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Abstract

This paper examines two types of preference shocks - shocks to the disutility of working and to demand for goods relative to services - in an otherwise standard New Keynesian model. Model-based processes for both shocks are constructed using postwar US data, and both show movements of unprecedented magnitude that coincide with the COVID-19 pandemic. In the model, the relative demand shock leads to opposite movements in inflation and labor between the two sectors, while the shock to labor disutility is stagflationary, with inflation rising and output decreasing. A pandemic-motivated experiment with simultaneous large shocks to both labor disutility and relative goods demand generates divergences between the sectors in inflation and labor, but higher inflation and reduced output overall.

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1 Introduction

This paper examines two types of preference shocks - shocks to the disutility of labor and to demand for goods relative to services - in an otherwise standard New Keynesian model. In doing so, it considers different sources of dynamics from those most commonly assumed in contemporary business cycle models, which are frequently driven by productivity shocks.

These particular shocks are motivated by the experience of the COVID-19 pandemic, which saw a dramatic reduction in labor supply partly due to elevated risks of interaction in the workplace, and large shifts in favor of goods consumption as in-person services such as restaurant dining became hazardous. The unusual nature of the pandemic shock compared with previous economic downturns has challenged economists and economic policymakers.

Although motivated by recent experience, the goal of this study is not to provide a model of the pandemic-era economy, but instead, to investigate preference shocks empirically and examine their dynamics in the context of a relatively simple and well-known model. A model-based empirical characterization of the shock process is developed below, and the COVID-19 pandemic is shown to coincide with increases in labor disutility and relative demand for goods that are extremely large relative to historical variations. In the model, a relative demand shock results in a large increase in the price of goods, but one that reverses quickly. This is because the increase in relative demand raises goods-sector wages and marginal costs initially as workers already in the sector work more, but, over time, the reallocation of labor between sectors reduces labor per worker and marginal costs. This shock has little aggregate impact, as the opposite dynamics occur in the services sector. An increase in the disutility of labor is stagflationary, leading to higher inflation and lower output. As an experiment to provide prospective on the COVID-19 shock, large (four standard deviation) shocks to both relative demand and labor disutility are imposed simultaneously. This is shown to result in divergent inflation and labor across goods and services but increased inflation and lower output overall.

Labor hours dropped at an unprecedented pace in March and April 2020 in the US and around the world. Of course, a quantity can decrease due to a reduction in supply or in demand, and in general equilibrium a supply reduction will reduce quantity demanded (and vice-versa). The approach here focuses on the supply side of the labor market as the initial source of the shock. It is consistent with Faberman et al. (2022), who find a significant reduction in desired labor supply during the pandemic based on survey data.

The abrupt shift in demand toward goods and away from services has been widely noted. In the US, this shift coincided with increased disposable income due to fiscal support such as the CARES act of 2020. Tauber and Van Zandweghe (2021) estimate that changes in disposable income and shifts in preferences contributed roughly equally to the increased spending on durable goods in 2020.

The COVID-19 pandemic has quickly given rise to a large body of economic research. Of particular relevance here are several recent papers that analyze both supply- and demand-side shocks based on the pandemic. In a two-sector model, Guerrieri et al. (2022) how a reduction in the labor supply of one sector spills over to the other sector. Their model has a number of features including incomplete markets and downward nominal rigidity. They also incorporate a preference shock as a reduction in relative demand. Although consumers are infinitely lived the shocks are one-period temporary changes so their model is effectively a two-period model. Baquee and Farhi (2022) study a two-period multisector model where a fraction of households are credit constrained and downward nominal wage rigidity is present. They consider supply shocks in the form of reductions in available labor, aggregate demand shocks, as well as shifts in the composition of demand. Guerrieri et al. (2021) examine optimal monetary policy in a two-sector model with downward nominal wage rigidity that is subject to a one-time, permanent shift in relative demand. That paper finds that optimal monetary policy is inflationary because inflation can facilitate relative price adjustment. Fornaro and Romei (2022) examine optimal monetary policy for open economies in a two-period (short- and long-run) model. They also find optimal policy to be inflationary and further demonstrate a coordination failure problem among national monetary authorities in the case of a global reallocation shock.

