Frictions, Net Worth Shocks, and Heterogeneous Impacts

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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

Key findings:

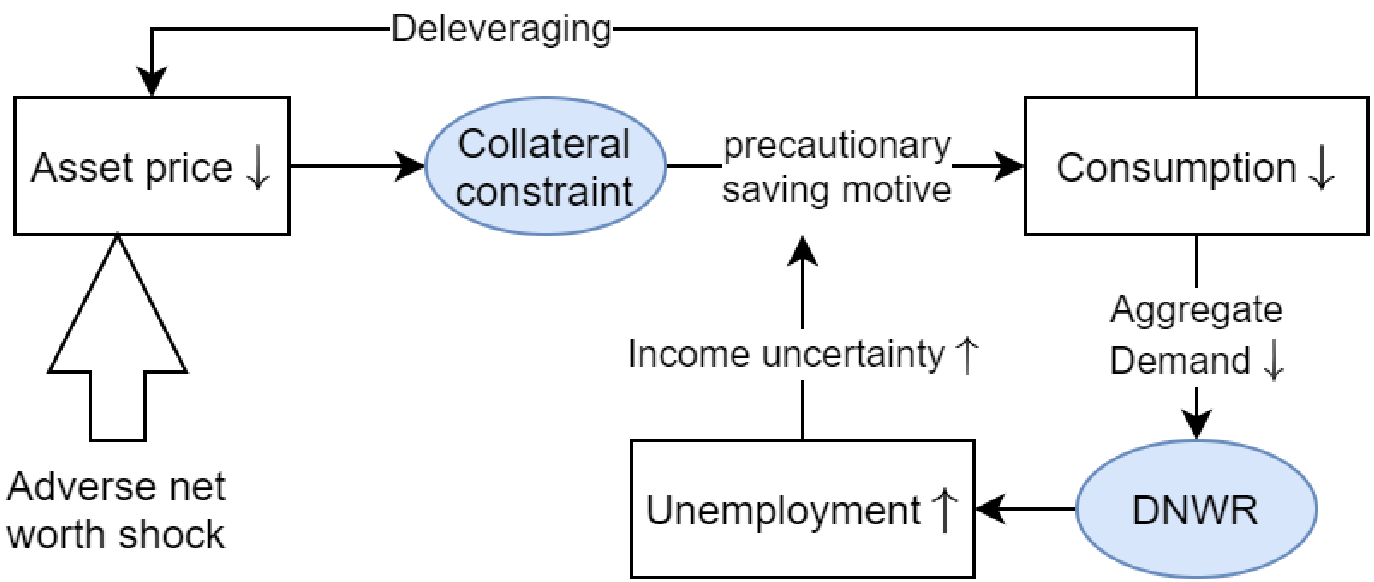
- Mechanism: adverse net worth shock → higher precautionary savings and deleverage in response to tightened collateral constraints. DNWR → higher income uncertainty. The adjustment process is prolonged, leading to a persistent decline in consumption.
- Found significant heterogeneity in the impact of 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 further 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.

The two-agent model

- **Features**: two agent (household and expert), two frictions (DNWR and collateral constraint), two assets (bond and housing wealth), and one-shot deviation scenario
- **Proposition 1**: If after-shock net worth falls below a threshold, the collateral constraint remains binding for a positive number of periods.
- **Proposition 2**: Under certain initial conditions, a range of shocks amplifies the effects on consumption, unemployment, and housing prices when both DNWR and collateral constraints bind.



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; empirical friction measure ...
- 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 leave-one-out aggregate growth of asset prices.

Definition: net worth | Definition: consumption | Definition: FWCP

Baseline specification

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

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

- where
  - $y_{i,t+h}$: outcome variables at horizon h
  - $x_{i,t}$: the identified net worth shock
  - $\beta_h(\boldsymbol{Z}_{i,t})$: effects of the net worth shock
  - $\Delta\boldsymbol{Z}_{i,t}$: *DENI* and *FWCP* deviation from the county's mean level
  - $g(N_{i,t-1}), \boldsymbol{W}_{i,t}$: functional control of the lagged net worth $N_{i,t-1}$ and other controls
  - $\iota_{i\in s}, \nu_t$: state and year fixed effects

- Sieve estimator of polynomial approximation:

$$\beta_h(\mathbf{Z}) \approx b_h^0 + b_h^1\Delta z^{fwcp} + b_h^2\Delta z^{deni} + b_h^3\Delta z^{fwcp}\Delta z^{deni} + b_h^4(\Delta z^{fwcp})^2 + b_h^5(\Delta z^{deni})^2$$

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

Page: robustness checks Page: Controls

MPC out of wealth

MPC out of wealth reflects the strength of the wealth effect on aggregate demand:

$$\widehat{\text{MPC}}(Z) = \hat{\beta}_0(Z) \cdot \frac{\hat{\mathbb{E}}\{c|Z\}}{\hat{\mathbb{E}}\{n|Z\}}$$

