Non-linear Heterogeneous Impact of Net Worth Shocks

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Outline

Introduction

- The wealth effect is a critical channel through which economic shocks propagate: and Mian, Rao and Sufi (2013); Mian and Sufi (2014) proposed **net worth shock** and the household balance sheet channel

- The presence of financial and nominal frictions can amplify the effects of net worth shocks and impede the recovery process
  - Financial friction: Collateral constraint
  - Nominal friction: Downward Nominal Wage Rigidity (DNWR)

- **This paper**:
  - Develops a tractable two-agent model to illustrate the how the interaction between the two frictions leads to non-linear heterogeneous impacts of net worth shock
  - Builds a novel county-level dataset (*CountyPlus*)
  - Empirically estimates and does inference on the non-linear heterogeneous effects using semi-varying coefficient local projections

Introduction

Related studies:

- Net worth shock and slow recovery: Mian, Rao and Sufi (2013); Mian and Sufi (2014); Bocola and Lorenzoni (2020); Guerrieri, Lorenzoni and Prato (2020); Greg Kaplan, Kurt Mitman and Giovanni L. Violante (2020); Greg Kaplan, Kurt Mitman and Giovanni L. Violante (2020) ...
- Financial, nominal frictions and their impact: Christiano, Eichenbaum and Trabandt (2015); Schmitt-Grohé and Uribe (2016); Shen and Yang (2018) ...

Methodology:

- Local projections (LP) and heterogeneous effect estimation: Jordà (2005); Jordà, Schularick and Taylor (2020); Cloyne, Jordà and Taylor (2023) ...
- Estimation and inference of semi-varying coefficient model: Fan, Zhang and Zhang (2001); Zhang, Lee and Song (2002); Fan and Huang (2005); Hu (2024) ...

Introduction

Key findings:

- Negative net worth shock $\rightarrow$ higher precautionary savings and deleverage in response to tightened collateral constraints. DNWR *to* higher income uncertainty. The adjustment process is prolonged, leading to a persistent decline in consumption.
- Found significant heterogeneity in the impact of net worth shocks across counties, with the effect magnitude varying by the degree of local financial and nominal frictions.
- Suggested that the impact of net worth shocks can be non-linearly amplified when both collateral constraints and DNWR are binding.

Main contributions:

- Adds empirical evidence of how financial and nominal frictions affect the impact of net worth shocks.
- Proposes a tractable model to illustrate the amplification mechanism of the frictions.

Outline

A tractable two-agent model

- $t = 0, 1, 2, ...$, economy's state s^t, and aggregate housing productivity shock $u(s^t)$
- Two assets:
  - Housing wealth $h(s^t)$ of price $p(s^t)$
  - State-contingent claims $b(s^{t+1})$ of price $q(s^{t+1}|s^t)$
- Two agents:
  - **Expert**: risk-averse on consumption; produce consumption goods using their housing wealth $h(s^t)$ and household's labor $l(s^t)$; borrow state-contingent claims
  - **Household**: risk-neutral on consumption and risk-averse on housing; constantly supply 1 unit of labor; save in the state-contingent claims
- Two frictions:
  - Collateral constraint: Experts face $b(s^{t+1}) \leq \theta p(s^{t+1})h(s^t), \forall s^{t+1}$
  - DNWR: $w(s^t) \geq \delta w(s^{t-1})$ and $(1 - l(s^t))(w(s^t) - \delta w(s^{t-1})) = 0$
- The collateral constraint prevents experts from very large amount of borrowing $\implies$ **not** complete market

A tractable two-agent model

Expert's problem

$$V^b(s^t) = \max_{c(s^t),\{b(s^{t+1})\},h(s^t),l(s^t)} \log c(s^t) + \beta \mathbb{E} V^b(s^{t+1})$$

$$c(s^t) + p(s^t)h(s^t) = n(s^t) + \sum_{s^{t+1}} q(s^{t+1} |\ s^t) b(s^{t+1}) \qquad \text{(Budget)}$$

$$n(s^t) := p(s^t)h(s^{t-1}) + y(s^t) - b(s^t) \qquad \text{(Net worth)}$$

$$y(s^t) := Y(s^t) - w(s^t)l(s^t) \qquad \text{(Profit)}$$

$$b(s^{t+1}) \leq \theta p(s^{t+1})h(s^t), \forall s^{t+1} \qquad \text{(CC)}$$

where

- $n(s^t) \geq 0$: net worth
- $Y(s^t) := Al^{\alpha}(s^t)[u(s^t)h(s^t)]^{\{1-\alpha\}}$

A tractable two-agent model

Household's problem

$$V^l(s^t) = \max_{c^l(s^t),\{a(s^{t+1})\},h^l(s^t)} c^l(s^t) + \gamma \log h^l(s^t) + \beta \mathbb{E} V^l(s^{t+1})$$

$$c^l + \sum_{s^{t+1}} q(s^{t+1}|\ s^t)a(s^{t+1}) + p(s^t)[h^l(s^t) - h^l(s^{t-1})] = w(s^t)l(s^t) + a(s^t)$$

Housing market

$$h(s^t) + h^l(s^t) = H, H \in \mathbb{R}$$

Bond market

$$a(s^{t+1}) = b(s^{t+1}), \forall s^{t+1}$$

DNWR conditions

$$w(s^t) \geq \delta w(s^{t-1})$$

$$[1 - l(s^t)][w(s^t) - \delta w(s^{t-1})] = 0$$

A tractable two-agent model

Scenario (one-shot deviation)

1. $t = 0$: Unbinding deterministic steady state
2. $t = 1$: u_1 drawn from a distribution over support $(0, \overline{u}]$
3. $t \geq 2$: The realized path of $\{u_t\}$ is always 1

Then,

- Solve the equilibrium of one-shot deviation analytically
- Prove: persistent effects of u_1 shock
- Prove: non-linear heterogeneous impact of u_1

A tractable two-agent model

Proposition (Persistent Effect)

There exist a unique continuation equilibrium that depends on the states

$$(u_1, h_0, b_1(u_1))$$

In the continuation equilibrium, the collateral constraint is binding for a finite number of periods J, *with* $J = 0$ *if* $n_1(u_1) \geq \overline{n}_1 := \overline{p}\overline{h}\frac{1-\beta\theta}{\beta}$, *where* $\overline{p}$ *and* $\overline{h}$ *are jointly determined by*

$$(1-\beta)\bar{p} = \frac{\gamma}{H - \bar{h}}$$

$$\bar{p}(1-\beta) = \beta(1-\alpha)\bar{h}^{-\alpha}$$

A tractable two-agent model

Proposition (Non-linear heterogenous effect)

There exist levels of the entrepreneur's financial friction parameter θ and the DNWR parameter δ, such that if

$$\frac{w_0}{n_0} \geq \frac{\alpha}{\delta(1-\alpha)}\left[1 + (1-\theta)(1-\alpha)(\frac{p_0 h_0^l}{\gamma} - 1)\right]$$

then, in equilibrium, the $t = 1$ collateral constraint and DNWR both bind when u_1 is in a non-empty interval $\left[\hat{u}_{\text{lb}}(\theta, \delta), \hat{u}_{\text{up}}(\theta, \delta)\right]$. In this case, the u_1 shock effects:

$$\frac{\partial c_1}{\partial u_1} > 0, \frac{\partial l_1}{\partial u_1} > 0, \frac{\partial p_1}{\partial u_1} > 0 \text{ or } < 0 \text{ or } = 0 \text{ depends}$$

in which these effects are also non-linear functions of θ and δ.

A tractable two-agent model

Comparative statistics

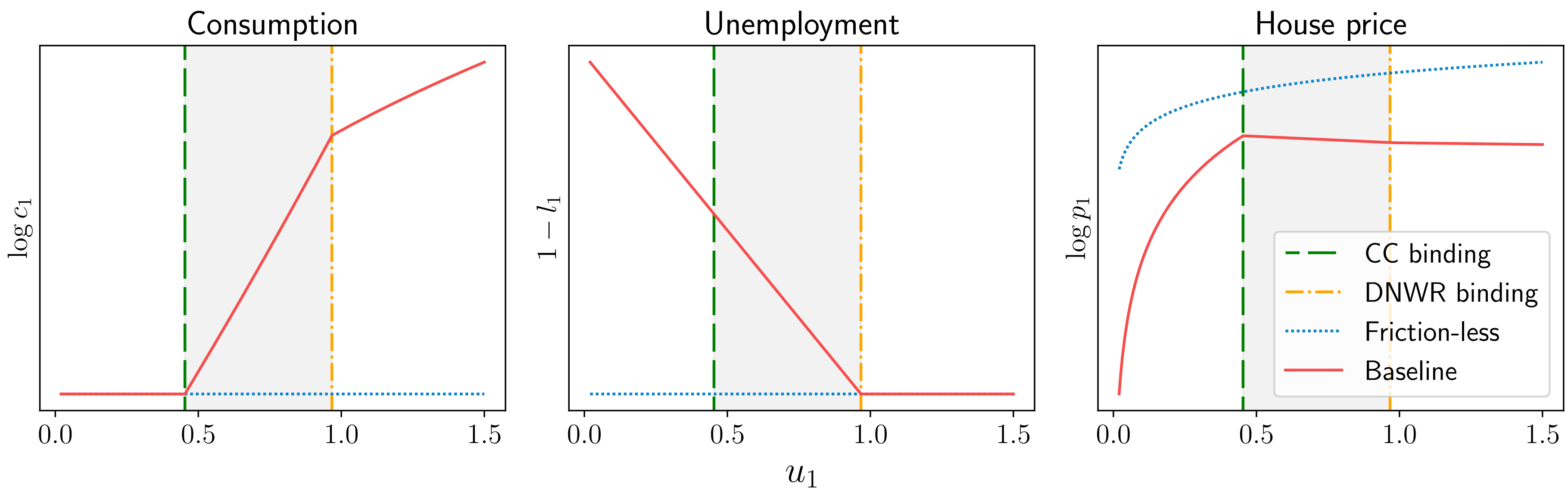


Figure 1: baseline vs. friction-less economy

where:

- Collateral constraint binds when $u_1 \geq$ Green line
- DNWR binds when $u_1 \leq$ Orange line
- Both binds: Grey area

$\Longrightarrow$ Amplification effects

Outline

Data: CountyPlus

- Build a new open-source panel data set *CountyPlus*
  - 03-19 yearly, 3058 US counties
  - Fully replicable: 20+ public available data sources
  - Github: github.com/Clpr/CountyPlus
- Covers: household balance sheet by asset; income and consumption; labor and housing market indicators; friction measures; demographics; ...
- Key variables:
  - Household net worth (wealth)
  - Consumption, unemployment and house price
  - ***DENI***: home mortgage denial due to lack of collateral / total denials
  - ***FWCP***: Fraction of Wage Cuts Prevented
- Net worth shock is identified as:

$$x_{i,t} := \sum_{j \in \{S,B,H\}} s^j_{i,t-1} g^j_{t-1,t}$$

where i is county, S is equity, B is bond, H is housing wealth; $s^j_{i,t-1}$ is lag asset share in the balance sheet; and $g^j_{t-1,t}$ is the lag aggregate growth of asset prices.

