Essays on Labour Market Fluctuations

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Declaration of Authorship

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

Abstract

This thesis consists of three chapters. In the first chapter, I study the long-run effect of financial shocks on labour market fluctuations. I propose a DSGE model where firms and households interact in a frictional financial and labour market. The results show that financial shocks have significant effects on extensive and intensive labour margin, unemployment, vacancy, and firm's flows of financing during the last three recessions: 1990-91, 2001, and 2008. These results rely on the period till the end of the 2008 financial crisis consistent with the literature. I extend the analysis by including the 2008 post crises period. The results suggest that even though the model can capture downturns and recoveries in 1990-91, 2001, and 2008, the model simulations cannot capture the vacancy-unemployment relationship implying that other factors have affected the Beveridge curve aftermath of the 2008 financial crisis. The second chapter shows that labour force participation and search intensity are quantitatively important for the unemployment dynamics. I estimate a search and matching model that incorporates endogenous labour force participation and variable search intensity. Business cycle fluctuations are driven by shocks to productivity and discount factor. The results suggest that participation and aggregate search intensity are procyclical, and search intensity amplifies the response of unemployment. Fluctuation in unemployment is higher than a standard search model, and discount factor shocks significantly affect labour market dynamics. The third chapter shows how uncertainty affects search intensity, participation, and unemployment dynamics. I obtain perceived uncertainty measure and construct search intensity data to match the key features of a medium-scale DSGE model. I find that uncertainty gives rise to a discouragement effect. Thus, labour force participation and search intensity decline during increased uncertainty in addition to the increase in unemployment. The model suggests that the presence of nominal rigidities reinforces the fluctuations in the labour market. Labour force participation increases only due to habit formation, which gives rise to the wealth effect. However, an increase in participation does not increase aggregate search intensity since unemployment is higher in this case.

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Contents

Chapter 1

Credit Market Imperfections, Financial Shocks, and Labour Market Dynamics

1.1 Introduction

Do financial shocks that originated in the financial market explain the volatility observed in labour market variables? What role do financial shocks play in an economy with frictions associated with vacancy creation, hiring and adjusting hours per worker?

After the 2008 financial crisis, there have been numerous studies to understand the role of financial factors and frictions that can affect macroeconomic variables. Recent studies mostly focused on financial frictions. These frictions mostly arise from a contract with imperfect enforcement. Early researches such as Moore and Kiyotaki (1997), Carlstrom and Fuerst (1997), Bernanke et al. (1999) focus on understanding the channels through which financial market disruptions affect the economic activity. These studies show that firms ability to borrow depends on the collateralizable assets they have. They can borrow only a fraction of their assets, and the lender can recover this amount in case of default. These studies have considered the financial sector to play a role in propagation shocks that originate in other sectors of the economy, such as propagation of productivity and monetary shocks. This study differs from this literature by focusing on the shocks that originated in the financial market by employing frictional labour and financial market model. To understand the role of financial shocks in labour market fluctuations, I develop a dynamic stochastic general equilibrium framework that incorporates financial and labour market frictions and adjustment in extensive and intensive labour margin.

The model builds on Jermann and Quadrini (2012) and extends it to incorporate search and matching frictions. The extension allows to generating cyclical variations of employment, unemployment, and hours per worker. Firms in the model adjust intensive and extensive margin of labour. In addition to vacancy creation costs, firms also face adjustment costs of hours per worker. The simulations show that labour market dynamics are primarily driven by financial shocks during last recessions: 1990s, 2000s, and Great Recession. However, financial shocks are not the only factor affecting long-run macroeconomic dynamics. Financial shocks and productivity shocks together explain the long-run macroeconomic dynamics. The simulations show that adjustment in intensive margin can be mostly explained by financial shocks. The model simulation and data for hours per worker fits perfectly as a response to financial shocks. The model captures the Beveridge

Curve-vacancy and unemployment relationship- very close to data. These findings are based on the period that the Great Recession has ended. I extend the model by including post crises recovery period. Interestingly, the model can not capture the Beveridge Curve just after the Great Recession. Model simulations can still capture the cyclicality of unemployment and vacancy in previous recessions. These findings raise questions regarding Beveridge Curve and structural change in labour market dynamics after the Great Recession. The model suggests that there have been structural changes in labour market dynamics after the Great Recession. This finding is consistent with Barnichon (2010) showing that the increase in the unemployment rate can not be fully explained by the drop in vacancy posting, which indicates a large shift in Beveridge Curve due to a structural change such as a decrease in matching efficiency. I also study different versions of the base model: hours bargaining and frictionless hours adjustment. The results suggest that the hours bargaining model and frictionless hours adjustment model can not replicate the volatility of labour market variables. When no adjustment cost in intensive margin is allowed, the model overstates the variations in hours adjustment and impairs the variation of labour market variables.

As the studies suggest, financial frictions, which are represented as the borrowing ability of firms, tightening credit conditions was followed by a substantial increase in unemployment rates. The response of the labour market variables such as job creation, unemployment, vacancy posting by firms to the changes in the credit/-financial conditions constitutes an important exercise for policy and theory. The search and matching model proposed by Mortensen and Pissarides (1994) has been argued because of its inability to explain high volatilities of unemployment, vacancy and market tightness. Researchers have focused on whether the lack of internal propagation stems from the structure of the model or setting different calibrations. In light of these findings, the link between credit and the labour market constitutes an important factor that can help understand the labour market dynamics.

This paper focuses on the link between financial and labour market frictions and how this framework affects the fluctuation in the labour market variables. This paper also analyzes the firms' flow of financing and the labour market outlook. I follow Jermann and Quadrini (2012) to model financial frictions. In terms of the labour market, they only study the variations in the hours worked as the labour input. I use their model by focusing on the extensive and intensive margin of labour. Many studies which focus on the effect of credit condition on macroeconomic aggregates model labour as either extensive or intensive margin. In other words, labour input is either total hours or the number of employed people. Ohanian and Raffo (2012) show that in many OECD countries, variation in extensive margin is as much as variation in the extensive margin. For instance, in the US economy, volatility of the intensive margin accounts for approximately one-third of the variability of aggregate hours. For Europe, the contribution of intensive margin is higher. However, for some countries such as Japan, intensive margin explains 79% of variations in total labour input Kudoh et al. (2019). Ohanian and Raffo (2012) also suggest that employment alone is a poor proxy for labour input and provides a poor measure of productivity because in many OECD countries, approximately 50% of labour adjustment is along the intensive margin. In the light of this evidence, it constitutes an important aspect for understanding the labour market dynamics with respect to financial and productivity shocks. Jermann and Quadrini (2012) show how total hours are affected by financial and productivity shock. Their study does not tell how the labour margins respond to these shocks from a theoretical perspective.

This paper is closely related to the recent papers that seek to understand the role of changes in credit conditions on macroeconomics aggregates and labour market dynamics. Garín (2015) develops a general equilibrium model that incorporates credit shocks into a search and matching model to study cyclical properties of unemployment and job creation. He finds that credit conditions significantly affect unemployment, vacancy, and labour market tightness. Petrosky-Nadeau (2014) finds that the opportunity cost of resources arises from a problem of asymmetric information, and this opportunity cost of resources allocated to hiring is the main driver of the cyclicality of job creation and labour market dynamics. This paper differs from these studies across a few dimensions. First, I focus on the extensive and intensive margin of labour and flows of financing such as equity and debt. Second, I study the long-run implication of financial shocks. This paper is also related to Zanetti (2019) which extends Jermann and Quadrini (2012) by incorporating search and matching frictions and estimating a DSGE model. He finds that financial shocks are an important source of fluctuations in wages, and shocks to the job destruction rate are important for unemployment fluctuations. This paper differs from his study in two aspects. First, I mainly focus on the extensive and intensive margin of labour adjustment and show how financial conditions affect the labour market. Secondly, different than Zanetti (2019), I focus on the long-run implication of financial shocks by including the aftermath of the Great Recession.

1.2 Model

I incorporate search and matching as in Cacciatore et al. (2019) and Kudoh et al. (2019) into the financial friction model in the spirit of Jermann and Quadrini (2012). The model consists of firms, households and government. Firms produce using capital and labour, transfer dividends to the shareowners(business owners). Households decide how much to consume and how much risk-free bond to purchase, and they get dividends for the share they have. The agents interact in frictional labour and financial market. The labour allocation from households to the firms is characterized by a costly matching process as in Merz (1995). Firms also face adjustment costs of hours per worker. Firms use debt and equity to finance the payments to workers, suppliers of investments, shareholders, bondholders and vacancy posting costs. The payment needs to be made before the realization of revenues. Firms face collateral requirements that limit their ability to borrow. There is a substitution between debt and equity financing. Otherwise, firms will be indifferent between debt and equity.

1.2.1 Timing

Timing of events in the labor market is similar to Kudoh et al. (2019). Given the state variables $s_t = (k_t, b_t, n_t, U_t)$, firm and workers bargain over earning schedule, which maps h into an amount of compensation W. Firm use intraperiod loan to finance labor compensation, hiring and investment costs, and issuing equity payout and net debt. The firm cash revenue after production takes place. The level of earning W is realized after hours of work are determined only after earning schedule is agreed. With bargaining outcome, $W(h_t; s_t)$, firm chooses hours of work per employee(h_t), and post vacancy (V_t) to hire workers for the next period. The production takes place and δn_t of employees exogenously separate from their jobs at the end of the period. The number of new employees for the next period is $p(\theta_t)V_t$

1.2.2 Firms

There is continuum of firms in the $[0, 1]$ interval. z_t is the stochastic level of productivity, common to all firms, k_t, n_t, and h_t are the input of capital, labor, and hours per worker respectively. Adjusting hours is costly for the firm and $\tilde{h}_t = h_t[1 - \frac{\phi_h}{2}(h_t - h)^2]$ denotes hours per worker net of a cost of adjustment $\phi_h \geq 0$. α is the capital share and k_t is predetermined at time t. Firms produce a homogeneous good using a Cobb-Douglas technology.

$$F(z_t, k_t, n_t, \tilde{h}_t) = z_t k_t^{\alpha} \tilde{h}_t^{1-\alpha} n_t^{1-\alpha} \tag{1.1}$$

Capital evolves according to the equation below. i_t is the investment and δ is the depreciation rate.

$$k_{t+1} = (1 - \delta)k_t + \left[\frac{\varrho_1 \left(\frac{i_t}{k_t}\right)^{1-\nu}}{1 - \nu} + \varrho_2 \right] k_t \tag{1.2}$$

Firms use equity and debt. Debt, b_t is preferred to equity because of its tax advantage τ represents the tax benefit. r_t is the interest rate and effective gross interest rate for the firm is given by;

$$R_t = 1 + r_t(1 - \tau) \tag{1.3}$$

The intraperiod loan covers payments to workers, shareholders and bondholders, investment expenditures, expenses related to posting vacancies. Moreover, the loan has to be made before the realization of revenues. Firms start the period with debt b_t. The intraperiod loan is repaid at the end of the period, and there is no interest. Loan contracted by the firm;

$$l_t = W_t n_t + \kappa_v V_t + i_t + d_t + b_t - \frac{b_{t+1}}{R_t} \tag{1.4}$$

Budget constraint of the firm;

$$b_t + \kappa_v V_t + W_t n_t + k_{t+1} + d_t = (1 - \delta)k_t + F(z_t, k_t, n_t, \tilde{h}_t) + \frac{b_{t+1}}{R_t} \tag{1.5}$$

Using Equation 1.4 and 1.5 can verify that intraperiod loan is equal to the firm's revenue.

$$l_t = F(z_t, k_t, n_t, \tilde{h}_t) \tag{1.6}$$

At this period, the firm's liabilities are the intra-period loan plus new debt, $l_t + b_{t+1}/R_t$. Ability to borrow is bounded by the limited enforceability of debt contracts as firms can default on their obligation. The liquidity, $l_t = F(z_t, k_t, n_t, \tilde{h}_t)$ firm holds can be easily diverted and can not be recovered by the lender in case of default. Therefore, the only asset available to liquidation is the physical capital. In the case of default, lender can recover a fraction of the value of k_{t+1}. This is a common property for most of the collateral constraint literature. The value of the physical capital is uncertain at the time of contracting loan. With a probability ξ_t the lender can cover the full value of k_{t+1} and with probability $1 - \xi_t$ recovers zero. The enforcement constraint

$$\xi_t \big(k_{t+1} - \frac{b_{t+1}}{1 + r_t}\big) \geq l_t \tag{1.7}$$

The enforcement constraint equation shows how debt, stock of capital are related to the enforcement constraint. Enforcement constraint is tighter when debt is high. It also shows that higher stock of capital relaxes enforcement constraint. ξ_t is stochastic and depends on the market conditions. Value of ξ_t affects the tightness of the enforcement constraint. Therefore, firms' borrowing capacity will be affected by the change of its value. The financial shock is defined as stochastic innovations. There are two sources of shocks: productivity and financial shock. The shocks are common to all firms; there are no idiosyncratic shocks.

To see how ξ_t affects the financing and production decision of firms; consider $\tau = 0$ and $R_t = 1 + r_t$ using 1.5 to eliminate $k_{t+1} - \frac{b_{t+1}}{1+r_t}$ enforcement constraint can be written as;

$$\big(\frac{\xi_t}{1 - \xi_t}\big)\big[(1 - \delta)k_t - b_t - W_t n_t - d_t - \kappa_v V_t\big] \geq F(z_t, k_t, n_t, \tilde{h}_t) \tag{1.8}$$

At the beginning of the period k_t, b_t, n_t are given. In other words, they are predetermined. The variables firms have control over are equity payout, d_t, and vacancy, V_t. In case of a negative financial shock, lower ξ_t, if the firms want to keep the production same, the shock will lead to either reduction in equity payout, d_t, or wages w_t, or hiring Υ_t. The impact of negative shocks differs from the case in which there is both labour and financial frictions. If the firms want to keep production at the same level, it is forced to increase their equity and decrease the new intertemporal debt. The firms have to cut employment if they can not reduce d_t. The effect of the shocks on employment depends on the firms' financial structure, the composition of debt and equity.

There is rigidity that affects firms' ability to substitute between debt and equity. The firms are subject to quadratic adjustment costs. Given d_t equity payout, the actual cost for the firms is;

$$\varphi(d_t) = d_t + \kappa(d_t - \bar{d})^2 \tag{1.9}$$

where $\kappa \geq 0$ and $\bar{d}$ is the steady-state(long-run payout). κ is important to determine the impact of financial shocks. When $\kappa = 0$, the economy is equivalent to a frictionless economy. The equity payout cost $\varphi(d_t)$ can be considered to include pecuniary costs such as share repurchases and equity issuance costs. In terms of modelling, this equity payout cost describes how firms change the source of funds when there is a change in the financial conditions. Adjustment cost of the equity payout can also be considered the managers' preferences concerned about the dividend smoothing over time. Lintner (1956) shows that managers are concerned about smoothing dividends over time. When $\kappa = 0$, equity cost is equal to dividend, $\varphi(d_t) = d_t$. We can see from the equation 1.5 that without equity adjustment cost, dividend cost is simply the amount of dividend, d_t, paid to the shareholders. Adjusting debt and equity becomes costly, and firms adjust their fund source slowly when $\kappa > 0$.

$s_t = (k_t, b_t, n_t, U_t)$ is the set of state variables. Firms and employees bargain over earning, which maps hours into earning $W(h_t; s_t)$ where $W(h_t; s_t)$ is earning profile. Hours of work are determined after the earning is bargained. Firm's optimization problem;

$$V(s_t) = \max_{d_t, h_t, v_t, i_t, k_{t+1}, b_{t+1}} \{d + E_t m_{t+1} V(s_{t+1})\} \tag{1.10}$$

subject to

$$F(z_t, k_t, n_t, \tilde{h}_t) - W_t n_t + \frac{b_{t+1}}{R_t} - = b_t + \varphi(d_t) + i_t + \kappa_v V_t$$

$$\xi_t \big(k_{t+1} - \frac{b_{t+1}}{1 + r_t}\big) \geq F(z_t, k_t, n_t, h_t)$$

$$n_{t+1} = (1-\delta_n)n_t + p(\theta_t)V_t$$

First order conditions for $d_t, i_t, , k_{t+1}h_t, v_t, , b_{t+1},;$ implies

$$\lambda_t = \frac{1}{\varphi_d(d_t)}$$

where λ_t is the Lagrange multiplier for budget constraint.

Foc i_t;

$$\lambda_t = q_t \varrho_1 (\frac{i_t}{k_t})^{-\nu}$$

$$\frac{1}{\varphi_d(d_t)} = q_t \varrho_1 (\frac{i_t}{k_t})^{-\nu}$$

Foc k_{t+1};

$$q_t = \mu_t \xi_t + E_t m_{t+1} \Bigg[(\frac{1}{\varphi_d(d_{t+1})} - \mu_{t+1}) F_{k,t+1} - \frac{1}{\varphi_d(d_{t+1})} W^k_{t+1} n_{t+1} + q_{t+1}(1 - \delta + \varrho_1 \frac{\nu}{1-\nu} (\frac{i_{t+1}}{k_{t+1}})^{1-\nu} + \varrho_2) \Bigg] \quad (1.11)$$

Foc b_{t+1};

$$R_t E_t m_{t+1} \left(\frac{\varphi_d(d_t)}{\varphi_d(d_{t+1})} \right) + \xi_t \mu_t \varphi_d(d_t) \left(\frac{R_t}{1+r_t} \right) = 1 \quad (1.12)$$

Foc V_t;

$$E_t m_{t+1} V_n(s_{t+1}) = \frac{\kappa_v}{\varphi_d(d_t) p(\theta_t)} \quad (1.13)$$

Foc h_t;

$$(1 - \mu_t \varphi_d(d_t))(1-\alpha) z_t k^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha} \Delta_{\tilde{h}_t} = W_t^h \quad (1.14)$$

where $\Delta_{\tilde{h}_t} = \frac{\partial \tilde{h}_t}{\partial h_t} = \frac{\tilde{h}_t}{h_t} - \phi_h h_t (h_t - h)$

We can see from equation 1.9 that $\varphi_d(d_t) = \varphi_d(d_{t+1}) = 1$ when $\kappa = 0$. In this case Equation 1.12 reduces to $R_t E_t m_{t+1} + \xi_t \mu_t R_t (1+r_t)$=1 which shows the negative relationship between ξ and μ.

1.2.3 Labor market

I introduce labour market frictions by following the common approach of Mortensen and Pissarides (1994) adapted to a representative agent framework as in Merz (1995), Krause et al. (2008). I also include hours adjustment cost per worker.

There is a real search and matching friction in the labour market, which prevents all job seekers from being matched with vacancies posted by the firms, and some of the workers end up unemployed. Firms face hours adjustment costs, which captures various frictions such as set-up costs and coordination issues.

The labor market matching process combines unemployed job seekers with job openings(vacancies). In order to be able to hire a worker, firms need to post a vacancy, V_t, which incurs vacancy-posting cost κ_v. Total cost of posting vacancies is simply $\kappa_v V_t$. Firms and workers have to meet and make a match. The search process is costly and a job match yields a rent which is shared according to a bargaining rule. The matching technology follows Cobb-Douglas function;

$$M(U_t, V_t) = \bar{\zeta} U_t^{\zeta} V_t^{1-\zeta} \tag{1.15}$$

where $\bar{\zeta}$ is the scale factor representing the state of the matching technology and ζ is the elasticity of matches with respect to unemployment. $\theta_t = \frac{V_t}{U_t}$ is the labor market tightness. Probability of filling a vacancy and probability of finding job are $\frac{M(U_t,V_t)}{V_t} = p(\theta_t) = \bar{\zeta}\theta_t^{-\zeta}$ and $f(\theta_t) = \bar{\zeta}\theta_t^{1-\zeta} = \theta_t p(\theta_t)$. Once there is a match, jobs are destroyed at the exogenous rate of δ_n per period. In this economy, the number of the unemployment U_t equals to the unemployment rate as the labor force is normalized to unity. Separation rate δ_n is constant over time. Employment n_t and U_t evolves accordingly;

$$n_{t+1} = (1 - \delta_n) n_t + p(\theta_t) V_t \tag{1.16}$$

$$U_{t+1} = U_t + \delta_n (1 - U_t) - \theta_t p(\theta_t) U_t \tag{1.17}$$

Firms begin a period with a stock of n_t workers. At the beginning of each period, a fraction, δ_n, of all employed workers are exogenously separated from the firms. Thus, the number of workers in the next period, n_{t+1}, consist of new matches in period t plus the number of workers who have not separated.

In steady state, flow into employment $\theta p(\theta)$ is equal to flow into unemployment $\delta_n(1-U)$ as defined Beveridge curve. Since the labor market tightness is given by $\theta_t = V_t/U_t$ and number of firms normalized to unity, I obtain

$$\frac{1 - U_t}{n_t} = 1 \tag{1.18}$$

which gives the aggregate number of firms in the economy.

1.2.4 Nash Bargaining Earning

The wage is determined by solving a Nash bargaining problem between workers and firms takes place in order to decide how to split the surplus produced by a match. The marginal value of having an extra worker for the firm, which is obtained by taking the derivative of the firm's value function, V, with respect to labour is:

$$V_n(s_t) = \frac{F_{n,t}}{\varphi_d(d_t)} - \frac{W_t}{\varphi_d(d_t)} - \frac{W_t^n n_t}{\varphi_d(d_t)} - \mu_t F_{n,t} + (1-\delta_n) E_t m_{t+1} V_n(s_{t+1}) \tag{1.19}$$

Hours of work are determined by the firm. Hours, h, and level of disutility is taken given by the worker. Value of being employed;

$$V^E(s_t) = W_t - e(h_t) + E_t m_{t+1} \big[(1-\delta_n) V^E(s_{t+1}) + \delta_n V^U(s_{t+1})\big] \tag{1.20}$$

An unemployed worker receives unemployment benefit s and expects to move into employment with probability $f(\theta_t) = \theta_t p(\theta_t)$. Thus, value of an unemployed worker is;

$$V^U(s_t) = s + E_t m_{t+1} \big[\theta_t p(\theta_t) V^E(s_{t+1}) + (1 - \theta_t p(\theta_t)) V^U(s_{t+1})\big] \tag{1.21}$$

the wage result from the bargaining problem:

$$arg \max_{W_t} [V_n(s_t)]^{1-\eta} [V^E(s_t) - V^U(s_t)]^{\eta} \tag{1.22}$$

$$\eta V_n(s_t) = (1-\eta) \frac{1}{\varphi_d(d_t)} (V^E(s_t) - V^U(s_t))$$

where $\eta \in (0, 1)$ is the worker's bargaining power in the process of wage negotiation. The solution to this problem is given by the Nash bargaining rule.

$$\psi_t V_n(s_t) = (1-\psi_t)(V^E(s_t) - V^U(s_t)) \tag{1.23}$$

where $\psi_t = \eta/(\eta + (1-\eta)/\varphi_d(d_t))$ is the effective bargaining power. I drive earning by using worker and firm surplus along with the Nash bargaining rule.

