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Stay At Home! Macroeconomic Effects of Pandemic-Induced Job Separation Shocks

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Stay At Home! Macroeconomic Effects of Pandemic-Induced Job Separation Shocks

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Abstract

To reduce the spread of COVID-19, governments have imposed mandatory stay-at-home orders leading to a sharp rise in the job separation rate (JSR) and levels of unemployment. The COVID-19 pandemic, along with mandatory stay-at-home orders, produced an unprecedented level of uncertainty in the labor market. In this paper, we examine the important role monetary policy plays to limit the economic damage caused by labor market uncertainties related to the COVID-19 pandemic. We model the labor market uncertainty as a second order shock to a time-varying JSR. Our theoretical model is guided by empirical evidence which finds that there is indeed a link between uncertainty in the JSR and macroeconomic variables. We show that the economic effects of heightened uncertainty in the JSR depend crucially on the Taylor-rule type adopted by the monetary authority. Our study finds that more severe recessions following JSR uncertainty shocks under rules with no interest rate smoothing.

Keywords: Uncertainty, pandemic, unemployment, business cycles, monetary policy.
JEL Classification: E24; E31; E32; E52; E58.

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1 Introduction

As of August 01, 2020, the United States (U.S.) Center for Disease Control and Prevention reported more than 1.8 million confirmed cases of the coronavirus disease (COVID-19) with nearly 150,000 deaths. One of the most common public health policy prescriptions to reduce the spread of COVID-19 has been to impose mandatory stay-at-home (shelter-in-place; safer-at-home) orders, which typically requires people to remain at home except for tasks and work deemed essential. The COVID-19 pandemic and stay-at-home orders have deeply affected the labor market - most retail businesses have been ordered to shut down; workers have been ordered to stay away from their place of work. For the month of April, 2020 alone, 20 million U.S. jobs were lost and the labor market participation rate had fallen sharply (Coibion et al., 2020); the number of claims for unemployment benefits has skyrocketed, exceeding in two months only (March-April/2020) the total from the entirety of the Great Recession (Gregory et al., 2020). The U.S. government, through a combination of fiscal and monetary policies, stepped in to limit the economic damage of the pandemic. On the fiscal policy side, the U.S. Congress passed a $2.2 trillion economic stimulus also known as the Coronavirus Aid, Relief, and Economic Security (CARES) Act. In terms of monetary policy, the U.S. Federal Reserve took a broad array of actions such as interest rate cuts, securities purchases, and direct lending to banks and local governments, among others.

In this paper, we ask whether monetary policy in the form interest rate rules can amplify or lessen the negative effects of pandemic-induced job separation shocks. We study the economic implications of stay-at-home orders and labor market uncertainty in order to better understand the role of alternative interest rate rules responses to uncertainty shocks. In our model, the source of uncertainty is attached to a pandemic-induced job separation rate (JSR) - a stochastic job separation shock described as time-varying standard deviations of innovations in the job separation. This is motivated by the unprecedented effects of stay-at-home orders on unemployment, by the unpredictability of when and how stay-at-home orders will be lifted, and whether future waves of the infection would trigger additional stay-at-home orders. We show that the severity of the pandemic-induced job separation shocks crucially depends on the interest rule followed by the monetary authority. Moreover, we find that the negative macroeconomic effects of JSR uncertainty shocks are more pronounced if the monetary authority cares about either inflation or output deviations (not both) *vis-à-vis* a standard and empirically plausible interest rate (Taylor) rule.

We build on the literature that studies the economic implications of uncertainty shocks (e.g., Leduc and Liu, 2016; Born and Pfeifer, 2014).[1] In our theoretical model, the labor market is characterized by search and matching frictions as in Leduc and Liu (2016) except that we allow the JSR to vary over time following an exogenous stochastic process. Departing from Leduc and Liu (2016, 2020), and others, we introduce a time-varying standard deviation of the innovation in

[1]See also Bloom (2009); Fernández-Villaverde et al. (2011); Gilchrist et al. (2014); Bloom et al. (2018); Stock and Watson (2012); Baker et al. (2016))

the JSR, which we view as pandemic-induced JSR uncertainty (second-order) shock. Real wages are sticky and adjust slowly to their Nash optimal value, and are determined by Nash bargaining between firms and workers. Retail sector firms compete under monopolistic competition and set their prices using quadratic adjustment costs. The government finances a fixed unemployment benefit through lump-sum taxes. The monetary authority follows a Taylor rule aiming to stabilize inflation using the short-run nominal interest rate as the main instrument. We consider six alternative interest rate rules to highlight the potential responsiveness of the monetary authority to inflation, output and interest rate deviations.

Pandemic-induced JSR volatility is very much related to uncertainties affecting labor market dynamics and the overall uncertainty in the economy; stock market volatility, newspaper-based economic uncertainty, and subjective uncertainty in business expectation surveys rose sharply as the pandemic worsened (Baker et al., 2020). We argue that the random nature of the infection and consequently of the stay-at-home orders render the JSR stochastic causing the unemployment to increase beyond its historical level. Hence, it is important to understand the economic effects of unexpected changes in the JSR (first-order effects) and the dispersion of these changes (second-order effects). Our framework allow us to quantitatively distinguish these effects on the economy. In fact, our theoretical framework is guided by empirical findings on job separation uncertainty in the U.S.

We use the total job separation rate from the U.S. Job Openings and Labor Turnover Survey (JOLTS; Bureau of Labor Statistics) to construct our empirical measure of job separation rate. The uncertainty in job separation is measured following Jurado et al. (2015) and Mumtaz and Theodoridis (2017). We find that the uncertainty in job separation during the period of the COVID-19 pandemic increased by 42% relative to its level of uncertainty pre-pandemic (December 2019); and it is substantially higher than in previous recessions (e.g., the Great Recession). A Vector Autoregression (VAR) model was used to empirically study the macroeconomic effects of the uncertainty in the JSR. We empirically show that a positive shock on the job separation uncertainty (i.e., caused by a pandemic) produces a significant increase in the job separation and unemployment rates. Consequently, as job separation becomes more uncertain, it causes significant downward pressures on macroeconomic aggregates such as output and consumption. We also find that the estimated relationship between the uncertainty in the JSR and macroeconomic variables is persistent. These empirical regularities served as our guide posts in calibrating and analyzing the results from our theoretical model.

According to our theoretical model, an increase job separation uncertainty acts as negative supply shock, causing employment relationships to be terminated and labor supply to decrease (extensive and intensive margins). As the JSR becomes more uncertain, the value of job matches decrease. Combined contractions in labor demand and supply exacerbate the upward (downward) pressure on unemployment (output, consumption), creating upward inflationary pressure and pushing real interest rates down. Nevertheless, the full impact of economic shocks associated to the

COVID-19 pandemic - shutdowns, layoffs, and firm exits - remain to be seen and depend on many factors and may trigger changes in aggregate demand larger than the shocks themselves (Guerrieri et al., 2020).

