

# UNCERTAINTY SHOCKS ARE AGGREGATE DEMAND SHOCKS

SYLVAIN LEDUC AND ZHENG LIU

**ABSTRACT.** We study the macroeconomic effects of diverse uncertainty shocks in a DSGE model with labor search frictions and sticky prices. In contrast to a real business cycle model, the model with search frictions implies that uncertainty shocks reduce potential output, because a job match represents a long-term employment relation and heightened uncertainty reduces the value of a match. In the sticky-price equilibrium, uncertainty shocks—regardless of their sources—consistently raise unemployment and lower inflation. We present empirical evidence—based on a vector-autoregression model and using a few alternative measures of uncertainty—that supports the theory’s prediction that uncertainty shocks act like aggregate demand shocks.

## I. INTRODUCTION

Since the Great Recession and following the influential work by Bloom (2009), there has been a rapidly growing literature that studies the macroeconomic effects of uncertainty shocks. Most of the studies focus on the effects of uncertainty on real activity such as investment and output. Less is known about the joint effects of uncertainty on inflation and unemployment, and thus about the trade-off that policymakers may face in an environment of heightened uncertainty.

In this paper, we provide a theoretical framework and some empirical evidence to show that uncertainty shocks consistently act like aggregate demand shocks, which raise unemployment and lower inflation. This finding suggests that uncertainty presents no trade-off between stabilizing output and inflation. Indeed, policymakers react to an increase in uncertainty by lowering the nominal interest rate, both in our model and in the data.

To study the macroeconomic effects of uncertainty, we consider a dynamic stochastic general equilibrium (DSGE) framework that incorporates labor search frictions and nominal rigidities. The type of search frictions that we consider takes its root from the original

---

*Date:* July 31, 2012.

*Key words and phrases.* Uncertainty, Demand shocks, Unemployment, Inflation, Monetary policy, Survey data.

*JEL classification:* E21, E27, E32.

Leduc: Federal Reserve Bank of San Francisco; Email: Sylvain.Leduc@sf.frb.org. Liu: Federal Reserve Bank of San Francisco; Email: Zheng.Liu@sf.frb.org. The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

contributions by Diamond (1982) and Mortensen and Pissarides (1994). In this model, we show that, in contrast to a standard real business cycle (RBC) model, uncertainty shocks are contractionary in the flexible-price equilibrium. In the RBC framework, a rise in uncertainty is expansionary because it triggers a decline in consumption and thus an increase in the household’s willingness to work (Basu and Bundick, 2011). In contrast, in a model with search frictions, positive uncertainty shocks lower potential output. Because of the long-term nature of employment relations in the presence of search frictions, firms are reluctant to hire new workers when the level of uncertainty rises. Therefore, heightened uncertainty lowers the expected value of a filled vacancy. Firms respond by posting fewer vacancies, leading to a decline in the job finding rate and an increase in the unemployment rate.

In the sticky-price equilibrium, however, uncertainty shocks—regardless of their sources—unambiguously act like a negative aggregate demand shock. Specifically, heightened uncertainty raises unemployment and lowers inflation. As the output gap rises and inflation falls, monetary policy makers react by lowering the nominal interest rate. Our results thus suggest that even when uncertainty shocks can have “supply-side” effects that lower potential output, which *ceteris paribus* could be inflationary, the demand effects of uncertainty shocks dominate. In equilibrium, unemployment rises and inflation falls following an uncertainty shock.

These predictions from our theoretical model are supported by empirical evidence, as we show in the second part of the paper. To examine the macroeconomic effects of uncertainty shocks in the data, we consider a few alternative measures of uncertainty and we estimate a vector-autoregression (VAR) model that includes a measure of uncertainty, unemployment, inflation, and a short-term nominal interest rate.<sup>1</sup> A consistent pattern emerges from our empirical exercises: uncertainty raises unemployment, lowers inflation, and policymakers accommodate by lowering the nominal interest rate. Thus, both theory and evidence suggest that uncertainty acts like aggregate demand shocks.

Our emphasis on the demand effects of uncertainty relates closely to that in Basu and Bundick (2011), who highlight the importance of nominal rigidities for uncertainty shocks to generate simultaneous declines in real macroeconomic variables. There are two key differences between our approach and theirs. First, we incorporate labor search frictions in

---

<sup>1</sup>We have considered 4 different measures of uncertainty, including the VIX index studied extensively by Bloom (2009), the policy uncertainty index constructed by Baker, Bloom, and Davis (2011), and 2 survey-based measures constructed by ourselves. The first measure that we construct is taken from the Michigan Survey of Consumers in the United States and the second measure is constructed from the CBI Industrial Trends Survey of firms in the United Kingdom. Both surveys tally responses that make explicit references to “uncertainty” as a factor affecting the purchases of durable goods (the Michigan Survey) or capital expenditures (the CBI Survey).

the DSGE model with sticky prices. Their sticky-price model, instead, is built on the standard RBC framework that abstracts from long-term employment relations. In our model, long-term employment relations are crucial for understanding the effects of uncertainty on potential output and equilibrium unemployment. Second, we provide evidence to show that the key prediction of our theory that uncertainty acts like a demand shock is a robust feature of the data. Such evidence, to our knowledge, is new to the literature.

Our work adds to the recent rapidly growing literature that studies the macroeconomic effects of uncertainty shocks in a DSGE framework. For example, Bloom, Floetotto, and Jaimovich (2010) study a DSGE model with heterogeneous firms and non-convex adjustment costs in productive inputs. They find that a rise in uncertainty makes firms pause hiring and investment and thus leads to a large drop in economic activity. They focus on real economic activity and abstract from the effects of uncertainty on inflation and monetary policy.

Uncertainty shocks can have important interactions with financial factors (Gilchrist, Sim, and Zakrajsek, 2010; Arellano, Bai, and Kehoe, 2011). In a recent study, Christiano, Motto, and Rostagno (2012) present a DSGE model with a financial accelerator in the spirit of Bernanke, Gertler, and Gilchrist (1999). They find that risk shocks (i.e., changes in the volatility of cross-sectional idiosyncratic uncertainty) play an important role for shaping the U.S. business cycles.

The effects of fiscal policy uncertainty on real economic activity is examined by Fernandez-Villaverde, Guerron-Quintana, Kuester, and Rubio-Ramirez (2011) in a New Keynesian model calibrated to the U.S. data. They find that an increase in fiscal policy uncertainty leads to a small contraction in aggregate output.

Most of these studies about uncertainty shocks abstract from labor search frictions and are not designed to study the impact of uncertainty shocks on labor market dynamics such as unemployment and job vacancies. An exception is Schaal (2012), who presents a model with labor search frictions and idiosyncratic volatility shocks to study the observation in the Great Recession period that high unemployment was accompanied by high labor productivity. As in other studies discussed here, he focuses on the effects of uncertainty on real activity, not on inflation and monetary policy.

In what follows, we present the DSGE model with labor search frictions in Section II, discuss the dynamic effects of uncertainty shocks on unemployment and other macroeconomic variables in the calibrated DSGE model in Section III, present empirical evidence that supports the DSGE model's prediction in Section IV, and provide some concluding remarks in Section V.

## II. UNCERTAINTY SHOCKS IN A DSGE MODEL WITH SEARCH FRICTIONS

In this section, we introduce a stylized DSGE model with two key ingredients: sticky prices and labor market search frictions. We show that incorporating search frictions in the labor market has important implications for understanding the effects of uncertainty shocks on both potential output (i.e., output in the flexible-price equilibrium) and equilibrium unemployment.

The model builds the basic framework in Blanchard and Gali (2010). We focus on the effects of uncertainty shocks. The economy is populated by a continuum of infinitely lived and identical households with a unit measure. The representative household consists of a continuum of worker members. The household owns a continuum of firms, each of which uses one worker to produce an intermediate good. In each period, a fraction of the workers are unemployed and they search for a job. Firms post vacancies at a fixed cost. The number of successful matches are produced with a matching technology that transforms searching workers and vacancies into an employment relation. Real wages are determined by Nash bargaining between a search worker and a hiring firm.

The household consumes a basket of differentiated retail goods, each of which is transformed from the homogeneous intermediate good using a constant-returns technology. Retailers face a perfectly competitive input market (where they purchase the intermediate good) and a monopolistically competitive product market. Each retailer sets a price for its differentiated product, with price adjustments subject to a quadratic cost in the spirit of Rotemberg (1982).

Monetary policy is described by the Taylor rule, under which the nominal interest rate responds to deviations of inflation from a target and of output from its potential.

**II.1. The households.** There is a continuum of infinitely lived and identical households with a unit measure. The representative household consumes and invests a basket of retail goods. The utility function is given by

$$E \sum_{t=0}^{\infty} \beta^t A_t (\ln C_t - \chi N_t) \quad (1)$$

where  $E[\cdot]$  is an expectation operator,  $C_t$  denotes consumption and  $N_t$  denotes the fraction of household members who are employed. The parameter  $\beta \in (0, 1)$  denotes the subjective discount factor and the parameter  $\chi$  measures the dis-utility from working.

The term  $A_t$  denotes an intertemporal preference shock. Let  $\gamma_{at} \equiv \frac{A_t}{A_{t-1}}$  denote the growth rate of  $A_t$ . We assume that  $\gamma_{at}$  follows the stochastic process

$$\ln \gamma_{at} = \rho_a \ln \gamma_{a,t-1} + \sigma_{at} \varepsilon_{at}. \quad (2)$$

The parameter  $\rho_a \in (-1, 1)$  measures the persistence of the preference shock. The term  $\varepsilon_{at}$  is an i.i.d. standard normal process. The term  $\sigma_{at}$  is a time-varying standard deviation of the innovation to the preference shock. We interpret it as a preference uncertainty shock. We assume that  $\sigma_{at}$  follows the stationary process

$$\ln \sigma_{at} = (1 - \rho_{\sigma_a}) \ln \sigma_a + \rho_{\sigma_a} \ln \sigma_{a,t-1} + \sigma_{\sigma_a} \varepsilon_{\sigma_a,t}, \quad (3)$$

where  $\rho_{\sigma_a} \in (-1, 1)$  measures the persistence of preference uncertainty,  $\varepsilon_{\sigma_a,t}$  denotes the innovation to the preference uncertainty shock and is a standard normal process, and  $\sigma_{\sigma_a}$  denotes the (constant) standard deviation of the innovation.

The representative household is a family consisting of a continuum of workers with a unit measure. The family chooses consumption  $\{C_t\}$  and saving  $\{B_t\}$  to maximize the utility function in (1) subject to the sequence of budget constraints

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

where  $P_t$  denotes the price level,  $B_t$  denotes the household's holdings of a nominal risk free bond,  $R_t$  denotes the nominal interest rate,  $w_t$  denotes the real wage rate,  $\phi$  denotes an unemployment benefit,  $d_t$  denotes profit income from the household's ownership of intermediate goods producers and of retailers, and  $T_t$  denotes lump-sum taxes. We assume that the labor income tax rate  $\tau_t$  follows the stochastic process

$$\ln \tau_t = (1 - \rho_\tau) \ln \tau + \rho_\tau \ln \tau_{t-1} + \sigma_{\tau t} \varepsilon_{\tau t}. \quad (5)$$

The parameter  $\rho_\tau \in (-1, 1)$  measures the persistence of the tax shock. The term  $\varepsilon_{\tau t}$  is an i.i.d. standard normal process. The term  $\sigma_{\tau t}$  is a time-varying standard deviation of the innovation to the tax shock. We interpret it as a tax uncertainty shock. We assume that  $\sigma_{\tau t}$  follows the stationary process

$$\ln \sigma_{\tau t} = (1 - \rho_{\sigma_w}) \ln \sigma_\tau + \rho_{\sigma_w} \ln \sigma_{\tau,t-1} + \sigma_{\sigma_\tau} \varepsilon_{\sigma_\tau,t}, \quad (6)$$

where  $\rho_{\sigma_\tau} \in (-1, 1)$  measures the persistence of tax uncertainty,  $\varepsilon_{\sigma_\tau,t}$  denotes the innovation to the tax uncertainty shock and is a standard normal process, and  $\sigma_{\sigma_\tau}$  denotes the (constant) standard deviation of the innovation.