Various types of preference shocks have been incorporated into a number of estimated larger-scale New Keynesian models. This paragraph discusses a few examples from this literature. Ireland (2004) includes a shock to the weight on consumption in the utility function, in addition to three other shocks. Variance decompositions show that preference shocks account for a substantial portion of variation in output growth, but are less important than technology and monetary policy shocks. Smets and Wouters (2003) use a Bayesian approach to estimate a model of the euro area with ten shocks, including a shock to the disutility of labor, which is substantial in their variance decompositions. An estimated shock to the disutility of labor plays a significant role in the Great Depression according to the model estimates of Christiano et al. (2003). However, they state that "it is a challenging to find an economically interesting interpretation of the rise in [labor disutility] from 1929 to 1933." Explaining heightened disutility of labor is more straightforward in the context of the COVID pandemic. While these papers lend support to the potential importance of preference shocks, their purpose is somewhat different than this study, which is focused on examining the dynamics following individual shocks in a simple, standard model rather than trying to provide an empirical accounting of the behavior of aggregate economic variables.

In the next section, a model is developed with two types of output - goods and services. A representative household supplies labor - the only factor of production - to both sectors and consumes each type of output. The weight in its utility function on the disutility of labor is stochastic, as is the weight on goods in its consumption bundle. The parameters of the model are discussed in section 3. Section 4 constructs empirical shock processes based on aggregate postwar US data that correspond with the stochastic terms in the utility function and consumption bundle. The estimated shock processes are used to generate model dynamics which are examined in section 5.

2 Model

A representative household of unit measure supplies labor to produce goods and services. It maximizes the following utility function:

$$U = \mathrm{E} \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \chi_t \nu_t \frac{\widetilde{L}_{G,t}^{1+\phi}}{1+\phi} - \chi_t (1-\nu_t) \frac{\widetilde{L}_{S,t}^{1+\phi}}{1+\phi} - \frac{\psi}{2} (\nu_{t+1} - \nu_t)^2 \right]. \quad (1)$$

It receives utility from consumption, C, and disutility from labor, where $\widetilde{L}_G$ and $\widetilde{L}_S$ are labor per worker in goods and services, respectively, and ν is the share of the household working in the goods sector. Total labor in goods is thus $L_G = \nu \widetilde{L}_G$ and in services it is $L_S = (1-\nu)\widetilde{L}_S$. The fraction of the household in the goods sector, ν_t, is predetermined and the household chooses the next period's value, ν_{t+1}. Reallocation across sectors entails a quadratic utility loss, governed by ψ. The case of $\psi = 0$ would be perfect intersectoral mobility, and $\psi = \infty$ would be a fixed sectoral allocation of labor. The inverse intertemporal elasticity of substitution is σ and ϕ is the inverse Frisch elasticity. The weight on the disutility of labor, χ, is subject to stochastic shocks, where an increase represents greater disutility from working.

Consumption is an aggregate of goods and services consumption,

$$C_t = \left[\omega_t^{\frac{1}{\gamma}} C_{G,t}^{\frac{\gamma-1}{\gamma}} + (1-\omega_t)^{\frac{1}{\gamma}} C_{S,t}^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}} \tag{2}$$

where γ is the elasticity of substitution between goods and services and ω is the weight on goods, which is subject to stochastic shocks. An increase in ω represents an increased preference for goods relative to services.