Proposition 1.1. *Nash bargaining earning profile is;*

$$W_t = (1-\mu_t\varphi_d(d_t))\frac{(1-\alpha)\eta z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}}{1-\alpha\eta}n_t^{-\alpha} + \\ (1-\eta)[e(h_t)+s] + \eta\frac{\kappa_v}{p(\theta_t)}\left[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\right] \quad (1.24)$$

Proof. See Appendix 1.5.2 □

Equation 1.24 shows that the wage depends on the bargaining power, credit conditions, vacancy cost, and labour market tightness. The marginal product of labour is influenced by the tightness of the credit market. The wage equation shows that both financial and productivity shocks affect the wage. The multiplier for the enforcement constraint μ and $\mu\varphi_d(d)$ determines the labour wedge. A negative financial shock increases the term $\mu\varphi_d(d)$ and makes the constraint tighter. The negative productivity shock will decrease the marginal product of labour F_n. However, the same shock also relaxes the constraint and leads to a decrease in μ as seen in Equation 1.8. Thus, the effect of negative productivity shock on the wage can not be seen clearly in the equation.

In addition to the μ in the wage equation, another friction comes from the equity cost adjustment. Since $\varphi_d(d) = 1 + 2\kappa(d-\bar{d})$, change in d or κ will also have an effect on the wage.

From Equation 1.24;

$$W_t^h = (1-\mu_t\varphi_d(d_t))\frac{\eta(1-\alpha)^2 z_t k_t^{\alpha}\tilde{h}_t^{-\alpha}n_t^{-\alpha}}{1-\eta\alpha}\Delta_{\tilde{h}_t} + (1-\eta)e'(h_t) \quad (1.25)$$

The marginal hourly wage rate, W_t^h, is nonlinear in hours worked and is influenced by the marginal product of hours per worker, marginal disutility from long hours of work, and wedge from financial friction.

$$W_t^n = -(1-\mu_t\varphi_d(d_t))\alpha\frac{(1-\alpha)\eta z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}n_t^{-\alpha-1}}{1-\eta\alpha} \quad (1.26)$$

$$W_t^k = (1-\mu_t\varphi_d(d_t))\frac{\eta\alpha(1-\alpha)z_t k_t^{\alpha-1}\tilde{h}_t^{1-\alpha}n_t^{-\alpha}}{1-\eta\alpha} \quad (1.27)$$

I use Equation 1.13 and 1.19 to obtain the job-creating condition, equating the average cost of filling a vacancy to the discounted expected marginal value of an additional employed worker.

$$\frac{\kappa_v}{p(\theta_t)} = E_t m_{t+1} \frac{\varphi_d(d_t)}{\varphi_d(d_{t+1})} \left[(1-\mu_{t+1}\varphi_d(d_{t+1})) \frac{(1-\alpha) z_{t+1} k_{t+1}^{\alpha} \tilde{h}_{t+1}^{1-\alpha} n_{t+1}^{-\alpha}}{1-\eta\alpha} - W_{t+1} + (1-\delta_n) \frac{\kappa_v}{p(\theta_{t+1})} \right] \tag{1.28}$$

From Equation 1.14 and 1.25, I obtain firm's optimal choice of hours.

$$(1-\alpha) z_t k^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha} (1-\mu_t \varphi_d(d_t)) \Delta_{\tilde{h}_t} = (1-\mu_t \varphi_d(d_t)) \frac{\eta (1-\alpha)^2 z_t k_t^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha}}{1-\eta\alpha} \Delta_{\tilde{h}_t} + (1-\eta) e'(h_t) \tag{1.29}$$

Or

$$(1-\mu_t \varphi_d(d_t)) \frac{(1-\alpha) z_t k^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha} \Delta_{\tilde{h}_t}}{1-\eta\alpha} = e'(h_t)$$

I consider an alternative model in which hours of work per employee are determined by bargaining

$$\frac{\partial [V_n(s_t)]}{\partial h} + \frac{\partial [V^E(s_t)]}{\partial h} = 0$$

where $\partial[V_n(s_t)]/\partial h_t = (1-\mu_t\varphi_d(d_t))(1-\eta)(1-\alpha)^2 z_t k^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha} \Delta_{\tilde{h}_t} / \varphi_d(d_t)(1-\eta\alpha) - (1-\eta)e'(h_t)/\varphi_d(d_t)$ and $\partial[V_t^E(s_t)]/\partial h_t = (1-\mu_t\varphi_d(d_t))\eta(1-\alpha)^2 z_t k^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha} \Delta_{\tilde{h}_t} / (1-\eta\alpha) - \eta e'(h_t)$

$$(1-\mu_t \varphi_d(d_t)) \frac{(1-\alpha)^2 z_t k^{\alpha} \tilde{h}_t^{-\alpha} n_t^{-\alpha} \Delta_{\tilde{h}_t}}{1-\eta\alpha} = e'(h_t) \tag{1.30}$$

Equation 1.30 and 1.29, hence, job-creation condition 1.28 and new job-creation equations are nearly identical. However, quantitative results of these two models are significantly different as shown in Table 1.3.

1.2.5 Household

There is a continuum of homogeneous household. The household has access to financial markets. In addition to equity, the household holds noncontingent bonds issued by the firm. All the household members will have the same level of consumption independent of their labour market status.

$$E_0 \sum_{t=0}^{\infty} \beta^t [U(c_t, n_t) - e(h_t)] \tag{1.31}$$

$e(h_t)$ represents disutility from working for h_t hours.

$$e(h_t) = e\frac{h_t^{1+\phi}}{1+\phi}$$

$$W_t n_t + b_t + d_t + U_t s = \frac{b_{t+1}}{1+r_t} + c_t + T_t \tag{1.32}$$

where W_t and r_t are the earning and interest rates, b_t is the one-period bond, d_t is the equity payout received from owning shares, s is unemployment benefit provided by the government. β is the discount factor $0 < \beta < 1$. The household uses its income to acquire new bonds $\frac{b_{t+1}}{1+r_t}$, consume and to pay lump-sum taxes to the government.

Every period households chooses consumption c_t and b_{t+1} to maximize utility function 1.31 with respect to budget constraint 1.32. First order conditions with respect to c_t, b_{t+1};

$$\lambda_{ct} = U_c(c_t, n_t) \tag{1.33}$$

$$U_c(c_t) = \beta(1 + r_t) E_t U_c(c_{t+1}) \tag{1.34}$$

where $U_c(c_t, n_t)$ is the marginal utility of consumption. Equation 1.34 is the household's Euler equation.

1.2.6 Government

The government collects lump-sum taxes T_t from the household to finance tax benefits of the firm debt and government expenditure G_t. The government's budget constraint is

$$T_t = b_{t+1}/R_t - b_{t+1}/(1 + r_t) + U_t s + G_t \tag{1.35}$$

1.3 Quantitative Analysis

I solve the model by using equilibrium conditions 1.7, 1.11, 1.12, 1.24, 1.28, 1.29, 1.34 and budget constraint of household, firm and government. I study three different cases. The first is the base model, which has bargained wages and costly adjustments in hours per worker. For the second case, I consider a model in which hours per worker are determined by bargaining. For the third case, I consider an alternative model in which the adjustment cost of hours per worker is zero. The third case is a different version of the base model. The only difference is the absence of hours per worker adjustment cost. I simulate the model with their counterpart data to show long rung implications of shocks. The model is log-linearized. Therefore, the model variables deviate around zero in the simulations. The data for the variables are detrended and compared with model simulations. In the simulations, model variables respond to the shocks in the first period. Therefore the starting values of model simulations and data are different.

Proposition 1.2. *Enforcement constraint binds in steady state if $\tau > 0$*

Proof. In a deterministic steady state $m = 1/(1+r)$ and $\varphi_d(d) = \varphi_d(d') = 1$. The first order condition for debt equation 1.14 reduces to $Rm + \xi\mu R/(1+r) = 1$ and we get $R(1+r) + \xi\mu R/(1+r) = 1$ implies that $\mu > 0$ if $\tau > 0$. As long as there is tax benefit of debt, the constraint is binding in a steady state. □

I follow Jermann and Quadrini (2012) for the financial and productivity shock process but I reestimate productivity shock process by including hours per worker. For the productivity variable z_t by following the standard Solow residuals approach I get shock process as;

$$\hat{z}_t = \hat{y}_t - \alpha\hat{k}_t - (1-\alpha)(\hat{n}_t + \hat{h}_t) \tag{1.36}$$

where $\hat{z}_t, \hat{y}_t, \hat{k}_t, \hat{n}_t$, and $\hat{h}_t$ are the percentage or log-deviations form the deterministic trend.

The ξ_t series are constructed from enforcement constraint $\xi_t(k_{t+1} - b^e_{t+1}) = y_t$ where $b^e_{t+1} = b_{t+1}/(1+r_t)$. The linearized version of this equation is written as

$$\hat{\xi}_t = \phi_k\hat{k}_{t+1} + \phi_b\hat{b}^e_{t+1} + \hat{y}_t \tag{1.37}$$

where $\phi_k = \bar{\xi}\bar{k}/\bar{y}$ and $\phi_b = \bar{\xi}\bar{b}^e/\bar{y}$.

The autoregressive system is estimated as follow;

$$\begin{pmatrix} \hat{z}_{t+1} \\ \hat{\xi}_{t+1} \end{pmatrix} = \mathbf{A} \begin{pmatrix} \hat{z}_t \\ \hat{\xi}_t \end{pmatrix} + \begin{pmatrix} \epsilon_{z,t+1} \\ \epsilon_{\xi,t+1} \end{pmatrix}$$

where $\mathbf{A}$ is the matrix for the shock process. $\epsilon_{z,t+1}$ and $\epsilon_{\xi,t+1}$ are i.i.d. with standard deviations σ_z and σ_ξ.

Government purchases follows the stochastic process;

$$\ln(G_t) = (1-\rho_G)\ln(G) + \rho_G \ln(G_{t-1}) + \epsilon_{Gt} \tag{1.38}$$

where G is the steady-state level of government purchases.

Steady state Earning(W)

$$W = (1-\mu)\frac{(1-\alpha)\eta z k^{\alpha}\tilde{h}^{1-\alpha}n^{-\alpha}}{1-\eta\alpha} + (1-\eta)[e\frac{h^{1+\phi}}{1+\phi} + s] + \eta\kappa_v\theta \tag{1.39}$$

Steady state job creation condition;

$$\frac{\kappa_v}{p(\theta)} = \beta\Big[(1-\mu)\frac{(1-\alpha)zk^{\alpha}\tilde{h}^{1-\alpha}n^{-\alpha}}{1-\eta\alpha} - W + (1-\delta_n)\frac{\kappa_v}{p(\theta)}\Big] \tag{1.40}$$

By using wage(earning) rule and job creation condition, gives equilibrium labor market tightness; θ

$$(1-\mu)\frac{(1-\alpha)(\eta-1)zk^{\alpha}\tilde{h}^{1-\alpha}n^{-\alpha}}{1-\eta\alpha} + (1-\eta)[e\frac{h^{1+\phi}}{1+\phi} + s] = \kappa_v\big[(1-\delta_n - \frac{1}{\beta})\frac{\theta^{\zeta}}{\bar{\zeta}} - \eta\theta\big] \tag{1.41}$$

1.3.1 Calibration

The basic unit of time is a quarter. Exogenous separation rate, δ_n, is set to 10% as in Shimer (2005). Elasticity of labor-matching function, ζ, is set to 0.50 corresponding the estimate in Shimer (2005) and it is also within the range of values (0.5 to 0.7) reported by Petrongolo and Pissarides (2006). Worker's bargaining power is set to 0.40 which is in the middle range of values reported in the literature. I choose vacancy posting cost κ_v to be 4.3% of steady state wage as it is reported in Silva and Toledo (2009) that total hiring cost to be around 4.3% of the quarterly compensation of a new hired worker.

Table 1.1: Parameters

Parameter	Description	Value
β	Discount factor	0.99
δ	Depreciation rate	0.025
e	Disutility parameter	3.6045
α	Capital share	0.36
τ	Tax advantage	0.35
κ	Payout cost parameter	0.146
$1/\phi$	Frish elasticity	2.5
ϕ_h	Hours adjustment cost parameter	6.95
s	Unemployment benefits	0.1946
κ_v	Vacancy posting cost	0.0335
ζ	Elasticity of match w.r.t unemployment	0.50
$\bar{\zeta}$	Efficiency of match	0.710
η	Worker's bargaining power	0.40
δ_n	Exogenous separation rate	0.10
σ_ξ	Standard deviation of financial shock	0.0086
σ_z	Standard deviation of productivity shock	0.0045
Matrix for shock process	$\mathbf{A}=$	$\begin{matrix} 0.9507 & -0.0174 \\ 0.2682 & 0.9319 \end{matrix}$

Steady state unemployment; the Beveridge curve, $U = \frac{\delta_n}{\delta_n + f(\theta)}$ shows the relationship between unemployment and labor market tightness. Since the model does not account for nonparticipation, several authors targeted steady-state rate of unemployment higher than observed unemployment. Setting high steady-state unemployment rate allows potential participants in the matching market such as discouraged workers and workers loosely attached to the labor force. Thus, the pool of effective searchers is larger than the measured unemployment rate.(Krause and Lubik (2007), Cole and Rogerson (1999)). I target unemployment rate to be 12% similar rate targeted in Krause and Lubik (2007).

Steady-state hours worked h is set to $1/3$ corresponding 8 hours per day or 40 hours per week. Disutility parameter e is determined endogenously. Hours adjustment cost parameter ϕ_h is set to 6.95 corresponding estimate in Cacciatore et al. (2019). s is defined as the unemployment benefit. Hall (2005) finds this ratio to be around 12%. Anderson and Meyer (1997) estimates the replacement ratio as 36% which is an upper bound. I take $s/W = 0.25$ as in Hall and Milgrom (2008). I set discount factor β equal to 0.99, capital depreciation rate δ equal to 0.025 as commonly used int the literature. I follow Jermann and Quadrini (2012) to set capital share α , tax rebate, τ, and shock process parameters. The mean value of the financial variable ξ is chosen to have a steady state ratio of debt over GDP equal to 3.36. The parameter values are given in Table 1.1.

1.3.2 Financial and Productivity Shocks

Figure 1.1 shows the impulse response of the variables to the one-time negative financial shock. The scale represents log deviations from the steady-state. The financial shock represents the change in the value of ξ, recovery probability. A negative shock, lower ξ, means that the lender's probability of recovering the loan is low. As a result of financial shock, the firm's ability to borrow decreases. The firm increases the dept repurchases and reduces equity payment. The firm restructures its financial position by cutting debt growth and reducing payments to the shareholders. Since there is rigidity for adjusting equity payout, the firm chooses to reduce equity payout and labour and vacancy in part. A negative financial shock increases the enforcement constraint multiplier,μ. As the multiplier shows up in the wage equation, the negative financial shock directly affects the wage. In contrast to Garín (2015), the translation of the change in the constraint/shock into the wage is higher. Therefore, the ability to create jobs differs.

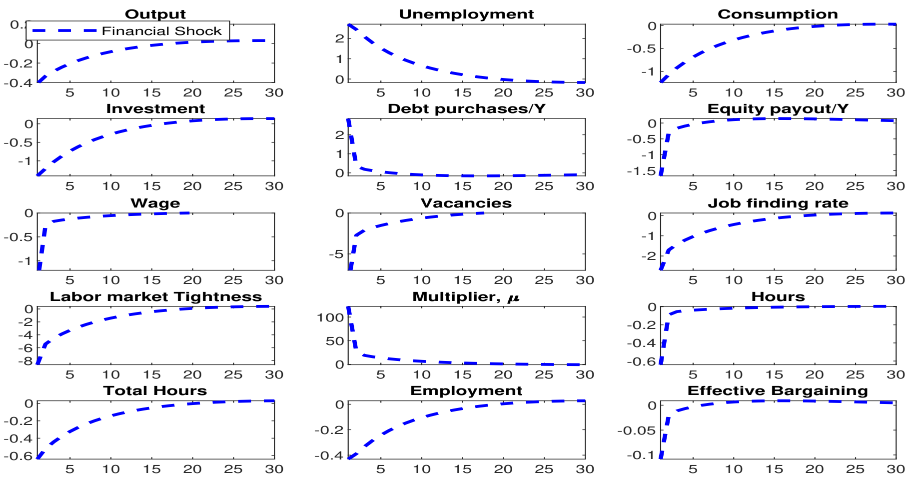

Figure 1.1: Impulse Response to One-Time Negative Financial Shock

Another factor affecting the wage is the equity cost which is also included in the wage equation. As it is discussed in the firm section, the equity cost parameter κ is crucial for friction. Moreover, that is transmitted into the wage equation in addition to the multiplier.(See Equation 1.28). Regarding the labour market variables, the responses are intuitive. Firm cuts vacancy and decreases employment which leads to unemployment. The firm also adjusts hours per worker. Due to the adjustment cost of hours, the change in hours per worker is not much. Labour market tightness gets less tight, and job finding probability decreases.

As it is discussed in the labour market section, the workers bargaining power was shown by η and is set to 0.4. However, I employed effective bargaining power, which results from the Nash bargaining process. Effective bargaining power also changes as a response to the financial shock. The model is consistent with the data by generating procyclical wages. In contrast to the present paper, Monacelli et al. (2012) shows that in their baseline model, credit tightening causes wages to rise. That results from the firm's decision to prefer higher debt to reduce future wages. The workers anticipate this and demand higher wages today to compensate for expected lower wages in the future. The model with labour friction and financial shock removes the shortcoming common to models with financial shocks. It is common that following a negative financial shock, firms ability to borrow decreases. This, in turn, implies that firms decrease payment to the bondholders. The households increase consumption because of the reduction in the interest rate and incentive to save. We can see in Figure 1.1, this is not valid for the labour friction case as the consumption decreases in response to a financial shock.

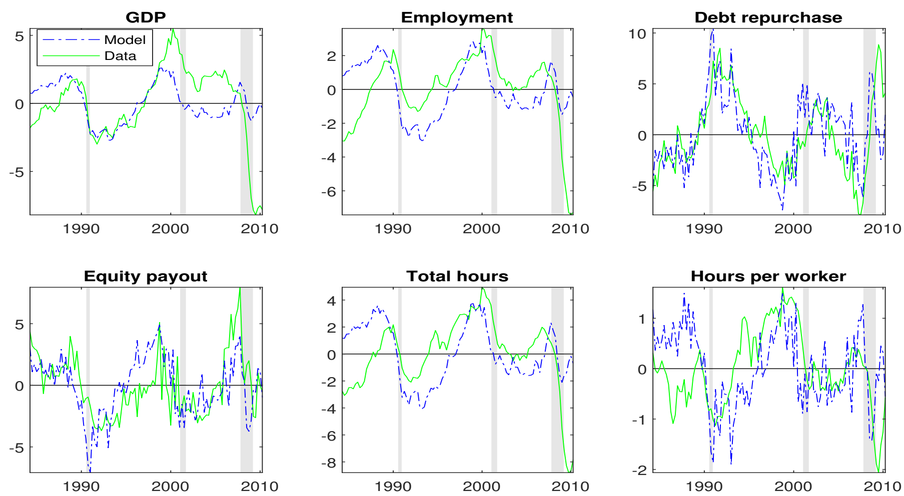

FIGURE 1.2: Financial Shock

Do financial shocks explain labour market behaviour during recessions over the long term? Figure 1.2 plots the series of output, employment, financial flows, total hours, and hours per worker. The empirical series of GDP and labour market variables are in logs and linearly detrended for 1984:Q1-2010:Q2. Debt repurchase and equity payout are linearly detrended but not logged. The NBER recessions were also shown in the graph. The cyclicality of the labour market is close to the data. Financial shock generates a fall in employment, hours per worker, and total hours in three recessions. The model captures the boom in output, employment, and total hours during the 1990s. Even though the drop in output is as much as the drop in the data, the model can not replicate the same amount of change during a boom. With financial shock, volatility and dynamics of hours per worker are quite close to the data. The drop of hours per worker generated by financial shocks is almost identical to the data, particularly during the 2008-2009 financial crises. These findings contrast with Petrosky-Nadeau (2014) and Petrosky-Nadeau and Wasmer (2013) who find productivity shocks to be the primary sources of fluctuations in labour market variables. Equity payout and dept repurchase data fit the model simulation well.

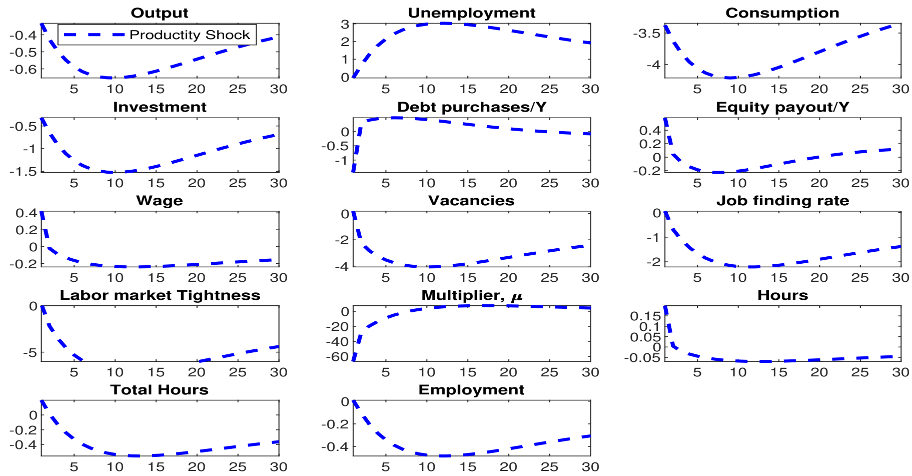

FIGURE 1.3: Impulse Response to One-Time Negative Productivity Shock

Figure 1.4 shows the effect of productivity shocks on the overall macroeconomic dynamics. With only productivity shock, the model cannot display dynamics of output, employment, and total hours, particularly during the 1990s. During the 1990-91 recession drop in output and employment generated by the model is significantly smaller than the data. The model with only productivity shock can not display the drop in output and employment during the 2001 recession. The dynamics of hours per worker and debt flows in response to productivity shocks differ from the data. However, in the recent recession, productivity shocks display some of the drops in output and employment. The movements in debt flow in response to productivity shocks are quite different from the data. Equity payout and dept repurchases series generated by the model can not replicate the data well. As it can be seen from Figure 1.3, the responses of labour market variables to the negative productivity shock are negative. Since the productivity shocks in this model do not generate much movement in labour and vacancy, whether the response is negative or positive has minor implications for the long term macroeconomic dynamics.

