Labor Market Frictions into Staggered Wage Contracts

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Abstract

This paper proposes a generalization of the Calvo wage-setting equation, which embeds labor market frictions in the form of a Nash wage bargain. Adding labor market frictions changes significantly the dynamics of the standard wage-setting equation, such that it may have non-trivial implications for the design of optimal monetary policy, and could improve the ability of a general equilibrium model to replicate important labor market stylized facts.

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1 Introduction

Adding staggered nominal wage contracts to standard New Keynesian models has been regularly used in recent discussions of monetary policy. In particular, a host of dynamic stochastic general equilibrium (DSGE) models use the microfounded Calvo wage-setting formulation first introduced in Erceg *et al.* (2000).[1] Such a setting is a crucial input for researchers who wish to characterize optimal monetary policy and, as pointed out in Rabanal and Rubio-Ramırez (2005), can help to produce a more accurate replication of observed inflation dynamics. Separately, the presence of labor market frictions in the form of wage bargaining has been well established as empirically important feature of many economies.[2] They have proved to be important for the design of monetary policy[3] and, as emphasized by Hall (2005), to be a crucial feature of models that seek to replicate important labor market stylized facts.

In this paper, we combine these two branches of the literature and provide a full description of a Calvo wage-setting equation which embeds labor market frictions in the form of a Nash wage bargain. We then study how labor market frictions affect the dynamics of a standard calibrated version of the Calvo wage-setting equation.

2 The Calvo wage-setting with labor market frictions

2.1 Optimal wage decision

To keep the model analytically simple, and directly comparable with previous studies, we adopt set-up and notation similar to Erceg *et al.* (2000), which derive a prototype Calvo wage-setting equation. In what follows, we characterize the wage-setting bargain between households and firms.

Every firm hires K_{t+j} units of capital and $N_{t+j}(h)$ units of labor from the household to manufacture $Y_{t+j}(h)$ units of good according to the constant returns to scale Cobb-Douglass technology $X_{t+j}K^{\alpha}_{t+j}N_{t+j}(h)^{1-\alpha}$, where X_{t+j} is the level of total factor productivity. The wage is the outcome of a Nash bargaining process between households and firms. Wage inertia is introduced by Calvo-style staggered contracts. From the perspective of an individual

[1] See, among others, Huang and Liu (2002), and Harrison *et al.* (2005) and references therein.

[2] See Nickell (1997) and references therein.

[3] See, for recent examples, Blanchard and Gali (2006), and Zanetti (2005).

household, the wage set at time t applies with probability 1 in t, with probability ξ_w in $t+1$ and so forth. Also, in each period, a constant fraction of households $1-\xi_w$ is chosen to reset their contract wages. We assume that whenever household h is not chosen to change its wage she updates her contacts at the gross steady-state inflation rate Π, so that wages are updated according to the rule $W_{t+j}(h) = \Pi^j W_t(h)$. When the household is chosen to set her wage in period $t+j$, she bargains with the associated firm and chooses the wage, $\{W_t(h)\}_{t=0}^{\infty}$, which maximizes the future expected weighted product of the surplus from employment:

$$\begin{aligned} & E_t \sum_{j=0}^{\infty} (\beta\xi_w)^j \left\{ \left[U_{C,t+j} \frac{\Pi^j W_t(h) N_{t+j}(h)}{P_{t+j}} - V\left(N_{t+j}(h), Z_{t+j}\right) \right]^{\delta} \right. \\ & \left. \left[X_{t+j} K_{t+j}^{\alpha} N_{t+j}(h)^{1-\alpha} - \frac{\Pi^j W_t(h) N_{t+j}(h)}{P_{t+j}} \right]^{1-\delta} \right\}, \qquad (1) \end{aligned}$$

where β is the discount factor, $U_{C,t+j}$ the marginal utility of consumption, P_{t+j} the aggregate price index, $V\left(N_{t+j}(h), Z_{t+j}\right)$ the disutility of working which depends on $N_{t+j}(h)$, the hours worked, and Z_{t+j}, a leisure shock. In equation (1), the first term in square brackets represents the surplus to households from working, and the second term the firm's profits. The parameter δ reflects the parties' relative bargaining power, and $0 < \delta < 1$. The advantage of using a Nash baragain is that the outcome of the bargain is privately efficient—the choice over employment coincides with that of a market without frictions—and the wage is set to split the surpluses from employment.

