma_7 \cdot \left( \text{Post}_t \times \text{LTV}_{\text{District,}_i,d} \times \text{2nd}_\text{Mrtg}_i \right) + D(t,t^*) + \theta' \cdot X_{i,t} + \beta' \cdot X_{b,t-1} + \eta_b + \xi_d + \delta_t + \varepsilon_{i,d,b,t} \]  

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**Note:** Full set of interaction terms suppressed for space.

- **ATT:** \(\text{Gap} \uparrow\) by \(\approx 15\%\) (\(\$2.3k\)) relative to average of \(\$15.5k\) gap for 2nd+ mortgages under the 2010 regime with the loophole

- Since market prices depend on lagged appraisals, collateral inflation creates **persistent mispricing** in regulated neighborhoods.
**Triple diff shows large inc. in collateral misreporting**

\[
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+ \gamma_4 \cdot \text{2nd\_Mrtg}_i + \gamma_5 \cdot \left( \text{Post}_t \times \text{2nd\_Mrtg}_i \right) + \gamma_6 \cdot \left( \text{LTV\_District}_{i,d} \times \text{2nd\_Mrtg}_i \right) \\
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(3)

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| **N**                        | 41,015           | 40,123          |
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- Since market prices depend on lagged appraisals, collateral inflation creates **persistent mispricing** in regulated neighborhoods
**Additional results for appraisal gap analysis**

1. **Baseline DiD:** average appraisal gap for entire mortgage market $\uparrow 6%$

2. **Winsorizing:** drop if $Gap$ outside $\pm 5 \times IQR$, or drop loans with extremely low or high bank appraisals relative to AVM (Demiroglu & James 2018)

3. **Controls:** lagged bank balance sheet variables, branch vs. bank fixed effects, and winsorized property controls

4. **Dropping older properties** to account for increased difficulty in valuing properties with historical amenity value

5. **Alternative scaling** of $Gap$
   - Baseline definition is $Gap = \log(A - A^*)$
   - Check using $Gap = (A - A^*)/.5(A + A^*)$ (Kruger & Maturana 2021)
Discussion: How do we choose between macroprudential policy instruments?
Comparing macroprudential policy elasticities

- Our results yield an elasticity of local house prices w.r.t. local leverage ratios of $\varepsilon \approx 0.75$
  - This number takes into account spillovers across the border to the unregulated control housing markets in the 2014 reform

\[
\varepsilon = \frac{\%\Delta P}{\%\Delta LTV} = \frac{- (5\% - 2\%) - (55\% - 60\%) / 60\% - (67\% - 70\%) / 70\%}{(55\% - 60\%) / 60\% - (67\% - 70\%) / 70\%} = 0.75
\]

- Lower bound due to avoidance through collateral appraisal inflation

- Appears consistent with $\varepsilon$ estimates from other broad-based LTV policies
  - Local semi-elasticity estimates for strict LTV policies (Armstrong, Skilling, Yao 2019 [NZ]; de Araujo et al. 2020 [Brazil]) $\implies 0.3 \leq \varepsilon \leq 1$
  - Caveat: estimates not reported in comparable ways across studies (local vs. macro)
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    - Caveat: estimates not reported in comparable ways across studies (local vs. macro)
Place-based policy welfare decomposition

- Anchoring min. downpayments to local HP growth is a type of place-based policy

- We can decompose the losses generated for each market actor between borrowers, lenders, incumbent homeowners, and policymakers (tax revenues)
  - Small effects on deed (stamp duty) tax of 1% drop in revenues
  - Ignore banking sector risk since no avg. effects on delinquency outcomes
  - Analog to decompositions in Busso, Gregory, Kline (2013); Lu, Wang, Zhu (2019)

- Borrowers don’t lose much because higher downpayment accompanied by lower rates
  - Housing supply shifts inward only slightly since mortgage lock-in channel is weak
  - Reform also targeted investors, who are more mobile in terms of housing choice

- Most losses driven by lenders who originate lower IRR loans and incumbent homeowners who see property values ↓
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CONCLUSION: PRICE VS. QUANTITY CONTROLS ON HOUSING

- We provide new evidence on how conditioning mortgage credit provision to investors on *ex ante* local $\Delta P$ can cool housing markets
  - Contrast to local transaction taxes which often result in $P \uparrow$ due to capital lock-in
  - Lower rate on mortgages since banks no longer charge insurance premia
  - No impact on delinquency outcomes $\implies$ not mitigating systemic risks

- **Policy implications** for current system in U.S. of local restrictions based on national rules (FHA, Conforming Loan Limit)
  - Potential macroprudential gains to moving to rule indexed to local $\Delta P$
  - But financial costs of mispricing collateral if incentives to collude are high
  - Small inc. in real commuting costs from moving further out from CBD

- Redistribution: losses borne by (high-income) incumbent homeowners and lenders
THANK YOU!
Appendix
### History of Targeted LTV Restrictions

<table>
<thead>
<tr>
<th>Effective date</th>
<th>Type</th>
<th>Property target</th>
<th>Region</th>
<th>Buyers</th>
<th>Maximum LTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1, 1989</td>
<td>T</td>
<td>Land, residential and non-residential properties</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>140% of the current appraisal value</td>
</tr>
<tr>
<td>June 25, 2010</td>
<td>T</td>
<td>Second (mortgaged) homes</td>
<td>Taipei and New Taipei (22 districts)</td>
<td>Individuals</td>
<td>70% of the collateral value</td>
</tr>
<tr>
<td>December 31, 2010</td>
<td>T</td>
<td>Second (mortgaged) homes</td>
<td>Taipei and New Taipei (+3 districts)</td>
<td>Individuals and institutions</td>
<td>60% of the collateral value</td>
</tr>
<tr>
<td>June 22, 2012</td>
<td>T</td>
<td>High-end properties</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>65% of (\min(\text{price, collateral value}))</td>
</tr>
<tr>
<td>June 27, 2014</td>
<td>T</td>
<td>Second (mortgaged) homes</td>
<td>Taipei, New Taipei, Taoyuan (+ 8 districts)</td>
<td>Individuals</td>
<td>60% of (\min(\text{price, collateral value}))</td>
</tr>
<tr>
<td>Third (mortgaged) homes</td>
<td>T</td>
<td>All regions</td>
<td>Individuals</td>
<td>50% of (\min(\text{price, collateral value}))</td>
<td></td>
</tr>
<tr>
<td>High-end properties</td>
<td>T</td>
<td>All regions</td>
<td>Individuals</td>
<td>50% of (\min(\text{price, collateral value}))</td>
<td></td>
</tr>
<tr>
<td>Residential properties</td>
<td>T</td>
<td>All regions</td>
<td>Institutions</td>
<td>50% of (\min(\text{price, collateral value}))</td>
<td></td>
</tr>
<tr>
<td>August 14, 2015</td>
<td>L</td>
<td>Third (mortgaged) homes</td>
<td>All regions</td>
<td>Individuals</td>
<td>60% of (\min(\text{price, collateral value}))</td>
</tr>
<tr>
<td>Second (mortgaged) homes</td>
<td>L</td>
<td>New Taipei and Taoyuan (− 6 districts)</td>
<td>Individuals</td>
<td>No LTV limit</td>
<td></td>
</tr>
<tr>
<td>High-end properties</td>
<td>L</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>60% of (\min(\text{price, collateral value}))</td>
<td></td>
</tr>
<tr>
<td>Residential properties</td>
<td>L</td>
<td>All regions</td>
<td>Institutions</td>
<td>60% of (\min(\text{price, collateral value}))</td>
<td></td>
</tr>
<tr>
<td>March 25, 2016</td>
<td>L</td>
<td>High-end properties</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>60% of (\min(\text{price, collateral value}))</td>
</tr>
<tr>
<td>All other mortgages</td>
<td>L</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>No LTV limit</td>
<td></td>
</tr>
</tbody>
</table>

