Effort and the Cycle: Cyclical Implications of Efficiency Wages*

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This revision: May 7, 1996

Abstract

A number of authors have proposed theories of efficiency wages to explain the behaviour of aggregate labor markets. According to these theories, firms do not adjust wages downwards despite available unemployed job seekers, because lower wages would induce hired workers to shirk more often, which in turn would be counterproductive for the firm. Efficiency wage theories thus aid in explaining, why "involuntary" unemployment can persist. According to one popular version by Shapiro and Stiglitz (1984), it is precisely the threat of unemployment which induces workers to provide effort.

The purpose of this paper is to examine the cyclical consequences of an efficiency wage theory, when effort is an adjustable variable. To that end, we examine such a theory in the context of a dynamic real business cycle framework. The paper shows, that increasing the variability of effort due to efficiency wage consideration helps in explaining the rather large cyclical employment movements as well as the rather low cyclical movements in real wages, supporting the point made by Solow (1979), but require unplausibly large movements in the technology parameter. Because of the latter aspect, we argue that adjustable effort due to efficiency wage considerations is unlikely to play an important role for understanding business cycles.

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*We are grateful to Willem Buiter, Michael Burda, Gerard Pfann, John Shea, Martin Lettau, Ed Prescott and V.V. Chari as well as seminar participants at several seminars for useful comments. The addresses of the authors are: Harald Uhlig; CentER for Economic Research; Tilburg University; Postbus 90153; 5000 LE Tilburg; HOLLAND; e-mail: uhlig@kub.nl and; Yexiao Xu; Princeton University; Department of Economics; Princeton, NJ 08544; U.S.A.

1 Introduction

One of the success stories of macroeconomic research over the last decade has been the development of real business cycle models. These models analyze business cycle movements as the systematic reactions of an economy to stochastic shocks, influencing, in particular, production (see Kydland and Prescott (1982) for the origin and Cooley (1995) and the volume in which it is published, for the latest summary of this line of research). Crucial in all of these models is the description of the labor market: since cyclical movements in output are foremost movements in aggregate labor, any model that proposes to explain business cycles must explain the rather large cyclical movements in employment. In the benchmark real business cycle model of Hansen (1985), these movements are explained as the result of indivisibilities in the labor market: agents are either employed or unemployed. They participate in a lottery for jobs: the "unlucky" agents are told to work, whereas the "lucky" ones are unemployed and can thus enjoy their additional leisure time. The device of the lottery ensures the desired high intertemporal substitutability of leisure in the social planners problem. Exogeneous, stochastic fluctuations in the aggregate productivity (the Solow residual) are then enough to drive the cycle and to explain the procyclicality of the average productivity of labor. Using standard Solow residual accounting, the size of these exogeneous shocks can be calibrated to actual data. The model then implies cyclical properties for all variables in the model, which compare favourably to their observed properties.

For a variety of reasons, however, some researchers do not find this line of reasoning convincing. It has been argued that unemployment is "involuntary", i.e. that unemployed workers would prefer to accept work at current wages rather than remaining unemployed. Efficient risk sharing as assumed in the real business cycle does not preclude involuntary unemployment, see Rogerson and Wright (1988). But there are other approaches: in particular, theories of efficiency wages have been suggested to understand involuntary unemployment and to explain why wages would thus not adjust downwards to clear the labor market. One popular version due to Shapiro and Stiglitz (1984) views unemployment as a device which threatens hired workers into providing the effort their employer seeks. For the threat to be effective, it must be more attractive to be a worker rather than to be unemployed. Firms will not lower their wages because reducing the wedge to being unemployed reduces its threat and may provide the workers to shirk more. Shapiro and Stiglitz (1984) examined a model, where workers only face a binary choice between providing effort or not doing so, but it seems natural to examine extensions, in which workers can choose the degree of effort provided.

The goal of this paper is to analyze how much efficiency wage considerations with variations in effort can contribute in understanding business cycle fluctuations. We develop a new real business cycle style model with efficiency wage features, in which this question can be analyzed. Depending on the choice of a particular parameter, the model allows for a continuum of possibilities between constant effort and large effort fluctuations. The paper develops the key insight, that the efficiency wage story above implies a countercyclical movements in effort: if unemployment acts as a threat, that threat should be more pronounced if unemployment is high. As a result, effort movements due to efficiency wage effects will partially offset movements in the technology parameter, requiring larger movements in that parameter in order to explain observed Solow residual fluctuations. This argument is, at the same time the rationale for performing these calculations in a real business cycle framework: since the model is driven by technology shocks, it has at least in principle the chance of explaining the observed procyclicality of productivity. Compared to other explanations of business cycle fluctuations, the model is therefore in principle favorably disposed to allowing for additional, countercyclical effort movements due to efficiency wages: the final judgement then becomes a matter of quantities. The paper shows, that increasing the variability of effort due to efficiency wage consideration helps in explaining the rather large cyclical employment movements as well as the rather low cyclical movements in real wages, supporting the argument of Solow (1979), but requires unplausibly large movements in the technology parameter.