The first order condition for the household who sets wages at period $t+j$ is

$$\begin{aligned} & E_t \sum_{j=0}^{\infty} (\beta\xi_w)^j \delta \left\{ \left[-V_n\left(N_{t+j}(h), Z_{t+j}\right) - F_{t,t+1} E_t(h) U_{C,t+j} \right] \right. \\ & \left. \left[X_{t+j} K_{t+j}^{\alpha} N_{t+j}(h)^{1-\alpha} - F_{t,t+1} E_t(h) N_{t+j}(h) \right] \right\} \qquad (2) \\ = \; & E_t \sum_{j=0}^{\infty} \left\{ (\beta\xi_w)^j (1-\delta) \left[(1-\alpha) X_{t+j} K_{t+j}^{\alpha} N_{t+j}(h)^{-\alpha} - F_{t,t+1} E_t(h) \right] \right. \\ & \left. \left[U_{C,t+j} F_{t,t+1} E_t(h) N_{t+j}(h) - V\left(N_{t+j}(h), Z_{t+j}\right) \right] \right\}, \end{aligned}$$

where $E_t(h) = W_t(h)/W_t$, and $F_{t,t+1} = W_t \Pi^j / P_{t+j}$. Equation (2) states that the household's weighted optimal condition for employment maximization, multiplied by the firm's surplus from labor must equal the firm's weighted profit maximization condition multiplied by the household's surplus from labor. Note that if the weight disappears, $\delta \to 1$, there is no longer any real bargaining, as in the standard case, and so expression (2) reduces to the standard Phillips equation for staggered wage contracts

$$E_t \sum_{j=0}^{\infty} (\beta\xi_w)^j \left[V_n \left(N_{t+j}(h), Z_{t+j} \right) + \frac{\Pi^j W_t(h)}{P_{t+j}} U_{C,t+j} \right] = 0.$$

In this instance, the household would set the wage so that the expected discounted marginal reward of working equals the expected discounted marginal sacrifice of working.[4]

2.2 The Calvo wage-setting equation under labor frictions

We can now log-linearize equation (2) around the steady-state to obtain:

$$\begin{aligned} & -E_t \sum_{j=0}^{\infty} (\beta\xi_w)^j \delta L \left[V_n \widehat{V}_{n,t+j}(h) + FU_C(\widehat{f}_{t,t+1} + \widehat{e}_t(h) + \widehat{U}_{C,t+j} \right] \qquad (3) \\ = \quad & E_t \sum_{j=0}^{\infty} (\beta\xi_w)^j (1-\delta) S \left[(1-\alpha) XKN^{-\alpha} (\widehat{x}_{t+j} - \alpha \widehat{n}_{t+j}(h)) - F(\widehat{f}_{t,t+1} + \widehat{e}_t(h)) \right], \end{aligned}$$

where a hat on a variable denotes the log-linear deviation from its steady-state, and $L = XK^{\alpha}N^{1-\alpha} - FN$, and $S = U_C FN - V$.[5] The total demand for the household's labor, $N_t(h) = [W_t(h)/W_t]^{-(1+\theta_w)/\theta_w} N_t$, implies that $\widehat{n}(h)_{t+j} = \widehat{n}_{t+j} + \eta(\widehat{e}_t(h) + g_{t,t+j})$, where $\eta = -(1 + \theta_w)/\theta_w$, for each household h whose price contract signed at date t remains in effect at date $t+j$. Log-linearizing the household's marginal disutility of working, $V_{nt}\left[N_t(h), Z_t\right] = -\left[1 - N_t(h) - Z_t\right]^{-\varkappa}$, around the steady-state, we can write $\widehat{V}_{nt}(h) = \chi(\Theta_N \widehat{n}(h)_t + \Theta_Z z_t)$, and averaging across households, $\widehat{V}_{nt} = \chi(\Theta_N \widehat{n}_t + \Theta_Z z_t)$, where $\Theta_N = N/(1-N-Z)$ and $\Theta_Z = Z/(1-N-Z)$. If we define $G_{t,t+1} = W_t \Pi^j / W_{t+j}$, the real wage deviation from the steady-state is $\widehat{\zeta}_{t+j} = \widehat{f}_{t,t+j} - g_{t,t+j}$, and $g_{t,t} = 0$. Log-linearizing the household's labor supply we can write her marginal rate of substitution as $\widehat{mrs}_t = \widehat{V}_t - \widehat{U}_{C,t}$. Substituting these relationships into equation (3) yields

[4] In this formulation, as in Erceg *et al.* (2000), it is assumed that the government subsidizes labor at the rate $\tau_w = \theta_w$.

[5] No that, in the steady-state, $E = 1$, and $F = W/P = -V_n/U_C = (1-\alpha)XKN^{-\alpha}$.

$$\left[\frac{\delta LFU_C-(1-\delta)SF+\delta LV_n\chi\Theta_N\eta}{1-\beta\xi_w}\right]\widehat{e}_t(h)+E_t\sum_{j=0}^{\infty}(\beta\xi_w)^j\delta LFU_C\left(\widehat{\zeta}_{t+j}-\widehat{mrs}_{t+j}\right)$$
$$+E_t\sum_{j=0}^{\infty}(\beta\xi_w)^j(1-\delta)\left[SXKN^{-\alpha}\left(\widehat{x}_{t+j}-\alpha\widehat{n}_{t+j}(h)\right)-SF\widehat{\zeta}_{t+j}\right]$$
$$+E_t\sum_{j=1}^{\infty}(\beta\xi_w)^j\left[\delta LFU_C-(1-\delta)SF+\delta LV_n\chi\Theta_N\eta\right]\widehat{g}_{t,t+j}$$
$$+E_t\sum_{j=0}^{\infty}(\beta\xi_w)^j\left(\delta LFU_C+\delta LV_n\right)\widehat{V}_{nt+j}=0. \tag{4}$$

