Reconciling the Relevance of Labor Market Institutions in Search and Matching Models with International Data*

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June 2011

PRELIMINARY

Abstract

This paper examines whether the search and matching frictions in the New Keynesian framework can account for cross-country differences in cyclical properties of labor markets. Our particular focus is the joint effect of two labor market institution variables: employment protection and replacement income of unemployed workers. We first document an empirical regularity that higher degrees of employment protection and/or lower replacement rates raise the standard deviation of real wages relative to unemployment in OECD members. However, there is a positive correlation between employment protection and replacement rates implying that the net effect of a systematic change in these two institution variables could be ambiguous. Then we show that a model of search and matching friction is broadly consistent with the stylized fact: in the model, higher firing costs and/or lower replacement rates generate higher volatility of real wages relative to unemployment. Although the model is not able to generate enough variation in the relative standard deviation observed in the data, we find that a good part of this feature arise from increases in real wage volatility which is tightly linked with the volatility of the labor market tightness.

*I thank ... and seminar participants in. Any remaining errors are my own. The views expressed in this paper are not necessarily those of the Bank of Japan.

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1 Introduction

Macroeconomic analyses on search and matching frictions in labor markets have flourished since Mortensen and Pissarides (1994) built an applicable framework to macroeconomic models. The framework was soon transplanted to a real business cycle model by Merz (1995). Shimer (2005) and Hall (2005) extensively examined cyclical properties of labor markets under the presence of search and matching frictions in partial equilibrium contexts. More recent studies, such as Walsh (2005) and Trigari (2009), synthesized the search and matching frictions with the New Keynesian framework and examine effects of labor market frictions on inflation dynamics.

Despite their prevalence, reconciling labor search models with data is an ongoing research topic. A line of literature, represented by Thomas (2006), Abbritti and Weber (2010) and Campolmi and Faia (2011), explores exact forms of frictions in labor markets that can account for the cross-country differences in business cycle properties within the class of labor search models. Many of them stress that labor market institutions, such as the strictness of employment protection, are crucial to better explain inflation and labor market fluctuations. However, the approaches of existing studies are, in my view, often insufficient to unveil the importance of labor market institutions as a system: many of them shed light only one aspect of labor market institutions. In addition, data handling in existing literature is sometime insufficient to isolate the propagation mechanisms arising from labor market institutions from effects of disturbances outside labor markets. In this sense, existing literature has not revealed a complete picture on the usefulness of the search and matching framework.

In this paper, we undertake the task to measure the relevance of the search and matching frictions in accounting for the cross-country differences in business cycle properties. Our primary focus is the effect of labor market institutions on the cyclical properties of labor markets as the labor search theory has originally developed to account for the behavior of actual labor markets. We begin with documenting the cyclical properties of labor markets across OECD members along with differences in labor market institutions. Then we construct a labor search model with sticky prices, a variant of Thomas and Zanetti (2009), and examine whether this framework can be reconciled with the stylized facts. While we spare much of our analysis on labor market fluctuations, we also remark on the relevance of labor market institutions to inflation dynamics.

Our result is two-fold. First we find that the degree of employment protection and benefit replacement rates are factors that can account for the stylized fact on cyclical properties of labor markets among OECD members: the standard deviation of real wage relative to unemployment tends to rise in countries with high degrees of employment protection and low replacement rates. We also find that there is a general tendency that countries with high degree of employment protection have high replacement rates. This implies that the net effect of labor market institutions as a system is often ambiguous.

Next, we find that our model is broadly consistent with the empirical findings: higher firing costs and lower replacement rates are associated with more volatile real wages relative to unemployment. And we find that this is related to the increase in the volatility of the labor market tightness defined as the scarceness of vacancies relative to unemployment. Because the labor market tightness measures the easiness to recruit workers for firms, its fluctuations affect the wage bargaining power of firms thereby affecting real wages. Raising firing costs increases the volatility of the labor market tightness because firms shift to the vacancy posting channel when adjusting labor force. When replacement rates are lowered, the relative importance of the labor market tightness in wage setting rises. This is because the equilibrium real wage is a linear combination of the labor market tightness and the replacement rates. A pitfall of labor search models is, however, the system of labor market institutions alone is not powerful enough to fully account for the cross-country variations in the volatility of real wages relative to unemployment.

The virtue of our study is that we shed light on the systematic differences in labor market institutions. Thomas (2006) and Campolmi and Faia (2011) retrieve novel implications on the effects of firing costs and replacement rates. However, each study considers only one dimension of labor market institutions resulting in a failure to take into account the correlation of these institutional variables. Abbritti and Weber (2010) considers frictions that cause unemployment rigidities as well as wage rigidity. However, the institutions that they consider in their model are conceptually inconsistent with those in their data analysis. It documents the empirical relevance of employment protection to unemployment fluctuations, yet it does not consider firing costs explicitly in their model. On the other hand, we incorporate firing costs and replacement rates jointly and build a clear connection between our model analysis and our empirical strategy. This setup enables us to draw a more accurate picture on the effect of labor market institutions on the cyclical properties of labor market as well as inflation dynamics.

Our study conveys more purified information on the endogenous propagation mechanism emerging from labor market institutions. Many of the existing studies pick the volatility of a single aggregate variable, *e.g.* unemployment, as a measure of business cycle properties. This method is insufficient to isolate the effect of labor market institutions from the historical magnitude of exogenous disturbances. Our approach, in contrast, focuses on the standard deviation of real wage relative to unemployment. This measure is more free from the size of disturbances thereby conveying more accurate information on the style of labor market fluctuations induced by endogenous propagation. By taking these steps our study offers a more comprehensive picture on the relevance of the search and matching frictions in labor markets on business cycles.

The remaining structure of this paper is following. Section 2 documents a stylized fact about cross country differences in cyclical properties of labor markets and their relations with labor market institutions. Section 3 sets up our model with emphasis on labor market institutions discussed in section 2. Section 4 presents the result of model simulation. Then, in section 5, we describe the background of the result and we make a concluding remark in section 6.

2 A stylized fact among OECD members

This section documents a stylized fact on the relation between labor market institutions and cyclical properties of labor markets among selected OECD members. Our sample covers OECD members in which time series data on unemployment and real wages[1] is available from the 1980s.

Our analysis begins with selecting a measure that conveys purified information on the cyclical behavior of labor markets propagated by labor market institutions. In this paper, we select the standard deviation of real wages relative to unemployment, denoted by σ_w/σ_u, as the proxy of cyclical properties of labor markets. In short, we intend to shed light on the relative importance of the price adjustment channel to the quantity adjustment channel in labor markets. We also want the proxy to be free from the magnitude of disturbances emerging from outside the labor markets. Comparing the unconditional variance of a single variable often confuses effects of endogenous propagation arising from economic structures with effects of the magnitude of exogenous disturbances. This problem can be serious when labor market institutions are correlated with these disturbances. Because the data we use in this paper is not normalized by the magnitude of exogenous disturbances, the relative standard deviation is a more preferable measure for cross-country comparisons.