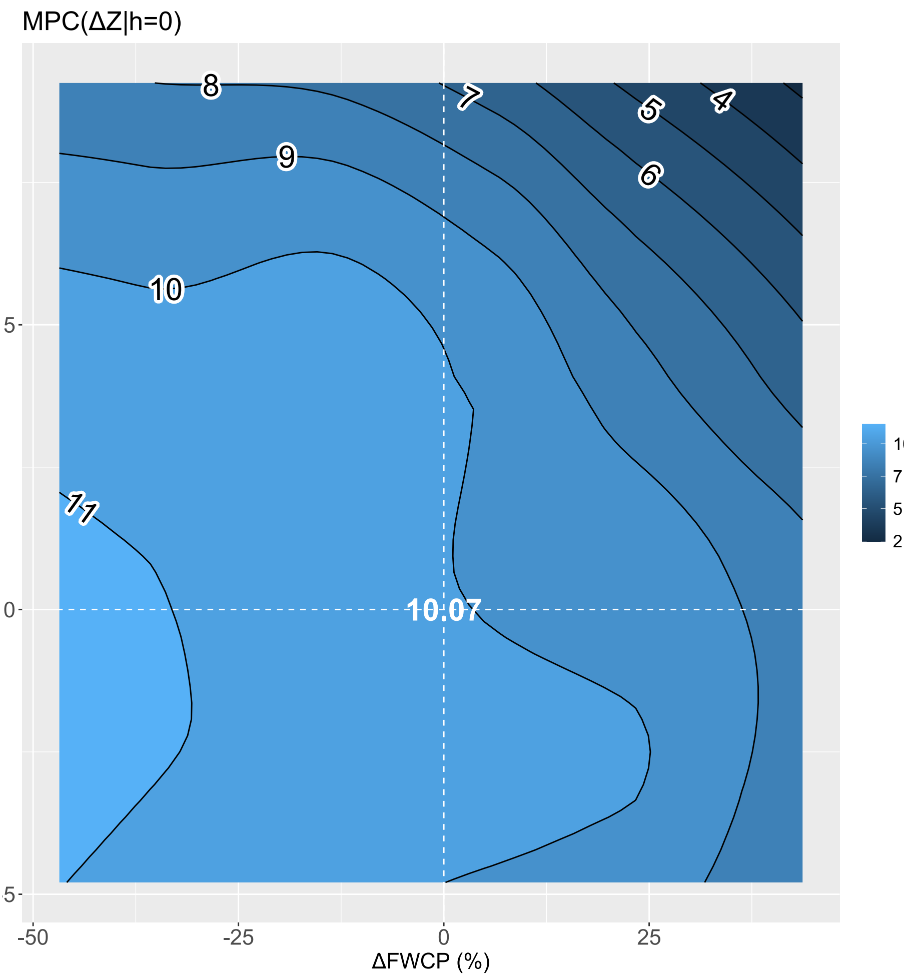
- x-axis: DNWR, right $\rightarrow$ more severe

  y-axis: collateral constraint, top $\rightarrow$ more severe
- Average MPC: 10.07 cents per dollar (literature: 7 out of housing wealth)

$\Rightarrow$ Large heterogeneity: $3 \sim 11$

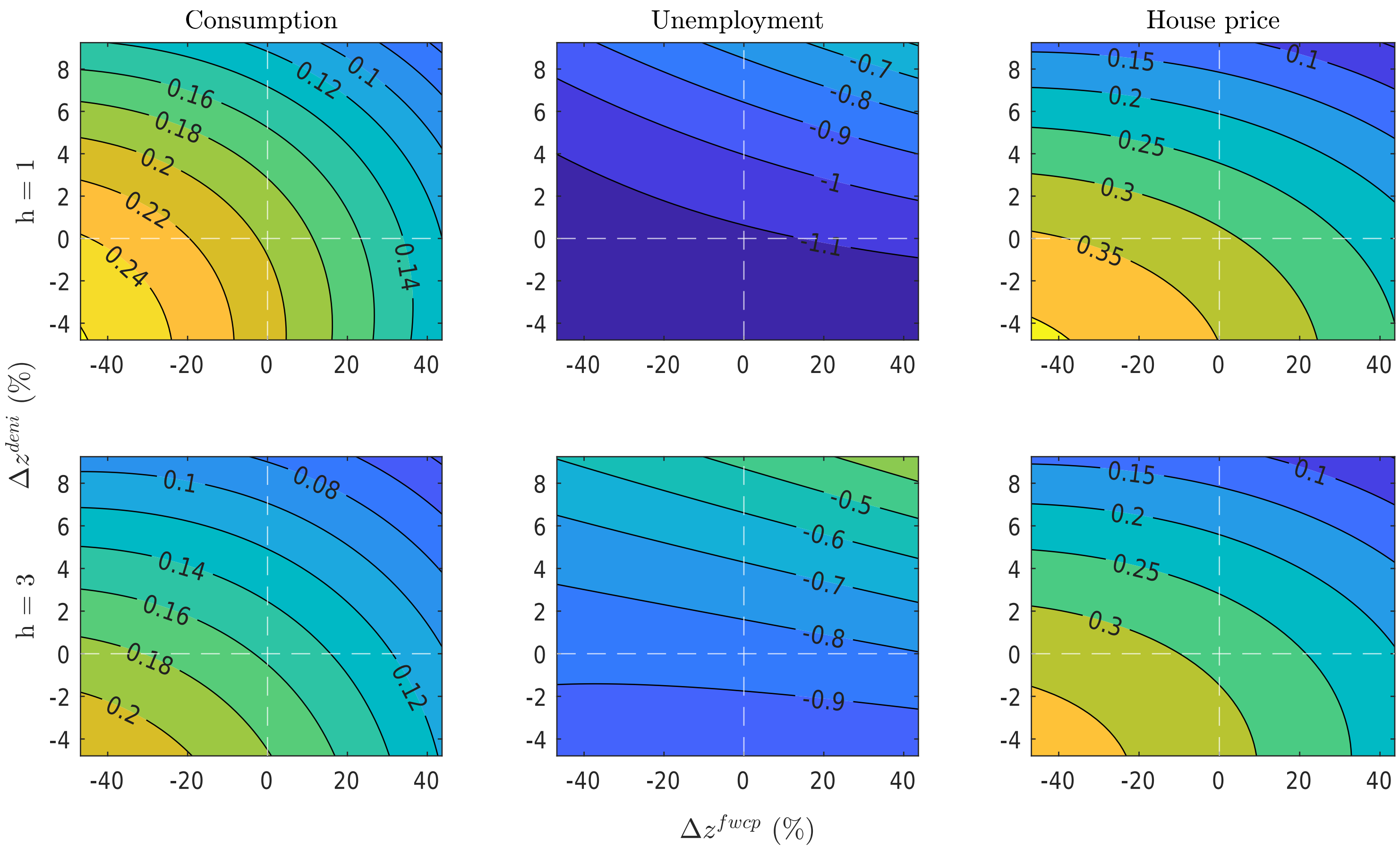
$\Rightarrow$ Amplification: Larger frictions, less consumption

