The Heterogeneous Effects of Monetary Policy

Theory and an application to the Chilean economy

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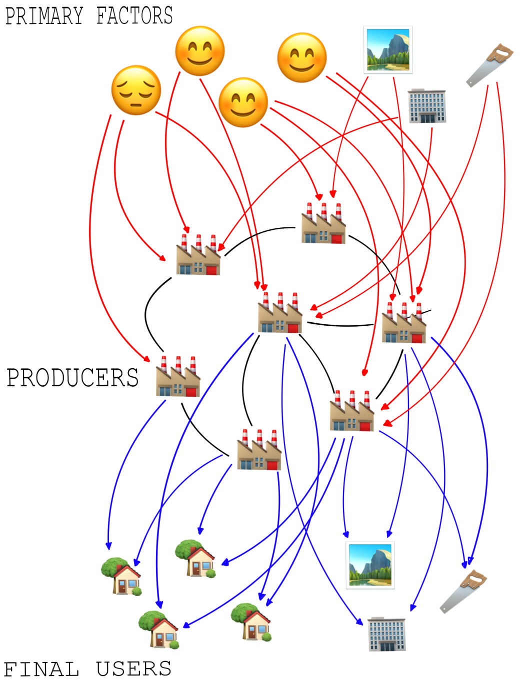
- Monetary policy mandate: aggregate inflation and employment
  - lots of work studiying aggregate effects
  - only recently theory and evidence of cross-sectional effects
- This paper: new theoretical framework
  - heterogeneous workers, produce and consume different goods
  - monetary policy $\rightarrow$ cross-sectional income, via production side
- Complementary to HANK
  - focus on consumption/saving decision
  - cross-sectional real income independent of policy


PRIMARY FACTORS
PRODUCERS
FINAL USERS

Basic mechanism

- Monetary expansion: prices $\uparrow$, output $\uparrow$
- Relative response governed by Phillips curve:

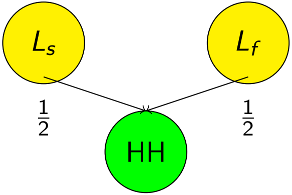
$$\pi_t = \kappa y_t + \rho \mathbb{E} \pi_{t+1}$$

- Flatter if elastic labor supply, sticky prices

$$\kappa = (\gamma + \varphi) \frac{\delta}{1 - \delta}$$

- Prices $\uparrow$ less $\iff$ output $\uparrow$ more
  - aggregate: $\pi_t + y_t =$ nominal demand
  - cross-section: expenditure switching

Heterogeneous agents



- Expenditure switching $\rightarrow$ cross-sectional non-neutrality
  - sticky-wage worker: rel wage $\downarrow$, rel employment $\uparrow$
  - relative income $\uparrow$ iff substitutes
- Expenditure switching $\rightarrow$ more aggregate non-neutrality
  - substitution towards sticky worker "flattens" aggregate PC

Quantitative takeaways

- Heterogeneous monetary non-neutality in the cross-section
  - cumulative employment and income response
  - ranges from $\sim 0.5\%$ to $\sim 3\%$ across demographic groups
- Industry heterogeneity $\rightarrow$ worker heterogeneity
  - input-output linkages amplify cross-sectional non-neutrality
- Agent heterogeneity: small effect on aggregate non-neutrality
  - input-output structure remains crucial

Literature

Framework: Baqaee and Farhi (2018)

HANK → uniform MPCs, heterogeneity from interaction with supply side

Werning (2015), Guerrieri and Lorenzoni (2017), Kaplan, Moll, Violante (2018), Auclert (2019), Auclert, Ronglie, Straub (2019);

Monetary policy with I-O → abandon rep agent

Basu (1995), Erceg et al (1999), Aoki (2001), Woodford (2003), Blanchard and Gali (2007), La'O and Tahbaz-Salehi (2021), Rubbo (2021); Carvalho (2006), Klenow and Kryvtsov (2008), Nakamura and Steinsson (2008, 2013), Carvalho and Nechio (2011), Bouakez, Cardia, and Ruge-Murcia (2014), Pasten, Schoenle and Weber (2016, 2017), Castro Cienfuegos (2019), Höynk (2019)

Models with HA-IO → derive analytical results, many instruments

Benigno (2004), Gali and Monacelli (2008), Engel (2011), Huang and Liu (2005), Bouakez, Rachedi, Santoro (2020), Cox, Muller, Pasten, Schoenle, Weber (2020), Flynn, Patterson, Surm (2021), Huber, Straub, et al. (2021)

