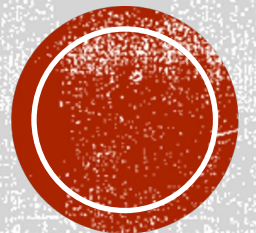# Strapped for Cash:
The Effect of Wages
and Minimum Wage Increases
on Delinquency Risk
for Residential Mortgages

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Submitted to Princeton University Department of Economics
In Partial Fulfillment of the Requirement for the A.B. Degree
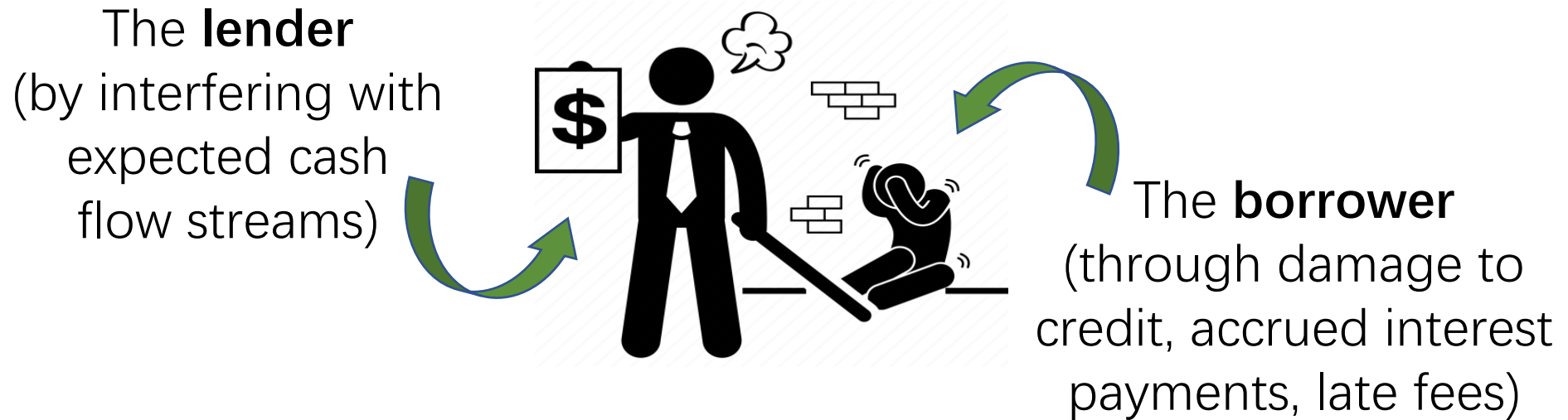April 2022

Agenda

I. Background

II. Section I: The Effect of Income Changes on Mortgage Performance

III. Section II: The Effect of Minimum Wage Increases on Mortgage Performance

IV. Section III: Summary and Concluding Remarks

V. References

Background

- Late mortgage payments are detrimental to both:

The **lender**
(by interfering with expected cash flow streams)

The **borrower**
(through damage to credit, accrued interest payments, late fees)

- Two key drivers of delinquency are:
  1. Lack of liquidity (e.g., negative income shocks)
  2. Negative home equity

Section I:
# The Effect of Income Changes on Mortgage Performance

Motivation

- Primary challenge: finding and linking detailed data on mortgage performance and borrower's income.

- Survey data has been used in previous literature, but:

  - Survey data tracking income and mortgage performance for individual borrowers is typically very limited.

  - We may be concerned about selection bias, response bias, and measurement error from the survey framework posing threats to internal and external validity.

My Approach

- The effect of **aggregate wage changes** on delinquency patterns is estimated at the county level using a two-way fixed effects (FE) model.

- Mortgage data is averaged across different geographic locations by quarter and merged with data tracking aggregate wage measures in those same locations.

  - Mortgage data from **CoreLogic**: data is pooled from a consortium of mortgage servicers and cover about 65% of active residential mortgages in the U.S. market.
  - Wage data from **Quarterly Census of Employment and Wages (QCEW)**: total compensation paid to workers each calendar quarter, covering over 95% of U.S. jobs in both the private and public sectors.

