Efficiency Wage and the Cost of Business Cycles

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November 28, 2020

Preliminary

Abstract

In many macroeconomic models, the cost of business cycle fluctuations is too small to justify the enormous effort being put into stabilization policies. This paper proposes efficiency wage as a new explanation for the observed large cost of business cycles. When high unemployment makes jobs more valuable, employed workers work harder to keep their jobs, making it less necessary for firms to use high wages to elicit efforts from their workers. Changes in wages eventually translate into changes in prices, and high unemployment is therefore not as disinflationary as low unemployment is inflationary, implying a higher cost of business cycles.

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1 Introduction

Lucas's 1987 seminal calculation finds that the consumption-equivalent welfare cost of business cycles in the post-war U.S. data is counterintuitively low—0.05% of annual consumption, making it hard to justify the huge amount of resources being spent in stabilization policies. A large literature has since tried to explain this model-reality inconsistency through increasing the sensitivity of welfare to fluctuations (e.g., Obstfeld, 1994; Otrok, 2001; Ellison and Sargent, 2015), exploring heterogeneous consumption risks (e.g., Imrohoroğlu, 1989; Tallarini Jr, 2000; De Santis, 2007), linking business cycles and economic potential (e.g., De Long and Summers, 1988; Barlevy, 2004; Gali et al., 2007), and examining data with more volatile fluctuations (e.g., Corbae and Chatterjee, 2000; Pallage and Robe, 2002).

This paper proposes efficiency wage as a new explanation for the observed high cost of business cycles. Firms uses high wages to elicit efforts from their workers (Cappelli and Chauvin, 1991; Krueger, 1991; Bewley, 2009). However, the workers' effort decision depends not only on the efficiency wages but also on the duration of unemployment, creating an inverse relationship between the efficiency wages and unemployment rate. As unemployment rate decreases, workers become less fearful of unemployment because they can find other jobs quickly, and firms in response need to pay higher wages to induce the workers to not shirk. Firms eventually have to pass the higher labor cost onto its customers through higher prices. Similarly, higher unemployment rate is associated with higher cost of unemployment, prompting the workers to exert effort even when firms are paying low wages that are associated with low prices.

The relationship between the efficiency wage and unemployment rate is nonlinear. Imagine that the unemployment rate goes to its limit of zero (from the above). In this scenario, if caught shirking and fired, any worker can instantaneously find another job, and as a result, firms have to pay a wage of infinity to elicit effort from the worker. In other words, high unemployment is not as disinflationary as low unemployment is inflationary, causing the Phillips curve to be convex rather than linear. Correspondingly, business fluctuations lead to higher average inflation when holding average unemployment constant and to higher average unemployment when holding average inflation constant, leading to a higher cost of business cycles.

To operationalize the idea, this paper integrates the real efficiency wage model of Shapiro and Stiglitz (1984) and Kimball (1994) into a representative-agent New Keynesian model with sticky prices and monopolistic competition. To use unemployment as a worker discipline device, the model also features involuntary unemployment in the spirit of Christiano et al. (2020).

Calibrated simulations from the model confirm that efficiency wage can generate significant cost of business cycles despite a representative-agent setting with low risk aversion. In particular, a one-episode demand fluctuation (with the relative standard deviation of 50%) is associated with a 1.7% consumption-equivalent welfare cost of business cycles, while a one-episode supply fluctuation (with the relative standard deviation of 50%) is associated with a 4.4% consumption-equivalent welfare cost of business cycles. When efficiency wage is absent from the model, the same fluctuations lead to a zero welfare cost, consistent with the crucial role of efficiency wage for explaining a high cost of business cycles.

The rest of the paper is organized as follows. Section 2 describes the model in details. Section 3 discusses the model calibration and the calculation of the cost of business cycle, as well as numerical results from the simulations.

2 Model

2.1 Households

The economy consists of households, firms, and a monetary authority. The time is discrete.

There is a continuum of households of length 1. Each household has a continuum of workers of length 1. Some workers are unemployed. In each period, employed workers choose to shirk or not to maximize lifetime utility:

$$V_t^e = \max\left\{V_t^{e,ns}, V_t^{e,s}\right\}$$

where e denotes employed, ns non-shirking, and s shirking.