Optimal bond-holding decisions result in the intertemporal Euler equation

$$1 = E_t \beta \gamma_{a,t+1} \frac{\Lambda_{t+1}}{\Lambda_t} \frac{R_t}{\pi_{t+1}}, \quad (7)$$

where  $\Lambda_t$  denotes the marginal utility of consumption and  $\pi_t \equiv \frac{P_t}{P_{t-1}}$  denotes the inflation rate.

**II.2. The aggregation sector.** Denote by  $Y_t$  the final consumption goods, which is a basket of differentiated retail goods. Denote by  $Y_t(j)$  a type  $j$  retail good for  $j \in [0, 1]$ . We assume that

$$Y_t = \left( \int_0^1 Y_t(j)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \quad (8)$$

where  $\eta > 1$  denotes the elasticity of substitution between differentiated products.

Expenditure minimizing implies that demand for a type  $j$  retail good is inversely related to the relative price, with the demand schedule given by

$$Y_t^d(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\eta} Y_t, \quad (9)$$

where  $Y_t^d(j)$  and  $P_t(j)$  denote the demand for and the price of retail good of type  $j$ , respectively. The price index  $P_t$  is related to the individual prices  $P_t(j)$  through the relation

$$P_t = \left( \int_0^1 P_t(j)^{\frac{1}{1-\eta}} \right)^{1-\eta}. \quad (10)$$

**II.3. The retail goods producers.** There is a continuum of retail goods producers, each producing a differentiated product using a homogeneous intermediate good as input. The production function of retail good of type  $j \in [0, 1]$  is given by

$$Y_t(j) = X_t(j), \quad (11)$$

where  $X_t(j)$  is the input of intermediate goods used by retailer  $j$  and  $Y_t(j)$  is the output. The retail goods producers are price takers in the input market and monopolistic competitors in the product markets, where they set prices for their products, taking as given the demand schedule in (9) and the price index in (10).

Price adjustments are subject to the quadratic cost

$$\frac{\Omega_p}{2} \left( \frac{P_t(j)}{\pi P_{t-1}(j)} - 1 \right)^2 Y_t, \quad (12)$$

where the parameter  $\Omega_p \geq 0$  measures the cost of price adjustments and  $\pi$  denotes the steady-state inflation rate. Here, we assume that price adjustment costs are in units of aggregate output.

A retail firm that produces good  $j$  solves the profit maximizing problem

$$\max_{P_t(j)} \mathbb{E}_t \sum_{i=0}^{\infty} \frac{\beta^i \Lambda_{t+i}}{\Lambda_t} \left[ \left( \frac{P_{t+i}(j)}{P_{t+i}} - q_{t+i} \right) Y_{t+i}^d(j) - \frac{\Omega_p}{2} \left( \frac{P_{t+i}(j)}{\pi P_{t+i-1}(j)} - 1 \right)^2 Y_{t+i} \right], \quad (13)$$

where  $q_{t+i}$  denotes the relative price of intermediate goods in period  $t+i$ . The optimal price-setting decision implies that, in a symmetric equilibrium with  $P_t(j) = P_t$  for all  $j$ , we have

$$q_t = \frac{\eta - 1}{\eta} + \frac{\Omega_p}{\eta} \left[ \frac{\pi_t}{\pi} \left( \frac{\pi_t}{\pi} - 1 \right) - \mathbb{E}_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} \frac{Y_{t+1}}{Y_t} \frac{\pi_{t+1}}{\pi} \left( \frac{\pi_{t+1}}{\pi} - 1 \right) \right]. \quad (14)$$

Absent price adjustment cost (i.e.,  $\Omega_p = 0$ ), the optimal pricing rule implies that real marginal cost  $q_t$  equals the inverse of the steady-state markup.

**II.4. The Labor Market.** In the beginning of period  $t$ , there are  $u_t$  unemployed workers searching for jobs and there are  $v_t$  vacancies posted by firms. The matching technology is described by the Cobb-Douglas function

$$m_t = \mu u_t^\alpha v_t^{1-\alpha}, \quad (15)$$

where  $m_t$  denotes the number of successful matches and the parameter  $\alpha \in (0, 1)$  denotes the elasticity of job matches with respect to the number of searching workers. The term  $\mu$  scales the matching efficiency.

The probability that an open vacancy is matched with a searching worker (or the job filling rate) is given by

$$q_t^v = \frac{m_t}{v_t}. \quad (16)$$

The probability that an unemployed and searching worker is matched with an open vacancy (or the job finding rate) is given by

$$q_t^u = \frac{m_t}{u_t}. \quad (17)$$

In the beginning of period  $t$ , there are  $N_{t-1}$  workers. A fraction  $\rho$  of these workers lose their jobs. Thus, the number of workers who survive the job separation is  $(1 - \rho)N_{t-1}$ . At the same time,  $m_t$  new matches are formed. Following the timing assumption in Blanchard and Gali (2010), we assume that new hires start working in the period they are hired. Thus, aggregate employment in period  $t$  evolves according to

$$N_t = (1 - \rho) N_{t-1} + m_t. \quad (18)$$

With a fraction  $\rho$  of employed workers separated from their jobs, the number of unemployed workers searching for jobs in period  $t$  is given by

$$u_t = 1 - (1 - \rho)N_{t-1}. \quad (19)$$

Following Blanchard and Gali (2010), we assume full participation and define the unemployment rate as the fraction of the population who are left without a job after hiring takes place in period  $t$ . Thus, the unemployment rate is given by

$$U_t = u_t - m_t = 1 - N_t. \quad (20)$$

**II.5. The firms (intermediate good producers).** A firm can produce only if it can successfully match with a worker. The production function for a firm with one worker is given by

$$x_t = Z_t,$$

where  $x_t$  is output and  $Z_t$  is an aggregate technology shock. The technology shock follows the stochastic process

$$\ln Z_t = (1 - \rho_z) \ln Z + \rho_z \ln Z_{t-1} + \sigma_{zt} \varepsilon_{zt}. \quad (21)$$

The parameter  $\rho_z \in (-1, 1)$  measures the persistence of the technology shock. The term  $\varepsilon_{zt}$  is an i.i.d. innovation to the technology shock and is a standard normal process. The term  $\sigma_{zt}$  is a time-varying standard deviation of the innovation and we interpret it as a technology uncertainty shock. We assume that the technology uncertainty shock follows the stationary stochastic process

$$\ln \sigma_{zt} = (1 - \rho_{\sigma_z}) \ln \sigma_z + \rho_{\sigma_z} \ln \sigma_{z,t-1} + \sigma_{\sigma_z} \varepsilon_{\sigma_z,t}, \quad (22)$$

where the parameter  $\rho_{\sigma_z} \in (-1, 1)$  measures the persistence of the technology uncertainty, the term  $\varepsilon_{\sigma_z,t}$  denotes the innovation to the technology uncertainty and is a standard normal process, and the parameter  $\sigma_{\sigma_z} > 0$  is the standard deviation of the innovation.

If a firm finds a match, it obtains a flow profit in the current period after paying the worker. In the next period, if the match survives (with probability  $1 - \rho$ ), the firm continues; if the match breaks down (with probability  $\rho$ ), the firm posts a new job vacancy at a fixed cost  $\kappa$ , with the value  $V_{t+1}$ . The value of a firm with a match is therefore given by the Bellman equation

$$J_t^F = q_t Z_t - w_t + E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} [(1 - \rho) J_{t+1}^F + \rho V_{t+1}]. \quad (23)$$

If the firm posts a new vacancy in period  $t$ , it costs  $\kappa$  units of final goods. The vacancy can be filled with probability  $q_t^v$ , in which case the firm obtains the value of the match. Otherwise, the vacancy remains unfilled and the firm goes into the next period with the value  $V_{t+1}$ . Thus, the value of an open vacancy is given by

$$V_t = -\kappa + q_t^v J_t^F + E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} (1 - q_t^v) V_{t+1}.$$

Free entry implies that  $V_t = 0$ , so that

$$\kappa = q_t^v J_t^F. \quad (24)$$

Substituting (24) into (23), we obtain

$$\frac{\kappa}{q_t^v} = q_t Z_t - w_t + E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} (1 - \rho) \frac{\kappa}{q_{t+1}^v}. \quad (25)$$



**II.6. Workers' Value Functions.** If a worker is employed, she obtains an after-tax wage income and suffers a utility cost for working in period  $t$ . In period  $t + 1$ , the match is dissolved with probability  $\rho$  and the separated worker can find a new match with probability  $q_{t+1}^u$ . Thus, with probability  $\rho(1 - q_{t+1}^u)$ , the worker who gets separated does not find a new job in period  $t + 1$  and thus enters the unemployment pool. Otherwise, the worker continues to be employed. The (marginal) value of an employed worker therefore satisfies the Bellman equation

$$J_t^W = (1 - \tau_t)w_t - \frac{\chi}{\Lambda_t} + E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} \{ [1 - \rho(1 - q_{t+1}^u)] J_{t+1}^W + \rho(1 - q_{t+1}^u) J_{t+1}^U \}, \quad (26)$$

where  $J_t^U$  denotes the value of an unemployed household member. If a worker is currently unemployed, then he obtains an (after-tax) unemployment benefit and can find a new job in period  $t + 1$  with probability  $q_{t+1}^u$ . Otherwise, he stays unemployed in that period. The value of an unemployed worker thus satisfies the Bellman equation

$$J_t^U = \phi(1 - \tau_t) + E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} [q_{t+1}^u J_{t+1}^W + (1 - q_{t+1}^u) J_{t+1}^U]. \quad (27)$$

**II.7. The Nash Bargained Wage.** Firms and workers bargain over wages. The Nash bargaining problem is given by

$$\max_{w_t} (J_t^W - J_t^U)^b (J_t^F)^{1-b}, \quad (28)$$

where  $b \in (0, 1)$  represents the bargaining weight for workers.

Define the total surplus as

$$S_t = J_t^F + J_t^W - J_t^U. \quad (29)$$

Then the bargaining solution is given by

$$J_t^F = (1 - b) S_t, \quad J_t^W - J_t^U = b S_t. \quad (30)$$

It then follows from equations (26) and (27) that

$$b S_t = (1 - \tau_t)(w_t^N - \phi) - \frac{\chi}{\Lambda_t} + E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} [(1 - \rho)(1 - q_{t+1}^u) b S_{t+1}]. \quad (31)$$

Given the Nash wage  $w_t^N$ , this last equation determines the total surplus  $S_t$ .

The Nash bargaining wage can be obtained by using (24), (30), and (31). In particular, we have

$$w_t^N [1 - \tau_t(1 - b)] = (1 - b) \left[ \frac{\chi}{\Lambda_t} + \phi(1 - \tau_t) \right] + b \left[ q_t Z_t + \beta(1 - \rho) E_t \frac{\beta \Lambda_{t+1}}{\Lambda_t} \frac{\kappa v_{t+1}}{u_{t+1}} \right]. \quad (32)$$

Thus, the Nash bargaining wage—adjusted for labor income taxes borne by the workers—is a weighted average of the worker's reservation value and the firm's productive value of a job match. By forming a match, the worker incurs a utility cost of working and foregoes the after-tax unemployment benefit; the firm receives the marginal product from labor in the current period and saves the vacancy cost from the next period.

