The Inflationary Effects of Sectoral Reallocation

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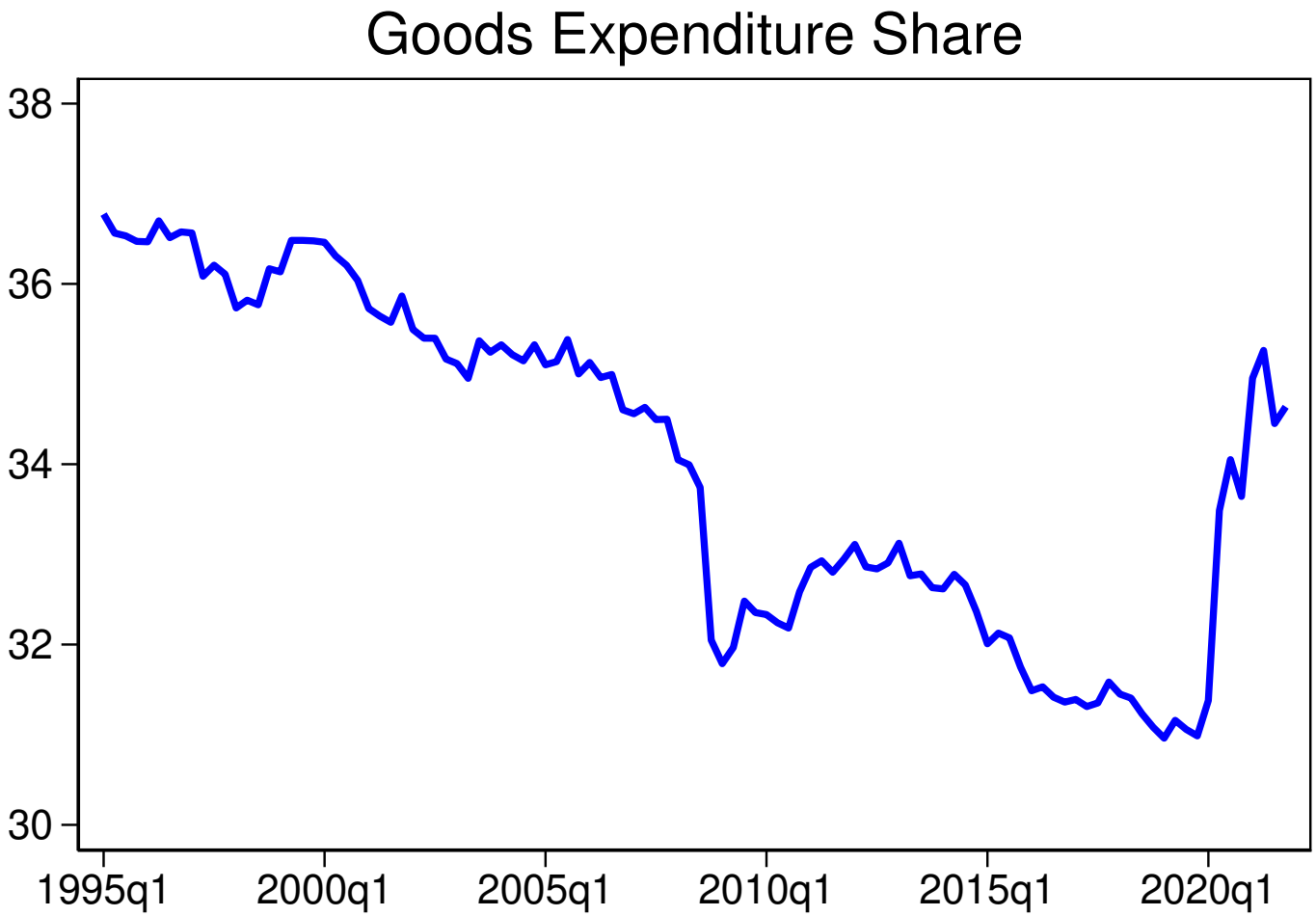
After the Lockdowns: Demand Reallocation and Inflation

Features of post-Covid macroeconomic landscape:

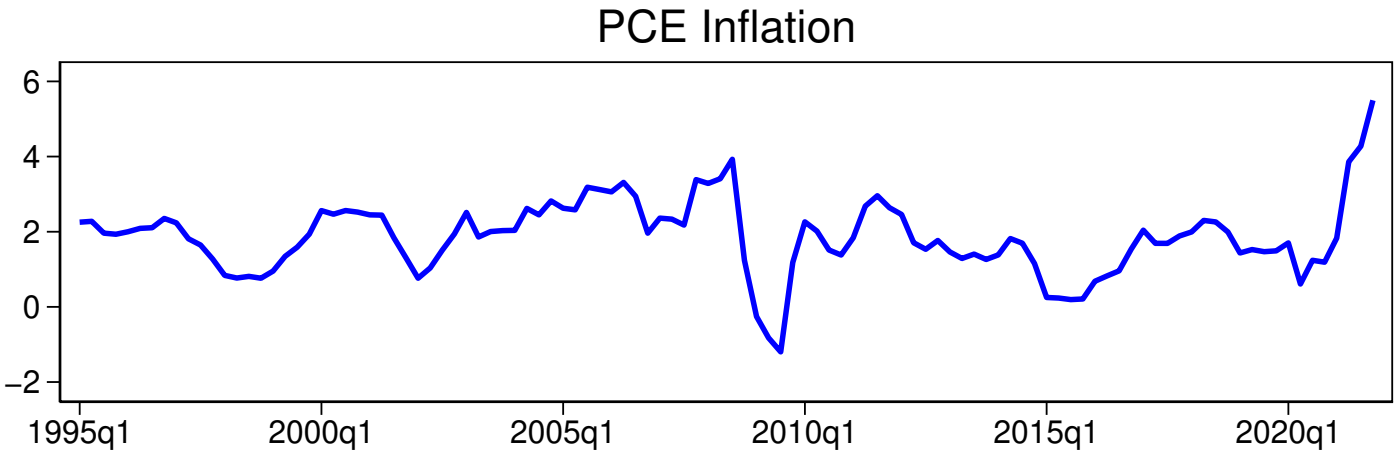
- Unprecedented shift in expenditures across consumption categories. Some sectors were hit very hard, some sectors experienced large increase in demand.
- Large and persistent rise in inflation
- Sectoral supply constraints

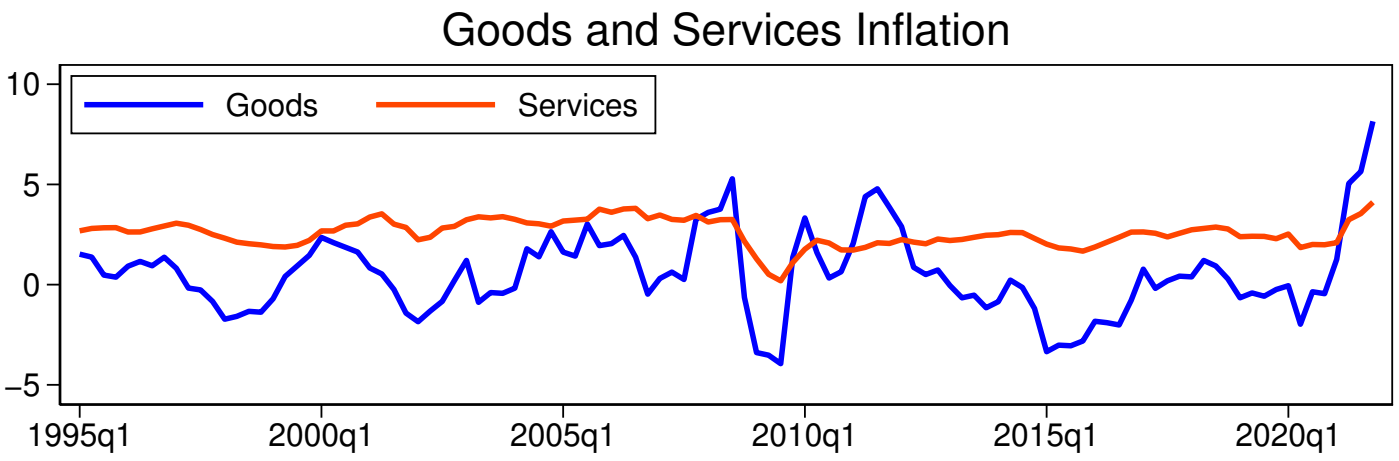
Sudden Shift in Consumption Expenditures



Goods Consumption as a Share of Total Consumption Expenditures in the US

Rise in Inflation





Supply Constraints

How Do Reallocation Shocks Affect Inflation?

