Why Do Borrowers Default on Mortgages? A New Method for Causal Attribution

Peter Ganong and Pascal Noel

UChicago and NBER

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Sources of mortgage default

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*In good times and bad, a mortgage default can be triggered by a **life event**, such as the loss of a job, serious illness or injury, or divorce.*

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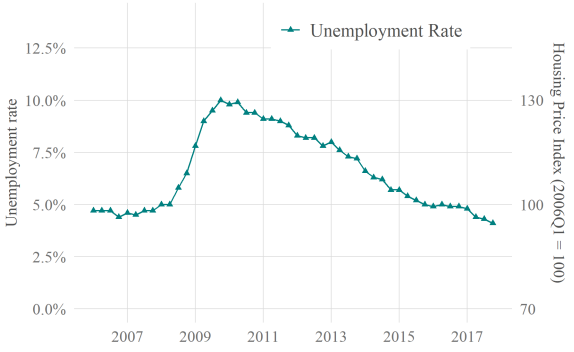

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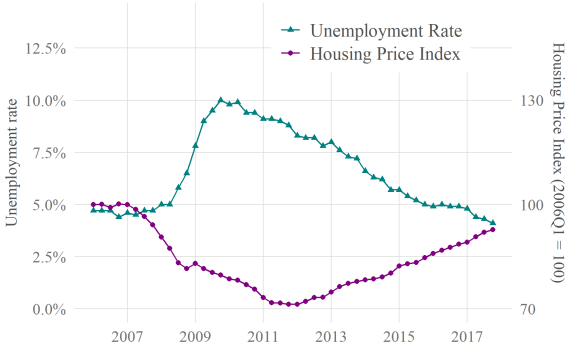

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1. **Negative equity**: option-value (Foster and Van Order 1984)
2. **Cash flow**: life event (Riddiough 1991)
3. Double-trigger: both negative equity and cash flow (Foote, Gerardi, and Willen 2008)

Related literature

Foster and van Order (1984), Epperson, Kau, Keenan and Muller (1985), Riddiough (1991), Vandell (1995), Deng, Quigley, and Van Order (2000), Elul, Souleles, Chomsisengphet, Gennon, and Hunt (2010), Ashworth, Goodman, Landy, and Yin (2010), Keys, Piskorski, Seru, and Vig (2012), Guiso, Sapeinza and Zingales (2013), Mayer, Morrison, Piskorski, and Gupta (2014), Gyourko and Tracy (2014), Ehrlich and Perry (2015), Fuster and Willen (2015), Palmer (2015), Bradley, Cutts and Liu (2015), Adelino, Schoar, and Severino (2016), Scharlemann and Shore (2016, 2018), Bhutta Dokko and Shan (2017), Gerardi, Herkenhoff, Ohanian, and Willen (2018), Haughwout, Okah and Tracy (2016), Agarwal et al. (2017a, b), Di Maggio et al. (2017), Hsu, Matsa, and Melzer (2018), Gupta, Morrison, Fedorenko, and Ramsey (2018), Abel and Fuster (2018), Campbell and Cocco (2018), Schelkle (2018), Bajari, Chu, and Park (2018), Hembre (2018), Ganong and Noel (2019), Gupta and Hansman (2019)

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This paper

Goal

- Separate "strategic" defaults from "cash-flow" and "double-trigger" defaults

Two challenges

1. Mortgage servicing data do not record adverse life events
   - Prior work: coarse measures such as regional unemployment
   - Ingredient #1: link default to contemporaneous bank account income for 3 million borrowers
2. What does a default look like when a life event is a necessary condition?
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Outline

1. Data
2. Empirics: main estimate
3. Empirics: internal and external validity
4. Comparison to model of mortgage default

Outline

Previously-available data

- Review of first wave: Vandell (1995)
  - *"Track a panel of several thousand mortgages from origination and gather detailed information whenever termination occurs"*
- Review of second wave: Foote and Willen (2018)
  - *"Develop data sets that match labor market experiences and default behavior at the individual level"*

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Mortgage servicing (standard)

- Default: three missed payments
- Loan-to-value ratio: $\frac{\text{total mortgage debt on home}}{\text{purchase price} \times \text{CoreLogic price index}}$
  - Robustness 1: Define abovewater as LTV$<$60 (truly abovewater unless house price error of 3 standard deviations)
  - Robustness 2: Measurement error correction using two-sample IV with validation data

Linked bank account (novel)

- Balance: January 2007 to October 2015 (n = 5 million)
- Income: October 2012 to October 2015 (n = 2.9 million)
  - Newly available: income data back to 2007, similar conclusions

Summary Statistics Program Participation

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▸ Summary statistics ▸ Representativeness

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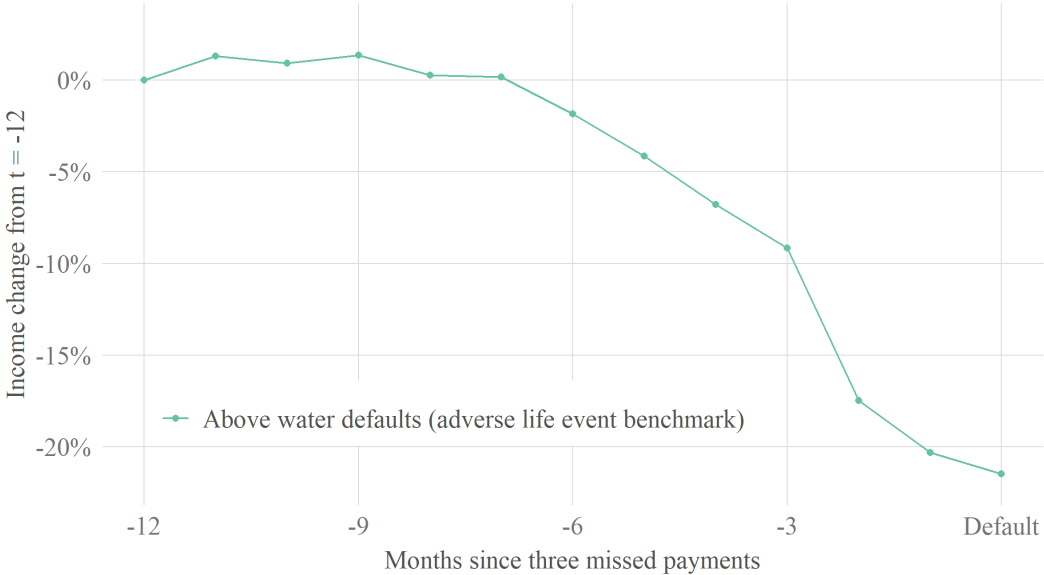

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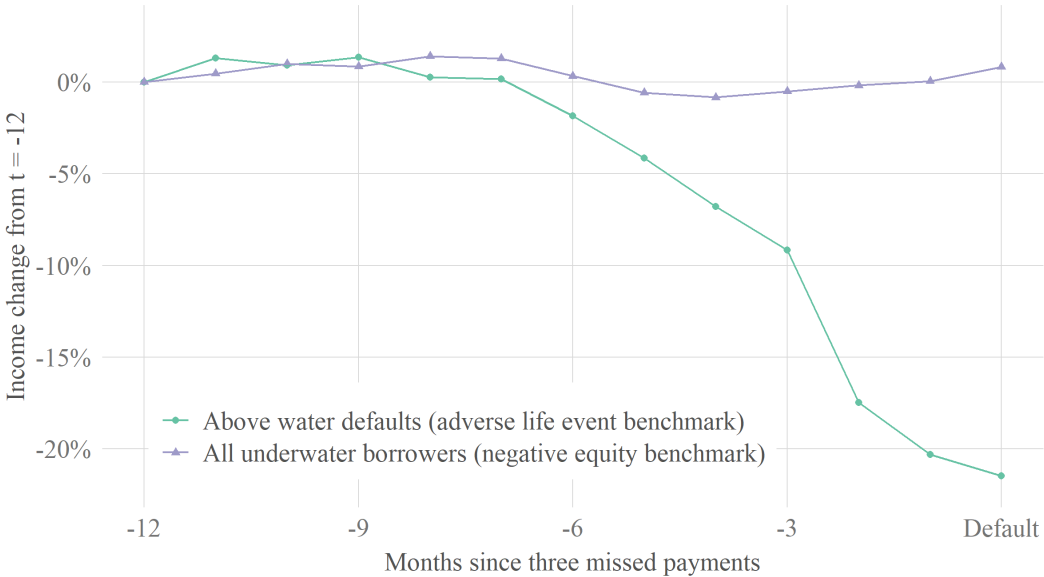

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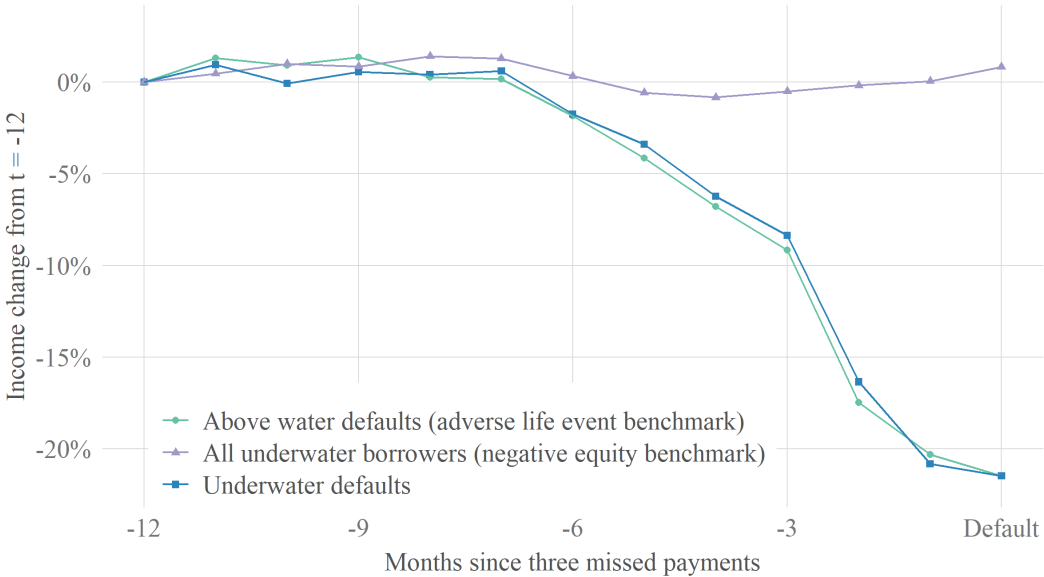

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▸ Formal assumptions

Interpretation relative to prior evidence

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Label	Potential outcomes type for default	Prior estimates	New results
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  - Why lower? Attenuation bias in estimated role of life events
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  - Why lower? Attenuation bias in estimated role of life events
- Double-trigger: *conditional* on life event, negative equity may raise likelihood of default [Gerardi et al. 2018, Mian and Sufi 2011, Palmer 2015, Chan et al 2016, Gupta and Hansman 2019]
- ...but negative equity not a necessary condition for *all* defaults (i.e. cash-flow) [Low 2018]

▸ Double Trigger Binscatter

Further decomposing mechanisms driving mortgage default

New estimates + prior evidence on causal impact of negative equity (Gupta and Hansman 2019, Palmer 2015):

Label	Prior estimates	New Results	Decomposition
			New + Palmer
Strategic	30-70%	3%	3%
Cash-flow	0%	97%	70%
Double-trigger	30-70%		27%

Lesson 1: 70% of underwater defaults driven *exclusively* by cash-flow

Lesson 2: How important is each channel?