Real business cycle models with efficiency wages have been studied before, notably by Danthine and Donaldson (1990, 1995), who have demonstrated that efficiency wage consideration can improve our understanding of business cycles. While we follow their modelling choices in several respect, we cannot do so completely as effort turns out to be constant in the equilibria of their models. Since effort movements are at the heart of the problem studied here, a new model needed to be developed, which we do. One way of thinking about the paper at hand is that there are indeed good reasons why Danthine and Donaldson (1990, 1995) did not consider model versions, in which effort varies systematically over the cycle. On the more technical side and compared to Danthine and Donaldson (1990, 1995), this paper presents the innovation to turn workers born in period t eventually into infinitely lived capital owners (" rentiers"), i.e. we use a Blanchard-Weil-type model structure, see Weil (1987). This has the advantage to tie in the labor supply and effort supply choices with the intertemporal savings problem and it makes it easier to explain the cyclical variability of investment at its data-given steady state share of output.

Section 2 develops the heuristics of the arguments above a bit further. Section 3 describes the model, while section 4 presents the results. Section 5 investigates the theoretical possibility of procyclical effort movements due to efficiency wages. Section 6 concludes.

2 A heuristic comparison

Before diving into the construction of the fully specified model, it is a good idea to examine the heart of our argument on a heuristic basis. Start from the Cobb-Douglas aggregate production function

$$Y_t = \bar{K}^{1-\alpha}(fA_tN_tQ_t)^{\alpha}, \tag{1}$$

where Y_t is (detrended) output, $\bar{K}$ is the capital stock, held constant for the sake of this argument, f is a constant scale factor, A_t is the (detrended) technological productivity parameter, N_t is total labor, Q_t is effort (or "quality") or work[2], and α is the labor share. We suppose that changes in A_t are stochastically driving the model, i.e. A_t fluctuates stochastically around some long-run mean and all other variables are functions of A_t. This point of view allows one to easily explain the procyclicality of the productivity of labor. In particular, high values of A_t signify "good times", resulting in high employment N_t.

We now compare three views with respect to effort movements Q_t. In the first benchmark view, Q_t is fixed for anybody who works. This point of view is taken in most of the real business cycle literature as e.g in Hansen (1985), but also in a sizeable part of the efficiency wage literature, where effort is (eventually) either provided or not provided, but not adjusted on a continuous scale, see e.g. Shapiro and Stiglitz (1984) or Danthine and Donaldson (1990, 1995). The second view, which is the point of view examined in this paper, sees effort movements due to the cyclically varying threat of unemployment. According to that point of view, effort should be the higher in recessions, because the threat of unemployment is larger then. According to the third view, firm-worker relationships are characterized by labor hoarding. With labor hoarding, firms hesitate to fire workers even during recessions e.g. because it is costly to find new workers in the next upswing, see e.g. Burnside, Eichenbaum and Rebelo (1993). To sum up, while Q_t is simply constant in the benchmark real business cycle model or in constant-effort efficiency wage models, it is an increasing function of A_t in the labor hoarding model, but a decreasing function in a variable-effort efficiency wage model. To remember this graphically, we have sketched the relationship in figure 1a.

Applying standard Solow residual accounting to equation (1) leads to

$$s_t = \alpha\,(a_t + q_t) \tag{2}$$

where s_t denotes the Solow parameter, a_t the log-deviation of A_t, and q_t the log-deviation of Q_t,

$$\begin{aligned} a_t &= \log(A_t) - \mathcal{E}[\log(A_t)] \\ q_t &= \log(Q_t) - \mathcal{E}[\log(Q_t)] \end{aligned}$$

[2]Using the symbol "E_t" instead to denote effort would be confusing.