Roadmap

- Theory (*Monetary Non-Neutrality in the Cross-Section*)
  - model setup
  - local and aggregate monetary non-neutrality
  - examples
- Calibration to Chilean economy
  - with Ernesto, Emiliano, and Matias

Outline

Environment

- H worker types, N production sectors, F capital assets
- Agents
  - consume different bundles of goods
  - have different labor supply elasticity
  - own different shares of sectors and capital assets
- Sectors
  - hire different bundles of workers and intermediate inputs
  - face different price and wage rigidity
  - face different demand elasticity
- Log-linearized model
  - parameters measured in national accounts

Consumers

- Type-h preferences:

$$\frac{C_h\left(x_1, \ldots, x_N\right)^{1-\gamma_h}}{1-\gamma_h} - \frac{L_h^{1+\varphi_h}}{1+\varphi_h}$$

- Budget constraint:

$$P_h^C C_h = \underbrace{W_h L_h}_{\text{labor}} + \underbrace{\sum_f \mathcal{Z}_{if} \frac{\varphi_f}{1+\varphi_f} R_f K_f}_{\text{capital assets}} + \underbrace{\sum_i \Xi_{ih}\left(\Pi_i - T_i\right)}_{\text{profits}} + \underbrace{TB_t}_{\text{borrowing}}$$

- Maximize PDV of utility

Good producers

- CRS sectoral production functions:

$$Y_i = F_i(\underbrace{\{L_{ih}\}}_{\text{labor}}, \underbrace{\{K_{if}\}}_{\text{captial assets}}, \underbrace{\{X_{in}\}}_{\text{intermediate inputs}})$$

- All producers minimize costs, given factor and input prices
- Fraction δ_i of producers adjust price to max profit (Calvo)
  - continuum of firms within sectors, CES bundle
  - optimal input subsidies $(\tau_i) \rightarrow$ efficient steady-state
- Sticky wages: add labor unions with sticky price

Capital assets

- Capital endowment $\bar{K}$, does not depreciate
  - augmented with "investment", fully depreciates

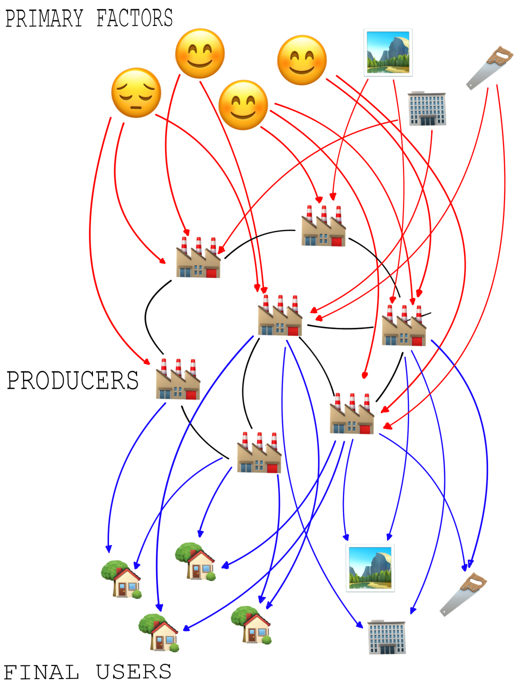
$$K_f = \left[(1 + \varphi_f) \, I_f \right]^{\frac{1}{1+\varphi_f}} \bar{K}_f$$

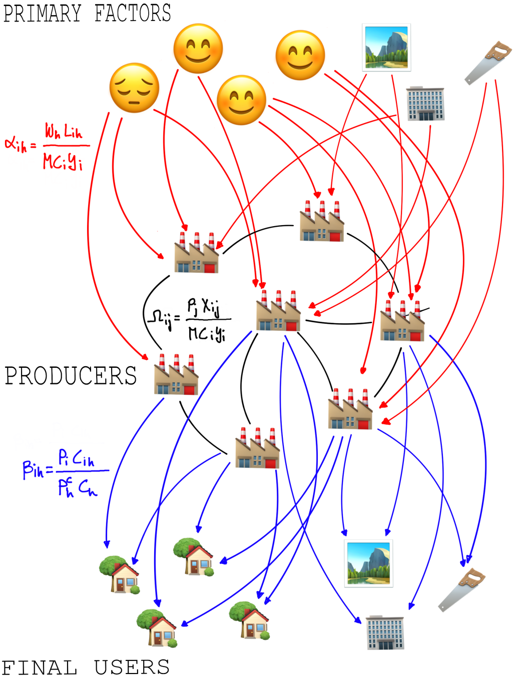
- CRS investment production, marginal cost P_f^I
- Choose I to max profits:

$$\Pi_f = \frac{\varphi_f}{1 + \varphi_f} R_f K_f$$

- Utilization:

$$U_f^{\varphi_f} \equiv \left[(1 + \varphi_f) \, I_f \right]^{\frac{\varphi_f}{1+\varphi_f}} = \frac{R_f}{P_f^I}$$