As for labor market institution variables, there are several candidates. Restrictions on firing would affect job flows and the behavior of unemployment. The generosity of unemployment benefit would affect real wage dynamics and employment decisions through the effect on reservation wages. Another prevailing view is the importance of the degree of unionization. The list of variables further expands. For example, Bank of Japan (2010 written in Japanese) points out that the active labor market policies toward unemployed workers, such as job training, would

[1] we use real wage in the manufacturing sector because nominal wage including other sectors is available only for a few countries in OECD database. We deflate nominal wage in the manufacturing sector by CPI excluding food and energy.

countries	EP	RR	UD	UC	ALMP
Australia	1.07	24.5	40.7	80.0	0.45
Belgium	2.71	48.2	53.8	90.0	1.26
Canada	0.75	53.6	34.0	36.0	0.54
Denmark	1.91	72.4	76.9	69.0	1.51
Finland	2.15	51.5	73.9	95.0	1.21
France	2.94	59.1	11.9	93.5	1.05
Germany	2.73	38.1	31.0	91.0	1.20
Ireland	0.96	42.6	49.4		1.46
Italy	2.97	19.2	39.9	82.5	1.24
Japan	1.66	29.5	25.7	22.0	0.16
Netherlands	2.51	69.7	26.7	85.0	1.56
Norway	2.75	58.9	57.0	70.0	0.87
Sweden	2.74	82.8	82.4	87.5	2.05
Spain	3.33	69.1	12.5	77.0	0.65
UK	0.64	23.2	39.2	47.0	0.56
U.S.A	0.21	28.3	15.9	17.5	0.20

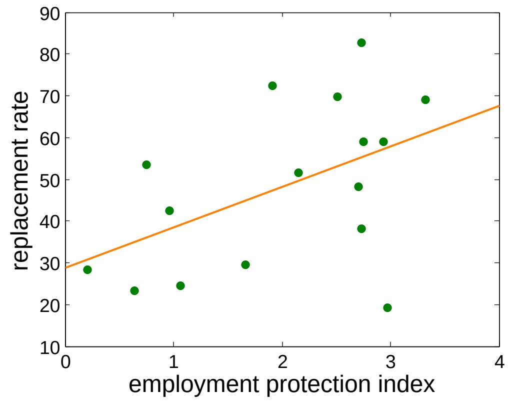

Table 1 & Figure 1: Labor market institutions by countries

reduce the cost of unemployment thereby increasing job mobilities.

We first check cross-country variation of the labor market institution variables listed above. We take the indicator of employment protection (EP), which is a proxy of firing costs, from OECD.stat and replacement rates, union density, union coverage and expenditures on active labor market policies (RR, UD, UC and ALMP respectively) from Nickell (2006). The Replacement rate is the ratio of unemployment benefit to wage income of employed workers. The union density and the union coverage are union members and workers covered by collective agreements normalized by total employment respectively. The active labor market policies measure expenditures as a percentage of GDP on government programs that intend to help unemployed workers find jobs. These measures are available from 1980s to the mid 2000s. Each figure in Table 1 represents the unweighted average of the time series.

As the empirical analysis below validates, our primary focuses are the employment protec-

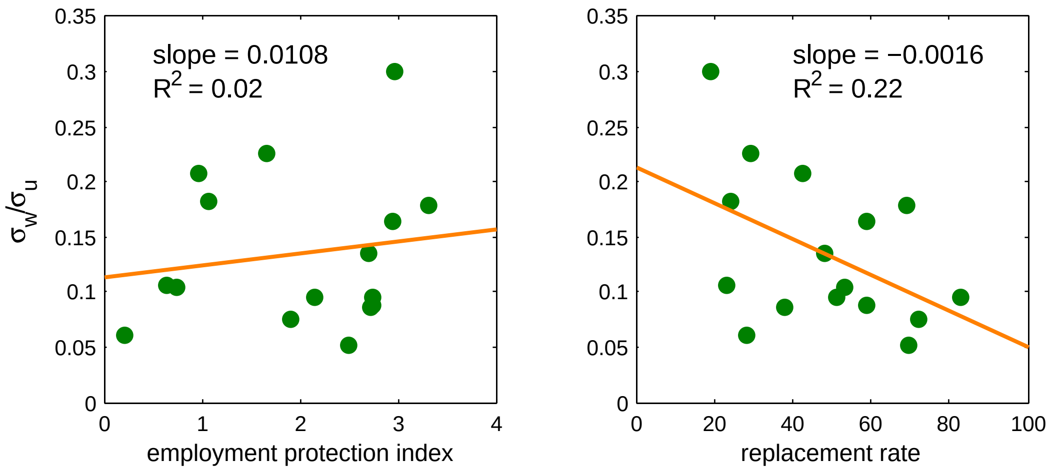

Figure 2: Bivariate relations between labor market fluctuations and labor market institution variables

tion index and the replacement rate. From Table 1, we can recognize that there is a wide range of variation in the employment protection (EP) and the replacement rates (RR). The employment protection index is as low as 0.2 in the United State followed by United Kingdom and Canada. In contrast, Western Continental Europe is featured as a set of countries with much stricter employment protection: the indices are typically more than two for these countries. As for the replacement rates[2], they vary from 20% to 80% across the countries.

Figure 1 points that countries with strict employment protection tend to have high replacement rates. However, the correlation is not so strong and there are substantial variations in the replacement rates for countries with the similar level of employment protection. This will help to identify the marginal effect of changes in the degree of employment protection and replacement rates listed below.

We now examine the relation between the standard deviation of real wages relative to unemployment and labor market institutions.[3] First, we compare the bivariate relations. It turns

[2]The unemployment benefit referred in this index is the benefit granted to unemployed workers in their first year of unemployment averaged over three family situations and two earning levels. (See Nickell (2006).)

[3]We compute the standard deviation of real wages and unemployment based on Hodrick-Prescott filtered cyclical components. As in many existing articles, we apply the smoothing parameter 1600 for all countries. However,

out that the bivariate correlations are not so strong. Figure 2 exhibits that there is hardly any correlation between the employment protection index and σ_w/σ_u. The replacement rate is negatively and more strongly correlated with the ratio. However, we find that the standard error of the coefficient is large.

To obtain a more complete picture, we regress the standard deviation of real wages relative to unemployment with sets of labor market institution variables. The result is shown in Table 2. The first two columns show the estimates of level equations and the remaining columns show those of ratio equations in which all variables are expressed in terms of the ratio between a pair of OECD members. In column 5 and 6, we report the results of the two-stage least square estimation. We use labor market institution variables in 1979 as instruments in these estimations. This would clear the possible endogeneity problems. The advantage of the ratio equations is that we can generate more samples thereby improving small sample biases. This is particularly relevant for the two-stage least square estimates as standard statistical inferences of this method are based on asymptotic theory.

A multivariate analysis highlights the degree of employment protection and replacement rates are influential factors that account for the cross country differences in the standard deviation of real wages relative to unemployment. The effect of stricter employment protection and higher replacement rate is positive and negative respectively. We find that both the coefficients are statistically significant. This finding is robust to the specifications in the estimated equation and endogeneity issues. Moreover, including these two variables together significantly improves the fit of the model: in the case of the level equations, the R-square jumps up to $0.4 - 0.6$.

To this end, we can establish the statement that restrictions on firing and the generosity of unemployment benefit are systematically correlated with the mode of labor market adjustments over business cycles. Increasing the strictness of employment protection and reducing replacement rates the raise real wage volatility relative to unemployment.

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we obtain similar results both qualitatively and quantitatively for different smoothing parameters such as 6400.

	method and level/ratio					
	OLS	OLS	OLS	OLS	2SLS	2SLS
variables	level	level	ratio	ratio	ratio	ratio
EP	0.0346^{*}	0.0644^{**}	0.1815^{**}	0.3178^{**}	0.1705^{**}	0.3402^{**}
	(0.0192)	(0.0274)	(0.0508)	(0.0696)	(0.0458)	(0.0635)
RR	-0.0025^{**}	-0.0023^{*}	-0.4860^{**}	-0.4690^{**}	-0.3917^{**}	-0.5510^{**}
	(0.0008)	(0.0010)	(0.0960)	(0.1226)	(0.0818)	(0.1545)
UD		0.0004		-0.0690^{*}		-0.1540^{**}
		(0.0009)		(0.0353)		(0.0537)
UC		-0.0006		-0.1764		-0.2151^{**}
		(0.0010)		(0.1812)		(0.0999)
ALMP		-0.0344		0.0028		
		0.0629		0.0740		
R-square	0.41	0.59	0.23	0.32	0.22	0.37
observations	16	15	120	105	120	91

Estimated equations are $\sigma_{w,i}/\sigma_{u,i} = \alpha + \mathbf{x}_i'\beta + \varepsilon_i$ for level equations and $(\sigma_{w,i}/\sigma_{u,i}) / (\sigma_{w,j}/\sigma_{u,j}) = \alpha + \mathbf{x}_{i,j}'\beta + \varepsilon_{i,j}$ for ratio equations. $\sigma_{w,i}/\sigma_{u,i}$ is the standard deviation ratio between real wage and unemployment, $\mathbf{x}_i$ is the vector of labor market institution variables in country i and $\mathbf{x}_{i,j}$ is the vector of the ratio of labor market institution variables between country i and j. ε_i and $\varepsilon_{i,j}$ are possibly heteroskedastic and autocorrelated random disturbances. * and ** on the estimates indicate 10% and 5% statistical significance. Figures in parentheses indicate standard errors. Those in level equations are White standard errors and those in the difference equations are Newey-West robust standard errors.