- This approach allows us to consider a much larger and more varied sample of mortgages than previous studies have.

Combined data spans 2,913 U.S. counties.
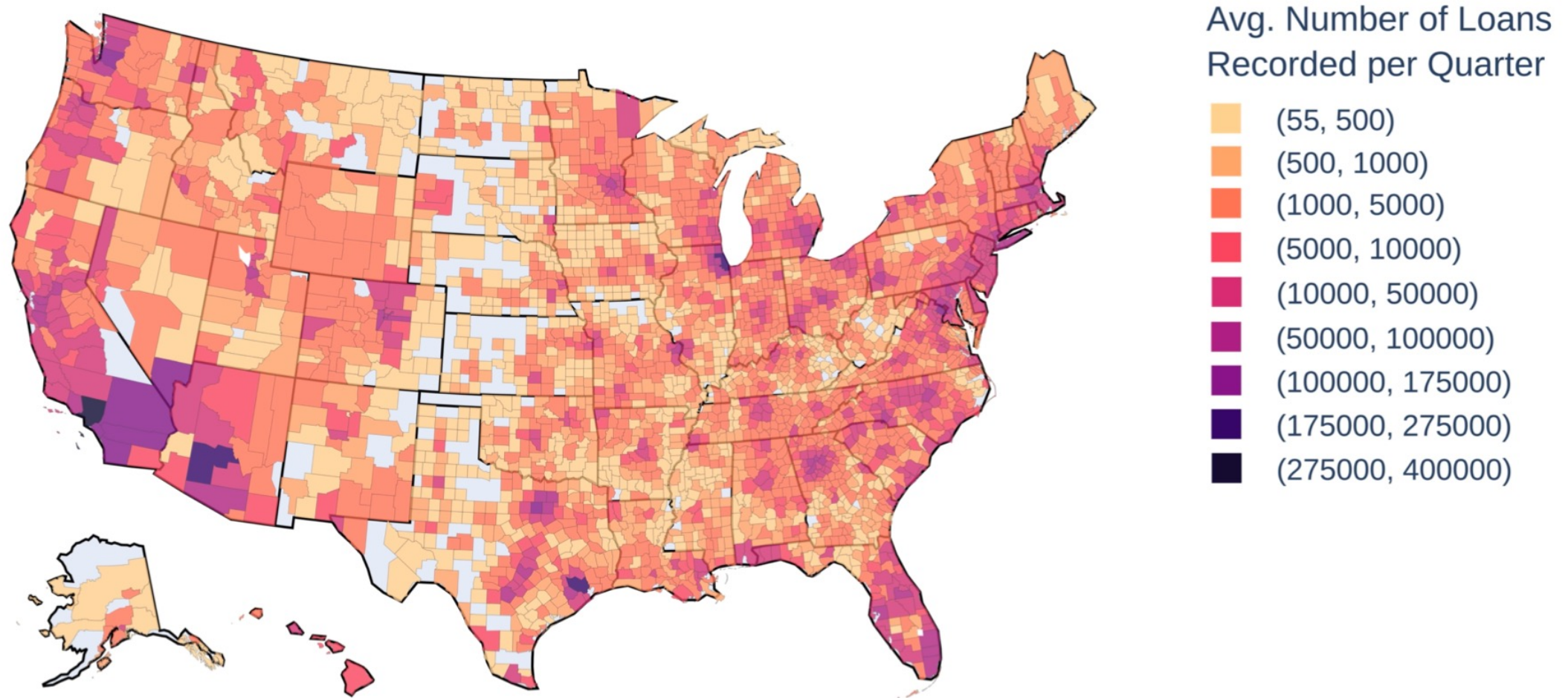
Notes: Map of all counties considered with color corresponding to the total number of mortgages recorded across all periods, divided by the number of periods (20 periods = 5 years × 4 quarters). Counties with missing wage data or with less than 55 unique loans recorded in any given period are eliminated from the sample. Color is discretized into nine intervals, with darker regions corresponding to more data availability. Gray regions correspond to counties not included.