(where $\mathcal{E}[\cdot]$ denotes unconditional expectations). While movements in s_t are synonymous with movements in the exogeneous technology parameter a_t, the measured Solow parameter movements overstate these exogeneous technological changes in the labor hoarding view, but understate them in the efficiency wage view. Thus, to explain the same measured fluctuations in the Solow residual, the labor hoarding model should be expected to need smaller and the efficiency wage model to need larger fluctuations in the exogeneous technological change than the benchmark real business cycle model, see figure 1b. This should be a warning sign for the efficiency wage model: uncomfortably large fluctuations in the exogeneous shocks are needed to explain business cycle dynamics. The difficulty which the efficiency wage model with flexible effort runs into is the well-documented and often discussed phenomenon of procyclical labor productivity or short-run increasing returns to labor (SRIRL), see e.g. Fay and Medoff (1985) or Bernanke and Parkinson (1991). Explaining this phenomenon has always been tricky: using countercyclical effort movements certainly doesn't help.

On the other hand, the efficiency wage model should easily be able to explain the rather large cyclical movements in employment. In a recession, i.e. for a low value of A_t, firms will cut back on their employment N_t. This increase in unemployment threatens workers with jobs into working harder, making them more efficient. As a result, firms need even fewer workers to produce some desired amount, resulting in even greater unemployment. The reaction of effort amplifies the unemployment dynamics. This together with the low cyclical variability of wages is the key point in Solow (1979). Efficiency wage models, in which effort can vary, can thus help in explaining the often documented observation by Dunlop (1938) and Tarshis (1939), that real wages move fairly little over the cycle and are fairly acyclical, see the discussion Christiano and Eichenbaum (1992), while employment moves quite a bit.

The opposite is true for the labor hoarding model. At the very heart of that model, firms aim at keeping workers on the payroll during recessions rather than firing them. As a result, the model must end up predicting low cyclical variation in unemployment These low cyclical variations are at odds with the observed facts. Figure 1c shows this dilemma graphically.

Thus, while the efficiency wage model is likely to resort to unreasonably large stochastic fluctuations in the exogeneous shocks driving the model, the labor hoarding model is likely to underpredict the rather large cyclical variations in unemployment, which is after all one of the key facts of business cycles. For these reasons, effort seems best to be ignored for understanding business cycle movements as is done in the benchmark Hansen (1985) model or in extensions such as Danthine and Donaldson (1990, 1995).

Such a heuristic argument can be only partially convincing, of course. Important general equilibrium effects can be easily overlooked in intuitive arguments such as these, and can be uncovered by fully specifying a complete model and solving for its implications. To do this for the variable-effort efficiency wage model is the purpose of the rest of this paper. The model can also lead one to investigate other possibly plausible aspects, see section 5.

3 The Model

Briefly, time is discrete, $t = 0, 1, \ldots$. There is a good each period which can be used for consumption or investment into capital. Furthermore, there is labor. There are capital owners, workers, competitive firms and a government. Each period, a new equally-sized generation of workers is born, seeking a job on the labor market in their first period of life. They work for a wage, if employed, but receive unemployment compensation, if unemployed. After their first period, they turn into capital owners ("rentiers") living forever after. The details are described now. We start with the problem of the capital owners, since it will be used later to derive the behaviour of workers on the labor market.

3.1 The rentiers problem

Each period t, a new generation of rentiers is added to the pool of existing capital owners.. A rentier "born" at date s with initial income I_s in terms of the date-t-good solves the problem

$$V_s(I_s) = \max_{\left(C_t^{(s)}, K_{t+1}^{(s)}\right)_{t \geq s}} (1-\beta) E_s \left[\sum_{t=s}^{\infty} \beta^t \log(C_t^{(s)}) \right] s.t.$$

$$\begin{aligned} C_s^{(s)} + K_{s+1}^{(t)} &= I_s \\ C_t^{(s)} + K_t^{(s)} &= R_t K_t^{(s)} \end{aligned}$$

where R_t is the return in period t per unit of capital $K_t^{(s)}, t > s$ held by rentiers born at date s, where $C_t^{(s)}$ is his consumption, and where β is the discount factor.

It is not hard to show that $C_t^{(s)} = (1-\beta) R_t K_t$ and $C_s^{(s)} = (1-\beta) I_s$ for the generation born at date s and that

$$V_s(I_s) = \log(I_s) + \bar{V} + \mathcal{E}_s \left[\sum_{j=1}^{\infty} \beta^s \log(R_{t+j}). \right] \tag{3}$$

These results will be useful below.

3.2 Production

Total capital K_t available for production at date t,

$$K_t = \sum_{s<t} K_t^{(s)}$$

is combined with labor N_t to produce output Y_t according to a Cobb-Douglas production technology

$$Y_t = K_t^{1-\alpha}(A_t N_t Q_t)^{\alpha}, \tag{4}$$

where α is the labor share, A_t is the (detrended) technological productivity parameter, evolving according to

$$\log A_t = (1-\rho)\log \bar{A} + \rho \log A_{t-1} + \epsilon_t,\ \epsilon_t \sim \mathcal{N}\left(0, \sigma_\epsilon^2\right)$$

and Q_t is effort (or "quality") or work, which evolves according to an incentive compatibility constraint, which we will state below, see equation (5).