Table 2: Cyclical properties of the labor market and inflation

The total effect of systematic differences in labor market institutions across countries can be obscure when we take into account the positive correlation between the degree employment protection and replacement rates. According to the empirical result listed in Table 2, raising the strictness of employment protection offsets the effect of raising replacement rates on the standard deviation of real wage relative to unemployment. We will revisit the issue of the systematic correlation among labor market institution variables in section 4.

It would be also interesting to examine how unionization affects the performance of labor markets as some empirical analyses find the relevance of union related variables in explaining business cycle properties.[4] However, these institutions are not straightforward to incorporate in models of search and matching frictions. We thus omit these variables from our scope of research.

3 The model

This section presents the New Keyneasian model with search and matching frictions in the labor market. There are five types of agents in the model: households, intermediate goods firms, retailers, a central bank and the government. Labor search takes place between households and intermediate goods firms. The price stickiness appears in the retail good sector. This is a way to avoid technical complications in aggregating firms' heterogeneous behavior as Trigari (2009) suggests. We assume that the central bank and the government obey mechanical policy rules.

3.1 households

Assume that a household contains a continuum of workers residing on the unit interval. As we will see later, each worker is either employed or unemployed as a result of labor search. However, workers can insure their consumption by being members of a household in which it pools and equally distributes member's income. The maximization problem of households is then written as:

$$\max E_t \textstyle\sum_{s=t}^{\infty} \beta^{s-t} u\left(c_s - \varsigma c_{s-1}\right), \tag{1}$$

$$s.t. \quad P_t c_t + B_{t+1} = P_t z_t + R_t B_t - T_t, \tag{2}$$

$$z_t = n_t \bar{\omega}_t + u_t b.$$

[4] Rumler and Scharler (2009) finds that high union density increases output volatility whereas the degree of coordination in wage bargaining affects inflation volatility. They control some disturbances outside labor markets, such as the volatility of the government expenditure. However, some incompleteness remains in this dimension as they do not control productivity and monetary disturbances.

where c_t is the consumption bundle of retail goods, B_t is stock of nominal bond, z_t is real income, and T_t is a lump-sum tax with P_t and R_t denoting the price of the consumption bundle and the nominal interest rate. The real income, z, consists of wage income, $\bar{\omega}_t$, contributed from employed workers and the unemployment benefit,[5] b, received by unemployed workers. $u()$ is the period utility function which is the argument of the current period consumption and the consumption one period ago. $\varsigma > 0$ means there is habit formation in consumption. We assume that the exact form of the period utility is:

$$u\left(c_t - \varsigma c_{t-1}\right) = \log\left(c_t - \varsigma c_{t-1}\right). \tag{3}$$

Because workers can insure risks regarding employment uncertainty, we can deal with a representative agent setting. Note that worker's job search and wage bargaining determine the income stream and it is given to households. Then the first order conditions of households' problem are given as:

$$\begin{aligned} E_t\left(\Lambda_{t+s,t}\right) &= \beta^s E_t\left(\lambda_{t+s}/\lambda_t\right), \\ \lambda_t &= \tfrac{1}{c_t - \varsigma c_{t-1}} - \beta\varsigma E_t\left(\tfrac{1}{c_{t+1} - k c_t}\right). \end{aligned} \tag{4}$$

where λ_t is the Lagrange multiplier on the budget constraint and $E_t\left(\Lambda_{t+s,t}\right)$ is the stochastic discount factor which governs the consumption-saving decision of households.

[5]In search and matching models, b is typically interpreted as the sum of unemployment benefits, other transfers obtainable by being unemployed and leisure of being unemployed. In this paper, we follow the same interpretation and set b such that it is larger than replacement rates observed in the data. And we also assume that b is totally transfered from the government which runs a balanced budget. The way the "unemployment benefit" is transferred is not crucial and we can obtain similar results if we assume b as leisure which falls from sky.

3.2 the labor market and intermediate goods firms

The labor market is characterized by search and matching frictions *a la* Mortensen and Pissarides (1994). In this market, intermediate goods firms, simply firms hereafter, search labor force while workers search jobs. An implicit assumption is that several forms of matching frictions prevent firms and workers from forming matches: some firms fail to fill vacancies at the same time some workers fail to find jobs. We assume that the number of matching can be described by the aggregate matching function below:

$$m_t = \chi u_t^{\alpha} v_t^{1-\alpha}. \tag{5}$$

where u is the pool of unemployment, which is equivalent to workers who search jobs, and v stands for vacancies posted by intermediate good firms. χ measures the efficiency of matching and $0 \leq \alpha \leq 1$.

By defining the labor market tightness as $\theta \equiv v/u$, we can formulate the probability that a unit of vacancy is filled with a worker, $q(\theta)$, and the probability that a job searching worker is matched with a firm, $s(\theta)$, as follows:

$$q(\theta_t) = \frac{m_t}{v_t} = \chi \theta_t^{-\alpha}, \tag{6}$$

$$s(\theta_t) = \frac{m_t}{u_t} = \chi \theta_t^{1-\alpha}. \tag{7}$$

Separations from the matches are two-fold. First, workers in existing matches leave their jobs exogenously with probability ρ.[6] The firms whose job posts are still filled, then, fire workers if the matches are unproductive.[7] The basis of firing is the idiosyncratic productivity of workers, a. In each period, workers draw their own productivity from a time-invariant contin-

[6] We assume that search and matching take place before exogenously separated workers reenter the labor market. Therefore, those workers who voluntarily quit jobs become unemployed at least for one period.

[7] At this point, new matches are already formed. Thus workers who are in the new matches but unproductive are also "fired". We pose this assumption only for analytical convenience.

uous distribution with support $[0, \infty)$. We detail the firing mechanism below, but the result is that firms fire workers if workers' productivity is below a certain threshold, $\bar{a}$. Let the $c.d.f$ of the distribution be $F(a)$. Then the law of motion of employment, n, is written as:

$$n_t = (1 - F(\bar{a}_t)) \left[(1 - \rho) \, n_{t-1} + q_t v_t \right]. \tag{8}$$

We normalize the number of workers to one. Thus unemployment at given time is $u_t = 1 - n_{t-1}$. Notice that unemployment which is relevant for the matching probabilities at given period is the unemployment at the beginning of the period.

The production of firm i is described by the level of technology times labor input. Workers, if they are hired, supply one unit of labor inelastically. Thus output of firm i is the multiple of aggregate productivity, A, and worker's idiosyncratic productivity[8]:

$$y_{i,t} = A_t a_{i,t}. \tag{9}$$

In recruiting workers, firms pay a cost, γ_v, per unit of vacancy posting. Also, they have to pay a firing cost, γ_f, per dismissed worker. These costs are denominated in unit of the consumption good and they are pure losses of the resources during production. Firm i pays real wage, $\omega_t(a_{i,t})$, to the matched worker with productivity $a_{i,t}$ if they keep the worker for production. Finally we assume that the intermediate goods sector is competitive and the firms sell their goods to retailers with real price $p_{m,t}$.[9]

We can now define the value of posting additional vacancy, V_t, and the value of keeping a

[8] We assume that each firm hires only one worker. However, we can assume that she/he hires more than one worker because the profit function of the firms can be written, eventually, as the linear function of the workers in the firm.