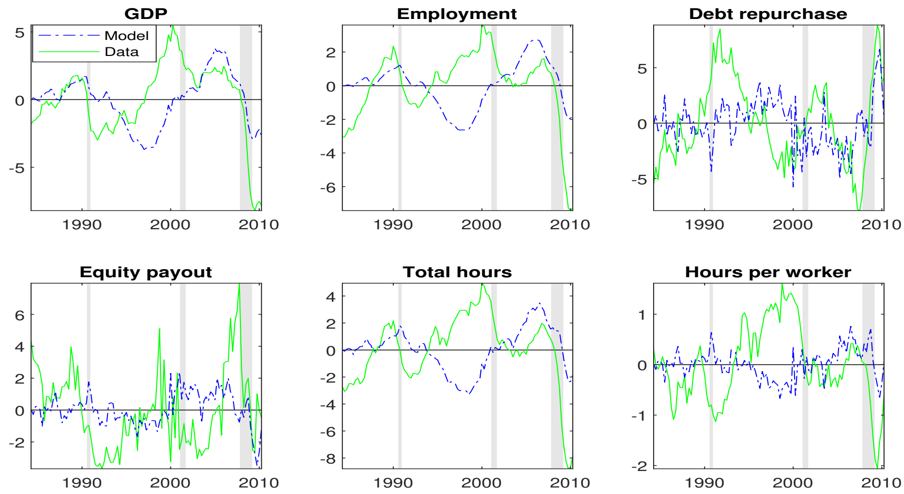

FIGURE 1.4: Productivity Shock

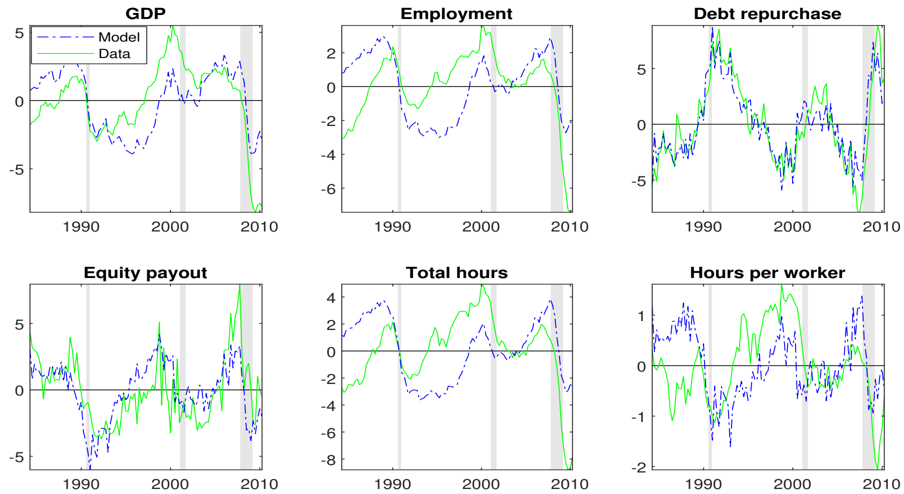

FIGURE 1.5: Both Shocks

Figure 1.5 shows the simulated series generated by financial and productivity shocks. The model can replicate dynamics of the labour market, financial flows, drops in labour market variables, and output during three major recessions. Four output, the model's performance is better than the case with only financial and productivity shock. Both shocks generate a boom in output and employment during the 1990s, consistent with the data. However, for employment, the model's performance during the last recession is worse than the model with only financial shock. While the model with only financial shock can predict the sharp drop in employment, total hours, and hours per worker during recessions, it also captures the recovery period observed in the data. Both shocks generate a more significant decline in employment during the last recession than the models with only financial and productivity shocks. Even though the variables follow the same cyclicality as in data, both shocks cannot perfectly capture the recovery period of the 1990s.

The model with only productivity shocks can not generate enough volatility of hours per worker. In fact, the dynamic of the hours per worker is far from the data. Financial shocks predict most of the volatility of hours per worker during the recent recession. Both shocks improve the model's ability to capture the cyclicality of labour market variables that is not well captured in the model with only productivity shock.

1.3.3 Business Cycles Statistics

Table 1.2 shows variance decomposition of two shocks. Table 1.3 shows some standard business cycles statistics from the data and alongside their counterparts from the model's simulation. We can see that the labour market variables' responses to financial shocks are quite high. Almost 90% variations in hours per worker are due to the financial shocks. Besides, the response of unemployment, vacancy creation, hours per worker, and labour market tightness to the financial shocks are also very high.

TABLE 1.2: Variance Decomposition

Variable		Financial Shock	TFP Shock
y	Output	35.23	64.77
U	Unemployment	59.87	40.13
h	Hours per worker	84.61	15.39
θ	Tightness	61.13	38.87
V	Vacancy	65.66	34.34
t	Total hours	61.36	38.64

Table 1.3: Standard Deviation

Variable	**Data**	Productivity Shock	Financial Shock	Both Shocks
Base Model: Bargained Wage				
U	**0.2091**	0.0876	0.1004	0.1203
h	**0.0076**	0.0030	0.0076	0.0065
θ	**0.3810**	0.2050	0.2370	0.2830
V	**0.1919**	0.1224	0.1475	0.1726
Bargained Hours				
U	**0.2091**	0.0272	0.0422	0.0426
h	**0.0076**	0.0053	0.0099	0.0092
θ	**0.3810**	0.0548	0.0822	0.0856
V	**0.1919**	0.0292	0.0444	0.0456

Table 1.3 shows the volatility of variables for two different models: Wage bargaining and hours bargaining. While the model solutions are not very different, the results are significantly different. Overall, bargained wage model is significantly closer to data than the hours bargaining model.

The standard deviation of unemployment improves with both shocks, and it is quite close to the data. Moreover, unemployment volatility is almost five times(4.25 times) that of output. That is an improvement compared to a labour search model without financial frictions and financial shocks. Thus, it is also a significant improvement when comparing other models with the labour search model with financial frictions and shocks. Some examples are Garín (2015) and Petrosky-Nadeau (2014) which generates unemployment volatility to be 3.8 and 2.37 times that of output. Labour market tightness and vacancy creation fit data better with both shocks. The model can capture most of the fluctuation observed during major recessions. It also captures cyclicality in the recovery and boom periods. With only financial shock, the standard deviation of vacancy is 0.1475, and it improves by having both shocks as the volatility increases to 0.1726. The standard deviation of labour market tightness, θ, is also close to data; 0.2050 for productivity shock, 0.2370 for financial shock. With financial and productivity shock, volatility increases to 0.2830, which is close to data.

1.3.4 Vacancy-Unemployment

This section shows the model properties in terms of vacancy and unemployment relationship. The model can capture the Beveridge curve-strong relationship between vacancy and unemployment during the last three recessions. However, the model has a shortcoming when the 2008-2009 post crises period is included in the analysis. For Figure 1.6 I estimate the shock process using data for the period 1984:Q1-2010:Q2.

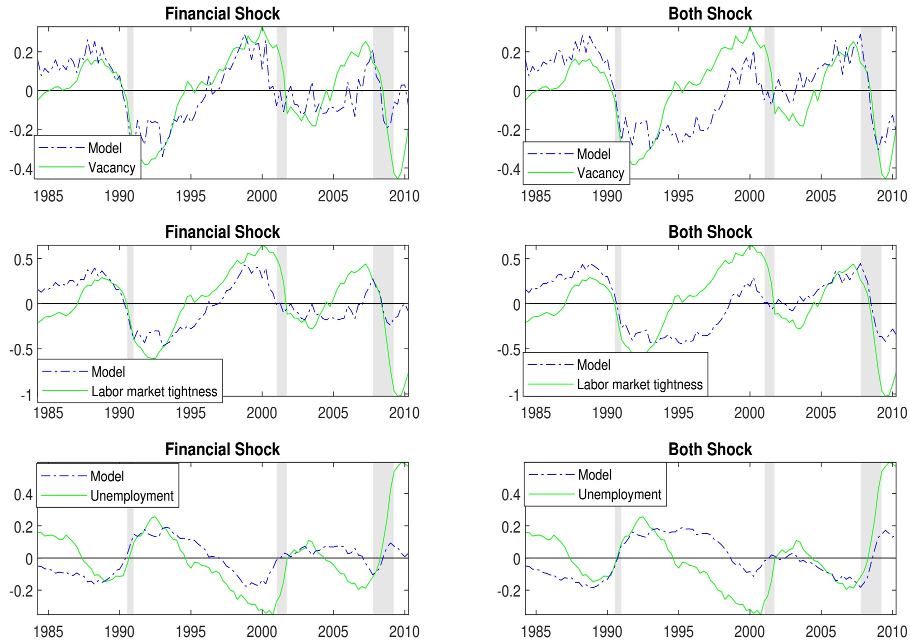

FIGURE 1.6: Vacancy, Unemployment, Labor Market Tightness-1984:Q1-2010:Q2

Series generated by the models using different periods have different outcomes. When the model is restricted to the period of 1984:Q1-2010:Q2, the movement in vacancy and labour market tightness series generated by the model is close to the data. The model can replicate drops in vacancies for the last three recessions. Figure 1.6 shows the importance of the financial shocks for the variation in vacancy and labour market tightness. A negative relationship between unemployment and vacancy can also be seen in Figure 1.6. Even though the model can replicate the rise in unemployment in all three recessions, the rise in unemployment is less than the data in the recent crisis. However, financial and productivity shocks improve the model behaviour.

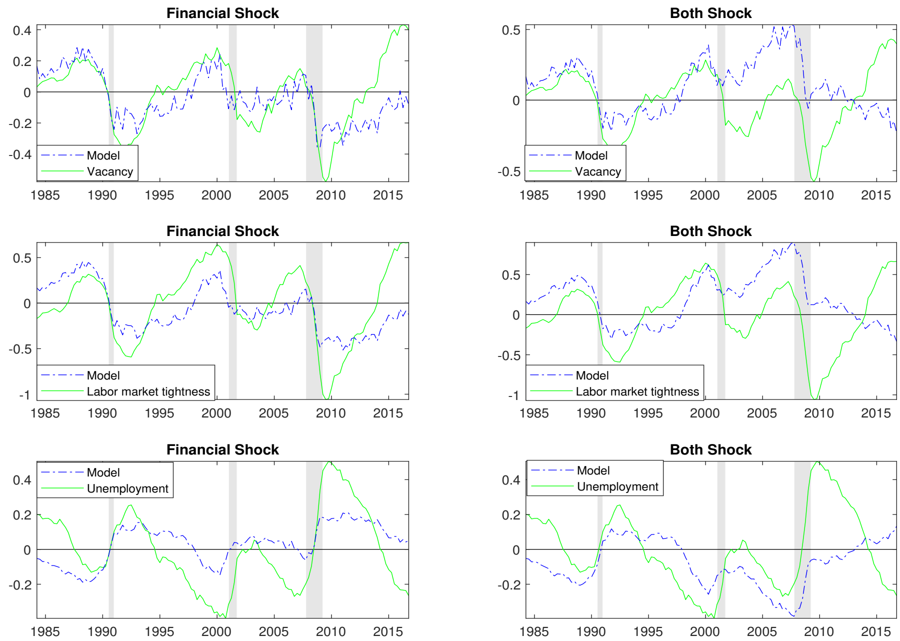

FIGURE 1.7: Vacancy, Unemployment, Labor Market Tightness-1984:Q1-2016:Q4

Figure 1.7 shows the simulated series of labour market variables for the base model. When the data between 1984:Q1-2016:Q4 is used and shock processes is estimated for this period, the model outcomes impair a few years after the recent crisis. The model can replicate a drop in vacancy and a rise in unemployment when the shocks hit the economy in 2008. However, the model can not replicate the variations during the recovery period. In fact, vacancy and labour market tightness series generated by the model with respect to both shocks worsen compared to the case with only financial shocks. The model shows that there is a change in Beveridge Curve, and the financial frictions can not explain this change after recent financial crises. It is important to note that the cyclicality of vacancy and unemployment mainly changes after the financial crises. The model can still generate fluctuations in vacancy and unemployment in previous recessions.

1.3.5 Frictionless Hours Adjustment

This section shows how the labour market dynamics are affected when a frictionless adjustment in intensive margin is introduced. In this case, firms can adjust extensive and intensive margin without frictions in hours per worker adjustment.

Gertler et al. (2008) shows that a model with only an extensive margin can produce dynamics of employment and macroeconomic variables. However, if we introduce intensive margin without frictions, the ability of the model to produce labour dynamics is impaired. Kudoh et al. (2019) use this approach and can replicate the relative variability of employment and hours per worker observed in Japan. They build a model where firms have the right to manage hours. From a theoretical perspective, this approach is reasonable because intensive margin accounts for almost 80% of the variations in total labour input in Japan. When the model allows firms to adjust hours per worker without cost, most of the variation occurs in intensive margin consistent with empirical data for Japan. However, intensive margin accounts for around 30% of the variations in total labour input for the US as shown by Cacciatore et al. (2019).

I allow for zero adjustments cost to the intensive margin. With $\phi_h = 0$, $\tilde{h}_t = h_t$. Since hours per worker are used for the production process along with employment, firms can adjust hours per worker. Hence, the response of total hours differs from the previous model with costly adjustment hours. The issue with the model is that hours per worker is too volatile in the model. Response of hours per worker is as large as employment for financial and productivity shock. However, the main important point is that financial shock is the dominant force driving the volatility of employment, hours per worker, and total hours in case of costless adjustment along the intensive margin. Moreover, this model version overstates the importance of hours per worker compared to the data. The results show that if the model is allowed to adjust intensive margin without adjustment cost, the model cannot produce labour market dynamics consistent with the data. Firms can adjust intensive margin more because there are no frictions for intensive margin. That result in more fluctuation in intensive margin than extensive margin. Table 1.4 shows that standard deviation of model variables are far from data.

Table 1.4: Standard Deviation

Variable	Data	Productivity Shock	Financial Shock	Both Shocks
U	**0.2091**	0.0558	0.0971	0.1017
h	**0.0076**	0.0098	0.0210	0.0198
θ	**0.3810**	0.1306	0.2287	0.2390
V	**0.1919**	0.0777	0.1408	0.1452

1.4 Conclusion

This paper examines how credit imperfections and financial shocks affect labour market dynamics. I propose a model that incorporates financing flows with unemployment and adjustment in extensive and intensive margin of labour to investigate to what extent financial shocks affect labour market dynamics. I show that financial shocks are an important contributor to labour market fluctuations. Since I focus long rung implications of financial shocks, I simulate the model and data to see the cyclicality of labour market variables. The results suggest that financial conditions played an important role in previous recessions in 1990-1991, 2001, and 2008. The results show that financial shocks are the main factor to generate fluctuations in debt, equity, and hours per worker. The results also show that financial shocks contributed significantly to the decline in employment, total hours and labour market tightness during the last three recessions. Literature on financial shocks and frictions mainly focused on the period in which the 2008 recession has ended. I extend the analysis to include the aftermath of the 2008 recession to investigate whether the shift in the Beveridge curve after 2008 is mainly because of the financial conditions or not. Interestingly, when the 2008 post crises period is included, and the model is simulated, the model can not replicate the cyclicality of labour market variables during recovery. However, the model still can capture downturns and recoveries in previous recessions. These results show that there have been structural changes in the labour market after the Great Recession, and financial conditions alone can not explain the vacancy-unemployment relationship and shift in the Beveridge curve.

1.5 Appendix A

1.5.1 Data

I get vacancy data from Barnichon (2010). The method combines job openings form the JOLTS data set and Help-Wanted Online Advertisement Index constructed by the Conference Board. Employment series is taken from the CPS series LNS12000000Q of BLS and seasonally adjusted . Hours per worker, h, is defined as the index of nonfarm business, average weekly hours duration from the Major Sector Productivity and Cost Series. Total hours is defined as $h * n$. Unemployment, u, is defined as the number of unemployed person, taken from CPS(LNS13000000Q, seasonally adjusted).

Financial data is from the Flows of Funds Accounts of the Federal Reserve Board. I follow Jermann and Quadrini (2012) for constructing financial variables.

Equity payout: Net dividends of nonfarm, nonfinancial business(Table F103 Line 3) − Net increase in corporate equities of nonfinancial business(Table F103 Line 43) − Proprietors' net investment of nonfinancial business(Table F102 Line 44)

Debt Repurchase : negative of Net increase in credit markets instruments of nonfinancial business (Table D.2 Line 5).

Equity payout and debt repurchase are diveded by business value added from the National Income and Product Accounts(NIPA) (Table 1.3.5). Total GDP; NIPA Table 1.1.6

Capital Stock :

$$k_{t+1} = k_t - Depreciation + Investment \tag{1.42}$$

Depreciation= consumption of fixed capital in nonfinancial corporate business(Table F4 Line 14) + consumption of fixed capital in non financial noncorporate business (Table F4 Line 15)

Investment: Capital expenditures in nonfinancial business (Table F102 Line 4)

Net borrowing: Net increase in credit markets instruments of nonfinancial business(Table D2 Line 5).

Investment, depreciation, net borrowing are deflated by the price index for business value added from NIPA Table 1.3.4

Debt Stock:

$$b^e_{t+1} = b^e_t + NetNewBorrowing \tag{1.43}$$

where e denotes end of period. $b^e_{t+1} = b_{t+1}/(1+r_t)$ is used instead of b_{t+1} as this is the model equivalent of the end-of-period debt in data.

1.5.2 Nash Bargaining

The earning profile is obtained by solving a linear ordinary differential equation with variable coefficients. The generalized derivation of wage function can be seen in Bertola and Caballero (1994), Cahuc and Wasmer (2001).

Using Nash bargaining problem as in the paper:

$$arg\max_{W_t}[V_n(s_t)]^{1-\eta}[V^E(s_t) - V^U(s_t)]^\eta$$

$$\eta V_n(s_t) = (1-\eta)\frac{1}{\varphi_d(d_t)}(V^E(s_t) - V^U(s_t))$$

Using worker surplus $V^E(s_t) - V^U(s_t)$ and firm surplus $V_n(s_t) - V^O(s_t)$; $V^O(s_t)$ is the value of vacancy to the firm and equal to zero due to the free entry condition

$$V^E(s_t) - V^U(s_t) = W_t - e(h_t) - s + (1-\delta_n - \theta_t p(\theta_t))E_t m_{t+1}\left[V^E(s_{t+1}) - V^U(s_{t+1})\right]$$

$$W^n_t n_t + \frac{1}{\eta}W_t = (1-\mu_t\varphi_d(d_t))F_{n,t} + \frac{1-\eta}{\eta}\left(e(h_t)+s\right) + \frac{\kappa_v}{p(\theta_t)}\left[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\right]$$

$$W^n_t n_t + \frac{1}{\eta}W_t = (1-\mu_t\varphi_d(d_t))F_{n,t} + \frac{1-\eta}{\eta}\left(e(h_t)+s\right) + \frac{\kappa_v}{p(\theta_t)}\left[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\right]$$

$$\frac{\partial}{\partial n}\left[W_t n_t^{\frac{1}{\eta}}\right] = \left[W^n_t n_t + \frac{1}{\eta}W_t\right] n_t^{\frac{1}{\eta}-1}$$

$$= \Bigg[(1-\mu_t\varphi_d(d_t))F_{n,t}+\frac{1-\eta}{\eta}\big(e(h_t)+s\big)+\frac{\kappa_v}{p(\theta_t)}\Bigg[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\Bigg]\Bigg]n_t^{\frac{1}{\eta}-1}$$

$$= \Bigg[(1-\mu_t\varphi_d(d_t))(1-\alpha)z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}n_t^{-\alpha}+\frac{1-\eta}{\eta}\big(e(h_t)+s\big)+ \frac{\kappa_v}{p(\theta_t)}\Bigg[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\Bigg]\Bigg]n_t^{\frac{1}{\eta}-1}$$

$$= (1-\mu_t\varphi_d(d_t))(1-\alpha)z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}n_t^{\frac{1}{\eta}-\alpha-1}+ \Bigg\{\frac{1-\eta}{\eta}\big(e(h_t)+s\big)+\frac{\kappa_v}{p(\theta_t)}\Bigg[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\Bigg]\Bigg\}n_t^{\frac{1}{\eta}-1}$$

$$W_t n_t^{\frac{1}{\eta}} = \int_0^n \Bigg\{(1-\mu_t\varphi_d(d_t))(1-\alpha)z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}i_t^{\frac{1}{\eta}-\alpha-1} + \Bigg\{\frac{1-\eta}{\eta}\big(e(h_t)+s\big)+\frac{\kappa_v}{p(\theta_t)}\Bigg[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\Bigg]\Bigg\}i^{\frac{1}{\eta}-1}\Bigg\}di \quad (1.44)$$

$$= (1-\mu_t\varphi_d(d_t))\frac{(1-\alpha)z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}}{\frac{1}{\eta}-\alpha}n_t^{\frac{1}{\eta}-\alpha}+ \Bigg\{(1-\eta)[e(h_t)+s]+\eta\frac{\kappa_v}{p(\theta_t)}\Bigg[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\Bigg]\Bigg\}n_t^{\frac{1}{\eta}}$$

We obtain Earning as;

$$W_t = (1-\mu_t\varphi_d(d_t))\frac{(1-\alpha)z_t k_t^{\alpha}\tilde{h}_t^{1-\alpha}}{\frac{1}{\eta}-\alpha}n_t^{-\alpha}+(1-\eta)[e(h_t)+s]+ \eta\frac{\kappa_v}{p(\theta_t)}\Bigg[1-\delta_n-(1-\delta_n-\theta_t p(\theta_t))\frac{\varphi_d(d_{t+1})}{\varphi_d(d_t)}\Bigg] \quad (1.45)$$

Chapter 2

Labor Market Participation, Unemployment, and Search Intensity

2.1 Introduction

Recent empirical studies emphasise the importance of movements in the labour force to explain cyclical variation in the unemployment rate. Diamond (2013) underlines the importance of flows into and out of the labour force to help understand the shifts of the Beveridge curve after the Great Recession. Elsby et al. (2015) and Barnichon (2010) show that movements in the labour force account for one-fourth and one-third of the fluctuation in the unemployment rate. Kudlyak and Schwartzman (2012) shows that while it is sufficient to consider only employment and unemployment to understand unemployment dynamics, nonparticipation matters for the unemployment dynamics in the Great Recession.