We show, however, that the severity of the pandemic-induced job separation shocks crucially depends on the interest rule followed by the monetary authority, constrained by the fact that rates cannot fall (much) below zero. We consider six interest rate rules. First, the interest rate rule where the monetary authority cares about the deviations of interest rate, inflation, and output to their averages (our benchmark Taylor rule). Second, the interest rate rule in Leduc and Liu (2016) where the monetary authority's response to deviations in the interest rate to its average is muted. Third, the interest rate rule where we mute the monetary authority's response to output deviations. Fourth, the interest rate rule where the monetary authority exhibits a strong response to output fluctuations. Fifth, the interest rate rule with a strong inflation targeting by the monetary authority response. And finally, the sixth rule which exhibits an interest rate rule with weak inflation targeting. Under the standard and empirically plausible Taylor rule (with interest rate rule smoothing), the pandemic-induced JSR uncertainty increases the overall uncertainty in the economy affecting aggregate supply negatively - output falls due to a reduction in employment and overall demand, which leads to higher prices (i.e., pandemic-fighting measures choke off production in addition to massive stimulus programs, resulting in too much money chasing too few goods). Following this kind of disturbance, a more severe recession and unemployment increase are observed under the interest rate rule with smoothing and a muted response to output. Inflation is the highest in the interest rate rule with smoothing, while an interest rate rule that reacts more strongly to inflation causes recession to be more severe and deflationary. As an additional exercise, we study the effects of alternative fiscal policy rules as our theoretical framework allows us to do so. We demonstrate that the generosity of fiscal policy, through increases in unemployment benefits or tax cuts, can help to alleviate the negative effects of pandemic-induced job separation shocks.

Related Literature. From an analytical perspective, we identify three recent papers are closely related to ours and we discuss them in detail here. Leduc and Liu (2020) study the importance of automation in driving business cycle dynamics following an increase in job uncertainty in a quantitative New Keynesian DSGE framework. They find that job uncertainty does stimulate automation, and increased automation helps mitigate the negative impact of uncertainty on aggregate demand. Baker et al. (2020) examined how forward-looking measures (e.g., stock market volatility, newspaper-based economic uncertainty) can be used to assess the macroeconomic impact of the COVID-19 crisis. They find that about half of the forecasted output contraction reflects a negative effect of COVID-induced uncertainty. Gregory et al. (2020) develop a search-theoretic model of the labor market in order to forecast the evolution of the aggregate US labor market during and after the coronavirus pandemic. They model the lockdowns associated with the pandemic as a temporary decline in labor productivity causing some employment relationships to be terminated, some to be suspended, and others to continue. Terminated relationships are those in which the surplus becomes negative because of the lockdown. Gregory et al. (2020) find that the lockdown instituted to prevent the spread of the novel coronavirus is shown to have long-lasting negative effects on unemployment.

Our study is different from these three papers in several respects. First, in contrast to these three studies, we analyze the effects of a range of monetary and fiscal policy responses to a pandemic-induced JSR, focusing on the second-order effects of JSR uncertainty. To the best of our knowledge, ours is the first to study the implications of monetary and fiscal policies in a DSGE framework in the presence of pandemic-induced labor market uncertainty. Second, unlike Leduc and Liu (2020) where they studied the macroeconomic effects of a first-order shock in the JSR, instead we introduce a second-order shock in the JSR to properly capture a pandemic-induced uncertainty in the JSR. Third, we constructed a specific measure of uncertainty derived from the JSR unlike Leduc and Liu (2020) and Baker et al. (2020) where they used broad-based uncertainty measures derived from the Michigan Survey of Consumers and the VIX/VXO index from the Chicago Board of Exchange.

From a conceptual point of view, our work contributes to the burgeoning literature that examines the relationship between macroeconomic activity, policy, and the unfolding COVID-19 pandemic. A non-exhaustive list of this line of work is Alvarez et al. (2020), Atkeson (2020), Coibion et al. (2020), Dave et al. (2020), Eichenbaum et al. (2020), Faria-e Castro (2020), Fernandez-Villaverde and Jones (2020), Glover et al. (2020), Gregory et al. (2020) Kapicka and Rupert (2020), and Jones et al. (2020).

The remainder of this paper is organized as follows. Section 2 presents empirical evidence on the job separation uncertainty in the U.S. Section 3 presents the main features of our model. In Section 4, we explore the quantitative implications of pandemic-induced job separation uncertainty shocks under alternative interest rate rules and fiscal policy rules. Section 5 offers further discussions and conclusions.

2 Empirical Analysis

In this section, we present our empirical findings on job separation uncertainty and its effect on U.S. macroeconomic variables. Precisely, we show how job separation uncertainty is computed and describe its behaviour over time. We also show that a positive shock on the job separation uncertainty (i.e., caused by a pandemic) produces an increase in the job separation and unemployment rates, and an adverse effect on output and consumption.

2.1 The Job Separation Rate

To measure the rate of job separations, we use the total job separation rate from the U.S. Job Openings and Labor Turnover Survey (JOLTS) which is a monthly survey of a sample of approximately 16,000 business establishments collected by the Bureau of Labor Statistics. It has been developed to address the need for data on job openings, hires, and separations. JOLTS define

Figure 1: U.S. monthly job separation rate from January 2001 to May 2020.

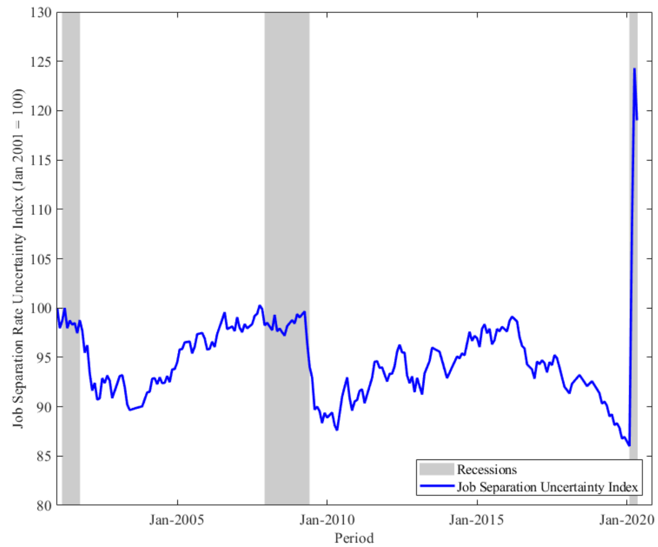

Figure 2: U.S. job separation uncertainty index, Jan/2001 - May/2020 (Jan/2001=100).

total job separation rate as the percentage of all employees separated from the payroll during the month (it includes employees who left voluntarily and those that were laid-off or discharged). Figure 1 presents the monthly total job separation rate (blue curve) as well as its trend (red curve, computed using Hodrick-Prescott (HP) filter) from January 2001 up to May 2020. Throughout this period, spanning 233 months, the average total job separation rate is 3.6%. Also shown in the shaded areas are the values of the total job separation rate during periods of recessions.

In early January 2020, the W.H.O. identified the novel virus COVID-19, informally known as coronavirus. Less than three months later, economies across the world were feeling the effects of nationwide lockdowns and economic uncertainty due to the coronavirus pandemic. One by one, U.S. cities are imposing the shutdown of public places and non-essential businesses, with numerous businesses temporarily closing off their own accord. These shutdowns have resulted in a massive, nationwide spike in layoffs. The adverse effect of these measures is shown in Figure 1 with the sharp rise in the total job separation rate in March 2020, increasing almost 3 times its value from December 2019. The U.S. officially entered in a recession in the middle of second quarter of 2020 and the total job separation rate averaged 5.35% during this period.

2.2 Job Separation Uncertainty

Generally, uncertainty in a macroeconomic variable characterises the degree as to how precise the forecast is or how volatile the variable is. A high degree of uncertainty is associated with less precise forecasts or a higher volatility which increases the level of risk. Throughout this section, uncertainty in job separation is measured using the standard deviations or the volatility of the job separation rate. In other words, uncertainty in job separation measures the size of the deviations of the realized values of the job separation rate from its mean or expected value.