$\Rightarrow$ Friction interaction: much smaller MPC when both frictions are severe



Full profiles of $\beta_h(\boldsymbol{Z})$

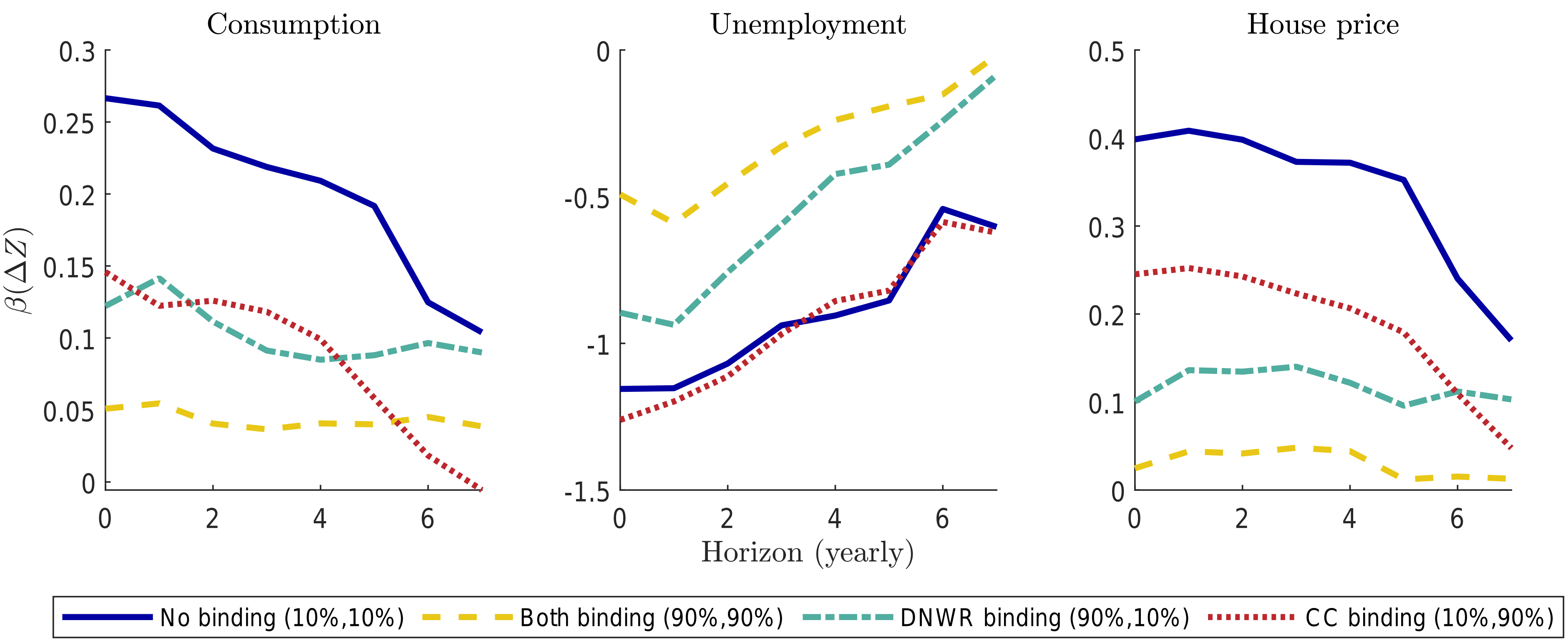
$\beta_h(\boldsymbol{Z})$ are trajectories of 2-dimensional functions (+1% shock) Other horizons



- Layout: projection horizon (row) × outcome variables (columns)
- Contour interval: heterogeneity of the effects
- Contour curvature: interaction & non-linearity

Counterfactual IRF

By scenario of frictions:



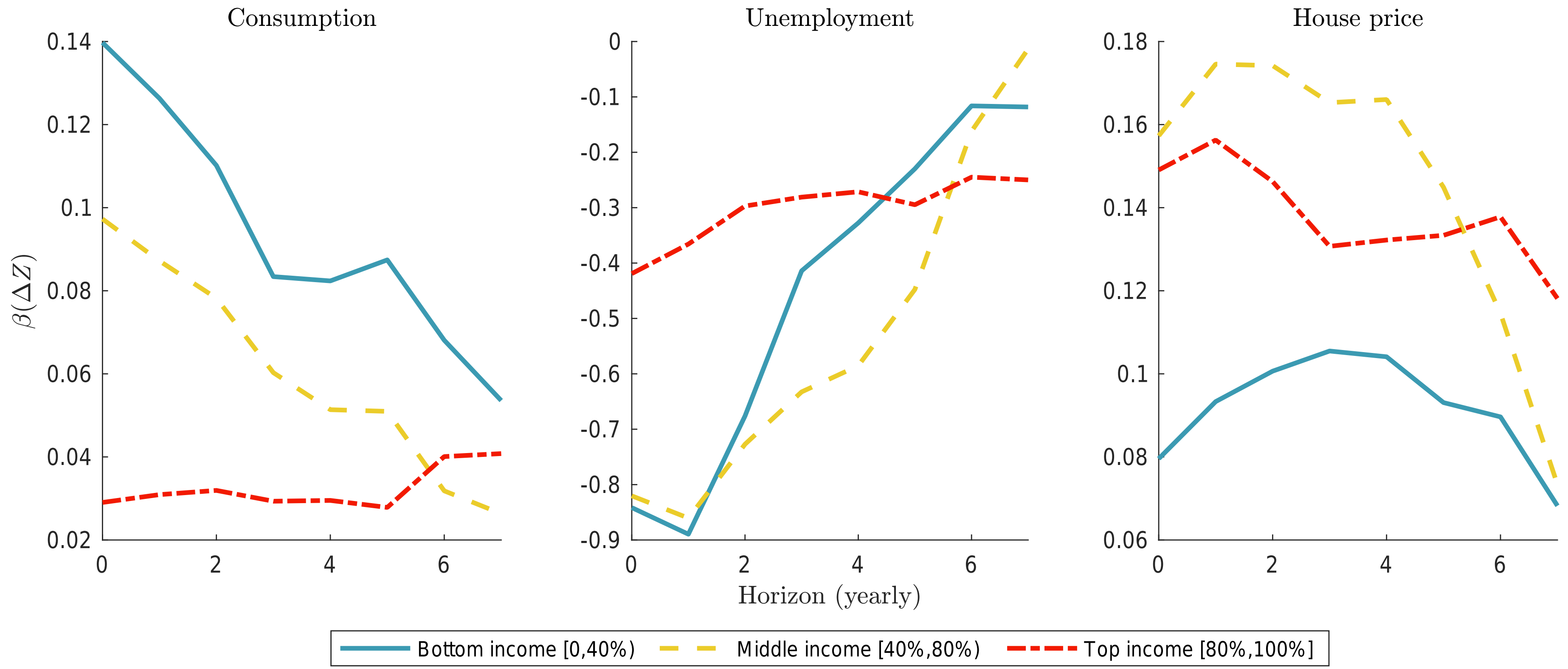
- High-friction counties merely response
- Same shock leads to largely different response ($3 \sim 5$ times difference)