In the light of this evidence, I develop and estimate a dynamic stochastic general equilibrium (DSGE) model that incorporates endogenous variation in labour force participation and search intensity. The model differs from the early models, including labour force participation in two ways. Firstly, the model does not rely on the calibration strategy, which imposes a low surplus share value on the worker. Secondly, the model reproduces the key cyclical property of the labour market through dynamic interactions of search intensity, labour force participation, and household decisions.

I show that households participation decision depends on the participation value and job search cost. Transmission from participation to search is costly as it requires some hidden costs such as forgone home production, time cost for search, and leisure. This feature is different from a standard model. When an exogenous negative shock hits the economy, firms reduce vacancies. Job finding probability falls as a response to reduced vacancies. Household decides the measure of employment, searchers, and the intensity of search. Job finding is positively correlated with search intensity. The model suggests that after a negative shock, labour force participation falls as the value of participation falls. Household reduces the measure of searcher. Since the search activity is less attractive, aggregate search intensity falls. The contraction in participation leads to a reduction in the potential pool of workers. Job finding probability and hiring fall more relative to an economy with constant participation inducing a sharper increase in the unemployment rate.

Early studies calibrating RBC models with search frictions and labour force participation were unable to match the key cyclical property of the labour market. Ravn

(2008), Tripier (2004), and Veracierto (2008) are the first papers dealing with this issue, and their models contradict the data by generating procyclical unemployment and a positively-sloped Beveridge curve. They find that including participation margin yields counterfactual effects resulting from participants' behaviour in response to aggregate shocks. In response to a positive shock, the household allocates more members into search. If the movement from non-participation into search activity is large, and the flow of workers from search into employment is small, unemployment increases and becomes procyclical. Therefore, unemployment exhibits a positive correlation with procyclical vacancies. Ebell (2011) addresses this issue and formulates a calibration strategy close to the one proposed by Hagedorn and Manovskii (2008) and can replicate volatility of participation and the negative slope of the Beveridge curve. This calibration strategy relies on the elasticity of labour supply chosen to match the volatility of participation and impose a low surplus-value on the worker. Arseneau and Chugh (2012) adopt the same strategy to achieve variation in unemployment and labour force participation. Their model can not reproduce labour dynamics if they do not follow Hagedorn and Manovskii (2008) calibration strategy.

Recently, Campolmi and Gnocchi (2016) introduce a participation margin in an otherwise New-Keynesian model embedding labour market frictions. Without a Hagedorn-Manoskii style calibration, they are able to reproduce key moments of aggregate labour market variables. For instance, the low volatility of participation and the negative relationship between vacancies and unemployment is reproduced. They also show that the abstraction of the labour force may lead to misleading results about the dynamics of the model economy. In particular, with participation, unemployment is four times more volatile than in a model without participation. Moreover, in a model with constant participation, the volatility of unemployment to inflation stabilization is too large. Finkelstein Shapiro and Olivero (2020) study the role of participation as an amplification mechanism of financial shocks. They find that endogenous participation and financial shocks lead to sharper vacancy and unemployment fluctuations. Cairó et al. (2021) study the cyclicality of labour market transition rates between employment, unemployment, and nonparticipation. They find that participation exhibits weak procyclical behaviour and the household's incentive to send the workers to the labour force falls in expansions. This finding contrasts findings in this paper as I show that households' incentive to send the workers to the labour force increase in expansions. Labour force participation falls in recessions. In other words, consistent with data [1], non-participation increases during recession. Erceg and Levin (2014) develop a New Keynesian model without introducing search frictions in which household's labour market exit and entry decisions are associated with significant adjustment costs. They show that decrease in labour force participation is relatively modest in most postwar recessions, but deeper recessions lead large declines in participation.

This paper is also related recent literature that extends general equilibrium models of employment and unemployment by including variable search effort. Leduc and Liu (2020) show that cyclical fluctuations in search and recruiting intensity are quantitatively important for weak job recovery from the Great Recession. However, their model do not explain interaction between endogenous labor force participation and search intensity. Empirical evidence on the cyclicality of search intensity is not conclusive. Gomme and Lkhagvasuren (2015), Krueger and Mueller (2010), and Yashiv (2000) find procyclical search intensity while Mukoyama et al. (2018) and Faberman and Kudlyak (2019) suggest evidence for countercyclical search intensity. By using a search and matching model with endogenous search effort, Mukoyama et al. (2018) find that search effort does not amplify labour market fluctuations but rather dampens them. They also find that unemployment rate would have been 0.5 to 1 percentage points higher in 2008-2014 period had search effort not increased. Their findings are consistent with their search intensity data which exhibits countercyclical behavior. However, this paper shows that considering the procyclical search intensity, search intensity amplifies unemployment rate due to fall in aggregate search intensity during recessions. Different from this paper, their model is silent on participation margin.

This paper contributes the literature by incorporating variable search effort and endogenous labor force participation. The results suggest that participation is quantitatively important for unemployment dynamics and search intensity works as an amplification factor. The results also suggest that search intensity and labor force participation are procyclical.

[1] See Graph 2.11

2.2 Model

I incorporate search intensity as in Leduc and Liu (2020) into a search and matching model with endogenous labor force participation in the spirit of Arseneau and Chugh (2012). The economy is comprised of households, firms, and government. Members of the household can be in three states: employed, unemployed but searching for jobs, and outside of the labour force(inactive). Job seekers choose level of search intensity. Search cost increases with search intensity but job finding probability also increases with increasing search intensity. Household chooses the measure of participants to send job search activity depending on the value of participation. Firms post vacancies to hire workers. Matching technology transforms searchers and vacancies into employment relation. Real wage is determined by Nash bargaining. The government finances unemployment benefits by lump-sum taxes.

2.2.1 Labour Market

The transition between search, unemployment, and employment is instantaneous. The new matches begin working within the period. Suppose that n_{t-1} individuals worked in period $t-1$. At the beginning of any period t, a fraction δ of employment that were active in period $t-1$ experience separations. Some of these newly separated individuals and some individuals out of the labour force in period $t-1$ may enter the period t job process. Taken together, these two groups constitute the measure s_t of individuals searching for jobs in period t. Of these s_t individuals, $(1-q_t^s)s_t$ individuals turn out to be unsuccessful in their job searches, where q_t^s is the probability that a searching individual finds a job, which is a market-determined variable. The measure $n_t = (1-q_t^s)n_t + s_t q_t^s$ of individuals are thus employed and produce in period t. Each of the $(1-q_t^s)s_t$ individuals who do not find a job receives an unemployment transfer ϕ from the government. With these timing events, the labour force in period t is

$$lfp_t = n_t + (1-q_t^s)s_t \tag{2.1}$$

Firms and workers have to engage in a costly and time-consuming search process, and matches are formed according to a constant-returns matching technology

$$m_t = \mu(e_t s_t)^{\xi} v_t^{1-\xi} \tag{2.2}$$

where e_t denotes search intensity, the parameter μ represents the scale of the matching efficiency and $\xi \in (0,1)$ is the elasticity of job matches with respect to efficiency units of searching workers. Job finding probability

$$q_t^s = \frac{m_t}{s_t} \tag{2.3}$$

Job filling probability

$$q_t^v = \frac{m_t}{v_t} \tag{2.4}$$

Unemployment rate is the ratio of unsuccessfully searchers, $(1-q_t^s)s_t$, to the labor force, lfp_t;

$$ur_t = \frac{(1-q_t^s)s_t}{lfp_t} \tag{2.5}$$

2.2.2 Household

There is a representative household in the economy. Each household consists of a continuum of measure one of family members, and each household member can be in one of three states. Employed, not working but actively searching for a job, or out of labour force. The individual household member out of the labour force enjoys leisure. Considering the notation lfp_t as the individuals participate in the labor force in period in t, nonparticipants are $1-lfp_t$. There is perfect risk pooling between household members, and each member of the household experiences the same level of consumption regardless of their labour market status. Perfect consumption insurance has been common since Merz (1995) and Andolfatto (1996).

Representative household chooses consumption c_t, bond holdings b_t, desired employment n_t, the measure of household members who search for employment s_t, and search intensity e_t to maximize expected lifetime discounted utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \Theta_t \{u(c_t) - h[(1-q_t^s)s_t + n_t]\} \tag{2.6}$$

subject to the budget constraints

$$c_t + \frac{b_t}{r_t} = b_{t-1} + w_t n_t + (1 - q_t^s) s_t(\phi - h(e_t)) + d_t - T_t \tag{2.7}$$

and the laws of motion for the measure of household members who are employed,

$$n_t = (1 - \delta) n_{t-1} + q_t^s s_t \tag{2.8}$$

b_t denotes the household's holdings of a risk-free bond, r_t denotes the gross real interest rate, w_t is the real wage rate, $h(e_t)$ denetos the resource cost of search efforts, d_t is the household's share of firm profits, and T_t is the lump-sum taxes. Discount factor shock $\theta = \Theta_t/\Theta_{t-1}$ follows the stationary stochastic process with persistent parameter ρ_θ, and an i.i.d. normal process $\epsilon_{\theta t}$ with a mean of zero and standard deviation of σ_θ. Mean value of θ is assumed to be one in the model solution.

$$\ln \theta_t = (1 - \rho_\theta) \ln \theta + \rho_\theta \ln \theta_{t-1} + \epsilon_{\theta t} \tag{2.9}$$

A searcher needs to spend effort e_{it} for the job search process. Under the assumption of random matching, -each job seeker of a given type has the same probability of being matched to a vacant job- for a worker with a search effort e_{it}, the probability of finding job

$$q^s(e_{it}) = \frac{e_{it}}{e_t} \frac{m_t}{s_t} \tag{2.10}$$

Marginal effect of raising search intensity on the job finding probability

$$\frac{\partial q^s(e)}{\partial e_i} = \frac{m_t}{e_t s_t} = \frac{q_t^s}{e_t} \tag{2.11}$$

Household's optimization consumption/saving decision implies the intertemporal Euler equation

$$u'(c_t) = E_t \beta \theta_{t+1} u'(c_{t+1}) r_t \tag{2.12}$$

Household's optimal search intensity decision is given by

$$h'(e_t) = \frac{q_t^s}{e_t(1 - q_t^s)} \Big[w_t - (\phi - h(e_t)) + \\ (1 - \delta) E_t \big\{ \theta_{t+1} \Xi_{t+1|t} (1 - q_{t+1}^s) \big(\frac{h'(lfp_{t+1}) + u'(c_{t+1})[h(e_{t+1}) - \phi)]}{q_{t+1}^s u'(c_{t+1})} \big) \big\} \Big] \tag{2.13}$$

At the optimum, marginal cost of search intensity equals marginal benefit, which is the increased odds of finding job relative to losing job multiplied by the net benefit of employment plus discounted continuation value of participation.

The other optimality condition is the household's labor force participation (LFP) condition,

$$\frac{h'(lfp_t)}{u'(c_t)} = q_t^s \Big[w_t + (1-\delta) E_t \{ \theta_{t+1} \Xi_{t+1|t} (1 - q_{t+1}^s) (\frac{h'(lfp_{t+1}) + u'(c_{t+1})[h(e_{t+1}) - \phi)]}{q_{t+1}^s u'(c_{t+1})}) \} \Big] - (1 - q_t^s)(h(e_t) - \phi) \quad (2.14)$$

At the optimum, the household sends a fraction of individuals to searching activity such that the MRS between participation and consumption is equal to the expected payoff of searching. The payoff is either a net benefit in the event of unsuccessfully searching, $\phi - h(e_t)$ or, if the search is successful, an immediate wage plus an expected discounted continuation value. Thus, LFP condition here is different from a free-entry condition on the part of household members transiting to the labour force. Matching frictions create separation of the labour force into those who are employed and unemployed. The LFP condition shows the transition of inactive individuals into the pool of searching. Some of the individuals are pulled into employment by the aggregate matching process.

2.2.3 Firms

A representative firm produces output using only labour. The representative firm has to engage in a costly search for a worker to fill the vacancies it posts. The firm begins period t with employment stock n_{t-1} and a fraction of δ separates immediately. The firm's period t employment stock depends on the period t vacancy posting and random matching process.

$$E_0 \sum_{t=0}^{\infty} \{ \Xi_{t|0} [z_t n_t - w_t n_t - \gamma v_t] \} \quad (2.15)$$

γ is the per vacancy posting cost, and $\Xi_{t|0}$ is the period 0 value to the representative household period t goods, which the firm uses to discount profit flows because the households are the owners of firms. The firm's first-order conditions with respect to v_t and n_t yield job creation condition

$$\frac{\gamma}{q_t^v} = z_t - w_t + (1-\delta)E_t\left[\Xi_{t+1|t}\theta_{t+1}\frac{\gamma}{q_{t+1}^v}\right] \tag{2.16}$$

The technology shock follows the stochastic process

$$\ln z_t = (1-\rho_z)\ln z + \rho_z \ln z_{t-1} + \epsilon_{zt} \tag{2.17}$$

where $\rho_z \in (-1,1)$ is the persistence of the technology shock. The term z denotes steady-state level of technology shock. ϵ_{zt} is an i.i.d. normal process with zero mean and a finite variance of σ_z^2.

2.2.4 Wage Determination

Firms and workers bargain over wages. Wages of all workers are set in period-by period Nash negotiations. Nash bargaining solution is presented in the Appendix. η represents workers' bargaining power, and $1-\eta$ is the firm's bargaining power. Nash bargaining outcome is given by

$$w_t^N = \eta z_t + (1-\eta)(\phi - h(e_t)) + \eta(1-\delta)E_t\{\Xi_{t+1|t}\gamma\frac{q_{t+1}^s}{q_{t+1}^v}\} \tag{2.18}$$

Different from the common wage equation, there is also search cost in addition to unemployment benefit. Thus, the value of unemployment is not only benefits received from the government. I follow the literature and introduce real wage rigidity (Hall (2005), Shimer (2005), Leduc and Liu (2020))

$$w_t = w_{t-1}^{\omega}(w_t^N)^{1-\omega} \tag{2.19}$$

where $\omega \in (0,1)$ represents the degree of real wage rigidity.

2.3 Quantitative Analysis

I solve the DSGE model by log linearizing the equilibrium conditions around the deterministic steady state. I calibrate a subset of the parameters to match steady-state observations and estimate the remaining structural parameters and shock processes to fit the US time series data.

2.3.1 Calibration

The model frequency is monthly. I adopt functional form $u(c_t) = \ln c_t$, and $h(Lfp_t) = [\frac{\psi}{1+1/\iota}](Lfp_t)^{1+\frac{1}{\iota}}$ where $\iota > 0$. Table 2.1 shows value of calibrated parameters. I first set values for some of the parameters exogenously. I follow the business cycle and labor search literature and set $\beta = 0.9967$ so that the model implies a steady-state annualized real interest rate about 4 percent. I set matching elasticity ξ and bargaining power η as 0.4 and 0.5 respectively. I set average monthly job-destruction rate to 0.034 and targeted steady-state job-filling rate, q^v to 0.6415 consistent with Davis et al. (2013). I calibrate the remaining parameters μ, ψ, γ, ϕ,ι to match the following targets; an average unemployment-benefit replacement rate of 50 percent; mean labour for participation(LFP) rate of 0.657; relative volatility of LFP of 0.20; and cost of opening a vacancy absorbing 4 percent of total output in the steady-state($\gamma = 0.04y/v$). The parameter ι is the elasticity of labor force participation with respect to the real wage and I set $\iota = 0.18$ to match relative volatility of participation of 20 percent consistent with Arseneau and Chugh (2012). The calibration strategy yields 5 percent unemployment rate.

TABLE 2.1: Parameters

Parameter	Description	Value
β	Discount factor	0.9967
δ	Seperation rate	0.034
ξ	Matching elasticity	0.40
μ	Matching efficiency	0.5221
η	Nash bargaining weight	0.50
ι	Elasticity of LFP	0.18
ϕ	Unemployment benefits	0.4781
h_1	Slope of search cost	0.7316
γ	Vacancy posting cost	0.7547
ψ	Disutility of LFP param	25.5634
ω	Real wage rigidity	0.95
$\bar{z}$	Mean value of technology shock	1

2.3.2 Estimation

I fit the DSGE model to monthly time series for the U.S. unemployment rate and a measure of search intensity covering July 1967 to July 2017. Measure of search intensity is based on Krueger and Mueller (2011) and Leduc and Liu (2020). Search cost function is consistent with quadratic search cost function estimated by Yashiv (2000),

$$h(e_t) = h_1(e_t - \bar{e}) + \frac{h_2}{2}(e_t - \bar{e}) \tag{2.20}$$

where $\bar{e}$ is the normalized steady-state level of search intensity giving zero search cost in the steady-state. In addition to calibrated parameters, I estimate the structural and shock parameters using Bayesian methods to fit the time series data of vacancies and search intensity. h_2 is the only structural parameter to be estimated. The shock parameters are ρ_j and σ_j, the persistence and standard deviation of shock $j \in \{z, \theta\}$. The prior for the structural parameter h_2 is drawn from the gamma distribution assuming with a prior mean of 5 and a standard deviation of 1. The priors of the persistence parameters of each shock process follow the beta distribution with a mean of 0.8 and a standard deviation of 0.1. The priors of the volatility parameters follow an inverse gamma distribution with a standard deviation of 0.01 and a prior mean of 0.001. The posterior estimation suggests that discount factor shock is highly persistent. Posterior mean of the technological shock parameter, $\rho_z = 0.8317$, is less persistent than discount factor shock parameter $\rho_\theta = 0.9989$.

TABLE 2.2: Estimated Parameters

Parameter	Description	Priors		Posterior		
		Type	Mean, std	Mean	5%	95%
h_2	Search cost function	G	[5, 1]	10.1840	9.7372	10.5603
ρ_z	AR(1) of tech shock	B	[0.8, 0.1]	0.8317	0.8117	0.8466
ρ_θ	AR(1) of dis.factor shock	B	[0.8, 0.1]	0.9989	0.9981	0.9999
σ_z	std of tech shock	IG	[0.01, 0.1]	0.0607	0.0579	0.0638
σ_θ	std of dis.factor shock	IG	[0.01, 0.1]	0.0206	0.0193	0.0218

2.4 Results

Figure 2.2 and 2.1 show the dynamic responses of some key variables to a one-standard negative technology and discount factor shock for two different models. The results show model dynamics and implication of search intensify. Model dynamic works as follow; in response to a negative shock value of job match decreases. Therefore, firms reduce vacancies, which puts pressure on wages and job finding probability drops in return. Due to endogenous participation, the marginal benefit of participation decreases, and the household reduces the measure of searchers sent to searching. Since optimal search intensity shows that the intensity will increase with the job finding probability and marginal benefit of participation, a negative shock lowering both will lower search intensity. Search intensity works as an amplification mechanism for unemployment fluctuation.

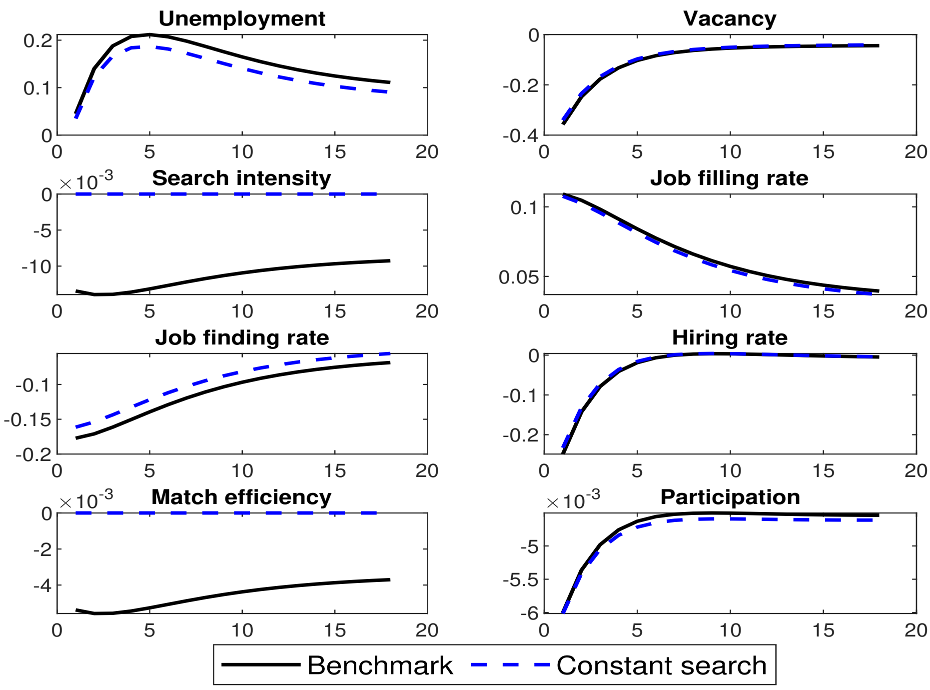

FIGURE 2.1: Impulse Responses To a Negative Discount Factor Shock

The model can generate cyclical behaviour of the labour market. These results are noteworthy as Arseneau and Chugh (2012) show that there are shortcomings of three-states models which display a positive correlation between search unemployment and vacancies in the presence of expansionary shock. Their model relies on a high replacement rate of 98.7 percent of after-tax wage to generate the Beveridge curve. However, with a lower unemployment benefit, 95 percent of after-tax wage, the correlation between search unemployment and vacancies becomes zero, sot that the Beveridge relation disappears. For even smaller values, correlation turns positive.