- No life events → eliminate 97% of defaults (cash-flow + double-trigger)
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Internal and External Validity: Roadmap

"Only 3% of defaults are strategic"

Internal validity

- Are results similar after relaxing expositional assumptions? Yes.
- Can the method detect *any* strategic default? Yes.

External validity

- Do we find similar results in another dataset? Yes.
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▸ Campbell-Cocco Model ▸ Conclusion

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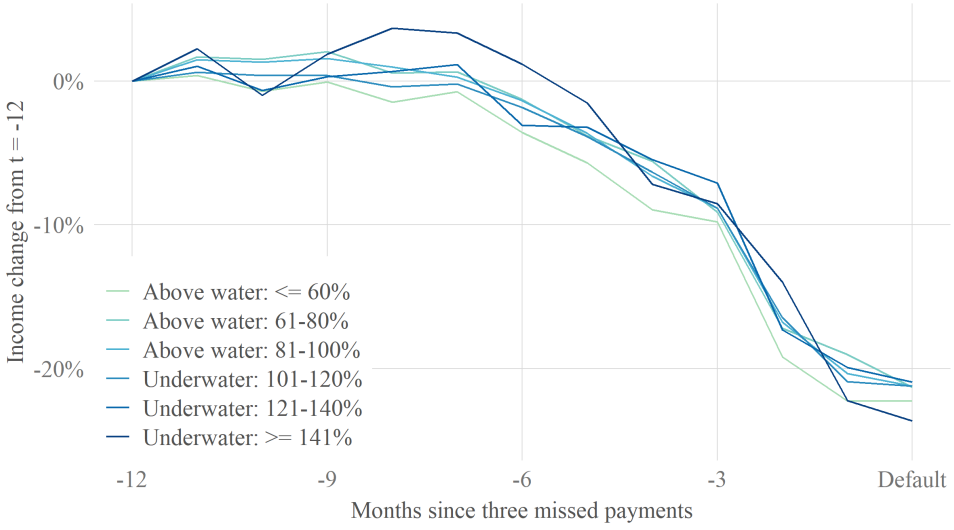

Relax expositional assumption: mean as summary statistic

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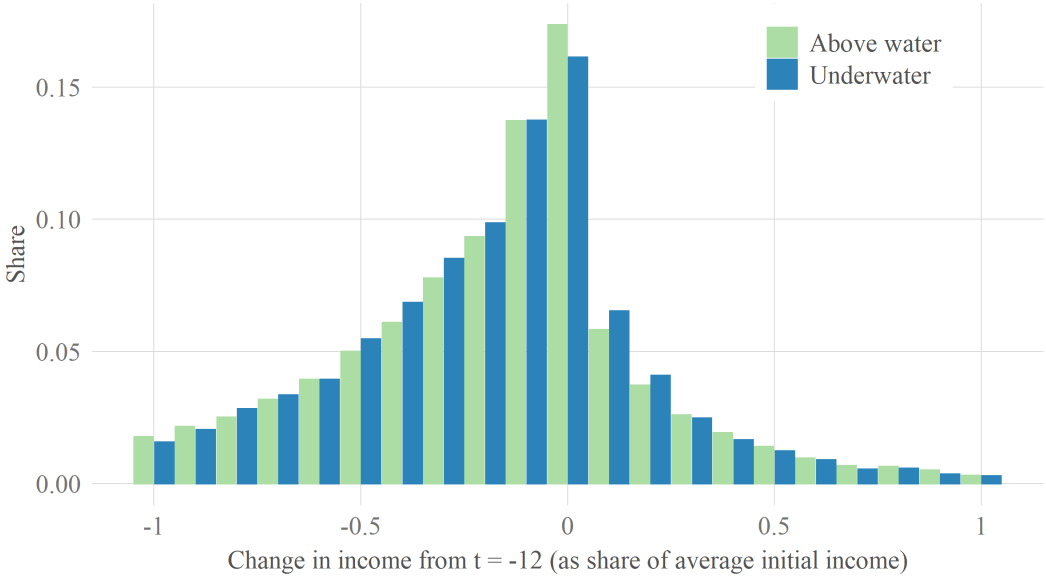

3% of defaults finding: relaxing assumptions

- Already shown
  - Alternative LTV cutoffs ▸ LTV income ▸ LTV balances
  - Entire distribution of change in income

- Further robustness
  - Account for LTV mismeasurement ▸ LTV Mismeasurement
  - Alternative numbers of missed payments ▸ Days past due
  - Bank account balance ▸ Balance
  - Separate estimates by year from 2008 to 2014 ▸ Years
  - Non-recourse states ▸ Non-recourse
  - Test for income manipulation ▸ Manipulation
  - Investors ▸ Investors

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- Motivated by Mayer, Morrison, Piskorski, and Gupta (AER 2014)
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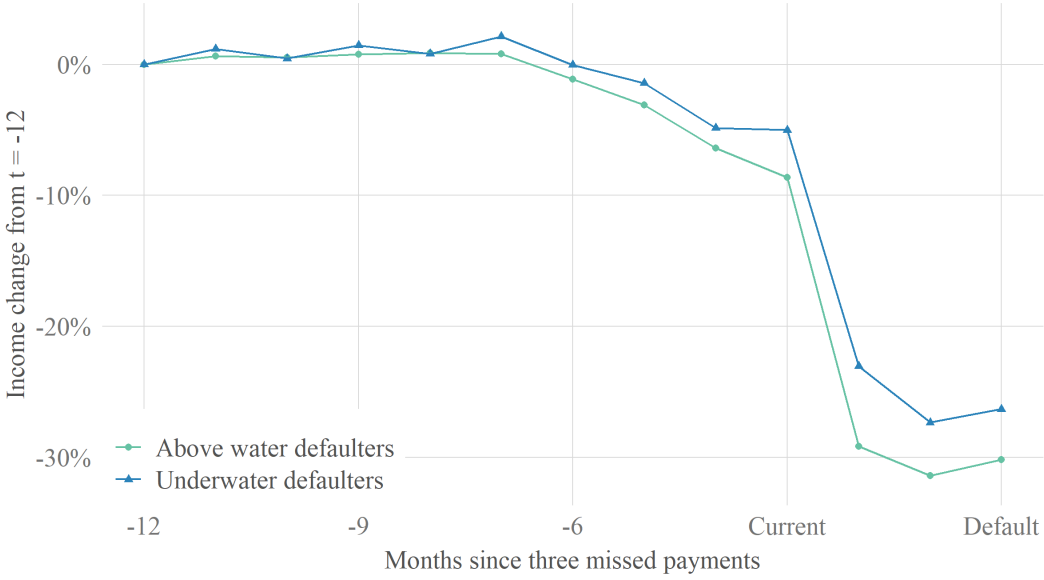
Figure: Defaults with three consecutive missed payments



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- Re-analyze Panel Survey of Income Dynamics (PSID)
- Survey data complement administrative data in three ways
  1. Enable crosswalk to prior estimates which showed substantial strategic default
     - Gerardi, Herkenhoff, Ohanian and Willen (RFS 2018): 30%-70%
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▸ CRISM

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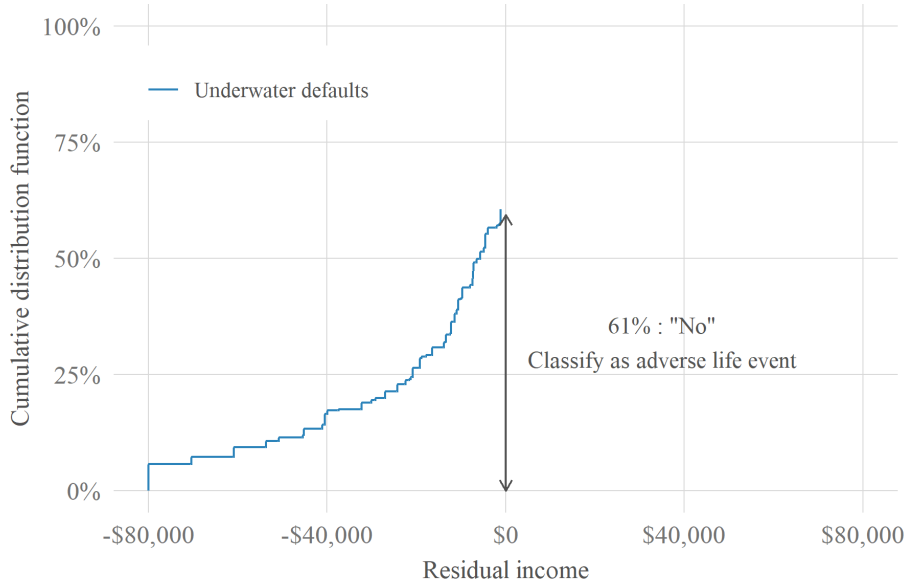