To formalize our notion of uncertainty in the job separation rate (JSR) at time t, denoted as U_t^{jsr}, we follow Jurado et al. (2015) and Mumtaz and Theodoridis (2017) by defining:

$$U_t^{jsr} = \sqrt{\frac{1}{m-1} \sum_{i=t-m+1}^{t} \left(JSR_t - \mathbb{E}\left[JSR\right]\right)^2}, \tag{1}$$

where $\mathbb{E}$ is the expectations operator, JSR is the job separation rate at period t, and m is the size of the rolling window. While our results are robust to reasonable lengths of the rolling window, we select a window size of 12 months as this length captures enough information in the data. For ease of presentation, Figure 2 shows the standard deviation as an index with its value at January 2001 as the base set at 100. We can see from the figure that uncertainty heightened during the following recession periods (shaded gray area): March 2001 to November 2001, December 2007 to June 2009, and beginning February 2020. Remarkably, uncertainty during the period of the COVID-19 pandemic increased by 42% relative to the level of uncertainty pre-pandemic (December 2019). It is clear from the data that the events surrounding the pandemic produced the greatest amount of uncertainty in the job separation rate thus far.

2.3 Job Separation Shocks and the U.S. Macroeconomy

After deriving an estimate of the uncertainty in the job separation rate, we now turn our attention to studying its effects on macroeconomic variables. We analyze the impact of a pandemic-induced uncertainty shock by estimating a VAR model for job separation uncertainty on macroeconomic variables. The reduced-form finite-order VAR equation is given by:

$$X_t = \sum_{j=1}^{p} A_j X_{t-j} + \eta_t, \tag{2}$$

where X_t is a vector of macroeconomic variables in the VAR system, A_j are the matrices of the coefficients, and η_t is a vector of residuals. All macroeconomic data used in equation (2) were converted into logs and first differenced. We assume that the vector of residuals is normally distributed with zero mean with a variance-covariance, Ψ. We settled at two lags ($p = 2$) because it gave us the lowest value of several information criteria (i.e., AIC, SBIC). The reduced form VAR system is estimated using OLS and identification is achieved by a Cholesky decomposition of the variance-covariance matrix of the VAR residuals (lower triangular). The vector X_t contains four macroeconomic variables: JSR uncertainty, JSR, unemployment rate, output, and consumption. We use quarterly macroeconomic data from the Federal Reserve of St. Louis or FRED for GDP, aggregate consumption, and the unemployment rate from the first quarter of 2001 up to the second quarter of 2020 (estimate). Since the job separation rate from the JOLTS is collected monthly, we had to transform the job separation uncertainty into quarterly data to conform with the other macroeconomic variables. The transformation was done by averaging the computed levels of uncertainty described in Section 2.2 for the months associated with each quarter. Similar to

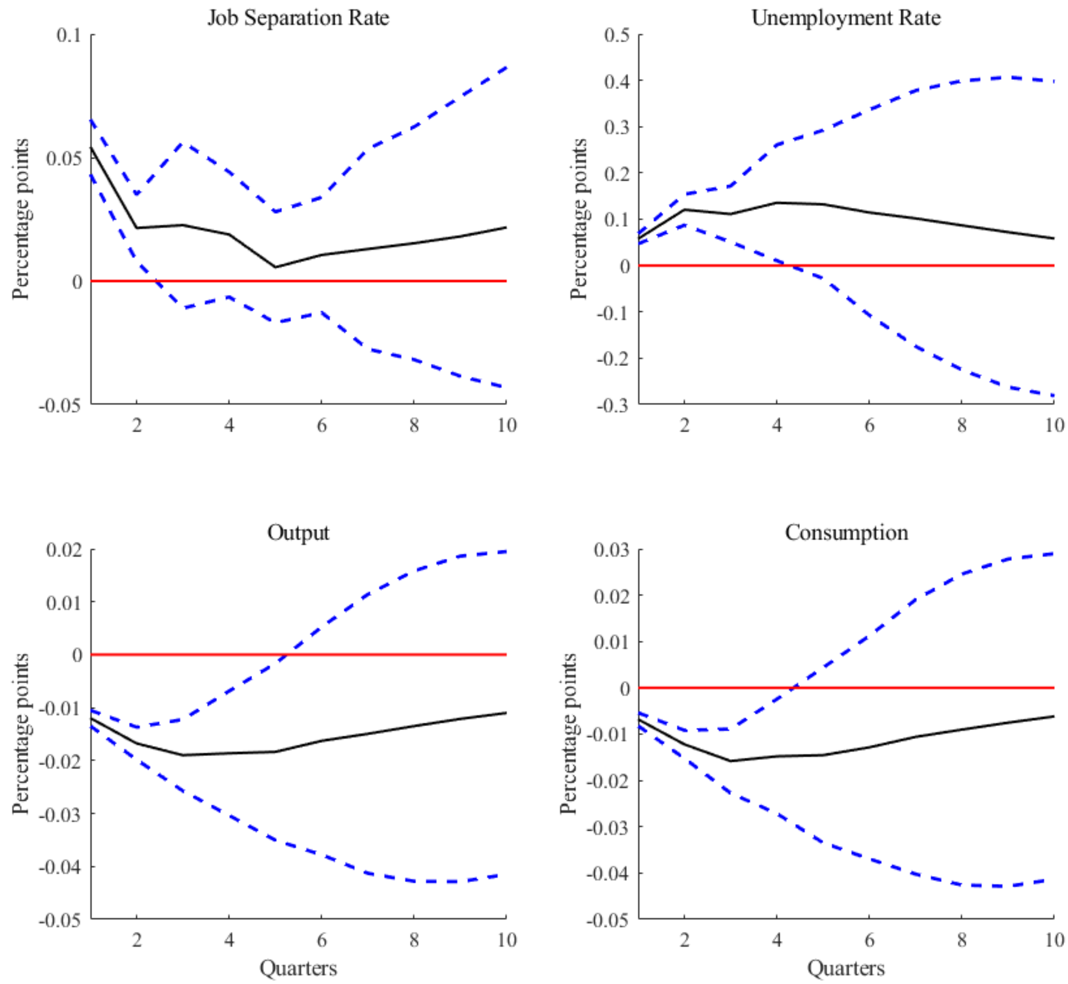

Figure 3: Impulse-response function of macroeconomic variables to a one-standard deviation shock in the uncertainty in the job separation rate.

Leduc and Liu (2016), Basu and Brent (2017), and Caggiano et al. (2020), we place the uncertainty measure as the first variable in the VAR model, followed by the JSR, unemployment rate, output, and consumption. The Cholesky ordering implies that job separation uncertainty does not respond to macroeconomic shocks in the initial period but the JSR, unemployment rate, output, and consumption are allowed to respond to an uncertainty shock.

Figure 3 shows the impulse-response functions of macroeconomic variables to a one-standard deviation shock in the uncertainty in the job separation rate. The impulse responses (solid lines in the figure) are based on the Cholesky orthogonalization of the VAR model with two lags. Our results suggest that an increase in the job separation uncertainty increases the job separation and unemployment rates, and decreases output and consumption. Precisely, one quarter after the job separation uncertainty shock hits, the job separation rate increases by 0.07 percentage points (pp), the unemployment rate increases by 0.6pp, GDP decreases by 0.01pp, and consumption decreases by 0.008pp. These observed effects are rather persistent lasting more than ten quarters and are statistically significant at the 95% confidence level (dashed lines in the figure) for the first four quarters.