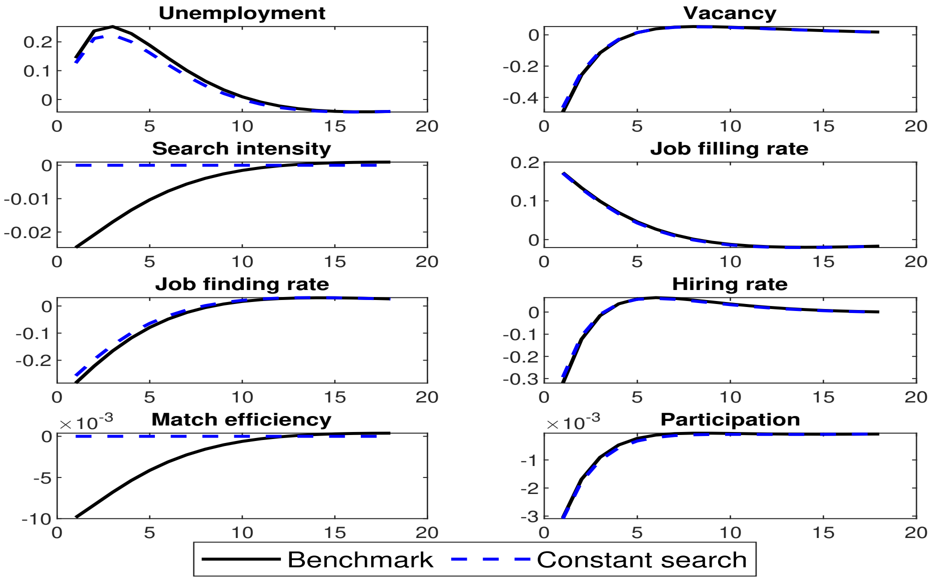

FIGURE 2.2: Impulse Responses To a Negative Technology Shock

In contrast to the three-state models relying on Hagedorn and Manovskii (2008) style calibration, which requires a very low worker's share of match surplus, the results of the model in this paper do not rely on calibration style to generate the Beveridge curve. Thus, the model does not require a calibration strategy used by Ebell (2011) who has also relied on Hagedorn-Manosvskii-style calibration to generate a Beveridge curve in a three-state model. Similar to this paper, Campolmi and Gnocchi (2016) show that market tightness becomes endogenously more volatile as the opportunity cost of home production and the reservation wage varies with participation. Their results also do not rely on Hagedorn-Manossvskii-style calibration.

Consistent with evidence, labour force participation is procyclical, and there is a modest decline in participation in response to both shocks. Response of labour force participation to the discount factor shock is larger than the response to the technology shock. For both shocks, search intensity is procyclical consistent with search intensity data. Since the search intensity declines, both technology and discount factor shocks lead to a decline in the measured efficiency and, in return, an outward shift on the Beveridge curve. The measured matching efficiency is defined as $\Omega_t = \mu e_t^{\xi}$. The measured efficiency, Ω_t, fluctuates with search intensity and is considered as the Beveridge curve shifter.

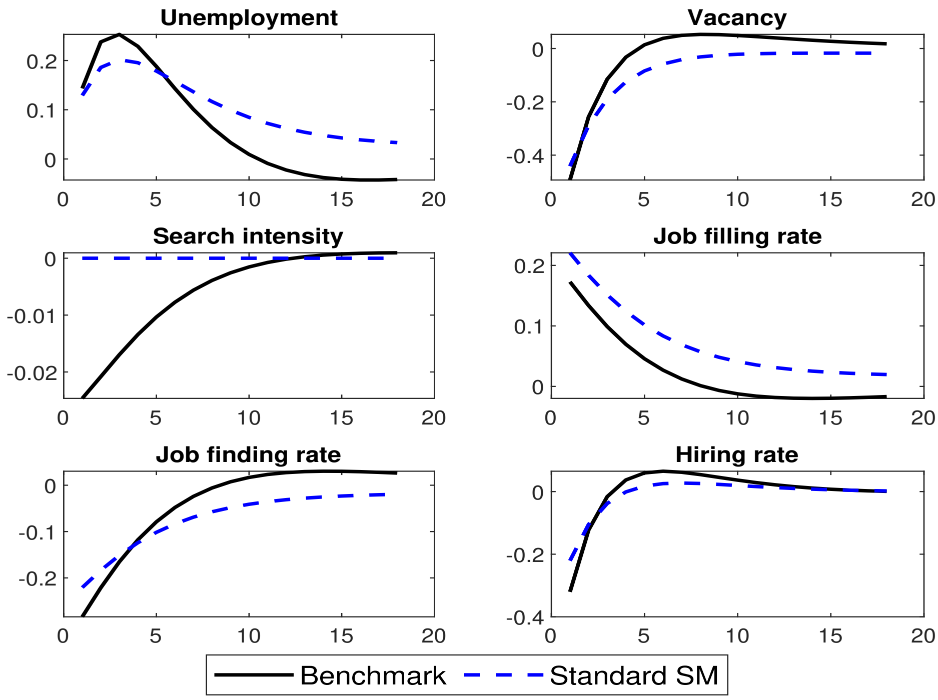

FIGURE 2.3: Impulse Responses To a Negative Technology Shock

Figure 2.3 and Figure 2.4 compares the dynamic responses of benchmark model and standard search and matching model. The results show that labour force participation contributes to the fluctuation in the labour market. With endogenous LFP, marginal benefits of participation and search intensity fall as a response to the fall in job-finding rate. Household reduces the number of searchers for a given level of job-finding rate. The Benchmark model exhibits a sharper decline in hiring and job-finding rate, leading to a sharper increase in the unemployment rate.

The model generates modest fluctuation in labour force participation. This result is consistent with the empirical studies showing that participation is the least volatile labour market variable. However, participation is quantitatively important for unemployment fluctuations. The transmission mechanism is the main difference between the standard search and matching model and the benchmark model. As a response to negative shocks, firms post fewer vacancies, leading to a decline in the job-finding rate. It is harder to find a job due to the lower job-finding rate.

The marginal benefit of participation falls with lower job finding probability. A decline in search intensity confirms that searching is less attractive. Therefore, the number of searchers declines. Relative to the standard model, the combination of a larger fall in job-finding rate and number of searchers implies that $(1-q_t^s)/lfp_t$ rises by more. Fall in s_t and search intensity shows that search is less attractive. Lower s_t and higher $(1-q_t^s)/lfp_t$ leads to a much sharper unemployment rate as the unemployment rate is in the Benchmark model is $ur_t = (1-q_t^s)s_t/lfp_t$.

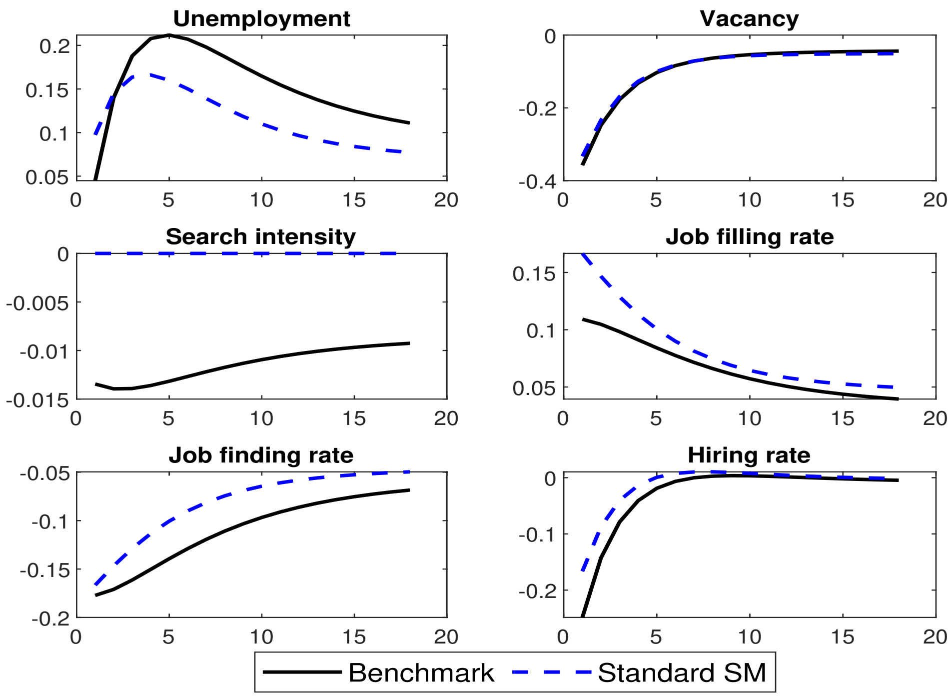

FIGURE 2.4: Impulse Responses To a Negative Discount Factor Shock

Figure 2.5 and Figure 2.6 show different calibration results in one graph. The Benchmark-1 model is equivalent to the Benchmark model in previous graphs. Benchmark-2 is the version of the benchmark model without endogenous participation and variable search intensity. Figure 2.5 and Figure 2.6 show hat the model with endogenous participation and search intensity(Benchmark-1) captures higher labour market fluctuations compared to the model without participation and search intensity(Benchmark-2). To understand the role of wage rigidity, I document the results of two models in the absence of wage rigidity. Results show that the responses of both models are quite weak. However, the response of the Benchmark-1 model without wage rigidity is stronger than the Benchmark-2 model without wage rigidity. Wage rigidity amplifies the response of model variables. Even in the absence of wage rigidity, the model with participation and variable search intensity(Benchmark-1) has stronger responses than the model with no participation and search intensity(Benchmark-2). The results show that the model with participation and variable search intensity is able to capture the fluctuation in labour market variables, and these results are not solely caused by wage rigidity.

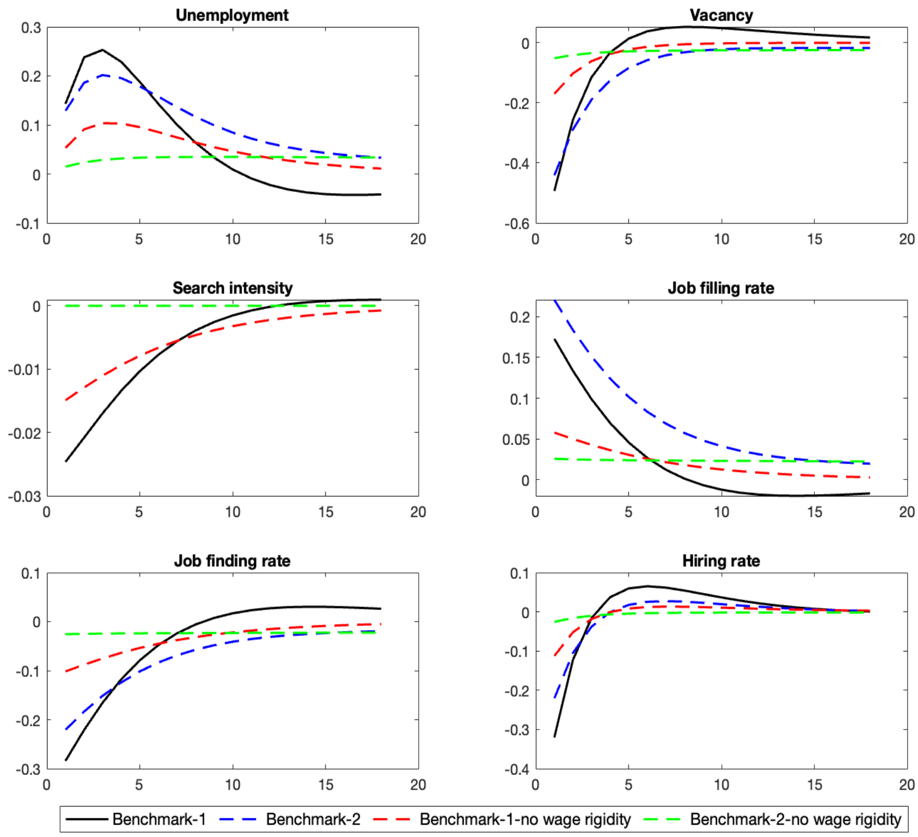

FIGURE 2.5: Impulse Responses To a Negative Technology Shock

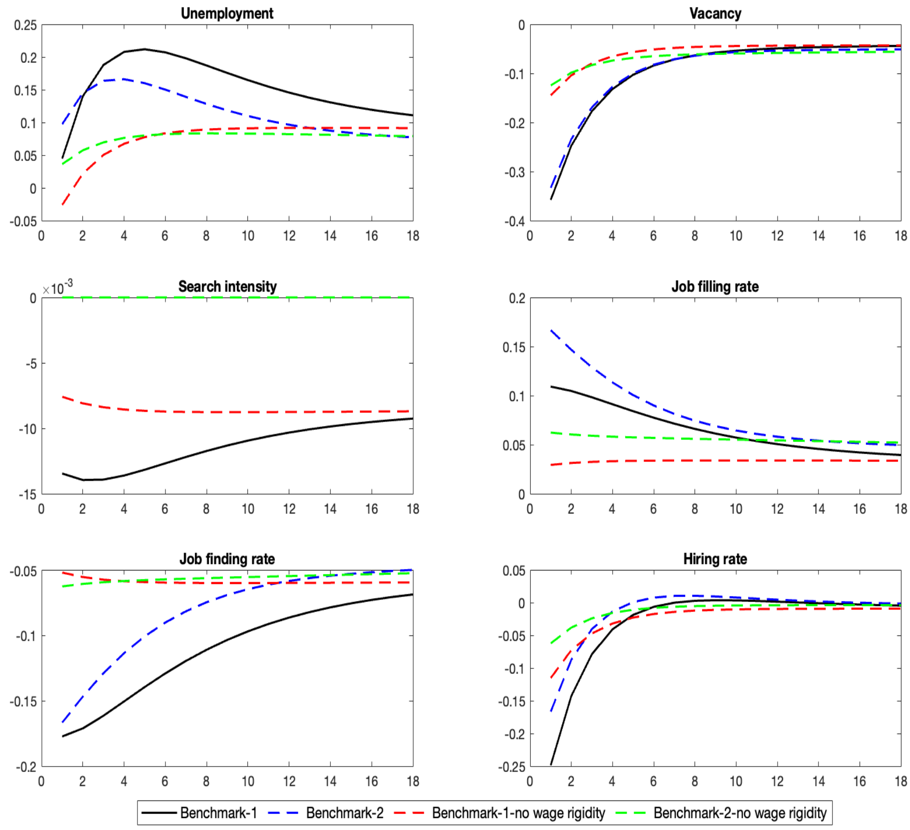

FIGURE 2.6: Impulse Responses To a Negative Discount Factor Shock

2.5 Conslusion

This paper studies the macroeconomic implication of labour force participation and variable search intensity. I extend and estimate a standard search and matching model incorporating labour force participation and search intensity. I focus on technology and discount factor shocks as the sources of business cycles fluctuations. I find that variable search intensity and labour force participation have quantitative implications for labour market fluctuations. The model suggests that search intensity is procyclical and amplifies the unemployment fluctuation. Endogenous labour force participation generates higher fluctuation in labour market dynamics. Moreover, the rise in the unemployment rate is higher than a standard search and matching model. Fluctuation in job-finding rate and hiring is also higher than a standard model.

2.6 Appendix B

2.6.1 Data

Search Intensity: Search intensity measure is constructed based on regression estimated by Krueger and Mueller (2011)

$$s_t = 122.30 - 0.90d_t \tag{2.21}$$

where d_t is seasonally adjusted monthly series of the median duration of unemployment which is taken from CPS(LNS13008276).

Job vacancies: seasonally adjusted job-opening rate series from JOLTS.

2.6.2 Equilibrium Conditions

Household's bond Euler equation

$$\beta E_t \frac{\theta_{t+1}\lambda_{t+1}}{\lambda_t} r_t = 1 \tag{2.22}$$

Marginal utility of consumption

$$\lambda_t = \frac{1}{c_t} \tag{2.23}$$

Matching function

$$m_t = \mu(e_t s_t)^{\xi} v_t^{1-\xi} \tag{2.24}$$

Job finding rate

$$q_t^s = \frac{m_t}{s_t} \tag{2.25}$$

Job filling rate

$$q_t^v = \frac{m_t}{v_t} \tag{2.26}$$

Law of motion for employment

$$n_t = (1-\delta)n_{t-1} + m_t \tag{2.27}$$

Labor force participation

$$Lfp_t = n_t + (1 - q^t)s_t \tag{2.28}$$

Unemployment rate

$$Ur = \frac{(1-q^{t})s_t}{Lfp_t} \tag{2.29}$$

Marginal disutility form the participation

$$h'(lfp_t) = \psi(Lfp_t)^{1/\iota} \tag{2.30}$$

Where

$$h(Lfp_t) = \Big[\frac{\psi}{1+1/\iota}\Big](Lfp_t)^{1+\frac{1}{\iota}}, \quad h' = \psi\big[n_t + (1-q^{t})s_t\big]^{1/\iota}$$

Production function

$$y_t = z_t n_t \tag{2.31}$$

Participation decision

$$\frac{h'(lfp_t)}{u'(c_t)} = q_t^s\Bigg[w_t + (1-\delta)E_t\Big\{\theta_{t+1}\Xi_{t+1|t}(1-q_{t+1}^s)\Big(\frac{h'(lfp_{t+1}) + u'(c_{t+1})[h(e_{t+1})-\phi)]}{q_{t+1}^s u'(c_{t+1})}\Big)\Big\}\Bigg] - (1-q_t^s)(h(e_t)-\phi) \tag{2.32}$$

Optimal search intensity

$$h'(e_t) = \frac{q_t^s}{e_t(1-q_t^s)}\Bigg[w_t - (\phi - h(e_t)) + (1-\delta)E_t\Big\{\theta_{t+1}\Xi_{t+1|t}(1-q_{t+1}^s)\Big(\frac{h'(lfp_{t+1}) + u'(c_{t+1})[h(e_{t+1})-\phi)]}{q_{t+1}^s u'(c_{t+1})}\Big)\Big\}\Bigg] \tag{2.33}$$