The household receives wages from labor supplied to each sector, w_G and w_S, the profits of the goods and services firms, Ξ_G and Ξ_S, and proceeds of one-period nominal bonds, B. It purchases consumption and bonds for the next period. Its budget constraint is thus

$$w_{G,t}\nu_t \widetilde{L}_{G,t} + w_{S,t}(1-\nu_t)\widetilde{L}_{S,t} + B_t + \Xi_{G,t} + \Xi_{S,t} = P_t C_t + q_t B_{t+1} \tag{3}$$

where P is an index of goods and services prices,

$$P_t = \left[\omega_t P_{G,t}^{1-\gamma} + (1-\omega_t) P_{S,t}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}, \tag{4}$$

and q_t is the price of a bond paying one unit of money in the next period. Note the bond price and the nominal interest rate, i_t, are related by $q_t = \frac{1}{1+i_t}$.

Household optimization implies labor per worker in each sector is related to relative wages as follows,

$$\frac{\widetilde{L}_{G,t}}{\widetilde{L}_{S,t}} = \left(\frac{w_{G,t}}{w_{S,t}}\right)^{\frac{1}{\phi}}, \tag{5}$$

as well as the Euler equation,

$$q_t = \beta \frac{P_t}{P_{t+1}} \left(\frac{C_t}{C_{t+1}}\right)^{\sigma}, \tag{6}$$

and the demands for goods and services, respectively,

$$C_{G,t} = \omega_t \left(\frac{P_{G,t}}{P_t} \right)^{-\gamma} C_t \tag{7}$$

$$C_{S,t} = (1 - \omega_t) \left(\frac{P_{S,t}}{P_t} \right)^{-\gamma} C_t. \tag{8}$$

The household's optimality condition with respect to ν_{t+1} can be written as

$$\psi(\nu_{t+1} - \nu_t) = \beta \mathrm{E}_t \left[\frac{\phi}{1+\phi} \chi_{t+1} \left(\widetilde{L}^{1+\phi}_{G,t+1} - \widetilde{L}^{1+\phi}_{S,t+1} \right) + \psi(\nu_{t+2} - \nu_{t+1}) \right] \tag{9}$$

which relates current-period adjustment costs to the next period's intersectoral difference in labor disutility and adjustment costs. In the absence of adjustment costs ($\psi = 0$), this reduces to $\widetilde{L}_{G,t+1} = \widetilde{L}_{S,t+1}$.

Firms in each sector produce differentiated varieties of output, using only labor. The production technology is linear where the output of firm j in sector k is given by:

$$y_{k,t}(j) = z_k L_{k,t}(j) \qquad k = G, S \tag{10}$$

where z is labor productivity.

Total consumption of goods and services are constant elasticity of substitution aggregates of the individual varieties, where μ is the elasticity of substitution between varieties. This implies demand for each variety has the form

$$c_{k,t}(j) = \left(\frac{p_{k,t}(j)}{P_{k,t}} \right)^{-\mu} C_{k,t} \qquad k = G, S \tag{11}$$

where $c_{k,t}(j)$ and $p_{k,t}(j)$ are the consumption of and price, respectively, of variety j in sector k.

Prices are sticky, with a fraction of firms, $1 - \theta$, receiving an opportunity to reset their prices each period. Firms' profit-maximization yields, after some algebra, a New Keynesian Phillips Curve (NKPC) for each sector,

$$\pi_{k,t} = \frac{(1-\beta\theta)(1-\theta)}{\theta}\widehat{MC}_{k,t} + \beta \mathrm{E}_t \pi_{k,t+1} \qquad k = G, S \tag{12}$$

where $\pi_{k,t}$ is inflation in sector k and $\widehat{MC}_{k,t}$ is the percentage deviation of real marginal cost in sector k from its steady state level, expressed in terms of that sector's output.

Overall inflation is a weighted average of goods and services inflation. Since the sectors are symmetric in the steady state, it is given approximately by:

$$\Pi_t \simeq \omega_t \pi_{G,t} + (1-\omega_t)\pi_{S,t}. \tag{13}$$

Since all output is consumed, total output is equal to consumption,

$$Y_t = C_t. \tag{14}$$

The monetary authority can set nominal interest rates and is assumed to do so following a traditional Taylor rule,

$$i_t = -\log\beta + \phi_\Pi \Pi_t - \phi_Y Y_t^{gap} \tag{15}$$

where $-\log\beta$ is the nominal interest rate in the steady state equilibrium, Y^{gap} is the percentage shortfall of output from steady state equilibrium, and ϕ_Π and ϕ_Y govern the responses of monetary policy to inflation and the output gap, respectively.

