INVESTIGATING RATIONALITY IN WAGE-SETTING

by

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Discussion Paper
No. DEDPS/10
February 1998

<u>NB:</u> This PDF was retrospectively created in August 2002 of the STICERD discussion paper previously known as DERP no.10 which was published in 1998.

Abstract

This paper investigates the efficiency wage hypothesis and derives a tractable expression for the profit loss incurred by deviations from the efficiency wage. The extent of the wage deviation can be inferred from production function parameters. The resulting profit loss is shown to depend upon the curvature of the effort function and the employment and wage elasticities of output. If the profit loss is small then near rationality may be claimed even if the hypothesis of rationality is statistically rejected. An application to Indian manufacturing is presented, which suggests that rationality cannot be rejected and that the profit function is remarkably flat around the optimum. This is consistent with positive effort returns to increasing the wage beyond its efficient level.

Keywords: Efficiency wages; near-rationality; panel data; India.

JEL Nos.: J41, C23, O15.

Investigating Rationality In Wage Setting

Sonia R. Bhalotra[1]

1. Introduction

This paper is concerned with testing rationality and the weaker condition of near-rationality in an environment in which worker effort is a function of the wage. Deviations of the wage from its efficient level are regarded as consistent with near-rationality if the profit losses incurred as a result are small. There is no rigorous definition of "small" just as there is no particular guide to choosing a statistical significance level. However, one may think of small profit losses as comparable to information or transactions costs that firms may have to incur to adjust to the efficient point. Alternatively, the firm may pay more than the efficiency wage in order to avoid the costs that a dissatisfied union may impose. Rent-sharing is encouraged in efficiency wage environments since increasing the wage beyond its optimal level yields positive, if diminishing, effort returns.

When effort depends on the wage, then firms can increase output in the short run either by increasing employment or by increasing the wage. The

[1] This paper has benefited greatly from the comments of David Demery, Nigel Duck, Ian Jewitt, John Muellbauer and, not least, Steve Nickell.

wage bill is symmetric in these alternatives. Therefore, at the optimal or efficiency wage, the wage elasticity of output equals the employment elasticity of output. If the data do not support this condition, we conclude that firms are not exercising rationality in wage setting[2]. It is then worth investigating whether the data satisfy the weaker condition of near rationality. On the other hand, if rationality cannot be statistically rejected, it is not strictly necessary to investigate near rationality. However, it may nevertheless be useful as a means of confirming the "statistical metric" with an "economic metric". The difference in the point estimates of the output elasticities of the wage and employment can be cast in terms of the implied deviation of the wage from its optimal level. Profit loss can then be calculated as a function of the wage deviation, the employment elasticity of output, and the curvature of the effort function. It is interesting to find out whether the profit loss is big or small, be it of second-order.

These questions are investigated using a panel of data for Indian manufacturing. The Indian labour market does not appear to be competitive (see Section 5), and investigation of the efficiency wage hypothesis seems the natural route to investigating profit maximising behaviour. The natural alternative hypothesis is that wages paid in the primary sector exceed the

[2] *Rationality* is used in this paper to refer to profit maximising behaviour given a technology in which effort is wage dependent.

optimal wage on account of the influence of unions and government. We obtain GMM estimates of a production function that includes wage-dependent effort. Careful attention is paid to potential biases arising from heterogeneity, endogeneity and measurement error, and the results are subjected to various robustness checks. The literature concerned with industrialised economies proposes that efficiency wages are paid to recruit, retain and motivate workers, and effort is usually taken to be a function of the relative wage. In a low-income country, an alternative reason for firms to offer wages in excess of market-clearing is that this might enable greater effort for physical reasons. In this case, effort is a function of the consumption wage. The model in this paper is specified so as to permit both the *recruit-retain-motivate* and the *enable* possibilities.

Section 2 describes existing research on the subject, delineating the contributions of this paper. Section 3 sets out the basic theory and the optimality condition, while Section 4 derives conditions that obtain in the neighbourhood of the optimum. Section 5 develops the Indian context. Section 6 develops an empirical specification and describes the data and issues arising in estimation. The estimates are discussed in Section 7. In Section 8, profit losses arising from deviations from the efficiency wage are calibrated for alternative values of the parameter describing the curvature of the effort-wage function. Section 9 concludes.