Finally, to express equation (4) in terms of deviation of wage inflation from its steady-state, $\widehat{\omega}_t$, we need to consider the aggregate wage $W_t=(1-\xi_w)W_t(h)+\xi_w(W_{t-1}+\Pi)$. Its log-linearized deviation from the steady-state implies $\widehat{e}_t(h)=[1/(1-\xi_w)]\widehat{\omega}_t$. Using this relationship, we account for the fact that in steady-state $FU_C=-V_n$, bring equation (4) forwards by one period, multiply the result by $\beta\xi_w$, subtract the outcome from equation (4), use the expression for the log-linearized marginal product of labor, $\widehat{mpl}_t=\widehat{x}_t-\alpha\widehat{n}_t(h)$, and rearrange, yielding

$$\widehat{\omega}_t=\beta E_t\widehat{\omega}_{t+1}+\frac{\delta NWU_c}{P}\kappa_\omega\left(\widehat{mrs}_t-\widehat{\varsigma}_t\right)+(1-\delta)H\frac{W}{P}\kappa_\omega\left(\widehat{\varsigma}_t-\widehat{mpl}_t\right), \tag{5}$$

where $\kappa_\omega=\frac{(1-\beta\xi_\omega)(1-\xi_\omega)}{\xi_\omega\left[\delta N\frac{W}{P}U_c(1-\chi\Theta_N\eta)+(1-\delta)\frac{HW}{P}\right]}$, and $H=U_c\frac{W}{P}N-V$.

Equation (5) links current wage inflation to expected future wage inflation, a term representing the difference between the marginal rate of substitution and the real wage, $(\widehat{mrs}_t-\widehat{\varsigma}_t)$, and a term representing the difference between the real wage and the marginal product of labor, $(\widehat{\varsigma}_t-\widehat{mpl}_t)$. In models with staggered wage-setting such as Erceg *et al.* (2000), equation (5) appears in a simplified form with $\delta\to 1$, such that the coefficient of the second term is different and the third term disappears. Since wage inflation is an important input to most standard microfounded welfare functions, this enriched formulation would probably alter the policy a monetary authority needs to implement to achieve a Pareto-optimum equilibrium.

This formulation changes significantly the dynamics of the wage inflation. For simplicity, we can re-write equation (5) as $\widehat{\omega}_t=\beta E_t\widehat{\omega}_{t+1}+a_1(\widehat{mrs}_t-\widehat{\varsigma}_t)+a_2(\widehat{\varsigma}_t-\widehat{mpl}_t)$, where $a_1=(\delta NWU_c\kappa_\omega)/P$ and $a_2=[(1-\delta)HW\kappa_\omega]/P$. Hence, the dynamics of the wage inflation therefore depend on the values of the coefficients a_1 and a_2. To understand how coefficients a_1 and a_2 vary with the household's wage bargaining power, we report some illustrative numerical results. Values for δ are in the range of $(0, 1)$. The other parameter values, as in Erceg *et al.* (2000), are $\beta = 0.99$, $\alpha = 0.3$, $\chi = \sigma = 1.5$, $\xi_\omega = 0.75$, $\theta_w = 1/3$, $Q = 0.32$, $X = 4.02$, $Z = 0.03$, $K = 30Q$, $N = 0.27$, $Y = 10Q$. As we increase δ, the value of a_1 increases, while that of a_2 decreases. Some illustrative results that show how the coefficients a_1 and a_2 vary for different values of δ are given in Table 1.

Table 1. Values of a_1 and a_2 as a function of δ

δ	0	0.2	0.4	0.6	0.8	1
a_1	0	0.0004	0.0011	0.0023	0.0054	0.0259
a_2	0.0081	0.0079	0.0078	0.0074	0.0064	0

As Table 1 shows, even a small change in the household's wage bargaining power affects the coefficients a_1 and a_2 significantly, particularly relative to the case in which there is no wage bargain. In fact, when $\delta = 0.8$ rather than 1, the coefficient a_1 decreases by approximately 80%, while a_2 increases substantially (from 0 to 0.0064). Once the wage bargain is introduced ($\delta \nrightarrow 1$), a_1 and a_2 become less sensitive to changes in δ. For instance, in response to a reduction of around 20% in the degree of wage bargaining power, such that $\delta = 0.6$ rather than 0.8, the coefficient a_1 decreases by approximately 60%, while a_2 increases by approximately 20%.

3 Conclusion

This paper proposes a full specification of the Calvo wage-setting equation, based on a Nash wage bargain. The equation nests the prototype Calvo wage-setting equation as a special case, and extends the analysis to incorporate the effect of labor market frictions. In this way, the standard wage-setting equation is enriched by a parameter for the household's wage bargaining power, and an extra term for the marginal product of labor. These change significantly the dynamics of the standard wage-setting equation, such that they may introduce additional constraints for the design of optimal monetary policy, and may improve the ability of a DSGE model to replicate important stylized facts in the data. The detailed investigation of these implications is open for future research.

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