Unemployment Insurance, Precautionary Savings, and Fiscal Multipliers

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Introduction

Unemployment insurance (UI) duration systematically extended during bad times in the US

- A four-fold increase during Great Recession and a three-fold increase during pandemic
- Stands out as one of the main countercyclical stabilization measures

Opposing effects of UI extensions on unemployment:

- Supply: increase wages and depress hiring, moral hazard
- Demand: increase transfers to high-MPC unemployed and reduce precautionary savings

Mixed results in the literature leave debate unsettled

- Contractionary effects: Hagedorn *et al.* (2019), Johnston and Mas (2018)
- Expansionary or non-negative effects: Di Maggio and Kermani (2016),Chodorow-Reich *et al.* (2018),Boone *et al.* (2021), Dieterle *et al.* (2020)

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What we do

We reconsider the **macroeconomic stabilization consequences of UI extensions**

- Propose a new identification scheme based on non-linear design of UI policy
- Use macroeconomic model to rationalize and extend empirical results

Identification based on the non-linear design of UI policy

→ **UI duration response to falling unemployment depends on pre-existing length of UI**, e.g.

- UI regular duration irrespective of state-level conditions
  - → Falling unemployment in state with regular UI will not change UI duration
- UI additional extensions depend state-level unemployment
  - → Same fall in unemployment in state with extended UI can cut UI duration
- Can apply similar logic to states that have *different lengths* of additional UI extensions
  - E,g. Regular UI provides a floor for UI duration

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We implement this by estimating **local fiscal multipliers conditional on UI duration**

- Gov't spending shock – demand shock – changes unemployment and hence UI duration
- Variation in fiscal multipliers across levels of UI duration infers effects of UI extensions

We find **UI extensions provide cushion against state-level shocks** (G shocks):

- Gov't spending crowds out UI in line with identification idea
- **Fiscal multipliers lower when UI duration extended**
- **Employment-UI elasticity of ≈ 0.27**

Model of small-open-economy that incorporates main channels

- Model accounts well for empirical results
- We use the model to **quantify channels** insurance $\geq$ transfers to high-MPC hhs.
- Back-out **union-wide effects of UI extensions**
  - UI extensions still stabilizing, but to a lesser extent

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Related Literature

Macro effects of UI benefits:

Empirics: Chodorow-Reich *et al.* (2018); Hagedorn *et al.* (2019); Di Maggio and Kermani (2016); Boone *et al.* (2021); Johnston and Mas (2018); Dieterle *et al.* (2020)

Theory: Kekre (2021); McKay and Reis (2021); Gorn and Trigari (2021); Mitman and Rabinovich (2019); Krusell *et al.* (2010); Jung and Kuester (2015); Landais *et al.* (2018); Gorn and Trigari (2021)

Fiscal multipliers:

Aggregate: Ramey and Zubairy (2018); Ramey (2011); Auerbach and Gorodnichenko (2012); Barnichon *et al.* (Forthcoming)

Regional: Nakamura and Steinsson (2014); Bernardini *et al.* (2020); Dupor *et al.* (2022); Chodorow-Reich *et al.* (2012); Suárez Serrato and Wingender (2016); Acconcia *et al.* (2014); Basso and Rachedi (2021)

Open economy with heterogeneous households: de Ferra *et al.* (2020); Auclert *et al.* (2021); Cugat (2019); Guo *et al.* (2020)

Empirical Strategy

UI Policy & Identification

Unemployment Insurance Duration in the US

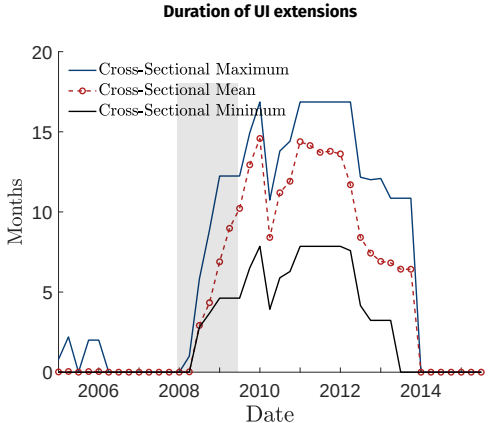
US states: 26 weeks of **regular UI duration**

Irrespective of local unemployment

UI duration extended during bad times:

EB program: if unemployment above threshold states can obtain additional UI extension of one quarter
EUC program (financial crisis): states could get additional UI extension of four quarters depending on unemployment

Substantial **variation in UI duration across time and states**



Idea behind identification strategy

Consider two states **A** and **B** to fix ideas:

Unemployment in **A** temporarily higher: **A** has extended UI and **B** has regular UI

Same demand shock (e.g. G_t) hits both **A** and **B** reducing unemployment

Effect on output in **A** = effect of G_t + effects of cutting UI duration
Effect on output in **B** = effect of G_t

Can apply similar logic if **B** also has extended UI, but different from **A**:

E.g. regular UI as floor: size UI duration cut in A $\neq$ size UI duration cut in B

Implementation: estimate **fiscal multipliers** is US states with different levels of **UI duration**

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Data

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Quarterly regional US dataset from Regional Economic Accounts of BEA (2005Q1 - 2015Q4)

- Quarterly GDP and government value added at state-level
- Gov. value added: spent within the region, excludes UI benefits

Quarterly employment data

- Employed persons obtained from Bureau of Labor Statistics (BLS)
- State-level population obtained from Boone *et al.* (2021)

Government spending shocks as in Blanchard and Perotti (2002):