$\Rightarrow$ Policies based on local economic conditions

$\Rightarrow$ Policies to reduce local friction levels

Heterogeneity among income groups

Check $\beta(\Delta \boldsymbol{Z} = 0)$, the average effect:



- Vulnerability against shock:
  - Consumption: Low & Middle
  - Unemployment: Low & Middle
  - House price: Middle & Top

$\Longrightarrow$ One-size-fit-all policy may potentially exacerbate existing inequalities

$\Longrightarrow$ Policies targeting at different outcomes in difference regions of income

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	9.680	9.709	9.392	8.086	8.226	11.013	8.152	5.830
	(.000)	(.000)	(.000)	(.001)	(.001)	(.000)	(.000)	(.001)
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.

- The F-test suggests significant non-linearity of the heterogenous effects and the interaction between collateral constraint and DNWR

Robustness: PLR test

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 $\beta_h(\boldsymbol{Z})$
- **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 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!

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Outline

Appendix: Other horizon of the baseline

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

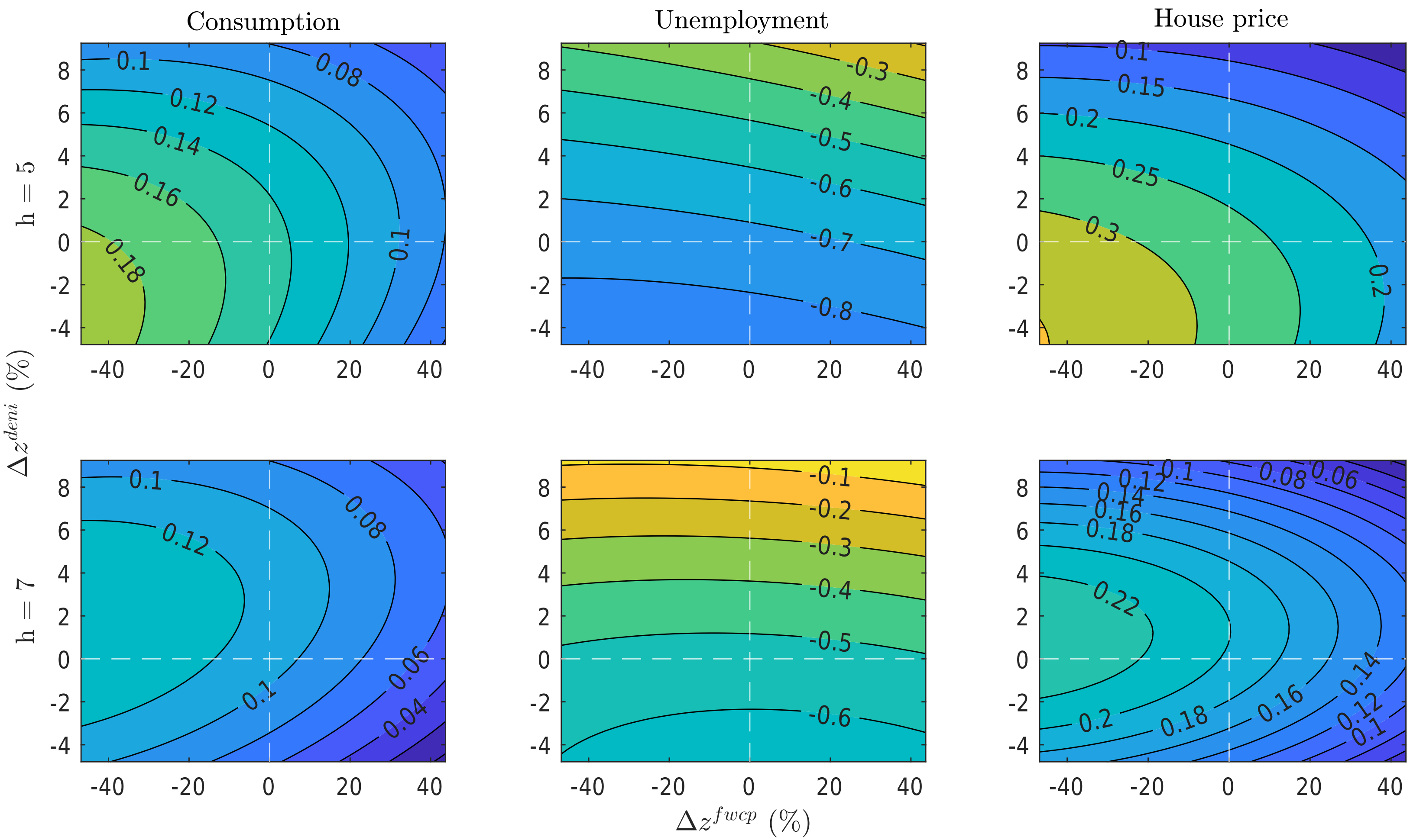


Figure 6: $\beta_h(\Delta \boldsymbol{Z})$

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

Appendix: variable definitions

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
$\overline{\nu}$	Steady state LTV ratio	0.79
γ	Housing preference	0.8
H	House supply	30