Empirical Strategy

- Only first-lien, fixed-rate residential mortgages originated between January 2010 and November 2014 are considered.

- These loans are observed for several months between January 2012 and December 2016.

- For c=2913 counties and t=20 time periods (5 years x 4 quarters), the econometric setup is as follows:

$$D_{ct} = \alpha + \beta X_{ct} + W'_{ct}\gamma + \delta_c + \eta_t + \epsilon_{ct}$$

- Standard errors are clustered at the county level to account for serial correlation in delinquency rates within each county.

Data: Summary Statistics of Independent Variables

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
Log Weekly Wage	58,260	6.56	0.21	5.82	8.08
Loan Age	58,260	25.6	9.40	8.61	47.4
Loan Age Squared	58,260	743	492	74.2	2,250
Loan Interest Rate	58,260	4.20	0.16	3.71	4.96
Term at Origination	58,260	303	12.6	216	350
LTV at Origination	58,260	79.8	4.91	44.6	102
FICO at Origination	58,260	731	12.7	684	771
DTI Ratio	58,257	35.5	2.14	26.8	50.4
Log Original Balance	58,260	11.8	0.26	11.2	13.3
Number of Units	58,260	1.01	0.019	1	1.35
Frac. Refinance	58,260	0.087	0.18	0	0.77
Frac. Originated 2010	58,260	0.23	0.10	0.036	0.67
Frac. Originated 2011	58,260	0.23	0.095	0.055	0.68
Frac. Originated 2012	58,260	0.25	0.075	0	0.59
Frac. Originated 2013	58,260	0.17	0.099	0	0.43
Frac. Originated 2014	58,260	0.064	0.061	0	0.36
Frac. Originated 2015	58,260	0.042	0.061	0	0.28
HPG Rate	58,260	0.00075	0.011	-0.18	0.63
County UR	58,260	6.51	2.48	1.10	27.7
RUCC	58,260	4.75	2.62	1	9
Relative Wage Level	58,260	1.90	0.81	1	3

County-specific wage data → Log Weekly Wage

Mortgage characteristics (aggregated) → Loan Age ... Frac. Originated 2015

Other county-specific data → HPG Rate, County UR, RUCC, Relative Wage Level

Notes: This table presents the mean, standard deviation, minimum, and maximum of averaged values across all 2,913 counties. "LTV" stands for "loan-to-value", "DTI" stands for "debt-to-income", "Pct." stands for "percent", "HPG" stands for "house price growth", "UR" stands for "unemployment rate", and "RUCC" stands for "rural-urban continuum code".

Data: Summary Statistics of Dependent Variables

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
30+ DELQ Rate (Pct.)	58,260	3.13	1.53	0	14.2
Default Rate (Pct.)	58,260	1.27	0.79	0	8.64
Pct. Loans Current → DELQ	58,260	0.75	0.38	0	5.97
Pct. Loans DELQ → Current/PO	57,682	36.2	13.8	0	100
Pct. Loans Current → Current/PO	58,260	99.3	0.38	94.0	100
Pct. Loans DELQ → DELQ	57,682	63.8	13.8	0	100

Notes: This table presents the mean, standard deviation, minimum, and maximum of averaged values across all 2,913 counties. "C" stands for "current", "PO" stands for "paid off", and "DQ" stands for "delinquent".

Principal Findings

- A 1% increase in the average wage of a county induces a:
    I.   0.0073 p.p. decrease in the percentage of delinquent loans.
    II. 0.0048 p.p. decrease in the percentage of loans in default.
    III. 0.00087 p.p. decrease in the percentage of current loans that become delinquent.

- Results robust to:
    - The inclusion of state-by-year fixed effects.
    - Grouping data by commuting zone as opposed to county.

Additional Findings

- Regressions repeated separately for counties that are rural (RUCC $\geq$ 6) and urban (RUCC $\leq$ 3).