- We focus on the June 2014 reform which tied LTV limits to **market prices**
- Use 2012 reform as a placebo since it only applied to very expensive homes
<table>
<thead>
<tr>
<th>Effective date</th>
<th>Type</th>
<th>Property target</th>
<th>Region</th>
<th>Buyers</th>
<th>Maximum LTV</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 8, 2020</td>
<td>T</td>
<td>Third (mortgaged) homes</td>
<td>All regions</td>
<td>Individuals</td>
<td>60% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First (mortgaged) homes</td>
<td>All regions</td>
<td>Institutions</td>
<td>60% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second (mortgaged) homes</td>
<td>All regions</td>
<td>Institutions</td>
<td>50% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High-end properties</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>60% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>65% of min(price, collateral value)</td>
</tr>
<tr>
<td>March 19, 2021</td>
<td>T</td>
<td>Third (mortgaged) homes</td>
<td>All regions</td>
<td>Individuals</td>
<td>55% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fourth (mortgaged) homes</td>
<td>All regions</td>
<td>Individuals</td>
<td>50% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First and second high-end properties</td>
<td>All regions</td>
<td>Individuals</td>
<td>55% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Third high-end properties</td>
<td>All regions</td>
<td>Individuals</td>
<td>40% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Residential properties</td>
<td>All regions</td>
<td>Institutions</td>
<td>40% of min(price, collateral value)</td>
</tr>
<tr>
<td>September 24, 2021</td>
<td>T</td>
<td>Second (mortgaged) homes</td>
<td>All regions</td>
<td>Individuals</td>
<td>Interest-Only mortgages not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>60% of min(price, collateral value)</td>
</tr>
<tr>
<td>December 17, 2021</td>
<td>T</td>
<td>Second (mortgaged) homes</td>
<td>8 major cities</td>
<td>Individuals</td>
<td>40% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Third (mortgaged) homes</td>
<td>All regions</td>
<td>Individuals</td>
<td>40% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High-end properties</td>
<td>All regions</td>
<td>Individuals</td>
<td>40% of min(price, collateral value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Land</td>
<td>All regions</td>
<td>Individuals and institutions</td>
<td>50% of min(price, collateral value)</td>
</tr>
</tbody>
</table>
$$\log p_{i \in g,q} = \delta^g_q + \gamma^g_b + \beta^g_t \cdot X_{i \in g,t} + \varepsilon_{i \in g,q} \implies \Delta \tilde{P}_{q,q+1}^g = \exp(\hat{\delta}_q^g) / \exp(\hat{\delta}_q^g) - 1$$

<table>
<thead>
<tr>
<th></th>
<th>$% \Delta \tilde{P}_{08Q1-10Q1}$</th>
<th>$% \Delta \tilde{P}_{10Q2-12Q2}$</th>
<th>$% \Delta \tilde{P}_{12Q2-14Q2}$</th>
<th>$% \Delta \tilde{P}_{14Q3-16Q3}$</th>
<th>$% \Delta \tilde{P}_{16Q4-18Q4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Dec. 2010 Treated Borders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treated districts</td>
<td>27.2%</td>
<td>16.4%</td>
<td>34.2%</td>
<td>12.6%</td>
<td>18.6%</td>
</tr>
<tr>
<td>Untreated border districts</td>
<td>3.7%</td>
<td>2.0%</td>
<td>37.5%</td>
<td>37.9%</td>
<td>35.2%</td>
</tr>
<tr>
<td>Untreated non-border districts</td>
<td>1.5%</td>
<td>1.1%</td>
<td>12.9%</td>
<td>10.0%</td>
<td>29.1%</td>
</tr>
<tr>
<td>B. June 2014 Treated Borders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treated districts</td>
<td>17.2%</td>
<td>14.7%</td>
<td>30.3%</td>
<td>12.2%</td>
<td>25.5%</td>
</tr>
<tr>
<td>Untreated border districts</td>
<td>5.5%</td>
<td>3.1%</td>
<td>21.1%</td>
<td>35.2%</td>
<td>16.2%</td>
</tr>
<tr>
<td>Untreated non-border districts</td>
<td>1.4%</td>
<td>0.7%</td>
<td>12.3%</td>
<td>9.6%</td>
<td>27.9%</td>
</tr>
<tr>
<td>Property controls</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>City block FEs</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Govt. picked high (resid.) price growth districts
Due to avoidance, 2010 reform had no impact on volume

A. Treated districts

- Post-reform volume = 16937
- Pre-reform volume = 13318
- Post-reform mean price = 10943
- Pre-reform mean price = 8855

B. Untreated (non-border) districts

- Post-reform volume = 35462
- Pre-reform volume = 31821
- Post-reform mean price = 4992
- Pre-reform mean price = 4806

Naive DiD in means: $(16,937/13,318) - (35,462/31,821) = 15.73\%$ ↑ in volume suggests no deterrence of investment buying due to collateral loophole
Clear drop in sales volume after 2014 LTV limits

A. Treated districts

<table>
<thead>
<tr>
<th>Transaction price (thousands of NTD)</th>
<th>Post-2014 LTV reform</th>
<th>Pre-2014 LTV reform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sales</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60000</td>
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<td>70000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post-reform volume = 35601
Pre-reform volume = 61241
Post-reform mean price = 11198
Pre-reform mean price = 10570

B. Untreated (non-border) districts

<table>
<thead>
<tr>
<th>Transaction price (thousands of NTD)</th>
<th>Post-2014 LTV reform</th>
<th>Pre-2014 LTV reform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sales</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>80000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post-reform volume = 139501
Pre-reform volume = 171259
Post-reform mean price = 6627
Pre-reform mean price = 5778

Chi, LaPoint, & Lin (2024)
Additional Matched DiD Results
2010 reform matched DiD estimates by bandwidth

Matched DID estimates

log(loan $)

log(unit price)

Interest rate (%)

Loan maturity in months

Closing cost (p.p. of loan)

Charge-off flag

LTV % bandwidth

Baseline  With property controls
2014 reform matched DiD estimates by bandwidth

```
Matched DiD estimates
log(loan $)
log(unit price)
Interest rate (%)
Loan maturity in months
Closing cost (p.p. of loan)
Charge-off flag
LTV % bandwidth
Baseline  With property controls
```
### No avg. effect on loan delinquency (2010)

<table>
<thead>
<tr>
<th></th>
<th>Ever-delinquent flag</th>
<th>Charge-off flag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0007</td>
<td>0.0037</td>
</tr>
<tr>
<td></td>
<td>(0.0004)</td>
<td>(0.0041)</td>
</tr>
<tr>
<td>Post(_t)</td>
<td>0.0008</td>
<td>0.0056</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
<td>(0.0042)</td>
</tr>
<tr>
<td>Post(<em>t) × 1{LTV &gt; 60%}</em>(j)</td>
<td>−0.0007</td>
<td>−0.0003</td>
</tr>
<tr>
<td></td>
<td>(0.0004)</td>
<td>(0.0048)</td>
</tr>
<tr>
<td>Income(_i) × Post(_t)</td>
<td>−0.0004</td>
<td>0.0064</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0066)</td>
</tr>
<tr>
<td>Income(<em>i) × 1{LTV &gt; 60%}</em>(j)</td>
<td>−0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>(0.0001)</td>
<td>(0.0012)</td>
</tr>
<tr>
<td>Income(_i) × Post(<em>t) × 1{LTV &gt; 60%}</em>(j)</td>
<td>0.0004</td>
<td>−0.0090</td>
</tr>
<tr>
<td></td>
<td>(0.0003)</td>
<td>(0.0082)</td>
</tr>
<tr>
<td>LTV bandwidth</td>
<td>±4%</td>
<td>±4%</td>
</tr>
<tr>
<td>Property controls</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>N</td>
<td>4,052</td>
<td>3,742</td>
</tr>
</tbody>
</table>