- Government spending predetermined within the quarter

UI benefits extensions:

- Actual additional UI duration for each US state (Chodorow-Reich *et al.*, 2018)

Effects of Gov't Spending on UI duration

Government Spending crowds out UI

Key in our approach: G_t induces UI duration changes

1. Estimate the **response of UI duration to gov. spending** by LPs (Jordà, 2005):

$$\sum_{h=0}^{H} \mathrm{T}^*_{i,t+h} - \mathrm{T}^*_{i,t-1} = \beta_h \log(G_{i,t} \backslash G_{i,t-1}) + \gamma_h(L) \log Z_{i,t-1} + \alpha_{i,h} + \delta_{t,h} + \varepsilon_{i,t+h}, \quad h \geq 0,$$

T^*: additional qrts. of UI duration

$G_{i,t}$: Gov't spending in state i

$Z_{i,t}$: lags of $\{G, Y, \mathrm{T}^*\}$

$\alpha_{i,h}$, $\delta_{t,h}$: state & time fixed-effects

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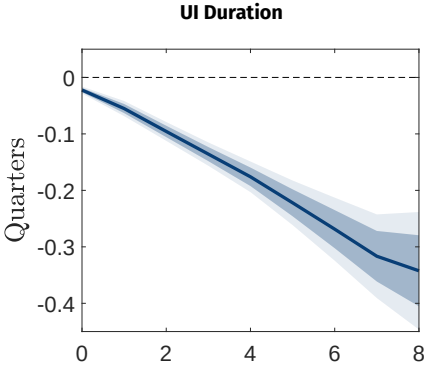

Fiscal Multipliers & UI duration

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2. Accouting for heterogeneity in slackness
3. Accouting for unobserved covariates

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Empirical Specification – Fiscal Multipliers

Estimate **local fiscal multipliers** using state-dependent LPs (Jordà, 2005; Ramey and Zubairy, 2018)

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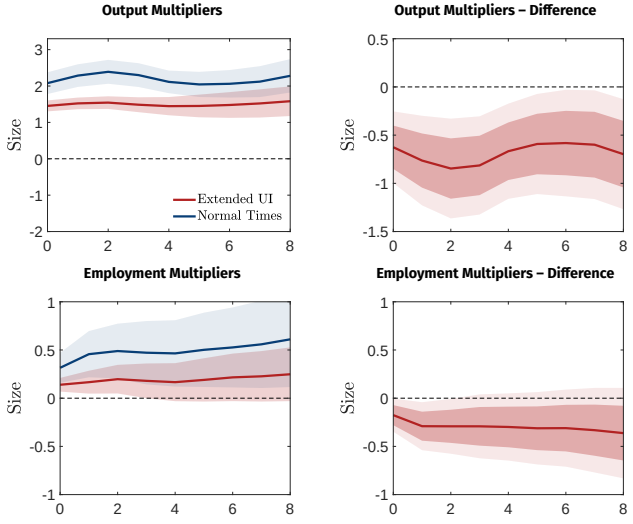
Fiscal Multipliers & UI Extensions

Consumption | gov't Direct Expenditure | Bartik Instrument



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1. Baseline
2. **Accouting for heterogeneity in slackness**
3. Accouting for unobserved covariates

Horse-race: Accounting for heterogeneity in slackness

Recessions or UI extensions?

If anything, fiscal multipliers *larger* in recessions (Auerbach and Gorodnichenko, 2012)

Yet, extend baseline to run **horse-race**:

$$\sum_{h=0}^{H} Y_{i,t+h} = \beta_h \sum_{h=0}^{H} G_{i,t+h} + \gamma_h(L) Z_{i,t-1} + \alpha_{i,h} + \delta_{t,h} + \varepsilon_{i,t+h}$$

$$+ T^{UI}_{i,t-1}\left(\beta^{UI}_h \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^s_{i,t-1}} + \gamma^{UI}_h(L) Z_{i,t-1}\right) + I^{Slack}_{i,t-1}\left(\beta^{Slack}_h \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^s_{i,t-1}} + \gamma^{Slack}_h(L) Z_{i,t-1}\right)$$

β^{UI}_h: additional effect of UI extended

$I^{Slack}_{i,t-1}$: state i with 2 qrts. of negative growth or unemployment rate above 6.5%

β^{Slack}_h: additional effect of recession

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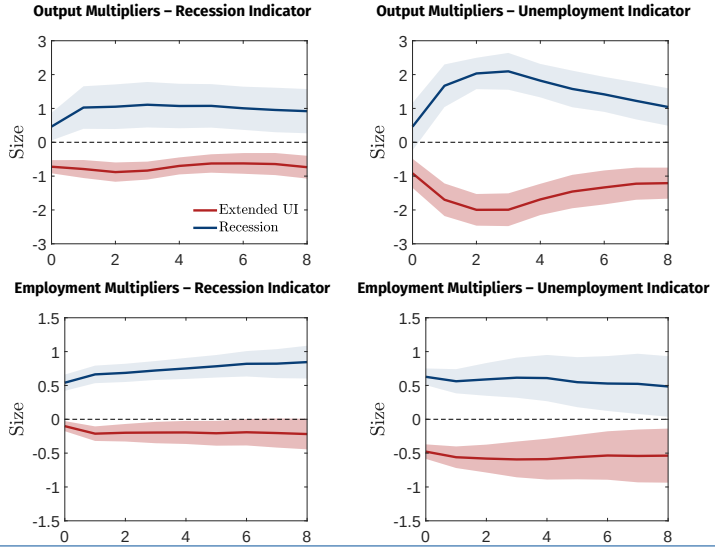

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Accounting for unobserved covariates

Unobserved covariates driving results?

