The Role of Real Wage Rigidity and Labor Market Frictions for Inflation Persistence*

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Abstract

We analyze the transmission mechanism of wages to inflation within a New Keynesian business cycle model with wage rigidities and labor market frictions. Our main focus is on the channel of real wage rigidities on inflation persistence for which we find the specification of the wage bargaining process to be of crucial importance. Under the standard efficient Nash bargaining the feedback of wage rigidities on inflation is ambiguous and depends on other labor market variables. However, under the alternative right-to-manage bargaining we find that more rigid wages translate directly into more persistent movements of aggregate inflation.

Keywords: Monetary Policy, Matching Models, Labor Market Search, Inflation Persistence, Real Wage Rigidity
JEL classification: E52, J64, E32, E31

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1 Introduction

The combination of a Mortensen and Pissarides (1994) labor market model with matching frictions with an otherwise traditional New Keynesian business cycle framework has attracted a lot of attention. It does not only allow to model labor market fluctuations within the New Keynesian framework, but also to analyze the impact of labor market frictions on inflation dynamics, see e.g. Walsh (2005). For example, Krause and Lubik (2007) highlight the potential importance of rigid wages for understanding the sluggishness in firms' marginal cost and for the persistence of inflation. However, they find that wage rigidities do not have a strong bearing on inflation dynamics.

In this paper we use the Trigari (2006) model with both efficient Nash bargaining and right-to-manage wage bargaining and complement it with a real wage rigidity in form of a Hall (2005) type wage norm, see also Blanchard and Gali (2007). Using this model, we show under which conditions wage rigidities can contribute to explain inflation persistence. We define the *direct* effect of the transmission of rigid wages on inflation dynamics by the property that wages have an impact on marginal costs, and hence inflation via the New Keynesian Phillips curve, directly. The *indirect* effect captures the property that the introduction of rigid wages will affect marginal costs indirectly via the hiring and employment decisions of firms and workers. In this context, we point to the importance of the underlying bargaining assumption for the magnitude of the two effects and hence for the transmission channel of wages to inflation.

Complementing the theoretical considerations, we use model simulations to analyze the impact of wage rigidities on inflation dynamics. In particular, we assess the quantitative implications of different degrees of wage rigidities for inflation persistence under two different assumptions on the bargaining scheme, different parameterizations with respect the labor market setup as well as habit formation in consumption.

2 The Business Cycle Model with Labor Market Matching

The exposition of the model follows Trigari (2006). The model structure is characterized by a separation between firms in the wholesale and retail market. The intermediate goods are produced by competitive firms in the wholesale sector employing labor as the only input to production, where the labor input is determined in a matching framework. The retail sector firms purchase wholesale goods at marginal cost, transform them into differentiated goods and sell them with a mark-up over marginal cost in a monopolistic competitive environment, see Walsh (2005).

Households: There is a continuum of households on the interval $[0, 1]$. The representative household chooses $\{c_t, h_t\}_{t=1}^{\infty}$ to maximize its utility given by:

$$\max \mathrm{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\sigma}}{1-\sigma} - \kappa_h \frac{h_t^{1+\phi}}{1+\phi} \right] \tag{1}$$

where the first term in brackets is the utility from consuming c_t of the final good while the second part represents the disutility from work by supplying h_t units of hours. The degree of risk aversion is given by σ, ϕ denotes the inverse of the intertemporal elasticity of substitution of labor and β gives the time discount factor. κ_h accounts for the relative importance of disutility of work and utility from consumption in total utility.

Households maximize consumption subject to the following budget constraint:

$$c_t + \frac{B_t}{p_t r_t^n} = d_t + \frac{B_{t-1}}{p_t} \tag{2}$$

where p_t is the aggregate price level, B_t is per capita holdings of a one period risk free bond, r_t^n is the gross nominal interest rate on this bond and d_t denotes the per capita income of the household in period t.

Household members can be employed or unemployed. When employed they receive the wage payments $w_t h_t$, when unemployed they receive unemployment benefits which are evaluated in consumption units, b. We assume that households pool their income and decide jointly on consumption and leisure.