2. Existing Work And Contributions

Although the efficiency wage hypothesis has a long history (see Dunlop, 1988), empirical investigations of it are still rather scarce. A fairly recent crop of studies documents persistent inter-industry wage differentials that are only marginally narrowed once controls for worker and job traits are introduced (e.g., Dickens and Katz 1987, Krueger and Summers, 1987). While such evidence is consistent with the efficiency wage hypothesis it does not, on its own, persuade the sceptic that efficiency wages are paid since competition and rent-sharing cannot be ruled out as alternative explanations. Other studies have sought to establish a positive correlation of high wages with measures of performance such as quits, absenteeism, or job satisfaction (see Katz 1986, Katz and Summers 1989). While these have the advantage of possibly discriminating between alternative efficiency wage models, they depend upon the availability of data on quits, satisfaction, etc. This paper takes the more direct approach of testing the optimality condition that derives from profit-maximising behaviour when the production function includes wage-dependent effort. Wadhwani and Wall (1991) and Levine (1992) take a similar approach, using company data for the UK and the US respectively. There are differences in methodology between the three studies. This paper augments a small body of evidence based on direct testing, and an even smaller body of evidence providing results for a developing country.

The paper does not stop with a statistical test of rationality but investigates the latitude available to near-rational behaviour in terms of deviating from the efficiency wage. This is expected to deliver a better handle on the degree to which any data sample supports the optimality condition than can be had from statistical testing alone. The idea of near rationality is discussed by Akerlof and Yellen (1985a, 1985b). Akerlof (1979) investigates this, showing that considerable deviations from optimal money holdings are associated with trivial costs. In a similar spirit, Cochrane (1989) shows that deviations from the rule for intertemporal allocation of consumption implied by the permanent income hypothesis result in very small losses in utility. There does not appear to have been any attempt to investigate near rationality in an efficiency wage setting. This paper sets out a structure for doing this and provides some empirical results for a sample of Indian industries.

3. A Direct Test of The Efficiency Wage Hypothesis

3.1. The General Case

The basic tenet of an efficiency wage model is that firms may find it profitable to pay wages in excess of the supply price of labour if this brings sufficiently large gains in productivity. Such behaviour is consistent with a range of theoretical models, surveyed by Katz (1986) and Akerlof and Yellen (1986: 1-21). The *recruit* (e.g. Weiss, 1980) *retain* (e.g., Stiglitz, 1974) and *motivate* (Shapiro and Stiglitz, 1984) models suggest that effort depends upon the relative wage, W/W^a. However, if higher wages *enable* greater effort (e.g., Leibenstein, 1957) the relevant wage is the absolute consumption wage, W/P^c, where W^a is the alternative or comparison wage and P^c is an index of the cost of living. ω is a shorthand for these two possibilities. It is recognized that effort may also depend upon perquisites such as housing provisions, which are typically not incorporated in the wage[3]. Our purpose is to investigate whether the wage counts nonetheless.

Let the unobserved effort of workers, E, be an input in the production function, $Y=Y(E(W), N(W), K, H, A)$, where Y is value added ouput, N is

[3] The Tata Iron and Steel Company has often been cited as a model private employer. It created the city of Jamshedpur from a small village in Bihar in the early 20th century, providing housing, schools and other amenities to workers. Morris (1960) reports that, although virtually all of its workforce was migrant, absenteeism and quits were insignificant, indicating the commitment of the workforce.