[9] To make this assumption valid, we assume that all firms set prices before observing the productivity of their employees. The equilibrium price, therefore, guarantees that the firms' expected profit is zero.

worker with productivity $a_{i,t}$ for the firms, $J_t(a_{i,t})$ as follows:

$$
\begin{aligned}
V_t &= -\gamma_v - \gamma_f q(\theta_t) F(\bar{a}_t) + q(\theta_t) \bar{J}_t, & (10)\\
J_t(a_{i,t}) &= p_{m,t} A_t a_{i,t} - \omega_t(a_{i,t}) + E_t \left[\Lambda_{t+1,t} \left\{(1-\rho)\left(\bar{J}_{t+1} - \gamma_f F(\bar{a}_{t+1})\right)\right\}\right], & (11)\\
\bar{J}_t &\equiv \int_{\bar{a}_t}^{\infty} J_t(a) dF(a).
\end{aligned}
$$

The cost of additional vacancy consists of the vacancy posting cost and the expected firing cost which enter with negative signs in (10). The latter emerges if firms successfully find a worker but she/he is unproductive, i.e. $a_{i,t} < \bar{a}_t$.[10] The benefit is the expected value of keeping a productive worker. This value, (11), is the sum of period profit, which is sales minus wage payment, and the expected value of keeping the worker tomorrow less tomorrow's expected firing cost.

Free entry in vacancy postings implies that firms post vacancies until V_t falls to zero. This generates the following vacancy posting condition:

$$
\gamma_v + \gamma_f q(\theta_t) F(\bar{a}_t) = q_t \bar{J}_t. \tag{12}
$$

Once a worker and a firm form a match, firing occurs if the surplus from keeping the worker falls short of the value of releasing the worker and keeping the job vacant ($E_t(V_{t+1}) - \gamma_f$ with $E_t(V_{t+1}) = 0$ in equilibrium). This brings the following job destruction condition:

$$
J(\bar{a}_t) + \gamma_f = 0. \tag{13}
$$

(13) implies the positive relationship between the cutoff productivity, $\bar{a}_t$, and the firing cost γ_f under moderate firing probability. As the firing cost increases, the benefit of releasing the

[10] Newly matched but low productive workers are fired before they engage in production to make the timing of firing consistent with that of existing workers.

matched worker and keeping the position vacant declines. Then keeping even lower productive workers makes sense for the firms.[11]

Similar to the value of workers for firms, we can define the value of being employed and unemployed for workers, $W_t(a_{i,t})$ and U_t, as follows:

$$\begin{aligned}
W_t(a_{i,t}) &= \omega_t(a_{i,t}) + E_t\left[\Lambda_{t+1,t}\left\{(1-\rho)\bar{W}_{t+1} + ((1-\rho)F(\bar{a}_{t+1}) + \rho)\,U_{t+1}\right\}\right] \quad (14)\\
U_t &= b + E_t\left[\Lambda_{t+1,t}\left\{s(\theta_{t+1})\bar{W}_{t+1} + (1 - s(\theta_{t+1}) + s(\theta_{t+1})F(\bar{a}_{t+1}))\,U_{t+1}\right\}\right] \quad (15)\\
\bar{W}_t &\equiv \int_{\bar{a}_{t+1}}^{\infty} W_t(a)dF(a)
\end{aligned}$$

The present value of being employed and unemployed are the period utility plus the expected future gains. The period utility of employed and unemployed are real wage and unemployment benefit respectively. In calculating the expected future gains, workers take into account the possibility of transitions between employment and unemployment. The surplus of being employed is defined as $W_t(a_{i,t}) - U_t$. Workers negotiate their real wages with firms to maximize it.

As in typical search and matching friction models, we assume that the result of wage bargaining takes the form of Nash bargaining solution. In this setup, a firm and a matched worker share the joint surplus of the match. How to share depends on the bargaining power of workers denoted by η, where $\eta \in [0,1]$. Formally, the formulation of the bargaining problem is written as:

$$\arg\max_{\omega_t(a_{i,t})} \left(J_t(a_{i,t}) + \gamma_f\right)^{1-\eta} \left(W_t(a_{i,t}) - U_t\right)^{\eta}. \quad (16)$$

[11]If $F(\bar{a})$ takes high value, then the reduction of the value of keeping workers, $J_t(a_{i,t})$, is large enough relative to the rise in γ_f implying firms prefer to fire productive workers in response to the rise of γ_f. However, under reasonable firing probability which is consistent with U.S. data, this channel is not strong enough.

The solution of real wage conditional on idiosyncratic productivity $a_{i,t}$ is:

$$\omega_t(a_{i,t}) = \eta \left[p_{m,t} A_t a_{i,t} + \gamma_v E_t \left(\Lambda_{t+1,t} \theta_{t+1}\right) + \gamma_f \left\{1 - E_t \left(\Lambda_{t+1,t} \left(1 - \rho - s(\theta_{t+1})\right)\right)\right\}\right] + (1 - \eta)\, b. \tag{17}$$

The terms in the square bracket after η are the real wage that the worker demands and b would be the wage offer that firms would offer if they had full bargaining power.

Finally, we can define the average productivity and the average real wage of employed workers as follows:

$$E(a_{i,t}|a_{i,t} \ \geq \ \bar{a}) \equiv H_t = (1 - F(\bar{a}_t))^{-1} \int_{\bar{a}_t}^{\infty} a dF(a), \tag{18}$$

$$E(\omega_t(a_{i,t})|a_{i,t} \ \geq \ \bar{a}) \equiv \bar{\omega}_t = (1 - F(\bar{a}_t))^{-1} \int_{\bar{a}_t}^{\infty} \omega_t(a) dF(a). \tag{19}$$

3.3 retailers and the New Keynesian Phillips curve

There is a continuum of monopolistically competitive retailers on the unit interval. Each retailer purchases the intermediate good with given the price $p_{m,t}$ and transform it to a differentiated retail good in one-to-one relation. The price of the retail good j, $p_{j,t}$, is set given the demand schedule $y_{j,t} = (p_{j,t}/P_t)^{-\varepsilon} Y_t$ where ε is the price elasticity of demand. We assume that prices of retail goods are sticky: in each period, each retailer obtains a chance of resetting price with constant probability, κ, as in Calvo (1983). After solving the profit maximization problem of retailers and aggregating the prices, we obtain the usual New Keynesian Phillips Curve:

$$\pi_t = \frac{(1 - \beta\kappa)(1 - \kappa)}{k} \hat{p}_{m,t} + \beta E_t (\pi_{t+1}). \tag{20}$$

where π is the inflation rate of the consumption good. The 'hat' sign on the variables denotes the log deviation from the steady state.

Because the intermediate good is whole input for retail goods production, the real marginal cost, which drives inflation in the New Keynesian theory, is equal to the price of the intermediate good. By combining (11) and (12), we can link the real marginal cost to the condition of the labor market as follows:

$$p_{m,t} = \frac{1}{A_t H_t}\left[\bar{\omega}_t + \gamma_v \left\{\frac{1}{q(\theta_t)(1-F(\bar{a}_t))} - \frac{\beta(1-\rho)}{q(\theta_{t+1})}\right\} + \gamma_f \frac{F(\bar{a}_t)}{1-F(\bar{a}_t)}\right]. \tag{21}$$

With Walrasian labor market, the formula shrinks to $p_{m,t} = \frac{\bar{\omega}_t}{A_t H_t}$ with $\bar{\omega}_t$ equalized to the marginal product of labor. However, the presence of search and matching frictions introduces two additional components to the real marginal cost equation. The first is costs associated with vacancy postings. To hire additional worker, firms have to post $\frac{1}{q(\theta_t)(1-F(\bar{a}_t))}$ of vacancy in expectation. However, if they succeeded to hire a worker, then they could save the vacancy positing cost tomorrow by $\frac{\beta(1-\rho)}{q(\theta_{t+1})}$. The net costs are passed prices. The second is the expected firing cost to hire an additional worker. This comes from the fact that firms dismiss matched but unproductive workers by paying the firing cost. Note further that the real wage, $\bar{\omega}$, is no longer the marginal product of labor as is evident from (17). These forces together potentially change inflation dynamics.