For simplicity and clarity, the model has a zero-inflation steady state and abstracts from the zero lower bound on nominal interest rates.

3 Parameterization

Parameters reflect a quarterly frequency and, to the extent possible, are set at standard values in the literature. The coefficient of relative risk aversion is set at $\sigma = 1.5$, the inverse Frisch elasticity is $\phi = 2$ and the discount factor is $\beta = 0.995$ which is consistent with a 2% annual rate of interest. Goods and services are assumed to be complements with $\gamma = 0.5$. Using bars to denote steady-state values, the steady-state weight on labor in the utility function, $\bar{\chi}$, is set to one and the share of goods in consumption is $\bar{\omega} = 0.44$, which the average share of US personal consumption expenditure on goods over the period 1948-2019. The steady-state share of the representative household working in the goods sector is set to $\bar{\nu} = 0.44$ so that the sectors are symmetric in equilibrium. The Taylor rule response parameters are set at canonical values of $\phi_{\Pi} = 1.5$ and $\phi_Y = 0.125$, which reflects that the model interest interest and inflation rates are quarterly, and is consistent with $\phi_Y = 0.5$ for an annual interest rate. One-quarter of firms are allowed to reset their prices each period, which implies $\theta = 0.75$. The elasticity between varieties is $\mu = 6$, which gives an equilibrium markup of 20% over marginal cost.

The parameter for the intersectoral labor mobility cost, ψ, is set based on the cost of moving between the goods and service sectors estimated by Lee and Wolpin (2006). For persons changing sectors while remaining in the same occupational category, they estimate an average value of \$8222 in 1983 dollars. This is equivalent to about 80% of per capita consumption of \$10,175 (also in 1983 dollars) at the midpoint of their 1968-2000 estimation period. The adjustment cost parameter is therefore set so that the loss of utility of reallocating one percent of labor is equivalent to the utility lost from a reduction in consumption of 0.8%. With the other parameters assumed, this gives $\psi = 0.82$.

4 Shock Processes

4.1 Relative Demand Shocks

Using X to denote expenditure, expenditure on services is $X_{S,t} = P_{S,t}C_{S,t}$ and overall consumption expenditure is $X_t = P_t C_t$. The form of the consumption aggregate used in (2) implies

$$X_{S,t} = (1 - \omega_t) \left(\frac{P_{S,t}}{P_t} \right)^{1-\gamma} X_t. \tag{16}$$

Log-linearizing around the steady state and using carets to denote percent deviations from the steady state gives an expression for variation in the weight on goods in consumption:

$$\widehat{\omega}_t = \frac{\bar{\omega} - 1}{\bar{\omega}} \left[\widehat{X}_{S.t} - \widehat{X}_t - (1 - \gamma) \left(\widehat{P}_{S,t} - \widehat{P}_t \right) \right] \tag{17}$$

A $\widehat{\omega}_t$ series is constructed using data on consumption expenditures on services (X_S), overall consumption expenditures (X) and the deflators for services expenditure (P_S) and the overall personal consumption expenditure deflator (P). Quarterly US data from the BEA for the period 1948-2019 is de-trended using the Hodrick-Prescott filter, and the log deviations from the trend for each variable are applied in (17) along with the assumed values of γ and $\bar{\omega}$. Due to the large movements in 2020, for the period 2020-2022Q1, the series is constructed with deviations from the Hodrick-Prescott filtered trend extrapolated from the fourth quarter of 2019. The resulting series is shown in Fig. 1.

The large increase in relative demand for goods due to the COVID-19 pandemic is clearly visible and substantially greater than previous movements. The peak deviation is 8.9% in the second quarter of 2021.