Chi, LaPoint, & Lin (2024)  
Spatially Targeted LTV Limits  
FSU-UF Real Estate 2024
## No avg. effect on loan delinquency (2014)

<table>
<thead>
<tr>
<th></th>
<th>Ever-delinquent flag</th>
<th>Charge-off flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Post_t$</td>
<td>−0.0058 (0.0059)</td>
<td>−0.0017 (0.0125)</td>
</tr>
<tr>
<td></td>
<td>−0.0076 (0.0071)</td>
<td>−0.0010 (0.0108)</td>
</tr>
<tr>
<td></td>
<td>−0.0089 (0.0082)</td>
<td>−0.0025 (0.0128)</td>
</tr>
<tr>
<td>$Post_t \times 1{LTV &gt; 60%}_j$</td>
<td>0.0031 (0.0040)</td>
<td>−0.0011 (0.0167)</td>
</tr>
<tr>
<td></td>
<td>0.0039 (0.0046)</td>
<td>0.0048 (0.0162)</td>
</tr>
<tr>
<td></td>
<td>0.0045 (0.0058)</td>
<td>0.0102 (0.0193)</td>
</tr>
<tr>
<td>$Income_i \times Post_t$</td>
<td>0.0019 (0.0023)</td>
<td>0.0030 (0.0130)</td>
</tr>
<tr>
<td>$Income_i \times 1{LTV &gt; 60%}_j$</td>
<td>0.0001 (0.0020)</td>
<td>0.0136 (0.0178)</td>
</tr>
<tr>
<td>$Income_i \times Post_t \times 1{LTV &gt; 60%}_j$</td>
<td>−0.0010 (0.0028)</td>
<td>−0.0087 (0.0166)</td>
</tr>
</tbody>
</table>

### LTV bandwidth
- ±4%
- ±4%
- ±4%
- ±4%
- ±4%
- ±4%

### Property controls
- ✓
- ✓
- ✓
- ✓
- ✓
- ✓

### N
- 960
- 922
- 922
- 960
- 922
- 922
**Hetero. delinquency effects by *ex ante* bank ROE**

<table>
<thead>
<tr>
<th></th>
<th>$Post_t$</th>
<th>$Post_t \times 1{LTV &gt; 60%}_j$</th>
<th>$ROE_{i,b} \times Post_t$</th>
<th>$ROE_{i,b} \times 1{LTV &gt; 60%}_j$</th>
<th>$ROE_{i,b} \times Post_t \times 1{LTV &gt; 60%}_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$-1.401^{***}$</td>
<td>$-1.430^{***}$</td>
<td>$-0.676$</td>
<td>$-0.669$</td>
<td>$1.175^{**}$</td>
</tr>
<tr>
<td></td>
<td>$(0.483)$</td>
<td>$(0.481)$</td>
<td>$(0.425)$</td>
<td>$(0.426)$</td>
<td>$(0.515)$</td>
</tr>
</tbody>
</table>

LTV bandwidth ±5% ±5% ±6% ±6%

Property controls ✓ ✓

N 426 426 484 484

- Results for ever-delinquent flag in 2014
- Caveat: low $N$ since bank balance sheets (TEJ+) required to compute ROE
Calculating internal rates of return on mortgages

- Internal rate of return (IRR) sets equal the value of the loan \( L_0 \) less closing costs \( C_0 \) equal to discounted monthly payments \( PMT \)

\[
L_0 = C_0 + \sum_{n=1}^{T} \frac{PMT}{(1 + IRR)^n} + \frac{L_T}{(1 + IRR)^T} \tag{4}
\]

- Since all loans are ARMs in our case, \( PMT \) is constant within a reset period \( n \leq T \)
- Feed in the observed set of interest rates to recalculate PMT within each reset period
- Expected IRRs determined by expected future loan balances:

\[
\mathbb{E}_t[L_{t+1}] = \mathbb{E}_t[L_0 \prod_{s=1}^{t+1} (1 + i_s/12)] - \mathbb{E}_t[TotalPaymentMade_{t+1}] \tag{5}
\]

- Assume lenders forecast \( i_t \) via 12-month lagged moving average
No statistically or economically significant effects on realized IRRs with LTV loophole
Robust, large 150-300 bps. decline in IRRs after 2014 reform

Pass through of lower mortgage insurance costs borne by lenders
### Realized vs. excess IRRs around 2014 LTV reform

<table>
<thead>
<tr>
<th></th>
<th>Realized IRR ($I R^{12}$)</th>
<th>Excess IRR ($I R^{e,12} - I R^{12}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>$A T T$</td>
<td>$-408^{***}$</td>
<td>$-487^{***}$</td>
</tr>
<tr>
<td></td>
<td>(101)</td>
<td>(69.3)</td>
</tr>
</tbody>
</table>

**Matched variables:**
- District & bank
- Salary income
- Age
- Education
- LTV bandwidth: ±4% ±4% ±5% ±5% ±4% ±4% ±5% ±5%
- Property controls
- N: 172 164 180 176 162 152 172 172

- Excess IRR at horizon $t$ months into loan is gap between expected and realized IRR
- Expectations became re-anchored to realized returns after closing of loophole
Additional Border Diff-in-Disc Results
**Implementation of border “diff-in-disc” design**

\[ Y_{i,d,t} = \gamma \cdot \left( LTV Cap_{i,d} \times Post_{d,t} \right) + f(lat_i, lon_i) + g(DTrain_i) + \beta' \cdot X_{i,d,t} + \xi_d + \delta_t + \sum_{s=1}^{N} \phi^s_i + \varepsilon_{i,d,t} \]

- Bandwidth \( x \): restrict to obs. within distance \( \leq x \) to border
- \( f(\cdot) \) local linear function in lat/lon
- \( g(\cdot) \) linear spline in distance to nearest commuter rail
- Border segment \( \phi^s \) or neighborhood FEs
- Standard errors either (i) clustered by district, or (ii) Conley correction
  - Use Conley distance cutoff which maximizes standard errors
  - Search over range from 2 km to max district distance to border (49 km)
<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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</thead>
<tbody>
<tr>
<td>$LTV Cap \times Post$</td>
<td>$-0.078^{***}$</td>
<td>$-0.058^{***}$</td>
<td>$-0.054^{***}$</td>
<td>$-0.050^{***}$</td>
<td>$-0.051^{***}$</td>
<td>$-0.066^{***}$</td>
</tr>
<tr>
<td></td>
<td>$(0.021)$</td>
<td>$(0.009)$</td>
<td>$(0.010)$</td>
<td>$(0.010)$</td>
<td>$(0.010)$</td>
<td>$(0.014)$</td>
</tr>
<tr>
<td></td>
<td>$[0.013]$</td>
<td>$[0.008]$</td>
<td>$[0.007]$</td>
<td>$[0.007]$</td>
<td>$[0.006]$</td>
<td>$[0.009]$</td>
</tr>
<tr>
<td>Sample</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Bandwidth (km)</td>
<td>Buildings</td>
<td>Buildings</td>
<td>Buildings</td>
<td>Buildings</td>
<td>Buildings</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>20</td>
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<td>20</td>
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<tr>
<td>$f(lat, lon)$</td>
<td>Linear</td>
<td>Linear</td>
<td>Linear</td>
<td>Linear</td>
<td>Quadratic</td>
<td>Linear</td>
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<tr>
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<td>✓</td>
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<td>$g(DTrain)$</td>
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<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>N</td>
<td>107,405</td>
<td>107,405</td>
<td>107,405</td>
<td>107,405</td>
<td>107,405</td>
<td>136,274</td>
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<td>74</td>
<td>74</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.376</td>
<td>0.823</td>
<td>0.823</td>
<td>0.835</td>
<td>0.836</td>
<td>0.635</td>
</tr>
</tbody>
</table>