PRIMARY FACTORS
PRODUCERS
FINAL USERS


PRIMARY FACTORS
$\alpha_{ih} = \frac{w_h L_{ih}}{MC_i y_i}$
$\Omega_{ij} = \frac{p_j x_{ij}}{MC_i y_i}$
PRODUCERS
$\beta_{ih} = \frac{p_i c_{ih}}{P_h^c C_h}$
FINAL USERS

Input-output notation

- Total input requirements:

$$(I - \Omega)^{-1} = I + \Omega + \Omega^2 + \ldots$$

- Total content of good i in h's final use:

$$\lambda_{hi}^T = \left[\beta^T (I - \Omega)^{-1}\right]_{hi}$$

- Total content of factor h in l's final use:

$$\left[\alpha^T \lambda\right]_{hl}$$

Supply and demand elasticities

- Factor supply:
  - wealth effects: $\Gamma \equiv diag\left(\gamma_1, ..., \gamma_H\right)$
  - Frish: $\Phi_L \equiv diag\left(\varphi_1, ..., \varphi_H\right)$, $\Phi_K \equiv diag\left(\varphi_1, ..., \varphi_F\right)$
- Demand: for each sector i, ES between inputs j and k is θ^i_{jk}
- Price adjustment probabilities: $\Delta = diag\left(\delta_1, ..., \delta_N\right)$

Aggregation

- (Endogenous) income shares $\mathbf{s} = (\mathbf{s}^C; \mathbf{s}^I)$:

$$s_h^C \equiv \frac{P_h^* C_h^*}{\sum_k P_k^* C_k^* + \sum_f P_f^* I_f^*}, \quad s_f^I \equiv \frac{P_f^* I_f^*}{\sum_k P_k^* C_k^* + \sum_f P_f^* I_f^*}$$

- Aggregate real GDP

$$d \log Y_t \equiv \sum_h s_h^C d \log C_{ht} + \sum_f s_f^I d \log I_{ft}$$

- GDP deflator

$$d \log P_t^Y \equiv \sum_h s_h^C d \log P_{ht}^C + \sum_f s_f^I d \log P_{ft}^I$$

Variables and policy instruments

- Variables:
  - sector-level inflation $\boldsymbol{\pi}$
  - factor-level employment gaps $\boldsymbol{\ell}$
  - aggregate output gap $\bar{y} \equiv \sum_h s_h \ell_h$
- Monetary policy pins down $\bar{y}$
  - today: cash-in-advance constraint and financial autarchy

$$\pi_t^Y + y_t = m_t - p_{t-1}^Y$$

  - nominal rate: similar, keep track of income transfers

seignorage timing

Outline

Equilibrium

- Supply block $\rightarrow$ Phillips curves:

$$\boldsymbol{\pi}_{it} = \sum_h \kappa_{ih} \ell_{ht} - \mathcal{V}\mathbf{p}_{t-1} + (I - \mathcal{V})\, \mathbb{E}\boldsymbol{\pi}_{t+1}$$

- Cross-sectional demand:

$$\boldsymbol{\ell}_t = (I - \mathcal{X})^{-1} \mathbf{1}\bar{y}_t + \mathcal{F}\left(\mathbb{E}\boldsymbol{\pi}_{t+1}, \mathbf{p}_{t-1}\right)$$

- Aggregate demand:

$$\pi_t^Y + \bar{y}_t = m_t - p_{t-1}^Y$$

Slope ($\Gamma = \mathbb{O}$)

- $\mathbf{l}, \mathbf{u} \uparrow \to \mathbf{w}, \mathbf{r} \uparrow \to \boldsymbol{\pi} \uparrow$:

$$\kappa = \Delta \left(I - \Omega\Delta\right)^{-1} \alpha \left(I - \delta_\beta\left(\alpha\right)\right)^{-1} \Phi$$

- Price rigidity in production:

$$\Delta \left(I - \Omega\Delta\right)^{-1} \alpha$$

- Price rigidity in consumption:

$$\delta_\beta\left(\alpha\right) \equiv \beta^T \Delta \left(I - \Omega\Delta\right)^{-1} \alpha$$