employment, K is capital stock, H is hours of work per worker, and A is an index of productivity[4]. Maximising profits with respect to the wage and employment in this very simple and general framework yields the first order conditions $\partial Y/\partial N = W/P$ and $(\partial Y/\partial E)(\partial E/\partial W) = N/P$. Solving these yields the condition which defines the efficiency wage: $e_{EW} = e_{YN} / e_{YE}$. This says that the effort-wage elasticity equals the ratio of the output-employment elasticity to the output-effort elasticity. Neither e_{EW} nor e_{YE} is observable but rearranging gives $e_{YE}\, e_{EW} = e_{YN}$, or

$$e_{YW} = e_{YN} \qquad (1)$$

The elasticities in (1) are estimable. If the elasticity of output with respect to the wage equals its elasticity with respect to employment, then the firm is paying the efficiency wage. This wage pays for itself. The intuition is straightforward. Since the wage bill is symmetric in W and N, the equilibrium must have the property that the marginal increase in N is as productive as the marginal increase in W. If wage bargaining coexists with efficiency wage considerations, we may expect that the agreed wage exceeds the pure efficiency wage. In that case, $e_{YW} < e_{YN}$, or the wage does not quite pay for itself. Notice that the Solow condition, $e_{EW} = 1$, is a special case of $e_{EW} = e_{YN} /$

[4] Effort will remain an unobserved entity and it may be interpreted fairly broadly. The turnover model, for instance, does not tell a story about effort at all. It is about averting turnover costs. However, like the rest of the literature, we think of the saving in turnover costs as similar to an increase in unobservable effort.

e_{YE} that arises if and only if effort is specified as labour-augmenting (i.e., $e_{YN} = e_{YE}$).

3.2. A Theoretical Structure

It is useful to impose some structure on the effort and production functions for purposes of the analysis in Section 4. Let the production function incorporating effort be

$$Y = A\,K^{\beta}\,H^{\mu}\,N^{\alpha}[E(\omega)]^{\alpha}\,\nu \tag{2}$$

where ν is an i.i.d. productivity shock that is assumed to be uncorrelated with changes in A, N, K and H. Departing from the tendency to assume that hours is labour-augmenting (Abramovitz (1950), Solow (1957)), we do not restrict μ to equal α. In fact, since additional hours are expected to increase capital utilization while additional workers may be knocking elbows over the same capital stock, it is expected that $\mu>\alpha$ (consistent with Feldstein (1967) and Craine (1973)). On the other hand, effort is specified as a perfect substitute for employment. While this does not affect the optimality condition, it simplifies the ensuing profit loss calculations. Let

$$E = -\theta + \omega^{\delta}; \quad 0 < \delta < 1 \tag{3}$$

$E'(\omega)>0$ and $E''(\omega)<0$, or there are positive but decreasing returns to increasing the wage. Now to avoid clutter, A, K and H are suppressed because they do not depend upon the wage[5]. The function we work with is

$$Y = N^{\alpha} [-\theta + \omega^{\delta}]^{\alpha} \tag{4}$$

A negative intercept is specified in the effort function so as to rule out the possibility of non-negative effort at a zero wage. If $\theta \leq 0$, then the zero wage is the efficiency wage[6].

If $\pi = PY\text{-}WHN$, then hourly profit is $\pi/H = (P/H)Y\text{-}WN$. Henceforth, P will refer implicitly to (P/H) and π to π/H. This is unrestrictive since P and H are treated as constants. The first order conditions for profit maximisation are

$$\partial\pi/\partial N = 0 \Rightarrow \alpha Y/N - W/P = 0 \tag{5}$$

$$\partial\pi/\partial W = 0 \Rightarrow P\partial Y/\partial W - N = 0 \tag{6}$$

[5] While it is clear that A and K do not depend upon the wage, the suggested independence of H needs justification. Recall that hours here refers to actual as opposed to official hours. We suspect that variation in actual hours is substantially driven by forces such as the unavailability of crucial imported inputs or the rationing of power supplies by the government (Bhalotra (1995) presents some evidence to this effect). These tend to be outside the control of the individual firm or industry.