- Response variable is default (DEF) rate and explanatory variable of interest is log of average weekly wage.

- Larger effect size observed across rural counties, suggesting that homeowners in rural areas respond more to wage increases than homeowners in urban areas.

	Urban	**Rural**
N	27460	28957
30+ DELQ Rate	-0.51	-0.88
DEF Rate	-0.35	-0.58
Current $\rightarrow$ DELQ	x	-0.11
DELQ $\rightarrow$ Current/PO	x	x

Notes: Effects that are not statistically significant at the 5% level are marked with 'x'.

Limitations

OEWS wage estimates do not consider individuals out of the labor force.

We lose within-household variation by aggregating data across counties.

Do county's overall wages serve as an effective proxy for the aggregate wages of county's mortgagors?

Section II:
## The Effect of Minimum Wage Increases on Mortgage Performance

Motivation

- The findings of the previous section suggest that mortgage delinquencies move opposite to wage increases.

- We might therefore expect minimum wage increases to reduce a homeowner's probability of delinquency.

- At the same time, minimum wage hikes may increase the probability of unemployment.

- The effect of a minimum wage increase on the probability of delinquency therefore depends on the relative strength of potential positive and negative income shocks.

- Little prior research on the effect of minimum wage increases on mortgage delinquencies specifically.

My Approach

- Study the effect of two consecutive state minimum wage increases in West Virginia on residential mortgage delinquencies for loans originated between 2010 and 2014.
  - The first increase took effect in January 2015, raising the minimum wage from $7.25 to $8.00.
  - The second increase took effect in January 2016, raising the minimum wage from $8.00 to $8.75.
- The minimum wages in West Virginia's three bordering states—Pennsylvania, Virginia, and Kentucky—remained constant throughout the decade.
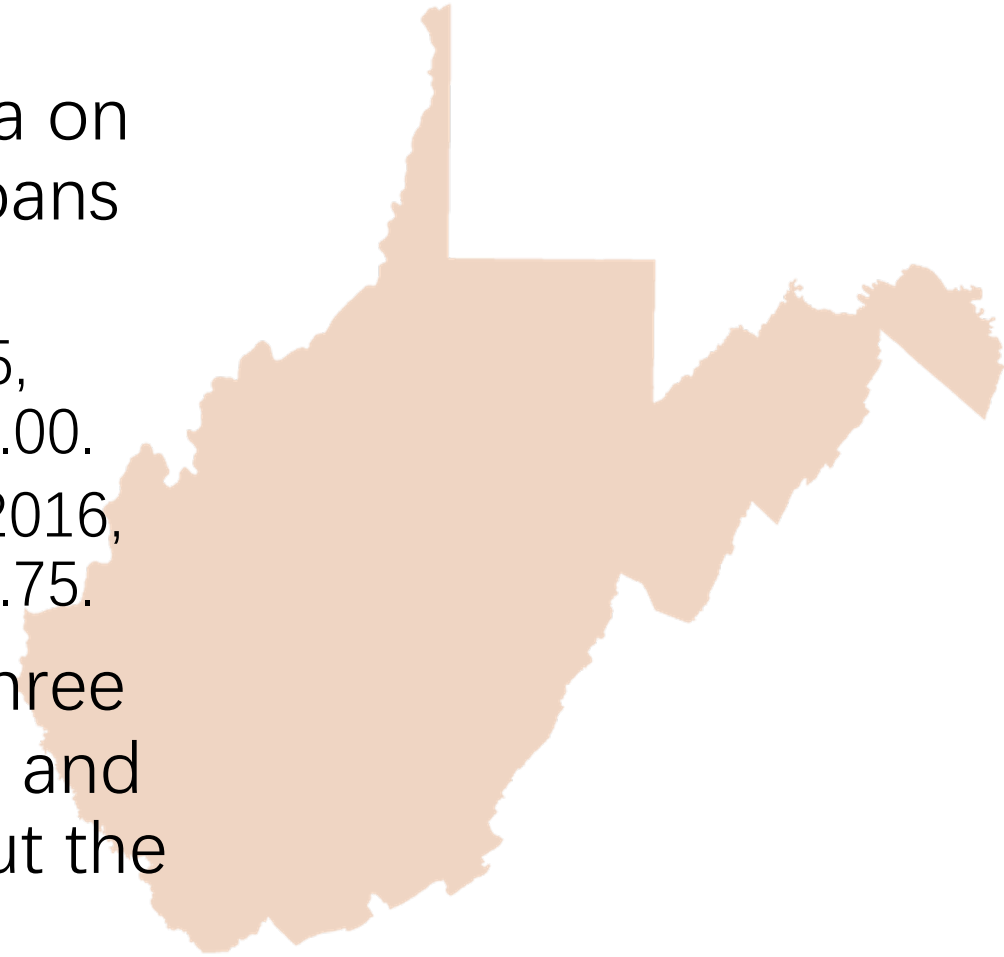
Combined data spans 2,669 ZIP codes.
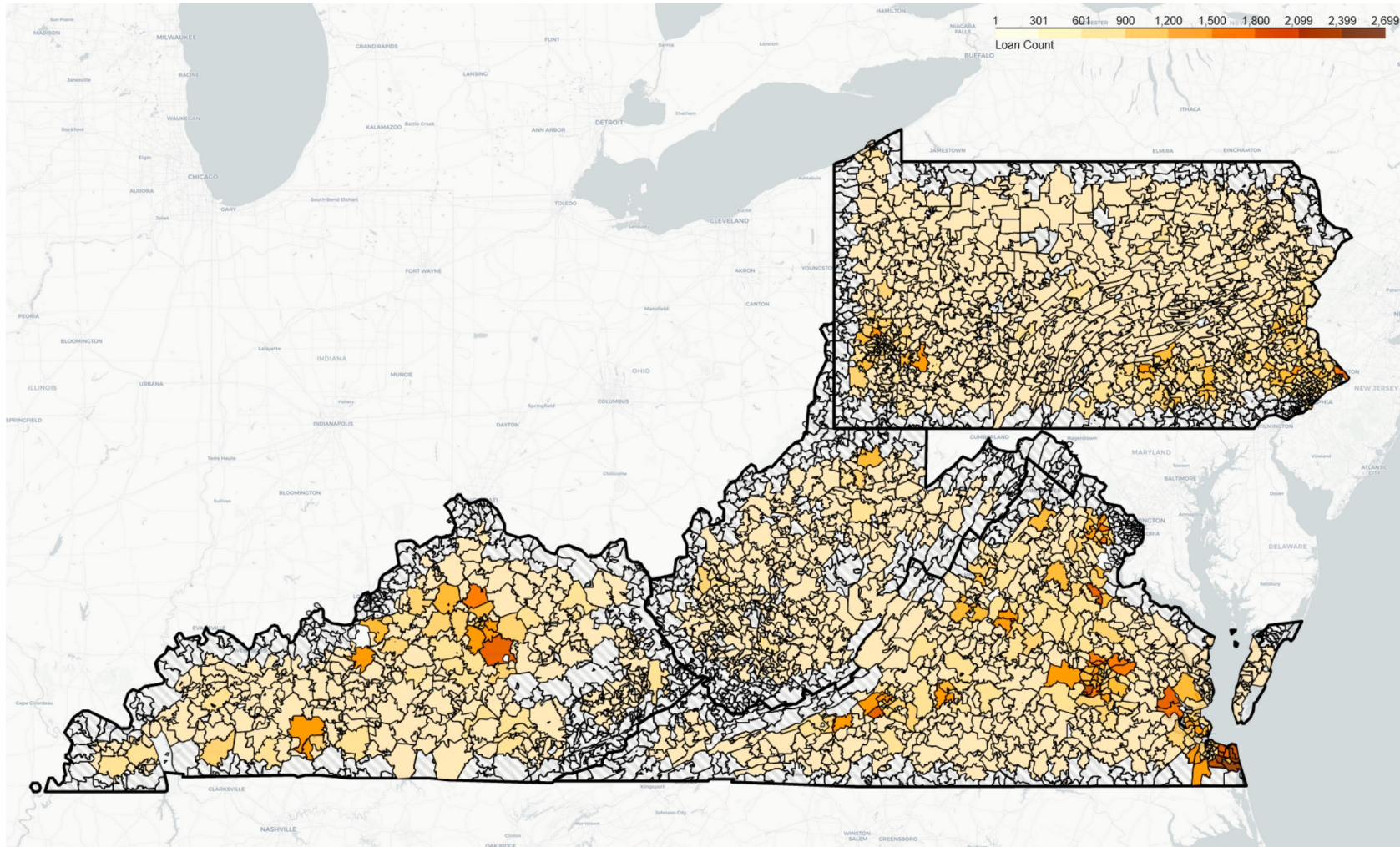
Notes: Map of ZIP codes included in data across WV, PA, VA, and KY. Notice ZIP codes along state borders (in particular, less than 15 miles from a state border) are filled with grey cross-hatching as they are excluded from the data. Color corresponds roughly to data availability and specifically to the number of unique loans recorded in each ZIP code averaged across all time periods.