3 A Model with Pandemic-Induced JSR Uncertainty

In this section, we present a model with search frictions and nominal rigidities, but without habit formation in order to study the macroeconomic effects of a temporary, pandemic-induced suspension of employment relationships. Our theoretical framework follows Leduc and Liu (2016), except that we allow for uncertainty in the JSR and interest rate smoothing. Here, we highlight the main features of the model and refer the reader to Leduc and Liu (2016) for additional details of the model.

The representative household chooses consumption C_t and saving B_t to maximize the utility function given by

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\ln\left(C_t - hC_{t-1}\right) - \chi N_t\right], \tag{3}$$

subject to the sequence of budget constraints

$$C_t + \frac{B_t}{P_t R_t} = \frac{B_{t-1}}{P_t} + w_t N_t + \phi(1 - N_t) + d_t + T_t \qquad \forall t \geq 0, \tag{4}$$

where $\mathbb{E}$ denotes the expectation operator, $\beta \in (0, 1)$ is the discount factor, N_t denotes the fraction of household members who are employed, h measures habit persistence, χ captures the disutility from working, P_t is the price level, B_t the holdings of a nominal risk-free bond, R_t the nominal interest rate, w_t the real wage rate, ϕ denotes an unemployment benefit, d_t the profit income from ownership of intermediate goods producers and of retailers, and T_t a lump-sum tax paid to the government.

There is a continuum of retailers, each producing a differentiated product using a homogeneous intermediate good as input. The production function of a retail good of type $j \in [0, 1]$ is given by $Y_t(j) = X_t(j)$ where $X_t(j)$ is the input of intermediate goods used by retailer j and $Y_t(j)$ is the output. A retail firm that produces good j chooses $P_t(j)$ to maximize the profit

$$\mathbb{E}_t \sum_{i=0}^{\infty} \frac{\beta^i \Lambda_{t+1}}{\Lambda_t} \left[\left(\frac{P_{t+i}(j)}{P_t(j)} - q_{t+i}\right) Y_{t+i}^d(j) - \frac{\Omega_p}{2}\left(\frac{P_{t+i}(j)}{\pi P_{t+i-1}(j)} - 1\right)^2 Y_{t+i}\right], \tag{5}$$

where q_t denotes the relative price of intermediate goods, the parameter $\Omega_p \geq 0$ measures the cost of price adjustment and π denotes the steady state inflation rate. Price adjustment costs are in units of aggregate output.

The labor market is characterized by search and matching frictions. In each period, there are N_{t-1} workers and a fraction ρ_t is separated from their jobs. Unemployed workers (u_t) search for jobs and firms post vacancies (v_t) at a fixed cost. Successful matches (m_t) are produced with a

Cobb–Douglas matching technology, as follows: $m_t = \mu u_t^{\alpha} v_t^{1-\alpha}$, where the parameter α denotes the elasticity of job matches with respect to the number of searching workers and μ scales the matching efficiency. Aggregate employment evolves according to

$$N_t = (1-\rho_t) N_{t-1} + m_t. \tag{6}$$

The number of unemployed workers searching for jobs in period t is given by $u_t = (1 - N_{t-1}) + \rho_t N_{t-1}$, and the unemployment rate is $U_t = u_t - m_t = 1 - N_t$.

Unlike Leduc and Liu (2016), we assume the JSR ρ_t varies over time, following an exogenous stochastic process:

$$\log \rho_t = \psi_\rho \log \rho_{t-1} + \sigma_{\rho t} \varepsilon_{\rho t}. \tag{7}$$

The parameter $\psi_\rho \in (0,1)$ measures the persistence of the JSR (first-order) shock. The term ϵ_t^U is an i.i.d. innovation to the JSR shock and follows a standard normal process. As a departure to Leduc and Liu (2016, 2020), we introduce a time-varying standard deviation of the innovation ($\sigma_{\rho t}$), which we interpret as pandemic-induced JSR uncertainty (second-order) shock. We assume the pandemic-induced JSR uncertainty shock follows a similar stochastic process:

$$\log \sigma_{\rho t} = \left(1 - \psi_{\sigma_\rho}\right) \log \sigma_\rho + \psi_{\sigma_\rho} \log \sigma_{\rho t-1} + \sigma_{\sigma_\rho} \varepsilon_{\sigma_\rho t}, \tag{8}$$

where the parameter $\psi_{\sigma_\rho} \in (0,1)$ measures the persistence of the pandemic-induced JSR uncertainty shock, the term $\varepsilon_{\sigma_\rho t}$ is an i.i.d. standard normal process, and $\sigma_{\sigma_\rho} > 0$ is the standard deviation of the innovation to the pandemic-induced JSR uncertainty.

The government finances a fixed unemployment benefit (ϕ) through lump-sum taxes (T) such that $\phi(1 - N_t) = T_t$. The monetary authority follows a Taylor rule aiming to stabilize inflation using the short-run nominal interest rate as the main instrument as follows:

$$\frac{R_t}{\overline{R}} = \left(\frac{R_{t-1}}{\overline{R}}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi^*}\right)^{\gamma_\pi} \left(\frac{Y_t}{\overline{Y}}\right)^{\gamma_y}\right]^{(1-\rho_R)}, \tag{9}$$

where R_t represents the short-run nominal interest rate, π_t (π^*) the inflation rate (target), Y_t real output, $\overline{R}$ and $\overline{Y}$ are the steady state interest rate and output, respectively. The parameters ρ_R, γ_y, γ_π determine the extent to which monetary policy accommodates interest rate, output, and inflation fluctuations, respectively.

Real wages are determined by Nash bargaining between firms and workers and the Nash bargaining wage is given by

$$w_t^N = (1-b)\left[\frac{\chi}{\Lambda_t} + \phi\right] + b\left[q_t Z_t + \beta(1-\rho_t)\mathbb{E}_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} \frac{\kappa v_{t+1}}{u_{t+1}}\right], \tag{10}$$

where $b \in (0,1)$ represents the bargaining weight for workers, κ is the fixed cost of posting a vacancy and Z_t is the aggregate technology. Real wages are sticky and adjust slowly to their Nash optimal value.

Intermediate goods market clearing implies that $Y_t = Z_t N_t$. And, goods market cleaning implies the following aggregate resource constraint:

$$C_t + \kappa v_t + \frac{\Omega_p}{2}\left(\frac{\pi_t}{\pi} - 1\right)^2 Y_t \;\; = \;\; Y_t. \tag{11}$$

4 Economic Implications of Stay-at-Home Orders

4.1 Model Parameterization and Calibration

In this section, we present our model parameterization and discuss how the calibration choices were made. The parameters in the first-moment JSR shock are calibrated using data from the Bureau of Labor Statistics (BLS) for the US, 2000:Q1-2020:Q2 period. Using the techniques described in Sections 2.1 and 2.2, we decompose the JSR into its trend and cyclical components. From this decomposition, we find the parameters in the first moment JSR shock, equation (7), to be $\psi_\rho = 0.879$ and $\sigma_\rho = 0.037$ (Table I). We calibrate the parameters in the second moment shock from the standard deviations of the cyclical component of the JSR. The estimated values of the second moment shock parameters in equation (8) are: $\psi_{\sigma_\rho} = 0.661$, $\sigma_{\sigma_\rho} = 0.793$.