Notes: Conley standard errors estimated with a maximal spatial correlation distance cutoff parameter of 2 km appear in brackets.
2012 reform left 2010 regime intact but added new restriction on loans for properties with $P > 80$ mil. NTD ($\approx 2.5$ mil. USD)

- We drop obs. below 1st or above 99th pct., so such sales are not included

- No significant effect on prices for all bandwidth choices

- $\implies$ border discontinuity not simply picking up differential neighborhood price trends

**Notes:** Shaded confidence intervals obtained by clustering standard errors at the district level. Conley standard error bands in green dashed lines obtained with spatial cutoff of 49 km. Baseline point estimate indicated by red dashed line obtained with a bandwidth of $x = 20$ km.
**Due to loophole, no impact of 2010 reform local prices**

**A. Robustness to bandwidth**

- **Log price pre vs. post difference between 2010 LTV-restricted vs. unrestricted districts**

**B. Dynamic border diff-in-disc effects**

- **Log house price response**

- **House prices in treated border neighborhoods continue to grow on trend**
  - 2010 treated group of districts also more positively selected based on $\Delta P$ path

- **Contrast to ATT (matched DiD) estimates which restrict to regulated 2nd mortgages**
In our baseline specification $\hat{\gamma}$ captures the sum of two effects:

1. Direct effect on treated properties in districts subject to LTV policy
2. Spillover effect due to increased demand for properties in neighboring untreated areas

One idea: augment baseline specification to isolate semi-circle $\mathcal{H}$ of length $r$

\[
Y_{i,d,t} = \gamma \cdot \left( \text{LTVCap}_{i,d} \times \text{Post}_{d,t} \right) + \eta \cdot \left( 1\{i \in \mathcal{H}(r)\} \times \text{Post}_{d,t} \right) \\
+ f(\text{lat}_i, \text{lon}_i) + \beta' \cdot X_{i,d,t} + \xi_d + \delta_t + \varepsilon_{i,d,t}
\]

$\eta$ (or $\gamma - \eta$) difficult to interpret due to GE effects on either side of border

- Ex: people move to unregulated areas but others move to regulated areas once prices fall

**Solution:** exclude $i$ in the “donut hole” $\mathcal{C}(r) := \{i \mid -r \leq x(i) \leq r\}$ and compare $\hat{\gamma}$
In our baseline specification $\hat{\gamma}$ captures the sum of two effects:

1. Direct effect on treated properties in districts subject to LTV policy
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One idea: augment baseline specification to isolate semi-circle $\mathcal{H}$ of length $r$

$$Y_{i,d,t} = \gamma \cdot \left( \text{LTVCap}_{i,d} \times \text{Post}_{d,t} \right) + \eta \cdot \left( 1\{i \in \mathcal{H}(r)\} \times \text{Post}_{d,t} \right)$$
$$+ f(lat_i, lon_i) + \beta' \cdot X_{i,d,t} + \xi_d + \delta_t + \varepsilon_{i,d,t}$$

$\eta$ (or $\gamma - \eta$) difficult to interpret due to GE effects on either side of border
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\[
Y_{i,d,t} = \gamma \cdot \left( \text{LTVCap}_{i,d} \times \text{Post}_{d,t} \right) + \eta \cdot \left( \mathbb{1}\{i \in \mathcal{H}(r)\} \times \text{Post}_{d,t} \right) 
+ f(\text{lat}_i, \text{lon}_i) + \beta' \cdot X_{i,d,t} + \xi_d + \delta_t + \varepsilon_{i,d,t}
\]  

(6)

$\eta$ (or $\gamma - \eta$) difficult to interpret due to GE effects on either side of border

- Ex: people move to unregulated areas but others move to regulated areas once prices fall

Solution: exclude $i$ in the “donut hole” $C(r) := \{i| -r \leq x(i) \leq r\}$ and compare $\hat{\gamma}$
Separating cross-border spillover effects

In our baseline specification \( \hat{\gamma} \) captures the sum of two effects:

1. Direct effect on treated properties in districts subject to LTV policy
2. Spillover effect due to increased demand for properties in neighboring untreated areas

One idea: augment baseline specification to isolate semi-circle \( \mathcal{H} \) of length \( r \)

\[
Y_{i,d,t} = \gamma \cdot \left( \text{LTVCap}_{i,d} \times \text{Post}_{d,t} \right) + \eta \cdot \left( \mathbb{1}\{i \in \mathcal{H}(r)\} \times \text{Post}_{d,t} \right) + f(lat_i, lon_i) + \beta' \cdot X_{i,d,t} + \xi_d + \delta_t + \varepsilon_{i,d,t}
\]

\( \eta \) (or \( \gamma - \eta \)) difficult to interpret due to GE effects on either side of border
   - Ex: people move to unregulated areas but others move to regulated areas once prices fall

Solution: exclude \( i \) in the “donut hole” \( C(r) := \{i \mid -r \leq x(i) \leq r\} \) and compare \( \hat{\gamma} \)
Robust to using faraway never-treated as control

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( LTV_{Cap} \times Post )</td>
<td>-0.076***</td>
<td>-0.057***</td>
<td>-0.058***</td>
<td>-0.056***</td>
<td>-0.056***</td>
<td>-0.082***</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.011)</td>
</tr>
<tr>
<td></td>
<td>[0.009]</td>
<td>[0.005]</td>
<td>[0.005]</td>
<td>[0.005]</td>
<td>[0.005]</td>
<td>[0.008]</td>
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</table>

<table>
<thead>
<tr>
<th>Sample function ( f(lat, lon) )</th>
<th>Buildings Linear</th>
<th>Buildings Linear</th>
<th>Buildings Linear</th>
<th>Buildings Linear</th>
<th>Buildings Quadratic</th>
<th>All Linear</th>
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<tr>
<td>District &amp; Time FEs</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>( g(D_{Train}) )</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Property controls</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>Census controls</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Border segment FEs</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

| N                                | 221,280          | 221,280          | 220,719          | 220,716          | 220,716           | 268,056    |
| # districts                      | 278              | 278              | 272              | 272              | 272               | 272        |
| Adj. \( R^2 \)                   | 0.256            | 0.818            | 0.818            | 0.823            | 0.823             | 0.607      |

- Nearly identical point estimates if compare properties in regulated districts to those in non-border, never-treated districts

Chi, LaPoint, & Lin (2024) | Spatially Targeted LTV Limits | FSU-UF Real Estate 2024
Price declines concentrated in high-income districts