Empirical Strategy

- One treatment group and two post-period windows, each one year in length.

- For i=415695 loans, z=2669 zip codes, s=4 states, and t=60 time periods (5 years x 12 months), the econometric setup is as follows:

$$D_{izst} = \beta_0 + \beta_1(\mathbb{1}_{s=1} \times \mathbb{1}_{2015M1 \leq t < 2016M1}) + \beta_2(\mathbb{1}_{s=1} \times \mathbb{1}_{t \geq 2016M1}) + X'_{izt}\gamma + \delta_s + \eta_t + \epsilon_{izst}$$

- Standard errors are clustered at the ZIP code level to account for serial correlation in the outcome within each ZIP code.

- β_1 and β_2 measure the average causal effect on treated loans ("ATT") in 2015 and 2016, respectively.

$$ATT_{2015} = (\mathbb{E}[D_{izst}|s=1, 2015M1 \leq t < 2016M1] - \mathbb{E}[D_{izst}|s=1, t < 2015M1])$$

$$- (\mathbb{E}[D_{izst}|s=0, 2015M1 \leq t < 2016M1] - \mathbb{E}[D_{izst}|s=0, t < 2015M1])$$

$$= \beta_1$$

$$ATT_{2016} = (\mathbb{E}[D_{izst}|s=1, t \geq 2016M1] - \mathbb{E}[D_{izst}|s=1, t < 2015M1])$$

$$- (\mathbb{E}[D_{izst}|s=0, t \geq 2016M1] - \mathbb{E}[D_{izst}|s=0, t < 2015M1])$$