Non-shirkers (ns) consumes C_t^e, provides one unit of labor, incurs effort cost e, and faces a probability of becoming unemployed (b_t) in the next period:

$$V_t^{e,ns} = \left[\ln\left(C_t^e\right) - e\right] Z_t + \beta E_t V_{t+1}^e - b_t \beta E_t \left(V_{t+1}^e - V_{t+1}^u\right) \tag{1}$$

where β is time discount factor and Z_t is an exogenous preference shifter with $z_t \equiv \log Z_t = \rho_z z_{t-1} + \varepsilon_t^z$.

Shirkers (s) also consumes C_t^e, but provides no labor due to shirking and thus incurs no effort cost. Shirking is caught with a probability of q, and once caught, the worker is fired and becomes unemployed in the next period:

$$V_t^{e,s} = \ln\left(C_t^e\right) Z_t + \beta E_t V_{t+1}^e - \left(b_t + q\right) \beta E_t \left(V_{t+1}^e - V_{t+1}^u\right). \tag{2}$$

The household determines the consumption levels of the employed (C_t^e) and the unemployed (C_t^u), and workers take them as given. The household also chooses wage such that all of its employed workers are indifferent between shirking and non-shirking:[1]

$$V_t^{e,ns} = V_t^{e,s} \quad \forall t. \tag{3}$$

Plugging equations (1) and (2) into equation (3) leads to

$$\beta E_t \left(V_{t+1}^e - V_{t+1}^u\right) = \frac{e}{q} Z_t. \tag{4}$$

[1]When indifferent between shirking and not shirking, the worker chooses not to shirk.

Substituting equation (4) into the value functions of the shirkers and the non-shirkers gives the period utility of the workers:

$$V_t^e - \beta E_t V_{t+1}^e = \left[\ln\left(C_t^e\right) - e - b_t \frac{e}{q}\right] Z_t, \tag{5}$$

where $V_t^e = V_t^{e,ns} = V_t^{e,s}\ \forall t$.

The measure of unemployed workers is u_t, and each of them consumes C_t^u and has a chance (of probability a_t) to become employed in the next period:

$$V_t^u = \ln\left(C_t^u\right) Z_t + \beta E_t V_{t+1}^u + a_t \beta E_t \left(V_{t+1}^e - V_{t+1}^u\right). \tag{6}$$

Substituting equation (4) into equation (6) gives the period utility of the unemployed

$$V_t^u - \beta E_t V_{t+1}^u = \left[\ln\left(C_t^u\right) + a_t \frac{e}{q}\right] Z_t. \tag{7}$$

The household allocates its total consumption to the workers in proportion to the income (excluding government transfers except unemployment benefit) they get

$$\frac{C_t^e}{C_t^u} = \frac{W_t}{\bar{W}_t} \tag{8}$$

where W_t and $\bar{W}_t$ are the nominal wage and nominal unemployment benefit.

To derive the non-shirking-condition wage in this model, first note that subtracting equation (7) from equation (5) gives

$$V_t^e - V_t^u - \beta E_t \left(V_{t+1}^e - V_{t+1}^u\right) = \left[\ln\left(\frac{C_t^e}{C_t^u}\right) - (q + a_t + b_t)\frac{e}{q}\right] Z_t,$$

which after substituting in equation (4) becomes

$$\frac{e}{\beta q} Z_{t-1} - \frac{e}{q} Z_t = \left[\ln\left(\frac{C_t^e}{C_t^u}\right) - (q + a_t + b_t)\frac{e}{q}\right] Z_t. \tag{9}$$

Plugging equation (8) into equation (9) and simplifying the resulting expression gives

$$w_t = \bar{w}_t + \left(a_t + b_t + q - 1 + \frac{1}{\beta} e^{z_{t-1} - z_t}\right) \frac{e}{q} \tag{10}$$

where the lower-case variables represent the log of their capital-case counterparts, if there is any. When $z_t = z_{t-1}$, this wage is exactly the same as the non-shirking-condition wages in Shapiro and Stiglitz (1984) and Kimball (1994).