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

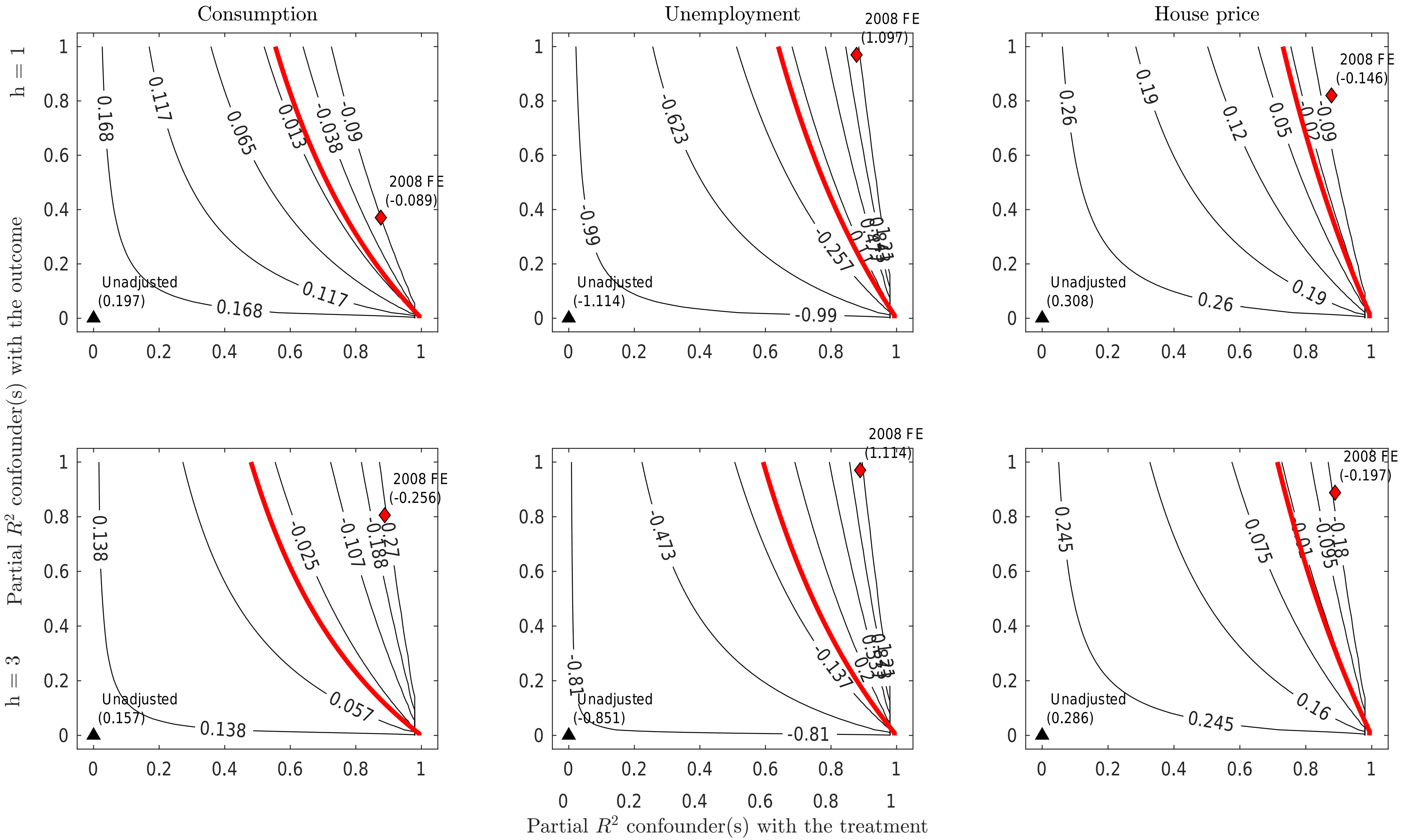


Figure 7: Point estimate of $\beta_h(\Delta \boldsymbol{Z} = 0)$

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

- Benchmarking: 2008 year fixed effects

Appendix: Sensitivity analysis

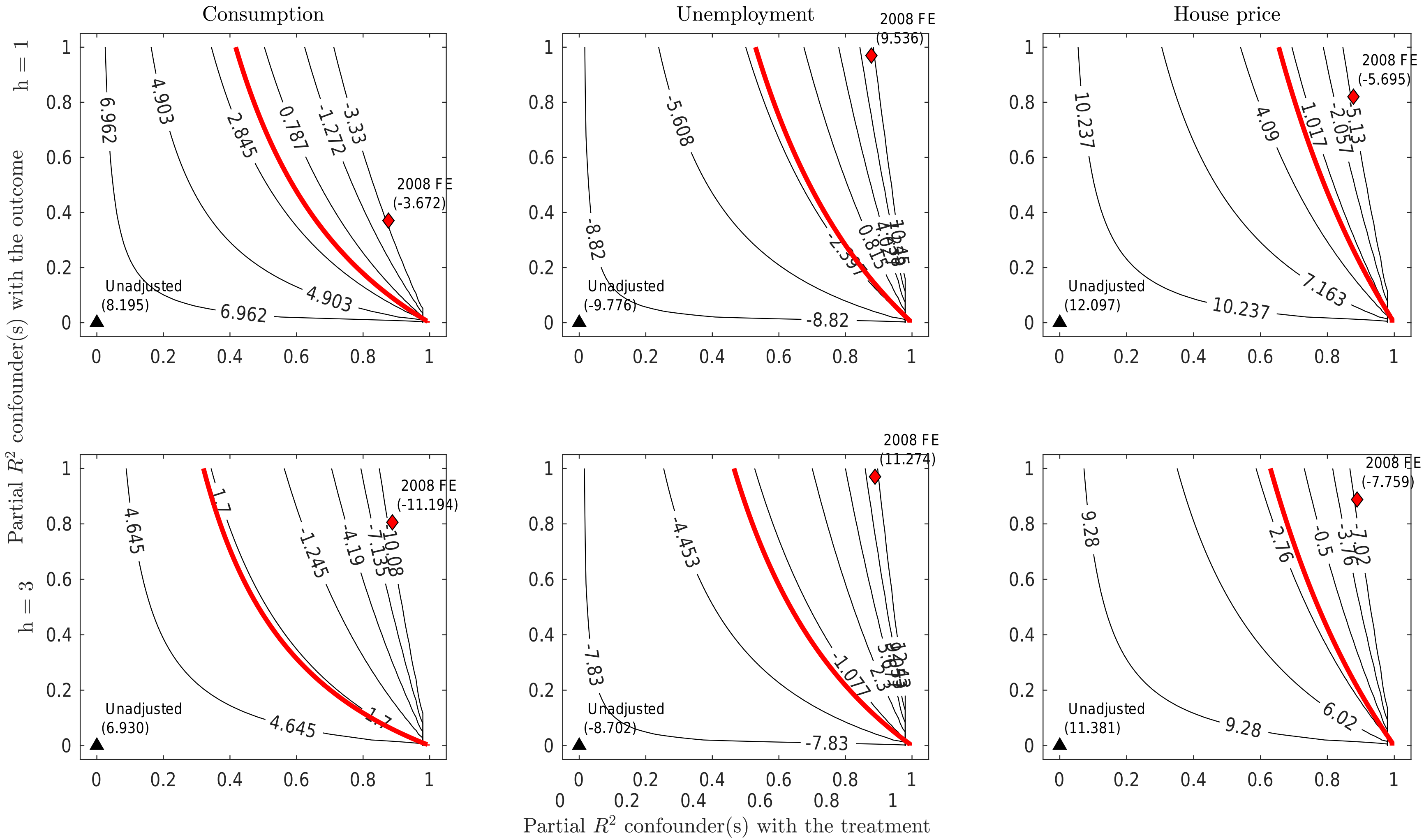


Figure 8: t-statistic of $\beta_h(\Delta \boldsymbol{Z} = 0)$