- Factor price Phillips curves:

$$\left(I - \delta_\beta\left(\alpha\right)\right)^{-1} = I + \delta_\beta\left(\alpha\right) + \delta_\beta\left(\alpha\right)^2 + \ldots$$

Cross-sectional employment

$$\frac{\boldsymbol{\ell}}{\bar{y}} = [I - \mathcal{X}]^{-1} [\mathbf{1} + ...]$$

- Impact effect: expenditure $\uparrow$ proportionately for all goods
- Propagation:
  - factor demand $\uparrow \rightarrow$ real wages (or rental rates) $\uparrow$
  - larger price increase for goods produced by steep-PC factors
  - demand for their labor falls
  - real wages and prices adjust
  - ...

Cross-sectional employment

$$\mathcal{X} = \text{expenditure switching} + \text{income reallocation}$$

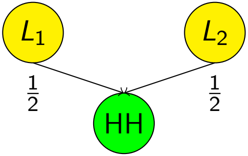
- Expenditure switching:
  - h's employment $\downarrow$ if h, co-workers,... have steep PC

$$-\frac{1}{s_h}\sum_i \lambda_i \theta_i Cov_{\Omega_{(i,:)}}\left(\left((I-\Omega)^{-1}\alpha\right)_{(:,h)}, \sum_n \kappa_{(:,n)}\ell_n\right) + \dots$$

- Income reallocation: real income
  - h's employment $\uparrow$ if h sells to final users whose real income $\uparrow$

$$\dots + Cov_s\left(\left(\alpha^T\lambda\right)_{h,n}, \text{real income}_n\right)$$

Price rigidity



- Phillips curves:

$$\kappa^Y_{sticky} = \frac{\varphi}{2}\frac{\delta_{sticky}}{1-\bar{\bar{\delta}}}, \quad \kappa^Y_{flex} = \frac{\varphi}{2}\frac{\delta_{flex}}{1-\bar{\bar{\delta}}}$$

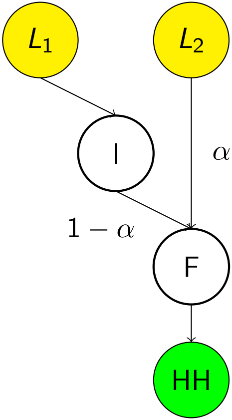
- Cross-section: employment ↑ for sticky workers

$$\ell_{sticky} - \ell_{flex} = \frac{\varphi\theta\bar{\delta}}{1+\varphi\theta\bar{\bar{\delta}}}\left(\delta_{flex} - \delta_{sticky}\right)\bar{y}$$

- Consumption:

$$c_{sticky} - c_{flex} = \frac{\varphi\left(\theta-1\right)\bar{\delta}}{1+\varphi\theta\bar{\bar{\delta}}}\left(\delta_{flex} - \delta_{sticky}\right)\bar{y}$$

Input-output linkages



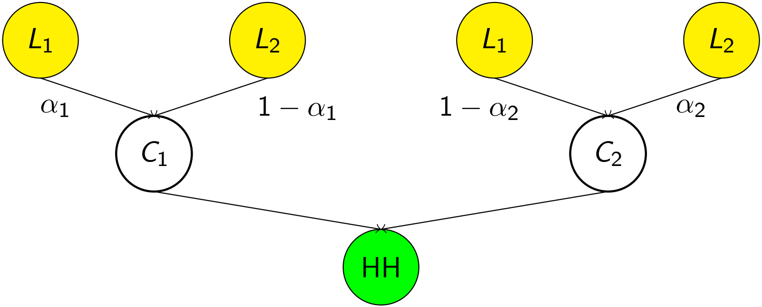
- Longer chain $\sim$ stickier wage

$$\ell_I - \ell_F \propto \frac{\varphi\theta\bar{\delta}}{1+\varphi\theta\bar{\delta}}(\delta_F - \delta_I)\bar{y}$$

- Replace

$$\delta_F - \delta_I = \delta - \delta^2$$

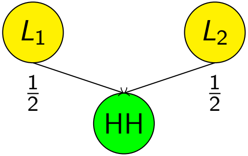
Chain-weighted ES



$$\ell_{sticky} - \ell_{flex} = \frac{\varphi \Theta}{1+\varphi \Theta} \left(\delta_{flex} - \delta_{sticky}\right) \bar{y}$$

$$\Theta \equiv \theta \left(1 - \frac{\beta_1 (1-\beta_1)(\alpha_1 - \alpha_2)^2}{s_1 (1-s_1)} \right) + \sigma\delta \frac{\beta_1 (1-\beta_1)(\alpha_1 - \alpha_2)^2}{s_1 (1-s_1)}$$