**II.8. Government policy.** The government finances exogenous spending  $G_t$  and unemployment benefit payments  $\phi$  through labor income taxes and lump-sum taxes. We assume that the government balances the budget in each period so that

$$G_t + \phi(1 - N_t) = T_t + \tau_t [w_t N_t + \phi(1 - N_t)]. \quad (33)$$

We assume that government spending to output ratio  $g_t \equiv \frac{G_t}{Y_t}$  follows the stationary stochastic process

$$\ln g_t = (1 - \rho_g) \ln g + \rho_g \ln g_{t-1} + \sigma_g \varepsilon_{gt}, \quad (34)$$

where  $\rho_g \in (-1, 1)$  is the persistence parameter, the innovation  $\varepsilon_{gt}$  is an i.i.d. standard normal process, and  $\sigma_g$  is the time-varying standard deviation of the innovation. We interpret  $\sigma_{gt}$  as an uncertainty shock to government spending.

The government spending uncertainty shock follows the stationary stochastic process

$$\ln \sigma_{gt} = (1 - \rho_{\sigma_g}) \ln \sigma_g + \rho_{\sigma_g} \ln \sigma_{g,t-1} + \sigma_{\sigma_g} \varepsilon_{\sigma_g,t}, \quad (35)$$

where the parameter  $\rho_{\sigma_g} \in (-1, 1)$  measures the persistence of the uncertainty shock to government spending, the term  $\varepsilon_{\sigma_g,t}$  denotes the innovation to the uncertainty shock and is a standard normal process, and the parameter  $\sigma_{\sigma_g} > 0$  is the standard deviation of the innovation.

The government conducts monetary policy by following the Taylor rule

$$R_t = r\pi^* \left( \frac{\pi_t}{\pi^*} \right)^{\phi_\pi} \left( \frac{Y_t}{Y} \right)^{\phi_y} \quad (36)$$

where the parameter  $\phi_\pi$  determines the aggressiveness of monetary policy against deviations of inflation from the target  $\pi^*$  and  $\phi_y$  determines the extent to which monetary policy accommodates output fluctuations. The parameter  $r$  denotes the steady-state real interest rate (i.e.,  $r = \frac{R}{\pi}$ ).

**II.9. Search Equilibrium.** In a search equilibrium, the markets for bonds, capital, final consumption goods, and intermediate goods all clear.

Since the aggregate supply of the nominal bond is zero, the bond market-clearing condition implies that

$$B_t = 0. \quad (37)$$

Goods market clearing implies the aggregate resource constraint

$$C_t + \kappa v_t + \frac{\Omega_p}{2} \left( \frac{\pi_t}{\pi} - 1 \right)^2 Y_t + G_t = Y_t, \quad (38)$$

where  $Y_t$  denotes aggregate output of final goods.

Intermediate goods market clearing implies that

$$Y_t = Z_t N_t. \quad (39)$$

### III. ECONOMIC IMPLICATIONS FROM THE DSGE MODEL

To examine the macroeconomic effects of uncertainty shocks in our DSGE model, we calibrate the model parameters and simulate the model to examine impulse responses of macroeconomic variables to a few alternative sources of uncertainty shocks. We focus on the responses of unemployment, inflation, and the nominal interest rate following an uncertainty shock.

**III.1. Calibration.** We calibrate the structural parameters to match several steady-state observations. For those structural parameters that do not affect the model's steady state, we calibrate their values to be consistent with other empirical studies in the literature. The structural parameters to be calibrated include  $\beta$ , the subjective discount factor;  $\chi$ , the disutility of working parameter;  $\eta$ , the elasticity of substitution between differentiated retail products;  $\alpha$ , the elasticity of matching with respect to searching workers;  $\mu$ , the matching efficiency parameter;  $\rho$ , the job separation rate;  $\phi$ , the flow unemployment benefits (in final consumption units);  $\kappa$ , the fixed cost of positing vacancies;  $b$ , the Nash bargaining weight;  $\Omega_p$ , the price adjustment cost parameter;  $\phi_\pi$ , the Taylor-rule coefficient for inflation;  $\pi$ , the steady-state inflation rate (or inflation target); and  $\phi_y$ , the Taylor-rule coefficient for output. In addition, we need to calibrate the parameters in the shock processes. The calibrated values of the model parameters are summarized in Table 1.

We set  $\beta = 0.99$ , so that the model implies a steady-state real interest rate of 4 percent per annual. We set  $\eta = 10$  so that the average markup is about 10 percent, in line with the estimates obtained by Basu and Fernald (1997) and others. We set  $\alpha = 0.5$  following the literature (Blanchard and Gali, 2010; Gertler and Trigari, 2009). We set  $\rho = 0.1$ , which is consistent with an average monthly job separation rate of about 3.4 percent as in the JOLTS data for the period from 2001 to 2011. Following Hall and Milgrom (2008), we set  $\phi = 0.25$  so that unemployment benefit is about 25 percent of normal earnings. We set  $b = 0.5$  following the literature.

We choose the value of the vacancy cost parameter  $\kappa$  so that, in the steady state, the total cost of vacancy posting is about 2 percent of gross output. To assign a value of  $\kappa$  then requires knowledge of the steady-state number of vacancies  $v$  and the steady-state level of output  $Y$ . We calibrate the value of  $v$  such that the steady-state vacancy filling rate is  $q^v = 0.7$  and the steady-state unemployment rate is  $U$  is 6 percent, as in den Haan, Ramey, and Watson (2000). Given the steady-state value of the job separation rate  $\rho = 0.1$ , we obtain  $m = \rho N = 0.094$ . Thus, we have  $v = \frac{m}{q^v} = \frac{0.094}{0.7} = 0.134$ . To obtain a value for  $Y$ , we use the aggregate production function that  $Y = ZN$  and normalize the level of technology such that  $Z = 1$ . This procedure yields a calibrated value of  $\kappa = 0.14$ .

Given the steady-state values of  $m$ ,  $u$ , and  $v$ , we use the matching function to obtain an average matching efficiency of  $\mu = 0.65$ . To obtain a value for  $\chi$ , we solve the steady-state system so that  $\chi$  is consistent with an unemployment rate of 6 percent. The process results in  $\chi = 0.46$ .

The price adjustment cost parameter  $\Omega_p$  and the Taylor-rule parameters  $\phi_\pi$  and  $\phi_y$  do not affect the model's steady state. We calibrate these parameters to be consistent with empirical studies in the literature. We set  $\Omega_p = 112$  so that the slope of the Phillips curve in the model corresponds to that in a Calvo staggered price-setting model with 4 quarters of price contract duration. For the Taylor rule parameters, we set  $\phi_\pi = 1.5$  and  $\phi_y = 0.2$ . We set  $\pi = 1.005$ , so that the steady-state inflation rate is about 2 percent per annual, corresponding to the Federal Reserve's implicit inflation objective.

The model does not provide information for the parameters in the exogenous shock processes. For purpose of illustration, we normalize the steady-state levels of the shocks such that  $\gamma_a = 1$ ,  $Z = 1$ . We set  $g = 0.2$  so that the steady-state ratio of government spending to aggregate output is about 20 percent. We also normalize the mean values of the uncertainty shocks so that  $\sigma_k = 0.01$  for  $k \in \{a, z, \tau, g\}$ . We set the standard deviation of the innovation to each uncertainty shock to  $\sigma_{\sigma_k} = 1$ , so that a one standard deviation shock to uncertainty represents a 100 percent increase in the level of uncertainty (i.e., the shock leads to a doubling of the level of uncertainty). The persistence parameters for all shocks, including the level shocks and the uncertainty shocks, are set to  $\rho_k = 0.90$  for  $k \in \{a, z, \tau, g, \sigma_a, \sigma_z, \sigma_\tau, \sigma_g\}$ .

**III.2. Macroeconomic effects of uncertainty shocks.** We solve the model using third order approximations around the steady state. We then compute the impulse responses following an uncertainty shock. We consider 3 different types of uncertainty shocks: (1) preference uncertainty  $\sigma_{at}$ ; (2) technology uncertainty  $\sigma_{zt}$ ; (3) and fiscal policy uncertainty  $\sigma_{\tau t}$ .<sup>2</sup> We show that incorporating search frictions renders the transmission mechanism for uncertainty shocks quite different from that of the standard New Keynesian model.

*III.2.1. Potential output effects of uncertainty.* We first consider the effects of uncertainty shocks in the flexible-price version of the DSGE model. We find that the impact of uncertainty shocks on potential output (i.e., output in the model with flexible prices) in the presence of search frictions differs substantially from that in the standard RBC model with spot labor markets.

In the standard RBC model, uncertainty shocks are expansionary since heightened uncertainty lowers consumption and thus creates an incentive for households to work harder at any

---

<sup>2</sup>We have also examined the effects of government spending uncertainty shocks and find that the qualitative results are similar to those of tax uncertainty shocks (not reported).

given wage rate (Basu and Bundick, 2011). Thus, the RBC model predicts that heightened uncertainty raises potential output.

The long-term employment relations stemming from search frictions create a different channel for uncertainty shocks to affect potential output. In our model, a firm represents a long-term employment relationship with a worker, so that heightened uncertainty reduces the value of a filled vacancy. Firms thus respond to uncertainty shocks by posting fewer vacancies. As a consequence, the job finding rate declines and the unemployment rate rises.

Figures 1-3 display the impulse responses of several macroeconomic variables in the DSGE model with flexible prices following the 3 types of uncertainty shocks—preference uncertainty, technology uncertainty, and fiscal policy uncertainty. The figures reveal that uncertainty shocks—regardless of the sources—generate a rise in unemployment and a decline in potential output when prices are flexible.

The decline in potential output following uncertainty shocks is important since it implies that, *ceteris paribus*, these shocks could be inflationary in an environment with sticky prices to the extent that they reduce the output gap. Thus, in principle, uncertainty shocks could create an important trade-off for policymakers between stabilizing inflation and unemployment, similar to the effects of a cost-push shock. To study the effects of uncertainty shocks on inflation and the associated policy trade-offs, we now turn to a version of our model with nominal rigidities

III.2.2. *Aggregate demand effects of uncertainty.* In this section, we show that, with sticky prices, uncertainty shocks unambiguously act like an aggregate demand shock that reduces real activity, raises unemployment, and lowers inflation, irrespective of their effects on potential output. Figures 4 through 6 show that, for all three types of uncertainty shocks, uncertainty indeed acts like an aggregate demand shock, once nominal rigidities are introduced.

When prices are sticky, the recessionary effects of uncertainty are amplified through an aggregate demand channel (see also Basu and Bundick (2011) for the importance of sticky prices in generating declines in output following uncertainty shocks in an otherwise standard RBC framework). Since retail prices are sticky, heightened uncertainty lowers the demand for retail goods and, as a result, for intermediate goods as well. Thus, the relative price of intermediate goods falls, lowering the firms' profit and the value of a filled vacancy. Firms respond by posting fewer vacancies, making it more difficult for searching workers to find a match. Thus, unemployment rises. Under the Taylor rule, the central bank lowers the nominal interest to alleviate the contractionary and disinflationary effects of the uncertainty shock. Nonetheless, equilibrium unemployment still rises and equilibrium inflation still falls following a rise in uncertainty.