Definition: net worth Definition: consumption Definition: FWCP

Data: CountyPlus

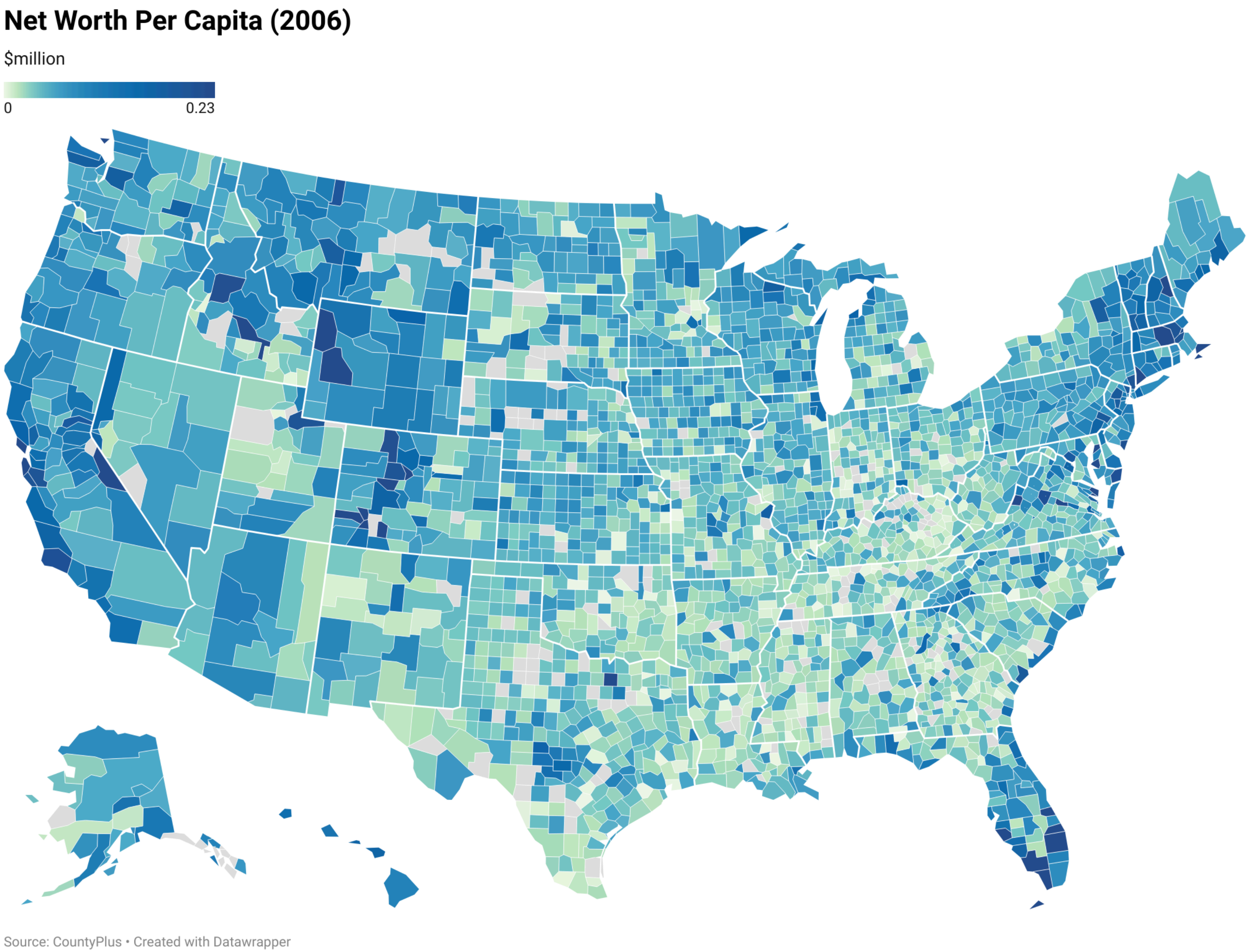


Figure 2: Geographical: Pre-crisis net worth

Data: CountyPlus

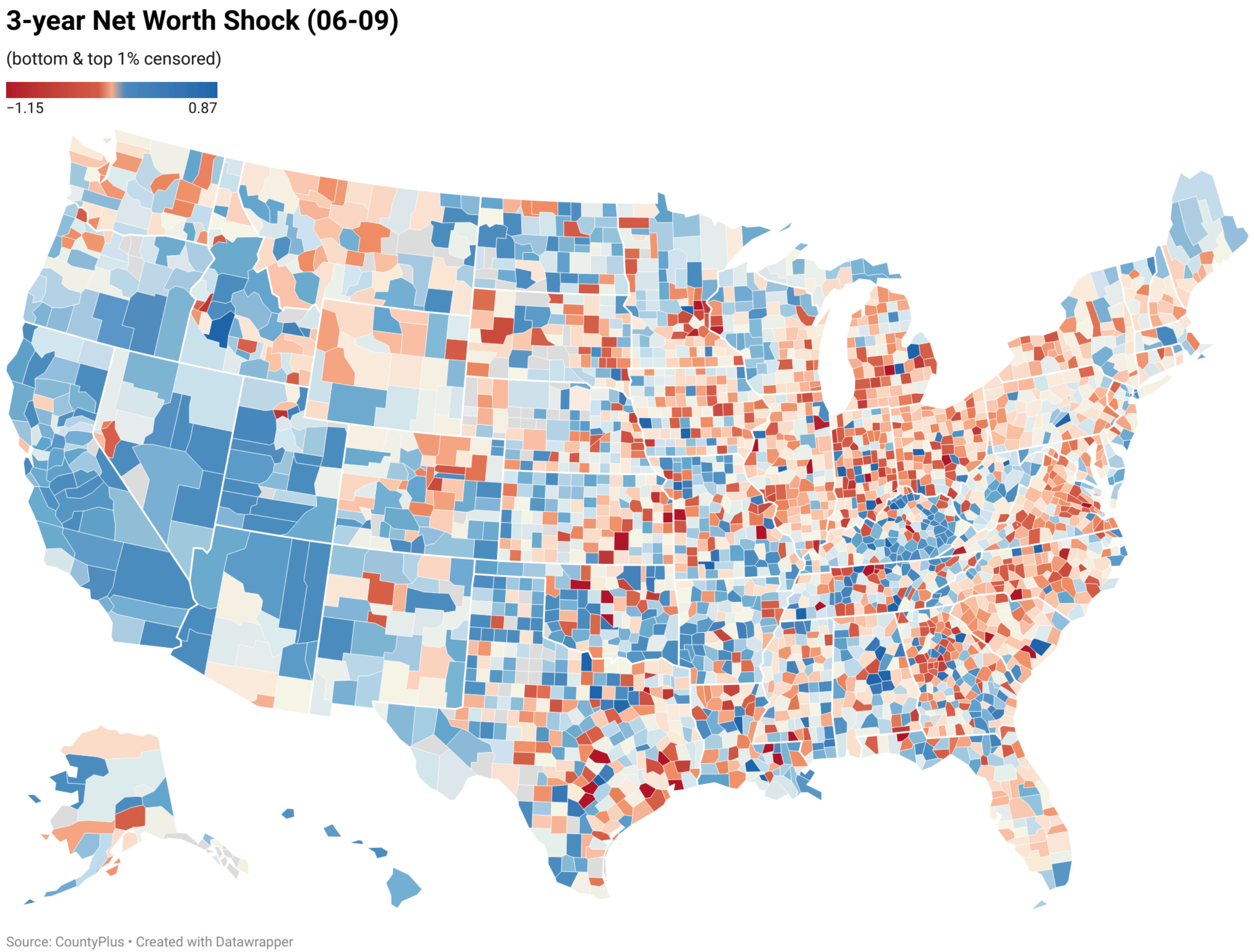


Figure 3: Geographical: Net worth shock during the Great Recession

Data: CountyPlus

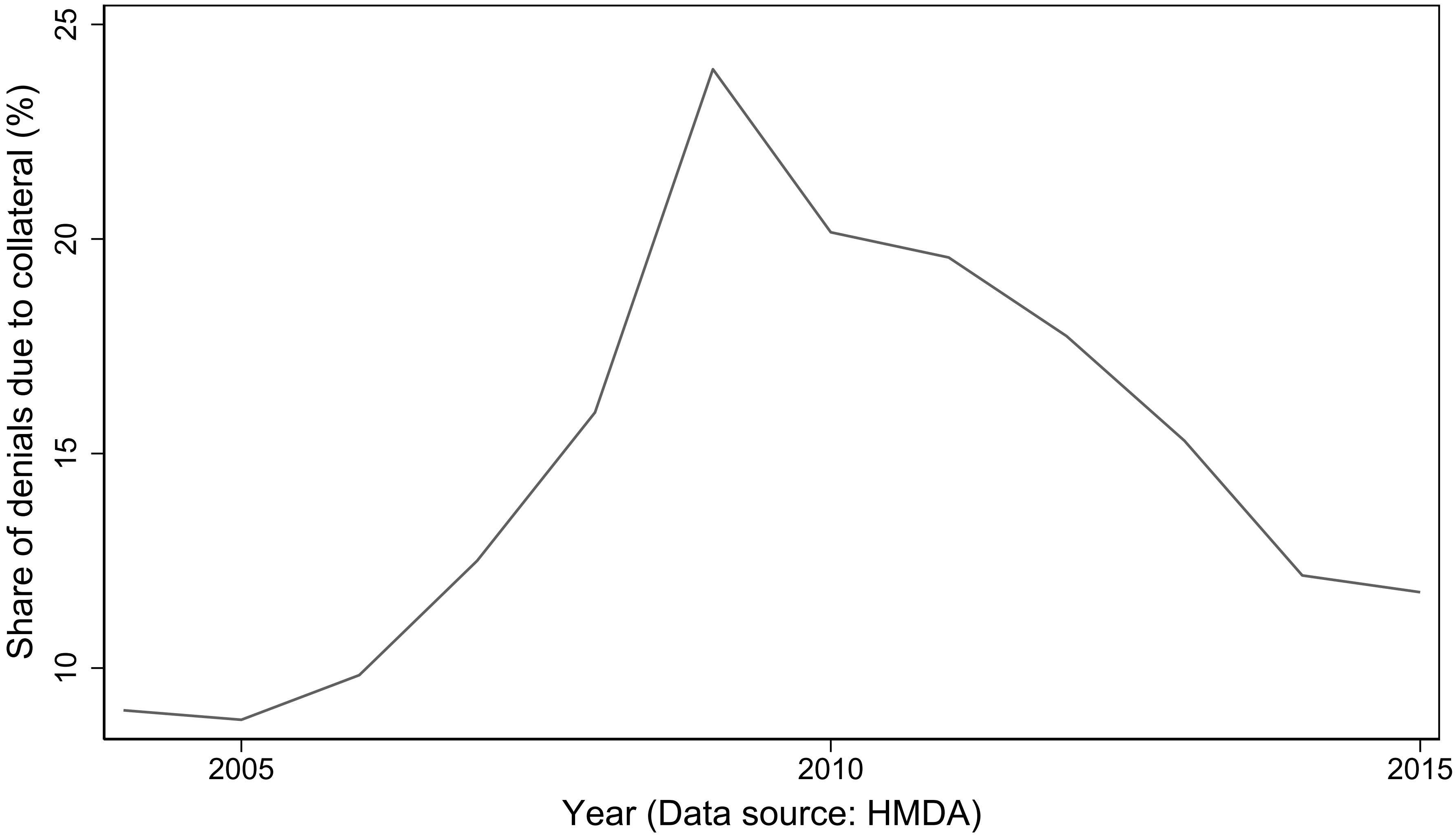


Figure 4: The aggregate extent of collateral constraint

- Larger *DENI*, larger friction

Data: CountyPlus

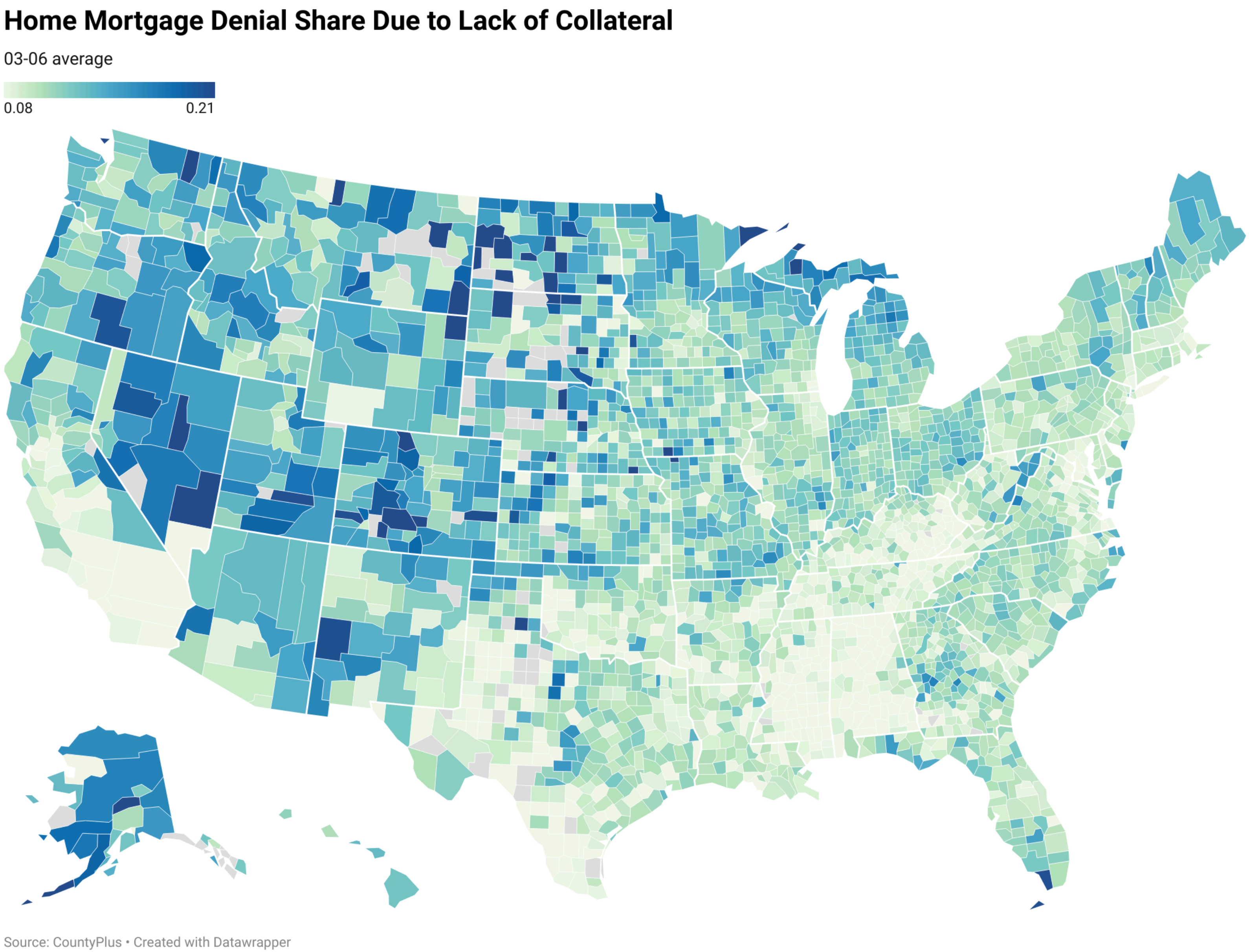


Figure 5: Geographical: Collateral constraint before the crisis

Data: CountyPlus

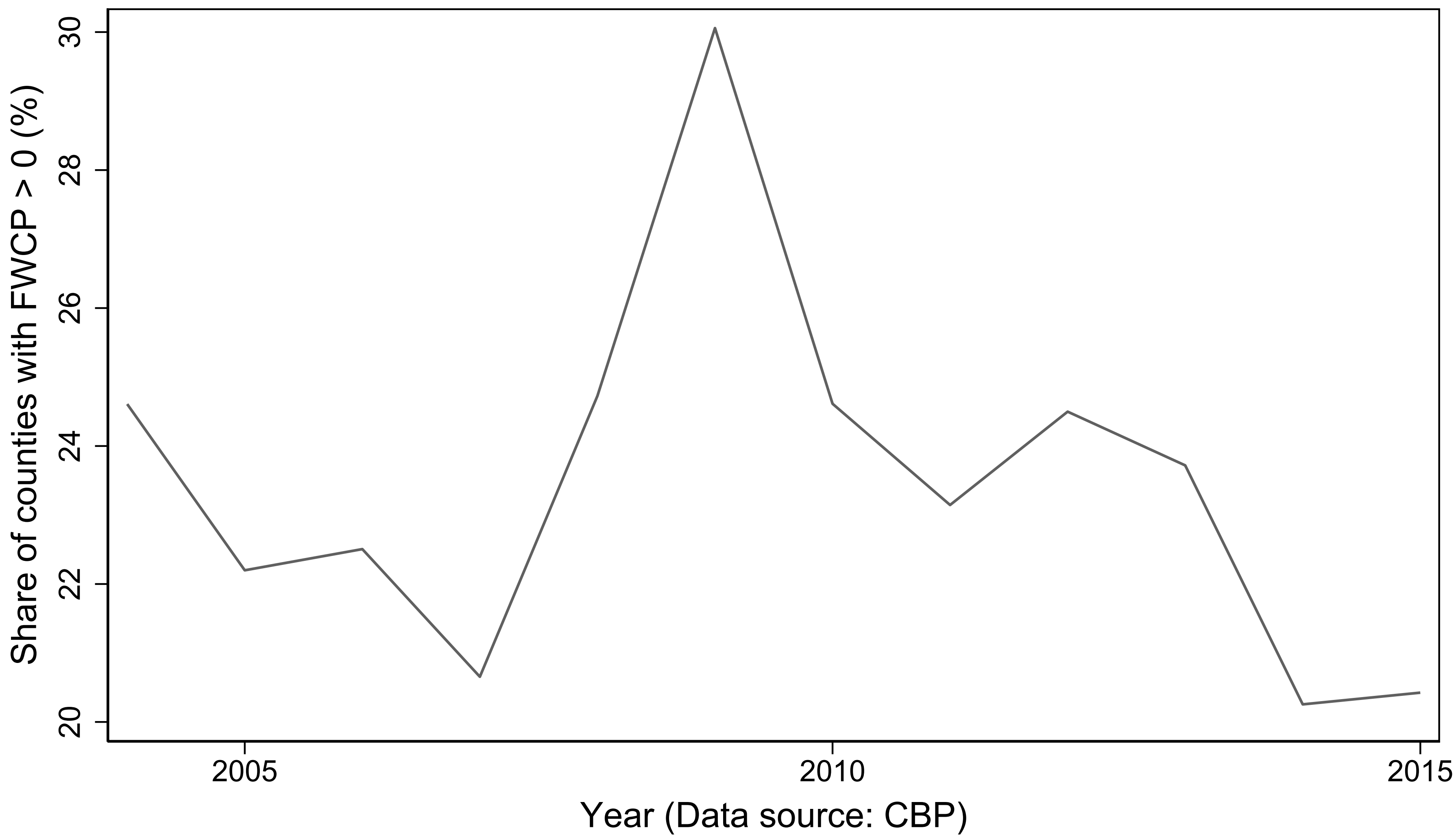