We study aggregate effects of reallocation in NK model with

- multi-sector input-output structure
- costly input adjustment
- Heterogeneous price rigidities across sectors

Main Results:

- With costly factor adjustment reallocation is inflationary through
  - Productive misallocation $\Rightarrow \downarrow$ TFP $\Rightarrow \uparrow$ inflation
  - Lower price stickiness in goods vs services $\Rightarrow \uparrow$ inflation
- Model can explain within-industry evolution of both prices and quantities during the pandemic

Model Framework

- Multi-sector NK-DSGE model with Input-Output linkages
- Assume costly adjustment of production factors
- We study effects of two types of shocks
  1. Preference shift from services to goods ("COVID shock")
  2. Sector-specific TFP shocks ("Bottlenecks")

Model Framework: Agents

- Households:
  - Consume a continuum of goods and services
  - Supply Labor
- Firms:
  - Use CES production in labor and intermediate inputs
  - Face adjustment costs on labor input
  - Final consumption either as goods or services
  - Set prices subject to Heter. price stickiness

Households

Households problem:

$$maxE_t \sum_{i=0}^{\infty} U(C_{t+i}, N_{t+i}) = \frac{C_{t+i}^{1-\gamma}}{1-\gamma} - \chi \frac{(N_{t+i})^{1+\psi}}{1+\psi} \tag{1}$$

where

$$C_t = \left(\frac{C_t^g}{\omega_t}\right)^{\omega_t} \left(\frac{C_t^s}{1-\omega_t}\right)^{1-\omega_t} \tag{2}$$

$$C_t^g = \prod_{i=1}^{N} \left(\frac{C_{i,t}}{\gamma_i^g}\right)^{\gamma_i^g} \text{ and } C_t^s = \prod_{i=1}^{N} \left(\frac{C_{i,t}}{\gamma_i^s}\right)^{\gamma_i^s} \tag{3}$$

subject to

$$P_t C_t + B_{t+1} = W_t N_t + (1+i_t) B_t + Profits_t \tag{4}$$

$$P_t C_t = P_t^g C_t^g + P_t^s C_t^s \tag{5}$$

Households (cont.)

Optimization implies

$$C_t^{-\gamma} = \beta E_t \left[C_{t+1}^{-\gamma} \frac{1 + i_{t+1}}{\Pi_{t+1}} \right] \tag{6}$$

$$C_t^{-\gamma} \frac{W_t^i}{P_t} = \chi (N_t)^{\psi} \tag{7}$$

$$P_t^g C_t^g = \omega_t P_t C_t \tag{8}$$

$$P_t = (P_t^g)^{\omega_t} (P_t^s)^{1-\omega_t} \tag{9}$$

and

$$P_t^g = \sum_{i=1}^{N} (P_t^i)^{\gamma_t^g} \tag{10}$$

$$P_t^s = \sum_{i=1}^{N} (P_t^i)^{\gamma_t^s} \tag{11}$$

Final Goods Producers

In each sector final goods producer buy intermediate goods from retailers

$$Y_t^i = \left[\int_0^1 Y_t^i(s)^{\frac{\epsilon-1}{\epsilon}} ds \right]^{\frac{\epsilon}{\epsilon-1}} \tag{12}$$

$$Y_t^i(s) = \left(\frac{P_t^i(s)}{P_t^i} \right)^{-\epsilon} Y_t^i \tag{13}$$

Monopolistically competitive retailers set prices subject to Rotemberg costs

$$1 - \epsilon + \epsilon \frac{MC_t^i}{P_t^i} - \kappa_i(\Pi_t^i - 1)\Pi_t^i + E_t \left(M_{t+1} \Pi_{t+1}^i (\Pi_{t+1}^i - 1) \frac{Y_{t+1}^i}{Y_t^i} \right) = 0 \tag{14}$$

where M_{t+1} is HHs stochastic discount factor and $\Pi_t^i = \frac{P_t^i}{P_{t-1}^i}$

Intermediate Producers

Intermediate goods producers solve

$$\max MC_t^i Y_t^i(s) - P_t^{M,i} M_t^i(s) - P_t^{L,i} L_t^i(s) \tag{15}$$

subject to

$$Y_t^i(s) = \left(\alpha^{\frac{1}{\epsilon_Y}} \left(M_t^i(s)\right)^{\frac{\epsilon_Y - 1}{\epsilon_Y}} + (1-\alpha)^{\frac{1}{\epsilon_Y}} \left(L_t^i(s)\right)^{\frac{\epsilon_Y - 1}{\epsilon_Y}} \right)^{\frac{\epsilon_Y}{\epsilon_Y - 1}} \tag{16}$$

$$M_t^i(s) = \left(\sum_{j=1}^{N} \Gamma_{i,j}^{\frac{1}{\epsilon_M}} \left(M_{j,t}^i(s)\right)^{\frac{\epsilon_M - 1}{\epsilon_M}} \right)^{\frac{\epsilon_M}{\epsilon_M - 1}} \tag{17}$$

Cost minimization implies

$$P_t^{M,i} = \left(\sum_{j=1}^{N} \Gamma_{i,j} (P_t^j)^{1-\epsilon_M} \right)^{\frac{1}{1-\epsilon_M}} \tag{18}$$

$$MC_t^i = \left(\alpha (P_t^{M,i})^{1-\epsilon_Y} + (1-\alpha)(W_t^i)^{1-\epsilon_Y} \right)^{\frac{1}{1-\epsilon_Y}} \tag{19}$$

Labor Adjustment Costs

- Labor agency in each sector hires labor from HHs and supplies it to intermediate producers at $P_t^{L,i}$
- Subject to non-pecuniary adjustment costs

$$V_t(L_{t-1}^i) = \max_{L_t^i} P_t^{L,i} L_t^i - W_t L_t^i \left(1 + \frac{c}{2}\left(\frac{L_t^i}{L_{t-1}^i} - 1\right)^2\right) + E_t[M_{t+1} V_{t+1}(L_t^i)]$$

FOCs imply

$$P_t^{L,i} = W_t \left(1 + \frac{c}{2}\left(\frac{L_t^i}{L_{t-1}^i} - 1\right)^2 + c\left(\frac{L_t^i}{L_{t-1}^i} - 1\right)\frac{L_t^i}{L_{t-1}^i}\right)$$

$$-E_t\left[M_{t+1} c W_{t+1}\left(\frac{L_{t+1}^i}{L_t^i} - 1\right)\frac{(L_{t+1}^i)^2}{(L_t^i)^2}\right]$$

Equilibrium

Monetary policy follows a standard Taylor rule.

$$log(i_{t+1}) = log(R_{ss}) + \phi \log \Pi_t \tag{20}$$

where $\Pi_t = \frac{P_t}{P_{t-1}}$
Goods market clearing:

$$Y_t^i = C_{i,t} + \sum_{j=1}^{N} M_{i,t}^j \quad \forall i \tag{21}$$

Labor market clearing:

$$\sum_{j=1}^{N} L_t^i = N_t \tag{22}$$

Calibration

- Use 66 sectors
- Price stickiness (κ_i) from Pasten et al. (2020) $\Rightarrow$ services are stickier than goods
- Set labor adjustment cost to match relative price movements form data
- Production elasticities and factor shares from the literature
- Solve model non-linearly

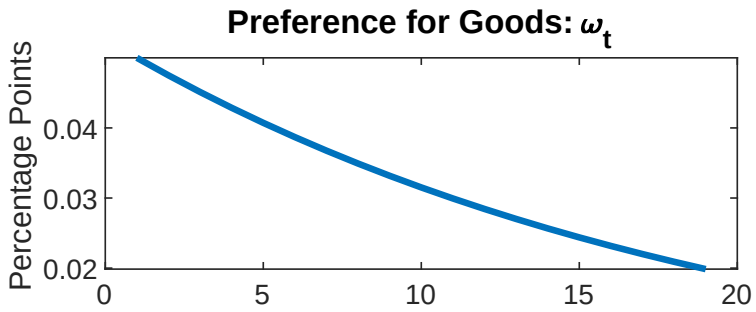
Demand Reallocation Shock

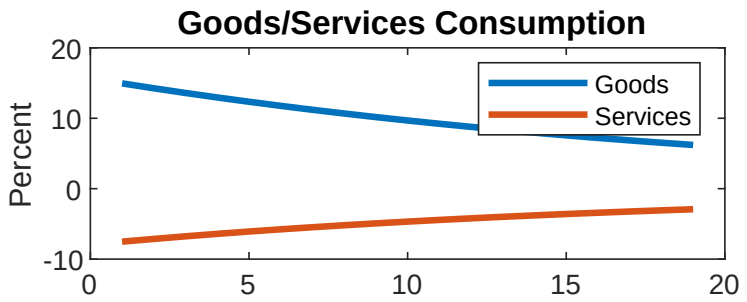
Experiment: Amidst the pandemic, large preference shock shifts preferences away from services and toward goods.