Comparing Figures 1 through 3 with Figures 4 through 6, we see that uncertainty shocks generate significant reductions in aggregate demand in the DSGE model with sticky prices, but have relative very small effects on unemployment and other macroeconomic variables with flexible prices. Thus, in this stylized DSGE model, uncertainty shocks do not seem to drive changes in the economy’s productive capacity, but they do generate large declines in aggregate demand.

#### IV. THE MACROECONOMIC EFFECTS OF UNCERTAINTY SHOCKS: EVIDENCE

We now present empirical evidence that supports the predictions of our theoretical model. To examine the macroeconomic effects of uncertainty shocks in the data, we estimate a vector-autoregression (VAR) model that includes a measure of uncertainty and a few macroeconomic variables. VAR models are used in the literature as a main statistical tool to estimate the responses of macroeconomic variables to uncertainty shocks. Examples include Alexopoulos and Cohen (2009), Bloom (2009), Bachmann, Elstner, and Sims (2011), and Baker, Bloom, and Davis (2011). Existing studies focus on the effects of uncertainty on real economic activity such as employment, investment, and output. We focus on the joint effects of uncertainty on unemployment and inflation.

We consider four alternative measures of uncertainty, including (1) a measure of perceived uncertainty by consumers from the Michigan Survey of Consumers, (2) a measure of perceived uncertainty by firms from the CBI Industrial Trends Survey in the United Kingdom, (3) the VIX index, which measures the implied volatility of the S&P 500 stock price index, and (4) a measure of economic policy uncertainty recently developed by Baker, Bloom, and Davis (2011).

While the VIX index and policy uncertainty are both standard, the two survey-based measures of uncertainty are new and deserve some explanations. We begin with the consumers’ perceived uncertainty constructed from the Michigan Survey.

Each month since 1978 the Michigan Survey conducts interviews of about 500 households throughout the United States asking question ranging from their perception of business conditions to expectations of future movements in prices. More important for our analysis, the survey also tallies the fraction of respondents who report that “uncertain future” is a factor that will likely limit their expenditures on durable goods (such as cars) over the next 12 months.<sup>3</sup>

---

<sup>3</sup>For instance, the question to vehicle purchases is “Speaking now of the automobile market—do you think the next 12 months or so will be a good time or a bad time to buy a vehicle, such as a car, pickup, van or sport utility vehicle? Why do you say so?” Reasons related to uncertainty are then compiled. Note that the series is weighted by age, income, region, and sex to be nationally representative.

Similarly, since 1978, the CBI surveys a large sample of roughly 1,100 firms in the United Kingdom each quarter. From this survey, we use the fraction of firms that report “uncertainty about demand” as a factor limiting their capital expenditures over the next 12 months.<sup>4</sup> So, U.K. firms are asked about a specific form of uncertainty (i.e., about the demand for their products), whereas no such specificity is attached to the measure of uncertainty in the Michigan survey.

We examine the macroeconomic effects of uncertainty shocks in a baseline VAR model with 4 variables. These variables include a measure of uncertainty, the unemployment rate, the CPI inflation rate, and the 3-month Treasury bills rate. We first look at the transmission of uncertainty shocks using the measure of consumer uncertainty from the Michigan Survey.

Using a recursive Cholesky identification scheme, we consider two alternative strategies to identify a shock to uncertainty. First, we take advantage of the timing of the survey relative to the release dates of the macroeconomic time series and place the measure of uncertainty first in a recursive ordering (Leduc, Sill, and Stark, 2007; Auerbach and Gorodnichenko, 2012; Leduc and Sill, forthcoming). With this ordering, we implicitly assume that uncertainty does not respond to macroeconomic shocks in the impact period, while unemployment, inflation, and the nominal interest rate are allowed to change on impact of an uncertainty shock.

This assumption seems reasonable given the timing of the surveys relative to the timing of macroeconomic data releases. For example, in the Michigan Survey, phone interviews are conducted throughout the month, with most interviews concentrated in the middle of each month, shortly after which, preliminary results are released. The final results are typically released by the end of the month. When answering questions about whether it is a good or a bad time to buy a vehicle, for example, survey participants know the previous month’s unemployment, inflation, and interest rates, but do not know the current realizations of these macroeconomic indicators since that information has yet to be made public. Hence, our identification strategy uses the fact that when answering questions at time  $t$  about their expectations of the future, the information set on which survey participants condition their answers will not include, by construction, the time  $t$  realizations of the unemployment rate and the other variables in our VAR.

Similarly, the questionnaires for the CBI survey must be returned by the middle of the first month of each quarter. The design of the survey implies that participants have information about the values of the variables in the VAR for the previous quarter when they filled in the survey, but they do not know those values for the current quarter. We take advantage of the survey timing to identify uncertainty shocks.

---

<sup>4</sup>The questions asked by the CBI is “What factors are likely to limit (wholly or partly) your capital expenditure authorisations over the next twelve months?” Participants can choose “uncertainty about demand” as one of six options. Firms can also provide other reasons. Finally, multiple reasons can be chosen.

Second, to examine the robustness of our results, we estimate an alternative VAR model with the same 4 variables, but with uncertainty ordered last. While the timing of the survey relative to macroeconomic data releases imply that survey respondents do not possess complete information about the macroeconomic data in the current period, we cannot rule out that they observe other, possibly higher-frequency variables, that give them information about the time  $t$  realizations of the variables in the VAR model. By ordering uncertainty last in the VAR model, we allow the measure of uncertainty to respond to contemporaneous macroeconomic shocks in the system. Despite this conservative assumption, we find that the estimated impulse responses of macroeconomic variables to uncertainty shocks are remarkably similar across the two very different identification strategies.

Figure 7 presents the impulse responses in the baseline VAR model with consumer uncertainty from the Michigan Survey ordered first. For each variable, the solid line denotes the mean estimate of the impulse response and the dashed lines represent the 90-percent confidence band around the point estimates. The figure shows that an unexpected increase in uncertainty leads to a persistent increase in the unemployment rate, which reaches a peak about 12 months after the shock and remains significantly positive for about three years. Heightened uncertainty also leads to a significant and persistent decline in inflation, with the peak effect also occurring roughly 12 months after the shock.

Figure 8 presents the impulse responses in the VAR model with consumer uncertainty (from the Michigan Survey) ordered last. The responses of the 3 macroeconomic variables to an uncertainty shock look remarkably similar to those in the baseline VAR with uncertainty ordered first. Under each identification strategy, a positive uncertainty shock acts like a negative aggregate demand shock that raises unemployment and lowers inflation. In response to the recessionary effects of uncertainty shocks, monetary policy reacts by easing the stance of policy and lowering the nominal interest rate.

The finding that uncertainty shocks act like aggregate demand shocks is fairly robust. It holds for the other 3 measures of uncertainty, including the VIX index (Figure 9), policy uncertainty (Figure 10), and firm uncertainty from the U.K. data (Figure 11). It also holds in a larger VAR model with additional variables. For example, we have estimated three alternative 6-variable VAR models that, in addition to the 4 variables in our baseline VAR model (with consumer uncertainty ordered first), also include (i) consumption of nondurables and services and business fixed investment; (ii) credit spread and stock price index; or (iii) full-time and part-time employment. In each case, as shown Figures 12-14, uncertainty shocks continue to act like an aggregate demand shock that raises unemployment, lowers inflation and the nominal interest rate. Further, we have estimated the baseline 4-variable VAR model with the sample ended by 2008, before the policy rates in the United States and



the United Kingdom hit the zero lower bound. We find that the qualitative results remain unchanged.

To summarize, the estimated VAR models using diverse measures of uncertainty and alternative identification strategies highlight, at a minimum, a robust comovement between uncertainty, inflation, and unemployment that supports our model's predictions.

## V. CONCLUSION

In this paper, we study the macroeconomic effects of uncertainty shocks and show that uncertainty shocks act like aggregate demand shocks both in theory and empirically. We present a DSGE model with search frictions and nominal rigidities. We show that the long-term nature of employment relationships in this framework significantly alters the transmission of uncertainty shocks compared to the standard RBC model or the New Keynesian models built on the RBC framework. When prices are flexible, uncertainty shocks have contractionary effects on potential output in our model. Since a job match represents a long-term employment relation, firms are reluctant to post new vacancies when the level of uncertainty rises. The reduction in vacancy posting lowers the job finding rate and raises the unemployment rate. Thus, unlike the standard RBC model that predicts an expansionary effect of uncertainty shocks on potential output, our model predicts a recessionary effect on potential output. The decline in potential output following uncertainty shocks is important since it implies that, *ceteris paribus*, uncertainty shocks could be inflationary in an environment with sticky prices to the extent that they lead to a fall in the output gap. However, in the presence of sticky prices in our model with search frictions, uncertainty shocks—regardless of their sources—always act like aggregate demand shocks that raise unemployment and lower inflation.

We have documented robust evidence that supports the theory's predictions. Our estimated VAR models show that an increase in the level of uncertainty leads to a rise in unemployment and declines in inflation and the nominal interest rate. This result is robust to alternative measures of uncertainty, alternative identification strategies, and alternative model specifications. Overall, both theory and evidence suggest that uncertainty shocks are aggregate demand shocks.

TABLE 1. Parameter calibration

Parameter	Description	value
Structural parameters		
$\beta$	Household's discount factor	0.99
$\chi$	Scale of disutility of working	0.68
$\eta$	Elasticity of substitution between differentiated goods	10
$\alpha$	Share parameter in matching function	0.50
$\mu$	Matching efficiency	0.65
$\rho$	Job separation rate	0.10
$\phi$	Flow value of unemployment	0.25
$\kappa$	Vacancy cost	0.14
$b$	Nash bargaining weight	0.5
$\Omega_p$	Price adjustment cost	112
$\pi$	Steady state inflation (or inflation target)	1.005
$\phi_\pi$	Taylor-rule coefficient for inflation	1.5
$\phi_y$	Taylor-rule coefficient for output	0.2
Shock parameters		
$\gamma_a$	Average value of preference shock	1
$Z$	Average value of technology shock	1
$g$	Average ratio of government spending to output	0.2
$\rho_k$	Persistence of shock $k \in \{\gamma_a, z, \tau\}$	0.90
$\sigma_k$	Mean value of volatility of shock $k \in \{\gamma_a, z, \tau\}$	0.01
$\rho_{\sigma_k}$	Persistence of uncertainty shock $\sigma_{kt}$	0.90
$\sigma_{\sigma_k}$	Standard deviation of uncertainty shock $\sigma_{kt}$	1