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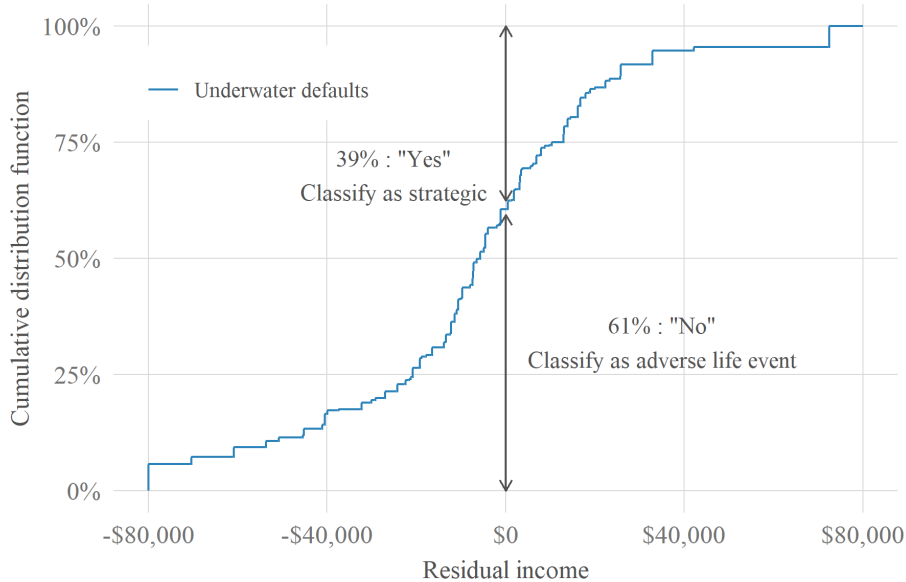

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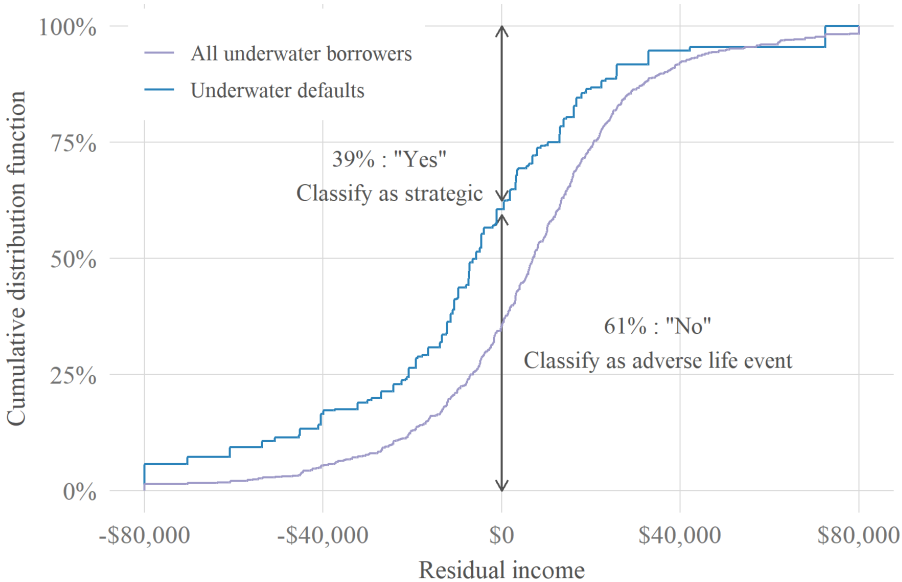

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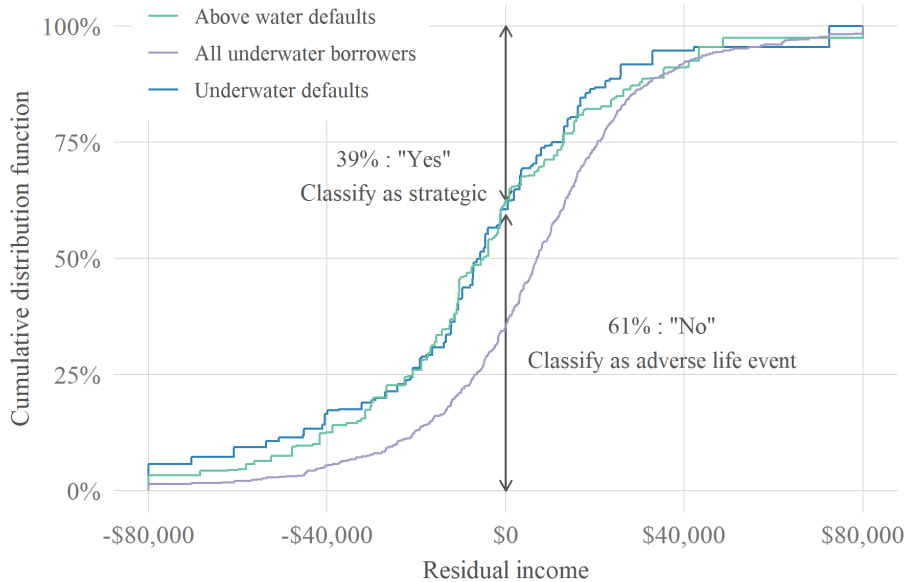

Internal and external validity: summary

- Finding of almost no strategic default is robust to
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  - Summary statistic for income
  - Dataset

- Does anyone strategically default?
  - Yes. Subsample with three consecutive missed payments.

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Comparison to model of mortgage default

Use Campbell and Cocco (JF 2015) [Campbell and Cocco (2015)]

- Why?
  - First structural model to incorporate *both* negative equity *and* cash-flow motives for defaulting
- How does the model work?
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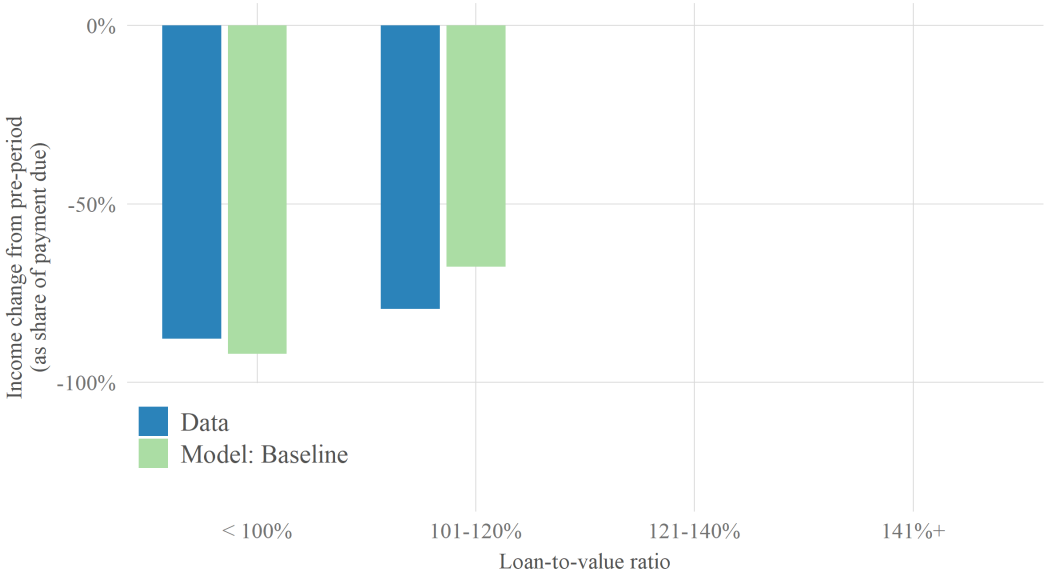

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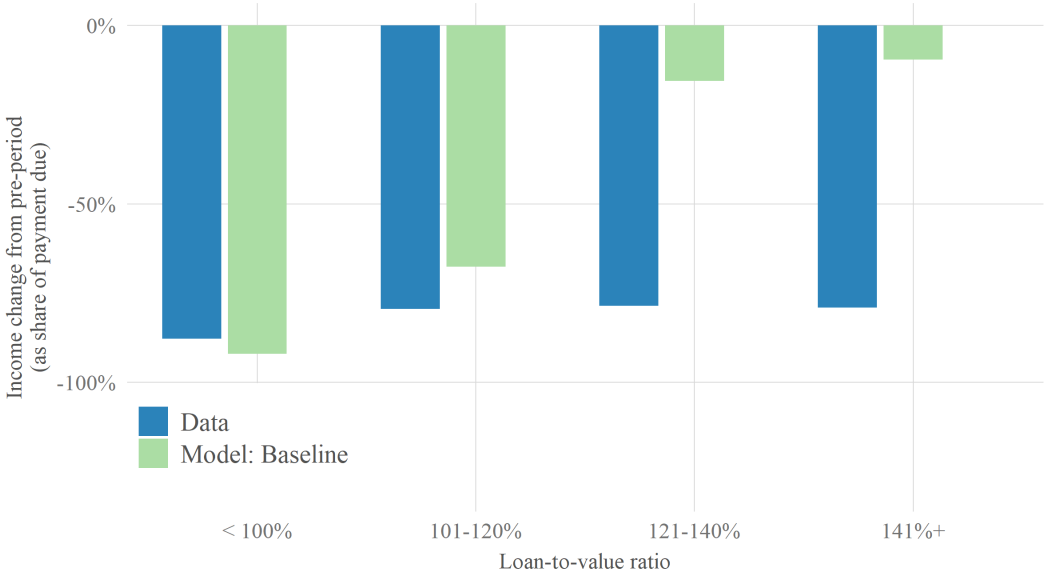

Reconciling model and data

- Why does baseline model expect defaults without income loss when deeply underwater?
  - Benefit of defaulting is large
  - Cost is small
- But in practice, default cost may be large
  - Reduced access to credit, attachment to one's home, social stigma, moral aversion to default
- Model allows for utility cost of default in an extension
  - ...but "the main difficulty with this extension of our model is determining an appropriate value"
  - Recent estimates range from 2%-70% decrease in constant-equivalent consumption stream [Hembre 2018, Schelkle 2018, Laufer 2018]
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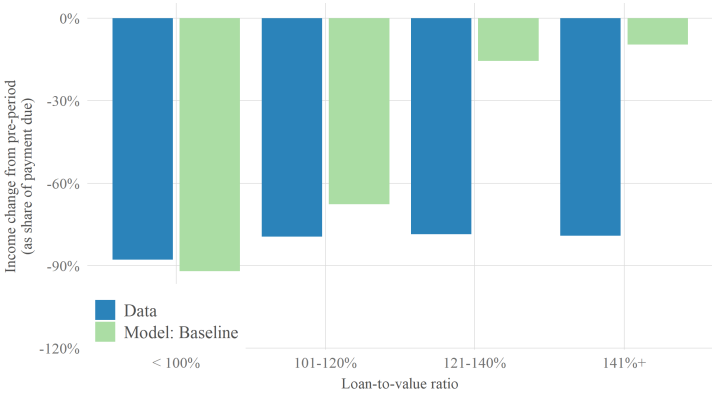