Final Good Firms and Price Setting: The final good firms aggregate the intermediate goods into the final consumption good. The output index is assembled using the standard aggregation technology: $y_t = \left(\int_0^1 y_{it}^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}$, with y_t, y_{it} and ϵ being aggregate output, the individual firm's output and the firm's own price elasticity, respectively. The resulting demand for each aggregator depends on the relative price and aggregate demand: $y_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\epsilon} y_t$. Let $(1-\varphi)$ denote the per-period probability that a firm is able to reset its price to the optimal price $p_t^\star$. The remaining fraction φ of firms keep their prices at the levels prevailing from the previous period. The optimal price $p_t^\star$ is chosen to maximize profits over the expected time span until the firm can re-optimize the price: $\mathrm{E}_t \sum_{s=0}^{\infty} \varphi^s \beta_{t+s} \left[\frac{p_{it}^\star}{p_{t+s}} - x_{t+s}\right] y_{i,t+s}$, where x_t gives the real marginal costs. The solution to this problem is given by

$$p_{it} = \frac{\epsilon}{\epsilon-1} \mathrm{E}_t \sum_{s=0}^{\infty} \omega_{t,t+s} p_{t+s} x_{t+s}. \tag{3}$$

The weights $\omega_{t,t+s}$ are given by $\omega_{t,t+s} = \frac{\varphi^s \beta_{t+s} R_{it,t+s}}{\mathrm{E}_t \sum_{k=0}^{\infty} \varphi^k \beta_{t+k} R_{it,t+k}}$ with R_{it} denoting revenues from good i at time $t+s$ conditional on the price set at date t.

Monetary Policy: The central bank's monetary policy is modelled via a Taylor-type interest rate rule according to which the nominal interest rate evolves as:

$$r_t^n = (r_{t-1}^n)^{\rho^m} E_t(p_{t+1}/p_t)^{\gamma_\pi(1-\rho^m)} (y_t)^{\gamma_y(1-\rho^m)} e^{\epsilon_t^m} \tag{4}$$

where ρ^m denotes the degree of interest rate smoothing and γ_π and γ_y give the reaction coefficients to inflation and output. The monetary policy shock is denoted by ϵ_t^m.

The Labor Market: The intermediate good is produced in a competitive sector in which the labor market matching takes place. In the Mortensen-Pissarides (1994) model, the number of matches (m_t) is given as a function of the number of unemployed persons, u_t, and the number of vacant jobs, v_t, in the labor market: $m_t = \varrho_m u_t^{\varrho} v_t^{1-\varrho}$, with ϱ being the elasticity of the number of matches with respect to the stock of unemployed persons and ϱ_m measures the efficiency of the matching function.

Once a worker and a firm are matched, they produce output according to the production function: $f(h_t) = z_t h_t^{\alpha}$, where labor, i.e. the number of hours, h_t, is the only input to production and z_t represents technological progress, subject to the constraint that firms produce the output necessary to provide the aggregate household demand $c_t = (1-\rho) n_t z_t h_t^{\alpha}$.

The exogenous rate of job destruction ρ indicates the proportion of existing matches that disappear at the beginning of each period, i.e. become unproductive for unspecified reasons resulting in firms terminating the job. The number of employed workers at the beginning of each period (n_t) evolves as follows: $n_t = (1-\rho)n_{t-1} + m_{t-1}$

Below we state the value functions of workers and firms:

$$J_t = \Psi_t + \mathrm{E}_t\, \beta_{t,t+1}(1-\rho)J_{t+1} \tag{5}$$

$$V_t = -\frac{\kappa}{\lambda_t} + \mathrm{E}_t\, \beta_{t,t+1}\left[q_t(1-\rho)J_{t+1} + (1-q_t)V_{t+1}\right] \tag{6}$$

$$W_t = w_t h_t - \frac{g(h_t)}{\lambda_t} + \mathrm{E}_t\, \beta_{t,t+1}\left[(1-\rho)W_{t+1} + \rho U_{t+1}\right] \tag{7}$$

$$U_t = b + \mathrm{E}_t\, \beta_{t,t+1}\left[s_t(1-\rho)W_{t+1} + (1-s_t+s_t\rho)U_{t+1}\right], \tag{8}$$

The value functions of the job market participants are given by the current period payoff and the continuation value conditional on the probabilities of remaining in the current state or passing into another state. The discount factor is defined as $\beta_{t,t+s} = \beta\frac{\lambda_{t+s}}{\lambda_t}$.