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:

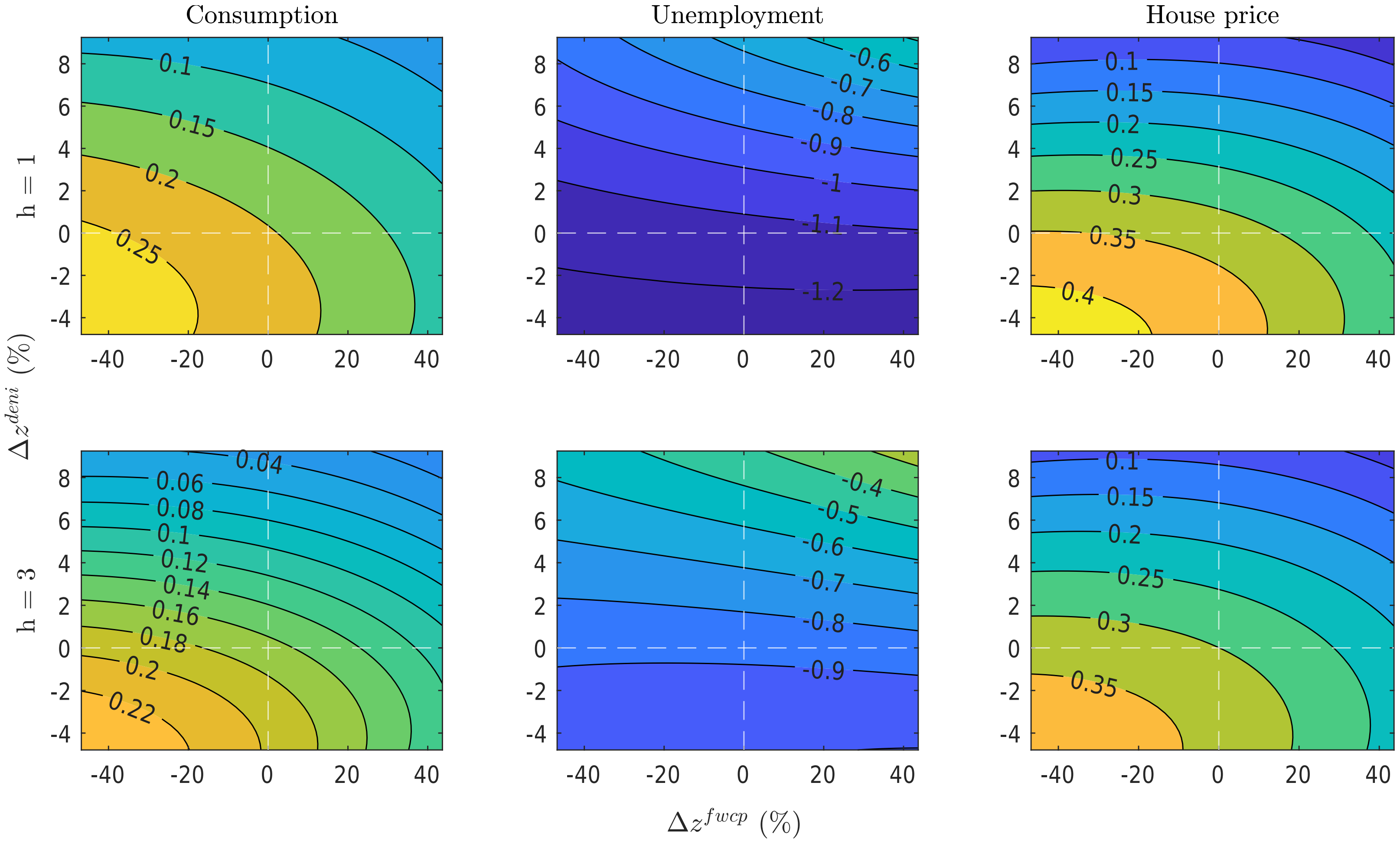


Figure 9: $\beta_h(\Delta \boldsymbol{Z})$

Goto: baseline

Appendix: Local linear estimator

- Global polynomial may mask important local features $\Longrightarrow$ check local estimators
- Use local linear estimator:
  - Gaussian kernel for $\boldsymbol{\Delta Z}$, 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