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \log(\text{Income}) \times \text{LTVCap} \times \text{Post} )</td>
<td>-0.097*** (0.020)</td>
<td>-0.103*** (0.021)</td>
<td>-0.102*** (0.019)</td>
<td>-0.104*** (0.019)</td>
<td>-0.027 (0.021)</td>
<td>-0.027 (0.020)</td>
<td>-0.024 (0.018)</td>
<td>-0.025 (0.018)</td>
</tr>
<tr>
<td>2nd Quintile ( \times \text{LTVCap} \times \text{Post} )</td>
<td>-0.014 (0.023)</td>
<td>-0.021 (0.022)</td>
<td>-0.023 (0.020)</td>
<td>-0.024 (0.020)</td>
<td>-0.045** (0.020)</td>
<td>-0.054*** (0.020)</td>
<td>-0.045** (0.018)</td>
<td>-0.044** (0.019)</td>
</tr>
<tr>
<td>3rd Quintile ( \times \text{LTVCap} \times \text{Post} )</td>
<td>-0.014 (0.023)</td>
<td>-0.021 (0.022)</td>
<td>-0.023 (0.020)</td>
<td>-0.024 (0.020)</td>
<td>-0.045** (0.020)</td>
<td>-0.054*** (0.020)</td>
<td>-0.045** (0.018)</td>
<td>-0.044** (0.019)</td>
</tr>
<tr>
<td>4th Quintile ( \times \text{LTVCap} \times \text{Post} )</td>
<td>-0.045** (0.020)</td>
<td>-0.054*** (0.020)</td>
<td>-0.045** (0.018)</td>
<td>-0.044** (0.019)</td>
<td>-0.066*** (0.021)</td>
<td>-0.074*** (0.021)</td>
<td>-0.074*** (0.019)</td>
<td>-0.072*** (0.019)</td>
</tr>
<tr>
<td>5th Quintile ( \times \text{LTVCap} \times \text{Post} )</td>
<td>-0.066*** (0.021)</td>
<td>-0.074*** (0.021)</td>
<td>-0.074*** (0.019)</td>
<td>-0.072*** (0.019)</td>
<td>-0.066*** (0.021)</td>
<td>-0.074*** (0.021)</td>
<td>-0.074*** (0.019)</td>
<td>-0.072*** (0.019)</td>
</tr>
</tbody>
</table>

\( f(\text{lat, lon}) \) | Linear | Linear | Linear | Linear | Quadratic | Linear | Linear | Linear | Quadratic |
---|---|---|---|---|---|---|---|---|---|
District & Time FEs | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ |
g(\text{DT}rain) | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ |
Property controls | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ |
Census controls | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ |
Border segment FEs | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ |
N | 105,569 | 105,569 | 105,569 | 105,569 | 105,569 | 105,569 | 105,569 | 105,569 | 105,569 |
# districts | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 |
Adj. \( R^2 \) | 0.823 | 0.824 | 0.835 | 0.836 | 0.823 | 0.824 | 0.835 | 0.836 | 0.836 |
Large drop in sales volume in regulated districts

\[
\log(Volume_{d,t}) = \gamma \cdot \left( LTVCap_{d,t} \times Post_{d,t} \right) + g(DTrain_{d,t}) + \beta' \cdot X_{c,t} + \xi_d + \delta_t + \varepsilon_{d,t}
\]

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTVCap x Post</td>
<td>-0.326***</td>
<td>-0.312***</td>
<td>-0.258***</td>
<td>-0.334***</td>
<td>-0.317***</td>
<td>-0.262**</td>
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<tr>
<td></td>
<td>(0.022)</td>
<td>(0.023)</td>
<td>(0.023)</td>
<td>(0.027)</td>
<td>(0.028)</td>
<td>(0.029)</td>
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<td>Buildings</td>
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<td>All</td>
<td>All</td>
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<tr>
<td>District &amp; Time FEs</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Census controls</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Lagged Census controls</td>
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<td></td>
<td>✓</td>
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<tr>
<td>( g(DTrain) )</td>
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<td></td>
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<tr>
<td><strong>N</strong></td>
<td>6,462</td>
<td>6,382</td>
<td>5,276</td>
<td>6,467</td>
<td>6,387</td>
<td>5,282</td>
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<tr>
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<td>291</td>
<td>272</td>
<td>297</td>
<td>291</td>
<td>272</td>
</tr>
<tr>
<td>Adj. <strong>R^2</strong></td>
<td>0.913</td>
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<td>0.909</td>
<td>0.921</td>
<td>0.924</td>
<td>0.917</td>
</tr>
</tbody>
</table>

- Control group: never-treated, non-border districts \(\implies\) unlikely to be driven by sorting
Dynamic DiD: sales volume around 2014 LTV reform

- Timing of drop in sales volume matches timing of price decline

Chi, LaPoint, & Lin (2024) Spatially Targeted LTV Limits FSU-UF Real Estate 2024
Misreporting test: land vs. buildings in 2010 regime

\[
\log(\text{Volume}_{d,t}) = \gamma \cdot \left( \text{LTV Cap}_{d,t} \times \text{Post}_{d,t} \right) + g(\text{DTrain}_{d,t}) + \beta' \cdot X_{c,t} + \xi_d + \delta_t + \varepsilon_{d,t}
\]

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTV Cap × Post</td>
<td>0.238</td>
<td>0.236</td>
<td>0.182</td>
<td>−0.635</td>
<td>−0.636</td>
<td>−0.497</td>
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<tr>
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<td>Adj. $R^2$</td>
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<td>0.855</td>
<td>0.871</td>
<td>0.646</td>
<td>0.643</td>
<td>0.696</td>
</tr>
</tbody>
</table>

- Sign flips if restrict to land sales subject to the $65\% \times \min\{\text{appraisal}, \text{price}\}$ rule
Sharper drop in prices around city policy boundary

- Zoom out and redraw boundary to include cities with treated districts
- Similar $\Delta P$ away from border, but clearer discontinuity than at district-level
- Idea: most lending done by multi-branch banks which reroute customers to nearest branch within city limits
- Suggests that targeting at the neighborhood level may be too fine
- Can improve spatial targeting by defining boundaries as span of mortgage market
Additional Appraisal Gap Results
**Steps to Compute the Appraisal Gap**

\[
Gap_{i,b,d,t} = \log(A_{i,b,d,t} - A^*_{i,d,t^*})
\]

- \(A^*\) is the official appraisal for tax purposes
- \(A\) is the collateral value reported by the lender at origination
- To obtain \(A^*\) we distinguish between land only, building + land, and building transactions
  - Land portion of appraised value observed directly in year \(t^*\), inflate using our index \(\Delta \tilde{P}_{t^*,t}^d\)
  - For buildings appraised every 3 years in \(t^*\), we use known local valuation formula:
    \[
    A^*_{i,d,t^*} = \text{standard value}_{i,c,t^*} \times \text{size}_i \times (1 - \delta_{i,d,t^*} \times \text{age}_{i,t^*}) \times \zeta_{i,d,t^*}
    \]
- \(\text{standard value}\), depreciation factor \((\delta)\) and road adjustment factor \((\zeta)\) depends on property type, updated by district in each year
- \(A > A^*\) in 99.2% of cases, so log transform does not censor the data
## DiD evidence of misreporting after 2014

<table>
<thead>
<tr>
<th></th>
<th>All transactions</th>
<th>Apartment units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>15.37***</td>
<td>14.08***</td>
</tr>
<tr>
<td></td>
<td>(5.52)</td>
<td>(7.24)</td>
</tr>
<tr>
<td>$Post_t$</td>
<td>0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td></td>
<td>(0.50)</td>
<td>(0.53)</td>
</tr>
<tr>
<td>$LTVCap_{i,d}$</td>
<td>-0.05</td>
<td>-0.06**</td>
</tr>
<tr>
<td></td>
<td>(1.31)</td>
<td>(1.96)</td>
</tr>
<tr>
<td>$LTVCap_{i,d} \times Post_t$</td>
<td>0.03</td>
<td>0.05**</td>
</tr>
<tr>
<td></td>
<td>(1.42)</td>
<td>(2.05)</td>
</tr>
<tr>
<td>$D(t,t^*)$</td>
<td>-0.06***</td>
<td>-0.08***</td>
</tr>
<tr>
<td></td>
<td>(2.69)</td>
<td>(3.40)</td>
</tr>
</tbody>
</table>