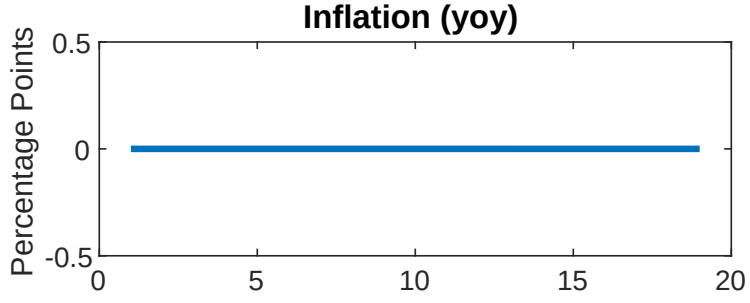
Three model versions:

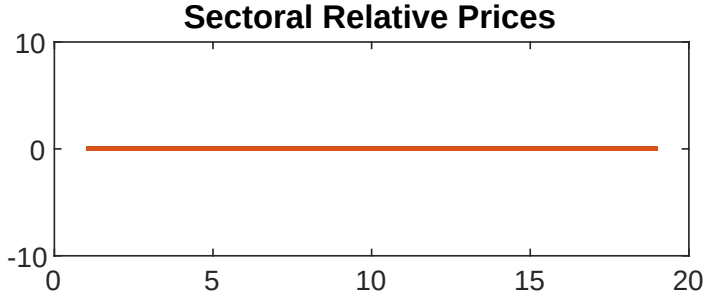
1. **IO Model + homogeneous P stickiness + fully mobile L**
   With fully mobile L, relative prices and total inflation are unchanged.
2. **IO Model + homogeneous P stickiness + costs of moving L**
   Reallocation shock causes misallocation of resources through production network, causing GDP and productivity to fall, π to rise.
3. **IO Model + Heter. P stickiness + L adjustment costs**
   Heter. price stickiness worsens labor reallocation. With stickier price in services, decline in demand for S more than offsets increase in demand for G, and activity falls more.

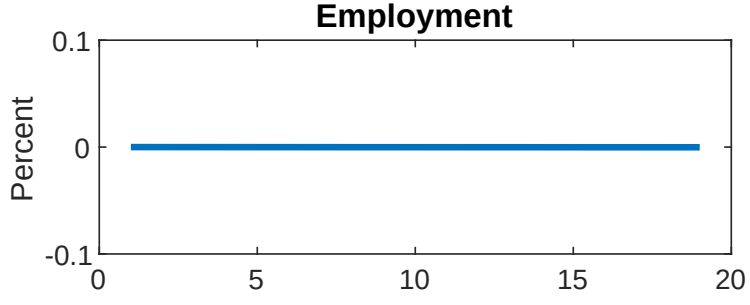
Reallocation Shock, Same P stickiness, Fully mobile Labor

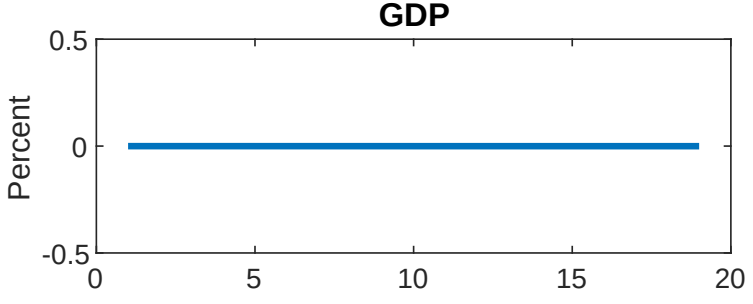




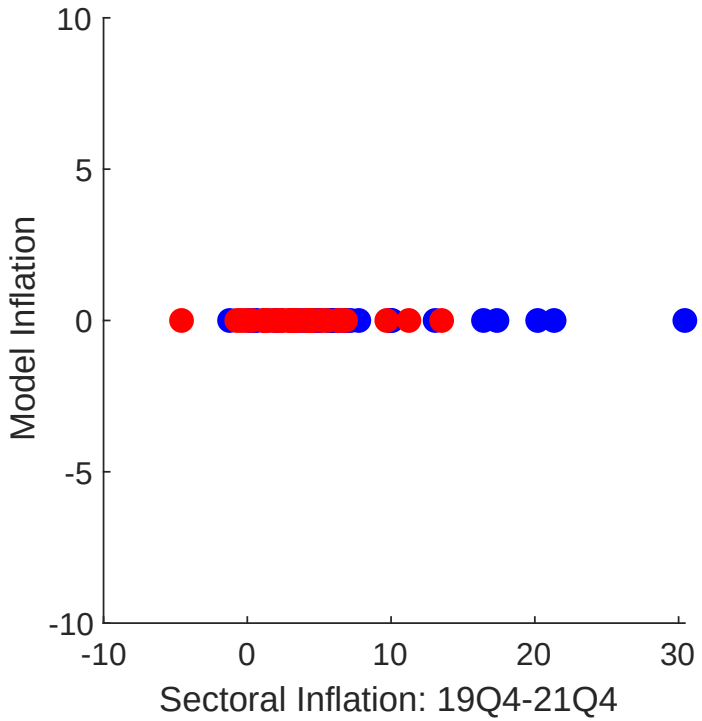


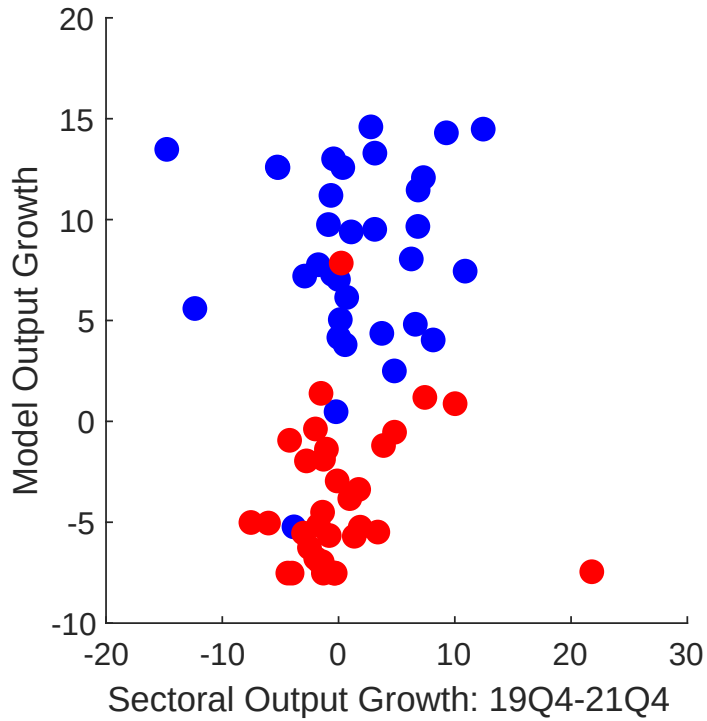






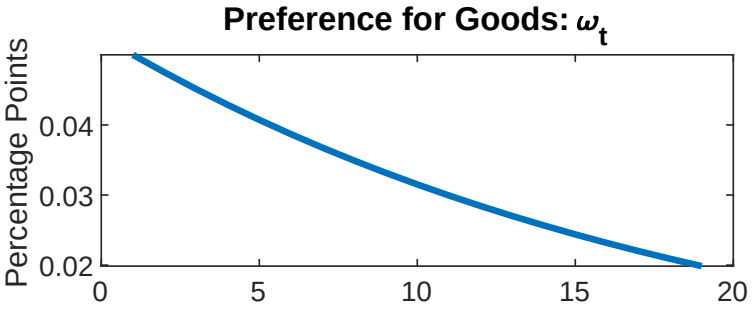
Reallocation Shock, Same P stickiness, Fully mobile Labor
Reallocation Shock: Cross-Sectional Effects: Model v Data