Total production is used for total consumption

$$C_t = \sum_{s\leq t} C_t^{(s)}$$

and investment, so that

$$C_t + K_{t+1} = Y_t + (1-\delta)K_t$$

where δ is the depreciation rate of capital.

3.3 Markets

Capital and labor are rented by firms on capital and labor markets for one period for a dividend D_t and wages W_t according to their marginal product,

$$D_t = (1-\alpha)\frac{Y_t}{K_t}$$

and

$$W_t = \alpha \frac{Y_t}{N_t}$$

Since capital depreciates at the rate $\delta > 0$, the return on holding capital is given by

$$R_t = D_t + 1 - \delta$$

Effort $Q_t = Q(W_t, U_t; Z_t)$ is a function of wages W_t, the unemployment rate $U_t = 1 - N_t$ and the (before-tax) unemployment compensation Z_t, implicitely defined by the relationship

$$\kappa G(Q_t) = \frac{U_t}{1-U_t}\log\left(\frac{W_t}{Z_t}\right) \tag{5}$$

where κ is a constant and the increasing function $G(Q)$ is the disutility for providing effort Q. In section 3.4 we will provide a detailed justification for (5), but for now it may suffice for now to accept (5) simply as an assumption about the behaviour of workers. Intuitively, the worker compares the disutility of providing effort $G(Q_t)$ with the indirect utility $\log(W_t/Z_t)$ of receiving a higher compensation (W_t rather than Z_t) if employed rather than unemployed. That utility is weighted with the factor $\frac{U_t}{1-U_t}$: with a larger unemployment rate, the replacement ratio wedge W_t/Z_t becomes more important, because unemployment becomes more threatening.

Equation (5) allows us to investigate some comparative statics. Since the disutility for providing effort is increasing, effort $Q_t = Q(W_t, U_t; Z_t)$ itself will be increasing in the unemployment rate U_t and the replacement ratio W_t/Z_t. For the numerical calculations, we assume a particular functional form for the disutility of providing effort:

$$G(Q) = \begin{cases} 0 & \text{if } Q = 0 \\ \theta(1 - \nu + \nu Q^{\phi}) & \text{if } Q > 0 \end{cases} \tag{6}$$

The parameter ν can be chosen freely in the model and allows to vary the effort response between very small (at ν close to zero) and very large (at $\nu = 1$). A graph of the disutility function for several parameters is given in figure 2: in that graph, we have arbitrarily set $\theta = 1$, but imposed a the relationship $\log \bar{W}/Z \phi\nu = 1$, which can be shown to hold in the steady state of this model. Also note that we normalize the steady state effort to be equal to $\bar{Q} = 1$.

Firms take the dependence of effort on wages into account, when hiring workers. Thus, there will be the usual Solow condition, stating that the elasticity of effort with respect to wages needs to unity,

$$\frac{\partial Q}{\partial W} / \frac{Q_t}{W_t} = 1 \tag{7}$$

As Solow (1979) pointed out, this condition enables one derive the prediction, that wages adjust less than in models without effort movements.

We will justify this condition in section 3.4 below and demonstrate, that one can also alternatively use the equation

$$1 = \kappa \frac{1 - U_t}{U_t} \theta \phi \nu Q_t^{\phi} \tag{8}$$

with some constant $\kappa > 0$ for the numerical calculations. More importantly, this equation shows the relationship between effort and unemployment claimed in the heuristic section of this paper quite clearly: when unemployment goes up, effort must go up as well to keep this equation satisfied.

The unemployment compensation Z_t is assumed to be paid by the government, which in turn finances it via a proportional tax τ_t on wage payments as well as unemployment compensation payments. The government is assumed to run a balanced budget each period. Thus, the budget constraint of the government is

$$Z_t U_t = \tau_t \left(Z_t U_t + W_t N_t \right)$$

We will concentrate on situations, in which the before-tax unemployment compensation is held constant, $Z_t \equiv Z$.

Workers born in period t become rentiers after one period of working, using their wage income $I_t = (1 - \tau_t) W_t$ or their unemployment compensation $I_t = (1 - \tau_t) Z_t$ to "get started". Thus, their expected utility will be

$$U_t = N_t \left(V_t \left((1 - \tau_t) W_t \right) - G(Q_t) \right) + U_t V_t \left((1 - \tau_t) Z_t \right),$$

where we have used N_t and U_t as probabilities for being employed resp. unemployed. This expected utility can be used to evaluate welfare consequences of, say, tax policies.