For the period 1948-2019, $\widehat{\omega}_t$, is less volatile than output (measured in deviations from the HP-filtered trend), with a standard deviation of 0.91%, compared with 1.58% for real GDP. It is also somewhat procyclical, with a correlation with real GDP of 0.59.

A regression of $\widehat{\omega}_t$ on lagged values, over 1948-2019,

$$\widehat{\omega}_t = \rho_\omega \widehat{\omega}_{t-1} + \varepsilon_t^\omega \tag{18}$$

yields an estimate of $\rho_\omega = 0.64$ where the standard deviation of the residual is $\sigma^2_{\varepsilon^\omega} = 0.0070$.

4.2 Labor Disutility Shocks

In a version of the model with only one sector, the representative household's optimality condition with respect to labor can be written as

$$W_t C_t^{-\sigma} = \chi_t \mathrm{L}_t^\phi, \tag{19}$$

where W_t is the real wage, i.e., $W_t = \frac{w_t}{P_t}$. Log-linearizing and expressing in terms of deviations from the steady state gives an expression for changes in the utility weight on the disutility of labor, $\widehat{\chi}$,

$$\widehat{\chi}_t = \widehat{W}_t - \sigma \widehat{C}_t - \phi \widehat{L}_t. \tag{20}$$

Real wages (W) are constructed by taking BEA data on nominal compensation of employees and dividing by the personal consumption expenditure price deflator and consumption (C) is real personal consumption expenditure. For labor (L), the quarterly average of the labor force from the BLS is used. Since the model does not incorporate involuntary unemployment, the labor force is used instead of employment to better capture desired labor supply[1]. For 1948-2019, all three series are de-trended using the Hodrick-Prescott filter, and the log deviations from trend are applied to (20) along with the assumed values for σ and ϕ. For 2020Q1-2022Q1, the the variables are deviations from trends that are extrapolated from the end of 2019.

The resulting series for $\widehat{\chi}_t$ is shown in Fig. 2. The increase in labor disutility in 2020 implied by the model was much larger than any prior movement, peaking at 21.8% in the 2nd quarter of 2020.

In the period 1948-2019, $\widehat{\chi}_t$ was somewhat more volatile than output, with a standard deviation of 2.67%. It was also acyclical, with a correlation of -0.04 with real GDP.

The regression,

$$\widehat{\chi}_t = \rho_\chi \widehat{\chi}_{t-1} + \varepsilon_t^\chi \tag{21}$$

over the period 1948-2019, gives an estimate of $\rho_\chi = 0.70$ and the standard deviation of the error is $\sigma_{\varepsilon^\chi} = 0.0118$.

5 Results

5.1 Response to Relative Demand Shock

Responses of selected variables to a one standard deviation positive ε_t^ω shock - i.e., an increase in relative demand for goods (ω) - following the process estimated in (18) are shown in Fig. 3.

This shock generates sharp inflation in the goods sector and deflation in the services sector. This occurs because ν_t is predetermined so, initially, the adjustment to the shock involves increased labor per worker in the goods sector.

[1]Using nonfarm payrolls data for L yields a $\widehat{\chi}_t$ series with slightly more persistence - the estimated AR(1) regression coefficient is 0.86 - and one that is, not surprisingly, strongly countercyclical, with a correlation of -0.83 with output.

This requires a substantial wage increase and therefore real marginal costs jump (and the opposite dynamics occur in the services sector). Note the real wages shown in Fig. 3 are in terms of overall prices, i.e., $\frac{w_{G,t}}{P_t}$ and $\frac{w_{S,t}}{P_t}$ while real marginal costs, following the standard derivation of the NKPCs, are in terms of sectoral prices, i.e., $MC_{G,t} = \frac{w_{G,t}}{P_{G,t}}$ and $MC_{S,t} = \frac{w_{S,t}}{P_{S,t}}$.