- **Gap** ↑ by ≈ 6% ($1k) relative to average of $20k gap under the 2010 regime with the loophole
  - Estimation sample: all mortgages (ITT effect)
  - Extend to triple diff to get ATT
- Recall that 2010 reform defined limit as 60% of collateral value
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<table>
<thead>
<tr>
<th></th>
<th>dummy</th>
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<tbody>
<tr>
<td>Drift function</td>
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<td>Time FEs</td>
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<td>✔</td>
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<tr>
<td>District &amp; bank FEs</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Bank controls</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Property controls</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Borrower controls</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

| N                | 41,015 | 40,123 | 29,648 | 29,283 |
| Adj. $R^2$       | 0.54   | 0.54   | 0.60   | 0.60   |
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<td>(5.52) (5.40)</td>
<td>(7.24) (7.18)</td>
</tr>
<tr>
<td>( Post_t )</td>
<td>0.01 0.00</td>
<td>−0.01 −0.02</td>
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<tr>
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<td>(0.50) (0.10)</td>
<td>(0.53) (1.04)</td>
</tr>
<tr>
<td>( LTVCap_{i,d} )</td>
<td>−0.05 −0.06*</td>
<td>−0.06** −0.07***</td>
</tr>
<tr>
<td></td>
<td>(1.31) (1.85)</td>
<td>(1.96) (3.12)</td>
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<tr>
<td>( LTVCap_{i,d} \times Post_t )</td>
<td>0.03 0.04**</td>
<td>0.05** 0.06***</td>
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<tr>
<td></td>
<td>(1.42) (2.03)</td>
<td>(2.05) (3.10)</td>
</tr>
<tr>
<td>( D(t, t^*) )</td>
<td>−0.06*** −0.00***</td>
<td>−0.08*** −0.00***</td>
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<tr>
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<td>(2.69) (4.65)</td>
<td>(3.40) (4.45)</td>
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### Drift function
- dummy
- linear
- Time FEs
- District & bank FEs
- Bank controls
- Property controls
- Borrower controls

<table>
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<th></th>
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<th>linear</th>
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<td>29,283</td>
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<td>0.60</td>
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</tbody>
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  - Extend to triple diff to get ATT
- **Recall that 2010 reform defined limit as 60% of collateral value**
  - Loophole: not a function of the price until 2014!
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2010 reform

- Estimation sample: all mortgages (ITT effect)

2010 reform
### DiD evidence of misreporting after 2014

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<td>13.33***</td>
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<td>(7.18)</td>
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<td>-0.01</td>
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<tr>
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<tr>
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<td>(1.31)</td>
<td>(1.85)</td>
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<tr>
<td></td>
<td>-0.06**</td>
<td>(1.96)</td>
</tr>
<tr>
<td></td>
<td>(3.12)</td>
<td></td>
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<tr>
<td>$LTV Cap_{i,d} \times Post_t$</td>
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<td>0.04**</td>
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<td>(2.05)</td>
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<td>-0.00***</td>
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<table>
<thead>
<tr>
<th></th>
<th>Drift function dummy</th>
<th>Drift function linear</th>
<th>Time FEs</th>
<th>District &amp; bank FEs</th>
<th>Bank controls</th>
<th>Property controls</th>
<th>Borrower controls</th>
<th>N</th>
<th>Adj. $R^2$</th>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>41,015</td>
<td>40,123</td>
<td>29,648</td>
<td>29,283</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>0.54</td>
<td>0.60</td>
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## Appraisal gap triple diff: full results table

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<th>All transactions</th>
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<td>$\alpha$</td>
<td>14.19*** 14.23***</td>
<td>13.43*** 13.11***</td>
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<tr>
<td></td>
<td>(5.62) (5.56)</td>
<td>(6.93) (6.74)</td>
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<tr>
<td>$Post_t$</td>
<td>0.08*** 0.08***</td>
<td>0.08 0.06</td>
</tr>
<tr>
<td></td>
<td>(3.62) (3.19)</td>
<td>(1.70) (1.52)</td>
</tr>
<tr>
<td>$LTV_{District_{i,d}}$</td>
<td>0.82*** 0.79***</td>
<td>0.90*** 0.83***</td>
</tr>
<tr>
<td></td>
<td>(4.86) (4.68)</td>
<td>(4.55) (4.44)</td>
</tr>
<tr>
<td>$Post_t \times LTV_{District_{i,d}}$</td>
<td>−0.10*** −0.11***</td>
<td>−0.12** −0.11**</td>
</tr>
<tr>
<td></td>
<td>(3.83) (3.61)</td>
<td>(2.58) (2.37)</td>
</tr>
<tr>
<td>$2nd_{Mrtg_i}$</td>
<td>0.09** 0.13***</td>
<td>0.07 0.12**</td>
</tr>
<tr>
<td></td>
<td>(2.53) (5.82)</td>
<td>(1.32) (3.01)</td>
</tr>
<tr>
<td>$Post_t \times 2nd_{Mrtg_i}$</td>
<td>−0.07* −0.10***</td>
<td>−0.05 −0.10**</td>
</tr>
<tr>
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<td>(1.91) (4.77)</td>
<td>(0.99) (2.46)</td>
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<td>−0.13** −0.18***</td>
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<tr>
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<td>(3.06) (4.94)</td>
<td>(2.18) (3.42)</td>
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<tr>
<td>$Post_t \times LTV_{District_{i,d}} \times 2nd_{Mrtg_i}$</td>
<td>0.09** 0.13***</td>
<td>0.09* 0.14***</td>
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<tr>
<td></td>
<td>(2.46) (5.75)</td>
<td>(1.81) (3.46)</td>
</tr>
<tr>
<td>$D(t, t^*)$</td>
<td>−0.05** −0.00</td>
<td>−0.06** −0.00***</td>
</tr>
<tr>
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<td>(2.45) (1.38)</td>
<td>(2.85) (3.14)</td>
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<table>
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<tr>
<th>Drift function</th>
<th>dummy</th>
<th>linear</th>
<th>dummy</th>
<th>linear</th>
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<tr>
<td>Time FEs</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>District &amp; bank FEs</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Bank/property/borrower controls</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

| N                  | 41,015 | 40,123 | 29,648 | 29,283 |
| Adj. $R^2$         | 0.56   | 0.55   | 0.62   | 0.61   |

- Reference group: first mortgages in untreated districts in the pre-reform period $\rightarrow \alpha$
- Add the coefficients on $2nd_{Mrtg_i}$ and $LTV_{District_{i,d}}$ to $\alpha$ to get the pre-existing average appraisal gap in the treatment group
- Drift function $D(t, t^*)$ loads negatively on the gap in all specifications, reflecting benign gap from delays between official appraisals
Appraisal gap triple diff: \( \text{Gap} = (A - A^*) / 0.5(A + A^*) \)

- Alternative measure proposed by Kruger & Maturana (2021)
- \( \text{Gap} \) centered at zero if \( A \) and \( A^* \) symmetrically distributed around same mean (not true here)
  - Here, there is a large existing pre-existing gap (\( \alpha \)), since typically \( A^* << A \)
- 2-3 p.p. increase in gap for 2nd+ mortgages relative to average valuation \( \bar{A} = 0.5(A + A^*) \)
- Similar result for \( \text{Gap} = (A - A^*) / A^* \)
Separating Credit Demand vs. Credit Supply Responses
How do spatially targeted LTV limits operate?