The value function of a matched firm J_t (Equation (5)) consists of the period profit ($\Psi_t = x_t f(h_t) - w_t h_t$) and the continuation value of an existing job. The value function of a vacancy posting firm V_t (Equation (6)) is given by the current cost of posting a vacancy in utility terms ($\frac{\kappa}{\lambda_t}$) and the continuation value conditional on the probability q_t of finding a worker in the current period and not being separated at the beginning of the next period.

On the worker side a matched worker has a value function W_t (Equation (7)) determined by the surplus of the wage payment over the the disutility of work ($\frac{g(h_t)}{\lambda_t}$) and the continuation value of being in job, conditional on the separation probability. Finally the value function of a searching, i.e. unemployed worker U_t (Equation (8)) is given by unemployment benefits b and the continuation value conditional on the probability s_t that a searching worker finds a firm in the current period and does not loose it at the beginning of the next period.

Subsuming the dynamics of job creation the key equation of the search model relates the cost of vacancy posting to the expected profit of the firm:

$$\frac{\kappa}{\lambda_t q_t} = \mathrm{E}_t\, \beta_{t,t+1}(1-\rho)\left(\Psi_{t+1} + \frac{\kappa}{\lambda_{t+1} q_{t+1}}\right) \tag{9}$$

Higher expected profits are implying an increased vacancy posting activity of firms.

The resulting employment and unemployment dynamics are also shaping the behaviour of marginal cost and inflation.

Wage Setting in Efficient Nash Bargaining and Right-to-Manage Bargaining: In a labor market with matching frictions and equilibrium unemployment the worker and the firm bargain over wages (and employment) to split the positive rent or match surplus arising from a successful match between the worker and the firm, see Mortensen and Pissarides (1994). In this section we contrast the efficient Nash bargaining (EB) with the right-to-manage bargaining (RTM). Both bargaining schemes share the definition of the joint surplus of the employment relation as shown in Equation (10).

Starting with the case of efficient bargaining, MacDonald and Solow (1981) proposed a bargaining game in which bargaining takes place over employment and wages at the same time. In this case, wages and the number of hours worked are chosen to maximize the joint surplus:

$$\max_{w,h} \left[W_t - U_t\right]^{\eta} \left[J_t - V_t\right]^{1-\eta} \tag{10}$$

subject to Equations (5) to (8), where η denotes the bargaining power of workers.

This implies the following optimality conditions:

$$\eta J_t = (1-\eta)(W_t - U_t) \tag{11}$$

$$\eta J_t(w_t - mrs_t) = -(1-\eta)(W_t - U_t)(x_t mpl_t - w_t) \tag{12}$$

Plugging the definitions of the value functions (Equations (5) to (8)) into the first optimality condition we can write the wage equation as follows:

$$w_t = \eta \left(\frac{x_t mpl_t}{\alpha} + \frac{\kappa \theta_t}{\lambda_t h_t}\right) + (1-\eta)\left(\frac{mrs_t}{1+\phi_t} + \frac{b}{h_t}\right) \tag{13}$$

The wage in this model can be interpreted as a weighted average of the two "threat" points of employers and employees, i.e. the marginal product of labour and the reservation wage, respectively. The stronger the bargaining power of the worker, the closer the wage is to the marginal product and vice versa.

Substituting further the first optimality condition into the second one we can express marginal cost as the ratio of the marginal rate of substitution to the marginal product of labor.

$$x_t = \frac{mrs_t}{mpl_t} \tag{14}$$

This implies that under efficient bargaining the bargaining outcome will lie on the contract curve, i.e. the locus of tangency points of the isoprofit curve of the firm and worker's indifference curves. Therefore, any change in hours will be accompanied by a corresponding change in wages.

In contrast to efficient Nash bargaining the right-to-manage model proposes that workers and firms only bargain over wages and that firms subsequently choose the level of employment, see Nickell and Andrews (1983) and Trigari (2006). Under this assumption the joint surplus is maximized with respect to w_t only, under the side constraint

$$x_t mpl_t = w_t \tag{15}$$

resulting from the per-period profit (Ψ_t) maximization of firms. According to this, wages are set through the bargaining process and are taken as given by the firms when choosing their level of hours. Therefore, in contrast to the EB model, under RTM every additional hour of work will cost the firm the previously bargained wage.