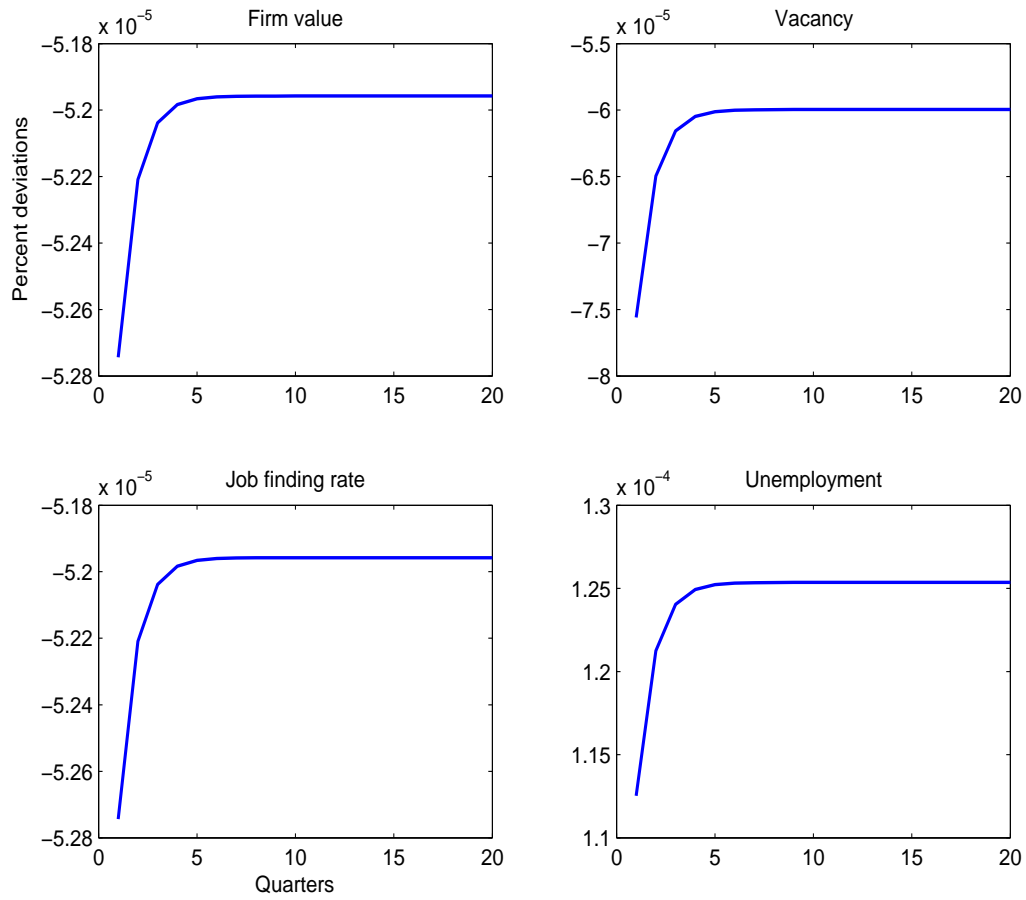


FIGURE 1. Impulse responses of macroeconomic variables to preference uncertainty shock in the DSGE model with flexible prices.

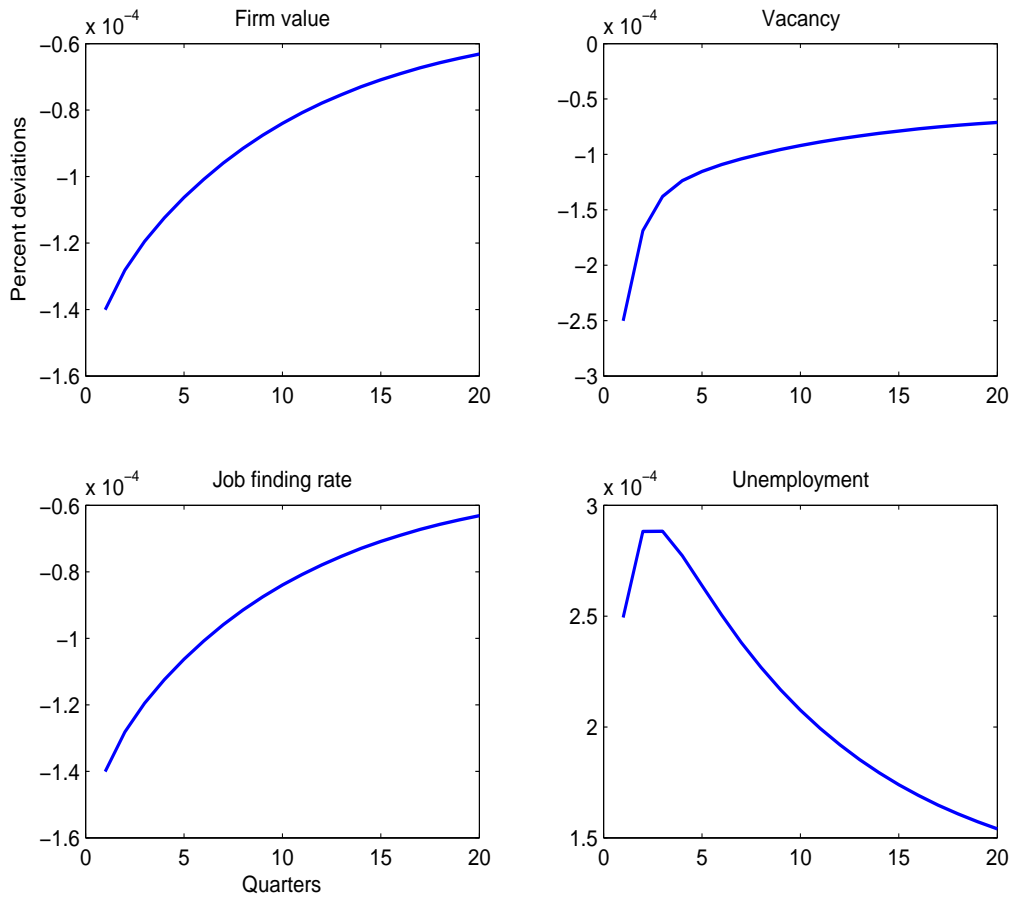


FIGURE 2. Impulse responses of macroeconomic variables to productivity uncertainty shock in the DSGE model with flexible prices.

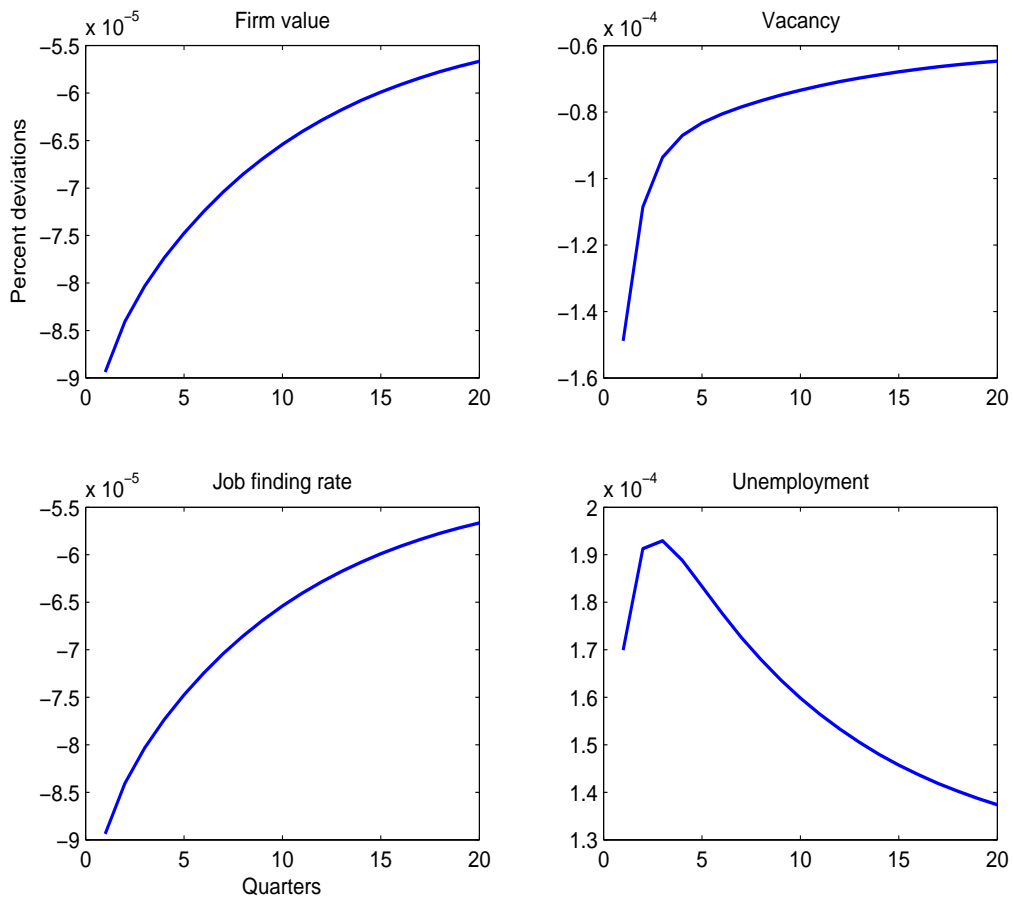


FIGURE 3. Impulse responses of macroeconomic variables to tax uncertainty shock in the DSGE model with flexible prices.

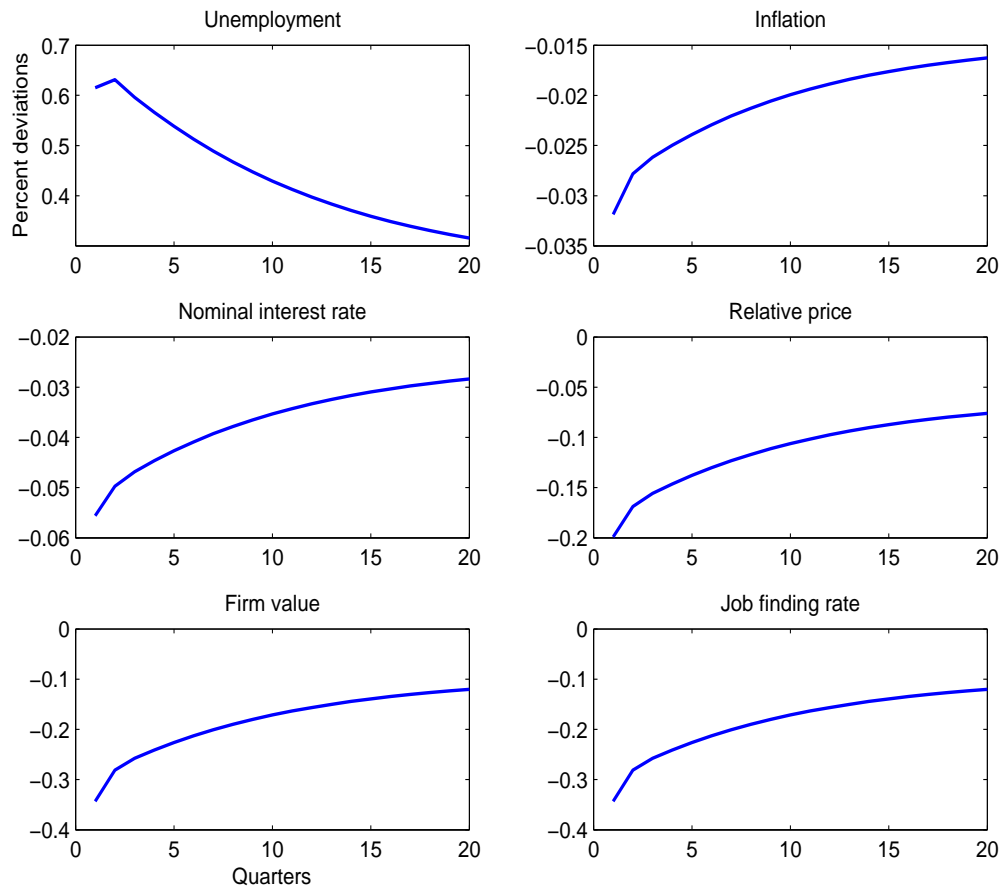


FIGURE 4. Impulse responses of macroeconomic variables to a preference uncertainty shock in the DSGE model with sticky prices.