Table I: Estimation of job separation rate (JSR) process and volatility

Parameter	Description	Value
ψ_ρ	Persistence of JSR	0.879
σ_ρ	Standard deviation of JSR	0.037
ψ_{σ_ρ}	Persistence of JSR uncertainty	0.661
σ_{σ_ρ}	Standard deviation of JSR uncertainty	0.793

Table II presents the benchmark parameters, taken from Leduc and Liu (2016) and we set the benchmark Taylor Rule parameters to $\rho_R = 0.8$, $\gamma_\pi = 1.5$, $\gamma_y = 0.2$ (Arbex et al., 2019; Fasani and Rossi, 2018). We solved the model using third-order approximations to the equilibrium conditions around the steady state and followed Fernández-Villaverde et al. (2011) to compute impulse responses.

4.2 Pandemic-induced JSR Uncertainty Shocks

Given the unprecedented nature of the COVID-19 pandemic, the second moment parameter σ_{σ_ρ} was re-set to 215 to produce a 40-standard deviation increase in the JSR in order to match the 15pp increase in the unemployment rate reported by the BLS for the month of April 2020. While we acknowledge that the increase in unemployment during this period can be attributed to a multitude of factors occurring at the same time (not merely limited to stay-at-home policies), there is growing evidence that stay-at-home orders have substantially contributed to a massive

Table II: Benchmark parameter calibration

	Parameter	Description	Value
Preferences			
	β	Household's discount factor	0.990
	χ	Scale of disutility of working	0.547
	h	Habit persistence	0.000
Matching Technology			
	α	Share parameter in matching function	0.500
	μ	Matching efficiency	0.645
Firms and Nash Bargaining			
	η	Elasticity of substitution parameter	10
	κ	Flow cost of vacancy	0.140
	b	Nash bargaining weight	0.500
	γ	Real wage rigidity	0.800
	Ω_p	Price adjustment cost	112
Government Policy			
	ϕ	Flow benefit of unemployment	0.250
Interest Rate Rule			
	π	Steady-state inflation (Inflation Target)	1.005
	ρ_R	Interest smoothing	0.800
	γ_π	Taylor rule inflation	1.500
	γ_y	Taylor rule output	0.200

Note: Parameters taken from Leduc and Liu (2016).

and sudden spike in unemployment during the first quarter of 2020.[2]

For our benchmark model (search frictions, nominal rigidities, interest rate smoothing and no habit formation) the solid lines in Figure 4 are the impulse response functions (IRFs) of select macroeconomic variables to a 40-standard deviation increase in the JSR uncertainty. The effects of a temporary, one quarter increase in the JSR uncertainty is akin to a negative supply shock. On impact, a rise in the JSR uncertainty leads to decreases in labor supply, the job finding rate, and the marginal value of a worker being employed. Likewise, an increase in the JSR leads to a decline in value for firms with matched workers and in the value of matches. The combined effects of a contraction in labor demand and supply causes a large increase in unemployment, and ultimately a fall in output and consumption, creating inflationary pressure, and a decrease in the real interest rate. We also present alternative scenarios to compare the effects of stay-at-home orders due to the COVID-19 pandemic with other events that generated large increases in unemployment. The blue and red IRFs in Figure 4 display other scenarios where the JSR uncertainty shock produces an unemployment rate of 10% and 25% observed during the Great Recession ($\sigma_{\sigma_\rho} = 135$) and the

[2]Beland et al. (2020), for instance, find that unemployment rates had significantly increased in U.S. states that implemented stay-at-home orders. Baek et al. (2020) estimates that an additional week of exposure to stay-at-home policy increases UI claims by approximately 1.9% of a state's employment level (of the 16 million UI claims made between March 14 - April 4, 2020, 4 million are attributable to the Stay-at-Home directives).

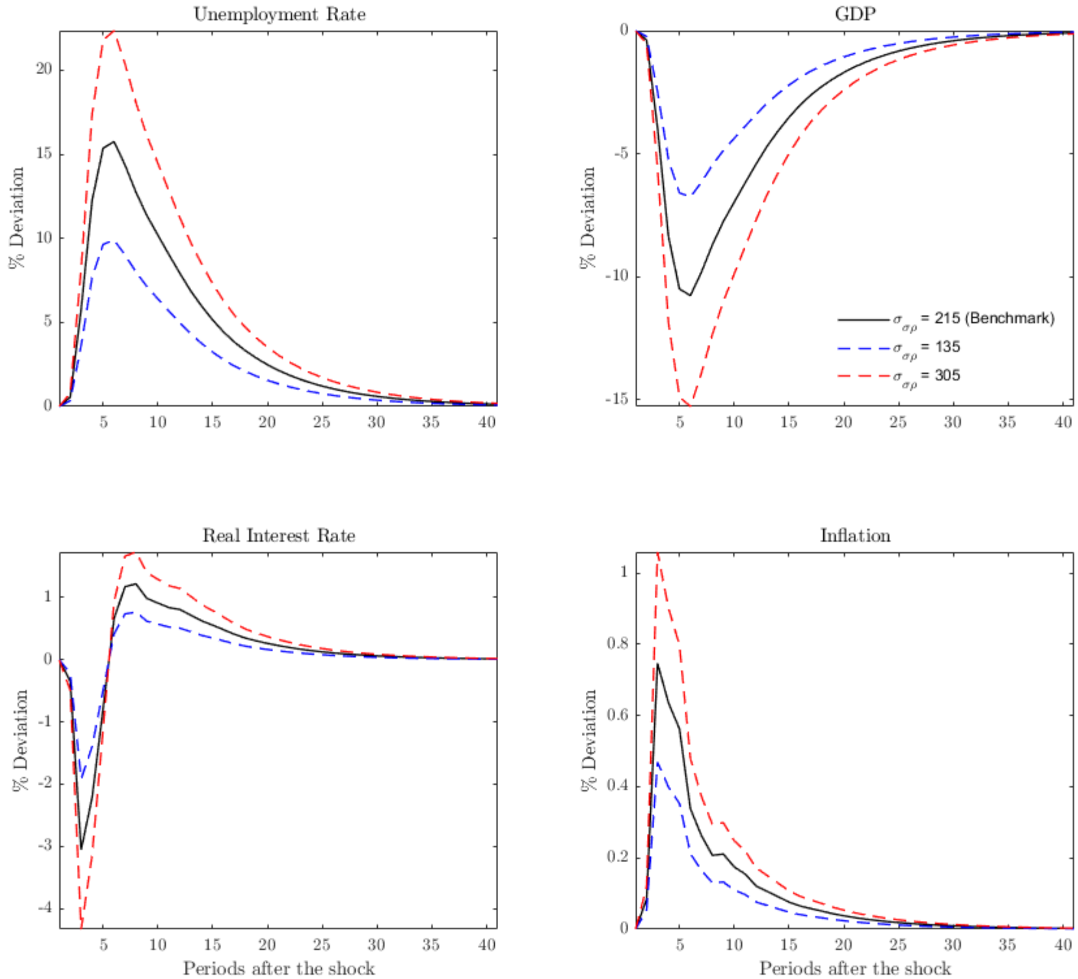

Figure 4: Benchmark IR Rule with Smoothing (IRRS): $\gamma_\pi = 1.5$; $\gamma_y = 0.2$; $\rho_R = 0.8$: Response of unemployment, output, real interest rate and inflation to increases in the volatility of the time-varying job separation rate.

Great Depression ($\sigma_{\sigma_\rho} = 305$), respectively.