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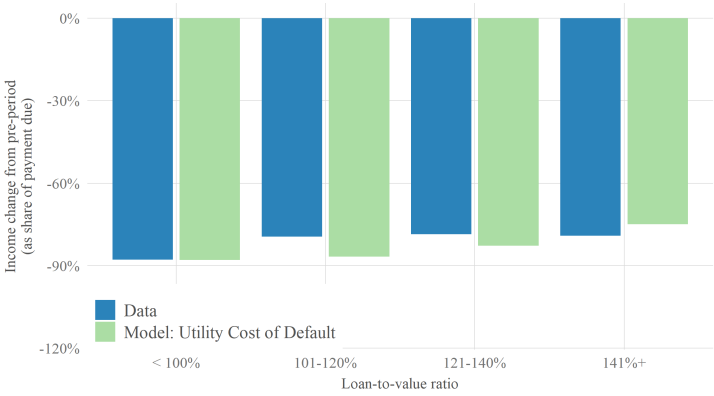

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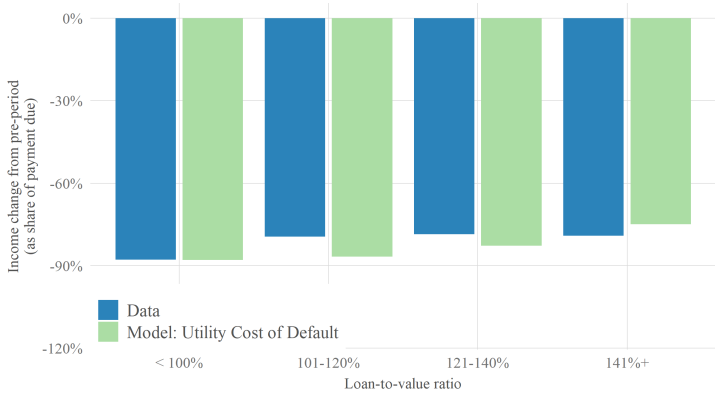

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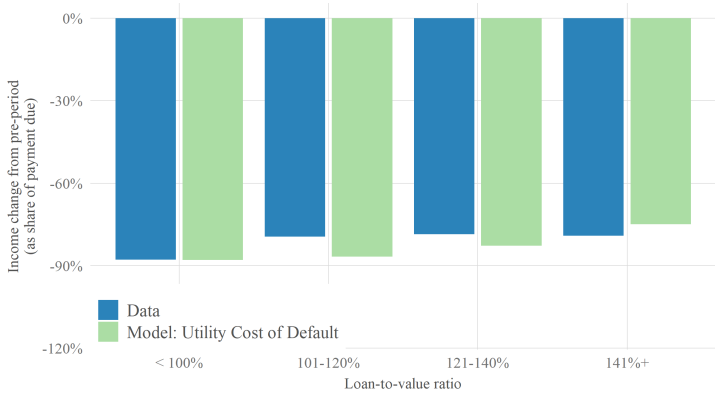

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Potential blueprint for mortgage default models

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  - Models used for analyzing optimal mortgage security design, origins of financial crisis, macroprudential regulation, etc.
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Why should we care about sources of mortgage default?

- Ex-ante policy
  - Payment-to-income target at origination, or ongoing affordability measures?
- Understanding default crises
  - Nouriel Roubini: 15 million "jingle mail" strategic defaults coming!
  - Method for better predicting defaults in future crisis
- Models
  - Endogenous default decision key input for macro/finance models
  - Example questions: mortgage security design, macroprodential regulation, origins of Great Recession

Back

Comparison to prior metrics literature

Comparison To Multiple Indicator Approach (Algebra)

$$Y(T_a, ...) \quad [Y \text{ is monotone in } T_a]$$

$$\tilde{T}_a = \alpha T_a + \eta \text{ with } \eta \perp Y(T_a) \quad [\text{Assumption 3}]$$

$$\tilde{T}_{a2} = \alpha T_a + \eta_2 \text{ with } \eta_2 \perp Y(T_a) \quad [\text{Standard Approach}]$$

$$Y(0,0) = 0 \quad [\text{Assumption 2}]$$

Comparison To Multiple Indicator Approach (Table)

Y	T_a	$\tilde{T}_a$	Z	T_b
#	...	#	#	...
#	...	#	#	...
1	1	#	...	0
1	1	#	...	0

Legend: shared, multiple indicator approach, our approach

Notes: # = data, ... = missing

Comparison to Difference-in-difference

Control group gives a counterfactual for what would have happened to...

- The outcome variable in the absence of treatment $Y(0)$
  - Enables causal impact of treatment
- The noisy measure of treatment A in the absence of treatment B and the presence of treatment A $\bar{T}_a(1,0)$
  - Enables causal attribution of treatment A (i.e.,α)

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  - Enables causal impact of treatment
- The noisy measure of treatment A in the absence of treatment B and the presence of treatment A $\tilde{T}_a(1,0)$
  - Enables causal attribution of treatment A (i.e.,α)

Comparison to Instrumental Variables

- Typical IV approach has instrument Z that
  - affects T_a
  - has no effect on Y except through T_a
- Our approach has placebo T_b
  - does not affect T_a
  - may affect Y

Back

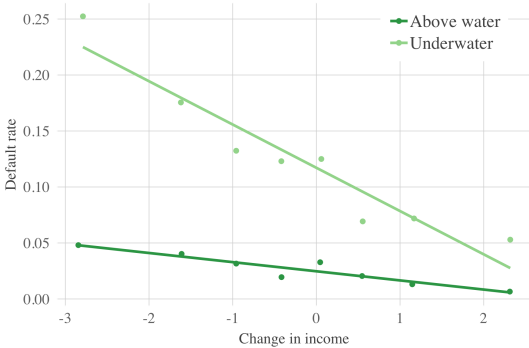
Comparison to Reverse Regression

- Goldberger (1984) wants to know if there is wage discrimination
  - cannot observe productivity, but can observe noisy measure (credentials)
  - put credentials on left-hand side, where noise averages to zero
  - condition on wage bin, compare average credentials of women and men
- Our approach
  - cannot observe adverse cash-flow shock, but can observe noisy measure (Δinc)
  - put Δinc on left-hand side, where noise averages to zero
  - condition on default, compare average Δinc for underwater and abovewater

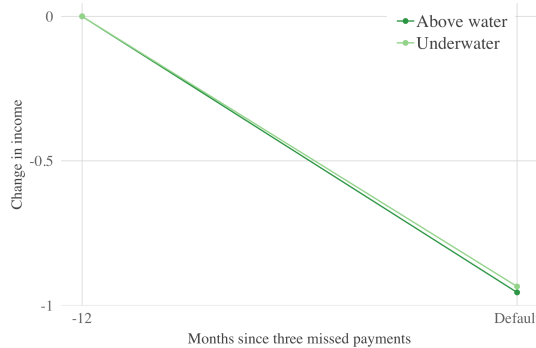
Back

Measurement error simulations

Figure: Simulation 1



(a) Regress Y on X



(b) $E(X|Y=1)$

Assumptions

Distribution (T, G, Y, Z) where T, G, and Y are binary

1. Conditional exogeneity $T \perp Y(t,g)_{\forall t,g} | G$ (standard)
   1. *Content: conditional on home equity, no omitted factor causing both life event and default*
2. Noisy measure of treatment (standard)
   1. $Z(T, Y, G) \perp (Y_{tg \forall t,g}, G)$
   2. $Z(T, Y, G) = Z(T)$
      1. *Content of (1) and (2): relationship between life event T and income change Z unrelated to home equity G or default decision Y*
   3. $E(Z(1)) \neq E(Z(0))$
3. $Y(0,0) = 0$ (novel)
   1. *Content: default requires either life event T or negative equity G*

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A new method for estimating α

- Two ingredients
  - Noisy measure of treatment (standard)
  - Group treated with certainty (novel)
- Intuition for proof
- Result

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Environment and ingredient: noisy measure of life event

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- T binary treatment, unobserved *(life event)*
- G binary group *(negative home equity)*
- $Y(T, G)$ binary outcome *(default)*
- $Z(T, G, Y)$ *(change in bank income)*

Assumptions

1. Conditional exogeneity $T \perp Y(t, g)_{\forall t,g} | G$
   - *Content: conditional on home equity, no omitted factor causing both life event and default*
2. Z is noisy measure of treatment T
   1. $E(Z(1, g, y)) \neq E(Z(0, g, y) \quad \forall g, y$
      - *Content: life event T affects income change Z*
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   3. $Z(T) \perp (G, Y(t, g)_{\forall t,g})$
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Recap: Y = Default(Life event, Negative equity)

3. Assume $Y(0,0) = 0$
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Institutional context on above water default

- Is it even possible?
  - Yes. Significant frictions to liquidating home equity (DeFusco and Mondragon 2018).
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Theorem

Under assumptions 1, 2 and 3

$$\alpha \equiv \frac{E(Y) - E(Y_0)}{E(Y)} = \frac{E(Z|Y=1, G=1) - E(Z|G=1)}{\underbrace{E(Z|Y=1, G=0)}_{\alpha=1 \text{ benchmark}} - \underbrace{E(Z|G=1)}_{\alpha=0 \text{ benchmark}}}$$

In our application

$$\alpha = \frac{E(\Delta Income^{UnderwaterDefaulter}) - E(\Delta Income^{UnderwaterAll})}{\underbrace{E(\Delta Income^{AbovewaterDefaulter})}_{\alpha=1 \text{ benchmark}} - \underbrace{E(\Delta Income^{UnderwaterAll})}_{\alpha=0 \text{ benchmark}}}$$

Goal of next section: estimate these three terms

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1. Default requires life event or negative equity: $Y(0,0) = 0$
   - Implication: above water defaulters had life event ($P(T^* = 1|Y = 1, G = 0) = 1$)
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Assumptions 2 and 3 (From classical errors-in-variables problem)

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Econometrics: algebra

- Assumptions
  - 1 & 2 (standard)
  - 3 (novel)
- Intuition for proof
- Result

Assumption 1: conditional exogeneity

$$T \perp \{Y(t,g)\}_{\forall t,g} | G$$

- Lost cash flow from adverse event is conditionally exogenous wrt $Y(.)$
- What does and doesn't this rule out?
  - Rules out: lose job $\rightarrow$ depressed $\rightarrow$ miss payment
  - Does not rule out heterogeneous treatment effects
    - Larger impact of adverse life events when home equity is negative
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Assumption 2: noisy measure of treatment

Without loss of generality

$$E(Z(t,g) \mid t, g, Y = 1) \equiv \lambda_0 + \lambda_t t + \lambda_g g + \lambda_{tg} tg$$

Intuition: treatment affects Z, group status does not.