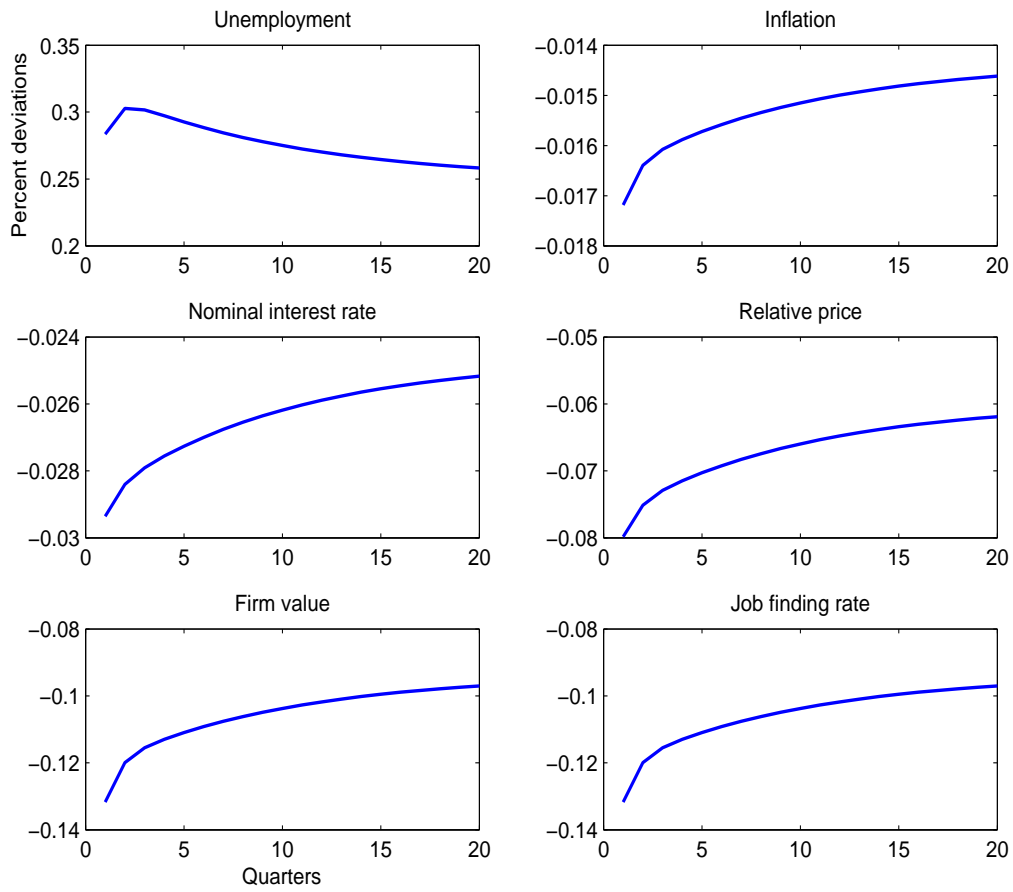


FIGURE 5. Impulse responses of macroeconomic variables to a technology uncertainty shock in the DSGE model with sticky prices.

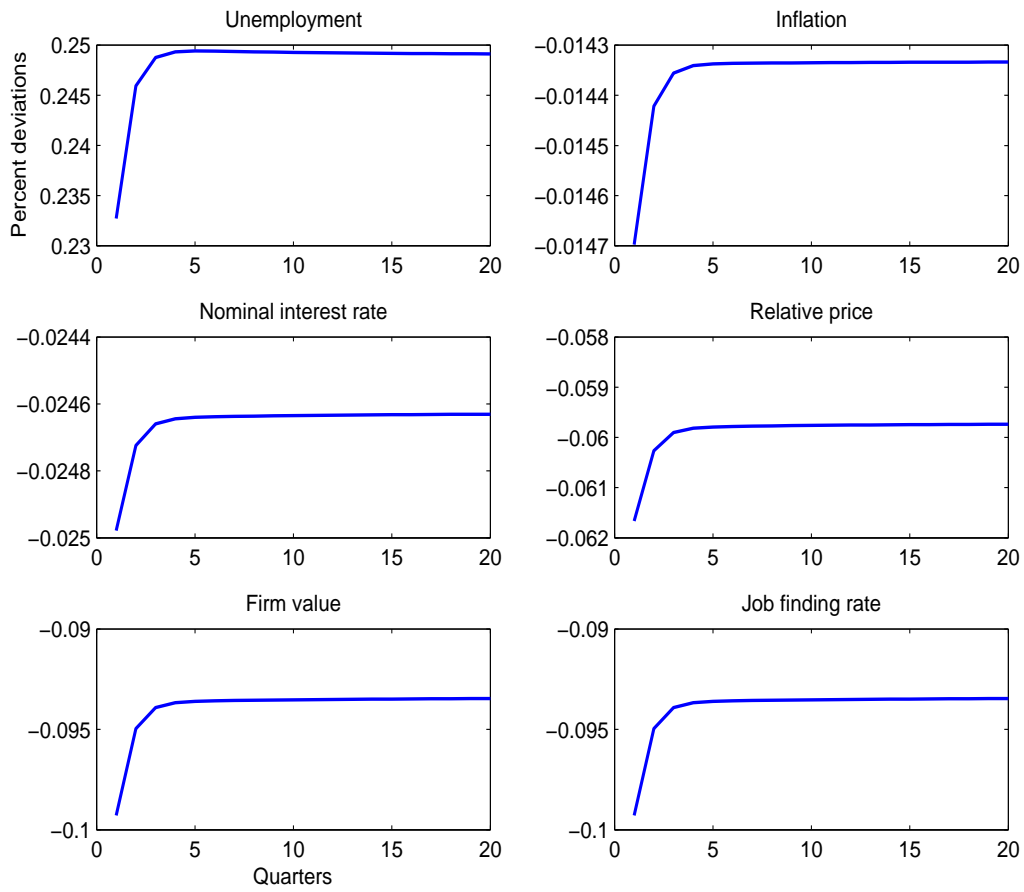


FIGURE 6. Impulse responses of macroeconomic variables to a tax uncertainty shock in the DSGE model with sticky prices.



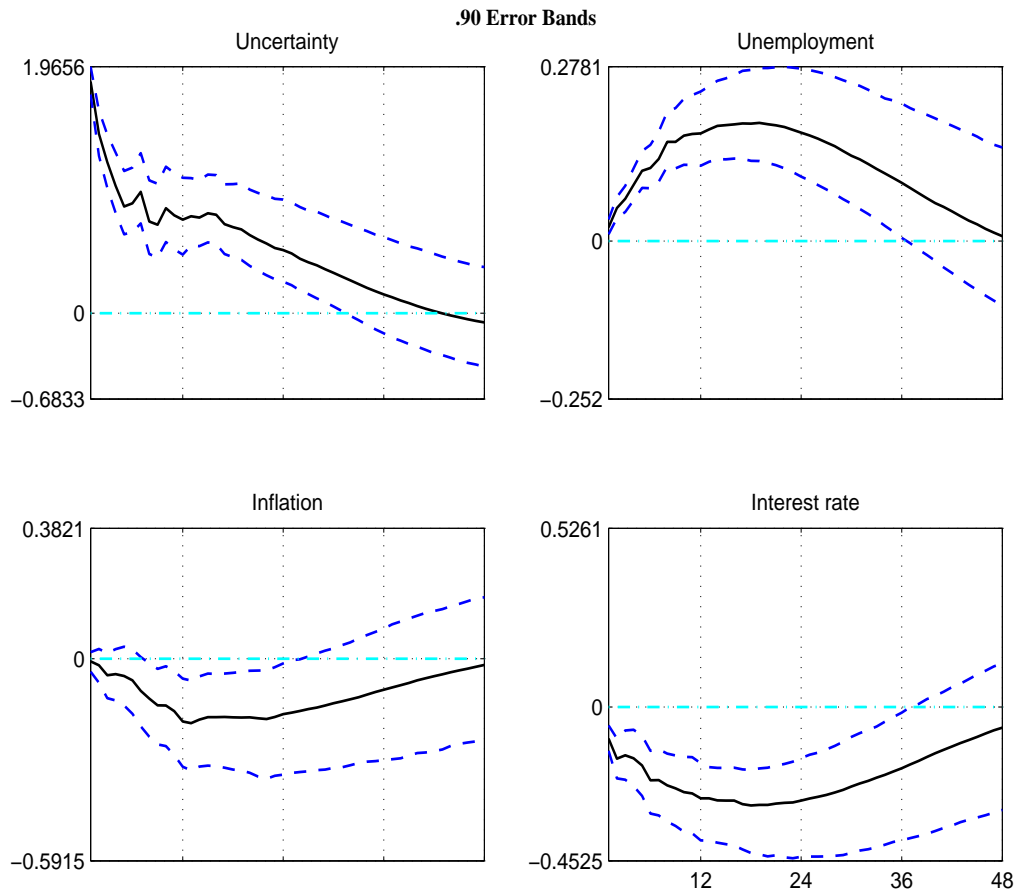


FIGURE 7. The effects of a one-standard deviation shock to perceived uncertainty in the Michigan Survey of Consumers: uncertainty measure ordered first.

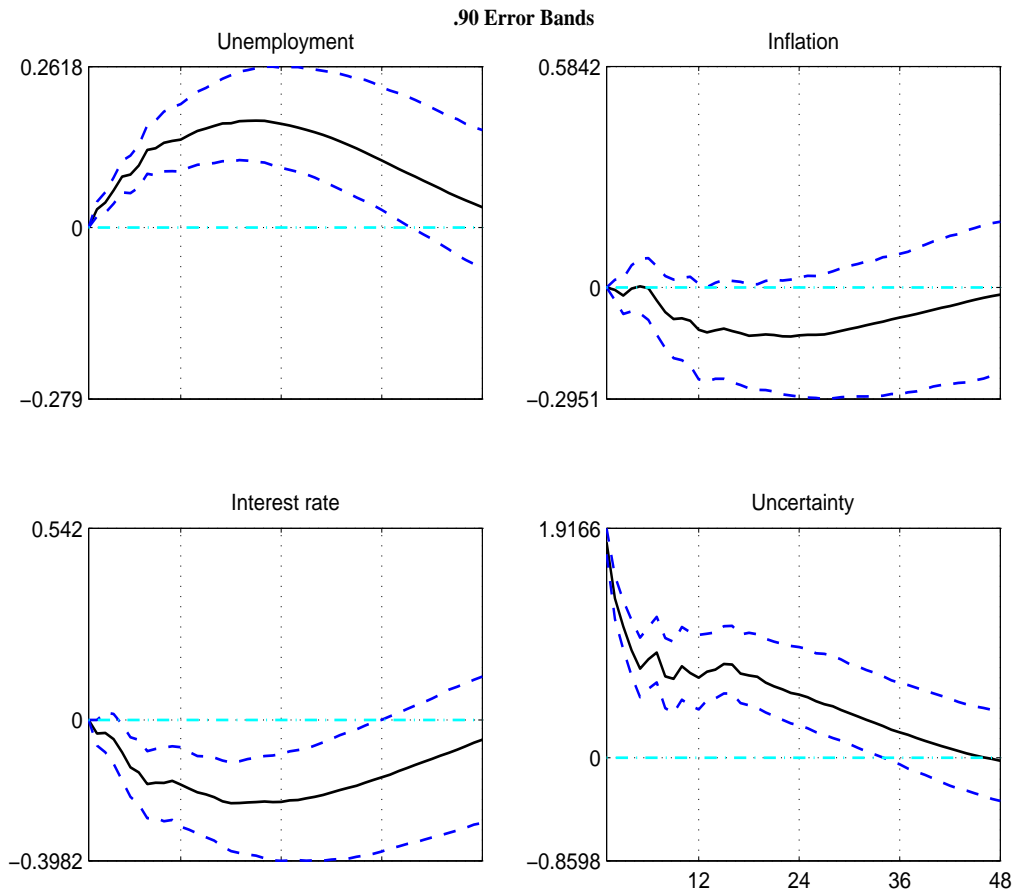


FIGURE 8. The effects of a one-standard deviation shock to perceived uncertainty in the Michigan Survey of Consumers: uncertainty measure ordered last.