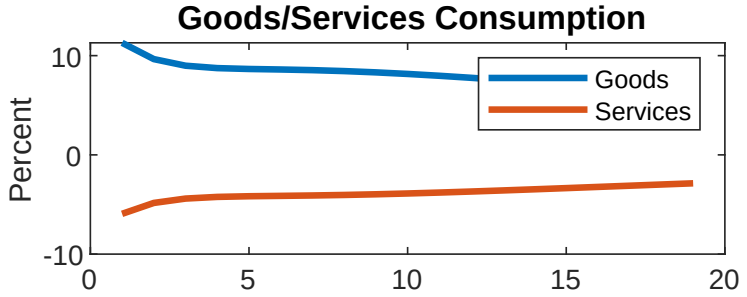


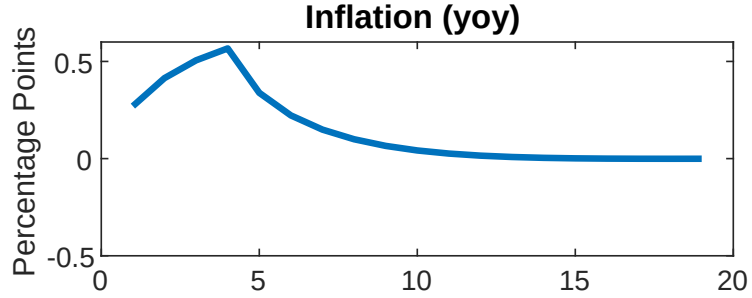


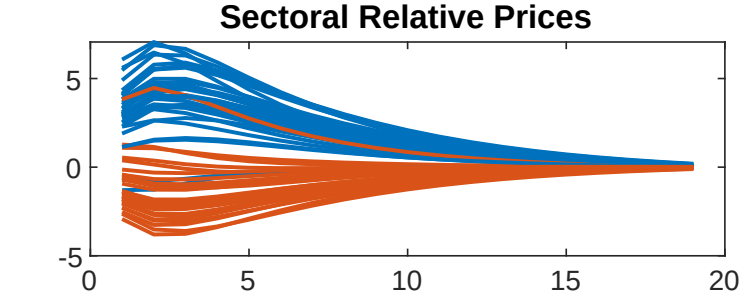
Sectors that grow the most are goods-producing sectors that are also used as goods by other sectors (e.g. xxx)

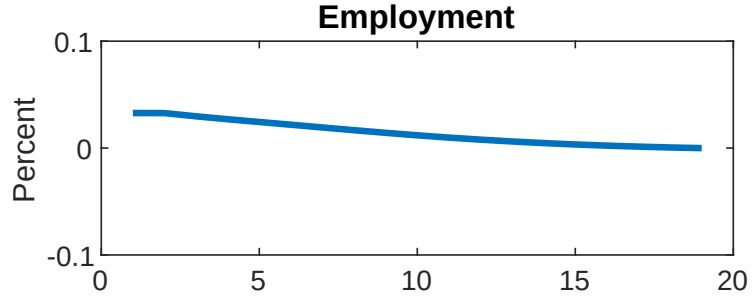
Reallocation Shock, Same P stickiness, Cost of Moving L

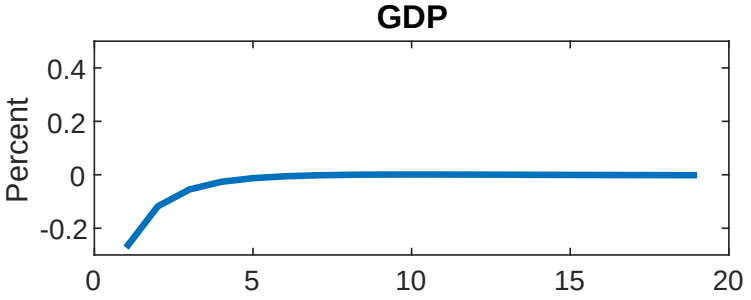












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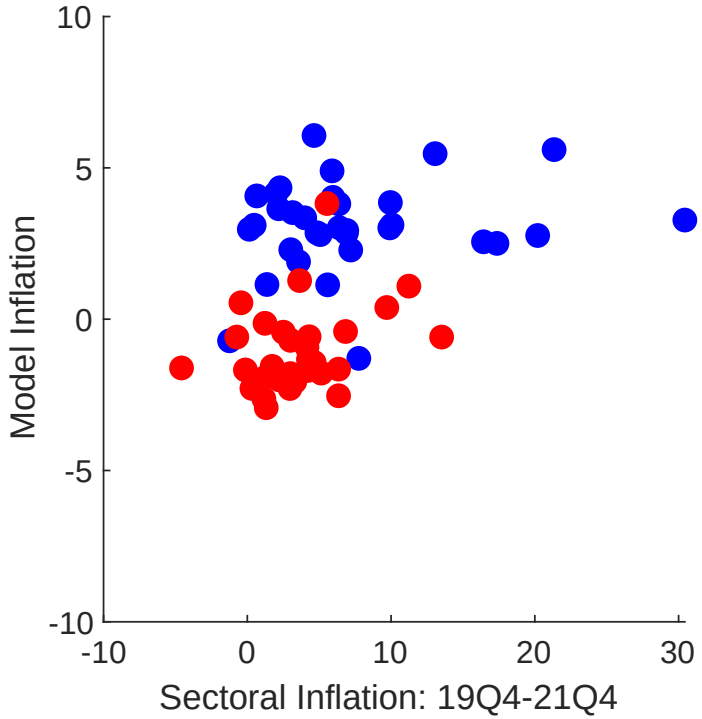
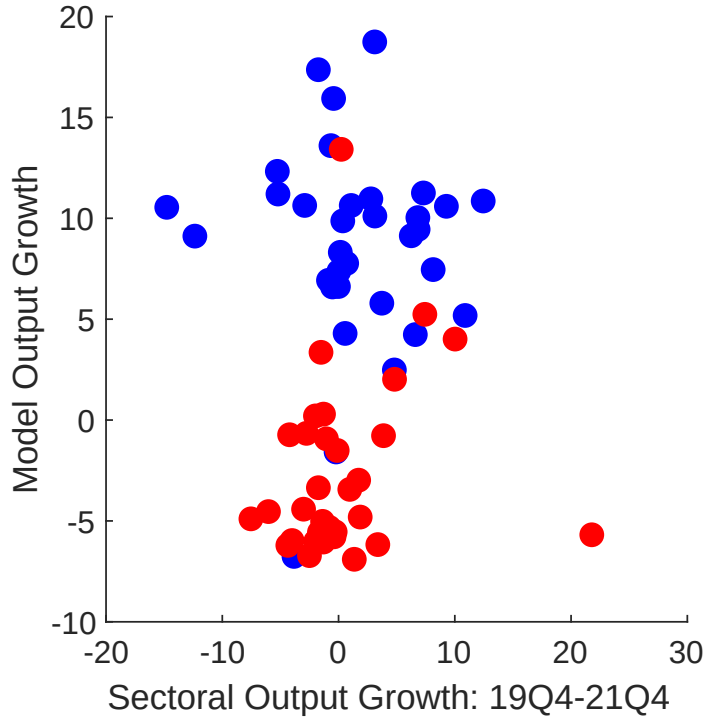
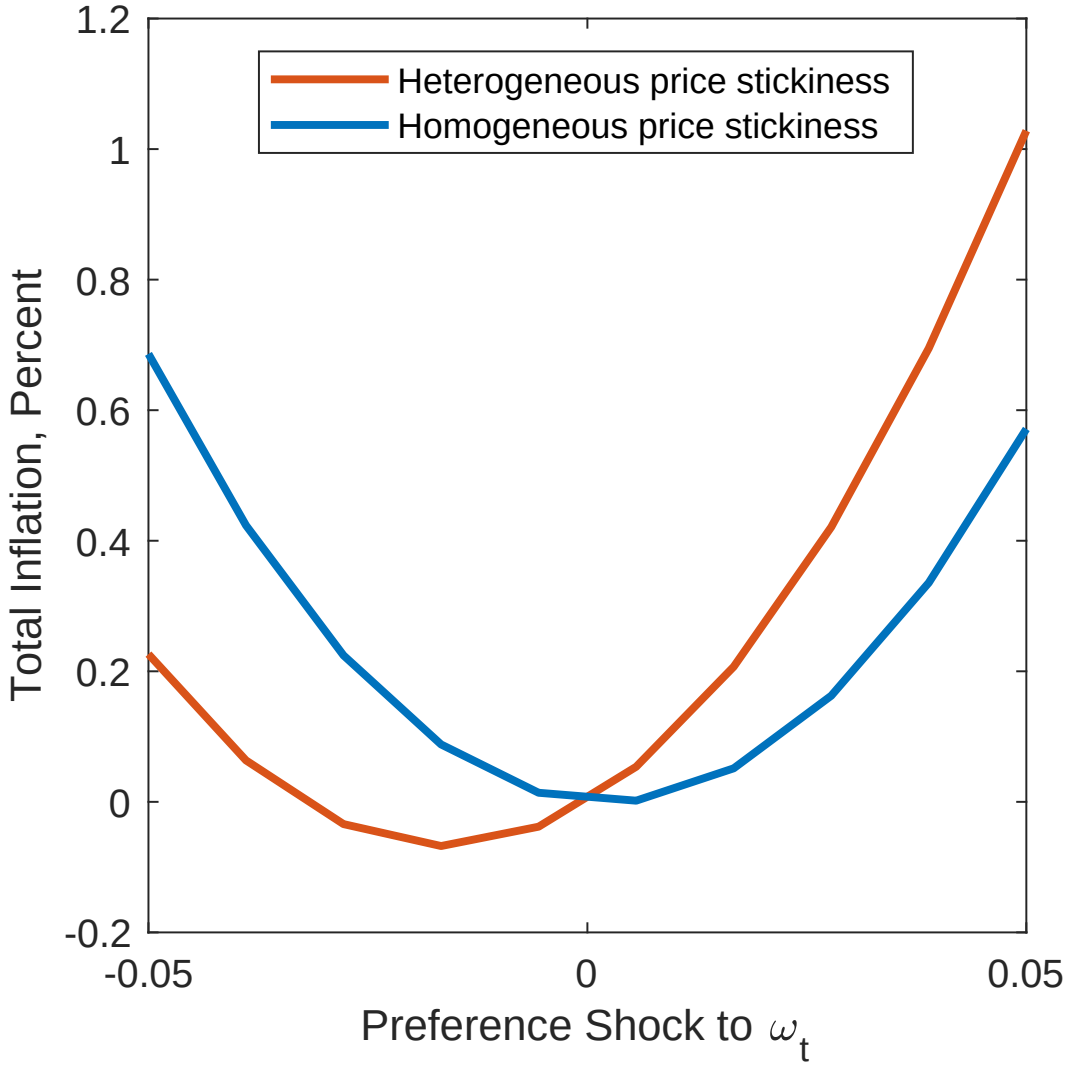
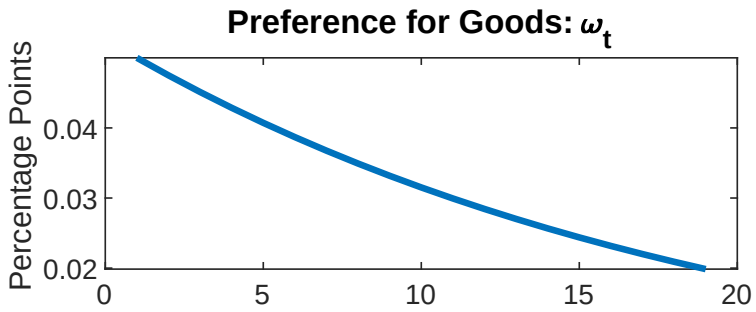