Note: This is key economic restriction. Additional details in paper.

Mortgage default application

- When adverse life event occurs, $E(\Delta Income) \neq 0$
- Foster and Van Order (1984) model of negative equity default: "personal characteristics of the borrower (income, employment status, etc.) are irrelevant"
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- Outcome $Y = 1$ requires either $T = 1$ or $G = 1$ ($Y(0,0) = 0$)
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- If default & above water $\Rightarrow$ experienced an adverse life event
  - Is above water default even possible?
    - Yes. Significant frictions to liquidating home equity (DeFusco and Mondragon 2018).
  - Is above water default common?
    - Yes. Even in nadir of crisis, $> 40\%$ of defaults (Low 2018).

Assumption 3: group treated with certainty

- Outcome $Y = 1$ requires either $T = 1$ or $G = 1$ ($Y(0,0) = 0$)
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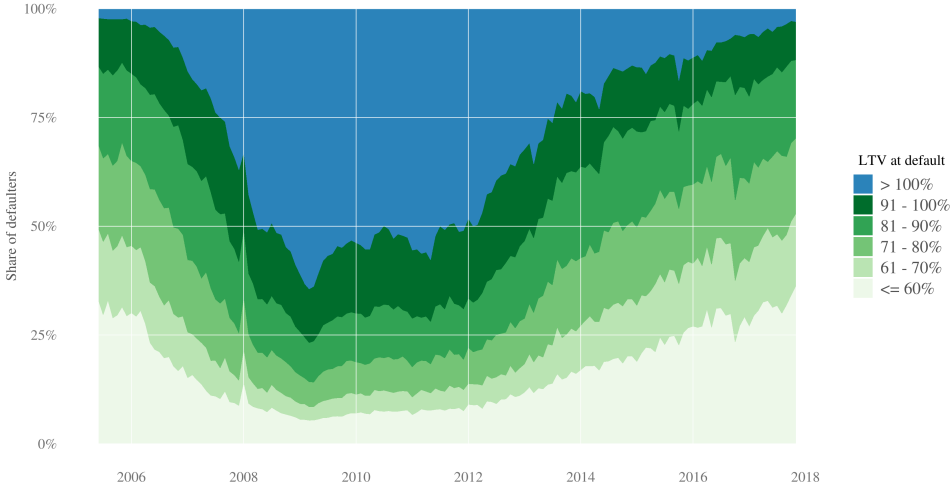
▸ Back



Source: CRISM

Sample description

Variable	Admin Bank	Benchmark
Median Monthly Payment	$810	$817
Median Loan Balance	$128,000	$118,000
Share 30 Days Delinquent	5.6%	7.7%
Median Monthly Income	$4,129	$5,519

Benchmark sources: American Community Survey, NBER Taxsim, Survey of Consumer Finances, Federal Reserve

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Table: Summary statistics by home equity

Sample	Benchmark	Chase	CRISM	McDash
All mortgages	90 day delinquency rate	3.2%	3.3%	3.8%
All mortgages	Share investor	6.8%	3.9%	5.6%
All mortgages	Share primary occupant	89%	93%	91%
All mortgages	Share underwater	19%	22%	
Defaulters	Share investor	6.4%	4.3%	5.9%
Defaulters	Share primary occupant	90%	94%	92%
Defaulters	Share underwater	50%	58%	
Defaulters	Share of above water defaults with foreclosure within year	40%	55%	
Defaulters	Share of underwater defaults with foreclosure within year	45%	57%	

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Figure: Balances prior to default

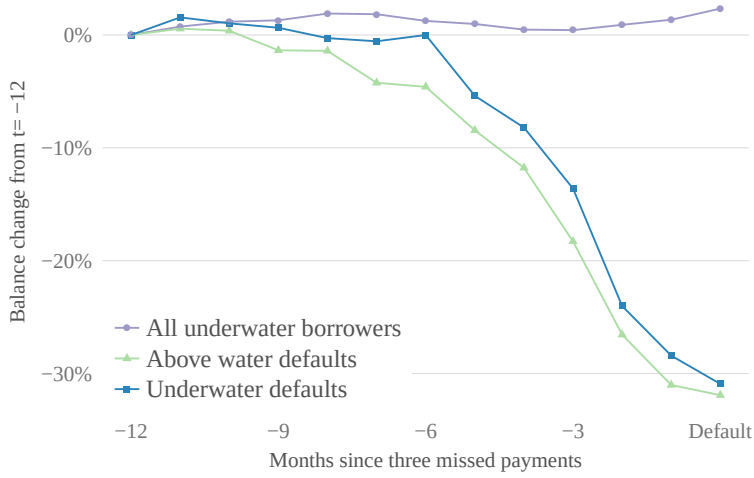

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Table: Summary statistics by home equity

Variable	Above water	Underwater
Combined loan-to-value ratio (%)	71	121
Monthly bank account income ($)	4,053	4,436
Bank account balance ($)	1,455	1,692
Property value ($)	243,094	235,149
Monthly mortgage payment due ($)	966	1,137
Age	50	50
Share with joint deposit account	0.4	0.44
N	22,687.0	6,347.00

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Interpretation relative to prior evidence

"Only 3% of underwater defaults are strategic; 50% driven solely by life events"

Default motivation	Potential outcomes interpretation	Prior estimates	Our findings
Strategic	Negative equity is necessary and sufficient	30-70%	3%
Double-trigger	Both life event and negative equity are necessary	30-70%	47%
Cash-flow	Life event is necessary and sufficient	NA	50%

- Defaults eliminated without negative equity: 50% (strategic + double-trigger)
- Defaults eliminated without life events: 97% (cash-flow + double-trigger)

Figure: Robustness: loan-to-value ratio

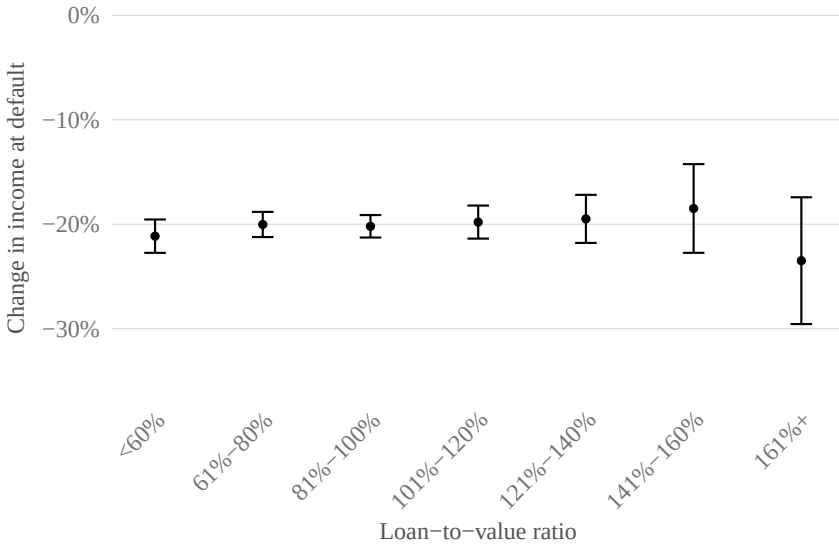

Figure: Distribution of Measurement Errors in LTV from Corelogic

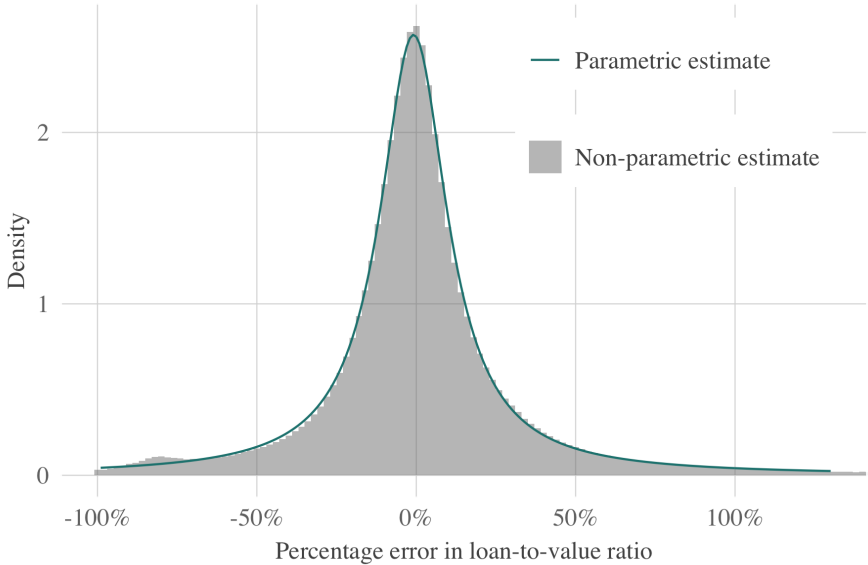

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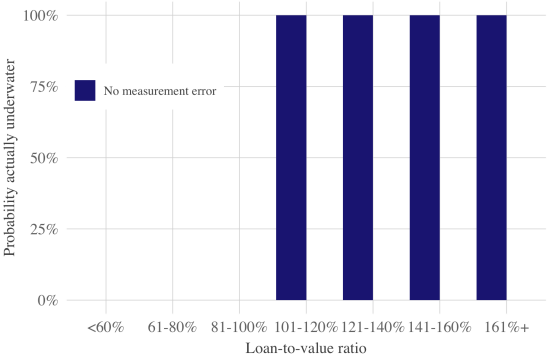
Figure: Correct for measurement error in observed LTV using two-sample IV