4.3 The Role of Monetary Policy

The analysis in Sections 2.3 (Figure 3) and 4.2 (Figure 4) suggests that JSR uncertainty shocks appear to cause considerable increase in unemployment and reduction in output. These results are under the assumption that the monetary authority follows an interest rate rule with smoothing (IRRS), our benchmark. In this section, we evaluate alternative monetary policy responses when the economy is facing a pandemic-induced job separation uncertainty shock. More specifically, we ask how the monetary authority responsiveness (or lack thereof) to deviation of inflation, output and interest rate to their target values can either amplify or lessen the negative effects of pandemic-induced job separation shocks. We consider six alternative interest rate (IR) rules as presented in the Table III.

Figure 5 display the IRFs of the benchmark model under these alternative rules. The JSR

Table III: Alternative Interest Rate Rules

Interest Rate Rule (IRR) with		Parameter Values: Interest Rate	Inflation	Output
Smoothing (*Benchmark*)	IRRS	$\rho_R = 0.8$	$\gamma_\pi = 1.5$	$\gamma_y = 0.2$
Leduc and Liu (2016)	LLIRR	$\rho_R = 0.0$	$\gamma_\pi = 1.5$	$\gamma_y = 0.2$
Muted Response to Output	IRRSMY	$\rho_R = 0.8$	$\gamma_\pi = 1.5$	$\gamma_y = 0.0$
Strong Response to Output	IRRSRY	$\rho_R = 0.8$	$\gamma_\pi = 1.5$	$\gamma_y = 5.0$
Strong Inflation Targeting	IRRSIT	$\rho_R = 0.0$	$\gamma_\pi = 5.0$	$\gamma_y = 0.0$
Weak Inflation Targeting	IRRWIT	$\rho_R = 0.0$	$\gamma_\pi = 1.2$	$\gamma_y = 0.0$

uncertainty shocks cause a sizeable recession in an economy where the monetary authority is responsive not only to inflation variability but also to output and interest rate deviations, as indicated by the parameter values $\rho_R = 0.8$, $\gamma_\pi = 1.5$, $\gamma_y = 0.2$ (IRRS). In a model with search frictions, nominal rigidities and no habit formation like our benchmark model, $\gamma_y > 0$ directly implies an accommodative policy attitude given an uncertainty disturbance that cause current employment and output contractions. Moreover, as the policymaker faces a tradeoff between inflation and unemployment, the way the monetary policy reacts to a JSR uncertainty shock might also affect the formation of expectations about the overall state of the economy. First, notice that the direct impact of a negative pandemic-induced JSR uncertainty shock is to decrease labor supply and increase unemployment via, in our model, stay-home orders that cause employment relationships to be terminated and labor supply to decrease (extensive and intensive margins). Keeping aggregate demand constant, this pushes the intermediate price of inputs up, as well as the price of the final good or, equivalently, inflation rises. Concomitantly, the shock reduces incomes and, hence, the demand for final goods. This puts additional downward pressure on the aggregate output but, at the same time, on prices too, which reduces the inflationary pressure. Leduc and Liu (2016) argue that uncertainty gives rise to a real option-value effect (option-value channel) that is contractionary (recessionary effects of uncertainty). Facing higher uncertainty, the option value of waiting increases and the expected value of a job match decreases, inducing firms to post fewer vacancies, making it harder for unemployed workers to find jobs, and ultimately raising the equilibrium unemployment rate. When pandemic-induced job-separation uncertainty shocks are at play, job matches do not necessarily represent an irreversible long-term employment relation and the relevance of the option-value decreases.

In the face of a 40-standard deviation increase in the JSR, the monetary authority can dramatically increase the severity of the economic contraction if it follows different Taylor rules. By not responding to output deviations ($\gamma_y = 0$), the monetary authority can dampen the effect of pandemic-induced uncertainty shocks on prices, at the expense of higher unemployment and output volatilities. For example, the recession triggered by the JSR volatility shock is much more severe if the monetary authority is not responsive to output deviations, i.e., $\gamma_y = 0$, as it is the case in three interest rate rules: IRRSMY, IRRSIT, IRRWIT (Table III). Notice that, in this case of unresponsiveness to output deviations, the price increase will also depend on the monetary authority's willingness to respond to inflation deviations from its target. To illustrate, suppose that the policymaker follows an interest rate rule with strong inflation targeting (IRRSIT), it is possible that the economy experiences the opposite effects such as deflation and output growth.

Regardless of the policymaker's stance on interest rates deviations ($\rho_R > 0$ or $\rho_R = 0$), it is worth mentioning that the effects observed under interest rate rules that do not respond to output variations ($\gamma_y = 0$) are qualitatively similar. Quantitatively, however, the recession triggered by the JSR volatility shock is much less severe if the monetary authority follows an interest rate rule that responds to both the interest rate and inflation deviations, but not to output variations, i.e., $\rho_R > 0$ rather than $\rho_R = 0$, as it is the case of IRRSMY (Table III). This can be attributed to some degree inertia of the policy rule regarding the deviations of the interest rate in the economy. The lag interest rate in the interest rate rule in equation (9) mechanically allows the gradual adjustment of the policy instrument R_t, after a pandemic-induced JSR shock and works to reduce business cycle volatility.

Next, we consider the effects of a pandemic-induced JSR uncertainty shock when the monetary authority follows an IR Rule with Smoothing (IRRS) in three alternative economies: our benchmark economy (search frictions, nominal rigidities and no habit formation), an economy with habit formation ($h = 0.6$) and a flexible prices economy ($\Omega_p = 0$). Figure 6 shows the responses of unemployment, output, real interest rate and inflation to increases in the volatility of the time-varying job separation rate under these three alternative economies. It is remarkable that allowing for habit formation does not substantially change the way the economy reacts to a pandemic-induced JSR uncertainty shock. On the other hand, in marked contrast to our nominal rigidities benchmark economy, the recession is more severe (characterized by a pronounced decline in economic activity, including a rise in the unemployment rate, as well as a sharp increase in prices) in an economy with flexible prices.

Pandemic-induced JSR uncertainty shocks affect the economy's supply side dynamics in such a way that an uncertainty shock causes current output to fall even under the assumptions of flexible prices. In particular, when future volatility in the economy is expected to rise, the conditional covariance between future firm dividends and aggregate consumption becomes more positive. In the search-and-matching framework, this amounts to households demanding a greater risk premium to hold firms' equity. The implied increase in the cost of equity funding leads to a fall in job-creation, beyond the reduction due to pandemic-induced JSR shock, causing an unambiguously positive effect on unemployment. At the same time, a more uncertain future also increases the precautionary behavior of households, which reduces interest rates and contracts demand.