2.6.3 Graphs

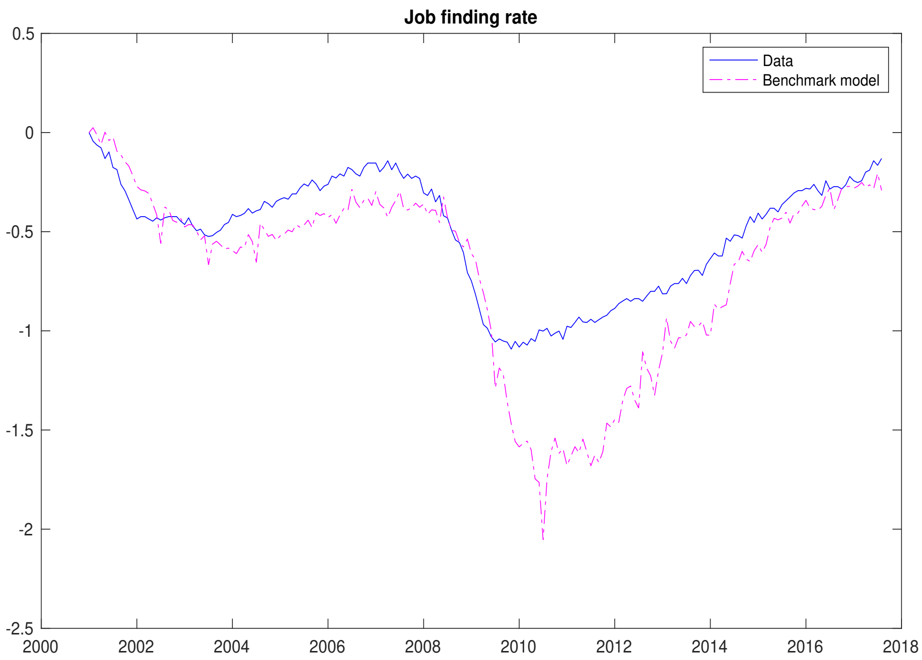

Figure 2.7: Job Finding Rate

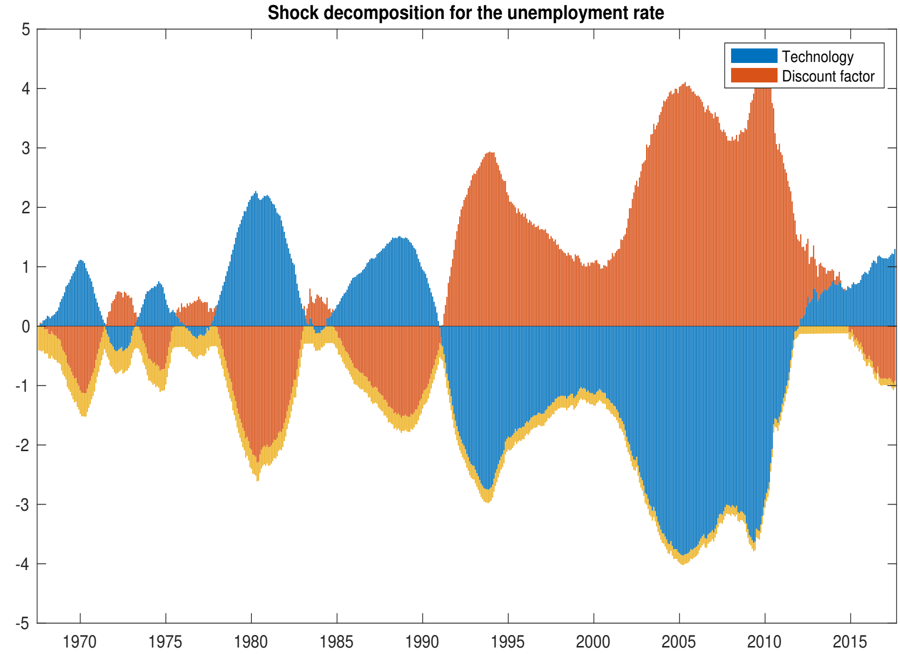

FIGURE 2.8: Unemployment

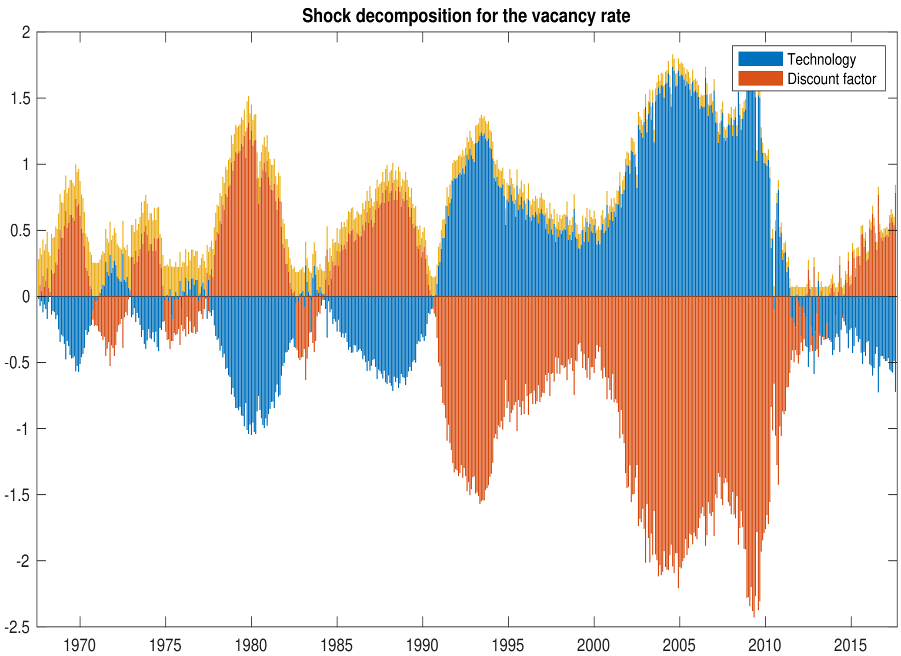

FIGURE 2.9: Vacancy

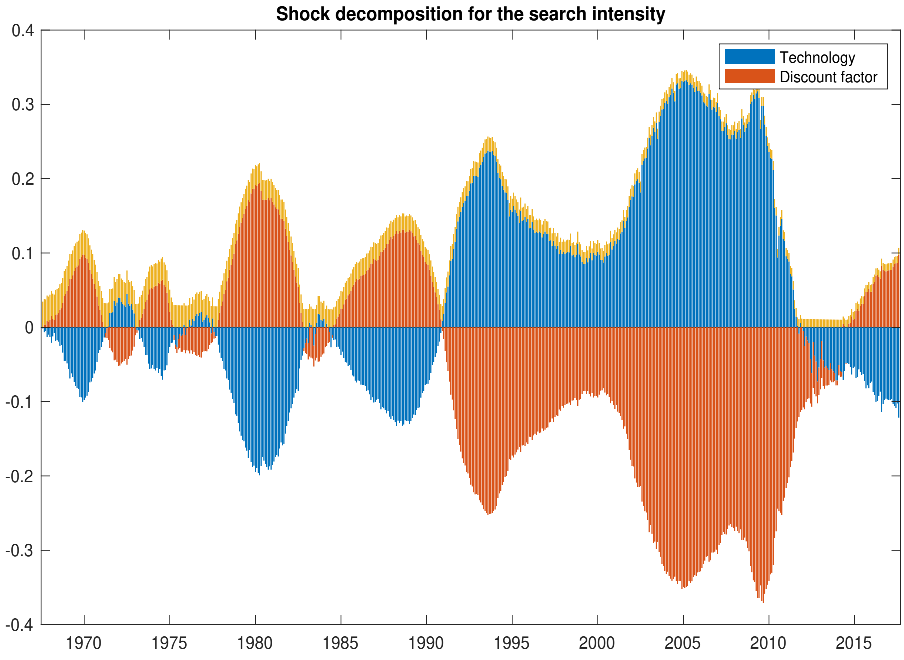

FIGURE 2.10: Search Intensity

FIGURE 2.11: Nonparticipants

Chapter 3

Uncertainty and Labour Market

3.1 Introduction

Uncertainty has been considered as an important factor impeding economic activity. A growing body of the literature has put forward several channels to explain the contribution of the uncertainty shocks in economic activity. The first channel focused on the option-value channel. The decision under uncertainty creates a large cost for the firms due to irreversible investment which creates an option-value effect(Bernanke (1983)). Leduc and Liu (2016) provides a similar option-value effect showing that with search frictions, a job match represents a long-term employment relationship that is irreversible. The second important channel is the risk aversion channel. Firms and investors may hesitate to undertake risky and high return project due to uncertain future and thus result in low growth. Uncertainty may create a precautionary motive that results in a decline in consumption and an increase in saving. Thus, this motive could negatively affect an economy subject to nominal rigidities as aggregate demand may fall(Basu and Bundick (2017), Leduc and Liu (2016), Fernández-Villaverde et al. (2015)). While these studies provide important results for the dynamic responses of the uncertainty shocks, there are some issues that are silent in those studies. How does uncertainty affect job search behaviour? Do the workers search more under increased uncertainty? How do labor force participation and unemployment respond to the uncertainty? I present a New Keynesian model with search frictions, nominal rigidities, search intensity, and endogenous labor force participation to answer these questions.

To understand the amplification mechanism of nominal rigidities, I first focus on the flexible-price version of the model. In the model with search frictions, search intensity and participation margin, uncertainty shock is contractionary. Uncertainty creates a precautionary saving motive thus consumption and real interest rate decline. In a standard RBC model without search frictions, as the real interest rate declines, the present value of a job match increases. Therefore, employment and output increase. This expansionary effect of uncertainty is common in several studies. (see Basu and Bundick (2017), Fernández-Villaverde and Guerrón-Quintana (2020)). However, in the flexible-price version of the model in this paper, search frictions provide and option-value channel. Employment contracts are usually long-term relationships that can not be easily terminated similar to the irreversible investment. Therefore, during increased uncertainty periods the option value of waiting increases and the match value decreases. As the firms delay hiring, job finding rate declines. Decline in job-finding rate makes it harder to find a job. Thus, labor force participation declines due to discouragement effect. Search intensity declines as the duration of unemployment increases and labor force participation declines. Figure 3.1 shows that search intensity declines during the increased uncertainty periods in line with theoretical results of the model.

In contrast to the model with flexible price, nominal rigidities amplifies the effect of uncertainty shocks on the unemployment rate. Uncertainty shocks behave as negative demand shocks. An increase in uncertainty leads to a decline in aggregate demand. Inflation and consumption fall. The fall in consumption results in a reduction in the relative price of intermediate goods. Thus, the decrease in firm profit reduces the match value. Firms post fewer vacancies which push the unemployment rate up and the job-finding rate down. Household income declines further as the number of searchers who can not find a job increases. Thus, a greater decline in aggregate demand magnifies the effect of the uncertainty shocks. Moreover, labour force participation declines as a response to a decrease in the job-finding rate and participation value. The demand channel and option-value channel reinforce each other and lead to a contraction. The workers out of the labour force transit to the labour force through searcher pool and with a low job-finding rate it is also difficult to find a job for the recently separated workers. Therefore, aggregate search intensity exhibits procyclical behaviour which is induced by the decline in the labour force participation and job finding-rate probability. Introducing habit persistence amplifies the effect of the uncertainty shocks and creates a wealth effect that increases the labour force participation. The wealth effect prevails over the discouragement effect. Thus, labour force participation increases.

The theoretical framework is guided by the measure of uncertainty and aggregate search intensity. For the measure of uncertainty, I use consumers' perceived uncertainty which is constructed based on the Michigan Survey. The Michigan Survey has been conducting monthly interviews of 500 households throughout the US since 1978. The Michigan Survey consists of questions regarding personal finances, savings, economic conditions, household durables and vehicle buying conditions. One question in the survey is " Speaking 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 car?" The reason for the opinion is also asked. A fraction of respondents reports that an uncertain future is the reason why they think it is a bad time to buy a car. The Survey is important for the theoretical framework of the paper. The Survey measure consumers' perceived uncertainty. Therefore, as the labour force

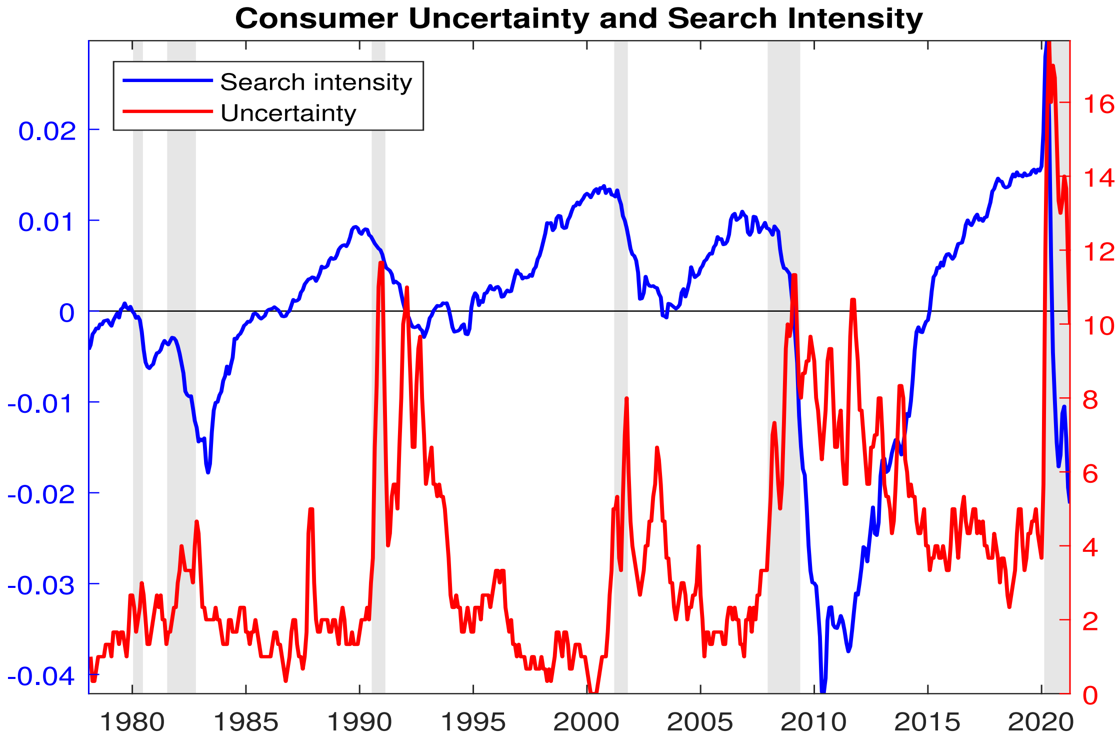

FIGURE 3.1: University of Michigan Survey of Consumers, three-month moving average. The search intensity series is imputed from the median duration of unemployment (weeks) based on the regression analysis of Krueger and Mueller (2011), three-month moving average, demeaned. Time Period: 02/1978-04/2021

participation and search intensity decision made by consumers, the perception of the consumers may be an important factor for the participation and search intensity decision. Figure 3.1 shows the time series of the plot of consumers' perceived uncertainty. The perceived uncertainty rises in recessions and falls in expansions. Along with the recent financial crises, the rise in uncertainty with the Covid-19 pandemic is also captured by the perceived uncertainty measure.

Numerous studies have investigated how uncertainty shocks affect labour market. To name a few, Langot and Kandoussi (2020), Jo and Lee (2019), Den Haan et al. (2021), Schaal (2017) shows that uncertainty shocks have significant impact on the U.S. labour market. This paper contributes to the recent theoretical literature on the effect of uncertainty shocks[1] in two ways . Firstly, I focus on the labour market behaviour and introduce endogenous labour force participation and variable search intensity. In terms of option-value and aggregate demand channel this paper exhibits similar features with Leduc and Liu (2016). Cacciatore and Ravenna

[1]Fernández-Villaverde and Guerrón-Quintana (2020),Bloom (2009),Born and Pfeifer (2014),Fernández-Villaverde et al. (2015)

(2021) present a similar mechanism where occasionally binding downward wage rigidity amplifies the impact of uncertainty shocks. However, their results are silent on the participation margin and search intensity. Secondly, this paper shed light on search behaviour under uncertainty. The empirical literature on search intensity is not conclusive. While empirical works such as Faberman and Kudlyak (2019), Mukoyama et al. (2018) finds countercyclical search intensity, Gomme and Lkhagvasuren (2015) and Leduc and Liu (2020) find procyclical search intensity. Mukoyama et al. (2018) propose a search and matching model with endogenous search effort and find that search effort has an important role in driving unemployment dynamics. Their model relies on the countercyclical search effort data, and they find that the unemployment rate would have been 0.5 to 1 percentage points higher if search effort had not increased. This paper shows that search intensity is procyclical, and a fall in search intensity during a recession leads higher unemployment rate as a response to uncertainty shock. Moreover, this paper also shows the role of participation in driving aggregate search intensity and unemployment dynamics. This paper is also closely related to the studies which extend standard search and matching models by including participation margin. Cairó et al. (2021) shows that labour force participation falls in expansions due to a fall in household's incentives to send the workers to the labour force. On the contrary, this paper shows that household's incentive to send a worker to the labour force participation increases and decreases during expansions and recessions, respectively. The main reason for the fall in participation is the discouragement effect due to the lower job-finding rate and longer duration of unemployment. In a search and matching model with endogenous labour force participation and financial shocks, Finkelstein Shapiro and Olivero (2020) find a sharper vacancy and unemployment dynamics as a response to financial shocks. Campolmi and Gnocchi (2016) show that with participation, unemployment is four times more volatile than a model without participation. This paper differs from those papers because this paper does not only focus on the role of participation but also the interaction between search intensity and participation. The studies have focused on either the role of search effort or participation. This paper makes a new contribution by emphasizing the importance of labour force participation, search intensity, unemployment dynamics, and labour market fluctuations in response to uncertainty shocks.

3.2 The Model

The economy is populated by a continuum of infinitely lived identical households. The representative household consists of working members, job seekers and non-participants. A continuum of intermediate goods firms, which is owned by the household, uses one worker to produce an intermediate good. In a frictional labour market search and matching outcome is produced through a matching technology that transforms searching workers and vacancies into employment relation. Firms post new vacancies to hire. Searchers face a search cost and choose the level of search intensity. Increasing search intensity increases the probability of finding a job but increases the search costs.

Real wages are determined by a Nash bargaining between firms and searchers. Retail good producers operate in a monopolistically competitive sector, whose outputs are aggregated in a competitive final goods sector, face a perfectly competitive input market where they purchase intermediate goods. Each retailer faces a price adjustment cost as in Rotemberg (1982). The monetary authority sets the policy interest rate. The government finances the unemployment payments through taxes on firm profits.

3.2.1 Labour Market

At the beginning of period t, there are s_t unemployed workers searching for jobs and there are v_t vacancies posted by firms. The Cobb–Douglas function describes the matching technology

$$m_t = \mu(s_t e_t)^{\alpha} v_t^{1-\alpha} \tag{3.1}$$

where m_t is the number of successful matches. e_t denotes search intensity and the parameter $\alpha \in (0,1)$ is the elasticity of matches with respect to the number of searching workers. The parameter μ represents the scale of matching efficiency. Job filling rate which is the probability that an open vacancy is matched with a searching worker is given by

$$q_t^v = \frac{m_t}{v_t} \tag{3.2}$$

Job finding rate, which is the probability that an unemployed and searching worker is matched with an open vacancy, is given by

$$q_t^s = \frac{m_t}{s_t} \tag{3.3}$$

I follow Campolmi and Gnocchi (2016) to model labour market flow. The mass of employed, unemployed, and non-participants/inactive members is represented by N_t, U_t,and I_t respectively. In period $t-1$, a fraction δ of the employed separated from their job. Thus, the number of workers who survives the job separation is $(1-\delta)N_{t-1}$. The household consists of a mass unit continuum of family members so that $U_t + N_t + I_t = 1$. The mass of unemployed, non-participants, and separated workers form the non-employment pool is;

$$U_{t-1} + I_{t-1} + \delta N_{t-1} = 1 - (1-\delta)N_{t-1} \tag{3.4}$$

Some members out of the non-employed pool become searchers s_t at the beginning of period t and the remaining ones enter non-participation I_t.

$$s_t + I_t = 1 - (1-\delta)N_{t-1} \tag{3.5}$$

Denoting $L_t = 1 - I_t$ as the labour force participation, we have

$$s_t = L_t - (1-\delta)N_{t-1} \tag{3.6}$$

where $s_t \geq 0$, and $L_t \geq (1-\delta)N_{t-1}$ implying that the number of participants has to be at least as large as the number of workers who survived from job separation process. Flows from unemployment to out of labour force can be as large as U_{t-1} implying that there are always enough unemployed workers to choose from if the household chooses to reduce participation. Assuming instantaneous hiring, new hires start working in the period they are hired, $U_t = (1-q_t^s)s_t$ and employment evolves according to

$$N_t = (1-\delta)N_{t-1} + \underbrace{q_t^s s_t}_{m_t} = (1-\delta)(1-q_t^s)N_{t-1} + q_t^s L_t \tag{3.7}$$

I define the unemployment rate as

$$u_t = \frac{U_t}{L_t} = \frac{(1-q_t^s)s_t}{L_t} \tag{3.8}$$

Relative to an economy with constant LFP, the combination of a larger equilibrium drop in vacancies and LFP (and ultimately market tightness) implies that the term $(1-q_t^s)/L_t$ rises more. Despite the fact that searching is less attractive and therefore s_t is lower, the rise in $(1-q_t^s)/L_t$ dominates quantitatively, leading to a much sharper increase in the equilibrium unemployment rate.

3.2.2 Household

The representative household consists of a mass unit continuum of family members. Family members can be in three states; employed, unemployed, and inactive/non-participant. The mass of employed, unemployed and non-participant members is denoted by N_t, U_t, and I_t, respectively. The pool of labour market participation is given by $L_t = 1 - N_t$. The household members who are not participating in the labour force gain utility from non-participation, increasing the utility of the whole household. There is complete risk-sharing within the household as in Merz (1995) and Andolfatto (1996). The representative household consumes a basket of retail goods. The utility function is given by

$$E\sum_{t=0}^{\infty}\beta^t\big[\ln(C_t - hC_{t-1}) - \chi\frac{N_t^{1+\zeta}}{1+\zeta} + \varphi\frac{(1-L_t)^{1-\omega}}{1-\omega}\big] \tag{3.9}$$

where $E[.]$ is an expectation operator. C_t, N_t, and L_t denote consumption, the mass of employed family members, and the mass of participants respectively. The parameter $\beta \in (0,1)$ denotes the subjective discount factor and h is the measure of habit persistence. χ and φ are the scaling parameters to pin down targeted steady-state values of employment and participation. Being out of the labour force yields a period utility benefit, $\varphi\frac{(1-L_t)^{1-\omega}}{1-\omega}$, that rises in the number of members allocated to the non-market activity, I. ζ and ω are both positive elasticity constants.

The representative household chooses consumption C_t, savings B_t, N_t, L_t and search intensity e_t to maximize the utility function 3.9 subject to the sequence of budget constraint and law of motion for employment

$$C_t + \frac{B_t}{P_tR_t} = \frac{B_{t-1}}{P_t} + w_tN_t + \phi(L_t - N_t) - s_th(e_t) + d_t - T_t \tag{3.10}$$

$$N_t = (1-\delta)(1-q_t^s)N_{t-1} + q_t^sL_t \tag{3.11}$$

where P_t denotes the price level, B_t denotes holdings of a nominal risk-free bond, R_t denotes the nominal interest rate, w_t denotes the real wage rate, ϕ denotes an unemployment benefit (the replacement ratio), d_t denotes profit income from the ownership of intermediate goods producers and of retailers, T_t denotes a lump-sum tax paid to the government, and $h(e_t)$ denotes the resource cost of search efforts. Consistent with empirical evidence, I follow Yashiv (2000) and Leduc and Liu (2020) assuming the quadratic search cost function.

$$h(e_t) = h_1(e_t - \bar{e}) + \frac{h_2}{2}(e_t - \bar{e})^2 \tag{3.12}$$

where $\bar{e}$ is the normalized steady-state level of search intensity, moreover, search cost is zero in the steady-state. The search cost function $h(e_i)$ for an individual unemployed worker i is increasing and convex. Raising search intensity, while costly, increases the job finding probability. There will be $m/(es)$ new matches formed for each efficiency unit of searching workers supplied. For a worker with search effort e_{it}, the probability of finding a job is

$$q^s(e_{it}) = \frac{e_{it}}{e_t s_t} m_t \tag{3.13}$$

where e (without the subscript i) denotes the average search intensity. The household takes the economy-wide variables e, s, and m as given when choosing the level of search intensity e_i. A marginal effect of raising search intensity on the job-finding probability is given by

$$\frac{\partial q^s(e)}{\partial e_i} = \frac{m_t}{e_t s_t} = \frac{q_t^s}{e_t} \tag{3.14}$$

which depends only on aggregate economic conditions. Denoting Lagrangian of the household problem λ_t, Focs with respect to C_t,B_t,L_t, N_t, and e_t yields

Marginal utility of consumption;

$$\lambda_t = \frac{1}{C_t - hC_{t-1}} - E_t \frac{\beta h}{C_{t+1} - hC_t} \tag{3.15}$$

The optimal bond-holding decision is described as the intertemporal Euler equation;

$$1 = E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{R_t}{\pi_{t+1}} \tag{3.16}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the inflation rate. Denoting μ_t as the Lagrangian multiplier associated with (lawofmotion), first order condition with respect to L_t;

$$\mu_t = \frac{\varphi(1-L_t)^{-\omega} - \lambda_t(\phi - h_t)}{q_t^s} \tag{3.17}$$

Foc with respect to N_t;

$$\mu_t = \lambda_t(w_t - \phi) - \chi N_t^{\zeta} + E_t\beta(1-\delta)\lambda_{t+1}h_{t+1} + E_t\beta(1-\delta)(1-q_{t+1}^s)\mu_{t+1} \tag{3.18}$$

Merging equations 3.17 and 3.18 yields participation condition

$$MRS_t = q_t^s\left[w_t - \frac{\chi N_t^{\zeta}}{\lambda_t} + E_t\beta(1-\delta)\frac{\lambda_{t+1}}{\lambda_t}\left(\left(\frac{1-q_{t+1}^s}{q_{t+1}^s}\right)(MRS_{t+1} - \phi + h_{t+1}) + h_{t+1}\right)\right] + (1-q_t^s)\phi - h_t \tag{3.19}$$

where MRS captures the value of marginal non-participant for the household.

$$MRS_t = \frac{\varphi(1-L_t)^{-\omega}}{\lambda_t} \tag{3.20}$$

The participation condition shows the transition of individuals from outside of the labour force into the participation pool. Household allocates members to search activity such that MRS between participation and consumption is equated to expected pay of searching/being in the labour force. In the event of an unsuccessful match, the payoff is the unemployment benefit ϕ received from the government. In addition to the unemployment benefit received in the event of an unsuccessful search, there is also a search cost denoted by $h(e_t)$ regardless of the match's outcome. This feature rules out the free entry condition to job search activities. If the search is successful, the payoff is the net gain from market activity plus a continuation value.