As the fraction of the household in the goods sector, ν_t, adjusts, labor per worker and wages in the goods sector come back down (and the opposite in services). The resulting 'overshooting' inflation dynamics reflect that the labor adjustment needed to produce more goods and fewer services is initially large in labor per worker, but, over time, the intersectoral reallocation of household members takes over. The adjustment of total labor in each sector is more gradual, and its dynamics reflect the slow diminution of the relative demand shock following the autoregressive process of (18).

Because the movements between the two sectors are largely offsetting, the dynamics in aggregate inflation and output are negligible and therefore not shown. Since overall inflation and output see very little change, the Taylor rule implies almost no change in interest rates.

5.2 Response to Labor Disutility Shock

Fig. 4 shows responses to an increase in the disutility of working (χ) from a one standard deviation ε_t^{χ} shock following the process in (21). This reduction in desired labor results in higher inflation and lower output - the increase in labor disutility acts as a negative supply shock. Total labor and labor per worker decline in both sectors by the same percentage. Following the Taylor rule, under canonical parameters, leads the monetary authority to increase interest rates.

5.3 Large, Combined Shock

The processes for $\widehat{\omega}_t$ and $\widehat{\chi}_t$ shown in Figs. 1 and 2 indicate very large and near-simultaneous increases in the relative demand for goods and disutility of working during the height of the pandemic in 2020 and 2021. As an experiment to consider what the New Keynesian model implies about such an event, large (four standard deviation) shocks to both relative demand and labor disutility are implemented simultaneously. Responses of selected variables are shown in Fig. 5. The effect of the combined shock is inflationary. The dynamics of inflation diverge between the two sectors, following the pattern seen with the relative demand shock, reflecting costs that initially reflect divergent changes in labor per worker (and therefore wages) but that even out across sectors as labor is reallocated. The overall decline in service sector labor is not fully offset by the increase in the goods sector, leading to a substantial drop in overall output. The Taylor rule implies a substantial increase in interest rates, contrary to actual US policy during the pandemic.

6 Conclusion

The COVID-19 pandemic was an unusual set of economic shocks, presenting a challenge to economists and policymakers. This paper has characterized historical processes for preferences for goods relative to services and for the disutility of labor, and shown that the pandemic corresponded with unprecedented increases in both. These shocks were implemented a standard New Keynesian model. The relative demand shock was shown to result in a sharp increase in goods sector inflation, but one that reverses quickly, as reallocation of labor takes over from increased labor per worker in the goods sector. There is little aggregate effect from the relative demand shock as the opposite dynamics occur in the services sector. An increase in labor disutility results in inflation and reduced output. If both types of shocks occur simultaneously, labor and inflation diverge between the goods and service sectors, but overall, inflation increases and output decreases. A standard Taylor rule implies higher interest rates.

The goal of this paper was not to provide a complete characterization of the effects of the COVID-19 pandemic, but, rather to investigate two particular types of shocks in an otherwise standard model. Other notable aspects of the pandemic-era economy such as supply chain constraints and expansionary fiscal policy, were not examined here, but could be fruitful elements to combine with the shocks implemented in this paper. Additional worthwhile extensions might involve combining the shocks in this paper with additional rigidities such as sticky wages or labor market search and matching.

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Fig.1. Relative Demand ($\widehat{\omega}_t$), 1948Q1-2022Q1