Comparing the impulse responses of unemployment in Figure 6 shows that the magnitude of unemployment responses to a JSR uncertainty shock in the flexible-price case is an order of magnitude greater than in the benchmark model with sticky prices. Consumption and the real interest rate both decline following an increase in uncertainty, indicating the presence of precautionary

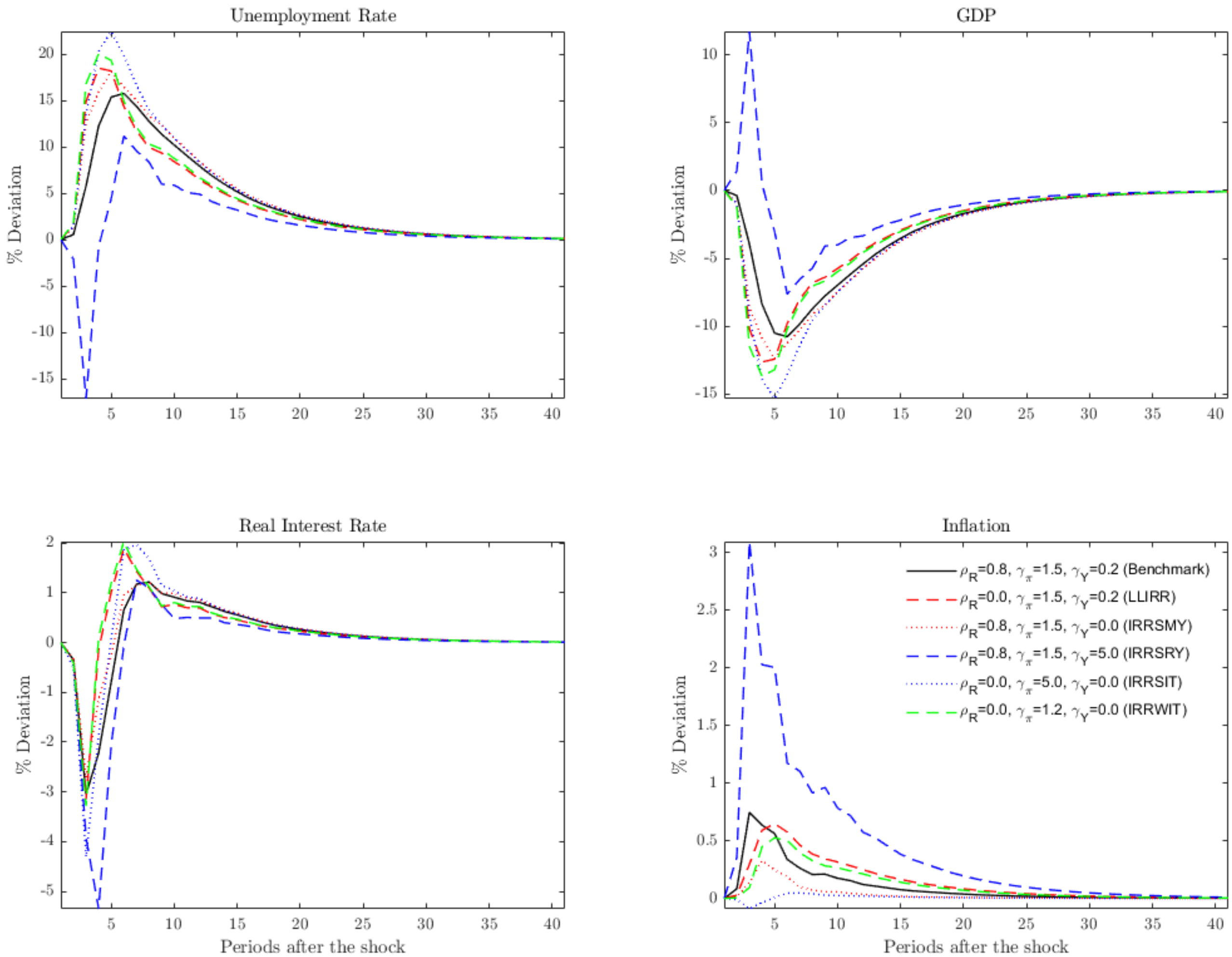

Figure 5: Alternative IR Rules: Response of unemployment, output, real interest rate and inflation to increases in the volatility of the time-varying job separation rate.

saving. However, with search frictions, the option-value channel prevails over the precautionary saving effects, leading to an overall recession with a lower match value and a higher unemployment rate (Leduc and Liu, 2016). Moreover, in the presence of nominal rigidities, monetary policy can stimulate employment and production by cutting the interest rate. A lower interest rate increases demand for the final good, which leads retail firms to set higher prices and to increase demand for intermediate goods, putting upward pressure on the relative price of intermediate goods. To the extent that the increase in marginal revenues is amplified by a decrease in wages (which is directly affected by the JSR uncertainty shock as shown in equation 10), the intermediate goods firms will post additional vacancies until the probability of filling a vacancy has decreased sufficiently to ensure free entry. In the case of flexible prices the above chain is broken (Freund and Rendahl, 2020). In particular, nominal rigidities therefore prevent these price movements to operate freely and the required reduction in the interest rate is substantially larger in a flexible prices economy than otherwise.

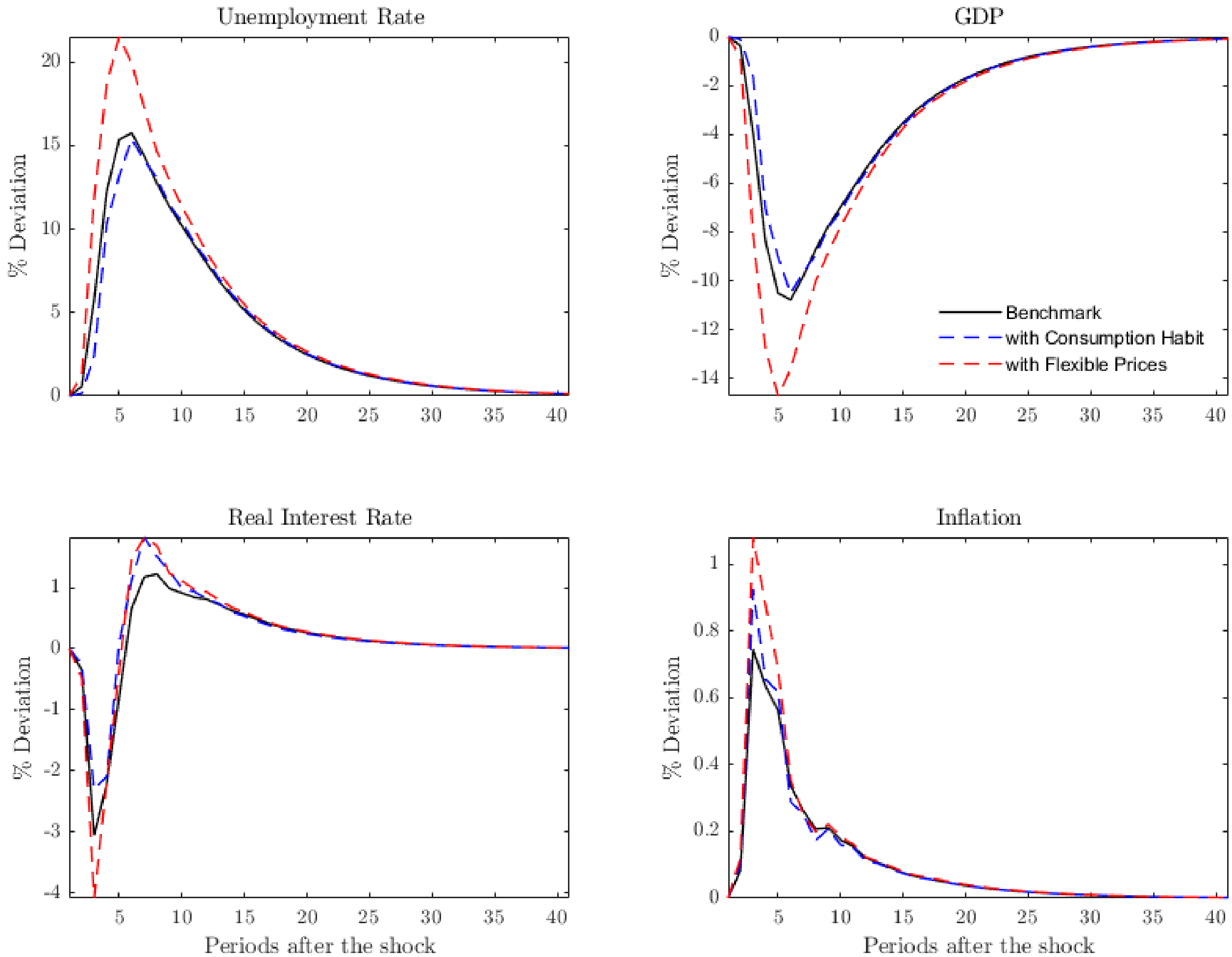

Figure 6: Alternative Economies: Response of unemployment, output, real interest rate and inflation to increases in the volatility of the time-varying job separation rate.