The Household's optimal search intensity decision is given by

$$h'(e_t) = \frac{q_t^s}{e_t}\left[w_t - \frac{\chi N_t^{\zeta}}{\lambda_t} - \phi + E_t\beta(1-\delta)\frac{\lambda_{t+1}}{\lambda_t}\left(\left(\frac{1-q_{t+1}^s}{q_{t+1}^s}\right)(MRS_{t+1} - \phi + h_{t+1}) + h_{t+1}\right)\right] \tag{3.21}$$

At the optimal level of search intensity, the marginal cost of searching equals the marginal benefit, which is the increased odds of finding a job multiplied by the net benefit of employment, including both the contemporaneous net flow benefits and the continuation value of participation. Equation 3.19 and 3.21 show the cyclical behaviour of labour force participation and aggregate search intensity. The cyclical behaviour of labour force participation and search intensity is ambiguous. During bad economic conditions, a fall in job-finding rate and worsening of the real wage cause households to allocate fewer search activity members. This is described as a discouragement effect. As search intensity increases with job finding probability and participation value, a decrease in job finding probability and labour force participation reduces search intensity. This is an important feature because the model does not assume that the discouragement effect can be described as a fall in labour force participation as there could be different reasons for this. I propose that If individuals are discouraged and move to non-participation, then aggregate search intensity in the economy should be falling as well. In this case, search intensity exhibits pro-cyclical behaviour.

Moreover, the sign of the response of labour market participation and search intensity to shocks depends on habit formation. Indeed, a recessionary shock implies a decrease in consumption and therefore yields a negative wealth effect (an increase in λ_t), leading to an increase in labour force participation. The higher the degree of internal habit formation, h, the stronger the wealth effect and the more likely labour supply and search intensity increase in the short run. The procyclical or even acyclical behaviour is well known, but empirical literature on the cyclical behaviour of search intensity is not conclusive.

3.2.3 Firms

The economy consists of intermediate good producers, retail good producers, and final good producers. A continuum of firms that operates in intermediate sector produce a homogeneous good and sell it to retailers in a competitive market. Retailers operate under monopolistic competition and take into account the demand schedule from the final goods firms' optimal production decisions. Final goods firms are perfectly competitive and use retail goods as the only input.

3.2.3.1 Intermediate Goods Producers

Intermediate goods-producing firms use only labour. A firm can produce only if the match process is successful. The production function for a firm with one worker is given by

$$x_t = Z_t \tag{3.22}$$

where x_t is output. The intermediate goods produced by the firms are sold to final goods firms at a price q_t. Each intermediate goods firms which find a match obtain flow profits of $q_t Z_t - w_t$ in the current period. In the next period, if the match survives with the probability of $1-\delta$, the firm continues. If the match breaks down with probability δ, the firm posts a vacancy at a cost κ, with the value of J_{t+1}^V. Therefore, the match value of a firm is given by the Bellman equation

$$J_t^F = q_t Z_t - w_t + E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\delta) J_{t+1}^F + \delta J_{t+1}^V \right] \tag{3.23}$$

Posting a new vacancy in period t costs κ units of final goods. The firm obtains the value of match when the vacancy is filled with probability q_t^v. If the vacancy is not filled, the firm goes into the next period with the value J_{t+1}^V. Therefore, the value of an open vacancy is given by

$$J_t^V = -\kappa + q_t^v J_t^F + E_t \beta \frac{\lambda_{t+1}}{\lambda} (1 - q_t^v) J_{t+1}^V \tag{3.24}$$

Using free entry condition $J_t^V = 0$

$$J_t^F = \frac{\kappa}{q_t^v} \tag{3.25}$$

denotes optimal job creation decision where the match value J_t^F is the benefit of creating a job and κ / q_t^v is the expected cost of creating a job.

Aggregate technology shock follows the stationary stochastic process.

$$\ln Z_t = \rho_z \ln Z_{t-1} + \sigma_{zt} \epsilon_{zt} \tag{3.26}$$

where $\rho_z \in (-1, 1)$ is the persistence of the technological shock. ϵ_{zt} is an i.i.d innovation to the technology shock and is a standard normal process. The term σ_{zt} is time-varying and used as a technology uncertainty shock which is a second-moment shock and follows the stationary stochastic process.

$$\ln \sigma_{zt} = (1-\rho_\sigma) \ln \sigma_z + \rho_\sigma \ln \sigma_{z,t-1} + \sigma_\sigma \epsilon_{\sigma,t} \tag{3.27}$$

The term $\epsilon_{\sigma,t}$ is an i.i.d standard normal process with standard deviation $\sigma_\sigma \geq 0$. The parameter $\rho_\sigma \in (-1, 1)$ represents the persistence of the uncertainty shock. Uncertainty shock process is constructed as second-moment shock and common in the literature. See Basu and Bundick (2017), Schaal (2017), Fernández-Villaverde et al. (2011), Fernández-Villaverde and Guerrón-Quintana (2020)

3.2.3.2 Final and Retail Goods Producers

The final consumption good Y_t is produced using CES production function.

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\eta-1}{\eta}} dj \right)^{\frac{\eta}{\eta-1}} \tag{3.28}$$

where $Y_t(j)$ denotes the retail good produced by firm $j \in [0,1]$. The parameter η is the elasticity of substitution between differentiated retail goods.

Denote $P_t(j)$ and P_t as relative price associated with retail good j and aggregate price level respectively. The optimization problem of the final good producer is

$$\max_{Y_t(j)} \left\{ P_t Y_t - \int_0^1 P_t(j) Y_t(j) dj \right\} \tag{3.29}$$

Optimization problem yields demand schedule as

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\eta} Y_t \tag{3.30}$$

where $Y_t(j)$ denotes demand for a retail good of type j. Zero profit in final good production implies that the price index P_t is related to the individual prices $P_t(j)$ through

$$P_t = \left(\int_0^1 P_t(j)^{\frac{1}{1-\eta}} \right)^{1-\eta} \tag{3.31}$$

A continuum of retailers indexed by j produce 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

$$Y_t(j) = X_t(j) \tag{3.32}$$

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 monopolistic competitors in the product markets. They set prices for their products, taking as given the demand schedule and price index and price takers in the input market. Price adjustments are subject to the quadratic cost, and price adjustment costs are in units of aggregate output.

$$\frac{\Omega_p}{2}\left(\frac{P_t(j)}{\pi P_{t-1}(j)}-1\right)^2 Y_t \tag{3.33}$$

where π denotes steady-state inflation rate and $\Omega_p \geq 0$ denotes the cost of price adjustment. A retail firm that produces good j chooses $P_t(j)$ to maximize the profit.

$$E_t \sum_{t=0}^{\infty} \beta^i \frac{\lambda_{t+i}}{\lambda_t}\left[\left(\frac{P_{t+i}(j)}{P_{t+i}}-q_{t+i}\right)Y_{t+i}(j)-\frac{\Omega_p}{2}\left(\frac{P_{t+i}(j)}{\pi P_{t+i-1}(j)}-1\right)^2 Y_{t+i}\right] \tag{3.34}$$

where q_t is the relative price of intermediate goods. In a symmetric equilibrium with $P_t(j) = P_t$ for all j, optimal price-setting decision implies

$$q_t = \frac{\eta-1}{\eta}+\frac{\Omega_p}{\eta}\left[\frac{\pi_t}{\pi}\big(\frac{\pi_t}{\pi}-1\big)-E_t\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{Y_{t+1}}{Y_t}\frac{\pi_{t+1}}{\pi}\big(\frac{\pi_{t+1}}{\pi}-1\big)\right] \tag{3.35}$$

Without price adjustment costs($\Omega_p = 0$), the optimal pricing rule implies that real marginal cost q_t equals the inverse of the steady-state markup.

3.2.4 Wage setting

Firms and workers bargain over wages. The Nash bargaining problem is given by

$$\max_{w_t}(S_t^H)^b(J_t^F - J_t^V)^{1-b} \tag{3.36}$$

where $b \in (0,1)$ represents the bargaining weight for workers. $J_t^F - J_t^V$ denotes firm surplus over Nash bargaining, and S_t^H denotes the employment surplus, which is the value of employment relative to unemployment as

$$S_t^H = w_t - \phi - \frac{\chi N_t^\zeta}{\lambda_t} + \frac{h(e_t)}{1-q_t^s} + E_t\beta\frac{\lambda_{t+1}}{\lambda_t}(1-\delta)(1-q_{t+1}^s)S_{t+1}^H \tag{3.37}$$

Using $J_t^V = 0$, the First-order condition implies that

$$bJ_t^F\frac{\partial S_t^H}{\partial w_t} + (1-b)S_t^H\frac{\partial J_t^F}{\partial w_t} = 0 \tag{3.38}$$

where $\partial S_t^H/\partial w_t = 1$ and $\partial J_t^F/\partial w_t = -1$. Define total surplus as $S_t = J_t^F + S_t^H$, the bargaining outcome is given by

$$J_t^F = (1-b)S_t, \quad S_t^H = bS_t \tag{3.39}$$

Therefore, The Nash bargaining wage w_t^N satisfies the Bellman equation.

$$\frac{b}{1-b}J_t^F = w_t^N - \phi + \frac{h(e_t)}{1-q_t^s} + E_t\beta\frac{\lambda_{t+1}}{\lambda_t}(1-\delta)(1-q_{t+1}^s)\frac{b}{1-b}J_{t+1}^F \tag{3.40}$$

Real wage rigidity is considered to be important to generate empirically reasonable volatility of vacancy and unemployment.(Hall (2005), Blanchard and Galí (2010)). Therefore, I follow Leduc and Liu (2016);

$$w_t = w_{t-1}^{\gamma}(w_t^N)^{1-\gamma} \tag{3.41}$$

where $\gamma \in (0,1)$ denotes the degree of real wage rigidity.

3.2.5 Government policy and market clearing

The government finances unemployment benefit ϕ through lump-sump taxes T. Assuming balanced government budget in each period, we have;

$$\phi(L_t - N_t) = T_t \tag{3.42}$$

Taylor rule. The monetary authority follows the Taylor rule

$$R_t = r\pi^*(\frac{\pi_t}{\pi^*})^{\phi_\pi}(\frac{Y_t}{Y})^{\phi_y} \tag{3.43}$$

where the parameter r denotes the steady-state real interest rate. π^* and Y denote targeted inflation rate and steady-state output, respectively. The parameter ϕ_π determines the aggressiveness of monetary policy against deviation of inflation from target π^*. ϕ_y determines the extent to which monetary policy accommodates output fluctuations.

In a search equilibrium, market for bonds, final goods and intermediate goods all clear. Bond market-clearing condition implies that $B_t = 0$. Intermediate goods market-clearing condition implies that $Y_t = Z_tN_t$ and good markets clearing implies the aggregate resource constraint

$$C_t + \kappa v_t + h(e_t)s_t + \frac{\Omega_p}{2}(\frac{\pi_t}{\pi} - 1)^2 Y_t = Y_t \tag{3.44}$$

where consumption spending, search costs ($h(e_t)s_t$), vacancy creation costs(κv_t) and price adjustment costs add up to aggregate production.

3.3 Solution and Calibration

Uncertainty shocks in the model are second-moment shocks and require at least third-order perturbation to obtain policy functions that contain volatility shocks. First-order perturbation is not useful to examine the dynamic effects of uncertainty shock due to certainty equivalence. A second-order perturbation captures the effects of uncertainty shocks indirectly by involving cross-products of level and volatility shocks. Solution that involves uncertainty shocks can be achieved by a third-order perturbation. By following Fernández-Villaverde et al. (2011), I perform third-order perturbation to trace the effect of uncertainty shocks. In particular, the model is first simulated for a large number of periods to compute the ergodic mean of each variable. It is then simulated using the ergodic means as a starting point. Finally, impulse responses to an uncertainty shock are computed as the differences between the simulated path with an uncertainty shock and the path with no shocks.

The timing of the model is one quarter. The model is calibrated to match key stylized facts of the US economy. The subjective discount factor β is set 0.99, so that the model implies a steady-state real interest rate of 4 percent per year. Following Blanchard and Galí (2010) and Gertler and Trigari (2009) the elasticity of the matching function α and the wage bargaining parameter b are set to 0.5. Consistent with the Job Openings and Labor Turnover Survey (JOLTS), quarterly separation rate δ is set to 0.1. The replacement ratio of unemployment is set to $\phi = 0.25$ in line with Hall and Milgrom (2008) and Leduc and Liu (2016). Search cost function parameter, h_2, is set equal to the value estimated by Leduc and Liu (2020), and is given by 0.9928. The habit formation parameter h is set to 0 in the baseline analysis. The reel wage rigidity is set to $\gamma = 0.8$ which is in line with Gertler and Trigari (2009). Given the steady-state value of m, s, and v the implied value of matching efficiency is $\mu = 0.6954$. The second parameter, h_1, in search

Table 3.1: Benchmark calibration

Parameter	Description	Value
β	Discount factor	0.99
δ	Separation rate	0.1
α	Matching elasticity	0.50
μ	Matching efficiency	0.6459
b	Nash bargaining weight	0.50
χ	Scale of disutility of working	1.4663
φ	Scale of utility of non-participation	0.2363
ϕ	Unemployment benefits	0.25
h_2	Curvature of the search cost function	0.9928
h_1	Slope parameter of search cost	0.1192
κ	Vacancy posting cost	0.14
ψ	Disutility of LFP param	1.495
h	Habit persistence	0
γ	Real wage rigidity	0.8
Ω_p	Price adjustment cost	112
π	Steady-state inflation	1.005
ϕ_π	Taylor rule parameter for inflation	1.5
ϕ_y	Taylor rule parameter for output	0.2
ζ	Elasticity parameter for preferences/employment	1
ω	Elasticity parameter for preferences/participation	1
ρ_z	Persistence of tech. shock	0.95
σ_z	Mean volatility of tech. shock	0.01
ρ_σ	Persistence of tech. uncertainty shock	0.76
σ_σ	Mean volatility of tech. shock	0.3920

intensity function is obtained by using optimal search intensity equation(Equation 3.21) in the steady-state.

The steady-state value of the mass of employed workers and participation are set to their historical values 0.59 and 0.63 yielding 6.4 percent unemployment rate. The value of χ and φ are chosen so that steady-state values of employment and participation are consistent with their steady-state targets. The total cost of posting vacancy in the steady-state is about 2 percent of gross output yielding vacancy cost parameter $\kappa = 2\%Y/v$. The steady-state vacancy filling rate q^v is set to 0.70 and the steady-state hiring rate is $m = \delta N = 0.059$ implying that $v = \frac{m}{q^v} = \frac{0.059}{0.70} = 0.084$. The steady state-level of technology is normalized to

$Z = 1$ implies steady-state output $Y = ZN$. That follows calibrated value of $\kappa = 0.14$.

I calibrate nominal rigidity parameters as in Leduc and Liu (2016). The elasticity of substitution between differentiated retail goods is set to $\eta = 10$ yielding an average markup of 11 percent. The price adjustment cost is set to $\Omega_p = 112$. The Taylor rule parameters, ϕ_π and ϕ_y, are set to 1.5 and 0.2 in line with the literature. The steady-state inflation rate(annual rate) is set to 2 percent which implies $\pi = 1.005$ in the quarterly model.

The parameters in the first-moment technology shock are set to empirically relevant values. In particular, the average standard deviation is set to $\sigma_z = 0.01$ and the persistence parameter is set to $\rho_z = 0.95$. The persistence and volatility of the uncertainty shock, ρ_σ and σ_σ, are set equal to those estimated by Leduc and Liu (2016) using a structural vector autoregressive model and are given by 0.76 and 0.392 respectively.

3.4 Quantitative Results

In this section, I examine the macroeconomic effects of uncertainty shocks. I focus on the response of the labour market variables such as unemployment, participation, and search intensity. I first solve and simulate a model with price flexibility. For the second model, I introduce price stickiness. Moreover, I also examine the role of habit as an amplification factor in labour market. I set wage rigidity parameter γ to 0.8, which is in line with Gertler and Trigari (2009). Moreover, I show the implication of habit persistence and the case in the absence of search cost.

Flexible price. The sign of the effects of uncertainty shocks, in general, is not constrained by the economic theory. They can be either expansionary or contractionary. Basu and Bundick (2017) show that uncertainty shocks in a flexible price model with no search frictions are expansionary. Increased uncertainty creates a precautionary saving motive, reduces the real interest rate, and increases employment and output. Using different uncertainty shocks such as uncertainty on preference shock, uncertainty on productivity shock, and uncertainty on financial shock, Fernández-Villaverde and Guerrón-Quintana (2020) show that uncertainty shocks are expansionary(at least in terms of output, the household consumes less

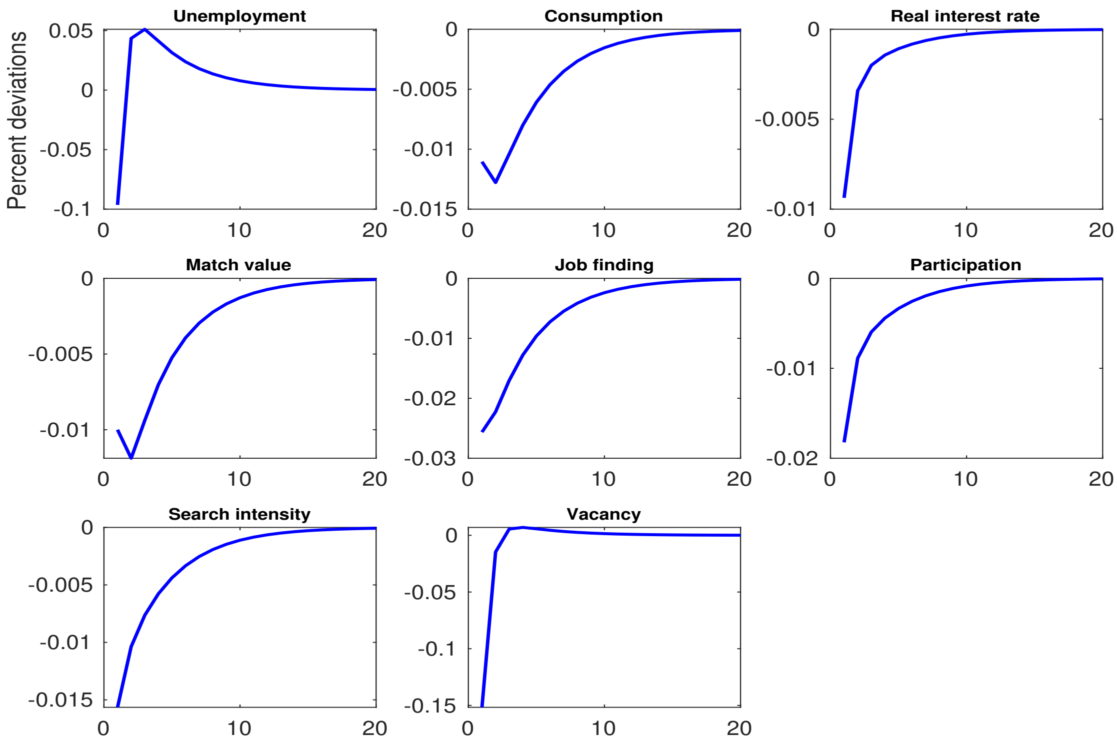

FIGURE 3.2: Impulse responses to an uncertainty shock with flexible prices.

and works more). In contrast to this paper, their model lacks the nominal rigidities and search frictions. The flexible price version of the model in this paper indicates that uncertainty is contractionary. For the firm side, the results are in line with Leduc and Liu (2016). Facing higher uncertainty, the option value of waiting increases and the value of job match decreases. As the match value decreases, firms post fewer vacancies. The fall in the number of new vacancies makes it harder for unemployed workers to find a job. Therefore, the job-finding rate falls. The decline in consumption and interest rate shows that uncertainty creates a precautionary saving motive. However, the option-value channel prevails over precautionary saving, which results in contraction as opposed to the literature finding an expansionary effect of uncertainty in a flexible-price model.

Higher uncertainty gives rise to procyclical participation and search intensity in the absence of price stickiness. The decline in the job-finding probability leads to discouragement. As the search intensity increases with job finding probability, sending non-participants to the labour force is less attractive due to search costs faced by the household. Thus, the decline in the number of participants and search intensity indicates a discouragement effect. The figure shows that the quantitative response of the model is weak under flexible price assumption, suggesting that the flexible-price version of the model do not generate amplification in response to uncertainty shocks. The shortcoming of the flexible-price version of the model is the fall in unemployment due to the inclusion of LFP. It is possible to see from the definition of unemployment rate, $u_t = U_t/L_t = (1 - q_t^s)s_t/L_t$, the fall in searchers s_t quantitatively dominates the rise in $(1-q_t^s)/L_t$[2]. Therefore, unemployment falls in the flexible-price model.

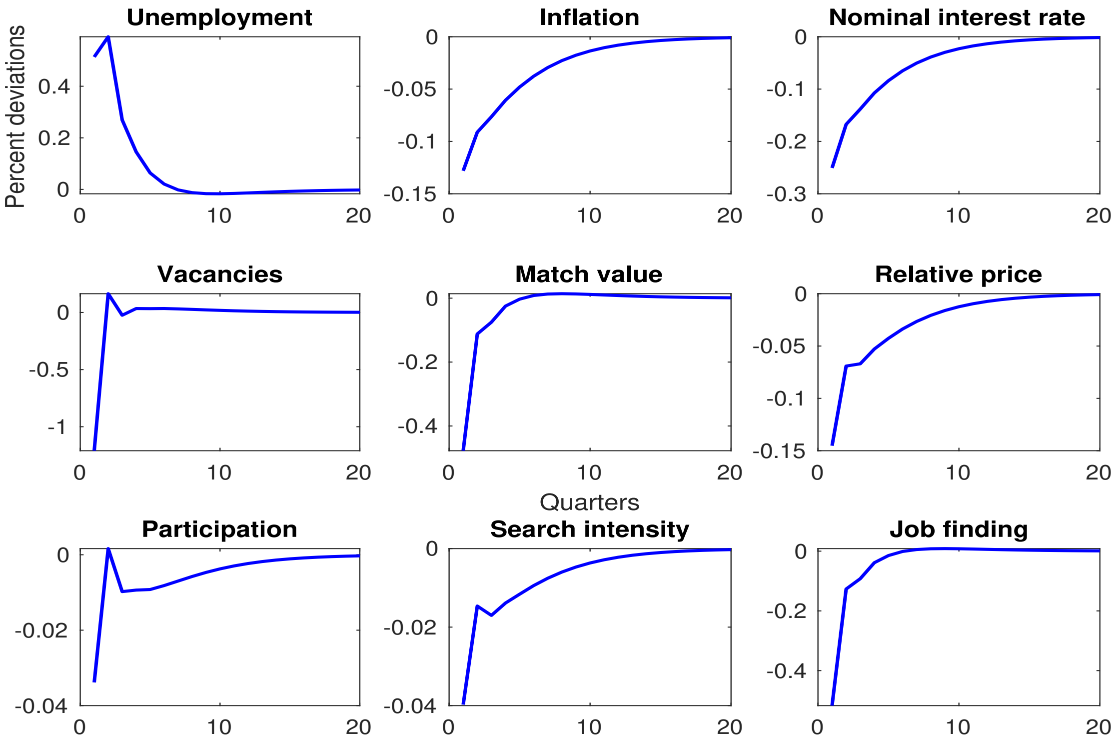

FIGURE 3.3: Impulse responses to an uncertainty shock with sticky prices.