Labor supply elasticity

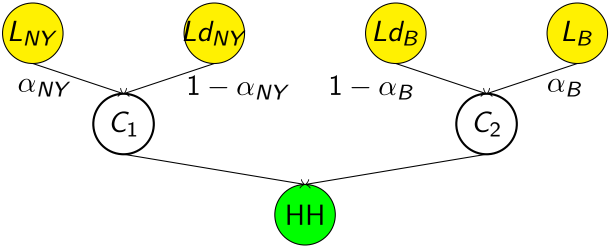


- Expansion benefits elastic workers ($\varphi_E < \varphi_I$):

$$\ell_E - \ell_I = (\varphi_I - \varphi_E)\frac{\theta\delta}{1+\bar{\varphi}\theta\delta}\bar{y}$$

$$c_E - c_I = (\varphi_I - \varphi_E)\frac{(\theta - 1)\,\delta}{1+\bar{\varphi}\theta\delta}\bar{y}$$

NYC vs Boise, ID



- Geographic mobility:
  - $\sigma\delta < \theta$: improve own apt $\rightarrow$ NYC more cyclical
  - $\sigma\delta > \theta$: buy big home in ID $\rightarrow$ Boise more cyclical

$$\ell_B - \ell_{NY} \propto \theta(\sigma\delta - \theta)(\alpha_B - \alpha_{NY})\bar{y}$$

Aggregate non-neutrality

- Representative agent, static

$$\begin{cases} \pi_t^Y + \bar{y}_t = m_t - p_{t-1}^Y & \text{cash in advance} \\ \pi_t^Y = \kappa \bar{y}_t & \text{Phillips curve} \end{cases}$$

- Non-neutrality = $\% L \uparrow$ if $M \uparrow$ by 1%

$$\bar{y} = \frac{m - p_{-1}^Y}{1 + \kappa}$$

Heterogeneous agents

- Aggregate non-neutrality:

$$\bar{y} = \frac{m - p_{-1}}{1 + \bar{\kappa}^Y + Cov_s\left(\frac{\kappa_h^Y}{s_h}, \frac{\ell_h}{\bar{y}}\right)}$$

- Employment $\uparrow$ for agents with flat Phillips curve $\rightarrow$ more non-neutrality

With dynamics

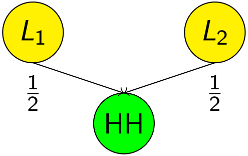
- Impact response of employment:

$$\bar{y}_0 = \frac{m_0 - p_{-1}}{1 + \sum_t \rho^t \left(\bar{\kappa}_t^Y + Cov_s\left(\frac{\kappa_{ht}^{CPI}}{s_h}, \frac{\ell_{ht}}{\bar{y}_t} \right) \right) \frac{\bar{y}_t}{\bar{l}_0}}$$

- Depends on
  - elasticity of current inflation to employment t periods ahead
  - rate of decay of employment response
- Representative agent, one sector:

$$y_0 = \frac{1}{1 + \frac{\kappa}{1 - \rho\eta}}$$

Example

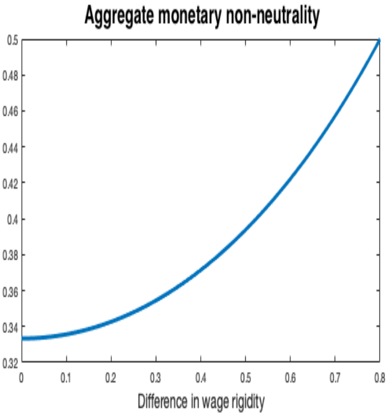


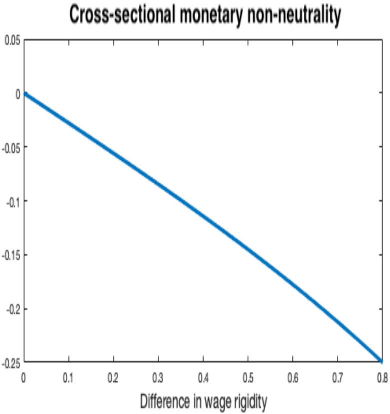
- Aggregate non-neutrality:

$$\bar{y} = \frac{m}{1 + \varphi \frac{\bar{\delta}}{1-\bar{\delta}} \left[1 - \frac{\varphi \theta \bar{\delta}}{1+\varphi \theta \bar{\delta}} \left(\frac{\delta_{flex} - \delta_{sticky}}{\bar{\delta}} \right)^2 \right]}$$