4.4 An Additional Exercise: JSR Uncertainty Shock and Fiscal Policy

Our theoretical framework likewise permit the analysis of fiscal policy with uncertainty in the JSR. Similar to Gertler et al. (2008), we assume a time-varying unemployment benefit ϕ_t. It is represented by $\phi_t = \bar{\phi} e^{\tau \sigma_{\sigma_\rho} \varepsilon_{\sigma_\rho t}}$, where the parameter τ links the pandemic-induced JSR uncertainty shock with the unemployment benefit; $\bar{\phi}$ is the steady state unemployment benefit. The resulting government budget constraint is reformulated as follows:

$$\left(\bar{\phi} e^{\tau \sigma_{\sigma_\rho} \varepsilon_{\sigma_\rho t}}\right)(1 - N_t) = T_t.$$

In the benchmark case, we set the unemployment benefit parameter $\bar{\phi} = 0.25$ (Table II) and is unaffected by fluctuations in the JSR ($\tau = 0$). Figure 7 displays the benchmark model under different fiscal policies in the form of reductions to the lump sum tax. As the lump sum tax becomes smaller, i.e., as the value of τ becomes more negative, the negative effects of the pandemic-induced JSR uncertainty shock becomes more dampened. Moreover, with larger tax cuts, we can observe a quicker transition to the steady state relative to the benchmark case.

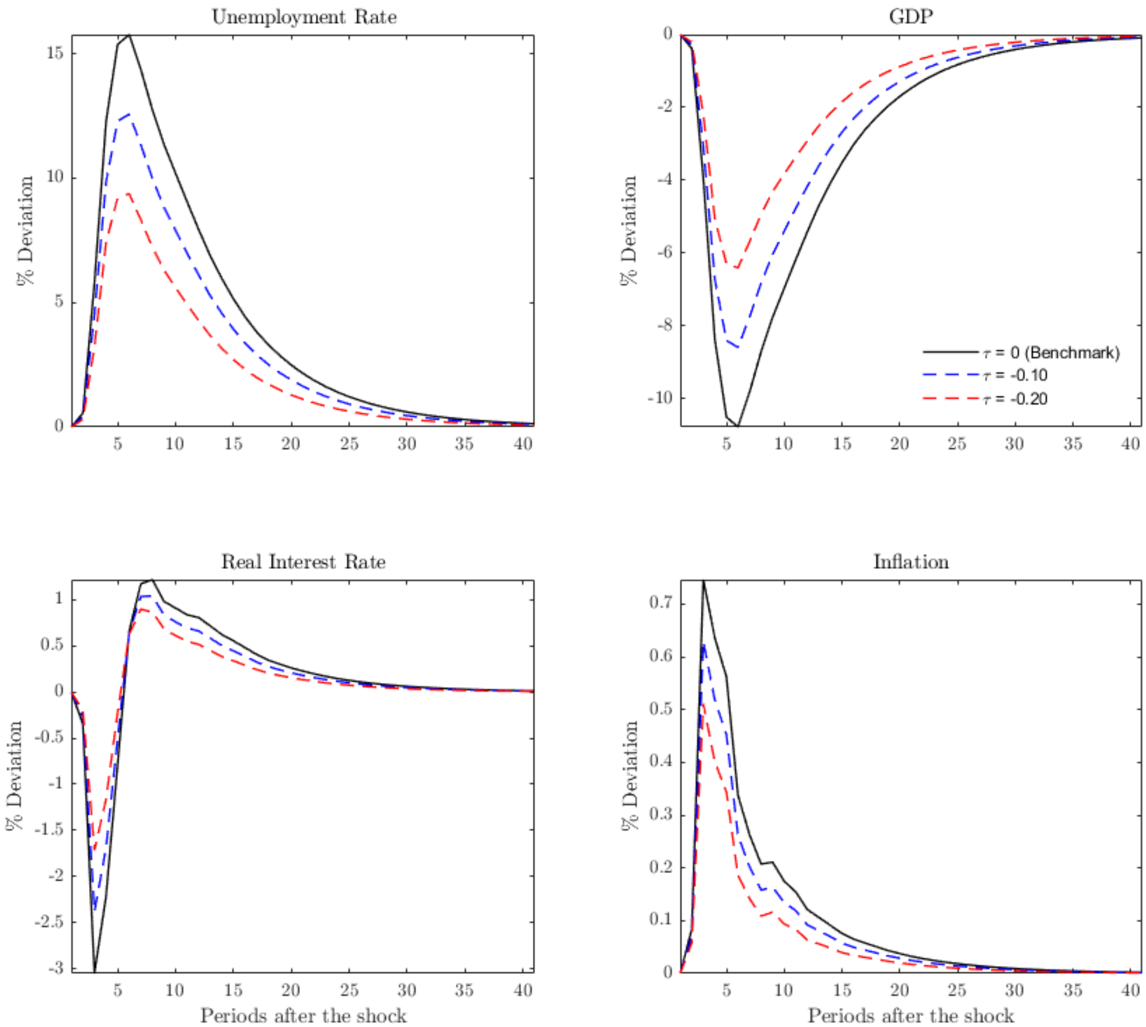

Figure 7: Alternative fiscal policy rules: Response of unemployment, output, real interest rate and inflation to increases in the volatility of the time-varying job separation rate.

5 Conclusion

To reduce the spread of COVID-19, the most common public health policy prescription has been to impose mandatory stay-at-home orders. In this paper, we study the economic implications of stay-at-home orders and labor market uncertainty to evaluate the role of alternative monetary policy responses to uncertainty shocks. The source of uncertainty is attached to a pandemic-induced JSR - a stochastic job separation shock described as time-varying standard deviations of innovations in the job separation. We find that the uncertainty in job separation during the period of the COVID-19 pandemic increased by 42% relative to its level of uncertainty prior to the pandemic. Empirically, a positive shock on the job separation uncertainty produces a significant increase in the job separation and unemployment rates.

Our theoretical model shows that the severity of the pandemic-induced job separation shocks crucially depends on the interest rule followed by the monetary authority, being more negatively pronounced if the monetary authority cares about either inflation or output deviations (not both). Pandemic-induced JSR uncertainty shocks can give rise to a recession-inflation (stagflation) situation - high inflation, slow economic growth, and unemployment steadily high. We note that our exercise covers the post-2008 period, a period during which U.S. monetary policy has been constrained by the zero lower bound (ZLB) on the short-term nominal interest rate. The monetary policy limitations to accommodate the negative effects of pandemic-induced uncertainty shocks, bounded by the ZLB, suggest that in order to further understand the role of monetary policy responses to uncertainty shocks we need also to consider unconventional monetary tools, along with standard interest rate rules. We leave this for future research.

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