E.g., local wage rigidity can affect T^* and multiplier

If anything, source of *amplification*

Use **UI extensions due unemployment measurement error** (Chodorow-Reich *et al.*, 2018) , ie. *orthogonal* to fundamentals

$$\sum_{h=0}^{H} X_{i,t+h} = \beta_h \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^*_{i,t-1}} + \gamma_h(L) Z_{i,t-1} + \alpha_{i,h} + \delta_{t,h} + \varepsilon_{i,t+h}$$

$$+ \widehat{T}_{i,t-1} \left(\beta_h^{\widehat{T}} \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^*_{i,t-1}} + \gamma_h^{\widehat{T}}(L) Z_{i,t-1} \right) + \mathbb{I}^{T^*}_{i,t-1} \left(\beta_h^{T^*} \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^*_{i,t-1}} + \gamma_h^{T^*}(L) Z_{i,t-1} \right)$$

$\widehat{T}_{i,t-1}$: UI extended due to *measurement error*

$\beta_h^{\widehat{T}}$: additional effect of UI extended *due to measurement error*

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If anything, source of *amplification*

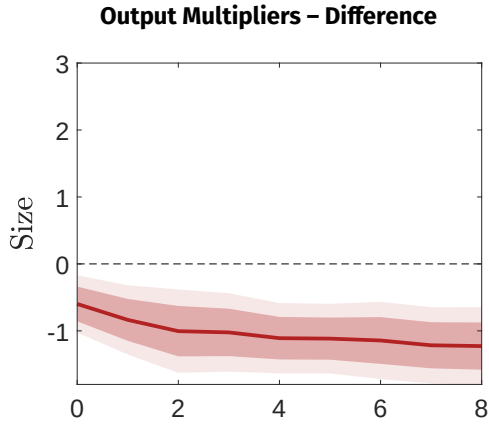
Use **UI extensions due unemployment measurement error** (Chodorow-Reich *et al.*, 2018) , ie. *orthogonal* to fundamentals

$$\sum_{h=0}^{H} X_{i,t+h} = \beta_h \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^*_{i,t-1}} + \gamma_h(L) Z_{i,t-1} + \alpha_{i,h} + \delta_{t,h} + \varepsilon_{i,t+h}$$
$$+ \widehat{T}_{i,t-1} \left(\beta_h^{\widehat{T}} \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^*_{i,t-1}} + \gamma_h^{\widehat{T}}(L) Z_{i,t-1} \right) + \mathbb{I}^{T^*}_{i,t-1} \left(\beta_h^{T^*} \sum_{h=0}^{H} \frac{G_{i,t+h} - G_{i,t-1}}{Y^*_{i,t-1}} + \gamma_h^{T^*}(L) Z_{i,t-1} \right)$$

$\widehat{T}_{i,t-1}$: UI extended due to *measurement error*

$\beta_h^{\widehat{T}}$: additional effect of UI extended *due to measurement error*

Accounting for unobserved covariates



Interpretation of Results

Government Spending crowds out UI – High vs. Low UI Duration

So far:

1. Gov't Spending crowds-out UI duration
2. Extended UI reduces fiscal multipliers

Implied effects of UI on employment? Compute:

1. Difference of employment elasticity to gov't spending (rather than multipliers)
2. Elasticity of UI extensions to gov't spending

1. Elasticity of employment to G ≈ 0.018
2. Elasticity of UI to G ≈ 0.065

$\rightarrow$ **Employment-UI duration elasticity**
$0.018 \backslash 0.065 \approx$ **0.27**

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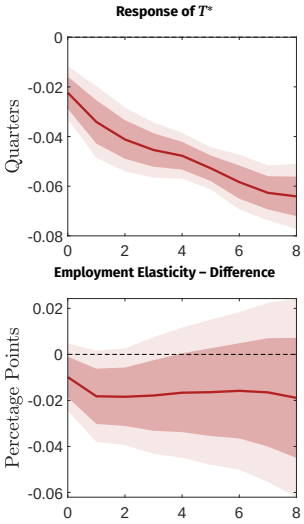


Model

Model Overview

Small-open-economy in a monetary union (Galí and Monacelli, 2005)

Search-and-matching frictions in the labor market (Mortensen and Pissarides, 1994)

Heterogeneous households (İmrohoroğlu-Bewley-Hugget-Aiyagary) see:

- **Receive unemployment benefits while unemployed if eligible** see
- **Risk of exhausting UI benefits** while unemployed

Firms see:

- Standard New Keynesian block
- Partly rigid **wages affected by UI policy**

Local fiscal authority see:

- **Government consumption** on home goods
- Sets **UI duration according to UI policy rule** that depends on unemployment

Calibration

Calibration

Parameter	Description	Value	Target / Source
Households			
$1/\sigma$	IES	0.5	Standard value
β_1	**Discount factor high**	0.98	$r = 0.04/4$
β_2	**Discount factor low**	0.93	MPC = 0.20
ρ_h	Persistence h	0.98	Bayer *et al.* (2019)
σ_h	Std. innovations to h	0.06	Bayer *et al.* (2019)
ε	Elast. subs. intermediate goods	7	Standard value
η	Elast. subs. H and F goods	1.5	Chari *et al.* (2002)
α	Share imported goods	0.3	Nakamura and Steinsson (2014)
Firms			
κ_v	Vacancy posting cost	0.05	4.5% of quarterly wage
w	St-st. real wage	1.13	$q = 0.71$
ϕ^w	**Wage rigidity**	0.30	Elast. wage - Output = 0.45
Z	St-st. productivity	1.24	$C = 1$
κ_p	Slope NKPC	0.05	Mean price duration of 5 q.