3.4 the central bank and the government

The central bank controls the short term nominal interest rate, r, as a tool of monetary policy. In log-linearized form, the policy rule is described as a Taylor-rule-typed reaction function augmented with interest rate smoothing:

$$\hat{r}_t = (1-\rho_m)\,\hat{r}_{t-1} + \rho_m\left(\varphi_\pi \pi_t + \varphi_y \hat{Y}_t\right) + \varepsilon_{m,t}. \tag{22}$$

$(1-\rho_m)$ measures the degree of the interest rate smoothing. φ_π and φ_y measure the degree of responsiveness to inflation and aggregate output, $\hat{Y}_t$, which we will define shortly. Finally, there is a random policy shock, $\varepsilon_{m,t}$, which obeys the normal distribution $N(0, \sigma_m)$.

There is the government which levies a lump-sum tax, T, to households to finance the payment of unemployment benefit. We assume that the government runs balanced budget:

$$T_t = (1-n_t)b. \tag{23}$$

3.5 equilibrium

In this economy, the aggregate output is solely consumed by households:

$$Y_t = c_t. \tag{24}$$

The aggregate output is the CES aggregator of retail goods less resource losses incurred by search and matching frictions:

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}} - \gamma_v v_t - \gamma_f F(\bar{a}_t)\left[(1-\rho)\, n_{t-1} + q_t v_t\right]. \tag{25}$$

Because retailers transform the intermediate good into retail goods in one-to-one relation, we could write the aggregate output as:[12]

$$Y_t = A_t H_t n_t - \gamma_v v_t - \gamma_f F(\bar{a}_t)\left[(1-\rho)\, n_{t-1} + q_t v_t\right]. \tag{26}$$

We assume that the vacancy posting cost and the firing cost are pure resource losses that firms incur when searching and firing workers.

[12]This is true up to the first order approximation of Y_t. See details in Gali (2009).

Finally, the aggregate productivity evolves with the following stochastic process:

$$\begin{aligned} \log(A_t) &= \rho_A \log(A_{t-1}) + \varepsilon_{A,t}, \\ \varepsilon_{A,t} &\sim N(0, \sigma_A). \end{aligned} \tag{27}$$

4 Results

This section presents the model's simulation results and examines whether the results are consistent with the empirical relationship between labor market institutions and the cyclical property of labor markets discussed in section 2.

4.1 calibration

The calibration strategy in this paper is followings: first we calibrate the model parameters on U.S. data, for which existing literature conveys rich information, as a benchmark; then we shift the firing cost and the replacement rate, $b/\bar{\omega}$, one at a time to examine the effects of labor market institutions on cyclical properties of the labor market of the model. There should be other sources that affect cyclical properties of labor markets.[13] We sidestep from fully identifying the sources of labor market fluctuations in this paper. We rather would like to stress the relevance of labor market institutions alone in the search and matching framework when accounting for the empirical regularity discussed in section 2.

The benchmark parameters in the labor market are in line with Krause and Lubik (2007).[14] The time frequency is quarterly. We choose the steady state total separation rate, $\rho+(1-\rho)F(\bar{a})$ to be 0.10. We set that the exogenous separation rate $\rho = 0.068$ which consequently implies $F(\bar{a}) = 0.034$. As assumed in the most of existing literature, a is log normally distributed

[13]

[14]Krause and Lubik (2007) incorporates results of data analyses by Hall (1995), den Haan et al (2000) and etc.

with mean μ_a and standard deviation σ_a. μ_a is normalized to zero and σ_a is set to 0.15.[15] To be consistent with job filling rate targeted in Krause and Lubik (2007) and job finding rate reported in Shimer (2005), we target $q(\theta) = 0.70$ and $s(\theta) = 0.76$ respectively.[16] There is still a wide range of possible values for $(\chi, \alpha, \gamma_f, \gamma_v, \eta)$ that would satisfy the targets above. Among them we fix $\alpha = 0.4$ and $\eta = 0.5$ and select low γ_f to be consistent with the fact that the employment protection index of U.S. is the lowest among OECD members.[17] As shown in Table 2, the remaining labor market parameters land at $\gamma_f = 0.02$, $\gamma_v = 0.067$, and $\chi = 0.73$. Finally, we set the replacement rate equal to 0.89. This is much larger than the actual replacement rate of U.S. reported in Table 1. Technically, lower replacement rates, such as 0.5 or even 0.8, are not consistent with the required assumption, $s(\theta) \leq 1$. We are forced to have high replacement rate. However, existing literature suggests there are rationales for choosing high replacement rates. First, some articles consider b as a composite of various forms of non-working benefits such as severance transfers and the value of leisure. Besides, Hagedorn and Manovskii (2008) recommend high replacement rates to obtain moderate elasticity of real wage and large elasticity of vacancies to a productivity shock witnessed by U.S. data.

The discount rate of households, β, is set to 0.99. We choose the habit parameter $\varsigma = 0.55$. This is the same as in Trigari (2009). The existence of habit formation is important to generate hump-shaped responses of output and employment to exogenous disturbances. The chance of resetting prices and the price elasticity of retail goods, κ and ε, are set to 0.2 and 11, which are in line with the most of New Keynesian literature. For the monetary policy parameters, we choose the interest rate inertia $1 - \rho_m = 0.85$ and the degree of responsiveness to output and

[15] Krause and Lubik (2007) sets $\sigma_a = 0.12$ and Thomas (2006) sets it to be 0.10. Thomas and Zanetti (2009) argues that the effect of changes in the standard deviation of idiosyncratic productivity shocks on inflation volatility is small.

[16] Shimer (2005) reports the average of the monthly job-finding rate is about 0.45 between 1951-2003. This translates into the quarterly job-finding rate of 0.77.

[17] In the next subsection, I conduct an experiment to raise the firing cost. The firing cost in the baseline is low in the sense it is quadrant of the firing cost in alternative scenario in the experiment.

	Description	Values		Description	Values
ρ	Exogenous separation	0.068	$b/\bar{\omega}$	Replacement rate	0.89
$F(\bar{a})$	Endogenous separation	0.034	β	Discount rate	0.99
$q(\theta)$	Job-filling rate	0.70	ς	Habit formation	0.55
$s(\theta)$	Job-finding rate	0.76	κ	Price resetting probability	0.2
μ_a	The mean of $F()$	0	ε	Elasticity of demand	11
σ_a	The SD of $F()$	0.15	$1-\rho_m$	Interest rate inertia	0.85
χ	Matching efficiency	0.73	ρ_A	Productivity inertia	0.92
α	Matching elasticity	0.4	φ_y	Interest rate reaction to output	0.1
η	Worker's bargaining power	0.5	φ_π	Interest rate reaction to inflation	2.0
γ_v	Vacancy posting cost	0.067	σ_m	The SD of monetary shocks	0.0014
γ_f	Firing cost	0.02	σ_A	The SD of productivity shocks	0.0034

Table 3: Benchmark parameter values

inflation $\varphi_y = 0.1$ and $\varphi_\pi = 2.0$ respectively.[18]

Finally, we must define the process of exogenous disturbances. For the monetary policy shock, we assume $\sigma_m = 0.0014$. The persistence of productivity, ρ_A, is set to 0.92 and the standard deviation of the productivity shock, σ_A, is set to 0.0034. These together replicate the output volatility of U.S.

4.2 the effects of changes in labor market institutions

Table 4 presents the effects of changes in labor market institution variables on the model's business cycle properties. σ_x stands for the standard deviation of variable x. In the table, column two displays the property under the baseline calibration. Column three and four display those under the 'high firing cost' scenario and the 'low replacement rate' scenario. The high firing cost scenario quadruples the firing cost parameter and the low replacement rate scenario

[18]Recent studies which estimate DSGE models with search and matching frictions find the similar magnitude for Taylor rule coefficients in U.S. See, for example, Gertler, Sala and Trigari (2008).

	Baseline	High firing cost	Low replacement rate	High FC and high RR
		$\gamma_f = 0.08$	$b/\bar{\omega} = 0.84$	$\gamma_f = 0.08, b/\bar{\omega} = 0.92$
$\sigma_{\bar{\omega}}/\sigma_u$	0.089	0.117	0.146	0.086
		(32%)	(65%)	(−3%)
σ_{jc}/σ_{jd}	1.56	7.94	2.54	4.59
		(409%)	(63%)	(194%)
σ_{π}/σ_y	0.168	0.172	0.226	0.153
		(2%)	(33%)	(−8%)

Figures in parentheses represent the percentage change of each measure from the baseline.