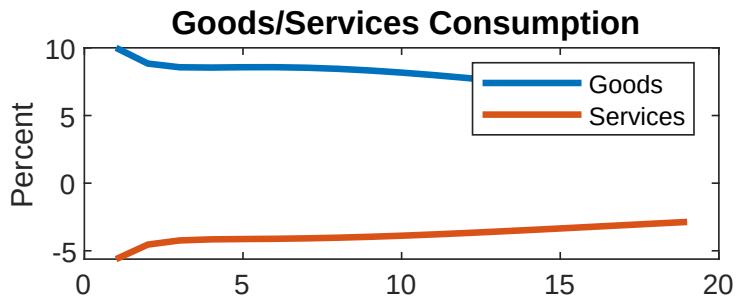


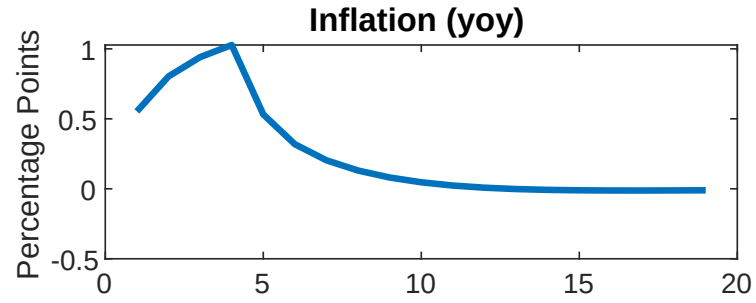
One Implication of Different Price Stickiness

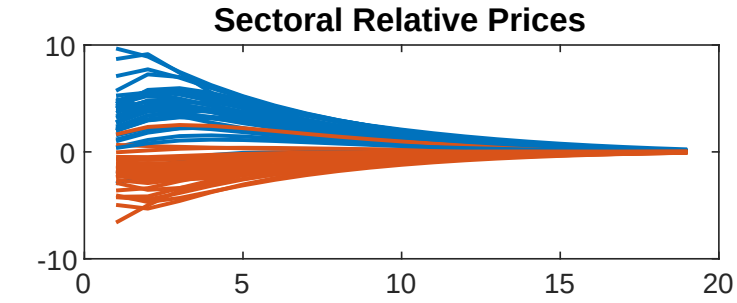


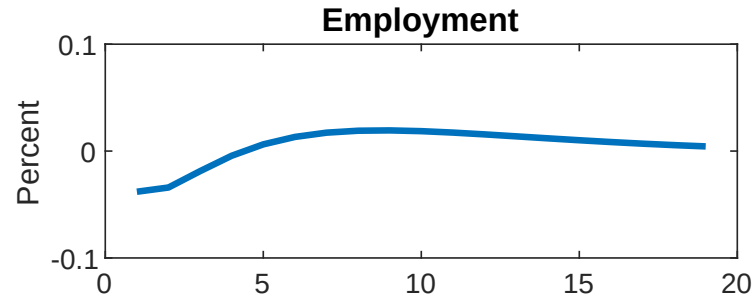
Reallocation Shock, Heter. P stickiness, Cost of Moving L