Figure 6: The aggregate extent of DNWR

- Larger $DNWR$, larger friction

Data: CountyPlus

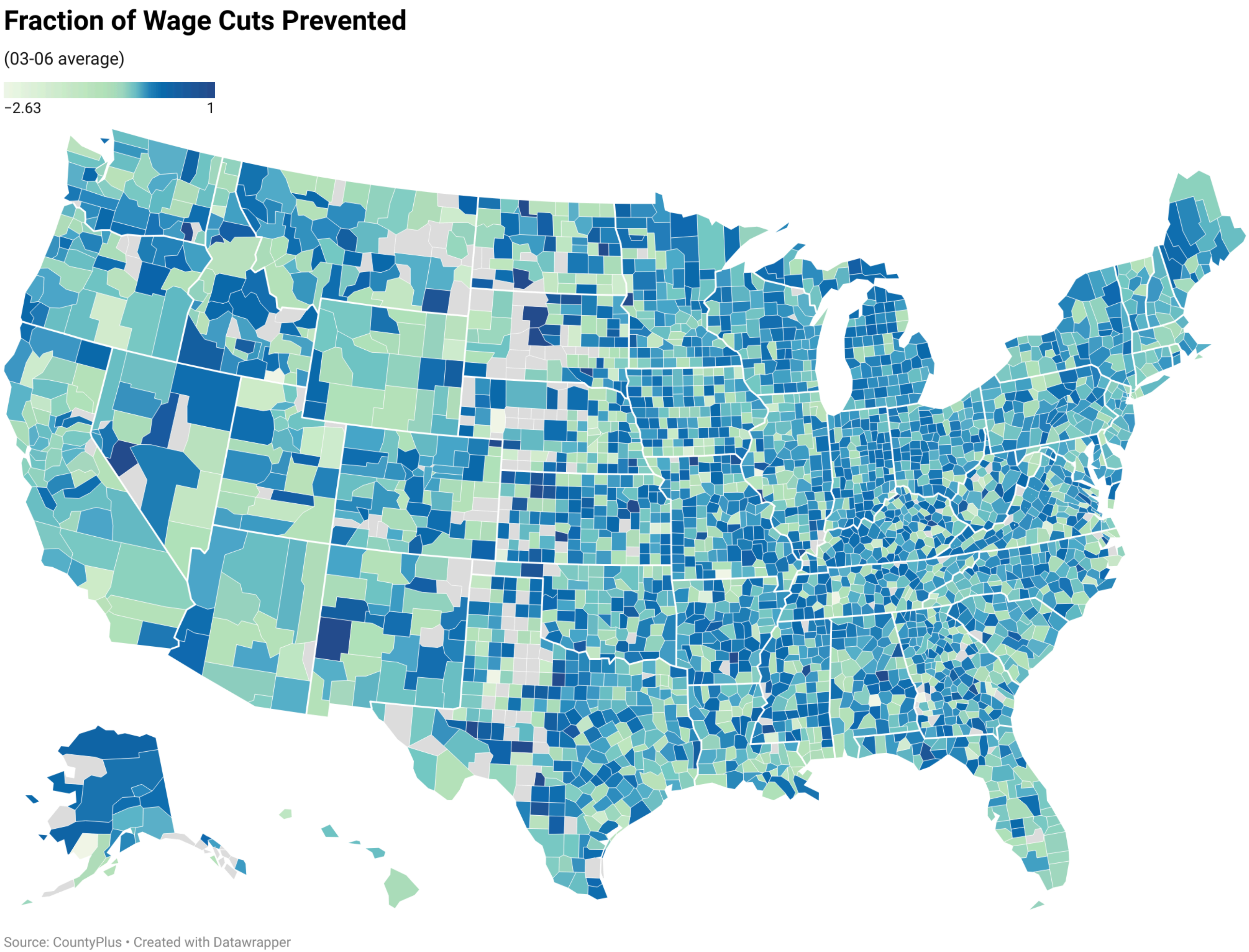


Figure 7: Geographical: DNWR before the crisis

Data: CountyPlus

Compare with the aggregate series:

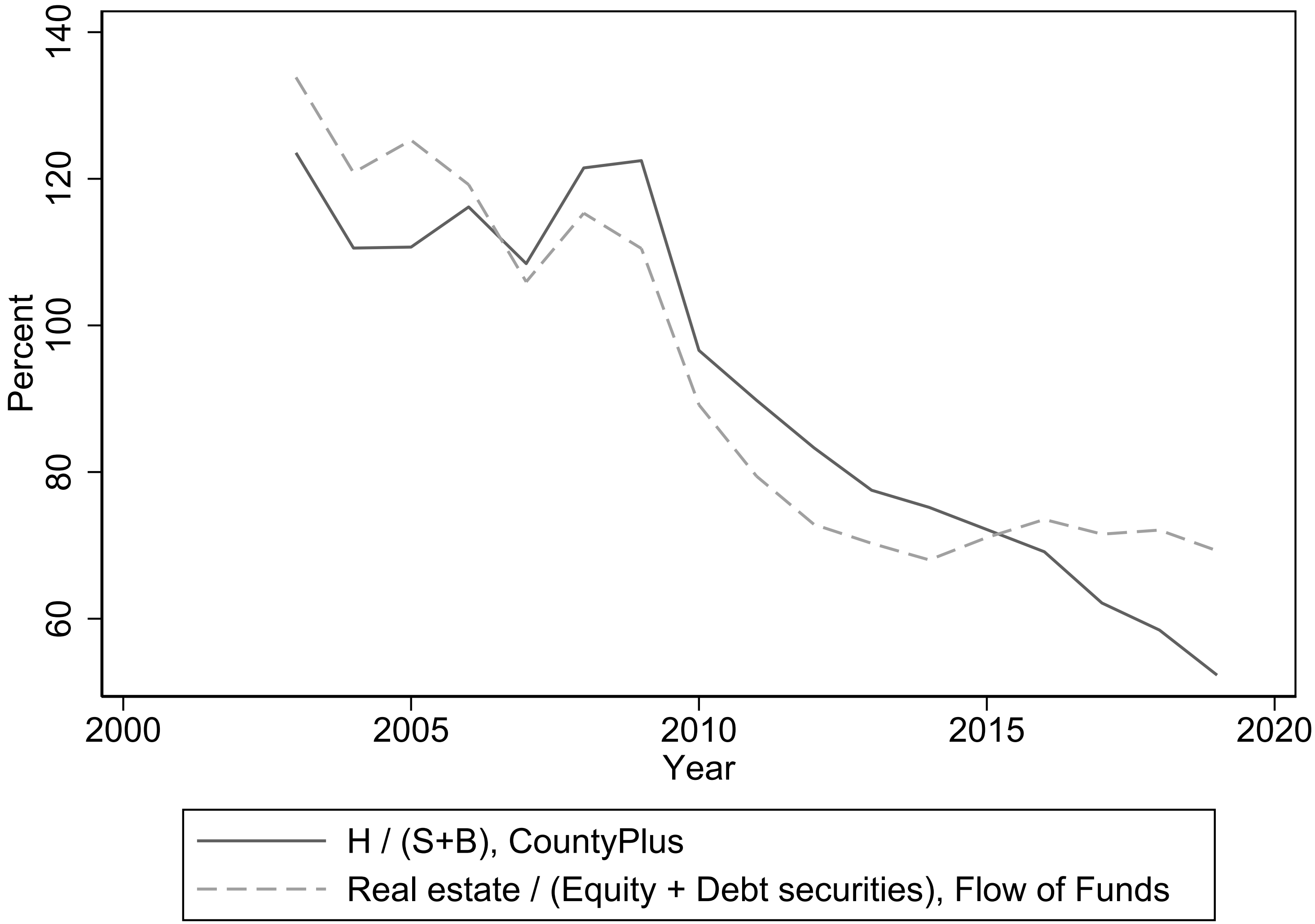


Figure 8: CountyPlus vs. Fed Flow of Funds

Baseline specification

A semi-varying coefficient variant of the linear LP in Cloyne, Jordà and Taylor (2023)

$$y_{i,t+h} = \alpha_h + x_{i,t} \cdot \beta_h(\Delta \mathbf{Z}_{i,t}) + \Delta \mathbf{Z}'_{i,t}\boldsymbol{\delta}_h + g(N_{i,t-1}) + \mathbf{W}_{i,t}\lambda_h + \iota_{i\in s} + \nu_t + \varepsilon_{i,t+h}$$