This results in the optimality condition

$$\eta \delta_t^w J_t = (1-\eta)\delta_t^f (W_t - U_t) \tag{16}$$

where $\delta_t^w = \frac{\partial W_t}{\partial w_t}$ is the marginal contribution of wages to the value of a job to the worker and $\delta_t^f = \frac{\partial J_t}{\partial w_t}$ is the marginal contribution of the wage to the value of a job to the firm. Using the relations in Equations (5)-(8) yields the following wage equation:

$$\begin{aligned} w_t = {} & \chi_t \left(\frac{x_t mpl_t}{\alpha} + \frac{\kappa \theta_t}{\lambda_t h_t} \right) + (1-\chi_t) \left(\frac{mrs}{1+\phi_t} + \frac{b}{h_t} \right) \\ & + \chi_t (1-s_t) \frac{\kappa}{\lambda_t q_t} \left(1 - \frac{1-\chi_t}{\chi_t} \frac{\chi_{t+1}}{1-\chi_{t+1}} \right) \end{aligned} \tag{17}$$

where $\chi_t = \eta \delta_t^n / (\eta \delta_t^w + (1-\eta)\delta_t^f)$

Wage Rigidity: Following Hall (2005), we introduce wage rigidity into the model in the form of a backward looking social norm. According to Hall (2005) a wage norm or social consensus can be perceived as a rule to select an equilibrium within the bargaining set. Without going into the details of the sources of this wage norm, we assume that the actual wage level is given by a weighted average of the bargained wage ($w_t^\star$) and the wage norm, $\widehat{w}$:

$$w_t = (1-\delta) w_t^\star + \delta \widehat{w} \tag{18}$$

where $\widehat{w} = w_{t-1}$ and δ denotes the respective weight. The wage norm used in this framework can be seen as encompassing various sources of wage rigidities.

3 Inflation Persistence and the Labor Market

The two different bargaining assumptions lead to two different sets of equations for wages and marginal costs, see Equations (13) and (14) for efficient bargaining and Equations (15) and (17) for the right-to-manage approach. The transmission of labor market factors to inflation depend both on their effect on wages and on the transmission of wages to marginal costs and hence inflation via the New Keynesian Phillips curve.

Here we focus to the transmission of rigid wages on inflation dynamics, where we can distinguish between the *direct* and the *indirect* effect. We define the *direct* effect by the property that wages affect marginal costs, and hence inflation via the New Keynesian Phillips curve, directly. In this case, the introduction of wage rigidities will translate directly into more persistent movements of inflation. The *indirect* effect captures the property that the introduction of rigid wages will affect the hiring and employment decisions of firms and workers. The resulting changes to labor market variables affect marginal cost in several ways, via their effect on wages, the marginal product of labour and the marginal rate of substitution.

Direct effect: Under RTM the direct effect of a wage rigidity on inflation dynamics is straightforward as wages enter the marginal cost expression directly, compare Equation (15). Therefore, all factors that have an impact on the rigidity of wages have a direct effect on the persistence of marginal costs and, accordingly, the persistence of inflation.

Under EB the direct effect is more subtle. Wages are only one of the various determinants of the marginal rate of substitution, which is the main driver of marginal costs. Using the optimality condition in Equation (11) together with the definitions of the value functions and the market entry zero profit condition (Equation 9), we can solve for the following expression of the marginal rate of substitution as a function of observable variables:

$$mrs_t = \upsilon w_t - \frac{\upsilon}{h_t}\left((1-\eta)b - \eta\kappa\theta_t\right) \tag{19}$$

where $\upsilon = \frac{\alpha(1+\phi)}{\eta(1+\phi)+(1-\eta)\alpha}$.

Equation (19) shows that in addition to the wage term, hours worked per person and labor market tightness appear as driving factors of the marginal rate of substitution. The direct effect is less important under EB compared to RTM because the normalized coefficient of wages in the numerator of the marginal cost term is lower than one under EB, while under RTM wages enter as the only determinant.[1]

Indirect effect: Assessing the indirect effect of the transmission of wage rigidities on inflation dynamics, two elements are of importance. First, the effect of the introduction of a wage rigidity on the size of labor market flows and, second, the transmission channel of labor market flows on marginal cost and, hence, inflation.