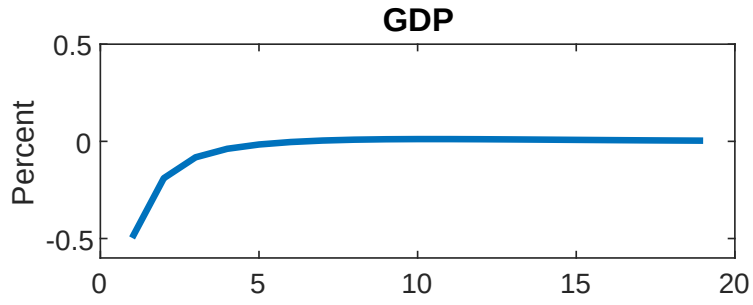












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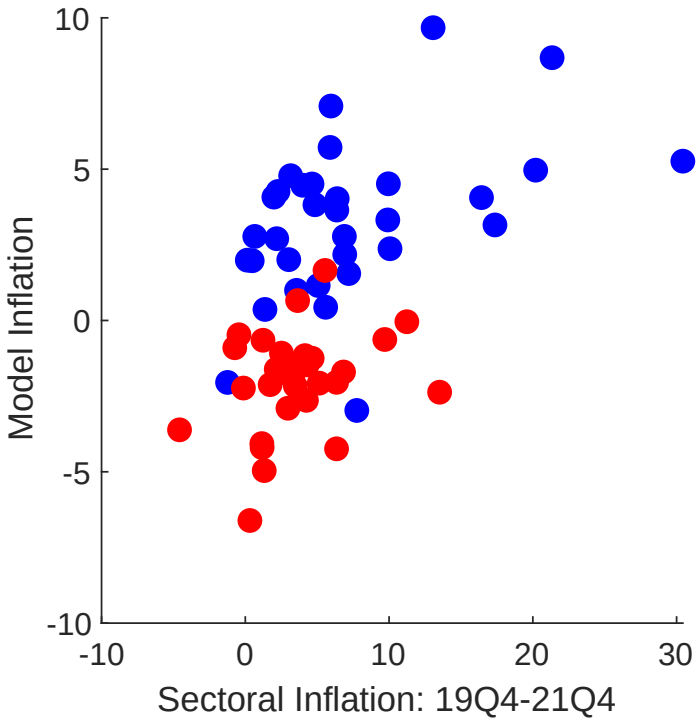
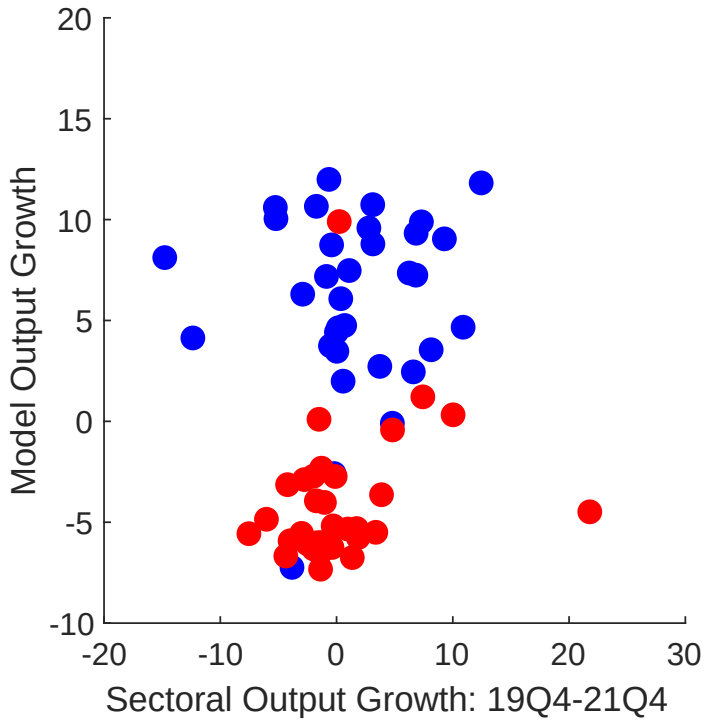
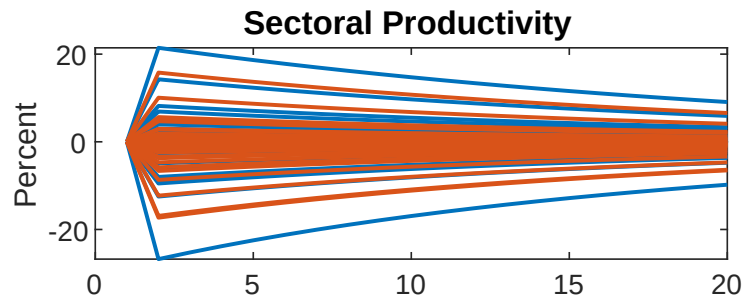


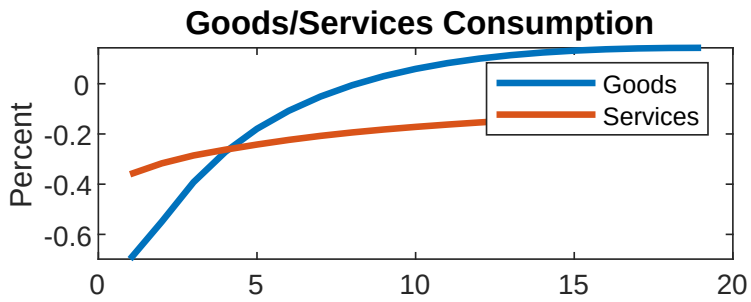


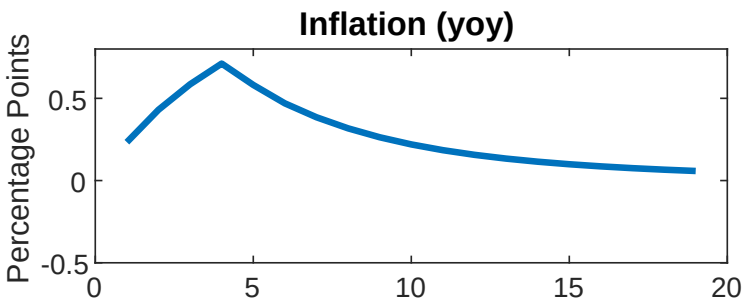
Adding TFP Shocks

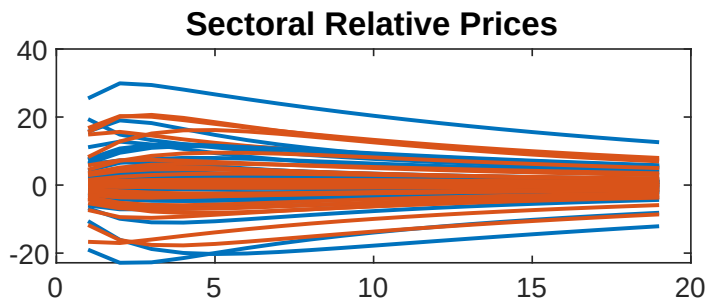
- For some industries, price and quantity dynamics are hard to explain with the dynamics following an aggregate reallocation shock.
- Example: "Motor Vehicle Parts and Dealer" sector, which has experienced a 25% decline in quantities and a 60% rise in prices between 2019 and 2021.
- Pandemic-related supply disruptions in some sectors may have contributed to the aggregate effects of disruption more broadly.
- We measure evolution of TFP at the industry level between 2019 and 2021 and feed estimated idiosyncratic TFP into model.

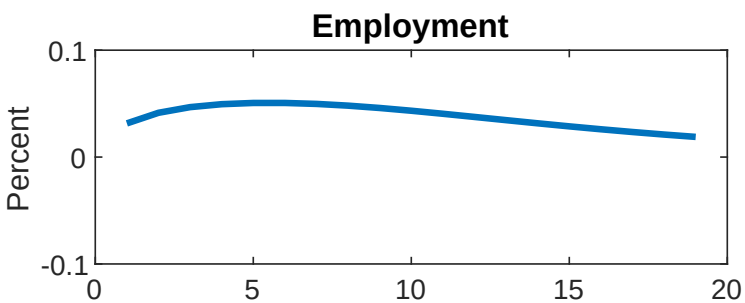
TFP Shock, Heter. P stickiness, Cost of Moving L