Calibration

Parameter	Description	Value	Target / Source
Labor market			
δ	Separation rate	0.10	Standard value
χ	Matching efficiency	0.66	$N = 0.94$
γ	Curvature matching function	0.5	Petrongolo and Pissarides (2001)
Government			
τ	Steady-state tax rate	0.19	G/Y = 0.14
B_H	Steady-state gov. debt	2.1	$B_H/4Y$ = 0.45
b	Replacement rate UI	0.83	Income drop upon unemployment
$\tilde{b}$	Replacement rate safety-net	0.54	Income drop upon UI exhaustion
pe	**Prob. loosing eligibility**	0.5	Avg. duration UI of 2 q.
pr	**Prop. regaining eligibility**	0.5	2 q. to regain eligibility
$\tilde{U}$	UI extension threshold	6.0%	Chodorow-Reich *et al.* (2018)

Steady State Results

Steady-state moments: Data vs. Model

Moment	Model	Data	Data Source
1. Marginal Propensities to Consume (MPC)			
Quarterly Agg. MPC (targeted)	0.20	0.20	Parker and Broda (2013)
Annual MPC Employed	0.49	0.47	Kekre (2022)
Annual MPC Unemployed	0.64	0.72	Kekre (2022)
2. Consumption and Unemployment			
Cons. drop during unemp. w/ UI benefits	6pp	8pp	Ganong and Noel (2019)
Cons. drop during unemp. w/o UI benefits	19pp	24pp	Ganong and Noel (2019)
Employed's cons. response to job loss risk	-0.62%	-0.70%	Graves (2023)

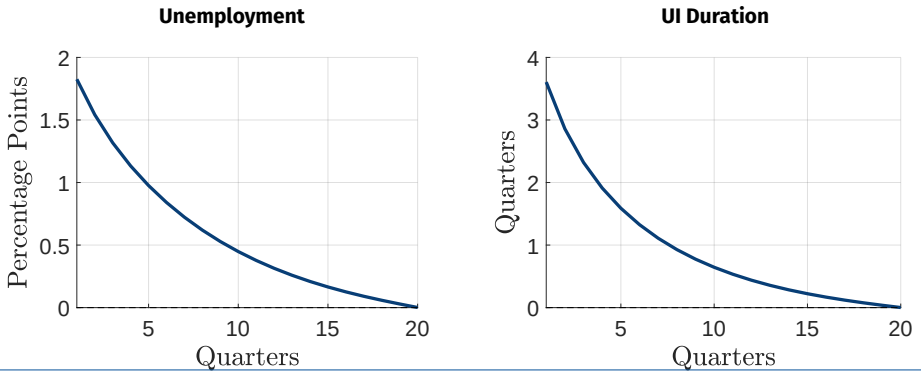
UI Extensions & Fiscal Multipliers in the model

Extended UI benefits in the model

We first replicate in the model the **average state in the data with extended UI**:

We feed in shocks such that U_t raises to 7.7% as in data

Pick response of UI duration ϕ^U such that UI_t^D raises to 5.5 qrts. as in data

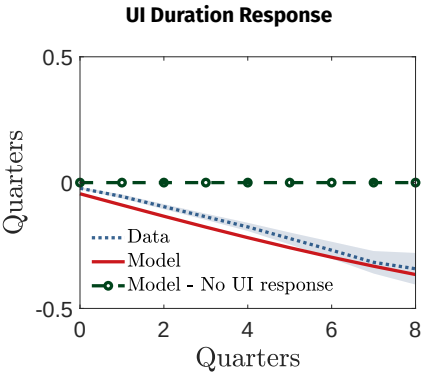


UI Extensions & Fiscal Multipliers in the model

We pick the size of the G shock to **approximate cumulative fall in UI duration in the data**

Model matches perfectly the difference in fiscal multipliers on impact

Model **without UI response predicts no difference in fiscal multipliers**



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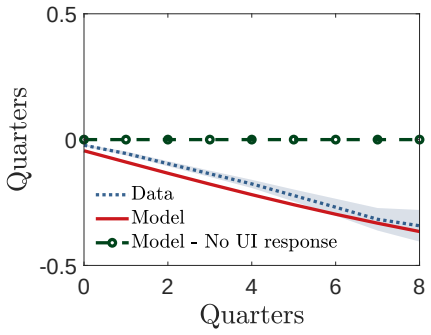
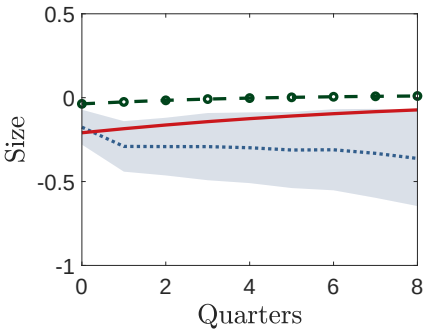
UI Duration Response



Fiscal Multipliers: Difference



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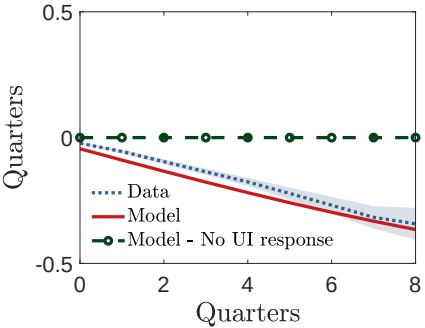