- where
  - $\Delta \boldsymbol{Z}_{i,t}$: *DENI* and *FWCP* deviation from the county's mean level
  - $\beta_h(\Delta \boldsymbol{Z}_{i,t})$: effects of the net worth shock
  - $h = 0, ..., H$: projection horizons
  - $y_{i,t+h}$: outcomes
  - $g(N_{i,t-1})$: a functional control of lagged net worth
  - $\iota_{i\in s}, \nu_t$: state and year fixed effects

- Sieve estimator of global polynomial approximation:

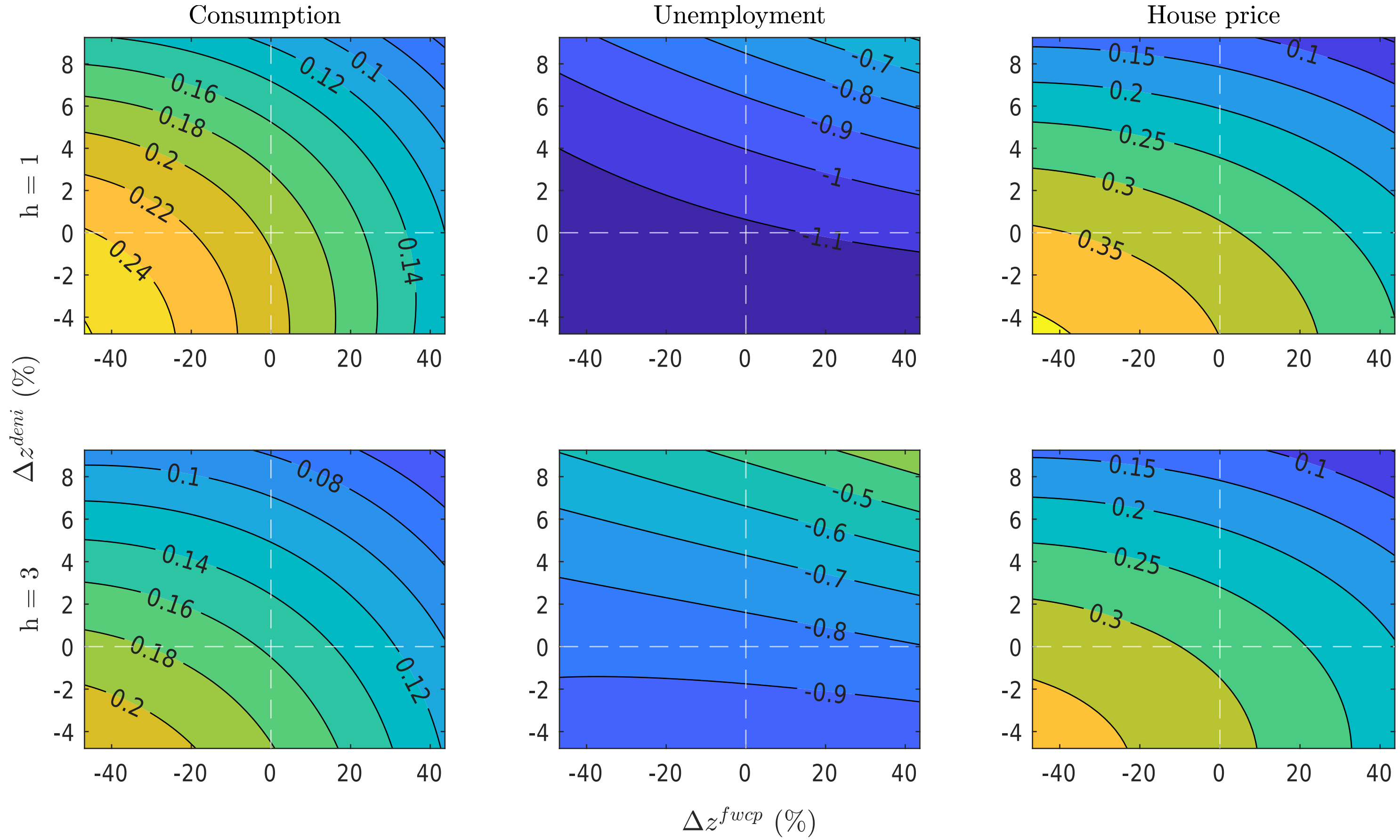
$$\beta_h(\Delta \mathbf{Z}_{i,t}) \approx b_h^0 + b_h^1 \Delta z_{i,t}^{fwcp} + b_h^2 \Delta z_{i,t}^{deni} + b_h^3 \Delta z_{i,t}^{fwcp} \Delta z_{i,t}^{deni} + b_h^4 (\Delta z_{i,t}^{fwcp})^2 + b_h^5 (\Delta z_{i,t}^{deni})^2$$

- Outcomes: Log real consumption per capita; Unemployment rate; Log real house price index

Page: robustness checks Page: Controls

Baseline estimates of $\beta_h(\Delta Z)$

The estimated effect $\beta_h(\Delta \boldsymbol{Z})$ is 2-dimensional functions (+1% shock):



- Contour interval: heterogeneity of the effects
- Contour curvature: interaction & non-linearity

Other horizons

Baseline estimates of $\beta_h(\Delta Z)$

Counterfactual IRF by scenario:

- Numbers in parenthesis are quantiles of ΔZ distribution: number $\searrow$, bindingness $\searrow$

Baseline vs. Linear LP

- Baseline specification

$$y_{i,t+h} = \alpha_h + x_{i,t} \cdot \beta_h(\Delta\mathbf{Z}_{i,t}) + \Delta\mathbf{Z}_{(i,t)'}\boldsymbol{\delta}_h + g(N_{i,t-1}) + \mathbf{W}_{i,t}\lambda_h + \iota_{i\in s} + \nu_t + \varepsilon_{i,t+h}$$

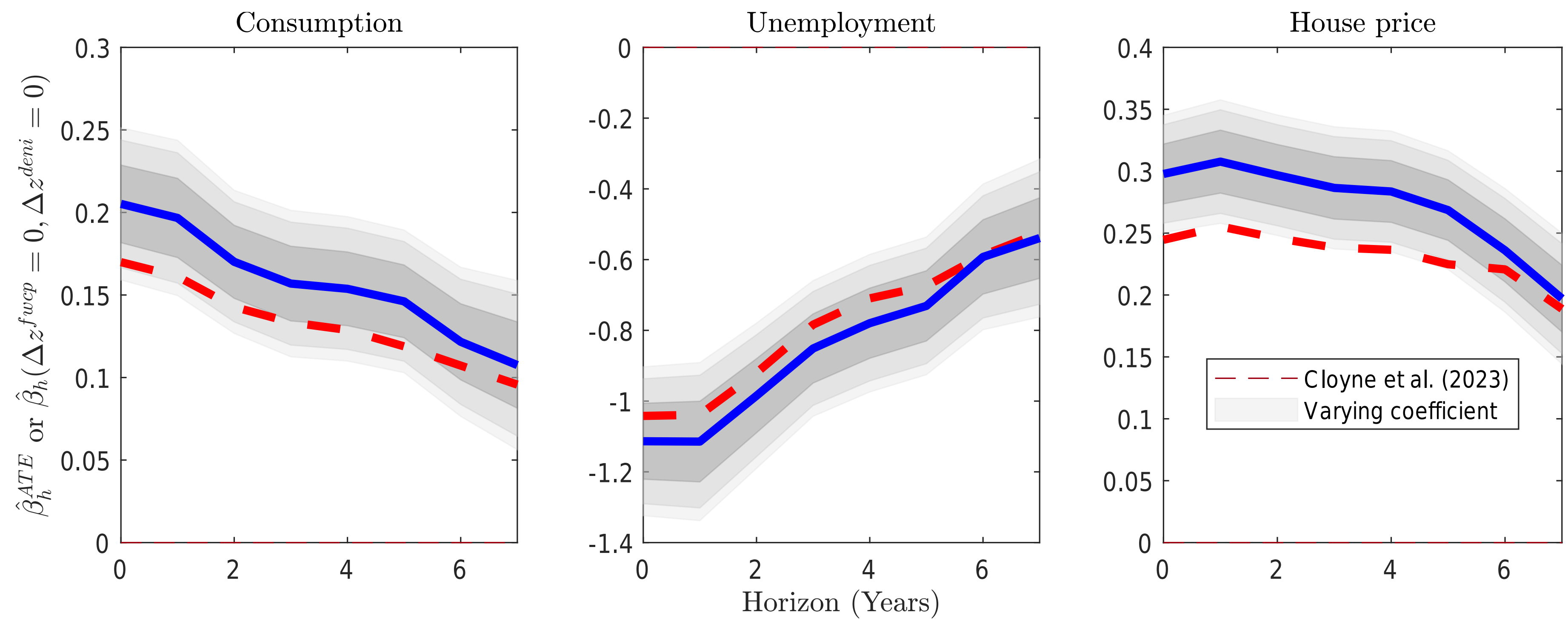
- Linear LP with linear heterogeneous effects Cloyne, Jordà and Taylor (2023)

$$y_{i,t+h} = \alpha_h + x_{i,t}\beta_h + x_{i,t}\Delta\mathbf{Z}'_{i,t}\begin{bmatrix}\gamma_h^{fwcp} \\ \gamma_h^{deni}\end{bmatrix} + \Delta\mathbf{Z}'_{i,t}\boldsymbol{\delta}_h$$
$$+g(N_{i,t-1}) + \mathbf{W}_{i,t}\lambda_h + \iota_{i\in s} + \nu_t + \varepsilon_{i,t+h}, h = 0, ..., H$$

where γ_h^{fwcp} and γ_h^{deni} are the linear heterogenous effects

Baseline vs. Linear LP

Consistent estimates at the average county:

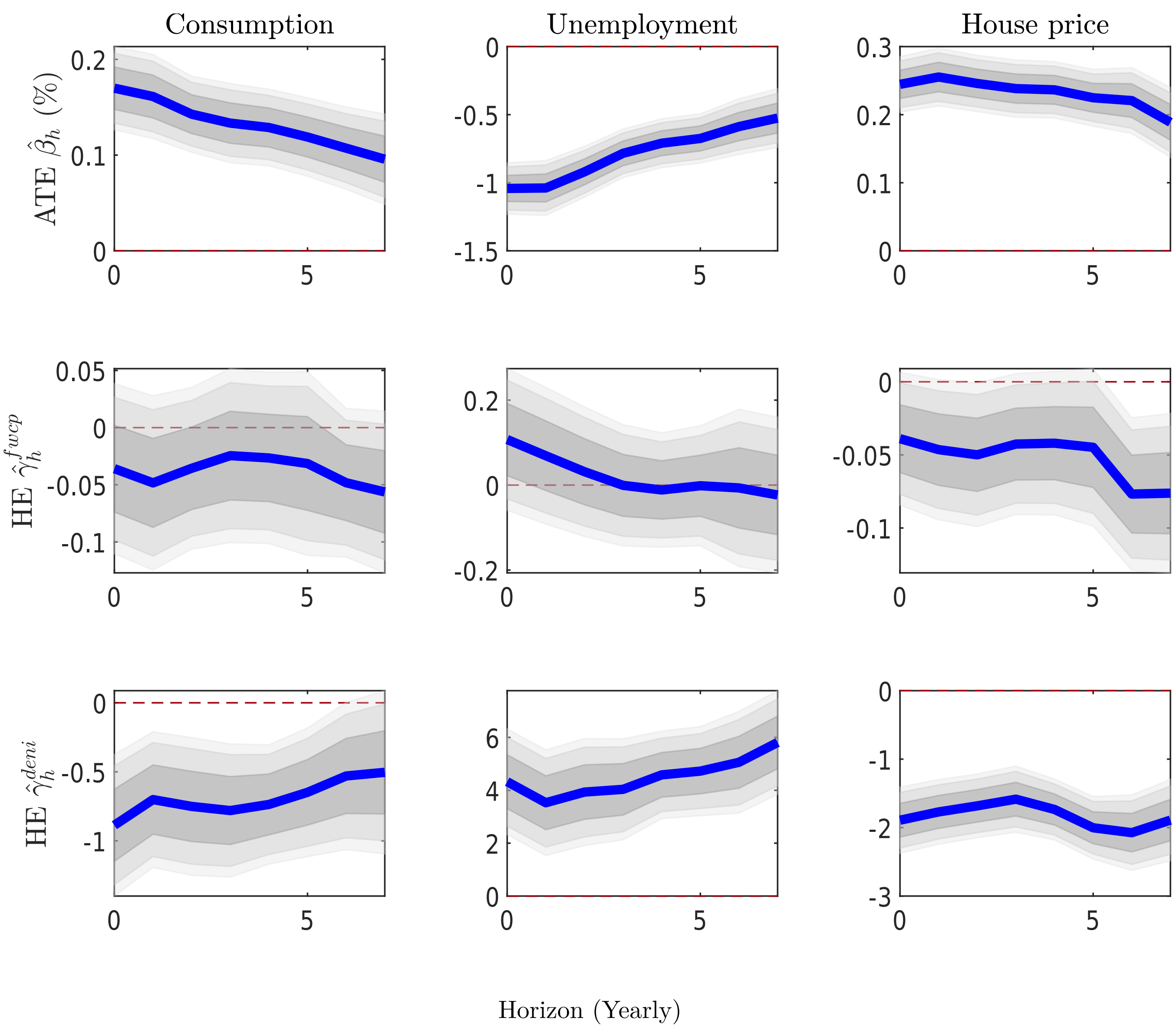


where

- Blue solid line: $\widehat{\beta}_h(\Delta \boldsymbol{Z} = 0)$ of the baseline model
- Red dashed line: $\widehat{\beta}_h$ of the linear LP model
- CI: 95%, 90%, 1-σ deviation

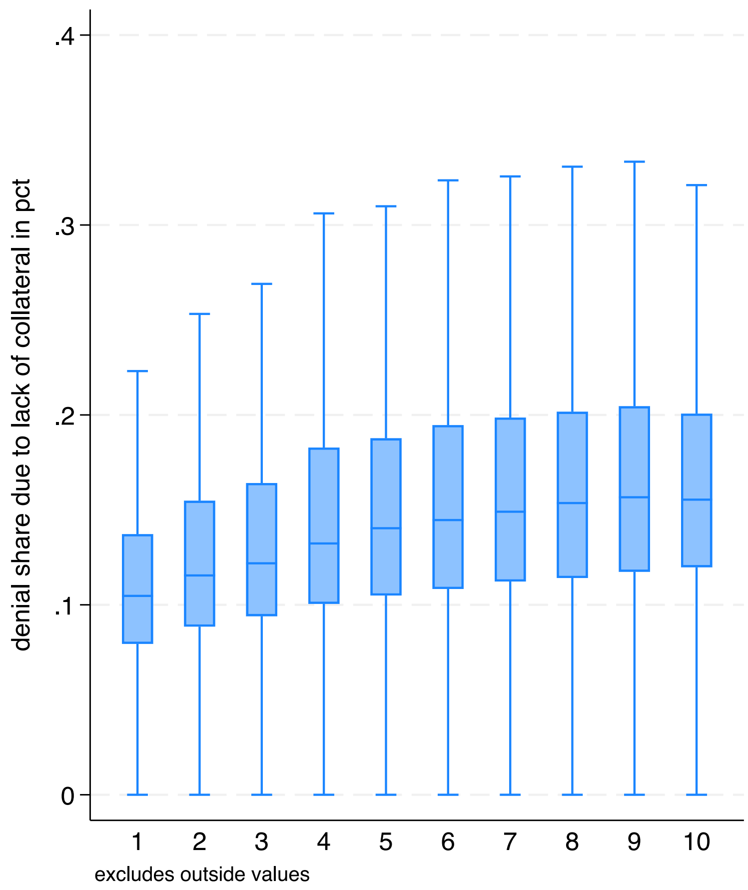
Baseline vs. Linear LP

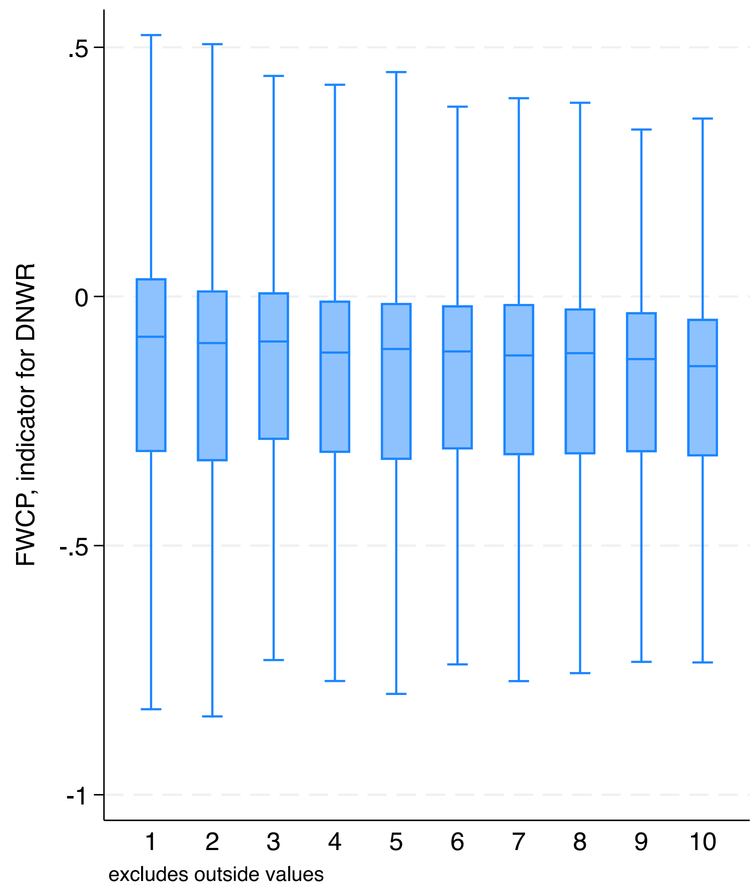
The linear LP misses the heterogeneous effects of DNWR & friction interaction:



Heterogeneity among income groups

Counties with different income levels experiencing varying degree of frictions:

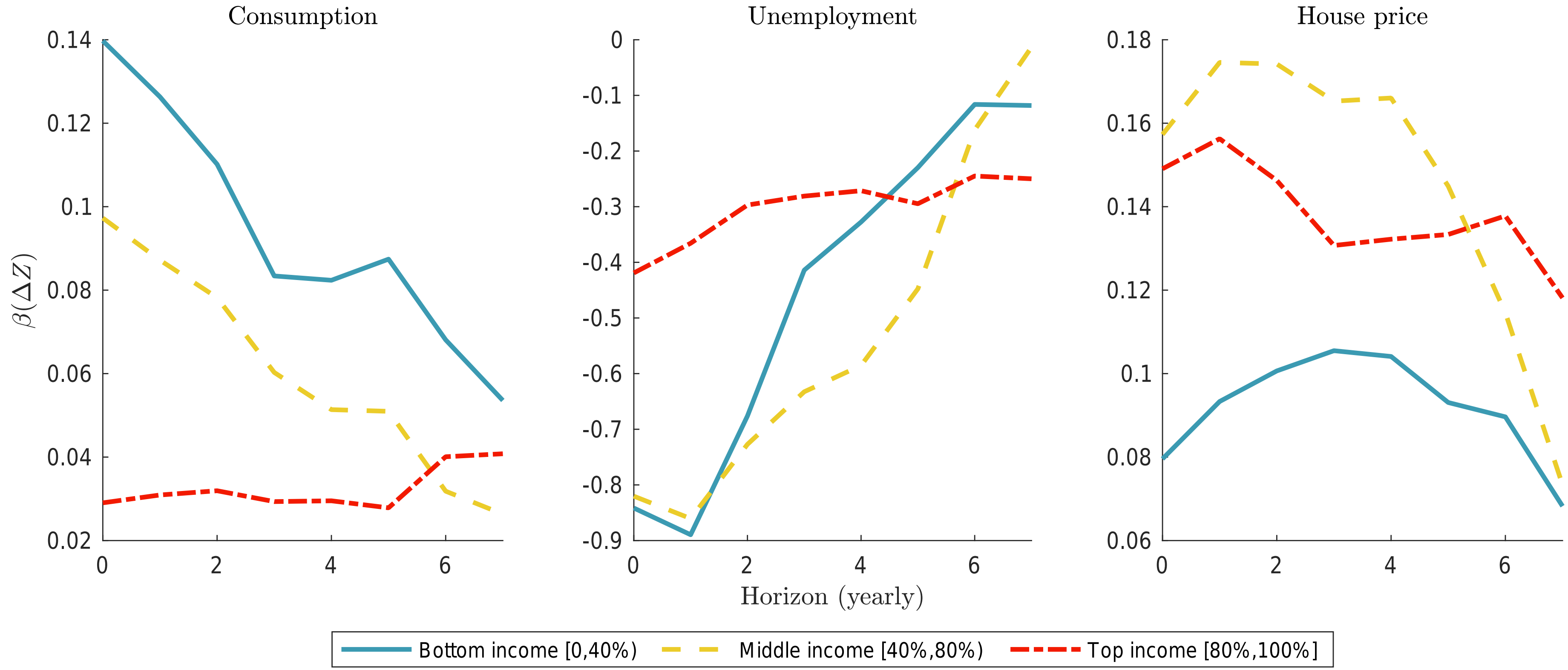




$\Longrightarrow$ Important implications for the transmission of macroeconomic shocks and the design of stabilization policies

Heterogeneity among income groups

Check $\beta(\Delta \boldsymbol{Z} = 0)$:



- 2006 cross-sectional distribution of county real median household income
- Vulnerability against shock:
  - Consumption: Low
  - Unemployment: Low & Middle
  - House price: Middle & Top

Inference

- F-test: non-linearity of heterogeneous effects and friction interaction

$H_0 : 0 = b_h^3 = b_h^4 = b_h^5$

Horizon	0	1	2	3	4	5	6	7
Consumption	8.403***	8.641***	6.127***	5.289***	5.627***	7.282***	5.286***	4.002***
	(.000)	(.000)	(.000)	(.001)	(.001)	(.000)	(.001)	(.008)
Unemployment	5.919***	3.874***	2.551*	2.963**	3.453**	3.292**	2.532*	1.627
	(.001)	(.009)	(.054)	(.031)	(.016)	(.020)	(.056)	(.181)
House price	24.967***	23.961***	22.215***	21.083***	22.661***	19.744***	14.116***	11.973***
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)

Notes: 1. Numbers in the parenthesis are the p-value. 3. $***$: $p < 0.01$, $**$: $p < 0.05$, $*$: $p < 0.1$

- The F-test suggests significant non-linear heterogneous effects and the interaction between collateral constraint and DNWR

Robustness

- **Order selection of the polynomial approximation** Appendix
  - Suggests higher order approximation not introduce new patterns
- **Sensitivity analysis against confounders** Appendix
  - Shows the baseline result is robust against potential confounders
- **Local estimator** Appendix
  - Shows the same patterns of $\beta_h(\Delta \boldsymbol{Z})$
- **Profile-likelihood ratio test** Appendix
  - Rejects H_0 as well
- **Geographical spillover effects of the shock** Appendix
  - Finds statistically significant spillover effects of the shocks on unemployment $\Longrightarrow$ larger non-linearity

Goto: Specification

Conclusion

- **Findings**
  - Economic frictions greatly shape the effect of net worth shocks in which collateral constraints and DNWR and their interaction could explain the US recovery after the Great Recession
  - There are large non-linear heterogenous effects of net worth shocks in the US which bring important policy implications
- **Policy implications**
  - Call for policies advocating for a strong labor market and mitigating financial risks
  - Call for policies based on local economic conditions
  - Country-wise interventions may have uneven effects across the income distribution, potentially worsening existing inequalities

End

Thank you!