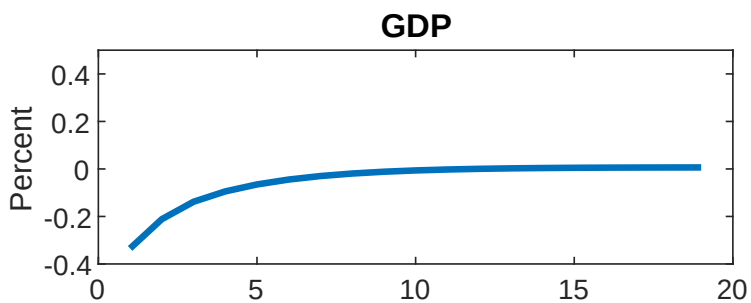












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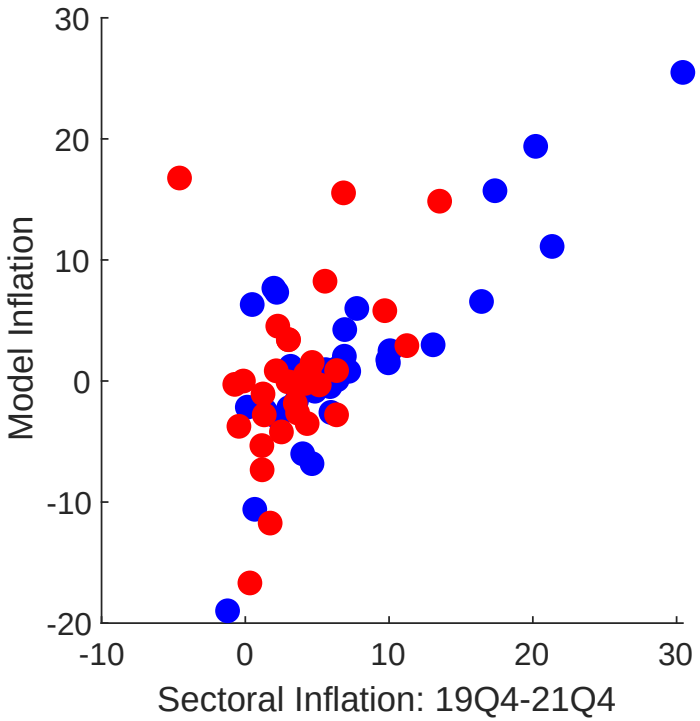
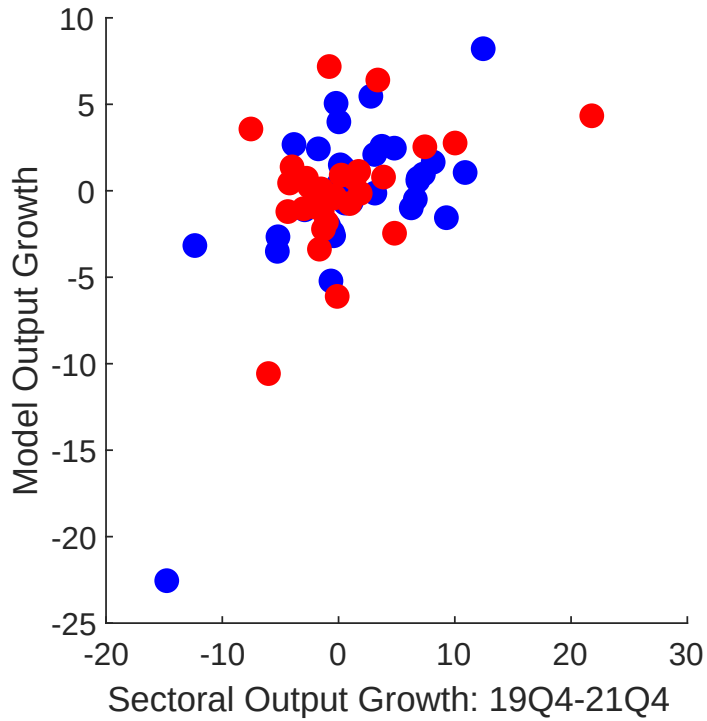
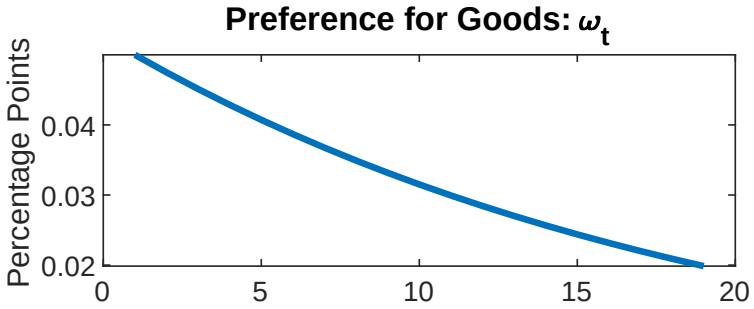
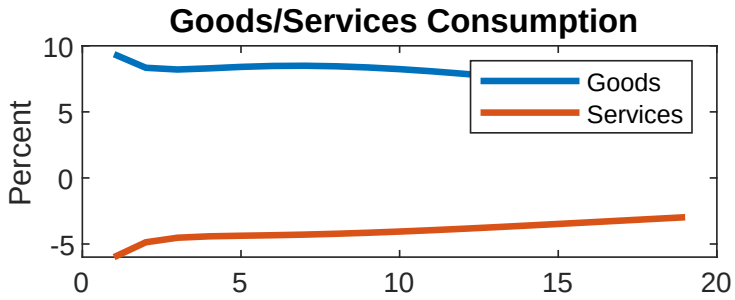
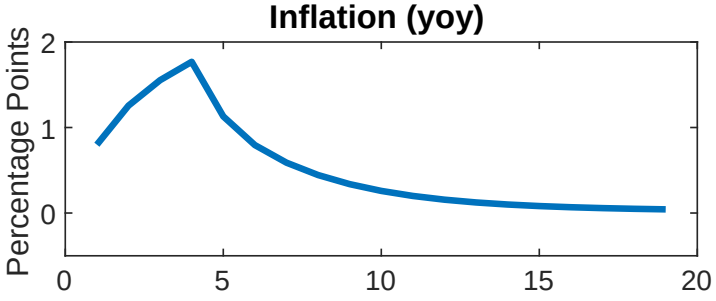


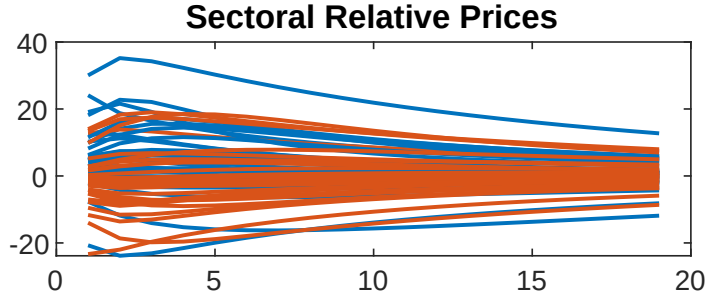


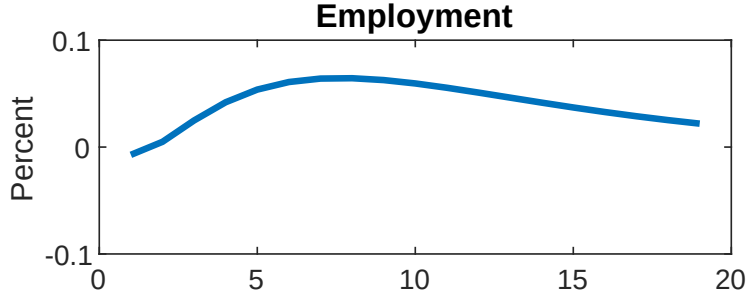
Reall.+TFP, Heter. P stickiness, Cost of Moving L