- Labor supply elasticity:

$$\bar{y} = \frac{m}{1 + \bar{\varphi} \frac{\delta}{1-\bar{\delta}} \left[1 - \frac{\bar{\varphi} \theta \delta}{1+\bar{\varphi} \theta \delta} \left(\frac{\varphi_I - \varphi_E}{\bar{\varphi}} \right)^2 \right]}$$


Aggregate monetary non-neutrality
0.5
0.48
0.46
0.44
0.42
0.4
0.38
0.36
0.34
0.32
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Difference in wage rigidity


Cross-sectional monetary non-neutrality
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Difference in wage rigidity

Eliminating cross-sectional effects

- Easy if heterogeneity only driven by nominal rigidities (same γ, φ)
  - subsidize inputs proportional to wage exposure

$$\tau_i - \tau_j \propto \left(\Delta \left(I - \Omega\Delta\right)^{-1} \bar{\alpha}\right)_i - \left(\Delta \left(I - \Omega\Delta\right)^{-1} \bar{\alpha}\right)_j$$

  - tax consumption to equalize incomes
  - set levels so that lump-sum taxes sum to 0 and budget is balanced
- Aggregate non-neutrality same as RA economy, no cross-sectional effects
- Heterogeneous Frish $\rightarrow$ cannot compensate different disutility of labor
- Capital assets $\rightarrow$ equity-efficiency tradeoff

Outline

Data

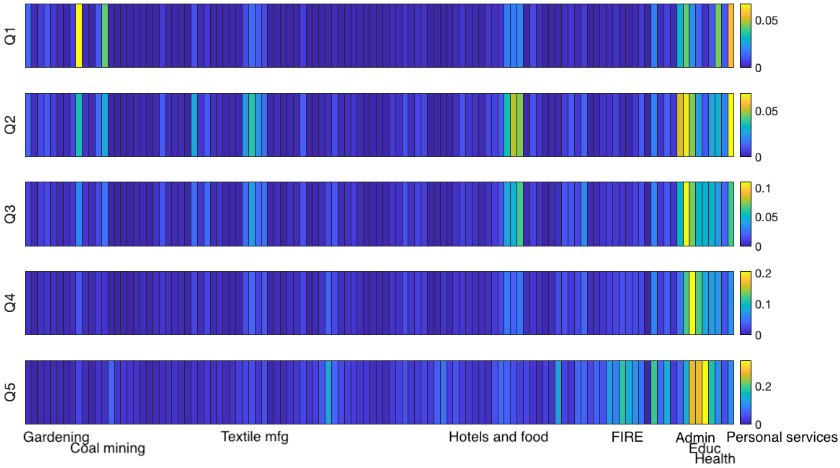
- Input-output: National Accounts
- Employment: Administrator of Severance Payments Funds
  - by gender, age quintile, income quintile
- Consumption shares: Family Budget Survey
- Price adjustment:
  - producer prices: electronic invoices
  - consumer prices: National Institute of Statistics

Still collecting

- Wage adjustment frequencies by demographic group
- Expenditure shares on capital assets
- Investment network

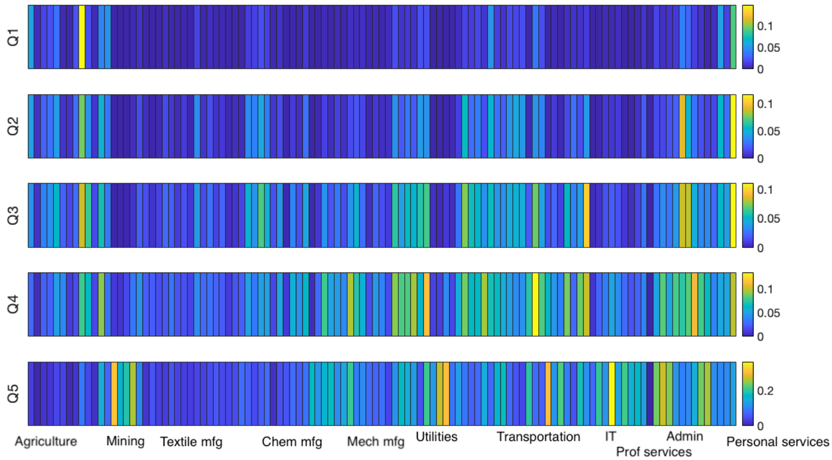
- Labor supply elasticities?
- Income group definition?
  - labor market boundaries