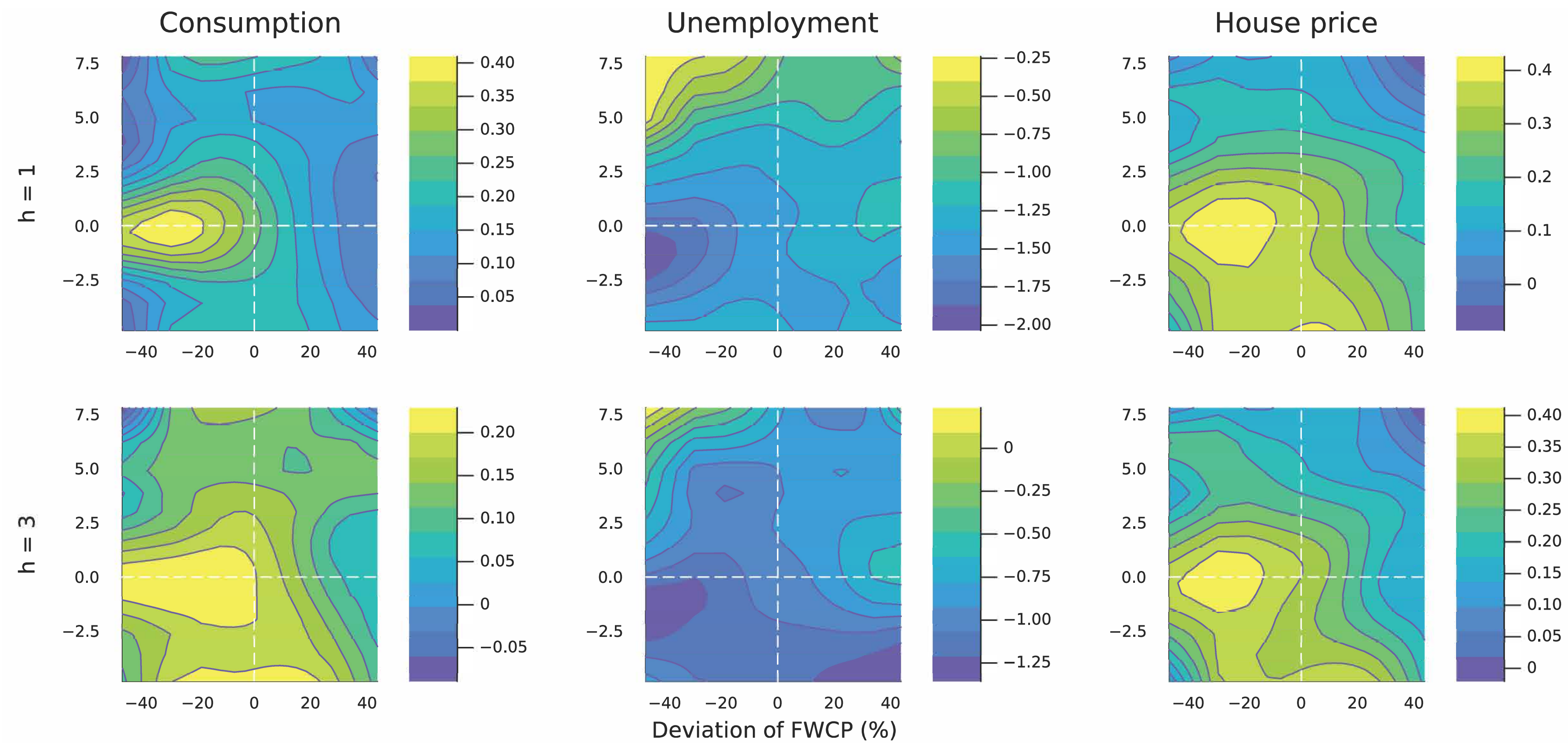


Figure 10: $\beta_h(\Delta Z)$

- 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: $\eta_h \cdot \boldsymbol{W X_t}$
  - assuming no spillover effects of the outcomes and error