Table 4: Cyclical properties of the labor market and inflation

lowers the replacement rate by five percent points relative to the baseline.[19] Larger changes in the targeted parameters are not admissible because either $q(\theta)$ or $s(\theta)$ exceeds one. In this sense, we pick extreme cases within the rage of admissible parameter values in column three and four. The last column displays the scenario when both the firing cost and the replacement rate are raised. This scenario most closely resembles Western European countries. The other parameters remain constant in each of the alternative scenarios.

The main finding is that the standard deviation of the real wage relative to unemployment rises when the firing cost rises or the replacement rate declines. Both margins yield economically sizable impacts on that measure (32% and 65% increase respectively). The data advocates this hypothesis: the empirical result reported in Table 2 revealed that a rise in the degree of employment protection and a decline in replacement rates raise the standard deviation of real wages relative to unemployment.

The simulation result predicts that the total effect of changes in the labor market institutions is ambiguous when the firing cost and the replacement rate comove positively. In column five, we show that the standard deviation of the real wage relative to unemployment in the economy

[19]We will see sizable impacts from only a small percentage change in replacement rate relative to the data. It might be possible to argue that small changes of replacement rates in the model correspond to large changes in actual replacement rates.

with a high firing cost and a high replacement rate is similar to that of the baseline economy where both indicators are low. Again the data advocates this result. Recall that the data exhibited positive correlation between firing costs and replacement rates in general. The empirical result in Table 2 then implies that one force offsets the other making the net effect ambiguous. For example, UK where both the firing cost and the replacement rate are low and Sweden where both are high have about the same real wage volatility relative to unemployment: they are 0.107 in UK and 0.095 in Sweden.

One shortcoming of our model is that the variation of the standard deviation of the real wage relative to unemployment is not large enough to fully account for the actual variation. In the data, it is as low as 0.05 in U.S. and as high as 0.3 in Italy. On the other hand, the range that the model can generate in this respect is relatively narrow. This result is robust to changes in non-labor market parameters as we will see below. The result indicates that we must seek other sources to fully account for the cyclical properties of labor markets in the data.

It is worthwhile to note that other aspects of the labor market are affected differently by the nature of changes in labor market institutions: there is a tendency that firms exploit the job creation margin to adjust work force when the firing cost rises. This is not the case when lowering the replacement rate. As it will be apparent in the next section, there are several courses that affect the real wage volatility relative to unemployment depending on the nature of changes in labor market institutions.

The effect of labor market institutions on inflation-output trade off, the traditional Phillips curve relation, is more muted than that on labor markets. Raising the firing cost has virtually no impact on the inflation-output trade off. Changing replacement rates exerts somewhat a larger impact to this measure. However, we will show that changing other parameters of the model brings about larger impacts on inflation dynamics.

	Low price stickiness, $\kappa = 0.8$			Low productivity inertia, $\rho_A = 0.8$		
	Baseline	$\gamma_f = 0.08$	$b/\bar{\omega} = 0.84$	Baseline	$\gamma_f = 0.08$	$b/\bar{\omega} = 0.84$
$\sigma_{\bar{\omega}}/\sigma_u$	0.094	0.125	0.173	0.081	0.108	0.136
		(33%)	(84%)		(34%)	(68%)
σ_{jc}/σ_{jd}	1.19	4.31	1.66	1.90	9.48	2.79
		(263%)	(39%)		(399%)	(47%)
σ_{π}/σ_y	0.439	0.473	0.681	0.221	0.233	0.359
		(8%)	(55%)		(6%)	(63%)

Table 5: Cyclical properties of the labor market and inflation under alternative parameters

4.3 Sensitivity analyses

We now turn to check the robustness of the above results. We check whether the cyclical properties of the labor market are robust to shifts in non-labor market parameters: we change two potentially relevant parameters, the degree of price stickiness and the persistency of the productivity shocks, one at a time and examine effects on the cyclical properties of the labor market. We also check effects on inflation-output trade off.

We find that the above findings on the standard deviation of the real wage relative to unemployment are robust to changes in parameters outside the labor market. The baseline values both in the case of lower degree of price stickiness and the lower productivity inertia are almost invariant to the baseline value in Table 4. Moreover, shifts in labor market institution variables within each of the alternative setups in non-labor market parameters exert similar impacts to the standard deviation of real wage relative to unemployment. This implies the relative importance of the price adjustment channel against the quantity channel in the labor market is free from non-labor market institutions in the search and matching framework.

Rather a significant difference appears in the inflation-output trade off. Lowering the degree of price stickiness or lowering productivity inertia raises the inflation volatility relative to output significantly (Compare the baseline cases in Table 5 and the baseline case of Table 4). Shifts in labor market institution variables within each of the alternative setups in non-labor market parameters somewhat bring larger impacts: When price stickiness or productivity inertia is lowered, five percentage points reduction in the replacement rate raises the standard deviation of real wage relative to unemployment by 50 to 60 percent. This is larger than the case of Table 4.

5 The background of the results

This section analyzes the underlying mechanism of the model's simulation results. The following points are important to understand the mechanism: first, labor market variables which firms are able to adjust flexibly. Depending on the form of obstacles in the labor market, firms prefer to exploit specific channels to encounter shocks. These incentives affect the cyclical properties of labor markets. Second, the steady state value of the labor market tightness. As emphasized in Thomas and Zanetti (2009), changes in the steady state due to variation in labor market institutions affect impulse responses of endogenous variables quantitatively.

5.1 the case of the firing cost

Figure 3 displays the impulse responses of labor market variables to a productivity shock by different degrees of the firing cost.[20] The top center panel exhibits that raising the firing cost restrains the job destruction channel. Yet firms do not lose all channels to adjust labor quantity: the job creation margin is still flexible. Therefore, firms concentrate on exploiting the job creation margin when the firing cost rises. However, it is only a substitution from job destruction to job creation resulting in a minor difference in the fluctuation of unemployment.[21]

[20] We exhibit the impulse responses to a monetary shock in the appendix for the sake of completeness. The essential mechanism does not change by the nature of shocks.

[21] This result contrasts with the claim of Abbritti and Weber (2010) that institutions such as employment protection legislation causes unemployment rigidities. The difference arises from the way they calibrate their model: They shift multiple parameters simultaneously to restrain both the job creation and the job destruction margin.

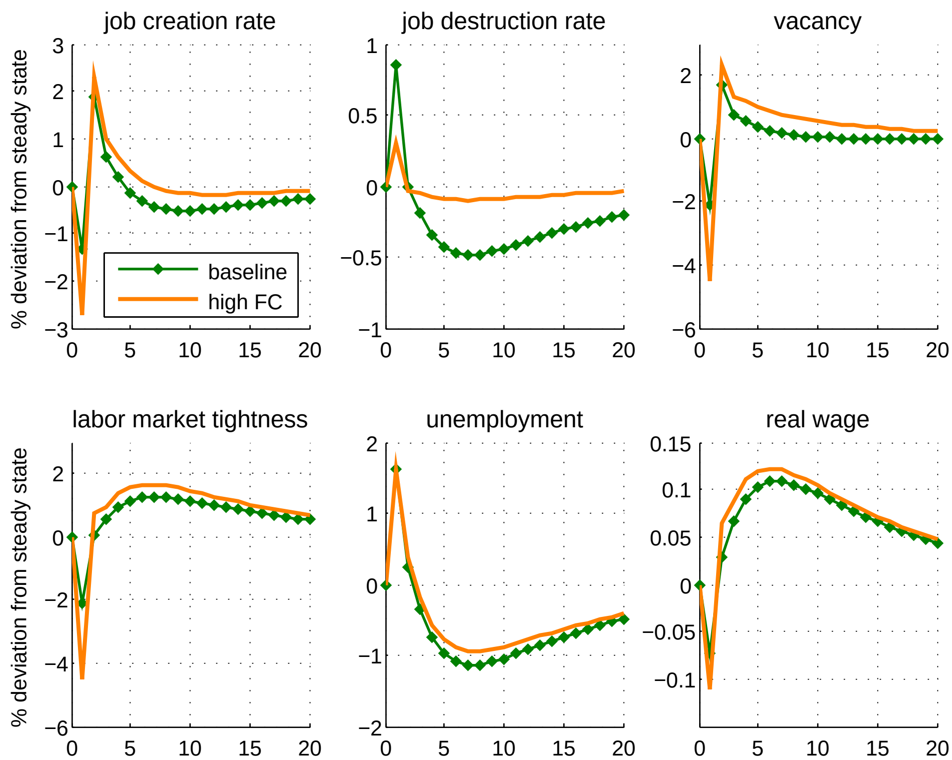

Figure 3: The labor market's responses to a productivity shock by alternative firing costs