A household's preference aggregates those of its workers, with period utility equal to

$$\begin{aligned} U_t = \Bigg[& \ln\left(C_t\right) + (1 - u_t)\left(\frac{1}{\beta} - 1\right)\frac{e_t}{q_t} - \ln\left(u_t e^{-\left(a + b_t + q_t + \frac{1}{\beta} - 1\right)\frac{e_t}{q_t}} + 1 - u_t\right) \\ & - \left(b_t + q_t + \frac{1}{\beta} - 1\right)\frac{e_t}{q_t}\Bigg] Z_t \end{aligned}$$

where i denotes individual workers,

$$C_t \equiv \int_0^1 C_t(i)\, di = u_t C_t^u + (1 - u_t)\, C_t^e,$$

and

$$N_t \equiv \int_0^1 N_t(i)\, di = 1 - u_t.$$

Each household maximizes the lifetime utility

$$V(B_{t-1}) = U_t + \beta V(B_t)$$

by choosing C_t and B_t subject to its budget constraint

$$P_t C_t + Q_t B_t = B_{t-1} + W_t^{HH} + D_t$$

where P_t is price level, C_t final consumption good consists of goods produced by all the firms—$C_t = \left(\int_0^1 C_t(j)^{1-\frac{1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}$, Q_t the nominal price of the zero-coupon bond, B_t the amount of bond owned at the end of period t, W_t^{HH} the total income of the household, and D_t the lump-sum transfer from the government, excluding unemployment benefit ($\bar{W}_t$).

N_t is viewed as exogenous by the household and is determined through labor market equilibration.

Household's consumption Euler equation is

$$c_t = E_t\left[c_{t+1} - (i_t - \pi_{t+1} - \rho)\right] + (1 - \rho_z)\, z_t \tag{11}$$

where the nominal interest rate $i_t \equiv \ln(1/Q_t)$, the inflation rate $\pi_{t+1} \equiv \ln(P_{t+1}/P_t)$, and time discount rate $\rho \equiv \ln(\beta)$.

Denoting output by y_t and plugging goods market equilibrium condition into equation (11) leads to the dynamic IS curve

$$y_t = E_t\left[y_{t+1} - (i_t - \pi_{t+1} - \rho)\right] + (1 - \rho_z)\, z_t. \tag{12}$$

Subtracting the flexible price version of equation (12) gives

$$\tilde{y}_t = E_t(\tilde{y}_{t+1}) - \frac{1}{\sigma}\left[i_t - E_t\left(\pi_{t+1}^p\right) - r_t^F\right] \tag{13}$$

where the tilde represents deviation of a variable from its flexible price counterpart.

Household's demand for good varieties produced by individual firms can be derived by the sub-problem of the household:

$$\max_{\{C_t(j)\}} \left(\int_0^1 C_t(j)^{1-\frac{1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}$$
$$s.t. \int_0^1 P_t(j)\, C_t(j)\, dj = X_t$$

where X_t denotes total consumption expenditure, and j indexes firm. Solving this sub-problem gives firms' demand

$$C_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon} C_t, \tag{14}$$

where $P_t \equiv \left(\int_0^1 P_t(j)^{1-\epsilon} dj\right)^{\frac{1}{1-\epsilon}}$.

2.2 Firms

There is a continuum of firms of length 1. Each firm (j) produces a differentiated good using an identical technology $Y_t(j) = A_t N_t(j)^{1-\alpha}$ where A_t is an exogenous technology parameter common to all the firms and $a_t \equiv \log A_t = \rho_a a_{t-1} + \varepsilon_t^a$, with $\rho_a \in [0, 1]$.

Firms take as given households' demand schedule (equation 14), aggregate price level P_t, aggregate consumption index C_t, and wage W_t. Given the demand schedule, firms choose price $P_t(j)$ to maximize profit.