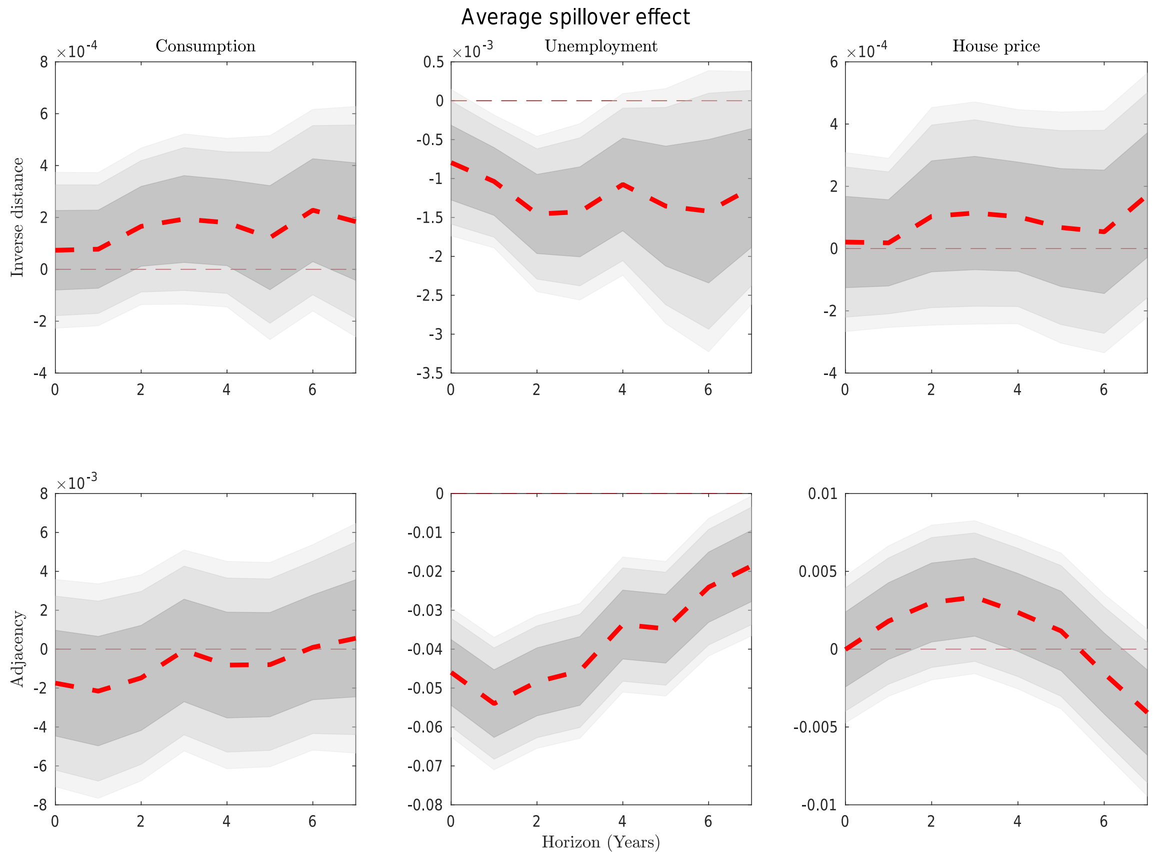
where $\boldsymbol{W}$ is spatial weighted matrix, $\boldsymbol{X}_t$ is stacked net worth shock in year t, and η_h is the coefficient of average spillover effect

- 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:

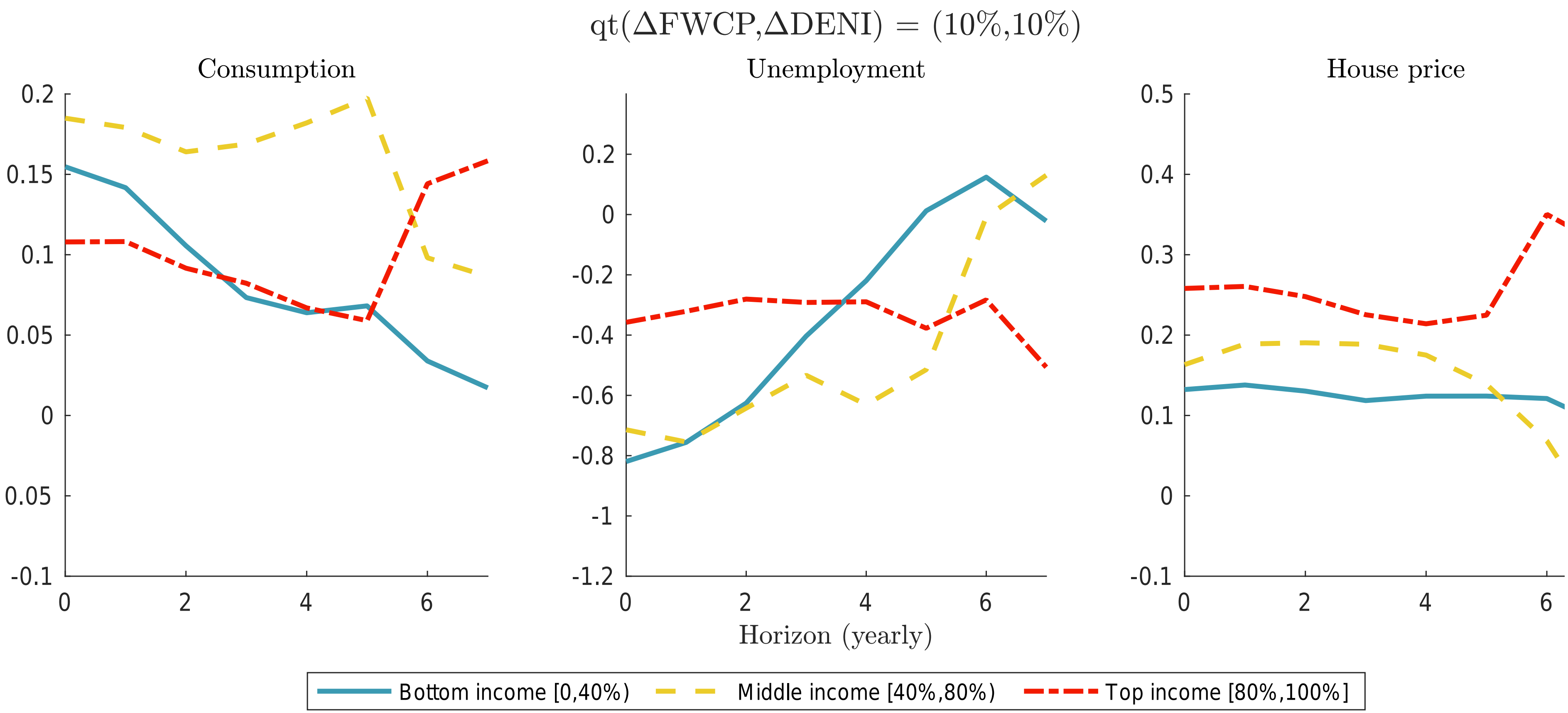


- Significant spillover effect of the shock on local labor markets
- Does not change $\beta_h(\Delta Z)$ in the other ΔZ areas except the "top-right" corner $\Longrightarrow$ even larger non-linearity

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
- $g\left(N_{i,t-1}\right)$: 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

Appendix: Other details in the baseline model

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