$$= \beta_2$$

Validity of Design: Parallel Trends Assumption
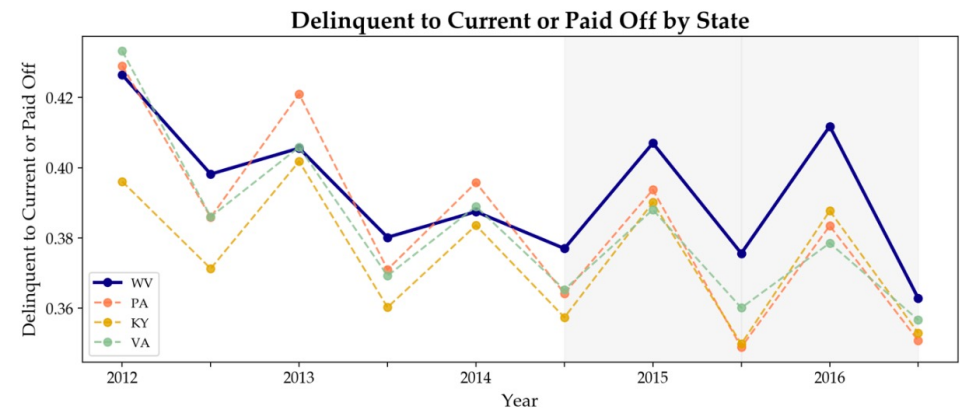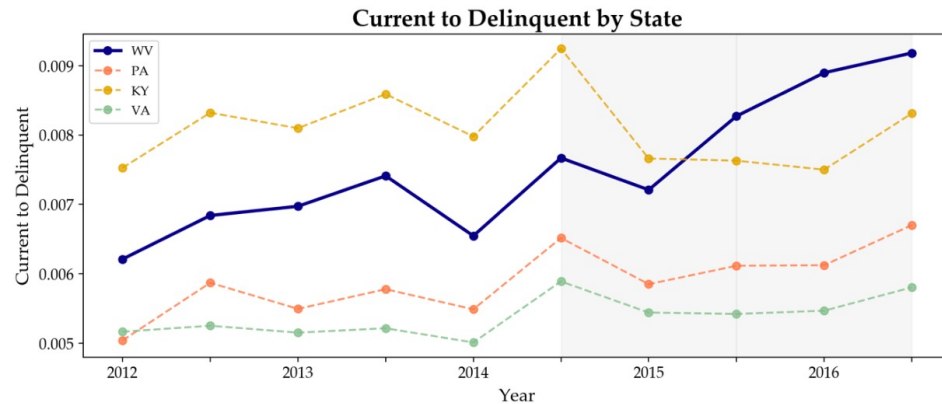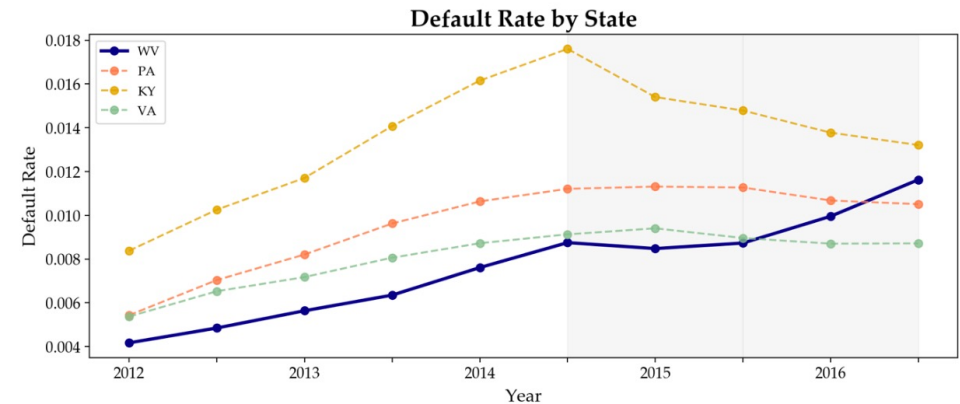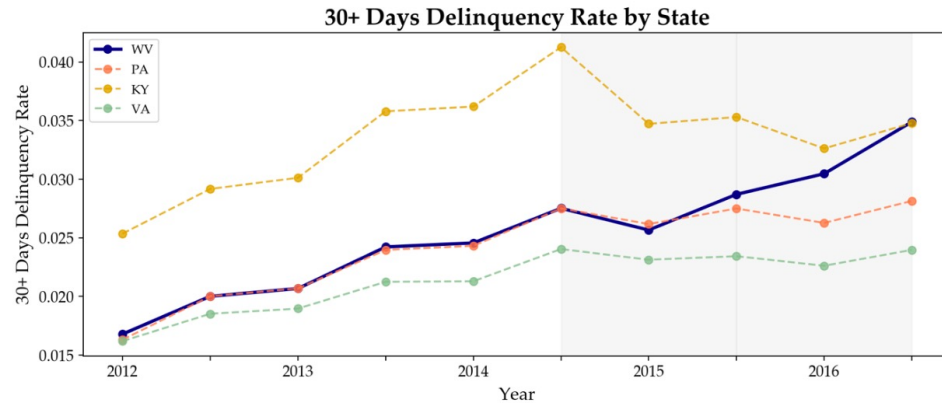
Notes: Exploration of the parallel trends assumption for each response variable. Y-axis ticks show fractional (rather than percent) values. Top left figure plots 30+ DELQ Rate. Top right figure plots DEF Rate. Bottom left figure plots Current → DELQ Rate. Bottom right figure plots DELQ → Current/PO Rate. Each point represents the average value in the response variable over the previous six months.