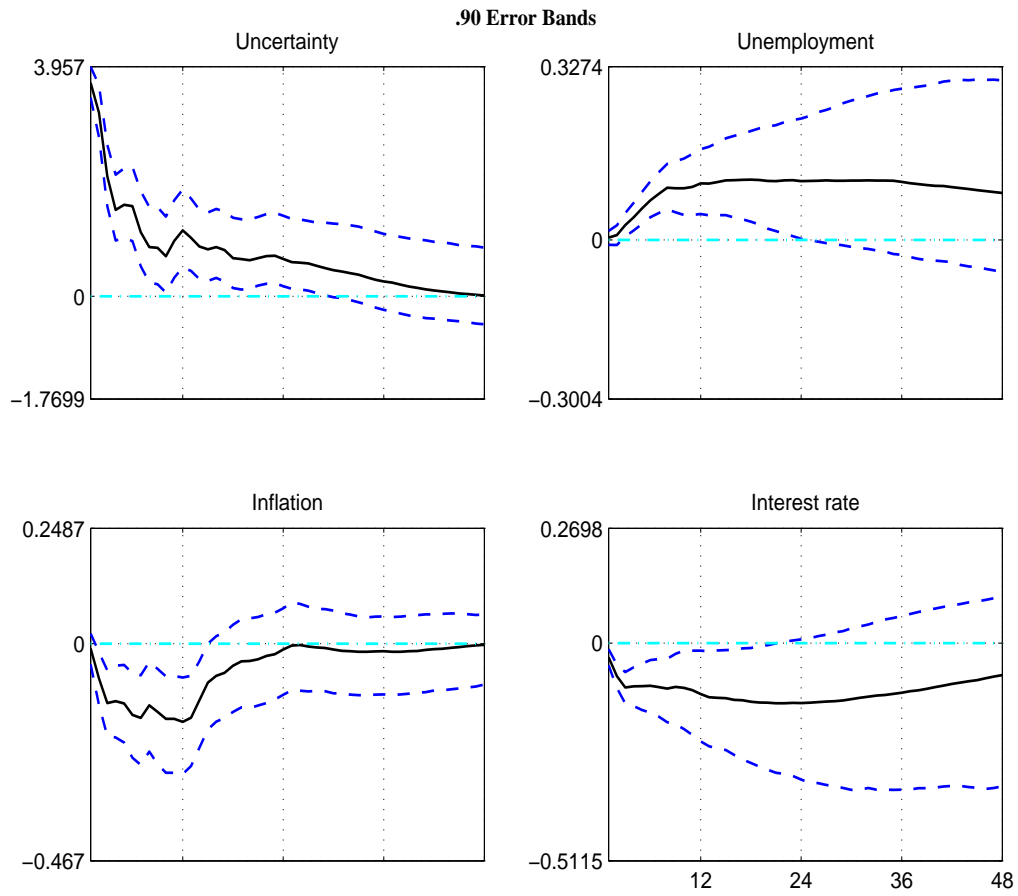


FIGURE 9. The effects of a one-standard deviation shock to the VIX index

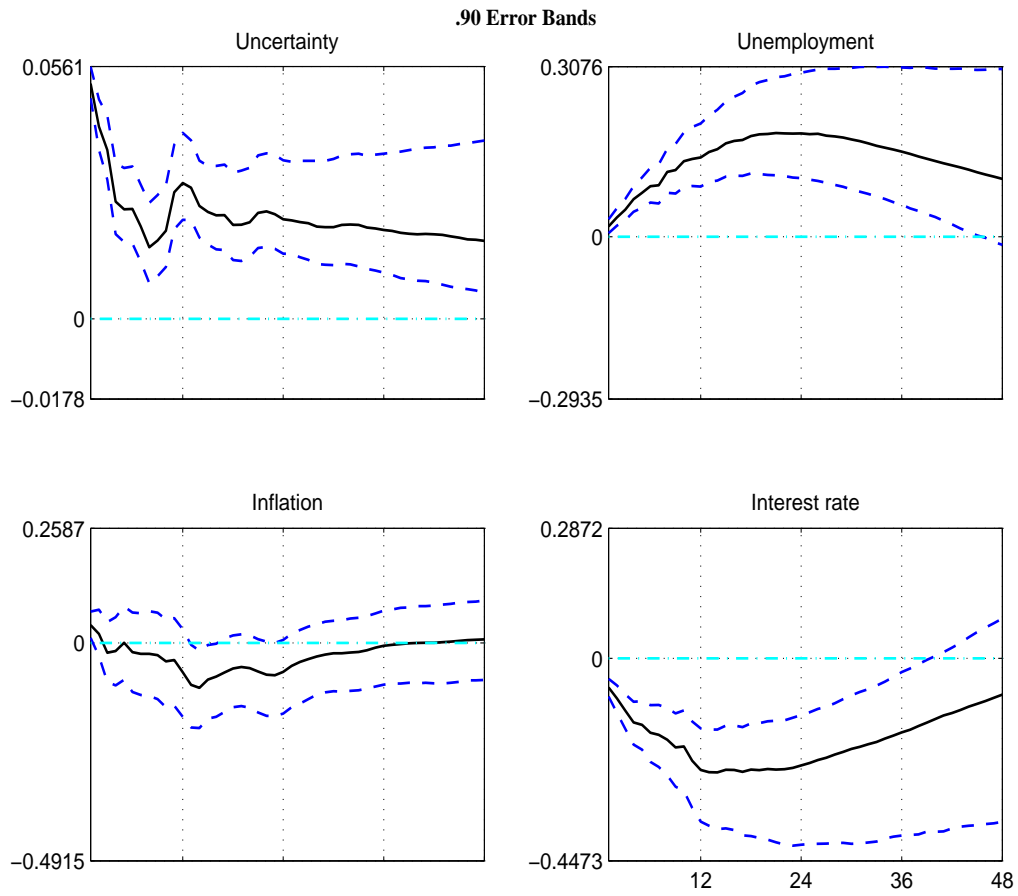


FIGURE 10. The effects of a one-standard deviation shock to policy uncertainty.

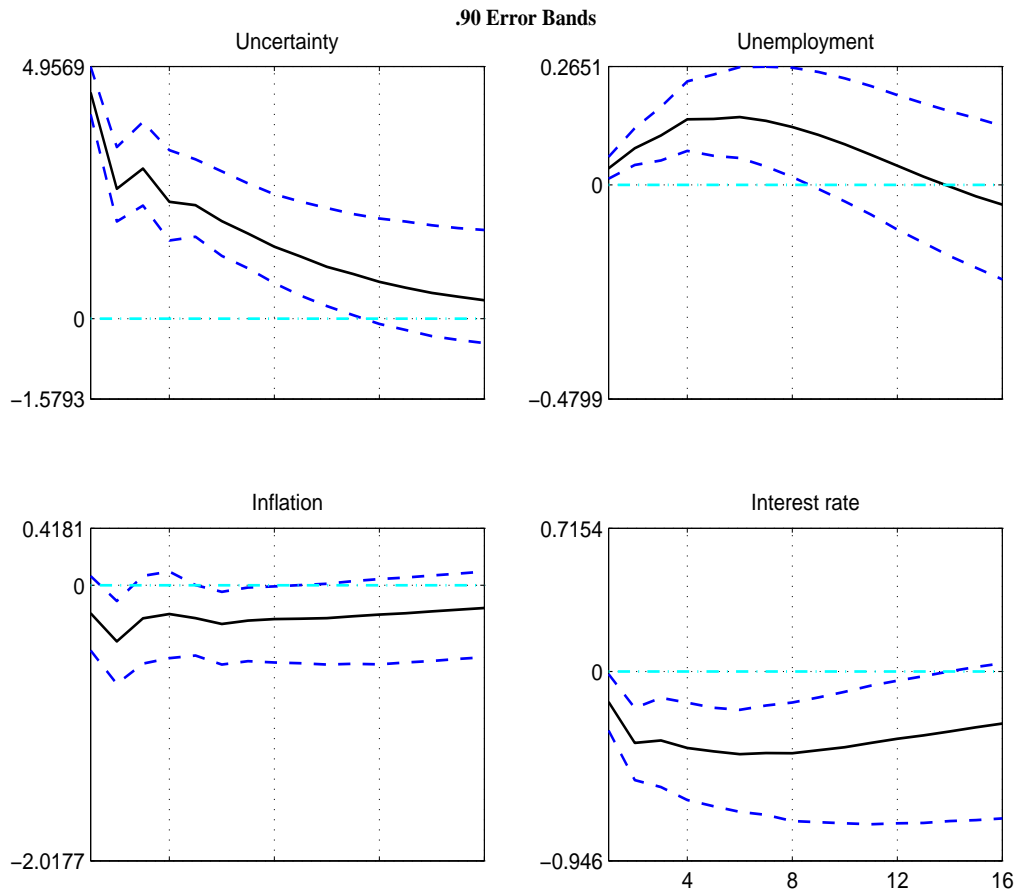


FIGURE 11. The effects of a one-standard deviation shock to perceived uncertainty in the CBI Industrial Trends Survey in the United Kingdom.

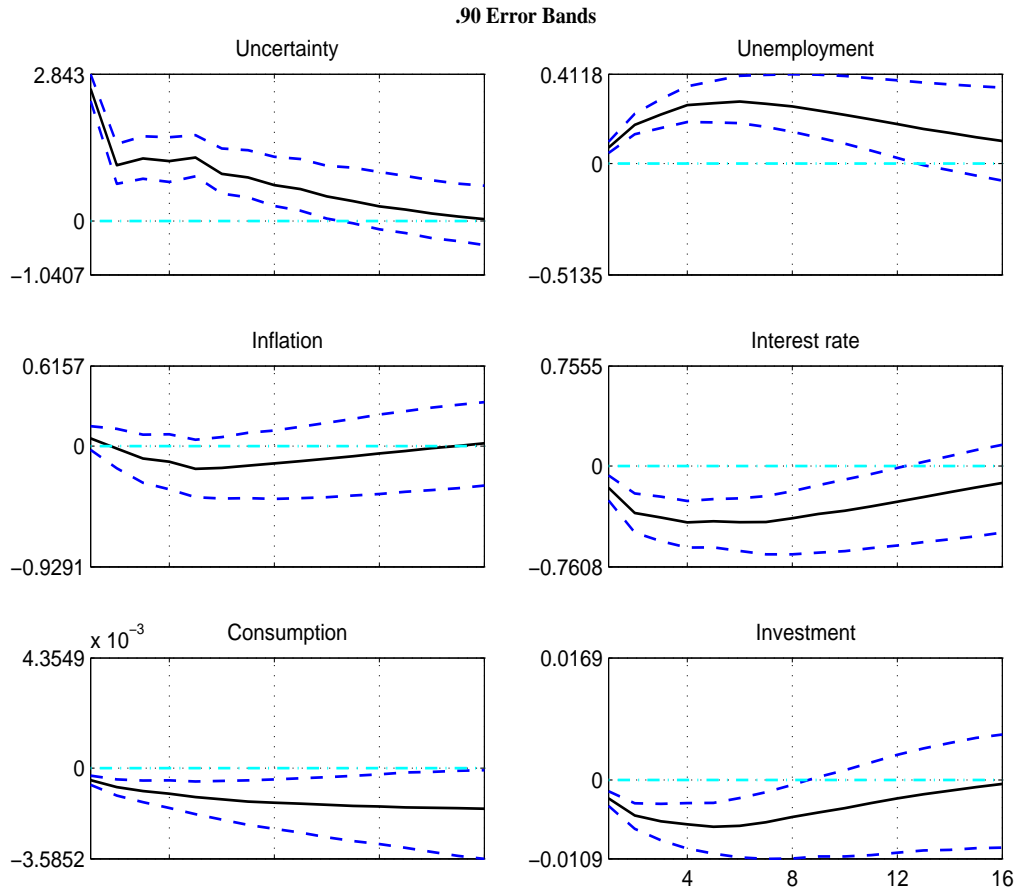


FIGURE 12. Uncertainty shock in the VAR model augmented with consumption and investment (quarterly U.S. data, 1978:Q1-2011:Q1)