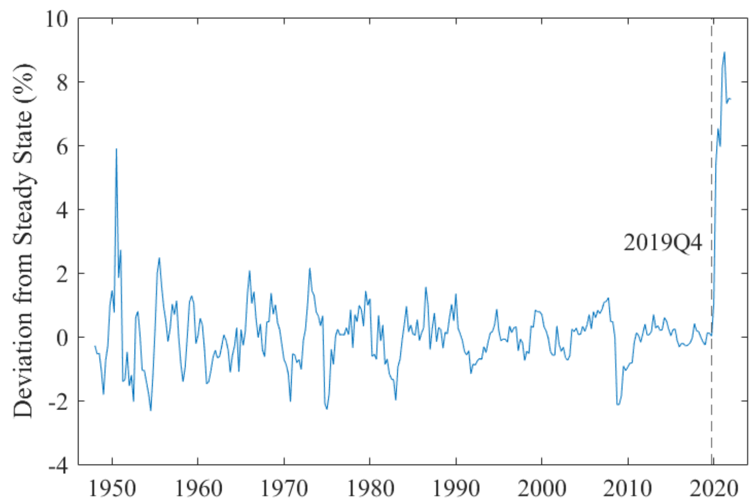


Fig. 2. Labor Disutility ($\widehat{\chi}_t$), 1948Q1-2022Q1

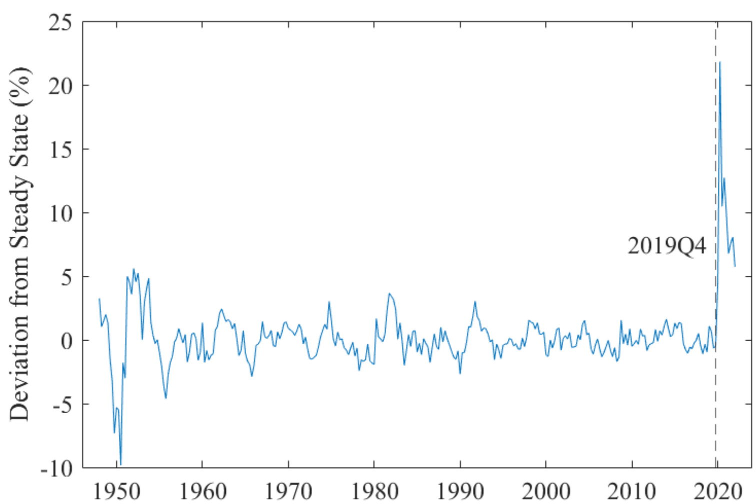
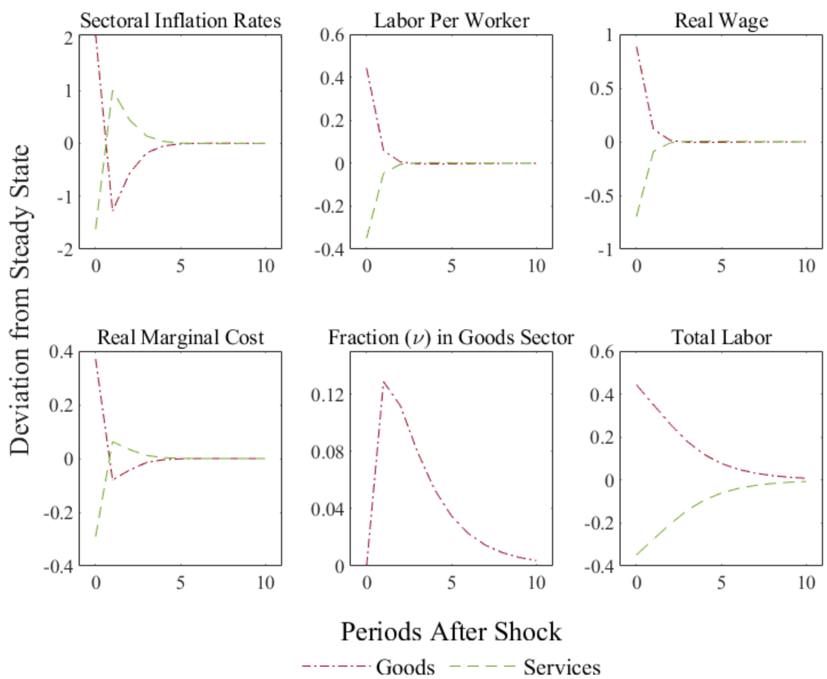
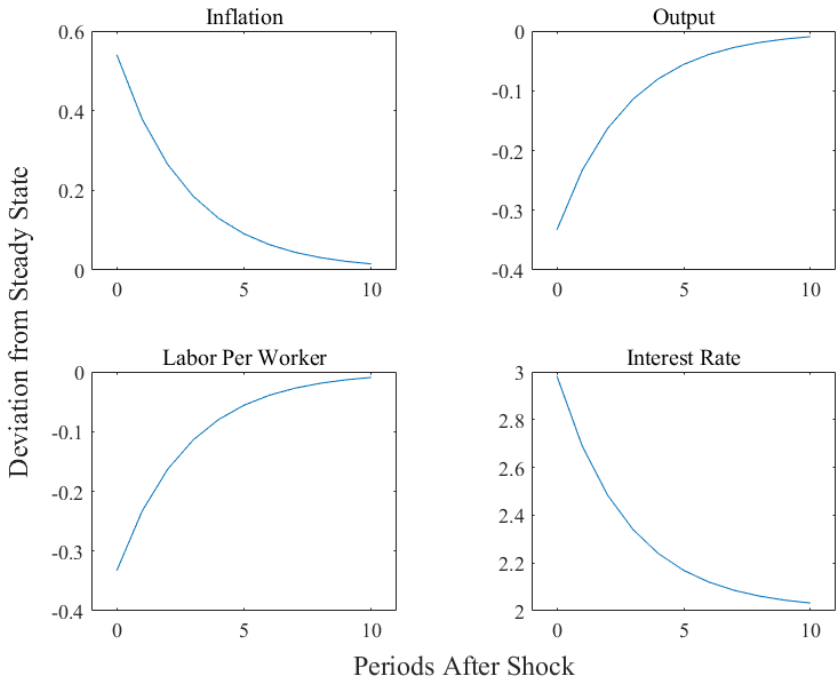