Women



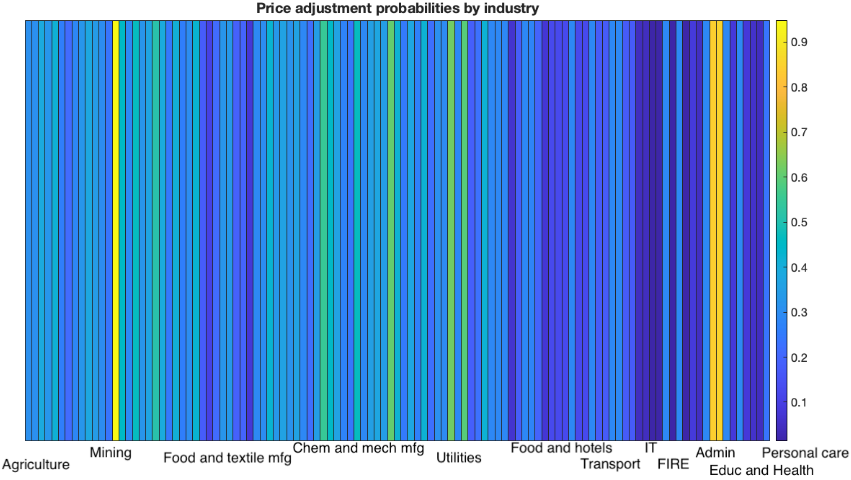
Q1
Q2
Q3
Q4
Q5
0.05
0
0.05
0
0.1
0.05
0
0.2
0.1
0
0.2
0
Gardening
Coal mining
Textile mfg
Hotels and food
FIRE
Admin
Educ
Health
Personal services

Men

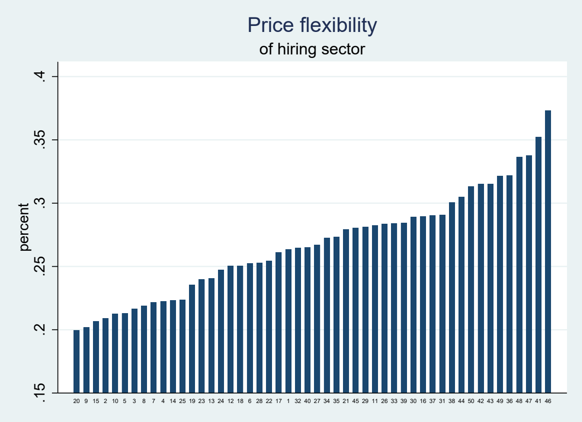


Q1
Q2
Q3
Q4
Q5
0.1
0.05
0
0.2
Agriculture
Mining
Textile mfg
Chem mfg
Mech mfg
Utilities
Transportation
IT
Prof services
Admin
Personal services