- LTV limits are enforced through banks but target household leverage
  - **Demand channel**: investors lower WTP for properties in regulated areas due to higher downpayment requirements
    - All else equal, higher leverage loans generate higher internal rates of return (IRR) for lenders
  - **Supply channel**: lenders might ration credit in regulated areas, or steer borrowers towards loan contracts which are unregulated or which carry higher IRR
    - Matched DiD: within treated areas no steering towards higher yield contracts

- Standard technique to separate supply vs. demand in loan origination is the Amiti & Weinstein (2018) decomposition for corporate loans
  - Problem: relies on identification of bank and borrower fixed effects
  - Very limited number, and very selected sample, of repeat borrowers within time window around each reform
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Isolating supply-side responses using regulation exposure

Idea: tease out credit rationing using measures of how ex ante exposed lenders’ loan portfolios are to LTV regulation

Define exposure as the dollar share of loans each lender $j$ originated in treated areas within a year before the reform:

$$Exposure_j = \frac{\sum_{i=1}^{N_j} (Loan_{amt_{i,j}} \times Treated_{i,d})}{\sum_{i=1}^{N_j} Loan_{amt_{i,j}}}$$

Further decompose into exposure by 1st (unregulated) vs. 2nd+ mortgages (regulated) or parent bank $b$ level vs. branch $j$ level

Collateral internalization: $Exposure_j$ also picks up the fact that collateral values may fall due to change in broader housing market demand (Favara & Giannetti 2017)

▶ Measure based directly on collateral values would require book-to-market conversion
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\[
Exposure_j = \frac{\sum_{i=1}^{N_j} (\text{Loan}_i \times \text{Treated}_{i \in d})}{\sum_{i=1}^{N_j} \text{Loan}_i}
\]  

(7)

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- Idea: tease out credit rationing using measures of how \textit{ex ante} exposed lenders’ loan portfolios are to LTV regulation

- Define \textbf{exposure} as the dollar share of loans each lender $j$ originated in treated areas within a year before the reform:

$$Exposure_j = \frac{\sum_{i=1}^{N_j} (\text{Loan}_\text{amt}_{i,j} \times \text{Treated}_{i \in d})}{\sum_{i=1}^{N_j} \text{Loan}_\text{amt}_{i,j}}$$ (7)

- Further decompose into exposure by 1st (unregulated) vs. 2nd+ mortgages (regulated) or parent bank $b$ level vs. branch $j$ level

- Collateral internalization: $Exposure_j$ also picks up the fact that collateral values may fall due to change in broader housing market demand (Favara & Giannetti 2017)
  - Measure based directly on collateral values would require book-to-market conversion
Drop in loans concentrated among most exposed branches

\[ L_{j,b,d,t} = \gamma_1 \cdot \text{Post}_t \times Treated_{j \in d} + \gamma_2 \cdot \text{Post}_t \times Exposure_j + \gamma_3 \cdot \text{Post}_t \times Treated_{j \in d} \times Exposure_j + \eta_j + \theta_{d,t} + \varepsilon_{j,b,d,t} \] (8)

<table>
<thead>
<tr>
<th>Outcome:</th>
<th>1st mortgages</th>
<th>2nd+ mortgages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>log(loan $)</td>
<td>log(# of loans)</td>
</tr>
<tr>
<td>Post t \times Treated_{j \in d}</td>
<td>-0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.22)</td>
<td>(0.34)</td>
</tr>
<tr>
<td></td>
<td>[0.16]</td>
<td>[0.24]</td>
</tr>
<tr>
<td>Post t \times Exposure_j</td>
<td>-0.20***</td>
<td>-0.13**</td>
</tr>
<tr>
<td></td>
<td>(2.79)</td>
<td>(2.54)</td>
</tr>
<tr>
<td></td>
<td>[2.23]</td>
<td>[1.86]</td>
</tr>
<tr>
<td>Post t \times Treated_{j \in d} \times Exposure_j</td>
<td>0.22**</td>
<td>0.13**</td>
</tr>
<tr>
<td></td>
<td>(2.37)</td>
<td>(2.12)</td>
</tr>
<tr>
<td></td>
<td>[2.01]</td>
<td>[1.53]</td>
</tr>
</tbody>
</table>

Branch FEs ✓ ✓ ✓ ✓
District \times time FEs ✓ ✓ ✓ ✓

N 28,280 28,280 10,013 10,013
Adj. \( R^2 \) 0.52 0.61 0.41 0.49

- Collapse data to branch-month level
- More exposed branches within the same district reduce their 2nd+ mortgage lending by more
- Suggestive of substitution towards unregulated first mortgage borrowers
- Extensive margin is important: stronger results for untransformed 2nd+ mortgage outcomes

Note: t-stats from standard errors clustered by bank-time in parentheses. t-stats clustered by branch in brackets. Exposure\(_j\) measured using 2nd+ mortgages originated on properties located in regulated areas but in the year prior to the 2014 reform.
Effects driven by anticipation among exposed branches

- Spike in loans comes around time public banks started enacting their own internal LTV policies
  - Public mortgages are not in our sample
  - Market interpreted this as a signal of future LTV tightening
- Points to brokers acting strategically to expedite loans under the preceding regime (higher commission), but no real change in screening standards after the reform

Note: We plot the dynamic coefficients on Post$_t$ \times Treated$_{j \in d}$ \times Exposure$_j$, with 95% confidence intervals obtained from clustering standard errors by bank-time.
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Note: We plot the dynamic coefficients on $Post_t \times Treated_{j \in d} \times Exposure_j$, with 95% confidence intervals obtained from clustering standard errors by bank-time.
ΔL_{j,b,d,t,t+1} = \alpha + \gamma_1 \cdot \text{Exposure}_{j,t-1} + \gamma_2 \cdot \text{Exposure}_{j,t-1} \times \text{Treated}_{j \in d} + \gamma_3 \cdot \sum_{k \neq j}^{N_b} \text{Exposure}_{k,t-1} + \gamma_4 \cdot \sum_{k \neq j}^{N_b} \text{Exposure}_{k,t-1} \times \text{Treated}_{j \in d} + \xi_d + \varepsilon_{j,b,d,t,t+1} \tag{9}

- Direct exposure \text{Exposure}_{j,t-1} vs. exposure of \(N_b\) peer branches within same bank chain

\sum_{k \neq j}^{N_b} \text{Exposure}_{k,t-1}

- **Hypothesis:** banks more exposed to regulatory risk through LTV limits might smooth out the shock across branches in their network \(\implies \gamma_4 \neq 0\)
  - Lower screening standards in unregulated areas or loan segments to make up lost profits
  - If so, spatial limits may have simply exported risk to unregulated areas

- **Our result:** no network effects on either 1st or 2nd+ mortgage issuance

Chi, LaPoint, & Lin (2024) Spatially Targeted LTV Limits FSU-UF Real Estate 2024
No evidence of branch network contagion effects

\[
\Delta L_{j,b,d,t,t+1} = \alpha + \gamma_1 \cdot \text{Exposure}_{j,t-1} + \gamma_2 \cdot \text{Exposure}_{j,t-1} \times \text{Treated}_{j\in d} \\
+ \gamma_3 \cdot \sum_{k\neq j}^{N_b} \text{Exposure}_{k,t-1} + \gamma_4 \cdot \sum_{k\neq j}^{N_b} \text{Exposure}_{k,t-1} \times \text{Treated}_{j\in d} + \xi_d + \varepsilon_{j,b,d,t,t+1}
\]

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  \[ \sum_{k\neq j}^{N_b} \text{Exposure}_{k,t-1}\]