- First stage: relationship of true underwater status and observed LTV in Corelogic
- Second stage: relationship of income drop and instrumented underwater status in Chase

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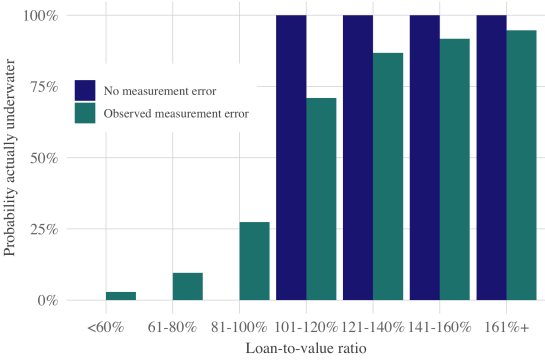

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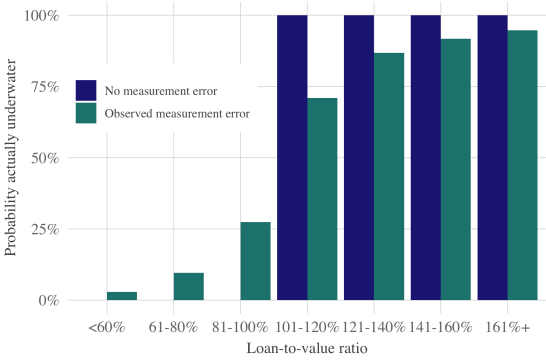

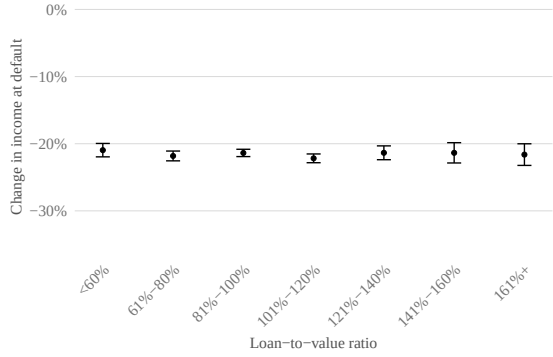

- First stage: relationship of true underwater status and observed LTV in Corelogic
- Second stage: relationship of income drop and instrumented underwater status in Chase

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LTV measurement error correction: methodology

If we could observe whether each borrower is underwater (G^*), our estimation equation would be

$$\frac{Income_{it}}{\bar{Income}_{pre}} = \lambda \mathbf{1}(G^* = 0) + \kappa \mathbf{1}(G^* = 1) + \gamma \times POST \times \mathbf{1}(G^* = 0) + \beta \times POST \times \mathbf{1}(G^* = 1) + \varepsilon.$$

Because we do not observe G^*, we use two-sample IV to instrument for it. Using $P(G^* = 1|LTV)$ implied by the Corelogic validation dataset (first stage), we run the second stage regression:

$$\frac{Income_{it}}{\bar{Income}_{pre}} = \lambda P(G^* = 0|LTV_i) + \kappa P(G^* = 1|LTV_i) + \gamma \mathbf{1}(t = -2, -1, 0) \times P(G^* = 0|LTV_i) + \beta \mathbf{1}(t = -2, -1, 0) \times P(G^* = 1|LTV_i) + \varepsilon_{it}. \quad (1)$$

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Figure: Robustness: loan-to-value ratio using bank account balances

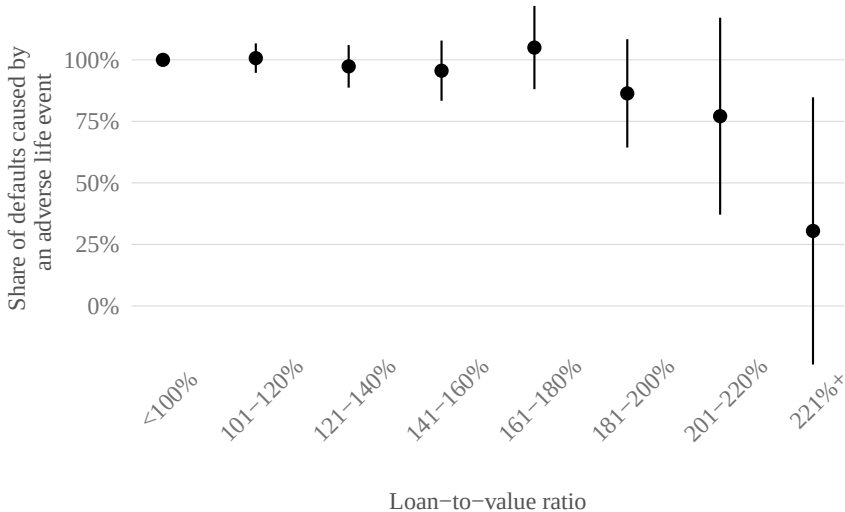

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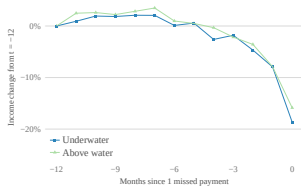
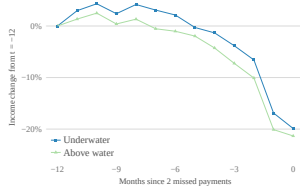
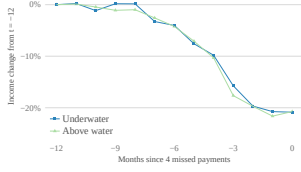
Figure: Income drops at default: missed payment thresholds



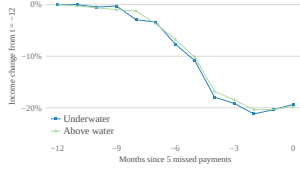
(a) One missed payment



(b) Two missed payments



(c) Four missed payments



(d) Five missed payments

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Figure: Heterogeneity by year

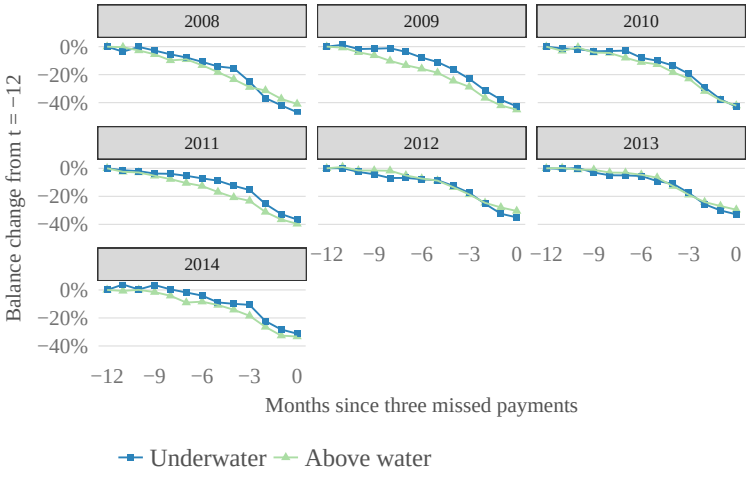

Figure: Non-recourse States

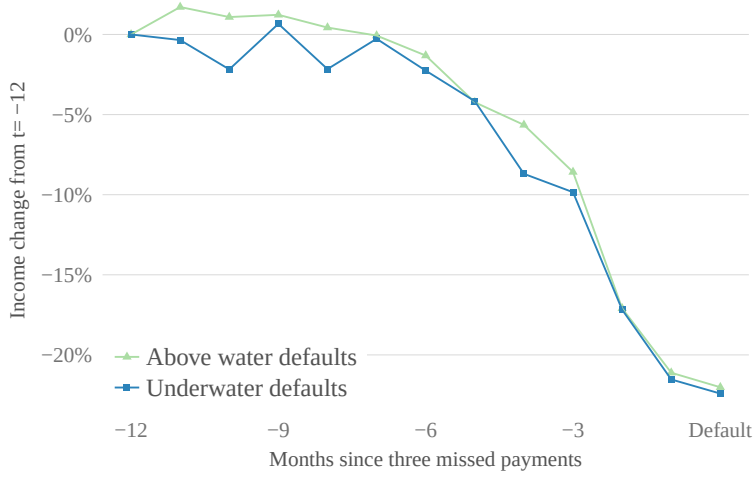

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Figure: Test for manipulation: Social Security income

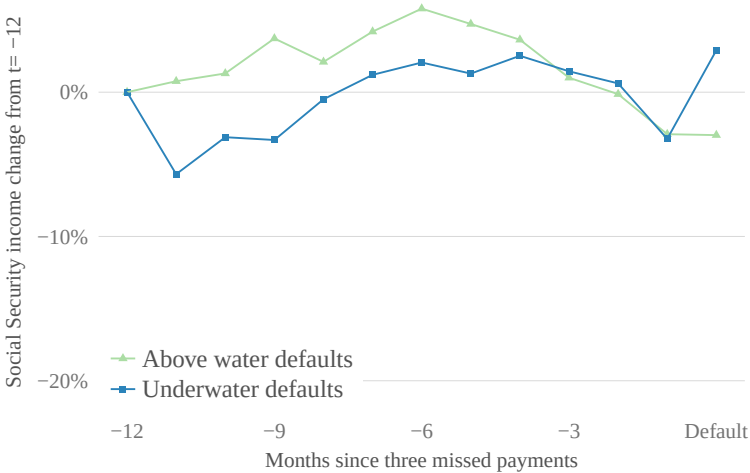

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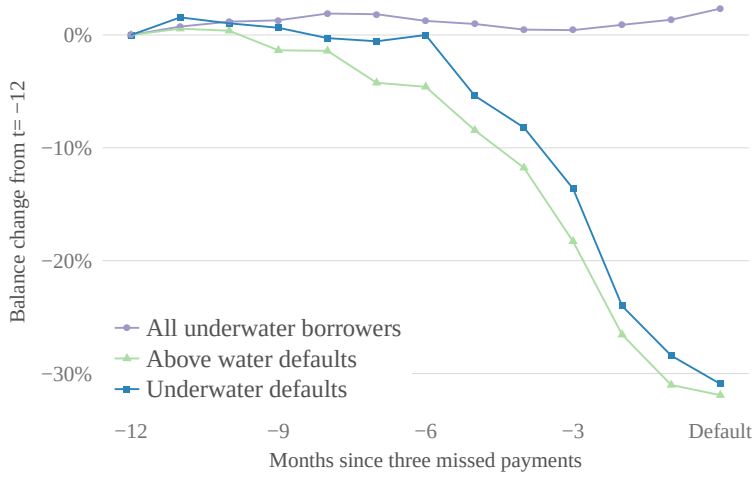
Figure: Balances prior to default