Turning to the first element, Equation (9) shows that fluctuations in expected profits are causal for hiring and employment fluctuations. Combining the definition of profits (Ψ_t) with the bargaining specific definitions of marginal costs (see Equations (15) and (14)), the

[1]This can be seen by plugging Equation (19) into Equation (14) and comparing it with Equation (15). To quantify this effect further, we can write the log-linearised equation as follows $\widehat{mrs}_t = \frac{\upsilon \bar{W}}{\bar{MRS}}\widehat{w}_t + \frac{\upsilon((1-\eta)b+\eta\kappa\bar{\theta})}{\bar{MRS}\bar{H}}\widehat{h}_t - \frac{\upsilon\eta\kappa\bar{\theta}}{\bar{MRS}\bar{H}}\widehat{\theta}_t$, where the normalized coefficients on wages, hours and labor market tightness are in a relation of 0.34 to 0.54 to 0.12 under the calibration reported below.

following definitions for profits can be obtained:

$$\Psi_t^{EB} = \left(\frac{mrs_t}{\alpha} - w_t\right) h_t \quad (20)$$

$$\Psi_t^{RTM} = \left(\frac{1-\alpha}{\alpha}\right) w_t h_t \quad (21)$$

As evidenced by Equation (20), under EB profits will fluctuate more strongly the more the dynamics of wages deviate from the dynamics of the marginal rate of substitution. Such deviations will be more pronounced, once wage rigidities are introduced, compare Shimer (2004). This implies that the presence of the wage rigidities will increase profit fluctuations and will shift the adjustment from the intensive to the extensive margin. Under RTM profits are proportional to the wage bill, since firms will always operate along their labor demand curve. In this setting the introducing of wage rigidities does not necessarily increase profit fluctuations and a larger proportion of overall fluctuations are captured along the intensive margin of hours worked.

Concerning the second element, i.e. the transmission of employment fluctuations on marginal cost, Equation (19) shows that under EB the overall impact of the indirect effect on inflation persistence depends on various factors. The marginal rate of substitution and consequently marginal cost are not only affected by wages, but additionally by fluctuations in hours worked and labor market tightness. The introduction of wage rigidities increases the fluctuations of vacancies and employment and labor market tightness, which in turn transmit to the marginal rate of substitution and to marginal costs. In contrast to this, under RTM the total effect of employment fluctuations on marginal cost is subsumed via the overall response of wages and the marginal product of labor.

Overall, from a theoretical perspective, we can conclude the following: First, the direct effect is stronger under RTM while the indirect effect is stronger under EB. Second, the overall impact of the introduction of wage rigidities on inflation persistence will depend on the behaviour of wages, hours and labor market tightness. To illustrate the quantitative implications, various model simulation are presented in the next section.

Quantitative Implications

We have argued that the effect (direct and indirect) of wages on inflation crucially hinges on the assumption of the underlying bargaining scheme. To illustrate the quantitative implications of the two bargaining regimes for the effect of wage rigidities on inflation persistence, we estimate the persistence of wages, hours worked, labor market tightness and inflation from the model simulated data. This will be particularly illustrative for assessing the importance of the direct and indirect effect of wage rigidities under the two bargaining assumptions. The model generated data is based on dynamic simulations of the log-linearized model using the Trigari (2006) calibration, see Table 1. In order to make the results comparable the wage norm is calibrated as to match a wage persistence of 0.8.[2]

[2]This is in line with evidence on US wage persistence found in macro wage data.

Table 1: Calibration for Benchmark Model without Wage Rigidity ($\delta = 0$)

parameter	δ	ρ_m	γ_π	γ_y	σ	φ	β	α	ϕ
value	0	0.9	1.5	0.5	0.98	0.85	0.99	0.9	10
parameter	ϱ	ϱ_m	ρ	η	n	ϵ	q	s	b/wh
value	0.5	0.4	0.08	0.5	0.8	11	0.7	0.24	0.47

Notes: We also provide results for a flexible labor market, where we assume a bargaining power of $\eta = 0.05$ and a replacement rate of $b/wh = 0.1$. For all variants the model is simulated with a monetary policy shock as the only source of stochastic fluctuations.