With these elements, it is now possible to solve for the model. We loglinearized all equations around the steady state, see e.g. Uhlig, 1995. Because the consumption-savings-problem can be solved in closed form, calculating the solution to the loglinearized set of equations is straightforward. Details are available from the authors.

3.4 A detailed view of the labor market

Above, we have assumed, that (5) describes the attitude of workers towards providing effort without providing more than a bit of heuristic support. The purpose of this section is to give a detailed justification by providing a detailed view of the labor market. To provide this description, we shall drop the time subscript for this subsection only. There is some large number of workers and an even larger number of firms. The labor market unfolds according to the following mechanism, described by a sequence of steps:

1. **Shirking choice:** Each worker i commits to a positive **effort-for-wage function** $Q_i(W)$, which, wherever $Q_i(W) > 0$, is twice differentiable with $Q_i''(W) < 0$. That choice is not observable to others. The worker announces an effort-for-wage function $Q_i^{(a)}(W)$, which may differ from $Q_i(W)$: below we will envoke the revelation principle to make sure that it does not. The announcement is publicly observable to everybody.

2. **First round of entry:**

   (a) Each firm decides whether to enter or not.

   (b) Upon entering, each firm chooses one worker. If several firms choose the same worker, a lottery is held to determine the "lucky" firms, whereas the other firms choose a new worker etc. until either all workers are matched with some firm or all entering firms are matched with one worker so that no firm and no worker is a member of two matches.

(c) **Monitoring:** With some exogenously given probability p_m, the firm gets to observe the effort-for-wage function $Q_i(W)$ actually chosen by the matched worker i.

(d) Firms having entered can choose to exit again, i.e. to fire the worker.

3. **Second round of entry:**

(a) Each unmatched firm, i.e. each firm not having entered in the first round or having chosen to exit again, decides whether to enter or not.

(b) Upon entering, each firm chooses one remaining worker, i.e. a worker who was not chosen or was fired in the first round. It cannot be observed whether the worker was previously fired or not. A lottery similar to the one described above is held to achieve unique matches.

4. **The workday:**

(a) For each final firm-worker pair, the firm chooses a wage W_i and rents some capital K_i at the market rate d. It pays the worker the wage and the worker supplies effort according to $Q_i(W_i)$. The firm produces and sells final output $Y_i = f(K_i, Q_i(W_i))$. Workers keep $(1-\tau)W_i$, where τ is a proportional labor income tax.

(b) Workers without a contract receive unemployment compensation Z and keep $(1-\tau)Z$

This structure seems complicated but it is not. The essence here is that effort Q is unobservable and can equal zero, if the worker chooses to shirk. What prevents him from shirking is the fear of loosing his job in the "first round" and then having a hard time getting rehired in the "second round". The larger the unemployment, the more unlikely it is to be rehired, and thus the greater the incentive effect. Spelling out the exact mechanism is necessary to allow for a precise contract-theoretic analysis.

Firms are assumed to maximize profits and workers are assumed to maximize expected utility $E[V(I) - G(Q)]$, where $V(\cdot)$ is the indirect utility function for after-tax income and where $G(Q)$ is the disutility of providing effort Q, $G(0) = 0$. Invoking the revelation principle, we can assume that $Q_i^a(W) = Q_i(W)$ for all wages W, provided that the worker has no incentive not to tell the truth. The appropriate incentive compatibility constraint has to hold, which we will develop below.

The production function was assumed to be Cobb-Douglas. Given $Q_i(W)$, a firm matched with this worker will need to solve

$$\max_{K_i, W} K_i^{1-\alpha}(AQ_i(W))^{\alpha} - DK_i - W.$$

Thus, firms will seek workers who promise the highest effort at any given wage, as long as the incentive compatibility constraint for truth telling is satisfied. This "Betrand competition" feature between workers leads all workers to choose the same $Q(W)$ which just satisfies the incentive compatibility constraint to be stated below. All firms thus end up solving the same problem at the last stage of the mechanism. Importantly, the wage paid by the firm or other features of the solution to the firms' problem do not depend on whether the worker was hired in the first or the second round or whether he was monitored and found to tell the truth. I.e., while the worker must commit to a particular effort-for-wage function by assumption, the firm cannot commit to other payment patterns beforehand: the contract is renegotiation-proof from the perspective of conceivable renegotiation possibilities for the firm. Should the firm monitor the worker and find him not to tell the truth and to actually provide less effort than announced, the firm will fire the worker since it will make a negative profit otherwise.