Fig. 3. Responses to Relative Demand (ε_t^{ω}) Shock



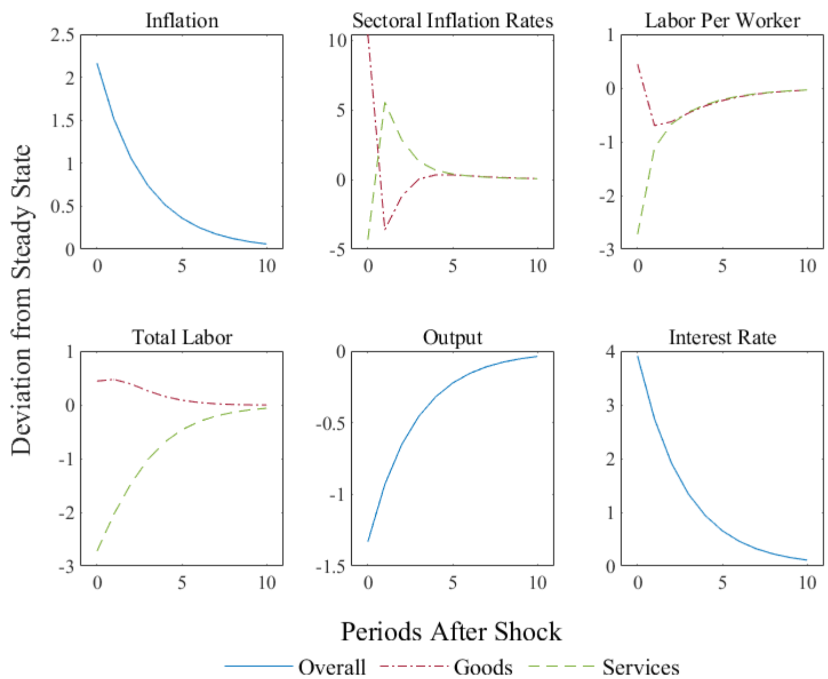
Deviations of inflation rates and ν are expressed in percentage points, all others are percentages. Inflation rates are annualized.

Fig. 4. Responses to Labor Disutility (ε_t^{χ}) Shock



Deviations of inflation and interest rates are expressed in annualized percentage points, all others are percentages.

Fig. 5. Responses to Large, Simultaneous ε_t^{ω} and ε_t^{χ} Shocks



Deviations of inflation rates and interest rate are expressed in annualized percentage points, all others are percentages.