[6] It is straightforward to demonstrate this. Without any loss of generality, let $\omega=(W/P^c)$. Now if $\theta=0$, then $\pi = [PN^{\alpha}\omega^{\alpha\delta} - P^c\omega N] = [PN^{\alpha(1-\delta)}(\omega N)^{\alpha\delta} - P^c(\omega N)]$. From this, it is clear that π can be made arbitrarily large by making N large while keeping ωN (costs) constant. In other words, the optimum is at $N=\infty$, $W=0$. Now let $\theta>0$. Then $\pi = [PN^{\alpha}(\theta + \omega^{\delta})^{\alpha} - P^c\omega N] \geq [PN^{\alpha}\theta^{\alpha} - P^c\omega N]$ and, as before, it is clear that profits can be expanded infinitely by raising employment, keeping the wage close to zero. Also see Akerlof (1982).

Define

$$\gamma \equiv \partial \ln Y/\partial \ln W = W/Y\ (\partial Y/\partial W) \tag{7}$$

Together (5), (6) and (7) imply the optimality condition,

$$\gamma = \mathbf{WN/PY} = \alpha \tag{8}$$

which is nothing but (1). Thus rationality implies that the wage will be set at a level that equates the wage elasticity of output (γ) to the employment elasticity of output (α). Now writing out the expression for γ using (4) and (7),

$$\gamma = \alpha\delta\omega^{\delta}\ [-\theta + \omega^{\delta}]^{-1} \tag{9}$$

At the efficiency wage (ω^*) where $\gamma = \alpha$, (9) implies

$$(\omega^*)^{\delta} = \theta\ /\ (\mathbf{1}\text{-}\delta) \tag{10}$$

Clearly, the optimal wage depends only upon the parameters of the effort function[7].

[7] Note that this follows directly from the specification of effort as labour-augmenting in (2). Equations (5)-(9) are written down because they are needed in Section 4.

4. Near Rationality And Deviations From The Efficiency Wage

4.1. The Wage Deviation

The optimal wage is unknown because it depends upon the unknown parameters of the effort function, θ and δ (see (10)). However, we can use the fact that the wage elasticity of output (γ) depends on the wage (ω) to infer the deviation of the actual wage, ω, from the optimal wage, ω^*. If $\omega = \omega^* + \Delta\omega$, then $\omega^\delta = (\omega^* + \Delta\omega)^\delta = (\omega^*)^\delta [1 + (\Delta\omega/\omega^*)]^\delta$, or

$$\omega^\delta \approx (\omega^*)^\delta [1 + \delta\Delta\omega/\omega^*] \tag{11}$$

We know from Section 3 that, at ω^*, $\gamma=\alpha$. Let us find γ when the wage deviates by $\Delta\omega$ from its optimal level. Substituting (11) in (9) gives

$$\gamma \approx \alpha\delta (\omega^*)^\delta [1 + \delta\Delta\omega/\omega^*] / \{(\omega^*)^\delta [1 + \delta\Delta\omega/\omega^*] - \theta \} \tag{12}$$

Substituting for ω^* using (10) gives $\gamma \approx \alpha [1 + \delta\Delta\omega/\omega^*] / [1 + \Delta\omega/\omega^*]$, or

$$\Delta\omega/\omega^* \approx (\alpha - \gamma) / (\gamma - \alpha\delta) \tag{14}$$

Though δ is unknown, we can use the fact that δ lies between 0 and 1 to calibrate the wage deviation implied by our estimates of α and γ for alternative values of δ in this range.

4.2. The Profit Loss

Profit in a neighbourhood of the optimum is given by a second-order Taylor series expansion

$$\pi\,(\omega^* + \Delta\omega) \approx \pi(\omega^*) + \pi'(\omega^*)\Delta\omega + (1/2)\,\pi''(\omega^*)(\Delta\omega)^2 \qquad (15)$$

where $\pi'(\omega^*)= d\pi/d\omega$ and $\pi''(\omega^*)= d^2\pi/d\omega^2 < 0$, both evaluated at the efficiency wage, ω^*. Optimality implies that $\pi'(\omega^*)=0$, so the proportional profit loss in deviating from the optimal wage, $[\pi(\omega^*) - \pi\,(\omega^* + \Delta\omega)] / \pi(\omega^*)$ is

$$\Delta\pi \,/\, \pi(\omega^*) = \mathbf{-\ (1/2)}\ \pi''(\omega^*)(\Delta\omega)^2 / \pi(\omega^*) \qquad \mathbf{(16)}$$