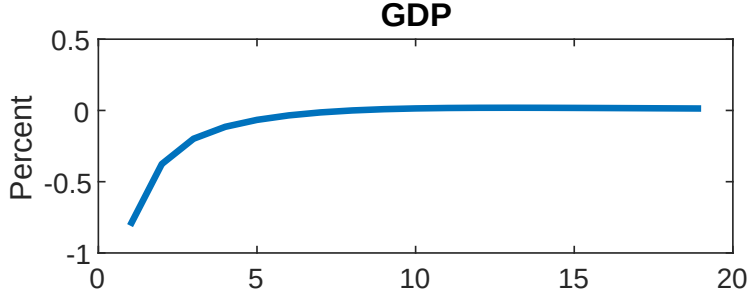




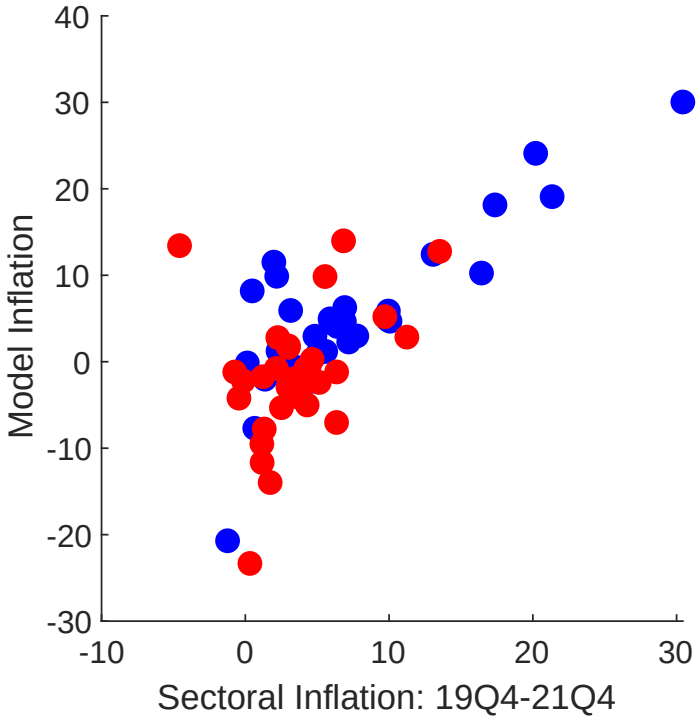


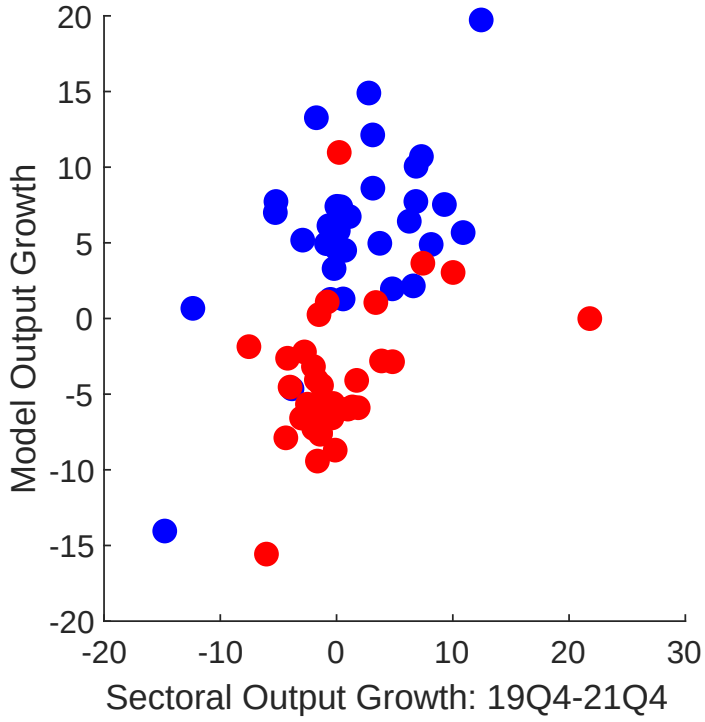






Reall.+TFP, Heter. P stickiness, Cost of Moving L
Reall.+TFP: Cross-Sectional Effects: Model v Data





Regression coefficients, model industries vs data

Shock	Version	P	P_g	P_s	Y	Y_g	Y_s
ω	mobile L, = sticky	0	0	0	0.25	0.39	0.06
ω	costly L, = sticky	0.18	0.24	-0.1	0.24	0.32	0.14
ω	costly L, heter.sticky	0.21	0.32	-0.22	0.23	0.31	0.12
TFP	costly L, heter.sticky	0.54	0.58	0.38	0.37	0.48	0.23
TFP+ω	costly L, heter.sticky	0.74	0.87	0.17	0.59	0.77	0.35

For each row, table shows regression coefficients of a regression of model implied changes in industry variables (prices or output) given the shocks in the first column, against the corresponding data changes over the 2019-2021 period.

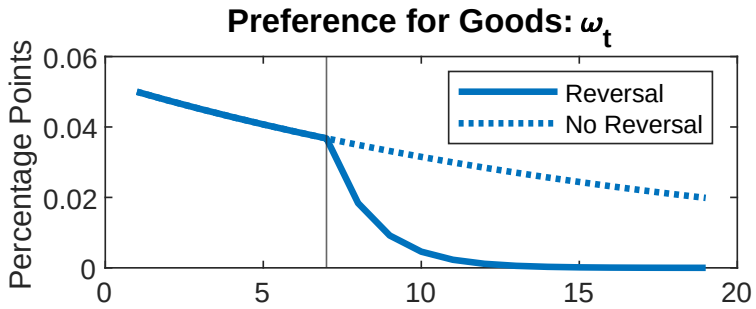
Taking Stock

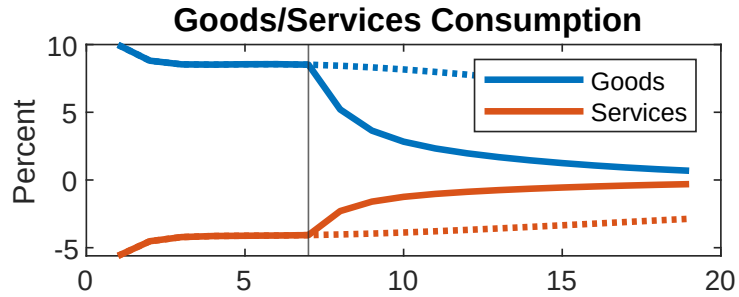
- Simple reallocation shock coupled with TFP shock explains large bulk of evolution of prices and quantities since onset of COVID-19
- Model also account for heteregeneous effects within industries, despite the fact that it affects final demand for goods and services uniformly
- Both input-output linkages and sectoral heterogeneity in price stickiness contribute to this result
- Sectors producing goods which are consumed by households or selling inputs which are heavily used in the production of these goods experience larger increase in inflation.
- Industries providing services to consumers or inputs to the service sectors experience weaker inflationary pressures.
- Goods sectors with more flexible prices exhibit larger increases in prices

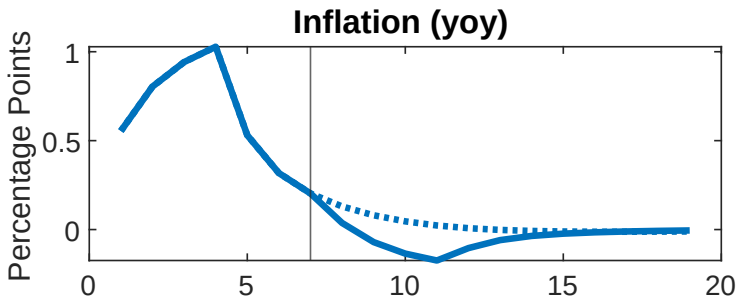
Reversal Experiment

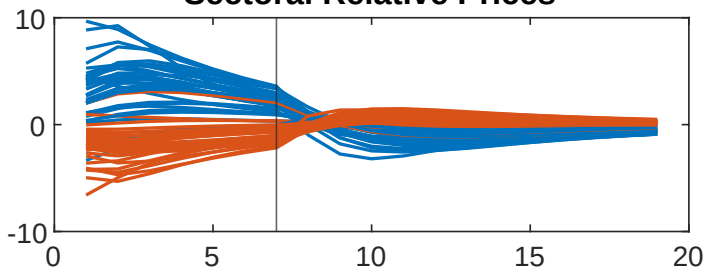
- What will happen if there is an unexpected reversal in household preferences?
- We study a second shock: the persistence of the reallocation shock falls from 0.95 to 0.5 after 2 years
- Result: Faster shift back to services reduces inflation faster and leads to improvement in allocative efficiency.

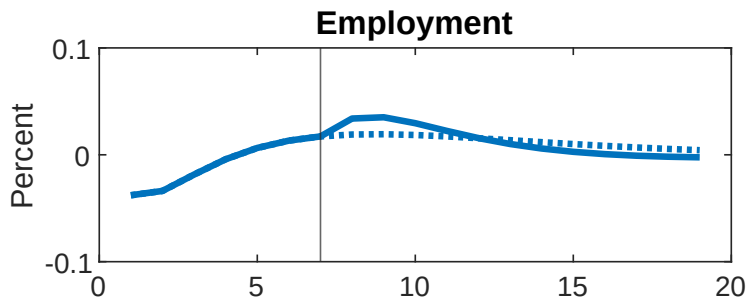
Faster reversal of reallocation shock

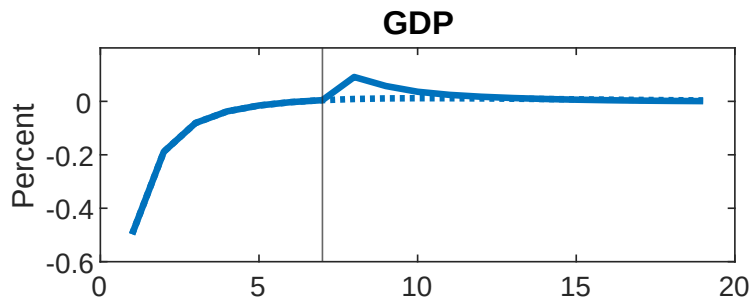












Conclusions

- Model can provide coherent accounting of various forces that may have driven prices and quantities in the post-COVID recovery.
- Plan to extend this model by including government sector and external sector and considering alternative monetary policy rules

Calibration

- Use 66 sectors
- Calibrate price stickiness (κ_i) from Pasten et al. (2020)
- Solve model non-linearly

Parameter	Value	Target/Source
γ	2	Standard
χ	1	N/A
ψ	1	Standard
ϕ	1.5	Standard
β	0.99	Standard
ϵ	10	Standard
ϵ_M	0.1	Atalay (2017)
ϵ_Y	0.8	Atalay (2017)
$\bar{\omega}$	0.31	Goods Expenditure Share
c	50	Relative price of goods and services
α	0.5	Pasten et al. (2020)