Due to the zero profit condition, firms are indifferent between entering and not entering in any of the two rounds, and thus may enter only with some probability. Let p_1 be the chance for a worker to be matched to some firm in the first round and p_2 the chance for a remaining worker to be matched to some firm in the second round. One may alternatively think of every worker being matched to some firm in the first round, but $1 - p_1$ firms closing again due to turnover: the mathematics does not depend on that interpretation. The chance for a nonshirking worker to have a job at the end of the second round is therefore $p_1 + (1 - p_1)p_2$, whereas he will be unemployed with probability $p_{ns} = (1 - p_1)(1 - p_2)$. The expected (indirect) utility for a nonshirker is therefore

$$V_{ns} = (1 - p_{ns})\left(V((1-\tau)W) - G(Q)\right) + p_{ns}V((1-\tau)Z)$$

If the worker chooses not to tell the truth, he fares best by providing zero effort throughout, risking firing when monitored. Such a shirkerr thus risks being fired, when monitored. His probability of being unemployed is thus the probability of being unemployed just as a nonshirker, plus the probability of having received a job in the first round, but being fired due to monitoring and not being rehired in the second round. Formally,

$$\begin{aligned} p_s &= p_{ns} + p_1 p_m (1 - p_2) \\ &= p_{ns}\left(1 + \frac{p_1}{1-p_1} p_m\right). \end{aligned}$$

The expected (indirect) utility for a shirker is thus

$$V_s = (1 - p_s)\, V((1-\tau)W) + p_s V((1-\tau)Z)$$

To make truth-telling incentive compatible, it needs to be the case that

$$V_s \leq V_{ns}$$

By assumption about all the bargaining power resting with the firms, this equation will be satisfied with equality. Substituting in from above, one obtains

$$V((1-\tau)W) - V((1-\tau)Z) = \left(\frac{1-p_1}{p_1 p_m}\right) \frac{1-p_{ns}}{p_{ns}} G(Q) \tag{9}$$

or

$$V((1-\tau)W) - V((1-\tau)Z) \geq \kappa \frac{1-U}{U} G(Q), \tag{10}$$

where

$$\kappa = \frac{1-p_1}{p_1 p_m}$$

and where the unemployment rate equals the probability of a nonshirker to be unemployed, $U = p_{ns}$, since everybody will tell the truth in equilibrium. Note that κ does not depend on p_2. Assuming only p_2 to fluctuate with total employment, i.e. assuming κ to be independent of time and exploiting the indirect utility function $V(\cdot)$ as given by equation (3), equation (10) turns into equation (5).

As for the firm, solving its problems leads to the following first order conditions from differentiation with respect to K_t and W_t:

$$D = (1-\alpha)\frac{Y}{K}$$

$$1 = \alpha \frac{Y}{Q(W)} Q'(W)$$

where $Y = K_i^{1-\alpha}(AQ_i(W))^\alpha$. Due to the zero profit condition, we must have $W = Y - DK = \alpha Y$ with the first first order condition. Using this in the second first order condition, we obtain the usual Solow condition

$$1 = \frac{Q'(W)}{Q(W)/W}$$

as claimed in equation (7).

To analyze the properties of the model, it shall be pointed out, that it is useful to differentiate (9) with respect to W, noting that $Q = Q(W)$. For $V(\cdot) = \log(\cdot)$ and (6), one obtains with (2)

$$1 = \left(\frac{1-p_1}{p_1 p_m}\right) \frac{p_1 + (1-p_1)p_2}{(1-p_1)(1-p_2)} \theta\phi\nu Q_t^\phi \tag{11}$$

With our assumption about κ above, this equation becomes

$$1 = \kappa \frac{1-U}{U} \theta\phi\nu Q^\phi$$

as claimed in equation (8). This equation can be used in place of (2), when numerically analyzing the behaviour of this model by, say, loglinearizing the system.

4 Results

To calibrate the model, a few additional parameters had to be chosen which do not typically appear in real business cycle models. The calibration is done by fixing the steady state values of some endogenous variables and then backing out the parameters implied this way. We normalized $\bar{Q} = 1$ in all steady states. We have normalized the steady state replacement ratio to equal $\bar{W}/\bar{Z} = 2$, which is a value found elsewhere in the literature. The steady state unemployment rate was set at $\bar{U} = 0.05$: one should think of this rate as the "threatening" part of unemployment, i.e. of workers trying hard to find a job. The parameter ν has been set to various values between 0 to 1 so as to vary the effort response to a technology shock between weak to strong. The other calibrating values are fairly standard: $\bar{R} = 1.01$, $\alpha = .64$, $\delta = .025$ and normalizing $\bar{Y} = exp(8.57)$. Backing out the fundamental parameters requires some algebra: details can be obtained from the authors.