Recall that ω is either of (W/P^c) or (W/W^a). It is assumed that value-added prices (P), the cost of living (P^c), and the alternative wage (W^a) are exogenous. Employment is taken to be set after the wage, by the marginal revenue product (MRP) condition. Until it becomes necessary to choose functional forms, the analysis proceeds with the most unrestrictive specifications. Hourly profit is given by $\pi(\omega) = PY[N(W), E(\omega)]-WN(W)$. The MRP condition $(\partial\pi/\partial N=0)$ implies

$$P(\partial Y/\partial N) = W \qquad (17)$$

Taking the total derivative of π with respect to the wage and using (17) to simplify gives

$$d\pi/dW = P\ \partial Y/\partial W - N \tag{18}$$

Taking the second derivative,

$$d^2\pi/dW^2 = P(\partial^2 Y/\partial W^2) - (dN/dW)\ [1 - P(\partial^2 Y/\partial N\partial W)] \tag{19}$$

Differentiating both sides of (17) gives d[P(∂Y/∂N)]/dW=1, or

$$P(\partial^2 Y/\partial N^2)\ (dN/dW) + P(\partial^2 Y/\partial N\partial W)] = 1 \tag{20}$$

Using this to substitute out the term in square brackets in (19) gives

$$\mathbf{d^2\pi/dW^2 = P\partial^2 Y/\partial W^2 - P(\partial^2 Y/\partial N^2)\ (dN/dW)^2} \tag{21}$$

Evaluated at the optimal wage and employment, (21) provides $\pi''(\omega^*)$ in (16).

So as to obtain an expression for profit loss in terms of estimable parameters, the terms in (21) are now computed for the specific production function, (4).

The second derivative of (4) with respect to N is

$$\mathbf{\partial^2 Y/\partial N^2 = \alpha(\alpha - 1)\ (Y/N^2)} \tag{22}$$

Taking the second derivative of (4) with respect to W gives

$$\partial^2 Y/\partial W^2 = (\alpha\delta\ N^{\alpha}/\ Z^2)\ (\omega^{\delta}-\theta)^{\alpha-2}\ \omega^{\delta-2}\ [\delta(\alpha-1)\ \omega^{\delta} + (\delta-1)\ (\omega^{\delta}-\theta)\ ] \tag{23}$$

where Z denotes P^c or W^a as the case may be. Since the second derivatives are evaluated at the optimum, we can use (10) in (23), substituting ω^* for ω. Writing N^* for $N(\omega^*)$ and simplifying, this gives

$$\partial^2 Y/\partial W^2 = [\alpha(\alpha+\delta-2)/(W^*)^2]\ [\theta\,\delta N^*/(1-\delta)]^\alpha \tag{24}$$

We now derive an expression for N^*, the optimal level of employment. Since Y $= N^\alpha[-\theta+\omega^\delta]^\alpha$, $Y^* = (N^*)^\alpha[-\theta+(\omega^*)^\delta]^\alpha$. Using (10) again to substitute for ω^*, this gives

$$Y^* = (\theta\delta N^*/1-\delta)^\alpha \tag{25}$$

Using (25) to substitute for N^* in (24), we have

$$\boldsymbol{\partial^2 Y/\partial W^2 = [\alpha(\alpha+\delta-2)\,Y^*/(W^*)^2]} \tag{26}$$

We now need an expression for the third term in (21), dN/dW. For a given wage, the optimal employment level is given by the MRP condition. For, $Y=N^\alpha E(W)^\alpha$, $\partial\pi/\partial N=0$ implies $\alpha N^{\alpha-1}E(W)^\alpha = W/P$. Taking the derivative of log N with respect to log W gives

$$(\alpha-1)\,d\ln N/d\ln W = 1-\alpha\,(d\ln E/d\ln W) \tag{27}$$

Since (2) implies that the effort-wage elasticity is unity (the Solow condition), (27) implies the intuitive result that *the wage elasticity of employment is minus one at the efficiency wage*[8]:

$$\mathbf{dlnN / dlnW = - 1 = W(dN/dW)/N} \qquad \mathbf{(28)}$$

Substituting (22), (26) and (28) in (21) gives

$$d^2\pi/dW^2 = \alpha\,(\delta - 1)\,PY^* / (W^*)^2 \qquad (29)$$

Substituting (29) into (16) gives the proportional profit loss incurred in deviating from the efficiency wage:

$$\boldsymbol{\Delta\pi / \pi(\omega^*) = - [\alpha\,(\delta - 1) / 2(1 - \alpha)]\,(\Delta W/W^*)^2} \qquad \mathbf{(30)}$$

where we have used the fact (see (8)) that $\pi(W^*) = PY^* - W^*N^* = PY^*(1-\alpha)$. With (14), the wage-deviation term in (30) can be eliminated if one wants an expression for profit loss in terms of α, γ and δ instead of in terms of α, δ and a wage deviation.

[8] Recall that a given percentage increase in employment has the same effect on costs (the wagebill) as the same percentage increase in the wage so that, at the efficiency wage, the output produced by marginal changes in employment and the wage is equal (Section 3).

5. The Indian Context

The efficiency wage hypothesis predicts involuntary unemployment, labour market segmentation, and inter-industry wage-differentials, all of which are strikingly evident in the Indian economy. In 1987/88, 6% of males and 8.5% of females in urban India were unemployed for the most part of the preceding year (Sarvekshana, 1990). In the absence of state-provided unemployment benefits, one might expect that reservation wages are low and unemployment amongst the poor is involuntary. The primary-secondary sector dualism highlighted by Doeringer and Piore (1971) is particularly striking in low-income countries. For instance, primary sector wages in India are, on average, more than twice secondary sector wages (Rs. 42 vs. Rs. 17 per day for urban males: Sarvekshana (1990)). Within the primary sector, apparently permanent inter-industry wage differentials suggest that, consistent with the efficiency wage model, technological factors play a role in wage determination. For instance, in registered manufacturing (or equivalently, *the factory sector*), nominal earnings in Transport Equipment were four and a half times those in Tobacco & Beverages during 1979-1987. This might reflect, amongst other things, a tendency for output in the former industry to be more sensitive to effort than in the latter industry. The industry wage differences display no tendency to convergence. The weighted standard deviation of the log of industry wages is 46%, a far greater spread than observed in other countries, for example, the US (24%), the UK (14%), Sweden (8%) and Mexico (15%) (see Krueger and Summers, 1987)). India is a big country, and the substantial variation in human capital across its states might be thought to explain this dispersion to a large extent. However, the within-state dispersion of industry wages is also very large, ranging from 30% in Rajasthan to 83% in Kerala. The year-by-year rank correlations of the industry wage structure are about 0.95 on average. Adjusting for location and for regional price variation does not make wage dispersion much smaller and the ranks hardly change at all (see Bhalotra, 1995). Productivity and other industry-specific variables are significant in factory wage determination (e.g., Bhalotra, 1995). Moreover, an analysis of regional unemployment rates in India indicates support for a queueing model (Bhalotra, 1996a), which suggests that the observed wage differentials denote a utility differential. They do not appear to be the compensating differentials that fall neatly within the scope of perfectly competitive models of the labour market.

Investigation of the efficiency wage hypothesis in the Indian context is topical. There is a widespread view that the Indian factory worker earns "too much", both with regard to the pay differential between factory and non-factory sector workers, and with regard to the prospects for factory employment growth (e.g., Lucas 1988, World Bank 1989). This view gathered momentum in the 1980s, when product wages in factories accelerated and factory employment declined. Its adherents demand policy reforms that curb union power and revoke job security legislation. Indeed, these demands are currently central to the controversy over India's new economic policies which, so far, have concentrated on product market deregulation. Unions and job protection are thought to nurture wage push and, thereby, to conflict with the objective of encouraging private enterprise[9]. It has not been recognized, in this context, that private manufacturers might have volunteered wage increases and that this is consistent with profit maximization on their part. Nor has it been appreciated that wage-induced effort might have contributed to the remarkable increase in the rate of total factor productivity growth in the 1980s. Deshpande (1992, p.91) appears to be an exception. In a comment on analyses of the productivity turnaround in India, he admits the possibility that rising consumption wages improved nutrition and morale. But, he says, "these logical possibilities are rarely entertained for want of attempts at empirical verification".