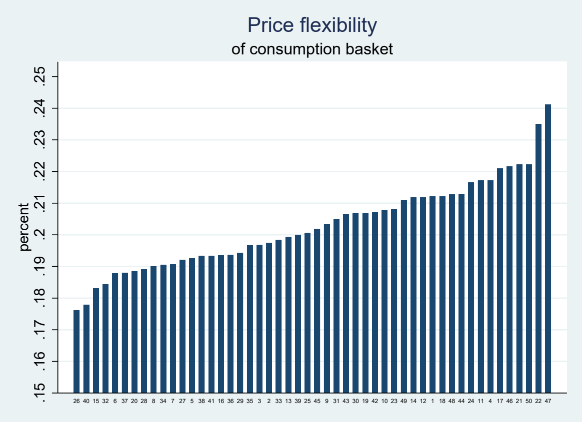
Price stickiness by sector

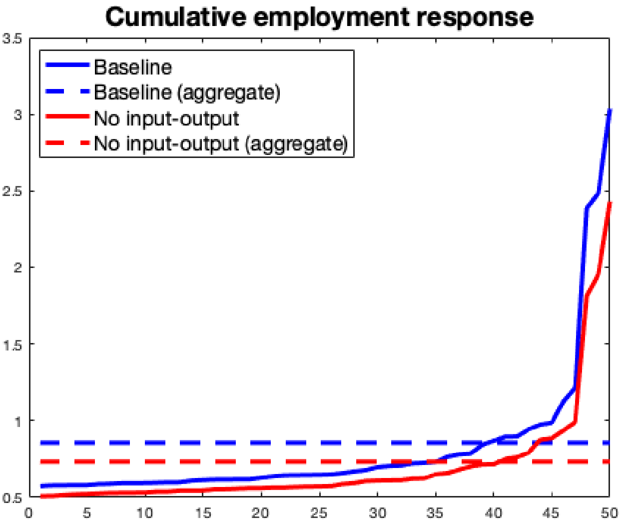


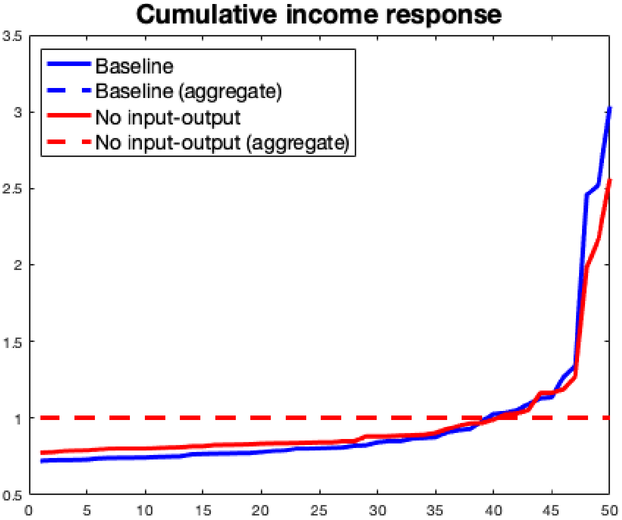
Employer's price stickiness

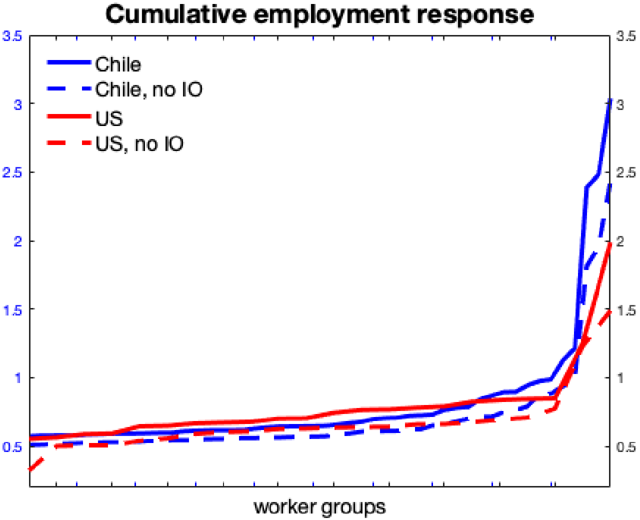


Consumer price stickiness




Cumulative employment response
Baseline
Baseline (aggregate)
No input-output
No input-output (aggregate)
3.5
3
2.5
2
1.5
1
0.5
0
5
10
15
20
25
30
35
40
45
50


Cumulative income response
Baseline
Baseline (aggregate)
No input-output
No input-output (aggregate)
3.5
3
2.5
2
1.5
1
0.5
0
5
10
15
20
25
30
35
40
45
50



Cumulative employment response
3.5
3
2.5
2
1.5
1
0.5
Chile
Chile, no IO
US
US, no IO
worker groups

Outline

Conclusion

- Monetary expansion:
  - cross-section: $l \uparrow$ for flat-PC workers
  - aggregate: substitution $\rightarrow$ more non-neutrality
- Quantitative results:
  - sizable cross-sectional effects on employment and income
  - input-output structure important driver of heterogeneity
- Widely applicable framework:
  - other shocks (spending, transfers...)
  - interpreting cross-sectional estimates
  - exchange rates in open economy

Thank you!

Real income

- Real income: employment + profits - final use prices

$$\text{real income}_n = l_n + \sum_i \frac{\xi_{in}}{s_n} \bar{\lambda}_i \left[\left(I - \Omega \right) \kappa \mathbf{l} \right]_i - \sum_k \left(\beta^T \kappa \right)_{nk} l_k$$

- Function of employment via Phillips curves

back

Timing

One-period model

- Period 0: prices are pre-set
- Period 1: money supply and spending shock
  - only a fraction of producers can adjust prices
  - production and consumption take place
  - the world ends

back

Seignorage

- Consumers need to purchase new money issuances
  - agent h buys share v_h
- Revenues are fully rebated through lump-sum transfers
- Budget constraint:

$$P_h C_h + \underbrace{v_h dM}_{\text{money purchase}} = \text{income}_h - T_h + \underbrace{v_h dM}_{\text{seignorage rebate}}$$

back