Table 2 displays the model implied persistence of wages, hours worked, labor market tightness and inflation under the assumption of different bargaining regimes (right-to-manage vs. efficient bargaining), different degrees of real wage rigidity (flexible wages vs. existence of a wage norm) and the existence of habit formation and demonstrates how these specifications have an impact on the dynamics of inflation. Moreover, we assess the robustness of the results with regard to changes in the parametrization of the unemployment benefits and the bargaining power of workers. Columns 3-6 of Table 2 display the model with the labor market parametrization shown in Table 1, while the last two columns display the model under an alternative calibration with larger steady state profits and lower unemployment.

The results from our simulation exercise are the following:

First, a higher degree of wage rigidity in the form of a wage norm increases the inflation persistence in all cases. Furthermore, we find that in the simulations with rigid wages the inflation persistence is higher under RTM bargaining than under EB (e.g. 0.67 vs. 0.49 in Column 4). As discussed above, this stems from the fact that under RTM wages feed directly into marginal costs, introducing a direct channel through which wage rigidities translate into inflation persistence. Under EB the direct effect is smaller as discussed in the previous section. Regarding the other determinants of marginal costs (compare Equation 19) we can see that hours are reacting only slightly more persistent (from 0.33 to 0.38 in Columns 3 and 4) and labor market tightness is becoming less persistent (from 0.39 to 0.17 in Columns 3 and 4). This counteracts the direct effect of more rigid wages on marginal cost and inflation dynamics via the marginal rate of substitution. Therefore, wage rigidities translate more strongly into inflation persistence under the assumption of RTM than under EB.

Second, wage rigidities can be transmitted to inflation dynamics indirectly as wages have an impact on expected profits and consequently the hiring activity, which in turn affect future marginal costs via hours worked per person and labor market tightness. We can observe that under RTM the introduction of wage rigidities tends to increase the overall persistence, reflected also in the persistence of hours and labor market tightness. In contrast

Table 2: Persistence ς in Wages and Inflation

	Persistence ς in	flexible wages	wage norm	flexible wages	wage norm	flexible wages	wage norm
		no Habit Formation		Habit Formation		Large Profits	
Right to Manage	Wages	0.22	0.80	0.33	0.80	0.22	0.80
	Inflation	0.27	0.67	0.39	0.65	0.26	0.68
	Hours	0.11	0.27	0.15	0.32	0.11	0.01
	Tightness	0.28	0.45	0.46	0.51	0.28	0.51
Efficient Bargaining	Wages	0.39	0.80	0.56	0.80	0.49	0.80
	Inflation	0.40	0.49	0.54	0.56	0.48	0.49
	Hours	0.33	0.38	0.57	0.61	0.46	0.46
	Tightness	0.39	0.17	0.52	0.43	0.47	0.46

Notes: Wage and inflation persistence is calculated according to: $w_t = c + \varsigma w_{t-1} + \sum_{i=1}^{4} \psi_i \Delta w_{t-i} + \varepsilon_t$ In order to make the results comparable the wage norm is calibrated as to match a wage persistence of 0.8. The first two columns denote the case of a standard utility function. In the two middle columns we assume additive, external habits with a coefficient of 0.6. The last two columns show the results under standard preferences and a modified steady state of the labor market, where we set the bargaining power of workers from 0.5 to 0.05 and the replacement rate from 0.47 to 0.1.

to this, under EB the persistence of labor market tightness decreases indicating higher fluctuations along the hiring margin.

Third, introducing another source of real rigidity such as habit formation in consumption amplifies the overall persistence of inflation, in all model variants irrespective of the bargaining regime and the degree of wage rigidity. Habit formation is implying smoother demand dynamics and, therefore, smoother series of hours worked which in turn imply higher inflation persistence, compare Columns 3 and 4 with Columns 5 and 6.