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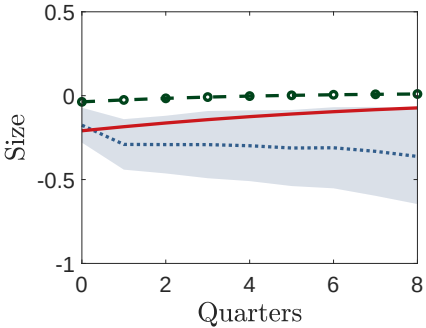
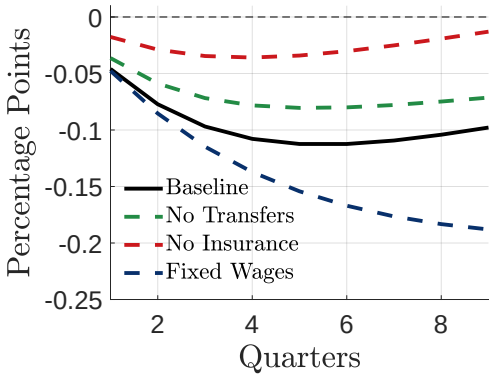


Effects of UI Extensions on Employment & Channels

- **UI-Employment elasticity** in baseline is 0.27, in line with the data
- **Three main channels** drive effects of UI extensions:
  1. **Wages**: improves outside option and raises wages
  2. **Transfers**: increases transfers to unemployed workers, households with high MPCs
  3. **Insurance**: reduces the need to accumulate precautionary savings

Employment Response to UI extensions



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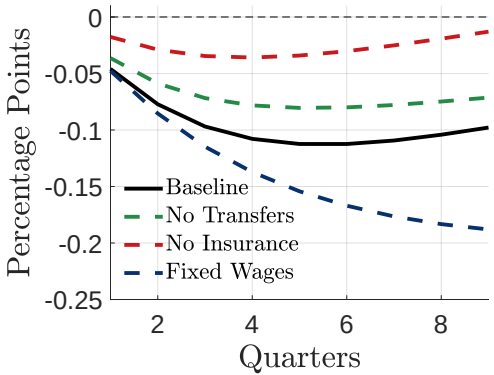

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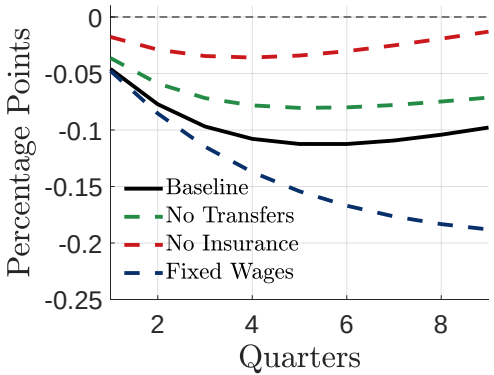

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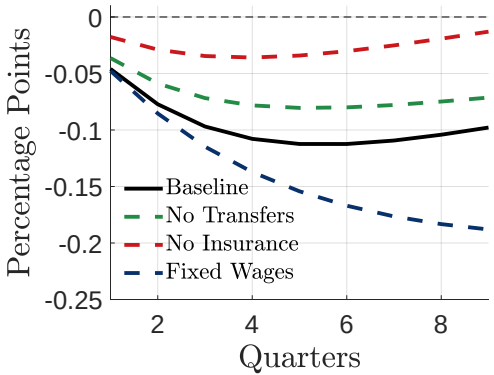

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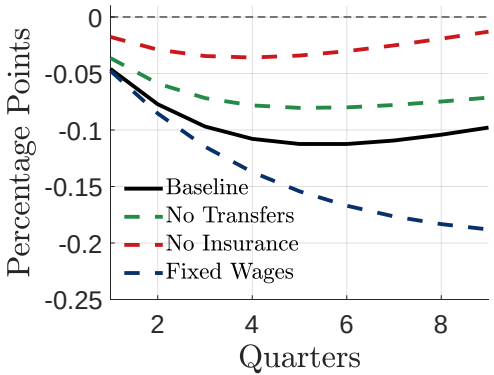

Effects of UI extensions in a Closed Economy

So far **UI extensions useful to deal with *state-level* demand shocks**

What about the *union-wide* effects of UI extensions?

Response of central bank to changes in UI duration? Spillover through cross-state trade?

We consider a **closed-economy** where the central bank sets nominal rate to stabilize Inflation

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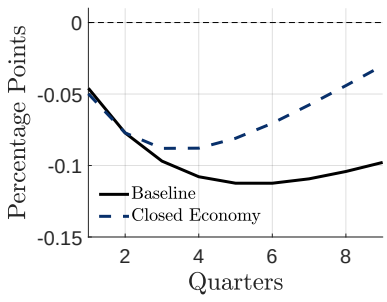
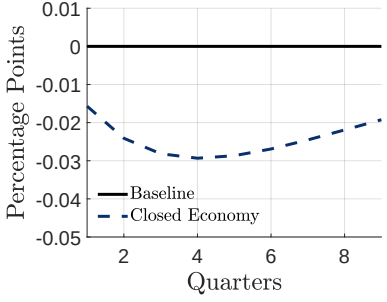
Employment



Nominal Interest Rate



Conclusion

Conclusion

Stabilization consequences of **countercyclical UI extensions**?