Latest version available at SSRN ID: 4915272

Outline

Appendix: Other horizon of the baseline

$\beta_h(\Delta \boldsymbol{Z})$ at horizon $h = 5, 7$

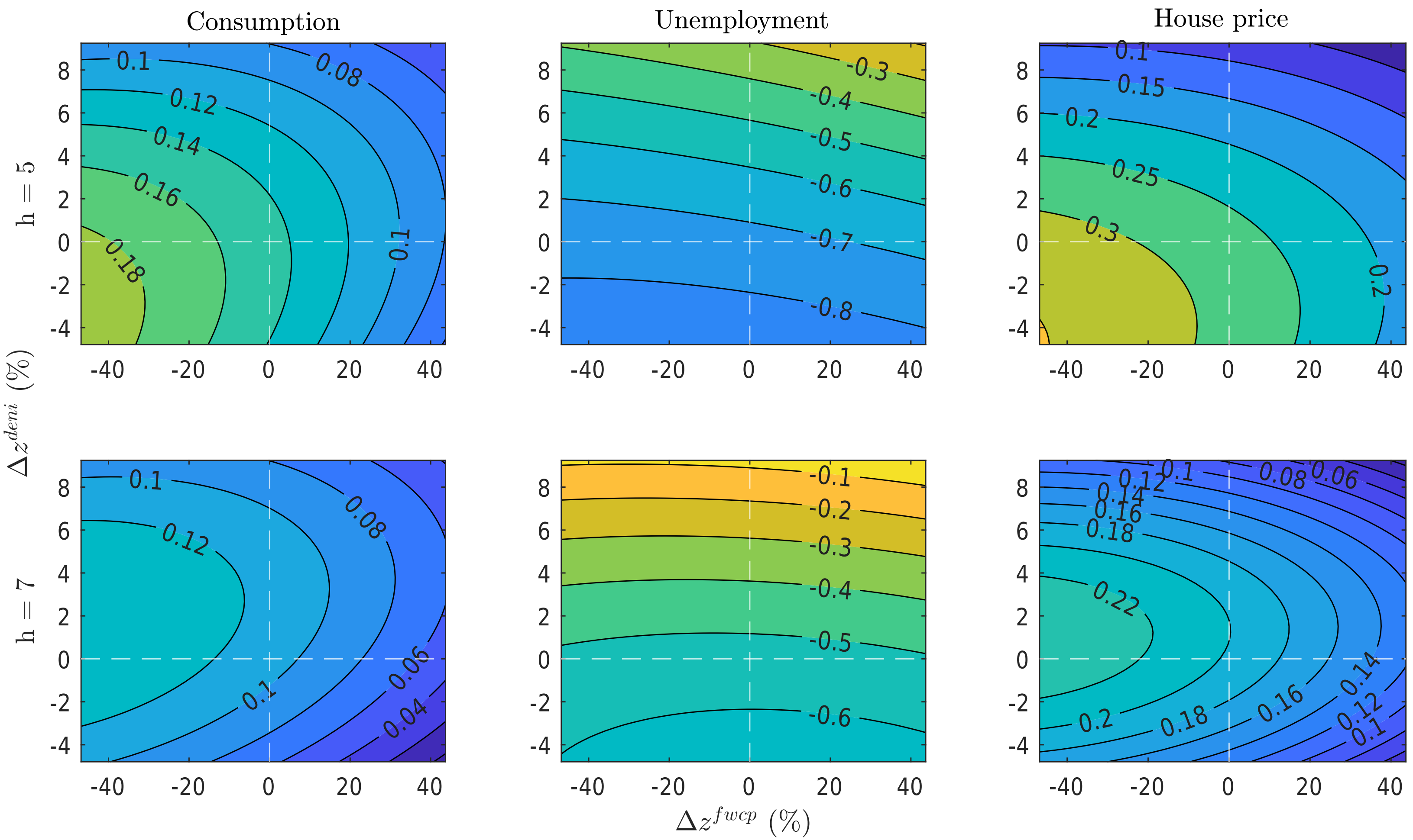


Figure 14: $\beta_h(\Delta \boldsymbol{Z})$

Goto: baseline

Appendix: variable definitions

- Household **net worth** of county i in year t:

$$NW_{it} = S_{it} + B_{it} + H_{it} - D_{it}$$

where S is equity, B is debt security, H is housing wealth, and D is debt

- **Equity** and **Debt security holding**:

$$S_{i,t} = \frac{\text{County dividend income}_{i,t}}{\sum_j \text{County dividend income}_{j,t}} \times \text{National total equity of household}_t$$

$$B_{i,t} = \frac{\text{County interest income}_{i,t}}{\sum_j \text{County interest income}_{j,t}} \times \text{National total debt security of household}_t$$

- Data sources of S and B: Survey of Income (SOI) by IRS, Fed Flow of Funds

Appendix: variable definitions

- **Debt**:

$$D_{i,t} = \text{Household debt-to-income ratio}_{i,t} \times \text{AGI}_{i,t}$$

where i is county index and t is year index, AGI is adjusted gross income.

- **Housing wealth**

$$H_{i,t} = \frac{\text{Total housing units}_{i,t}}{\text{Average housing units per house}} \times \text{Median house value}_{i,2019} \times \frac{\text{HPI}_{i,t}}{\text{HPI}_{i,2019}}$$

where the average housing units per house is 1.8

- Data sources of D and H: SOI; Enhanced Financial Account of Fed Flow of Funds; Census Bureau; American Community Survey (ACS); Federal Housing Finance Agency (FHFA)

Goto: Data

Appendix: variable definitions

- Spirit of Zhou and Carroll (2012): tax data
- Sales tax data from local department of revenues: 27 states, 1700 counties

$$C_{i,t} = \text{PCE}_{s,t} \times \text{Population}_{s,t} \times \frac{\text{Taxable sales}_{i,t}}{\sum_{j \in s} \text{Taxable sales}_{j,t}}$$

- Currently available states (sorted by FIPS code):

1 Alabama, 4 Arizona, 5 Arkansas, 6 California, 8 Colorado, 12 Florida, 17 Illinois, 18 Indiana, 19 Iowa, 22 Louisiana, 27 Minnesota, 29 Missouri, 31 Nebraska, 32 Nevada, 36 New York, 37 North Carolina, 38 North Dakota, 39 Ohio, 42 Pennsylvania, 45 South Carolina, 47 Tennessee, 49 Utah, 50 Vermont, 51 Virginia, 55 Wisconsin, 56 Wyoming.

Appendix: variable definitions

- Some states only report tax revenue $\Longrightarrow$ measurement error due to differential tax rate
- Year t, county i, total J types of goods; True consumption: $C_{j,i,t}$, tax revenue $T_{j,i,t}$, tax rate $\tau_{j,t}$
- True consumption distribution:

$$\tilde{S}_{i,t} := \frac{C_{i,t}}{\sum_{m=1}^{I} C_{m,t}} = \frac{\sum_{j=1}^{J} C_{j,i,t}}{\sum_{m=1}^{I} \sum_{j=1}^{J} C_{j,m,t}}$$

- Estimates:

$$S_{i,t} := \frac{T_{i,t}}{\sum_{m=1}^{I} T_{m,t}} = \frac{\sum_{j=1}^{J} C_{j,i,t}\tau_{j,t}}{\sum_{m=1}^{I} \sum_{j=1}^{J} C_{j,m,t}\tau_{j,t}}$$

- Measurement error:

$$S_{i,t} = \frac{\bar{\tau}_{i,t} \sum_{j=1}^{J} C_{j,i,t}}{\bar{\tau}_{t} \sum_{m=1}^{I} \sum_{j=1}^{J} C_{j,m,t}} = \frac{\bar{\tau}_{i,t}}{\bar{\tau}_{t}} \tilde{S}_{i,t}$$

where:

$$\bar{\tau}_{i,t} = \frac{\sum_{j=1}^{J} C_{j,i,t}\tau_{j,t}}{\sum_{j=1}^{J} C_{j,i,t}} \quad \bar{\tau}_{t} = \frac{\sum_{m=1}^{I} \sum_{j=1}^{J} C_{j,m,t}\tau_{j,t}}{\sum_{m=1}^{I} \sum_{j=1}^{J} C_{j,m,t}}$$

are county & state average tax rates

Goto: Data

Appendix: variable definitions

- Methodology of Holden and Wulfsberg (2009)
- **Idea**: true nominal wage distribution vs. constructed notional rigidity-free distribution
- Notional distribution: all county-industry pairs with upper 25% wage growth in a given year
- Fraction of Wage Cuts Prevented:

$$\mathrm{FWCP}_{i,t} = 1 - p_{i,t}/\tilde{p}_{i,t}$$

$$\tilde{p}_{i,t} := \frac{\#\{Z_{i,t} < 0\}}{N_t^{\text{top } 25\%}}$$

$$p_{i,t} := \frac{\#\{\Delta w_{j,i,t} < 0\}}{N_{i,t}}$$

where $Z_{i,t}$ is the rigidity-free wage growth from the notional distribution of county i in year t; $\Delta w_{j,i,t}$ is the true wage growth of industry j

Goto: Data

Appendix: Illustration parameters

Parameter	Definition	Value
β	Utility discounting factor	0.9
α	Labor income share	0.7
δ	Parameter of DNWR	0.99
θ	Collateral constraint as LTV ratio	0.8
A	Technology level	1
$\bar{\nu}$	Steady state LTV ratio	0.79
γ	Housing preference	0.8
H	House supply	30

Goto: comparative statistics

Appendix: Sensitivity analysis

- Framework of Cinelli and Hazlett (2020)
- If there are confounder(s), how strong must it be explaining the residual to:
  - Flip the coefficient sign
  - Overturn the *t*-tests
- e.g. Policy intervention not captured by fixed effects
- Scalar measures and **contour figures** regarding:
  - $R^2_{D\sim Z,X}$: partial R^2 of confounder(s) Z wrt treatment D
  - $R^2_{Y\sim Z|D,X}$: partial R^2 of confounder(s) Z wrt outcome Y
- Benchmark variable: what if confounder(s) are as strong as an a specific existing regressor?