Fourth, changing the calibration by setting both the unemployment benefit and bargaining power of workers to a very low value changes the steady state of the model (e.g. lower steady state unemployment and higher steady state profits), but leaves the dynamics of inflation largely unaffected, see alternative calibration in the last two columns of Table 1. We find that under EB, the introduction of a wage rigidity increases wage persistence but the effect on inflation persistence is negligible, see Table 1, Columns 7 and 8. This stems from the fact that under this calibration profits are large and wages are low. This in turn implies that the small wage fluctuations will trigger only low percentage fluctuations in profits. Consequently, the introduction of wage rigidity will not have any major effect on profit fluctuations and hence on employment dynamics. The channel from wage rigidity to inflation persistence is, therefore, muted under this parameterizations. Under RTM the effect of wage rigidities on inflation persistence remains largely unaffected by the changed calibration.

In sum, we can conclude that under RTM the direct channel from wage rigidity to inflation persistence is rather robust with respect to the remaining specification of the model. The indirect effect of wages via hours worked on inflation is present under both bargaining regimes. The simulation of our model shows that the size of this channel varies significantly with the various specification of the model. If the wage rigidity leads to a sizeable increase in employment variation the channel from wages to inflation increases. If the employment effect is muted the channel becomes negligible. This implies, in particular, that under EB all factors that influence wages but not the employment decision do not affect inflation. In contrast, under RTM all variations in wages are passed through to inflation.[3]

4 Conclusions

We extend the analysis of Trigari (2006) by incorporating wage rigidities into both the efficient Nash bargaining and the right-to-manage bargaining framework of her model. We investigate the question whether the specific form of wage bargaining and the degree of wage rigidity affects inflation persistence in a New Keynesian framework.

We find that the transmission of wages to inflation hinges on the choice of the bargaining scheme, as this introduces a key difference for the determination of marginal costs. Using a right-to-manage bargaining framework, wages feed directly into firm's marginal cost and hence into inflation dynamics via the New Keynesian Phillips curve. Therefore, introducing a real wage rigidity, e.g. in form of a Hall type wage norm, we can show that more rigid wages translate into more persistent movements of aggregate inflation. In contrast, the direct channel from wages to inflation is less pronounced under the assumption of an efficient bargaining model and, therefore, generates lower degrees of inflation persistence.

Nonetheless, we show that under both bargaining schemes there exists an indirect effect of wages to inflation via the hiring activity of firms. While the size of the direct effect is robust with respect to different parameterizations and specifications, we find that the size of the indirect effect varies with the underlying parametrization of the labor market (unemployment benefits, bargaining power of workers, etc.) and the introduction of other more traditional real rigidities like habit formation in consumption.

More generally, we can conclude that the institutional framework of the labor market, i.e. factors such as the respective bargaining power of the negotiating parties, the reservation wage, the general tightness of the labor market or the degree of wage rigidity are important for inflation dynamics. The transmission of theses factors on inflation, however, crucially depends on the assumption with respect to the wage bargaining scheme. While, under right-to-manage all factors that drive wage dynamics will also affect inflation, under efficient

[3]Note that we could also confirm that our results are robust to changes in nominal rigidities such as increased price rigidity. The results are omitted due to brevity.

bargaining only those factors that affect the employment decisions will have a sizeable impact on inflation.

References

Blanchard, O. J., and J. Gali (2007): "Real Wage Rigidities and the New Keynesian Model," *Journal of Money, Credit, and Banking*, 39.s1, 35–65.

Hall, R. E. (2005): "Employment Fluctuations with Equilibrium Wage Stickiness," *American Economic Review*, 95(1), 50–65.

Krause, M., and T. Lubik (2007): "The (Ir)relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions," *Journal of Monetary Economics*, 54(3), 706–727.

MacDonald, I., and R. M. Solow (1981): "Wage Bargaining and Employment," *American Economic Review*, 71, 896–908.

Mortensen, D., and C. Pissarides (1994): "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, 61(3), 397–415.

Nickell, S. J., and M. Andrews (1983): "Unions, Real Wage and Employment in Britain 1951-79," *Oxford Economic Papers*, 35, suppl., 183–206.

Shimer, R. (2004): "The Consequences of Rigid Wages in Search Models," *Journal of the European Economic Association*, 2(2).

Trigari, A. (2006): "The Role of Search Frictions and Bargaining for Inflation Dynamics," *IGIER Working Paper No. 304, Bocconi University/Milan.*

Walsh, C. (2005): "Labor Market Search, Sticky Prices, and Interest Rate Policies," *Review of Economic Dynamics*, 8(2005), 829–849.