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NO EVIDENCE OF BRANCH NETWORK CONTAGION EFFECTS

\[ \Delta L_{j,b,d,t,t+1} = \alpha + \gamma_1 \cdot \text{Exposure}_{j,t-1} + \gamma_2 \cdot \text{Exposure}_{j,t-1} \times \text{Treated}_{j \in d} + \gamma_3 \cdot \sum_{k \neq j}^{N_b} \text{Exposure}_{k,t-1} + \gamma_4 \cdot \sum_{k \neq j}^{N_b} \text{Exposure}_{k,t-1} \times \text{Treated}_{j \in d} + \xi_d + \varepsilon_{j,b,d,t,t+1} \] 

- **Direct exposure** \( \text{Exposure}_{j,t-1} \) vs. exposure of \( N_b \) peer branches within same bank chain \( \sum_{k \neq j}^{N_b} \text{Exposure}_{k,t-1} \)

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Chi, LaPoint, & Lin (2024)
Spatially Targeted LTV Limits
FSU-UF Real Estate 2024
**No Evidence of Branch Network Contagion Effects**

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\Delta L_{j,b,d,t,t+1} = \alpha + \gamma_1 \cdot \text{Exposure}_{j,t-1} + \gamma_2 \cdot \text{Exposure}_{j,t-1} \times \text{Treated}_{j \in d} \\
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\[
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Chi, LaPoint, & Lin (2024)  Spatially Targeted LTV Limits  FSU-UF Real Estate 2024
Distribution of branch exposure measure

Exposure before 2010 LTV reform

Exposure before 2014 LTV reform

Note: \( \text{Exposure}_j \) defined in terms of 2nd+ mortgage loan amounts.

- Share of unexposed branches rises by 6 p.p. after initial 2010 reform
- Use balanced panel of branches b/c some stop originating 2nd+ mortgages altogether
We define the indirect branch network exposure of a branch $j$ of parent bank $b$ as:

$$
\sum_{k \neq j} N_b \times Exposure_{k,t-1} = \sum_{k \neq j} \left( \frac{\sum_{i=1}^{N_k} (\text{Loan}_amt_{i,k} \times \text{Treated}_{i \in d})}{\sum_{i=1}^{N(b)} \text{Loan}_amt_{i,b}} \right)
$$

- $N_b$ is the # of branches within bank $b$
- $N_k$ is the # of loans originated within branch $k$
- $N(b)$ is the # of loans originated within bank $b$

**Interpretation:** this measure captures how much the branch peers contribute to the overall regulation exposure of the parent bank’s mortgage portfolio.
null results from branch network regressions

\[ \Delta L_{j,b,d,t,t+1} = \alpha + \gamma_1 \cdot Exposure_{j,t-1} + \gamma_2 \cdot Exposure_{j,t-1} \times Treated_{j \in d} \]

\[ + \gamma_3 \cdot \sum_{k \neq j}^{N_b} Exposure_{k,t-1} + \gamma_4 \cdot \sum_{k \neq j}^{N_b} Exposure_{k,t-1} \times Treated_{j \in d} + \xi_d + \varepsilon_{j,b,d,t,t+1} \]

<table>
<thead>
<tr>
<th>Outcome:</th>
<th>1st mortgages</th>
<th>2nd+ mortgages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\Delta \log(\text{loan } $))</td>
<td>(\Delta \log(\text{# of loans}))</td>
</tr>
<tr>
<td>Exposure_{j,t-1}</td>
<td>-0.043</td>
<td>0.017</td>
</tr>
<tr>
<td>Exposure_{j,t-1} \times Treated_{j \in d}</td>
<td>-0.041</td>
<td>-0.017</td>
</tr>
</tbody>
</table>
| \(\Sigma_{k 
eq j}^{N_b} Exposure_{k,t-1}\) | 0.062 | 0.074 | -0.252 | -0.068 |
| \(\Sigma_{k 
eq j}^{N_b} Exposure_{k,t-1} \times Treated_{j \in d}\) | -0.015 | -0.019 | 1.000 | 0.269 |

| District FE \(N\) | \(20,815\) | \(20,815\) | \(4,272\) | \(4,272\) |

**Note:** Column headings indicate which subsample (first mortgages vs. mortgages on a second property) of loans are included in the lending growth outcome measure. Exposure measured using 2nd+ mortgages originated on properties located in regulated areas but in the year prior to the 2014 reform. Exposure rescaled in terms of 10 p.p. increments. t-stats from standard errors clustered at the branch level in parentheses.

- **Collapse data to branch-year level**
- **Results here use 2nd+ mortgages to construct exposure measures, but also null if use all loans**
- **\(\xi_d\) compare two branches located within same district but which have differential network exposure through peer branches of same parent bank**
- **Still null effects without the district FEs**
Welfare Decomposition
Approximately 1% drop in deed tax revenues at district level

Property: \( \text{DeedTax}_{i \in d,t} = \alpha + \beta \cdot LTVCap_{i \in d} \times Post_t + \eta_i + \gamma_t + \epsilon_{i,t} \)

District: \[ \sum_{i \in (d,t)} \text{DeedTax}_{i \in (d,t)} = \alpha + \beta \cdot LTVCap_d \times Post_t + \xi_d + \gamma_t + \epsilon_{d,t} \]

- \( \text{DeedTax}_{i \in d,t} = 6\% \times A^*_{i,d,t} \times \mathbbm{1}\{\text{sale}_{i,t}\} \)
- Since sales volume \( V = \sum_i \mathbbm{1}\{\text{sale}_{i,t}\} \) falls, revenues drop at the district level
- \( A^* \) is sticky because reval only occurs once every 3 years
- Repeat sales regression \( (\eta_i) \rightarrow \) policy is revenue neutral at individual property level
- Total decline is 1% of annual revenue raised in regulated districts

<table>
<thead>
<tr>
<th>Policy date:</th>
<th>December 2010</th>
<th>June 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs. unit:</td>
<td>Property</td>
<td>District</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>27.90***</td>
<td>3291.10***</td>
</tr>
<tr>
<td></td>
<td>(54.57)</td>
<td>(46.58)</td>
</tr>
<tr>
<td>( LTVCap_{i \in d} \times Post_t )</td>
<td>1.32</td>
<td>-3,597.70***</td>
</tr>
<tr>
<td></td>
<td>(0.94)</td>
<td>(-3.64)</td>
</tr>
<tr>
<td>Unit FEs</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Month-year FEs</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>N</td>
<td>455,968</td>
<td>4,058</td>
</tr>
<tr>
<td>Adj. ( R^2 )</td>
<td>0.008</td>
<td>0.749</td>
</tr>
</tbody>
</table>

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Our companion paper: PR ratio targeting via taxes

- Common alternative to leverage-based MPPs is to tax housing transactions

- **Idea:** sellers pass along costs of the tax to buyers, which acts like an increased downpayment requirement

- **Reality:** taxes create an inventory crunch, as investors hold onto properties for longer to subdivide the fixed cost over a longer holding period

In our companion paper, we show in a structural model that such flip taxes...

1. Increase house prices for most tax rates, but help achieve price-rent (PR) ratio targets by pushing more people into rentership

2. Renters on margin of homeownership gain, but aggregate welfare losses are large and equal to $\approx 55\%$ of housing consumption

- Targeting buyers directly using spatially targeted LTV limits helps improve affordability *in price levels* without large welfare losses
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Transfer taxes generate large welfare losses

- Model from Chi, LaPoint, Lin (2023)
  - Investors with heterogeneous beliefs about house prices and rents
  - Government taxes housing sales to bring PR ratio down
  - Idea is that investors are noise traders, so tax moves their beliefs more in line with fundamental value

- Result: aggregate welfare loss is almost invariant to PR ratio target
  - Calibrate to 2014-16 transfer tax
  - Loss is roughly 55% of aggregate housing-based consumption