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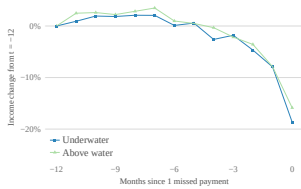

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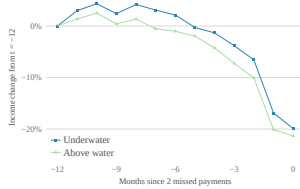
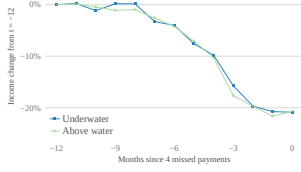


(b) Two missed payments



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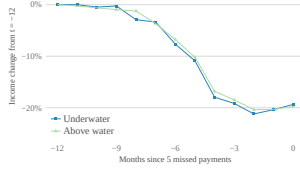

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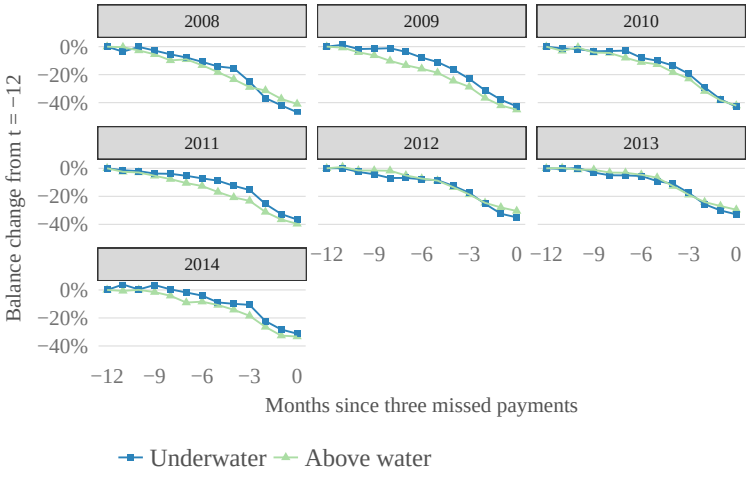

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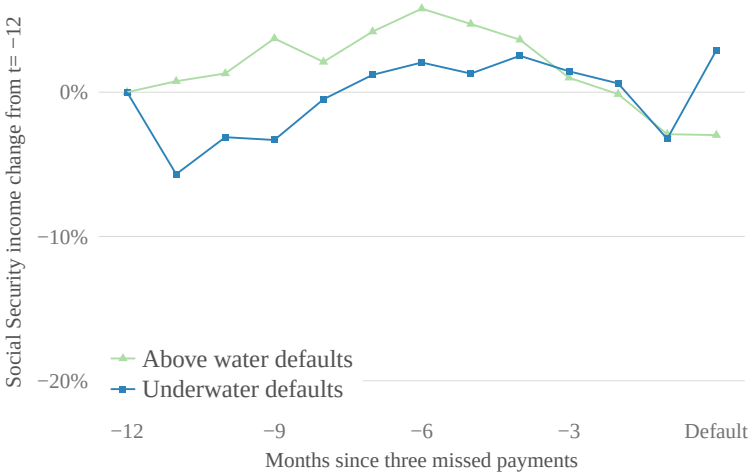

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Payment before default by LTV

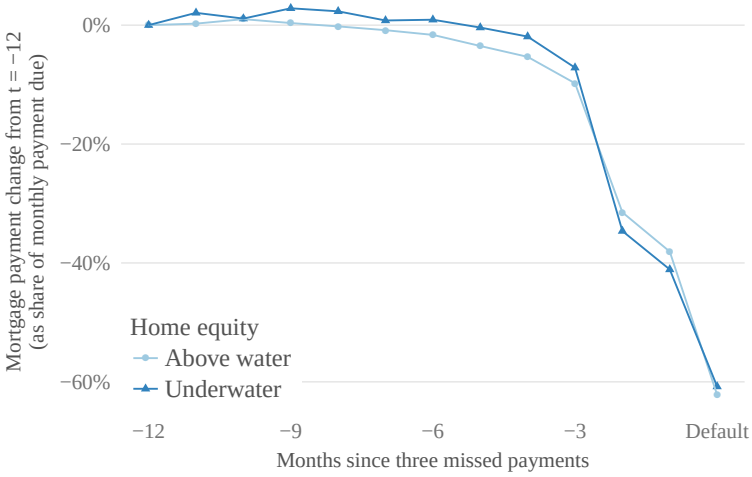

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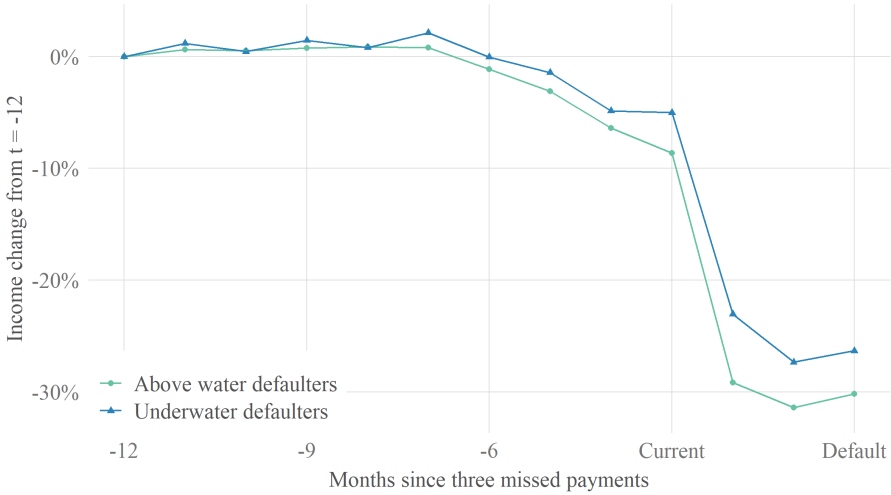
Figure: Defaults with three consecutive missed payments



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Might investors be more strategic?

- We can measure self-declared investors
  - Make up about 6% of mortgages and 6% of defaults, both in bank dataset and LPS (2011)
  - No excess defaults, income loss big for underwater investor defaults too

- Real concern may be fraudulent investors
  - Elul and Tilson (2016): 6% of mortgages but 12% of defaults
  - Evidence *consistent* with substantial fraction being strategic

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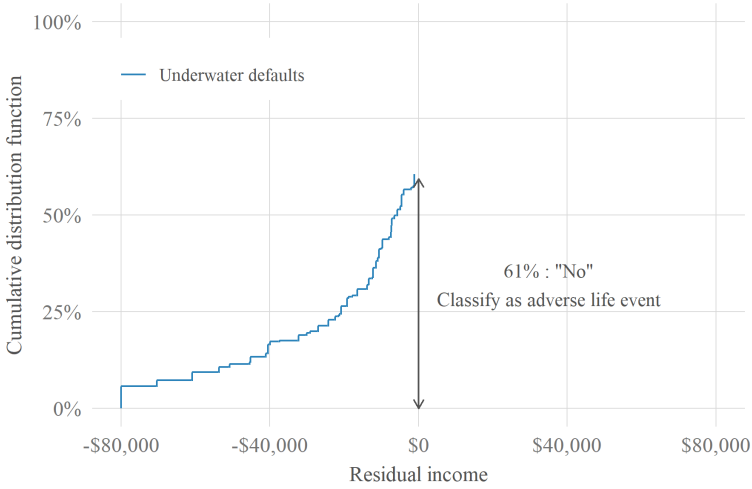
Figure: Can borrower pay mortgage without cutting consumption?



Source: Panel Study of Income Dynamics

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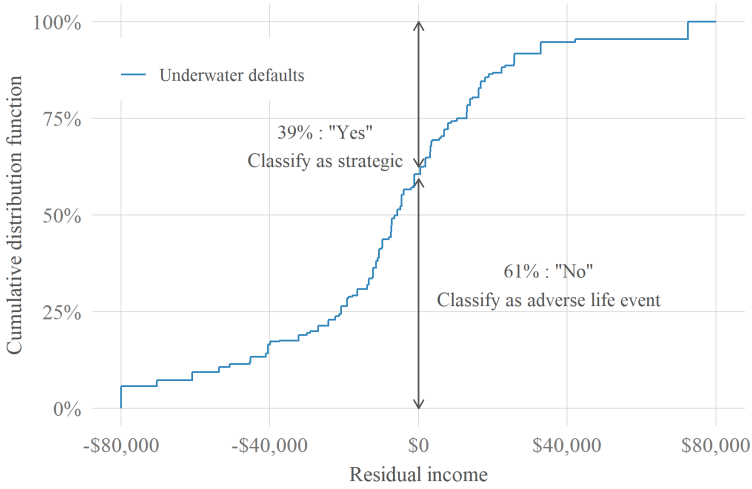

Source: Panel Study of Income Dynamics

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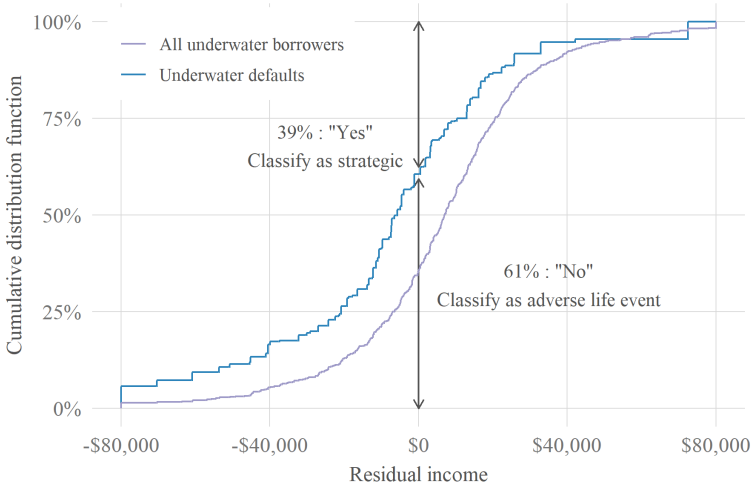