Firms set product price à la Calvo (1983), with the probability of resetting its price being $1-\theta$. This implies the following aggregate price dynamics:

$$\left(\Pi_t^p\right)^{1-\epsilon} = \theta + (1-\theta)\left(\frac{P_t^*}{P_{t-1}}\right)^{1-\epsilon} \tag{15}$$

where $\Pi_t^p \equiv P_t/P_{t-1}$ is the gross rate of inflation between $t-1$ and t, and P_t^* is the price set in period t by firms reoptimizing their prices in that period.

Log-linearizing equation (15) around zero inflation steady state gives

$$\pi_t^p = (1-\theta)(p_t^* - p_{t-1}) \tag{16}$$

where $p_t^* \equiv \ln P_t^*$ and $p_{t-1} \equiv \ln P_{t-1}$.

Log-linearize the first-order condition for firm j's profit maximization problem around the perfect foresight zero inflation steady state leads to

$$p_t^*(j) = \mu + (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\left(\psi_{t+k|t}(j)\right) \tag{17}$$

where $\psi_{t+k|t}(j) \equiv \ln \Psi_{t+k|t}(j)$ and $\mu \equiv \ln M$.

Expressing firm-specific (log) nominal marginal cost as a function of average (across-firm) (log) nominal marginal cost—

$$\psi_{t+k|t}(j) = \psi_{t+k} - \frac{\alpha\epsilon}{1-\alpha}\left(p_t^*(j) - p_{t+k}\right),$$

plugging it into firm's optimal pricing equation (equation 17), and rearranging terms yield

$$p_t^*(j) = \frac{1-\alpha}{1-\alpha+\alpha\epsilon}(1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\left(\psi_{t+k} + \frac{\alpha\epsilon}{1-\alpha}p_{t+k} + \mu\right)$$

whose recursive form is

$$p_t^*(j) = \beta\theta E_t\left(p_{t+1}^*(j)\right) + \frac{1-\alpha}{1-\alpha+\alpha\epsilon}(1-\beta\theta)\left(\psi_t + \frac{\alpha\epsilon}{1-\alpha}p_t + \mu\right).$$

By the symmetry of firms' problem, $p_t^* = p_t^*(j) \;\; \forall j$. Plugging this into the above equation gives

$$p_t^* = (\beta\theta)E_t\left(p_{t+1}^*\right) + \frac{1-\alpha}{1-\alpha+\alpha\epsilon}(1-\beta\theta)\left(\psi_t + \frac{\alpha\epsilon}{1-\alpha}p_t + \mu\right).$$

Replace p_t^* by $\frac{1}{1-\theta}\pi_t + p_{t-1}$ (see equation 16) and rearrange terms lead to

$$\pi_t^p = \beta E_t\left(\pi_{t+1}^p\right) - \frac{1-\alpha}{1-\alpha+\alpha\epsilon}\frac{(1-\beta\theta)(1-\theta)}{\theta}(\mu_t - \mu) \tag{18}$$

where the log markup $\mu_t \equiv p_t - \psi_t$.

Plugging $\mu_t - \mu = -\frac{\alpha}{1-\alpha}\tilde{y}_t - \tilde{\omega}_t$, where $\omega_t \equiv w_t - p_t$ is real wage, into equation (18) gives the price Phillips curve

$$\pi_t^p = \beta E_t\left(\pi_{t+1}^p\right) + \frac{1-\alpha}{1-\alpha+\alpha\epsilon}\frac{(1-\beta\theta)(1-\theta)}{\theta}\left(\frac{\alpha}{1-\alpha}\tilde{y}_t + \tilde{\omega}_t\right), \tag{19}$$

where the law of motion for real wage gap

$$\tilde{\omega}_t = \tilde{\omega}_{t-1} + \pi_t^w - \pi_t^p - \Delta\omega_t^F, \tag{20}$$

and the law of motion of natural real wage follows from profit maximization:

$$\Delta\omega_t^F = \Delta\phi_t + \alpha\left(u_t^F - u_{t-1}^F\right). \tag{21}$$

2.3 Labor Market Equilibration

Labor market reaches equilibrium when labor demand equals labor supply. Equating the labor demand from firms' problem with labor supply from households' problem to get

$$-\frac{\alpha}{1-\alpha}\tilde{y}_t - \tilde{\omega}_t - \mu + \ln(1-\alpha) + \phi_t + \alpha u_t = \kappa + m_t + \left(q + a_t + b_t + \frac{1}{\beta}e^{z_{t-1}-z_t} - 1\right)\frac{e}{q}. \tag{22}$$