Exploit institutional **non-linear design of UI policy** in the US

- Government spending crowds out UI duration
- UI extensions reduce local fiscal multipliers
- Effects are unlikely to be explained by recessions or unobserved covariates
- UI-Employment elasticity of roughly 0.27

Model: SOE in monetary union with equilibrium unemployment

- Heterogeneous agents economy rationalizes empirical findings
- Transfers to **high-MPC unemployed** and **insurance** both key in driving results

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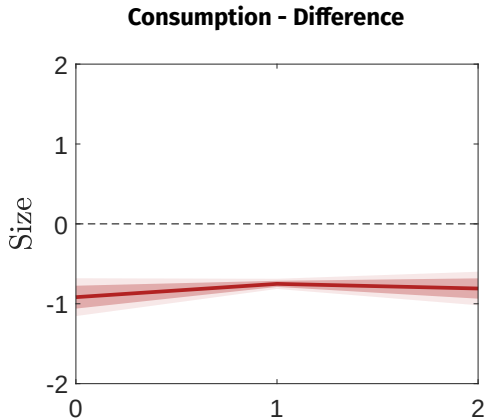
Appendix

Employment & Consumption Multiplier back

State-level consumption expenditures from US Census at annual frequency

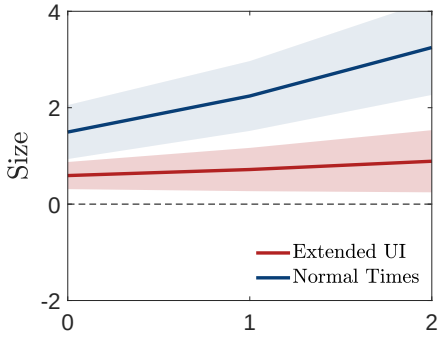


Gov't Direct Expenditures back

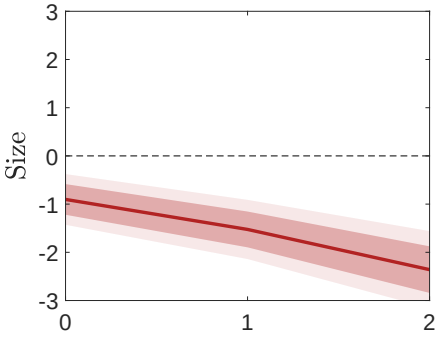
We replace gov't value-added by state-level government expenditure

Only available at annual frequency from US Census

Multipliers: Extended UI vs. Normal Times

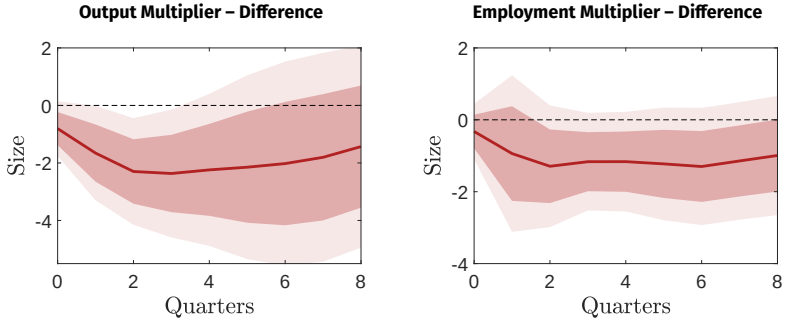


Difference



Bartik Identification back

- Bartik-type identification as in Nakamura and Steinsson (2014)
- Weaker identification assumption federal gov't spending does not react within the quarter to economic conditions that receive a disproportionate amount of national spending (Bernardini *et al.*, 2020)



UI Eligibility & Households

UI eligibility

labor market back

UI benefits expire stochastically ≈ limited duration of UI benefits

Loose eligibility during unemployment

Regain eligibility during employment

1. Eligible employed

- Keep job: remains eligible
- Loose job: loose eligibility with prob. pe_t

2. Non-eligible employed

- Keep job: eligible with prob. pr
- Loose job: remains non-eligible

3. Eligible unemployed

- Find job: remains eligible
- Unemployed: non-eligible with prob. pe_t

4. Non-eligible unempl.

- Find job: eligible with prob. pr
- Unemployed: remains non-eligible

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Regain eligibility during employment

1. Eligible employed

- Keep job: remains eligible
- Loose job: loose eligibility with prob. pe_t

2. Non-eligible employed

- Keep job: eligible with prob. pr
- Loose job: remains non-eligible

3. Eligible unemployed

- Find job: remains eligible
- Unemployed: non-eligible with prob. pe_t

4. Non-eligible unempl.

- Find job: eligible with prob. pr
- Unemployed: remains non-eligible

Domestic Households

Household with idiosyncratic state vector $s = \{\beta, h, n, e, a\}$

Chooses consumption of home (c_{Ht}) and foreign (c_{Ft}) goods, savings a_t in mutual fund:

$$V_t(s) = \max_{c_{Ht}, c_{Ft}, a_t} u(c_{Ht}, c_{Ft}) + \beta \mathbb{E}_t V_{t+1}(s')$$

$$\text{s.t.} \quad \frac{P_{Ht}}{P_t} c_{Ht} + \frac{P_{Ft}}{P_t} c_{Ft} + a_t = (1 - \tau_t) h_t \left(d_t + \mathbb{I}_{n=1} w_t + \mathbb{I}_{(n=0,e=1)} b_t + \mathbb{I}_{(n=0,e=0)} \tilde{b}_t\right) + (1 + r_t^a) a_{t-1}, \quad a_t \geq 0.$$

Income depends on employment & eligibility status:

- Employed: wage w_t
- Unemployed and eligible: UI benefits b_t
- Unemployed non-eligible: "safety-net" transfers $\tilde{b}_t$

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Firms & Wages

Differentiated goods producers: set prices s.t. Rottemberg adjust. costs.