Goto: Robustness

Appendix: Sensitivity analysis

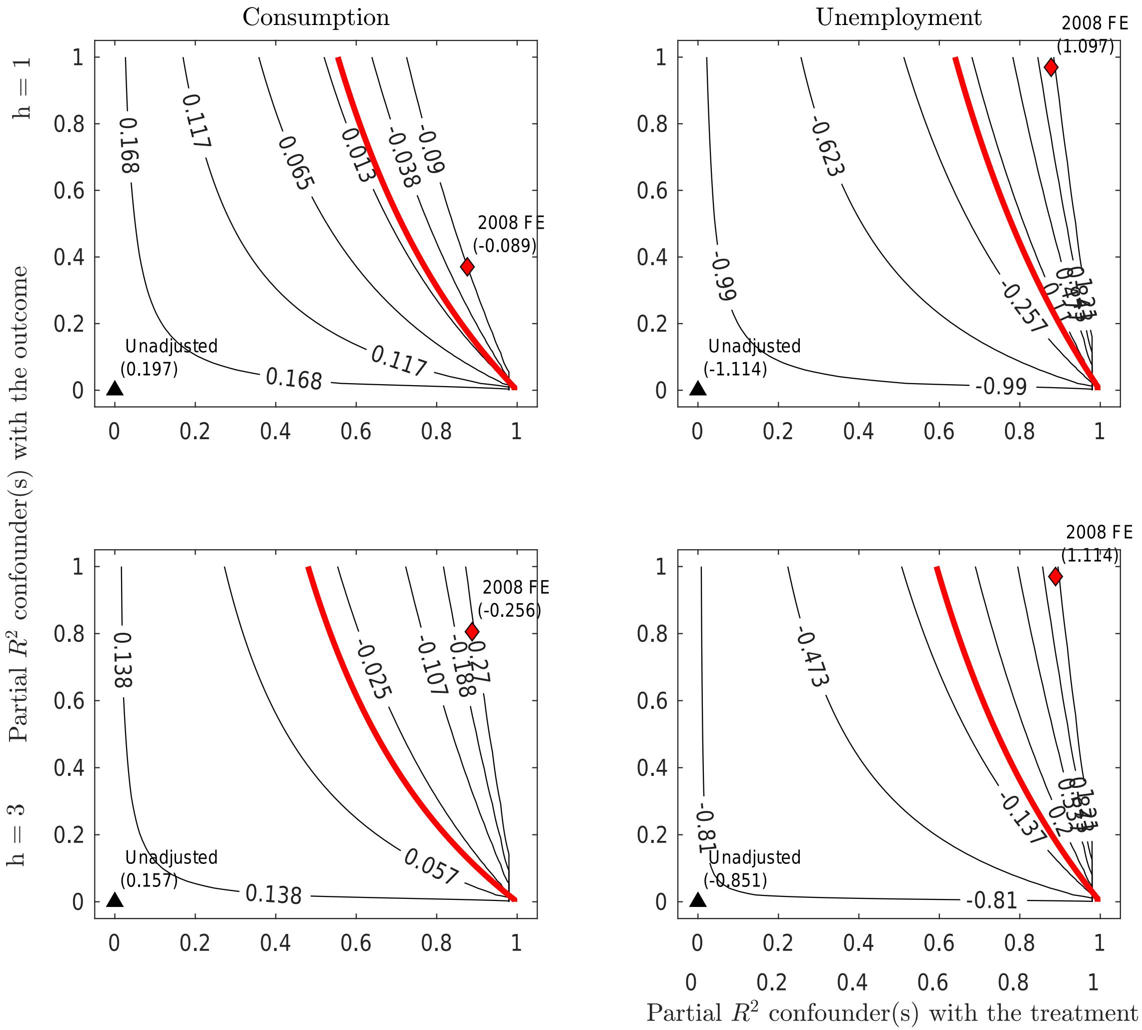


Figure 15: Point estimate of $\beta_h(\Delta \boldsymbol{Z} = 0)$

where the red line marks zero (threshold of sign flip)

- Benchmarking: 2008 year fixed effects

Appendix: Sensitivity analysis

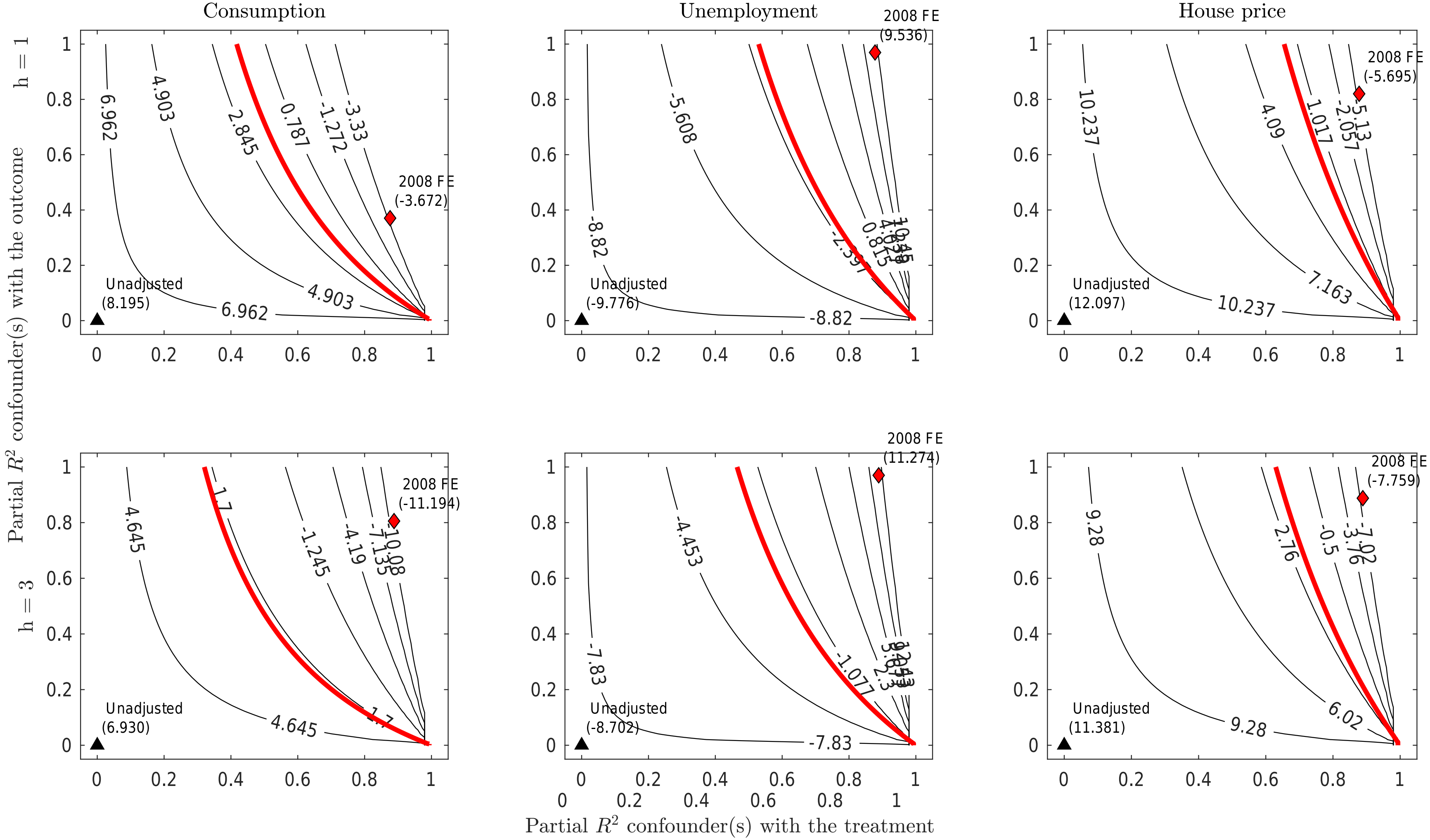


Figure 16: t-statistic of $\beta_h(\Delta \boldsymbol{Z} = 0)$

where the red line marks $\alpha = 5\%$ criteria value of t-test

- Benchmarking: 2008 year fixed effects

Appendix: Order selection

Expanding $\beta_h(\Delta \boldsymbol{Z})$ to the 3rd order:

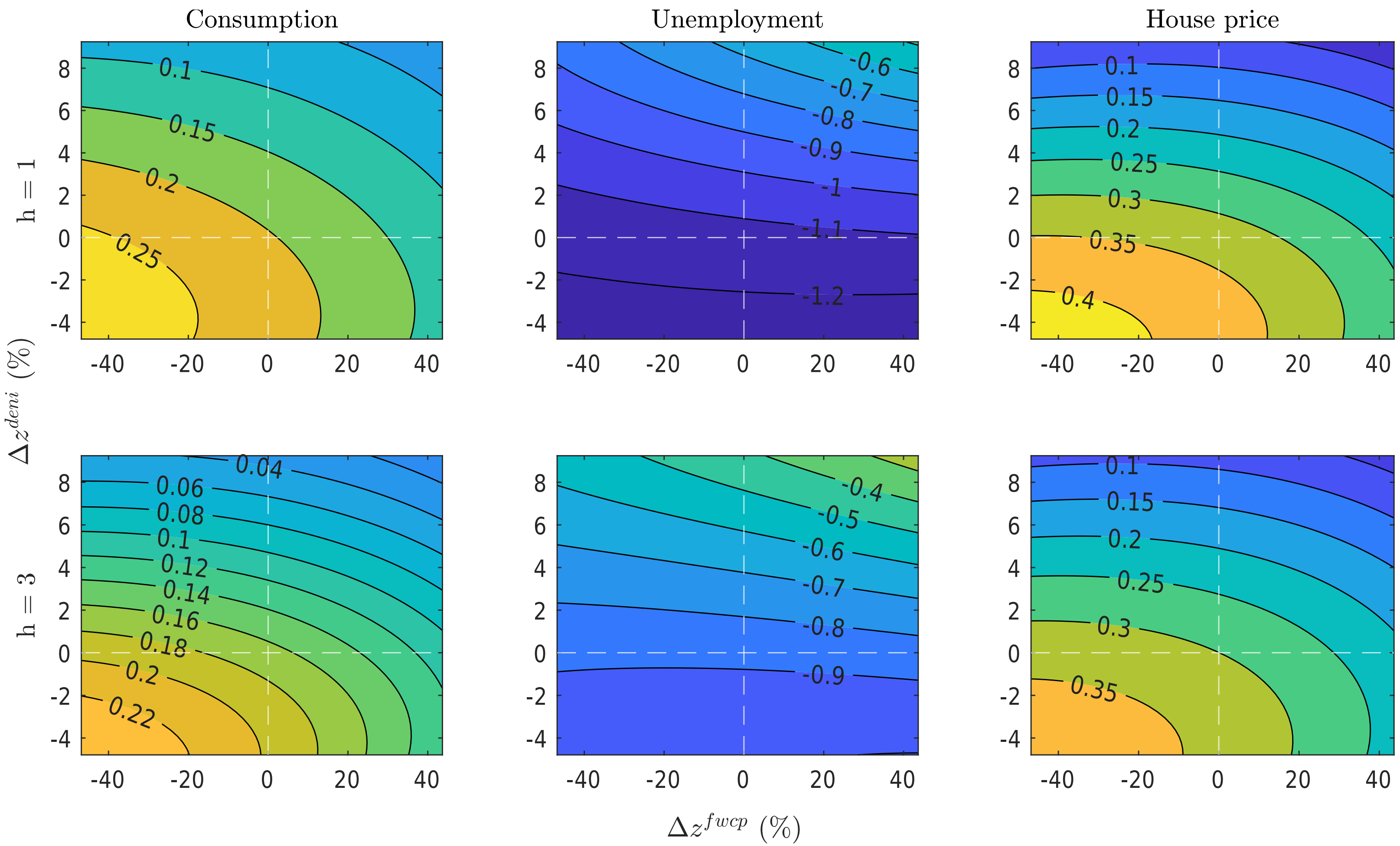


Figure 17: $\beta_h(\Delta \boldsymbol{Z})$

Goto: baseline

Appendix: Local linear estimator

- Global polynomial may mask important local features $\Longrightarrow$ check local estimators
- Use local linear estimator:
  - Gaussian kernel for $\Delta \boldsymbol{Z}$, Normalized Euclidean distance
  - 17×17 quantile knots in percentage range $[10\%, 90\%]^2$ (every 5%)
  - Two-step estimation procedure in Zhang, Lee and Song (2002)
  - Plug-in bandwidth estimator in Yang and Tschernig (1999)