	US Data	Hansens benchmark	With efficiency wages				
ν			0.0	0.5	0.9	0.95	1.0
σ_y	1.72	1.62	1.25	1.30	1.63	1.92	3.26
σ_c	0.86	0.86	0.39	0.40	0.49	0.58	0.98
σ_x	5.34	4.29	4.48	4.66	5.86	6.90	11.75
σ_h	1.69	1.30	0.08	0.16	0.68	1.13	3.26
σ_w	0.76	1.23	1.16	1.14	0.95	0.79	0.01
σ_q			0.00	1.13	8.53	14.92	44.24
σ_{SR}	1.18	1.18	1.18	1.18	1.18	1.18	1.18
σ_ϵ		1.4	1.4	2.3	8.0	12.9	36.1

Table 1: *This table compares the results of the model considered here with US data as well as Hansen benchmark RBC model. The standard deviation σ_ϵ of the innovation to the technology paramater has been chosen so as to keep σ_{SR} constant at the US level for the calculations for the model considered in this paper.*

The results can best be seen from the table 1, comparing the behaviour of the model to some key characteristics of business cycle features in the US as well as to Hansens (1985) benchmark model. The numbers about the US Data are taken from Cooley and Prescott (1995). All data is Hodrick-Prescott-filtered. The cyclical average deviation from trend in percent is given by σ_y for output, by σ_c for consumption, by σ_x for investment, by σ_h for hours worked, by σ_w for (real) wages, while σ_ϵ is the standard deviation of the technology innovation. A period denotes quarters of a year. As is standard practice in this literature, the standard deviation of the shock ϵ_t to the log-technology process $\log(A_t)$ has always been chosen so as to deliver the observed

Solow residual fluctuations. A plot of the impulse response functions is given in figure 3.

As one can see, the efficiency wage features help in explaining the rather large cyclical variation in employment (σ_h) as well as the puzzlingly low cyclical variation in wages (σ_w), if one uses $\nu \approx .95$, say. However, this comes at a price: the standard deviation of the technology innovation required to explain the observed output fluctations is easily seven times as large as the value used by Hansen (1985), and thus unreasonably large. The explanation is simple: in this model, effort movements are countercyclical. Large effort reactions therefore largely offset the technology innovation, so that the movement in the observed procyclical Solow parameter is just a fraction of the underlying technology parameter. If one was willing to accept such large technology shocks, the parameterization with $\nu = 0.95$, in which the observed Solow residual fluctuations are matched, actually come remarkably close to observed numbers. However, most researchers will probably have difficulties accepting technoloogy fluctuations amounting to more than 12 percent per quarter: this just does not seem like a fruitful explanation.

5 Procyclical Effort?

In our heuristic arguments, we have stressed that the effort movements predicted by efficiency wage theories are countercyclical: in fact, most of the argument above rests on this claim. We have backed up this theoretical insight with equation (8), which shows that effort needs to go up when unemployment does. However, the theory does not preclude other cases, and it is interesting to examine them. To that we need to recall how equation (8) was actually derived from equation (11). In that equation, p_1 was the chance of keeping a job on a primary labor market p_m was the chance of being monitored and possibly fired, when found to be shirking, and p_2 was the chance of receiving a job on the secondary labor market, given not having a job from the first labor market. What we have assumed to arrive at equation (8) was, that only the probability of finding a job p_2 on some secondary labor market fluctuates with total employment. In economic terms, a fired worker will have a lesser chance of finding another job, when unemployment is high: this is precisely what makes unemployment so threatening. Times of high unemployment are thus characterized by lower job turnover: it simply means less rehiring.

However, Burda and Wyplosz (1994) have recently documented, that the opposite appears to be true: times of high unemployment seem to be times of high job turnover as well. This can be captured here as well: rather than having p_2 respond to employment fluctuations, one might assume that p_1 fluctuates with employment instead, while p_2 and p_m remain constant. Higher unemployment means a lower value for p_1, which also means that, in absolute terms, more people will be hired on the secondary labor market. After some rewriting, equation (11) can be restated as

$$1 = \frac{1}{p_m} \frac{1 - U_t}{1 - p_2 - U_t} \theta \phi \nu Q_t^{\phi}$$

Now, effort responds *negatively* to higher unemployment! The intuition is simple. According to our “microfoundation” of the labor market, workers only fear to be monitored on the primary labor market. If the chance of keeping a job there is decreased as in times of high unemployment, less importance needs to be attached to that fear. In essence, the workers cannot induced to provide a lot of effort by threatening them to monitor and possibly fire them, if they face the prospect of loosing their job anyhow.