Source: Panel Study of Income Dynamics

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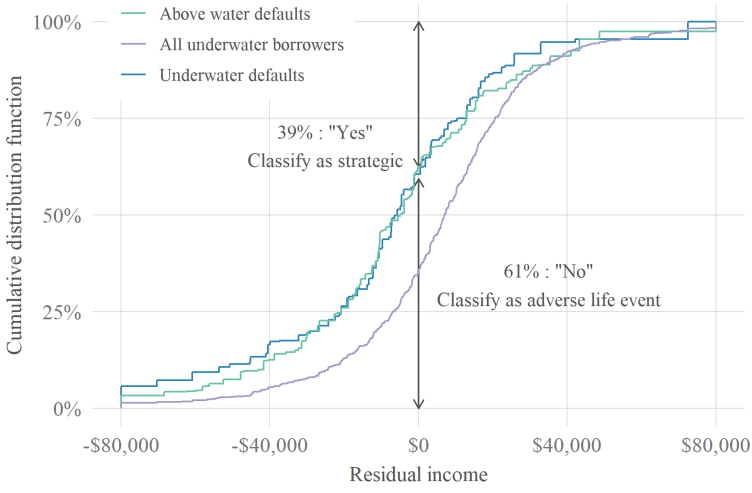

Source: Panel Study of Income Dynamics Back

Relation to prior research on mortgage modifications?

1. How? Use different moments
   1. Use variation in cash-flow, not variation in mortgage contract
2. Who? Larger set of compliers. Includes defaulters:
   1. Who did not receive modifications
   2. Who have LTV > 130
      1. This is group where prior work said strategic default is most likely
   3. Who are not compliers in quasi-experimental research designs
3. What can we learn from this larger group?
   1. Main goal: understand mechanisms to inform models with default
   2. Remark: still have some implications for modification policy

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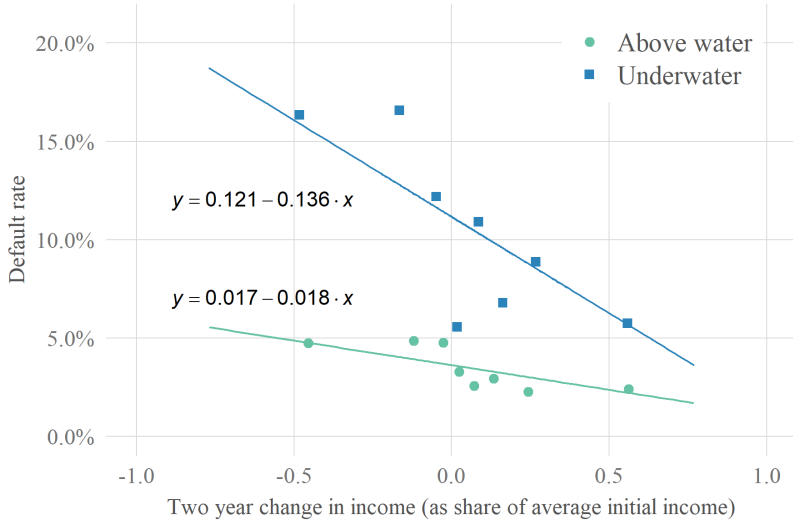
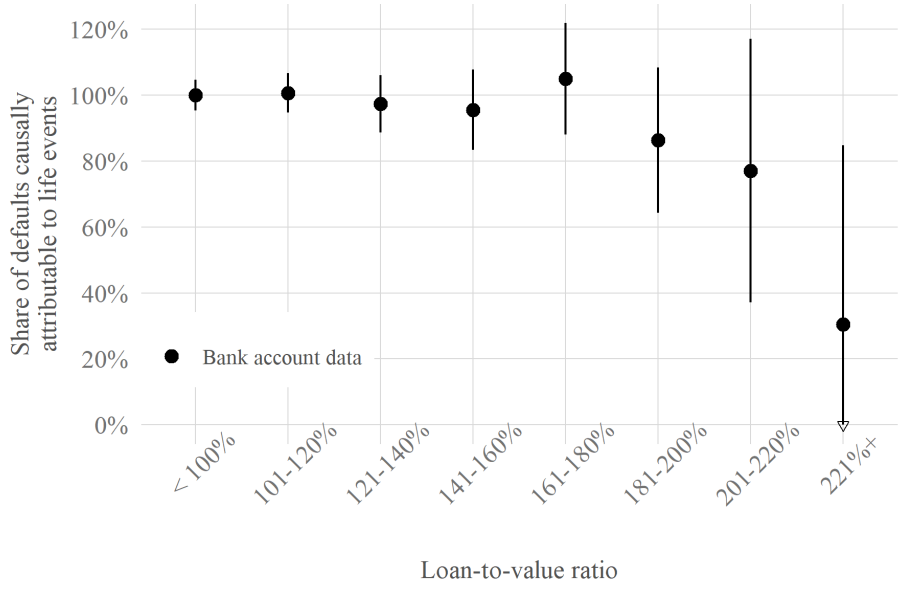
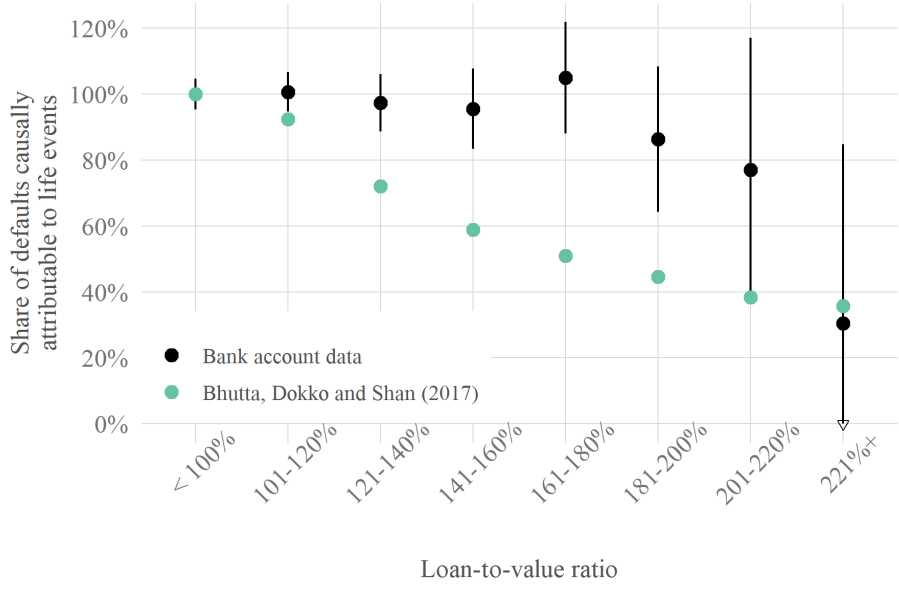
Figure: Income shocks and default by LTV



Back to Prior Lit


Share of defaults causally attributable to life events
120%
100%
80%
60%
40%
20%
0%
Bank account data
< 100%
101-120%
121-140%
141-160%
161-180%
181-200%
201-220%
221%+
Loan-to-value ratio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Bank account data
Bhutta, Dokko and Shan (2017)
< 100%
101-120%
121-140%
141-160%
161-180%
181-200%
201-220%
221%+
Loan-to-value ratio

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Table: Regression estimates of income drop at default

	Dependent variable:			
	Change in income from one year before default			
	Mean	Median	p25	p75
	(1)	(2)	(3)	(4)
Date of default	−0.203	−0.175	−0.145	−0.269
	(0.004)	(0.005)	(0.004)	(0.008)
Date of default * underwater	0.006	−0.014	−0.004	−0.006
	(0.007)	(0.010)	(0.010)	(0.017)
N mortgages	29,034	29,034	29,034	29,034
Observations	174,204	174,204	174,204	174,204

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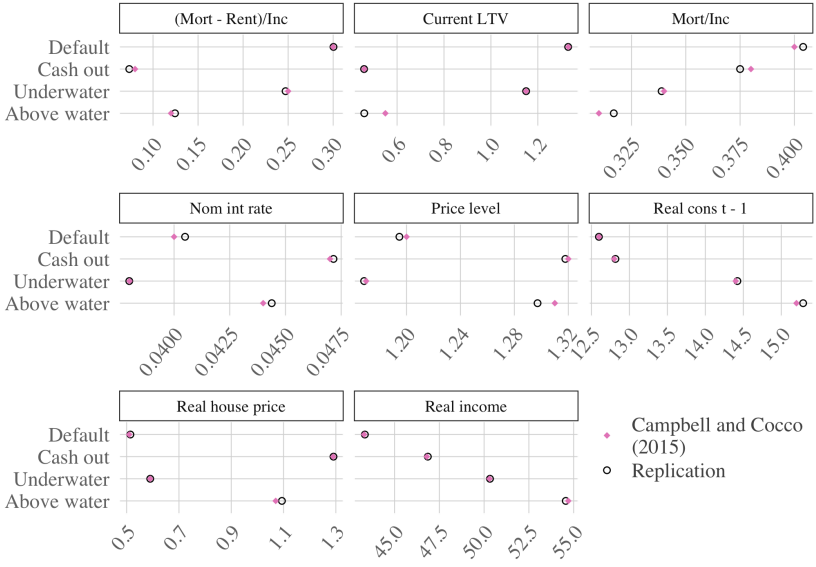
(Mort - Rent)/Inc
Current LTV
Mort/Inc
Nom int rate
Price level
Real cons t - 1
Real house price
Real income
Default
Cash out
Underwater
Above water
0.10
0.15
0.20
0.25
0.30
0.6
0.8
1.0
1.2
0.325
0.350
0.375
0.400
0.0400
0.0425
0.0450
0.0475
1.20
1.24
1.28
1.32
12.5
13.0
13.5
14.0
14.5
15.0
0.5
0.7
0.9
1.1
1.3
45.0
47.5
50.0
52.5
55.0
Campbell and Cocco (2015)
Replication

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