The above fact implies that a good portion of the difference in labor market reactions stems from the behavior of the real wage. A tight link between the real wage and the labor market tightness helps to understand this point. By log-linearizing the real wage equation (17) in which the terms associated with $p_{m,t}$ are eliminated using (21), we obtain the following equation:

$$\widehat{\omega}_t = \frac{\eta}{\bar{\omega}\,(1-\eta)} \left[\begin{array}{c} \frac{\gamma_v \chi \theta^{\mu}}{1-F(\bar{a})} \left(\mu \hat{\theta}_t + f(\bar{a})\bar{a}\widehat{a}_t \right) + \gamma_v \beta \theta E_t \left(\hat{\Lambda}_{t+1,t} + \hat{\theta}_{t+1} \right) \\ + \gamma_v \beta (1-\rho) \mu q E_t \hat{\theta}_{t+1} - \gamma_f \beta (1-\rho-s) \hat{\Lambda}_{t+1,t} \\ + \gamma_f \beta (1-\mu) s E_t \hat{\theta}_{t+1} + \gamma_f \frac{f(\bar{a})\bar{a}}{\{1-F(\bar{a})\}^2} \widehat{a}_t \end{array} \right] \tag{28}$$

In this formula, variables without the time subscript, such as θ, denote the steady state values

Moreover, they do not introduce firing costs explicitly in their model. Our experiment has advantages over their experiment in that clarity regarding control parameter(s) is guaranteed and firing costs are explicitly considered.

while variables with hat on the top, such as $\hat{\theta}_t$, denote the log deviations from the steady state. We can see that today's labor market tightness, $\hat{\theta}_t$, and that of tomorrow, $\hat{\theta}_{t+1}$, are positively correlated with the real wage. Therefore the larger response of the real wage in the high firing cost scenario is resonant with the larger response of the labor market tightness exhibited in the bottom left panel of Figure 3.[22]

Intuitively, fluctuations of the labor market tightness shift the bargaining power from workers to firms and firms to workers thereby affecting real wages. One effect emerges from changes in marginal revenue of labor. As the labor market tightness affects the job-filling probability, its changes affect required vacancy postings to fill jobs. Firms perceive them as changes in production costs and they pass them through to prices. The part of the pass through is redeemed to workers through wage bargaining. $\hat{\theta}_t$ in (28) mirrors this effect. Another effect comes from opportunity costs of replacing current workers. Releasing current workers is costly because firms have to pay additional vacancy costs tomorrow to refill jobs. When opportunity costs of releasing current workers are high due to difficulty in refilling jobs, firms are more willing to offer higher wages in exchange of having rights to keep the workers. Its effective cost is measured in terms of the tomorrow's labor market tightness, $\hat{\theta}_{t+1}$.

The larger response of the labor market tightness in the high firing cost scenario, in turn, stems from the mode of labor quantity adjustment. Recall that firms tend to concentrate on the job creation margin when the firing cost rises. This induces large fluctuations in vacancy postings leading to large fluctuations in the labor market tightness.

One may wonder fluctuations of the effective firing cost (the last term in (28)) under the baseline scenario could be volatile so that the real wage in baseline scenario is as volatile as under the high firing cost scenario. It turns out that fluctuations of the effective firing cost are

[22]An offsetting effect emerges from decline in the steady state value of the labor market tightness. Find that θ enters positively in the first term in the square bracket in (28). When the firing cost is raised, firms refrain from posing vacancy because it gets more costly in case firms want to fire workers in future. This reduces the steady state labor market tightness and mitigate the impact of changes in the labor market tightness on real wages.

tiny in any case. This is because $f(\bar{a})$, the slope of the distribution function of F evaluated at the steady state cutoff productivity, is small when the job destruction rate is an order of a few percent which is consistent with data and calibrations in existing literature.[23]

5.2 the case of the replacement rate

Figure 4 displays the impulse responses of labor market variables to a productivity shock by different replacement rates. In contrast to the case of the firing cost, there are no meaningful differences in both the job creation and the job destruction margin. This is quite intuitive because the replacement rate matters only in the real wage bargaining, the price adjustment channel in the labor market.

On the contrary, significant difference emerges in the responses of real wage. The bottom right panel indicates that the response of real wage under the low replacement scenario is more volatile over the entire course of the adjustment path. This is the primary reason why the standard deviation of the real wage relative to unemployment rises when lowering the replacement rate though the volatility of unemployment also rises slightly.[24]

A tricky part in the low replacement rate scenario is that the labor market tightness does not evolve hand in hand with the real wage. The response of the labor market tightness on impact is larger in absolute term under the low replacement scenario, however it is muted over longer horizon under that scenario. To restore the link, we must focus on the steady state effect; the terms associated with $\hat{\theta}_t$ and $\hat{\theta}_{t+1}$ in (28) are multiplied by the steady state labor market tightness, θ. In this exercise, the steady state labor market tightness in the low replacement rate

[23]Thomas (2006) calls this effect as the 'marginal job effect'. He also argues that this effect is small under his calibration.

[24]the slightly larger response of unemployment in the low replacement rate scenario is due to following two effects. One is slightly larger falls in job creation rate and the slightly larger rise in the job destruction rate as exhibited in Figure 4. The other is smaller steady state unemployment in the low replacement scenario. When the steady state unemployment is lower, the percentage difference from the steady state in response to the same magnitude of job flows gets larger.

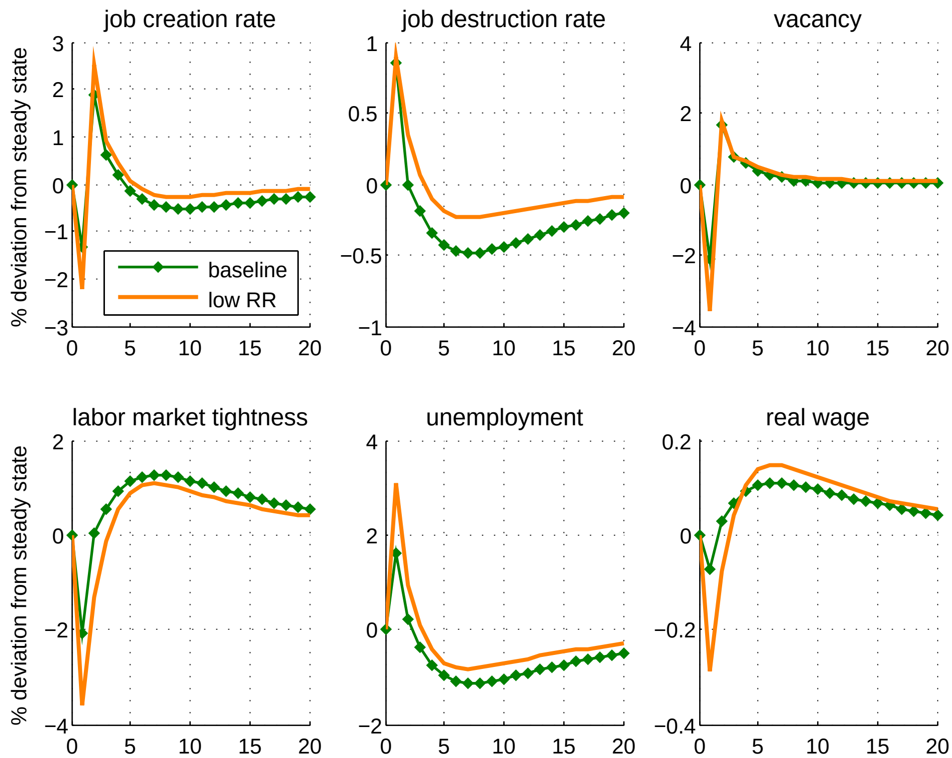

Figure 4: The labor market's responses to a productivity shock by alternative replacement rates

scenario is about 70% greater than that of the baseline. This magnifies the response of the real wage to changes in the labor market tightness.