The relationship between a_t and u_{t+1} (conditional on u_t) is nonlinear:

$$a_t = \frac{1}{1 + e^{\frac{\tau}{u_t}\left(u_{t+1} - b(1-u_t) - \frac{u_t}{2}\right)}}.$$

Time differencing equation (10) and substituting in the nonlinear relationship of a_t and u_{t+1} lead to the wage Phillips curve

$$\begin{aligned}\pi_t^w = &\pi_t^{\bar{w}} + \left(\frac{1}{1 + e^{\frac{\tau}{u_t}\left(u_{t+1} - b(1-u_t) - \frac{u_t}{2}\right)}} - \frac{1}{1 + e^{\frac{\tau}{u_{t-1}}\left(u_t - b(1-u_{t-1}) - \frac{u_{t-1}}{2}\right)}}\right. \\ &\left. + \frac{1}{\beta}\left(e^{z_{t-1}-z_t} - e^{z_{t-2}-z_{t-1}}\right)\right)\frac{e}{q}.\end{aligned} \tag{23}$$

The log real unemployment benefit

$$\bar{w}_t - p_t = \kappa + m_t \tag{24}$$

is set by the government that targets a constant level of real unemployment benefit (κ) subject to an unemployment benefit shock $m_t = \rho_m m_{t-1} + \epsilon_{m,t}$. This implies that

$$\pi_t^{\bar{w}} - \pi_t^p = \Delta m_t. \tag{25}$$

2.4 Monetary Authority

The monetary authority targets nominal interest rate according to

$$i_t = \rho + \psi_\pi \pi_t^p + \psi_y \tilde{y}_t + v_t \tag{26}$$

where the monetary policy shock evolves according to $v_t = \rho_v v_{t-1} + \epsilon_{v,t}$.

3 Numerical Strategy and Results

3.1 Calibration

The effort cost is calibrated so that $b = u$ in steady state. The government's target of log real unemployment benefit is calibrated to be consistent with $u^F = 0.03$ in steady state. Table 1 reports the calibrated values of other parameters.

Table 1: Calibrated Parameter Values

Parameter	Notation	Value
Effort cost	e	0.228
Probability getting caught shirking	q	0.167
Time discount rate	ρ	0.01
Non-labor share	α	0.25
Elasticity of substitution between good varieties	ϵ	9
Probability firms not resetting price	θ	0.75
Government's target of log real unemployment benefit	κ	-2
Feedback coefficient to inflation in monetary policy rule	ψ_π	1.5
Feedback coefficient to output gap in monetary policy rule	ψ_y	0.125
Autocorrelation of preference shifter under shock	ρ_z	0.5
Autocorrelation of TFP under shock	ρ_ϕ	0.9
Autocorrelation of monetary policy shock	ρ_v	0.5
Autocorrelation of real unemployment benefit shock	ρ_m	0.5
Standard deviation of preference shock	σ_z	0.5
Standard deviation of TFP shock	σ_ϕ	0.5
Standard deviation of monetary policy shock	σ_v	0.25
Standard deviation of real unemployment benefit shock	σ_m	1

3.2 The Measure of Cost of Business Cycles

Conventional measures of cost of business cycles requires the analytical form of the policy functions, which are infeasible for this model due to a lack of analytical solutions. I therefore calculates the consumption-equivalent welfare cost of business cycles (λ) through simulated series of consumption and employment. In other words, λ solves

$$V\left(C_{\text{with BC}} \cdot (1+\lambda), N_t(\lambda)\right) = V\left(C_{\text{without BC}}, N_{\text{without BC}}\right).$$

3.3 Results

To simulate fluctuations, I shock the economy with both a positive shock and a negative shock with equal probability and magnitude (of a standard deviation). When the fluctuation is induced by the preference shifter, $\lambda \approx 0.0168$. When the fluctuation is induced by TFP, $\lambda \approx 0.0437$.

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