Appendix: Local linear estimator

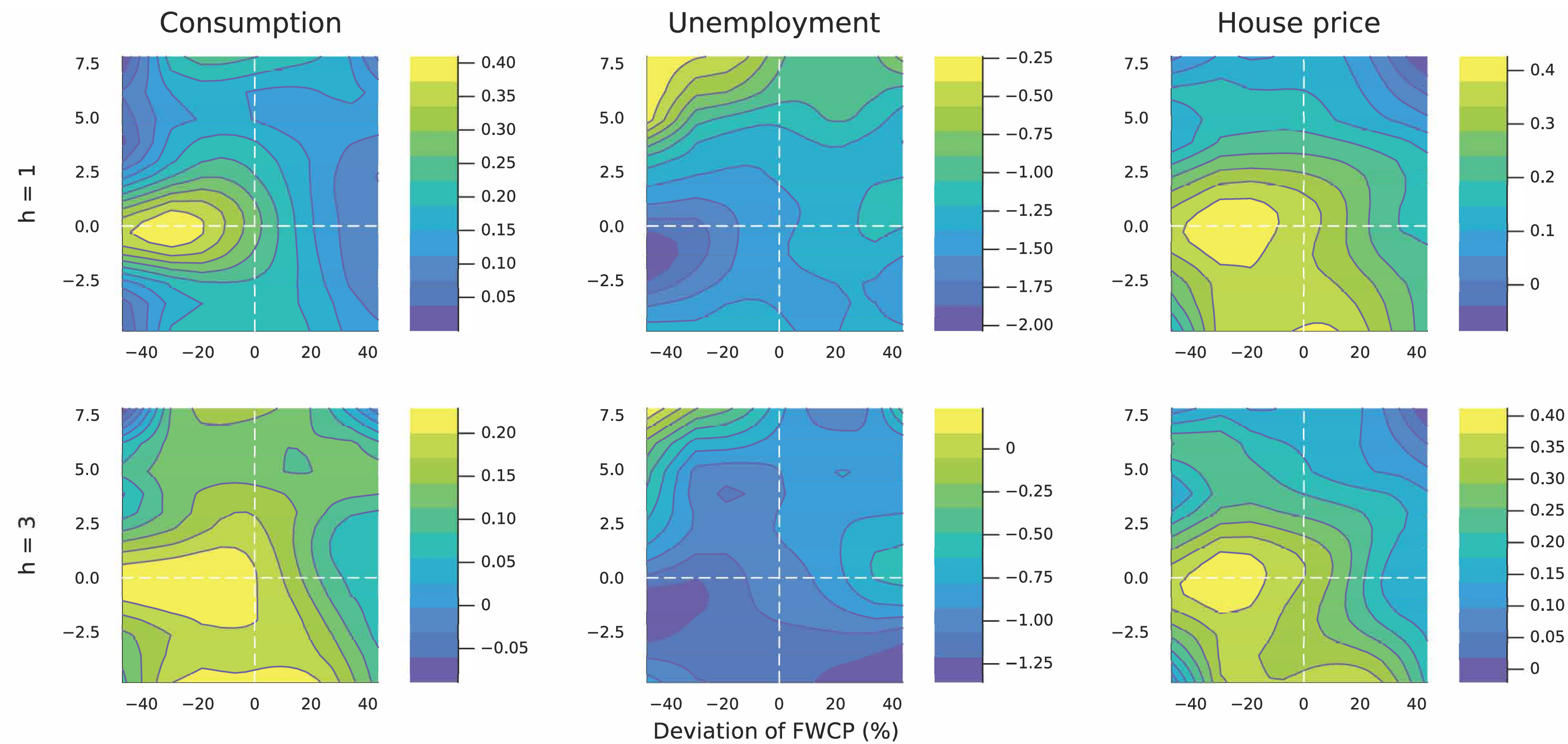


Figure 18: $\beta_h(\Delta Z)$

- No significant new features cp. baseline

Goto: robustness

Appendix: Profile-likelihood ratio (PLR) test

- The F-test depends on the parametric assumption of the global polynomial

$\Longrightarrow$ PLR test by Fan and Huang (2005) which test $\beta_h(\Delta \boldsymbol{Z})$ as a whole

- H_0: if the overall treatment effect β_h is dependent on Δz^{fwcp} and Δz^{deni} and the baseline model is correctly specified, then it equals to the estimates from the linear LP model

Goto: Robustness

- Table (next page):

Appendix: Profile-likelihood ratio (PLR) test

Horizon	Consumption	Unemployment	House price
0	3230.96***	328.46***	1596.15***
	(0.1503)	(0.1503)	(0.1503)
1	2921.63***	355.91***	1166.61***
	(0.1504)	(0.1504)	(0.1504)
2	3345.83***	1301.31***	1230.62***
	(0.1504)	(0.1504)	(0.1504)
3	3069.98***	1684.84***	1127.61***
	(0.1504)	(0.1504)	(0.1504)
4	2615.89***	1605.61***	589.91***
	(0.1504)	(0.1504)	(0.1504)
5	2264.8***	1829.66***	770.64***
	(0.1503)	(0.1504)	(0.1504)
6	1886.03***	1837.51***	841.8***
	(0.1503)	(0.1503)	(0.1503)
7	1630.81***	1799.62***	935.84***
	(0.1502)	(0.1502)	(0.1502)

where the number with stars are the generalized likelihood ratio statistic T_0, the number in parenthesis is δ_n the degree of freedom of the asymptotic $\chi^2_{\delta_n}$ distribution, the other asymptotic parameter $r_K \approx 0.51579$ for our Gaussian kernel.

Appendix: Spatial spillover effects

- Neighboring counties may share markets (e.g. labor market of a metropolitan) $\Longrightarrow$ spillover effects of net worth shocks

- Re-estimate the baseline model but:
  - adding a spatial Durbin term: $\eta_h \cdot \boldsymbol{W}\boldsymbol{X_t}$
  - assuming no spillover effects of the outcomes and error

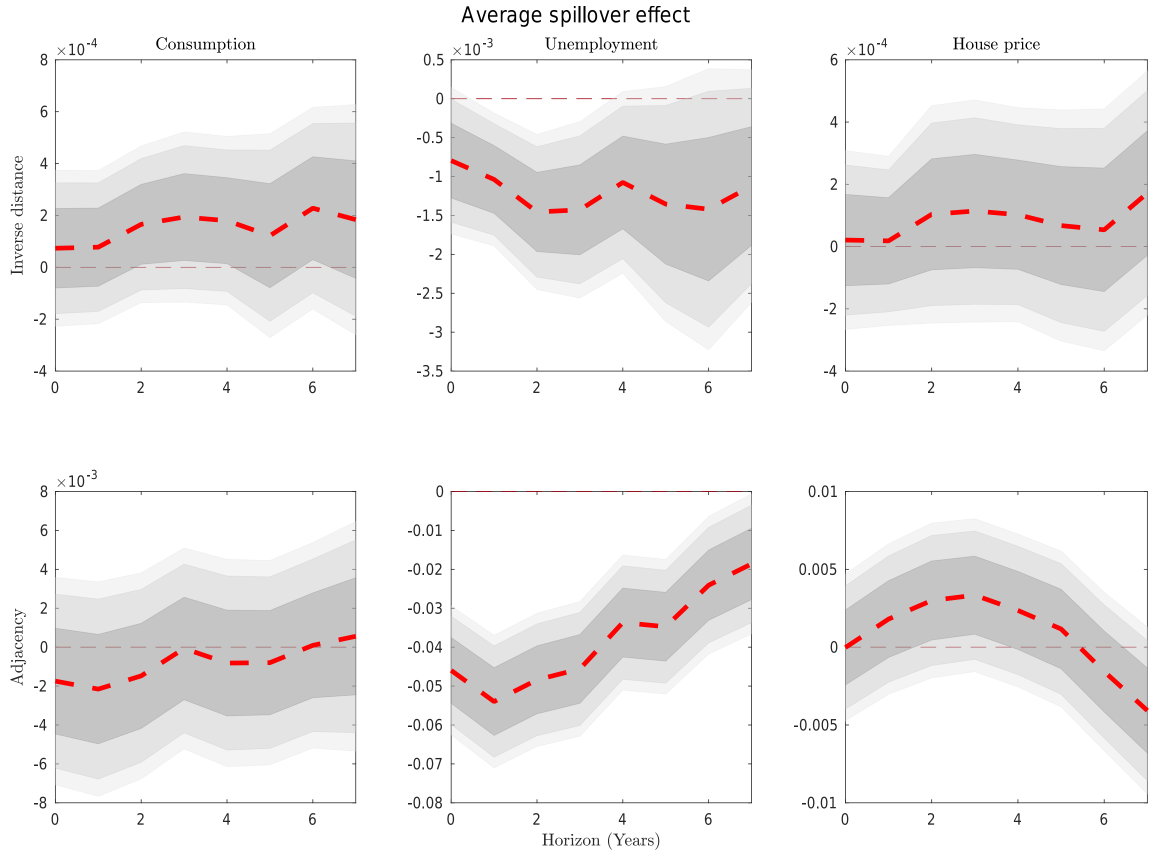
where $\boldsymbol{W}$ is spatial weighted matrix, $\boldsymbol{X}_t$ is stacked net worth shock in year t, and η_h is the coefficient of average spillover effect

- In this special case of Spatial Durbin model, the average indirect/spillover effect defined by LeSage and Pace (2009) degenerates to a number constantly proportional to η_h

- We test two types of spatial weight matrices:
  - Inverse distance weighting
  - 1st-closest neighbor adjacency weighting

Appendix: Spatial spillover effects

Average spillover effect η_h:

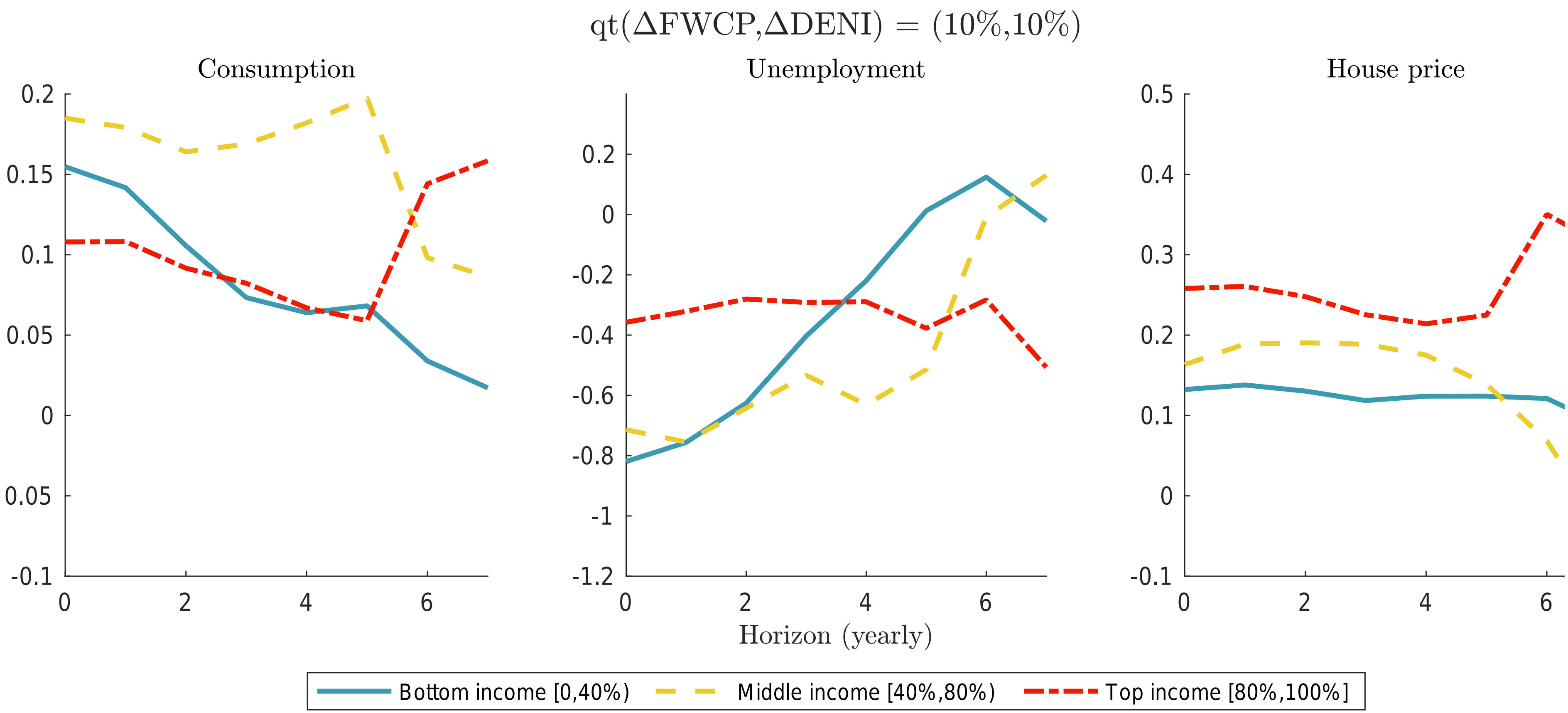


- Significant spillover effect of the shock on local labor markets
- Does not change $\beta_h(\Delta \boldsymbol{Z})$ in the other $\Delta \boldsymbol{Z}$ areas except the "top-right" corner $\Longrightarrow$ even larger non-linearity

Goto: Robustness

Appendix: Counterfactual IRF among income groups

Scenario: Neither binding $(10\%, 10\%)$:



- Similar effect size among income groups

Appendix: Other details in the baseline model

Controls:

- $\boldsymbol{W}_{i,t}$: Similar to Mian, Rao and Sufi (2013)
  - Total housing units
  - Share of housing wealth in household net worth
  - Share of tradable sector employment in total employment
  - Share of construction sector employment in total employment
- $g(N_{i,t-1})$: 3rd order polynomial approximation; controlling pre-determined economic conditions

Sample: 2004-2019; 1700 counties with consumption data available

Weights: county population

SE Cluster: state level

Goto: baseline

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