[9] Note that traditional models of the development process have also tended to *assume* that wage determination in the registered sector is `institutional' (eg., Lewis 1954, Harris and Todaro, 1970).

6. An Empirical Specification

6.1. Data and Variables

For reasonably small changes in the wage, the production function (2) can be approximated by a loglinear equation in which α and γ are estimable parameters (see Appendix 1).

The data used are a panel of 18 two-digit industries disaggregated by their location across the 15 major Indian states and observed annually during 1979-87 (see the Data Appendix). Availability of the regional dimension is an advantage as it permits the comparison wage and the cost of living to be defined at the state level. It also permits controls for industry-region fixed effects on productivity. Regional variance in productivity can be especially large in developing countries, for example, on account of their limited infrastructural development and relatively slow diffusion of skills. Firm-level data were not available for Indian manufacturing. However, if we are willing to assume constant returns to scale and common capital-labour ratios across firms then it is straightforward to demonstrate that the aggregation implicit in specifying an industry-level production function is valid[10]. Using subscripts i, s and t for industry, state and year, the estimated equation is

[10] See Bhalotra (1996b), which also investigates the pooling restrictions implicit in specifying common slopes in the production function. It appears that pooling cannot be rejected though it must be said that relatively large standard errors on the GMM estimates create a bias towards this result.

$$\ln Y_{ist} = \tau_t + \alpha \ln N_{ist} + \beta \ln K_{ist} + \mu \ln H_{ist} + \gamma \ln \omega_{ist} + (a_{is} + \varepsilon_{ist}) \quad (31)$$

where τ_t are time dummies denoting productivity growth common to the industry-state units including, for example, the effects of changes in the competitiveness of the manufacturing sector. a_{is} are unobserved time-invariant efficiency effects and ε_{ist} is stochastic.

The book value of capital stock (K_{ist}) is adjusted to get gross stock at replacement cost. Employment (N_{ist}) refers to production workers and supervisory staff. The ratio of production to non-production workers is 2:1. In the absence of skill-disaggregated data, this ratio was included in the production function as a proxy for skill. It emerged with a completely insignificant coefficient. So as to streamline the discussion, it is not discussed any further. Value added (Y_{ist}) is available in nominal terms and is deflated by the wholesale price index for industry output (P_{it}). Single-deflation in this manner may bias the estimated parameters if the ratio of input to output prices experienced considerable industry-time variation in the period of the study. However, Bhalotra (1996b) investigates controls for input prices and finds no change in the estimates. Nevertheless, as a check on the robustness of our results to the omission of any industry-time varying variables including material prices and labour quality, we shall report estimates of a production function that includes industry-time dummies (τ_{it}) (Section 7.3). Actual hours worked per worker (H_{ist}) is a utilization variable that averages overtime and "undertime" across workers and over time. Thus overtime or multiple shifts per worker may result in actual hours exceeding official hours, whereas input shortages may result in actual hours falling below official hours. Of course *actual* time worked is precisely what is desired in a production function[11].

The wage (ω_{ist}) refers, in different specifications, to the consumption wage and the relative wage. In both cases, the numerator is earnings per hour of actual work. Deflating this by a *regional* cost of living index (P^c_{st}) gives the consumption wage. P^c_{st} is defined uniquely for the category of industrial workers for every Indian state. To obtain a relative wage, we divide by W_{st}, the state average of the factory wage. If the reference group or the relevant alternatives of factory workers lie outside the factory sector, incomes in the rural and urban informal sectors might better represent the alternative wage, W^a. In the absence of time-variant data on these variables, it is hoped that they will be adequately proxied by W_{st}. This is defensible if the sectoral wage structure in a state is fairly rigid. Alternatively, the time dummies (τ_t) and fixed