Price stickiness. To examine the aggregate demand channel for the transmission of uncertainty shocks I introduce nominal rigidities. The figure shows that nominal rigidities play an important role in the amplification mechanism. Higher uncertainty raises the unemployment rate by reducing aggregate demand. A fall in demand leads to a decline in consumption resulting in a decline in the relative price of intermediate goods, reducing firms profit and the value of a job match. As the value of match decreases, firms post fewer vacancies. As a result fall in the job-finding rate leads to higher unemployment. When it is harder to find a job, household allocates fewer members to the labour force. Thus, labour force participation declines due to discouragement. As the participation declines and more workers are unemployed, household income falls. Thus, the initial decline in

[2]See Figure 3.6 in Appendix for IRFs

aggregate demand is depressed more and inflation falls. The central bank lowers the interest rate as a response to the decline in aggregate demand.

Optimal search intensity(Equation 3.21) shows that search intensity increases with job-finding probability, employment and continuation value of the participation. Since the uncertainty shock lowers both the job-finding and participation value, it reduces search intensity as well. The procyclical search intensity generated by the model is consistent with Krueger and Mueller (2011), which finds that search intensity declines as unemployment increases.

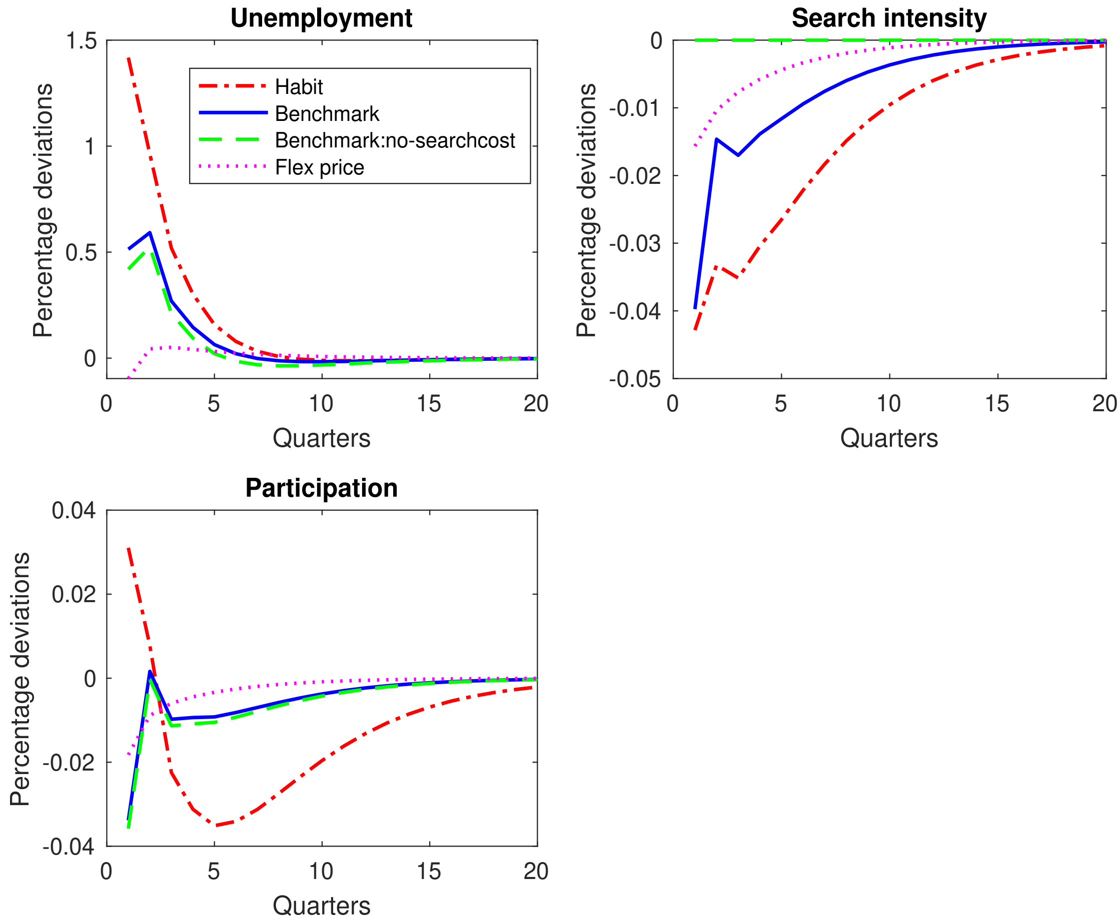

FIGURE 3.4: Amplification mechanism for uncertainty shock: alternative calibrations

Figure 3.4 shows the response of unemployment, labour force participation and search intensity to an uncertainty shock in four different models. Search frictions, rigidities, and habit formation have important effects that amplify the effects of uncertainty shock in the model. Figure 3.4 shows that the response of unemployment, search intensity, and participation to uncertainty shock in the benchmark model is larger than the model with flexible price. Benchmark and flexible-price version of the model gives rise to a discouragement effect, which leads to a decline in participation and search intensity. Introducing habit formation amplifies the effects of uncertainty shock and increases the labour force participation due to the wealth effect. Habit formation induces a greater decline in consumption and therefore yields a negative wealth effect(an increase in λ_t). Therefore, household allocates more members to labour force participation. It can also be inferred that movement in and out labour force participation is not the sole factor affecting the search intensity. Unemployment rises sharply as habit formation increases the persistence of the negative effects of uncertainty, which induces a greater decline in the present value of job match.

The pool of searchers is composed of the participants and the workers who are exogenously separated from their jobs. Thus, while habit formation increases the labour force participation due to the wealth effect, low job-finding probability makes it harder for recently separated workers to find a match. As the duration of unemployment increases, the aggregate search intensity decreases too. The results conclude that search intensity is procyclical for three different models and labour force participation is countercyclical in the model with habit formation.

Figure 3.5 shows the response of unemployment, participation, and search intensity when the values of elasticity parameters and curvature of search intensity, h2, change. The value of elasticity parameters is set to unity for the benchmark model. The benchmark model is calibrated for different values of h2. Setting the parameter h2 to zero implies that there is no search intensity cost. A higher value of h2 shows that the response of unemployment gets closer to the benchmark model. However, the magnitude of the change in search intensity is lower in that case. For both cases, participation falls. For the case in which values of ζ and ω are set to 5, the quantitative response of the labour market is weak.

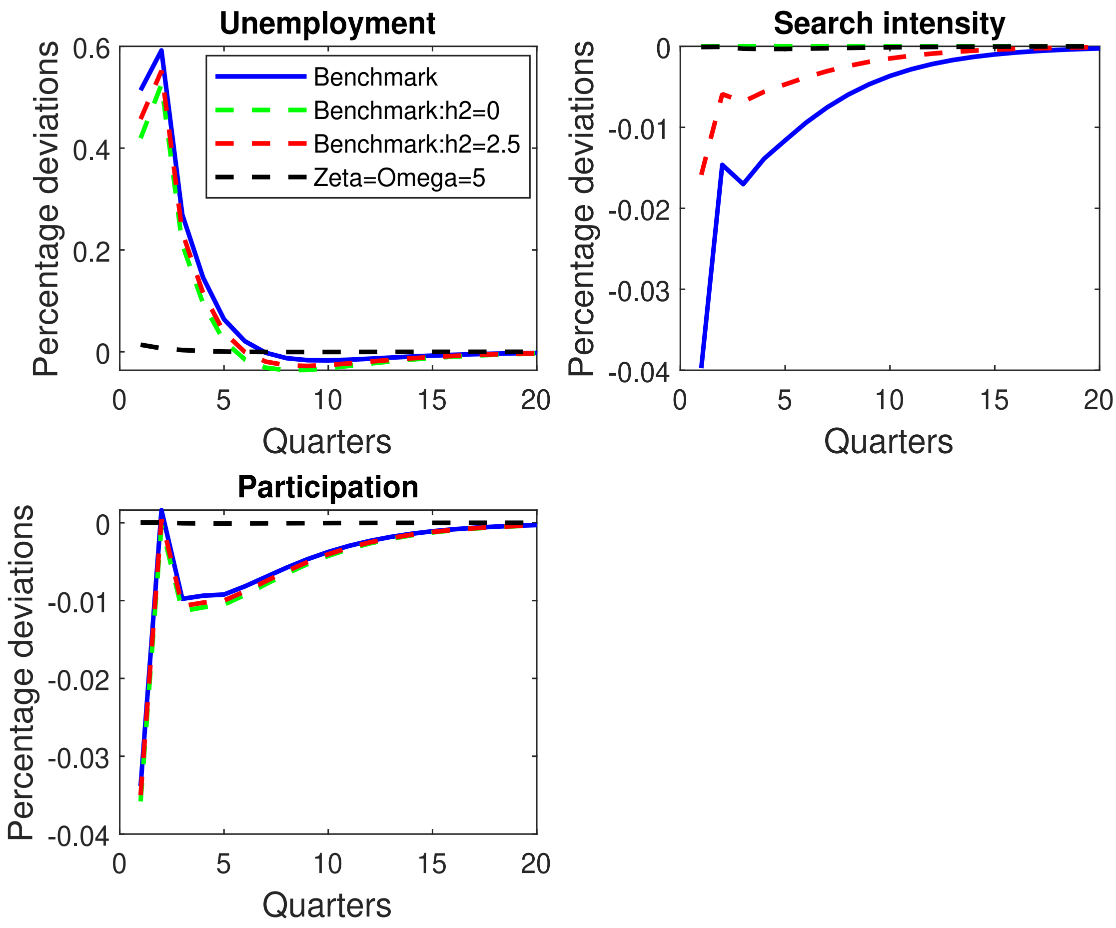

FIGURE 3.5: Sensitivity analysis

3.5 Conclusion

This paper investigates the effect of uncertainty shocks on labour force participation, unemployment and search intensity. I build a New Keynesian model that incorporates endogenous labour force participation and variable search intensity. I show that uncertainty shocks lead to a recession in the flexible-price and sticky-price models. Moreover, I show that labour force participation and search intensity decline due to increased uncertainty. The discouragement effect becomes the dominant factor pushing labour force participation down. However, in the presence of habit formation, the wealth effect prevails over the discouragement effect inducing an increase in labour force participation. Search intensity exhibits procyclical behaviour in all three models, in line with the constructed search intensity data. This study abstracts from some important features of the actual labour market. The searchers in this study are described as the unemployed pool which is composed of the new participants and the ones recently separated from their job. However, on-the-job search behaviour may have important implications for the quantitative magnitude of the labour market dynamics. Mueller et al. (2017) recently is going in this direction by focusing on the job search behaviour among the employed and non-employed. Since the evidence on the search behaviour among the employed is scant, incorporating on-the-job search may have important implications for the quantitative response of unemployment, participation and search intensity.

3.6 Appendix C

3.6.1 Equilibrium Conditions

Euler Equation

$$1 = E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{R_t}{\pi_{t+1}} \tag{3.45}$$

Marginal utility of consumption

$$\lambda_t = \frac{1}{C_t - hC_{t-1}} - E_t \frac{\beta h}{C_{t+1} - hC_t} \tag{3.46}$$

Retail firm's optimal pricing decision:

$$q_t = \frac{\eta - 1}{\eta} + \frac{\Omega_p}{\eta} \left[\frac{\pi_t}{\pi} \big(\frac{\pi_t}{\pi} - 1 \big) - E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{Y_{t+1}}{Y_t} \frac{\pi_{t+1}}{\pi} \big(\frac{\pi_{t+1}}{\pi} - 1 \big) \right] \tag{3.47}$$

Matching function:

$$m_t = \mu (e_t s_t)^{\alpha} v_t^{1-\alpha} \tag{3.48}$$

Job finding rate:

$$q_t^s = \frac{m_t}{s_t} \tag{3.49}$$

Vacancy filling rate:

$$q_t^v = \frac{m_t}{v_t} \tag{3.50}$$

Employment dynamics:

$$N_t = (1 - \delta) N_{t-1} + m_t \tag{3.51}$$

Number of searching workers:

$$s_t = L_t - (1 - \delta) N_{t-1} \tag{3.52}$$

Unemployment:

$$U_t = L_t - N_t \tag{3.53}$$

Aggregate production function:

$$Y_t = Z_t N_t \tag{3.54}$$

Taylor rule:

$$R_t = r \pi^* \big(\frac{\pi_t}{\pi^*} \big)^{\phi_\pi} \big(\frac{Y_t}{Y} \big)^{\phi_y} \tag{3.55}$$

Aggregate resource constraint:

$$C_t + h(e_t)s_t + \kappa v_t + \frac{\Omega_p}{2}(\frac{\pi_t}{\pi} - 1)^2 Y_t = Y_t \tag{3.56}$$

Match value:

$$J_t^F = q_t Z_t - w_t + E_t\beta\frac{\lambda_{t+1}}{\lambda}(1-\delta)J_{t+1}^F \tag{3.57}$$

Vacancy posting:

$$J_t^F = \frac{\kappa}{q_t^v} \tag{3.58}$$

Tightness:

$$\theta = \frac{v_t}{s_t} \tag{3.59}$$

Nash bargaining wage:

$$\frac{b}{1-b}J_t^F = w_t^N - \phi - \frac{\chi N_t^\zeta}{\lambda} + \frac{h(e_t)}{1-q_t^s} + (1-\delta)E_t\beta\frac{\lambda_{t+1}}{\lambda}(1-q_{t+1}^s)\frac{b}{1-b}J_{t+1}^F \tag{3.60}$$

Actual real wage (with real wage rigidity):

$$w_t = w_{t-1}^\gamma (w_t^N)^\gamma \tag{3.61}$$

Participation condition:

$$\frac{\varphi(1-L_t)^{-\omega}}{\lambda_t} = q_t^s\left[w_t - \frac{\chi N_t^\zeta}{\lambda_t} + E_t\beta(1-\delta)\frac{\lambda_{t+1}}{\lambda_t}\left((\frac{1-q_{t+1}^s}{q_{t+1}^s})(\frac{\varphi(1-L_{t+1})^{-\omega}}{\lambda_{t+1}} - \phi + h_{t+1}) + h_{t+1}\right)\right] + (1-q_t^s)\phi - h_t \tag{3.62}$$

Aggregate search intensity:

$$h'(e_t) = \frac{q_t^s}{e_t}\left[w_t - \frac{\chi N_t^\zeta}{\lambda_t} - \phi + E_t\beta(1-\delta)\frac{\lambda_{t+1}}{\lambda_t}\left((\frac{1-q_{t+1}^s}{q_{t+1}^s})(\frac{\varphi(1-L_{t+1})^{-\omega}}{\lambda_{t+1}} - \phi + h_{t+1}) + h_{t+1}\right)\right] \tag{3.63}$$

3.6.2 Data

Search Intensity: Search intensity measure is constructed based on regression estimated by Krueger and Mueller (2011)

$$s_t = 122.30 - 0.90d_t \tag{3.64}$$

where d_t is seasonally adjusted monthly series of the median duration of unemployment which is taken from CPS(LNS13008276).

Uncertainty measure: Uncertainty index is taken from Michigan Survey which is conducted by University of Michigan.

The sample range covers the period form February 1978 to March 2021

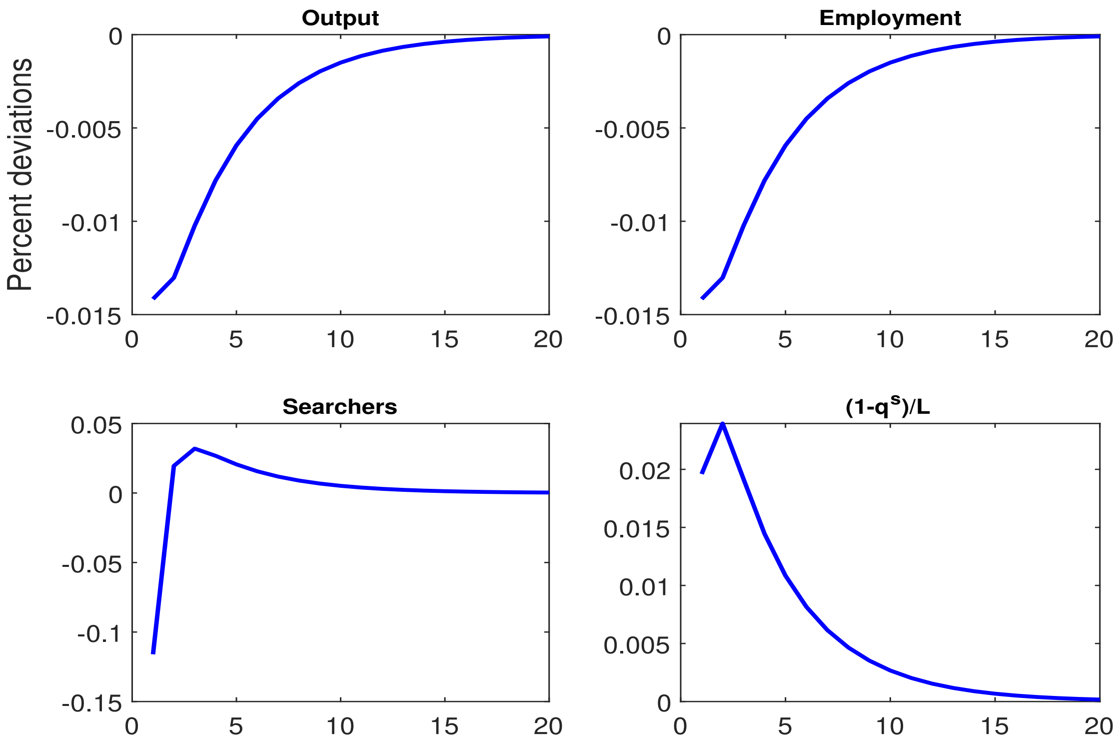

Figure 3.6: Driving factor for the fall in unemployment in flexible-price model

Chapter 4

Conclusion

This thesis studies the labour market fluctuations. First chapter investigates the long-rung implication of financial shocks and financial conditions on labour market dynamics. I propose a search and matching model that incorporates financial shocks and frictions. I simulate the model dynamics with the data for the U.S. The results suggest that financial factors played significant role in unemployment, employment, hours per worker, total hours, vacancy creation and labour market tightness. These results rely on the estimates of shock process using data till the end of the Great Recession as the literature mainly focused. I extend the analysis by including aftermath of the Great Recession to investigate whether the labour market behaves different than the previous recession or not. I find that financial shocks have an important effect on unemployment and vacancy creation until the end of recent financial crises. . However, the model still can capture the cylclicality of labour market variables in previous recessions in 1990-1991, 2001. The results suggest that there might be structural changes in the labour market after financial crises. The Beveridge curve shifts after financial crises and this shift can not be explained by only financial shocks. Recently, studies started to investigate why the Beveridge curve shifted after the 2008 financial crises. Change in matching efficiency, decline in labour force participation, search and recruitment intensity are considered some of the factors might have caused the shift in the Beveridge curve and requires more investigation.

The second chapter studies macroeconomic implications of labour force participation and variable search intensity. I propose a model that incorporate endogenous labour force participation and variable search intensity. Technology and discount factor shocks are the sources of business cycle fluctuations in the model. I estimate search intensity parameters and shocks process by using search intensity and unemployment data serious for the U.S. The results suggest that including endogenous labour force participation has significant effect on unemployment fluctuation. I find that search intensity and labour force participation are procylical. During recession, when the duration of unemployment increases, labour force participation and search intensity declines. I compare the benchmark model with a standard search and matching model. The results show that search intensity works as an amplification factor. To conclude, including endogenous labour force participation and search intensity into a search and matching model improves the model behaviour.

The third chapter investigates the effect of uncertainty shocks on labour force participation, search intensity, and unemployment dynamics. I propose a New Keynesian model that incorporates endogenous labour force participation and variable search intensity. Uncertainty shocks lead to a recession in the flexible and sticky-price model. Labour force participation and search intensity decline as a response to increased uncertainty. The discouragement effect becomes the dominant factor pushing labour force participation down. However, in the presence of habit formation, the wealth effect prevails over the discouragement effect and induces an increase in labour force participation. An increase in labour force participation due to the wealth effect can not generate countercyclical search intensity since labour force participation is not the sole factor affecting search intensity. Search intensity exhibits procyclical behaviour in flexible-price, sticky-price and habit models in line with the constructed search intensity data.

Job transitions account for one-third of all hiring in the U.S. labour market. However, the majority of the literature has focused on the behaviour of the unemployed. The primary reason for that is the lack of data on employed and on-the-job search. Macro-labour literature provides a framework for business cycles fluctuations by introducing aggregate shocks into search and matching models developed by Diamond (1982), and Mortensen and Pissarides (1994), where only the unemployed workers look for jobs. The hiring process includes firms looking to fill vacancies and unemployed workers searching for jobs. Recent studies attempt to investigate this gap and document the importance of on-the-job search and job ladder dynamics. Understanding job search behaviour and intensity are difficult due to the availability of data on employed, unemployed, and non-participants. Studies that investigate job search behaviour rely on survey data and online job application data which is mostly for unemployed individuals. For the future research avenue, it might be important to investigate the quantitative consequences of the on-the-job search for unemployment dynamics. In that way, it would be possible to show how job finding and unemployment fluctuates in the absence of on-the-job search. Another contribution to the literature would be to focus on how the searcher decomposition changes over time and how this decomposition affects aggregate search intensity and unemployment dynamics. Accessing novel micro-data sets on individuals and their search behavior can help to improve DSGE models for further improvements.

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