NKPC:

$$\log(1+\pi_{H,t}) = \kappa_p \left(\frac{MC_t}{P_{Ht}} - \frac{\varepsilon - 1}{\varepsilon} \right) + \mathbb{E}_t \frac{1}{1+r^a} \log(1+\pi_{H,t+1}) \frac{Y^D_{t+1}}{Y^D_t}$$

Labor goods producers: post vacancies v_t to hire workers

Free-entry: value of job J^L_t, vacancy filling rate q_t

$$\kappa_v = q_t J^L_t$$

Wage rule: weighted between Nash wage and st.-st. wage :

$$w_t = \left(w^{nash}_t\right)^{\phi^w} (\bar{w})^{1-\phi^w}$$

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Nash Wage full back

Union bargains w_t^{nash} on behalf of workers to maximize average surplus from employment

$$w_t^{nash} = \arg\max_{w_t} (J_t^L)^{1-\eta} (\Delta_t^{n,u})^{\eta}$$

Average surplus from employment $\Delta_t^{n,u}$:

$$\Delta_t^{n,u} = (n_t^e + u_t^e)\Delta_{t,e=1}^{n,u} + (n_t^{ne} + u_t^{ne})\Delta_{t,e=0}^{n,u}$$

Average surplus from employment for eligible workers $\Delta_{t,e=1}^{n,u}$:

$$\Delta_{t,e=1}^{n,u} = U(C_{t,e=1}^n) - U(C_{t,e=1}^u) + \beta(1-\delta)(1-f_{t+1})(\Delta_{t+1,e=1}^{n,u} + pe_t \Delta_{t+1,n=0}^{e,ne})$$

Average surplus from employment for non-eligible workers $\Delta_{t,e=0}^{n,u}$:

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Local Government

Government back

Monetary authority sets nominal rate to fix nominal exchange rate

Fiscal authority, budget constraint:

$$\frac{P_{Ht}}{P_t} G_t + (1 + r_t) B_{H,t-1} + b_t U_t^e + \tilde{b}_t U_t^{ne} = B_{H,t} + \tau_t \left(w_t N_t + b_t U_t^e + \tilde{b}_t U_t^{ne} + d_t \right) + T_t$$

Government consumption G_t: $log\left(\frac{G_t}{G}\right) = \rho_G \log\left(\frac{G_{t-1}}{G}\right) + \varepsilon_t^G, \quad , \quad \varepsilon_t^G \sim \mathcal{N}(0,1)$

Federal transfers pay for UI expenses: $T_t - T = (b_t U_t^e + \tilde{b}_t U_t^{ne}) - (bU^e + \tilde{b}U^{ne})$

Local government debt $B_{H,t}$ stays constant and taxes τ_t adjusts to balance budget

UI benefits level: $b_t = bw_t, \quad b \in (0,1)$

Safety-net transfers to non-eligible: $\tilde{b}_t = \tilde{b}w_t, \quad \tilde{b} < b$

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Government - UI benefits extensions back

UI benefits duration $\text{UI}_t^D = 1/pe_t$:

$$\text{UI}_t^D = \begin{cases} \text{UI}^D & \text{if} \quad U_t \leq \tilde{U}, \\ \text{UI}^D \left(\frac{U_{t-1}}{\tilde{U}} \right)^{\phi_U} & \text{else.} \end{cases}$$

If unemployment below threshold $\tilde{U}$ keep UI duration at regular UI duration UI^D

We let UI duration follow a Taylor (1993)-type rule **when unemployment above** $\tilde{U}$

- Captures parsimoniously multiple thresholds active during our sample period
- We will calibrate ϕ_U to match dynamics of UI_t^D observed in our data

Labor Market

Law of motion for **employment** N_t:

$$N_t = (1-\delta)N_{t-1} + M_t$$

δ: exogenous separation rate
M_t: new matches

New matches M_t formed according to:

$$M_t = \chi_t V_t^{\gamma} \left(1-(1-\delta)N_{t-1}\right)^{1-\gamma}$$

V_t: firms' vacancies, posted at cost κ_v
χ_t: matching efficiency follows log AR(1) process

UI eligibility

N_t^e: employed eligible

N_t^{ne}: employed non-eligible

U_t^e: unemployed eligible

U_t^{ne}: unemployed non-eligible

pe_t: prob. loosing eligibility

pr: prob. regaining eligibility

$$
\begin{aligned}
N_t^e &= (1-\delta+\delta f_t)N_{t-1}^e + pr(1-\delta+\delta f_t)N_{t-1}^{ne} + f_t\left(U_{t-1}^e + prU_{t-1}^{ne}\right) \\
N_t^{ne} &= (1-pr)(1-\delta+\delta f_t)N_{t-1}^{ne} + (1-pr)f_t U_{t-1}^{ne} \\
U_t^e &= (1-f_t)(1-pe_t)\left(U_{t-1}^e + \delta N_{t-1}^e\right) \\
U_t^{ne} &= (1-f_t)\left(U_{t-1}^{ne} + \delta N_{t-1}^{ne}\right) + (1-f_t)pe_t\left(U_{t-1}^e + \delta N_{t-1}^e\right)
\end{aligned}
$$