Principal Findings

- Relative to outcomes in the pre-period in West Virginia, we find:
    I. The probability of being 30+ days delinquent increased by 0.45 p.p. in 2015 and 0.97 p.p. in 2016.
    II. The probability of being in default increased by 0.20 p.p. in 2015 and 0.46 p.p. in 2016.
    III. The probability of being current one month and turning delinquent the next month increased by 0.1 p.p. in 2015 and 0.2 p.p. in 2016.
- A joint hypothesis test for each pair of coefficients in (I) − (III) suggests that the 2015 and 2016 effects are statistically different from each other.
- No significant effect was found on the probability of delinquent loans turning current in 2015 or 2016.

Robustness Checks

- Results robust to:
  - Changes in the pre-treatment window.

- Entire analysis repeated on:
  - Nebraska, which also increased its minimum wage in 2015 and again in 2016 while its bordering states—Iowa and South Dakota—left theirs unchanged.
  - West Virginia ZIP codes *only* near (<15 miles from) the state's border, where we would expect considerably more cross-state commuting for work.

Additional Findings

- Effect of treatment on default (DEF) probability estimated separately for individuals with high, medium, and low LTV and DTI ratios at origination relative to other borrowers in the same state.

- We see the effect in 2016 is more prominent among individuals with higher LTV and/or higher DTI.

  - Suggests that individuals with lower initial equity in their home and tighter initial debt constraints are affected more by the minimum wage increase.

- Interestingly, we see the greatest effect in 2015 among households in the middle-tier DTI.

	2015	2016
Low LTV	x	0.14
Med LTV	x	0.19
High LTV	0.49	1.07
Low DTI	x	0.29
Med DTI	0.28	0.35
High DTI	x	0.74

Notes: Effects that are not statistically significant at the 5% level are marked with 'x'.

Section III:
Summary and Concluding Remarks

Summary

- Important to keep in mind:
  - The nuances of the different empirical strategies used in each section.
  - What these results might suggest about minimum wage policy as a particular *type* of wage increase.

	Section I	Section II
Analysis	• Explored the effect of aggregate wage changes on county-wide delinquency and default rates. • Regressors were fractions describing composition of mortgages within counties over time. • Analysis helped us discern whether wage changes at the county level are associated with people's tendencies to meet their mortgage payments.	• Explored the effect of minimum wage increases on delinquency and default trends.
Results	• Found a negative statistically significant relationship between wages and delinquencies.	• Found precisely the opposite outcome: higher delinquency risk in WV following each of the 2015 and 2016 minimum wage increases.

Conclusion

- This thesis establishes some unique empirical strategies and contributes a strong analytical framework to literature examining mortgage delinquency risk.

- Important takeaway: mortgage debt response to wage changes is complex.
  - On the one hand, mortgage payments may respond positively to aggregate wage increases, though the effect is small.
  - On the other hand, homeowners may be less likely to meet payments after a statewide minimum wage increase.

- Future researchers and policymakers should bear in mind that minimum wage policies may not realize their intended effects.

Further Research Considerations

- Explore the differing effects of permanent and transitory changes by studying how unemployment benefits, lump-sum payments, and/or principal reductions affect borrowers' probability of default.

- Explore how wage increases affect a borrower's timing to delinquency, as opposed to the probability thereof.

- Apply this paper's DID framework or similar methodology to the study of minimum wage increases within other states, augmenting my analysis on West Virginia.

- Consider the effects of other policy implementations on mortgage market dynamics.

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