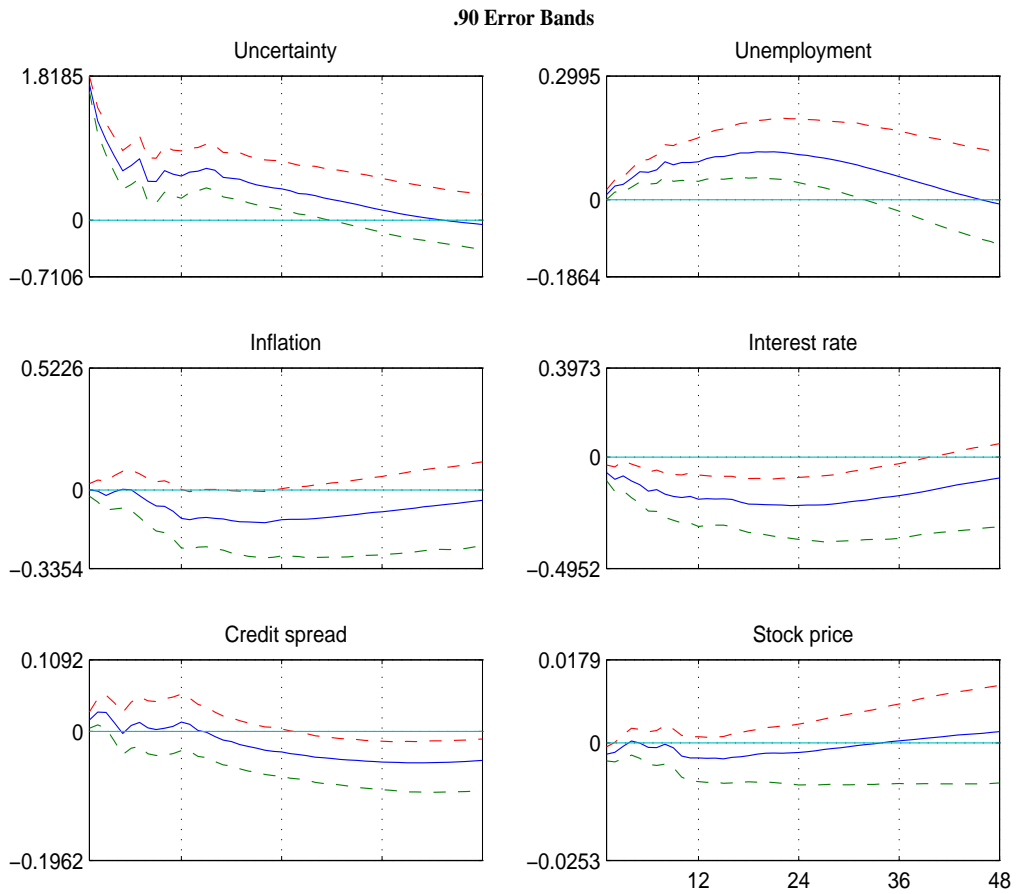


FIGURE 13. Uncertainty shock in the VAR model augmented with credit spread and stock prices (monthly U.S. data, January 1978–March 2011).

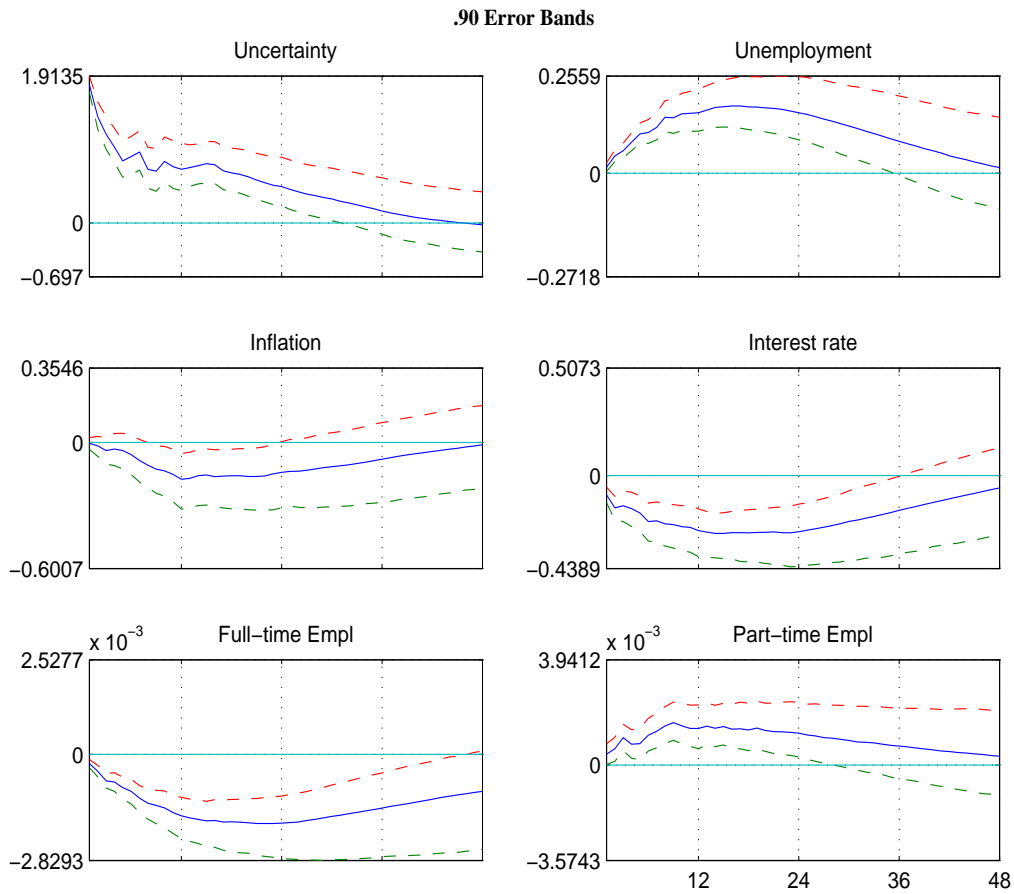


FIGURE 14. Uncertainty shock in the VAR model augmented with full-time and part-time employment (monthly U.S. data, January 1978–March 2011).



## REFERENCES

- ALEXOPOULOS, M., AND J. COHEN (2009): “Uncertain Times, uncertain measures,” University of Toronto Department of Economics Working Paper 352.
- ARELLANO, C., Y. BAI, AND P. KEHOE (2011): “Financial Markets and Fluctuations in Uncertainty,” Federal Reserve Bank of Minneapolis Research Department Staff Report.
- AUERBACH, A. J., AND Y. GORODNICHENKO (2012): “Measuring the Output Responses to Fiscal Policy,” *American Economic Journal: Economic Policy*, 4, 1–27.
- BACHMANN, R., S. ELSTNER, AND E. SIMS (2011): “Uncertainty and Economic Activity: Evidence from Business Survey Data,” University of Michigan Working Paper.
- BAKER, S. R., N. BLOOM, AND S. J. DAVIS (2011): “Measuring Economic Policy Uncertainty,” Stanford University Working Paper.
- BASU, S., AND B. BUNDICK (2011): “Uncertainty Shocks in a Model of Effective Demand,” Boston College Working Paper.
- BASU, S., AND J. G. FERNALD (1997): “Returns to Scale in U.S. Production: Estimates and Implications,” *Journal of Political Economy*, 105(2), 249–283.
- BERNANKE, B. S., M. GERTLER, AND S. GILCHRIST (1999): “The Financial Accelerator in a Quantitative Business Cycle Framework,” in *The Handbook of Macroeconomics*, ed. by J. B. Taylor, and M. Woodford, pp. 1341–1393. Elsevier Science B.V., Amsterdam, North Holland.
- BLANCHARD, O. J., AND J. GALI (2010): “Labor Markets and Monetary Policy: A New Keynesian Model with Unemployment,” *American Economic Journal: Macroeconomics*, 2, 1–30.
- BLOOM, N. (2009): “The Impact of Uncertainty Shocks,” *Econometrica*, 77(3), 623–685.
- BLOOM, N., M. FLOETOTTO, AND N. JAIMOVICH (2010): “Really Uncertain Business Cycles,” Stanford University Working Paper.
- CHRISTIANO, L., R. MOTTO, AND M. ROSTAGNO (2012): “Risk Shocks,” Unpublished manuscript, Northwestern University.
- DEN HAAN, W. J., G. RAMEY, AND J. WATSON (2000): “Job Destruction and Propagation of Shocks,” *American Economic Review*, 90, 482–498.
- DIAMOND, P. A. (1982): “Aggregate Demand Management in Search Equilibrium,” *Journal of Political Economy*, 90(5), 881–894.
- FERNANDEZ-VILLAVARDE, J., P. GUERRON-QUINTANA, K. KUESTER, AND J. RUBIO-RAMIREZ (2011): “Fiscal Volatility Shocks and Economic Activity,” University of Pennsylvania Working Paper.
- GERTLER, M., AND A. TRIGARI (2009): “Unemployment Fluctuations with Staggered Nash Wage Bargaining,” *Journal of Political Economy*, 117(1), 38–86.

- GILCHRIST, S., J. W. SIM, AND E. ZAKRAJSEK (2010): “Uncertainty, Financial Frictions, and Investment Dynamics,” Boston University Working Paper.
- HALL, R. E., AND P. R. MILGROM (2008): “The Limited Influence of Unemployment on the Wage Bargain,” *American Economic Review*, 98,(4), 1653–1674.
- LEDUC, S., AND K. SILL (forthcoming): “Expectations and Economic Fluctuations: An Analysis Using Survey Data,” *Review of Economics and Statistics*.
- LEDUC, S., K. SILL, AND T. STARK (2007): “Self-Fulfilling Expectations and the Inflation of the 1970s: Evidence From the Livingston Survey,” *Journal of Monetary Economics*, 54(2), 433–459.
- MORTENSEN, D. T., AND C. A. PISSARIDES (1994): “Job Creation and Job Destruction in the Theory of Unemployment,” *Review of Economic Studies*, 61(3), 397–415.
- ROTEMBERG, J. J. (1982): “Sticky Prices in the United States,” *Journal of Political Economy*, 90(6), 1187–1211.
- SCHAAL, E. (2012): “Uncertainty, Productivity and Unemployment in the Great Recession,” Unpublished manuscript, Federal Reserve Bank of Minneapolis.