Foreign households back

Export demand from Foreign households C^*_{Ht}:

$$C^*_{Ht} = \alpha \left(\frac{P^*_{Ht}}{P^*_t} \right)^{-\eta} C^*_t,$$

Nominal exchange rate: $\mathscr{E}_t$

Law of one price holds: $P_{Ht} = \mathscr{E}_t P^*_{Ht}$ and $P_{Ft} = \mathscr{E}_t P^*_{Ft}$

Real exchange rate: $Q_t := \frac{\mathscr{E}_t P^*_t}{P_t}$

Terms of trade: $S_t := \frac{P_{Ft}}{P_{Ht}}$

Firms - Labor good producers

Value of a firm with a worker:

$$J_t^L = Z_t \frac{MC_t}{P_t} - \frac{W_t}{P_t} + \mathbb{E}_t \frac{1}{1+r^a}(1-\delta)J_{t+1}^L,$$

Free entry:

$$\kappa_v = q_t J_t^L$$

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Union bargains w_t^{nash} on behalf of workers to maximize average surplus from employment

$$w_t^{nash} = \arg\max_{w_t} (J_t^L)^{1-\eta} (\Delta_t^{n,u})^{\eta}$$

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Average surplus from employment for eligible workers $\Delta_{t,e=1}^{n,u}$:

$$\Delta_{t,e=1}^{n,u} = U(C_{t,e=1}^n) - U(C_{t,e=1}^u) + \beta(1-\delta)(1-f_{t+1})(\Delta_{t+1,e=1}^{n,u} + pe_t \Delta_{t+1,n=0}^{e,ne})$$

Average surplus from employment for non-eligible workers $\Delta_{t,e=0}^{n,u}$:

$$\Delta_{t,e=0}^{n,u} = U(C_{t,e=0}^n) - U(C_{t,e=0}^u) + \beta(1-\delta)(1-f_{t+1})(\Delta_{t+1,e=0}^{n,u} + pr\Delta_{t+1,n=1}^{ne,e})$$

Average surplus from employment for eligible workers $\Delta^{n,u}_{t,e=1}$:

$$\Delta^{n,u}_{t,e=1} = U(C^n_{t,e=1}) - U(C^u_{t,e=1}) + \beta(1-\delta)(1-f_{t+1})(\Delta^{n,u}_{t+1,e=1} + pe_t \Delta^{e,ne}_{t+1,n=0})$$

Average surplus from eligibility for unemployed workers $\Delta^{e,ne}_{t+1,n=0}$:

$$\Delta^{e,ne}_{t,n=0} = U(C^u_{t,e=1}) - U(C^u_{t,e=1}) + \beta\left[(1-f_{t+1})(1-\text{pe}_{t+1})\Delta^{e,ne}_{t+1,n=0} + f_{t+1}(1-\text{pr})\Delta^{e,ne}_{t+1,n=1}\right]$$

Average surplus from employment for non-eligible workers $\Delta^{n,u}_{t,e=0}$:

$$\Delta^{n,u}_{t,e=0} = U(C^n_{t,e=0}) - U(C^u_{t,e=0}) + \beta(1-\delta)(1-f_{t+1})(\Delta^{n,u}_{t+1,e=0} + pr\Delta^{ne,e}_{t+1,n=1})$$

Average surplus from eligibility for employed workers $\Delta^{e,ne}_{t+1,n=1}$:

$$\Delta^{e,ne}_{t,n=1} = U(C^n_{t,e=1}) - U(C^n_{t,e=1}) + \beta\left[\left(1-\delta(1-f_{t+1})\right)(1-\text{pr})\Delta^{e,ne}_{t+1,n=1} + \delta(1-f_{t+1})(1-\text{pe}_{t+1})\Delta^{e,ne}_{t+1,n=0}\right]$$

Firms - Producers of differentiated goods

Set prices s.t. quadratic adjustment costs:

$$\max_{\{P_{jHt+k}\}_{k=0}^{\infty}} \mathbb{E}_t \sum_{k=0}^{\infty} (1+r^a)^{-k} \left[\left(P_{jHt+k} - MC_{t+k} \right) Y^D_{jt+k} - \frac{\kappa_p}{2\varepsilon} \log\left(\frac{P_{jHt+k}}{P_{jHt+k-1}} \right)^2 P_{Ht+k} Y^D_{t+k} \right],$$

$$\text{subject to} \quad Y^D_{jt} = \left(\frac{P_{jHt}}{P_{Ht}} \right)^{-\varepsilon} \left(C_{Ht} + C^*_{Ht} + G_t \right).$$

NKPC:

$$\log(1+\pi_{H,t}) = \kappa_p \left(\frac{MC_t}{P_{Ht}} - \frac{\varepsilon - 1}{\varepsilon} \right) + \mathbb{E}_t \frac{1}{1+r^a} \log(1+\pi_{H,t+1}) \frac{Y^D_{t+1}}{Y^D_t},$$

Risk-neutral mutual fund issues A_t, purchases domestic B_{Ht} and foreign B_{Ft} bonds

$$A_t = B_{Ht} + Q_t B_{Ft}$$

Beginning-of-period flow constraint:

$$(1 + r_t^a)A_{t-1} = (1 + r_t)B_{H,t-1} + (1 + r_t^*)Q_t B_{F.t-1}.$$

Non-arbitrage conditions:

$$\mathbb{E}_t \frac{1 + i_t}{1 + \pi_{t+1}} = \mathbb{E}_t \frac{1 + i_t^*}{1 + \pi_{t+1}^*} \frac{Q_{t+1}}{Q_t},$$

$$\mathbb{E}_t 1 + r_{t+1}^a = \mathbb{E}_t 1 + r_{t+1}$$