The reason that the labor market in the steady state is tighter under the low replacement scenario is straightforward. Lower replacement rates imply less real wages and larger profits in equilibrium (Remember unemployment benefit enters into the real wage equation (17)). Then firms have more incentives to expand operation. This raises the vacancy postings and tighten the labor market.

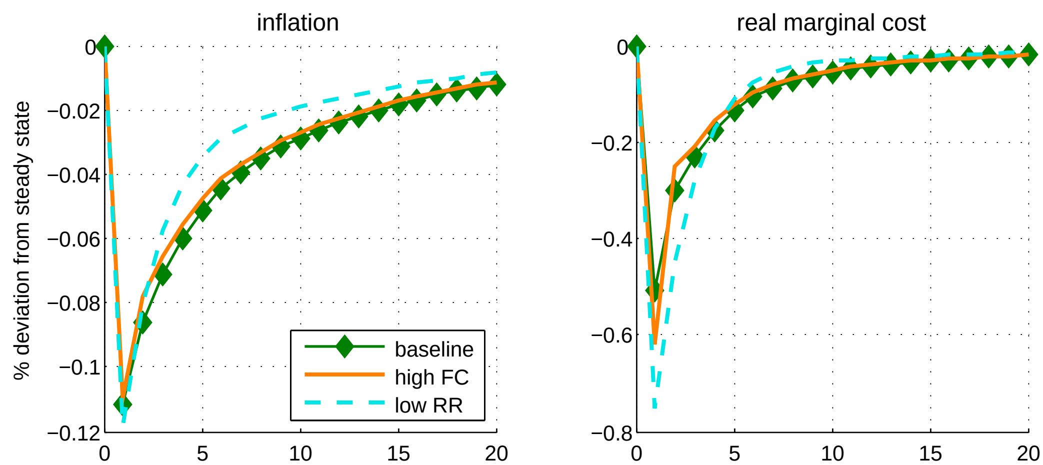

Figure 5: The responses of inflation and real marginal cost

5.3 Effects on inflation

Figure 5 displays the impulse responses of inflation and the real marginal cost under three different setups in the labor market institutions. Deflationary pressure under the low replacement scenario is slightly ameliorated, however the differences are minor.[25]. The real marginal costs, the driving force of inflation, exhibit a similar pattern.

In essence, the labor market institutions which we consider in this paper are almost irrelevant for inflation dynamics.[26] This is consistent with recent studies, such as Thomas and Zanetti (2009), which incorporate price stickiness into models of search and matching frictions.

Note that the above argument does not undermine the importance of the price stickiness to account for the cyclical behavior of the labor market. We have shown in (17) that the real price of intermediate goods, which is equal to the real marginal cost for retailers, enters into the wage

[25]In appendix, we show that inflation dynamics in response to a monetary shock are more variant to changes in labor market institutions. However, productivity shocks explain a large part of the inflation volatility under the baseline calibration.

[26]the response of inflation varies when we consider monetary shocks. However, the contribution of monetary shocks for inflation volatility is small. See appendix.

equation. However, when there is no price stickiness, retailers can always set markups at a desired level, $(\varepsilon - 1) / \varepsilon$. This implies $\hat{p}_{m,t} = 0$ at any events and decouples the contemporaneous link between the labor market tightness and the real wage.

6 Conclusion

This paper has examined the relevance of search and matching frictions in accounting for the cross country differences in cyclical behavior of labor markets. We first find that the strictness of employment protection and replacement rates are empirically influential variables to the labor market fluctuations. Then we find that a model of search and matching frictions with sticky prices are qualitatively consistent with the data. This points that models of search and matching frictions in labor markets retain a certain accountability to analyze cyclical behavior of labor markets and other aggregates in the international dimension. Yet the framework is not powerful enough to quantitatively match the observed differences in the style of labor market fluctuations across countries. Thus we need to explore more sources which strengthen the usefulness of models of search and matching frictions in explaining labor market dynamics. Our analysis suggests that exploring other labor market institutions or labor market structure would be a more promising direction than digging into non-labor market institutions.

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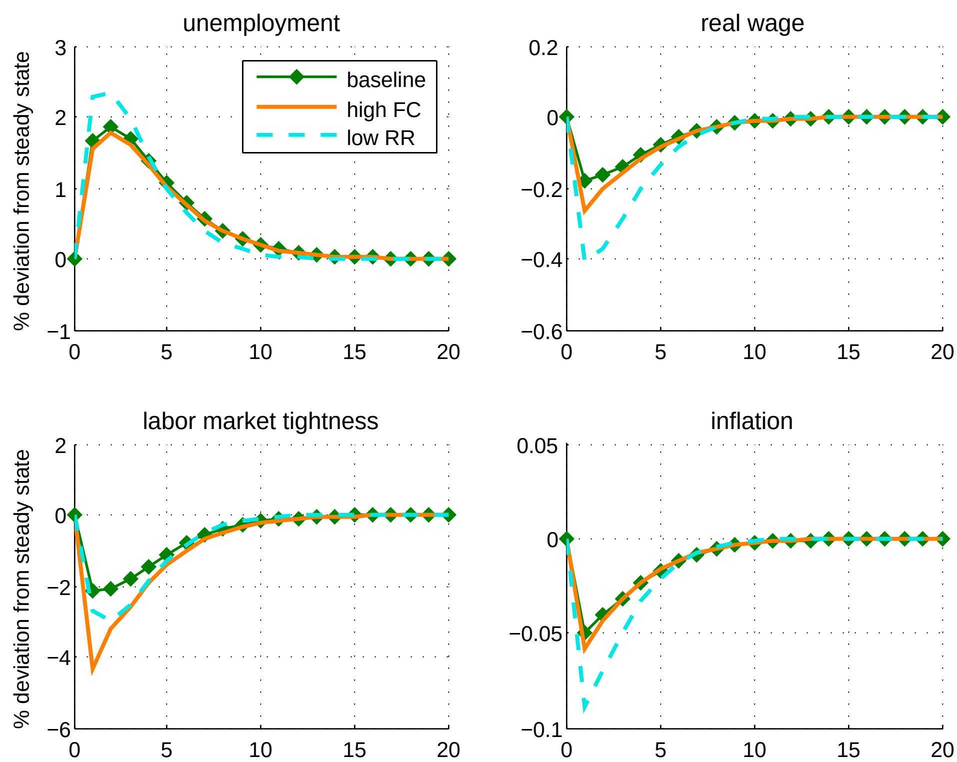

Figure A: Impulse responses to a monetary shock

A the model's response to a monetary shock

In this appendix, we show the impulse responses of labor market variables and inflation to a monetary shock. Figure A indicates that the cyclical properties of the model's labor market are not sensitive to the nature of shocks. The real wage becomes more volatile when the firing cost rises and the replacement rate declines. This is tied with the response of the labor market tightness. The effect of the labor market tightness on the real wage is inflated for the case of the high firing cost and deflated for the case of the low replacement rate. This is due to the steady state effect discussed above.

We observe a marked difference in the response of inflation. This contrasts with the case of a productivity shock. Therefore, the difference in the inflation-output trade off in Table 4 is partly due to the contribution of monetary shocks. However, our variance decomposition exercise shows that productivity shocks account for the most of the variance of inflation (65% to 90%, depending on calibrations in labor market institutions). We conclude that the interaction between the labor market institution variables and monetary shocks is a minor factor to account for the difference in the inflation-output trade off.