	US Data	Hansens benchmark	With efficiency wages				
ν			0.0	0.5	0.9	0.95	1.0
σ_y	1.72	1.62	1.13	1.06	0.33	1.62	3.28
σ_c	0.86	0.86	0.35	0.32	0.10	0.48	0.97
σ_x	5.34	4.29	4.06	3.82	1.19	5.86	11.80
σ_h	1.69	1.30	0.10	0.20	1.34	4.33	3.28
σ_w	0.76	1.23	1.22	1.27	1.67	2.70	0.00
σ_q			0.00	1.27	15.00	51.31	40.97
σ_{SR}	1.18	1.18	1.18	1.18	1.18	1.18	1.18
σ_ϵ		1.4	1.4	2.4	12.9	40.9	30.2

Table 2: *Procyclical effort movements, $p_2 = 0.9$. The standard deviation σ_ϵ of the innovation to the technology paramater has been chosen so as to keep σ_{SR} constant at the US level for the calculations for the model considered in this paper.*

The model allows us to examine the consequences of this choice too. We have presented two fairly typical tables in 2 and 3, even though the choices for p_2 may have been a bit extreme. Impulse response functions to a technology shock for these two parameters can be found in figure 4 and figure 5. One finds one of two situations:

p_2 **large** , see table 2. Employment now reacts negatively to a productivity shock and thus moves countercyclically. Essentially, times in which productivity is high already from the underlying technology, effort gets stimulated even further by decreasing employment. Certainly, countercyclical employment is highly counterfactual.

p_2 **small** , see table 3. Employment reacts positively to a productivity shock as it should, but the dynamics becomes explosive: in table 3, we have also listed the elasticity η_k of capital with respect to the existing capital stock and as one can see, that elasticity is greater than 1. The intuition here is, that a positive reaction of employment to a productivity shock induces a positive upward movement of effort, which in turn acts like an additional productivity shock, leading to further expansion of employment etc.. Due to the unstable dynamics, our numerical approach of loglinearizing around the steady state is no longer valid: the numbers of table 3 should thus just be seen as indicative of what can happen. In fact, this model may give rise to endogeneous cycles: a further investigation may be merited.

One can show, that the dividing line for these two cases is given by

$$\frac{\alpha + \frac{1}{\nu} - 1}{\phi} \frac{p_2}{1 - p_2 - \bar{U}} \frac{\bar{U}}{1 - \bar{U}} - (1 - \alpha) \frac{\bar{U}}{1 - \bar{U}} = 0$$

We have just investigated the possibilities of keeping either p_1 or p_2 constant: a rich set of intermediate cases is certainly conceivable, and investigating them would require too much additional space. It does not seem that this "caveat" alters our conclusions from the previous section much, however.

6 Conclusion

The purpose of this paper was to examine the cyclical consequences of an efficiency wage theory, when effort is an adjustable variable. To that end, we examined such a theory in the context of a dynamic real business cycle framework. The paper shows, that increasing the variability of effort due to efficiency wage consideration helps in explaining the rather large cyclical employment movements as well as the rather low cyclical movements in real wages, but requires unplausibly large movements in the technology parameter. Because of the latter aspect, we argued that adjustable effort due to efficiency wage considerations is unlikely to play an important role for understanding business cycles.

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σ_c	0.86	0.86	1.24	1.13	1.07	1.06	1.05
σ_x	5.34	4.29	13.85	12.70	11.95	11.87	11.79
σ_h	1.69	1.30	80.2	70.3	64.1	63.4	62.7
σ_w	0.76	1.23	0.34	0.15	0.03	0.01	0.00
σ_q			0.00	0.15	0.25	0.26	0.27
σ_{SR}	1.18	1.18	1.18	1.18	1.18	1.18	1.18
σ_ϵ		1.4	1.4	1.3	1.24	1.23	1.22
η_k			1.017	1.016	1.016	1.015	1.015

Table 3: *Procyclical effort movements,* $p_2 = 0.1$. *The standard deviation* σ_ϵ *of the innovation to the technology paramater has been chosen so as to keep* σ_{SR} *constant at the US level for the calculations for the model considered in this paper. The numbers in this table should not be trusted, since the dynamics of this model is now inherently unstable, see the root* η_k. *These numbers should thus simply be understood to be indicative of the phenomena that will arise.*