[11] Muellbauer (1984) argues that finding an appropriate measure of utilization dominates the other classical problems arising in production function estimation, namely of aggregation and identification. He proposes a variable that controls for actual hours and demonstrates that it makes a significant contribution in the production function for British manufacturing.

effects (a_{is}) in the model will together control for state-specific variables (x_{st}) to a first-order approximation, $x_{st} = a_s + t_t + \varepsilon_{st}$. If the approximation is good, ε_{st} is random. If effort is stimulated not only by the wage but also by unemployment, then unemployment should appear in the production function. In the absence of annual unemployment rate data (U_{st}), we rely on this first-order approximation. An analysis of the available quinquennial data on unemployment suggests that this is reasonable (see Bhalotra, 1996a). Four state-level cross-sections, spanning 1972-1987 show that there is enormous regional variation in unemployment rates but not very much time variation and, when unemployment rates change over time, the rankings of states do not change very much. First lags of the wage terms are included in the empirical specification to permit delayed effects.

6.2. Estimation Issues

If the unemployment rate does have an impact on effort and it is inadequately controlled by a combination of fixed effects and time dummies, then the omitted variable bias on γ will be negative. Therefore, this will not lead us to find efficiency wage effects where they do not exist. Similarly, if any error implicit in denoting the comparison wage by the state average of factory wages is random, then γ will be biased *downwards* on account of measurement error. Another potential estimation problem is that the fixed effects, a_{is}, may be correlated with the inputs (N, H, K, ω) (e.g., Demsetz (1973), Zellner *et al* (1966)). Any resulting heterogeneity biases can be eliminated by transforming the equation using either within-groups[12] or first-differences (e.g., Hsiao, 1986). A third issue relates to the wage coefficient being subject to a simultaneity bias. While a positive wage effect on productivity constitutes support for the efficiency wage hypothesis, the reverse effect can arise in a rent-sharing model. An instrumental variables (IV) estimator is needed to avoid conflation of these two effects. In fact, the capital stock is probably measured with error, and productivity shocks (ε_{ist}) are likely to be correlated with employment and factor utilization (H). Therefore, each of the regressors needs to be instrumented.

Since the first-differenced error only involves shocks of the current and preceding period, whereas the within-groups error incorporates shocks of every period through the time-mean, it is easier to find instruments for a first-difference estimator, which is therefore preferred. Finally, there is the question of consistency, given that the panel has a short time series. For these reasons, the generalized method of moments (GMM) estimator proposed by Arellano and Bond (1991) is used. This performs instrumental variables estimation on a

[12] A within groups transformation of the equation consists of expressing every variable as the deviation from its mean over time. For every variable x, the transformation gives ($x_{ist} - x_{is.}$), where $x_{is.} = (1/T)\,(x_{is1} + x_{is2} + .. + x_{isT})$.

first-differenced equation and produces consistent estimates even on short panels. The instruments are the second and more remote lags of the endogenous variables, which are valid under the assumption that the levels error is serially uncorrelated, which is subject to testing. If the levels error is MA(1), then instruments dated t-2 are invalid but instruments dated t-3, t-4, and earlier, are still valid. Simulations conducted by Arellano and Bond indicate that use of remote lags, or additional moment restrictions, brings significant efficiency gains. Two tests of instrument validity are provided with the GMM estimates. *Serial correlation(2)* is a test for the absence of second-order serial correlation in the differenced residuals. The test statistic is distributed as standard normal under the null of no serial correlation. *Sargan* is a test for overidentifying restrictions. This is asymptotically distributed as chi-squared under the null of instrument validity, with as many degrees of freedom as overidentifying restrictions.

7. Results: Do Indian Factories Pay Efficiency Wages?

7.1. Alternative Estimators

Table 1 explores alternative estimators of a production function that incorporates the relative wage[13]. Since production function estimation is an important but difficult problem, the alternative estimates are considered in some detail. Time dummies (θ_t) are included in every specification and Wald tests (χ^2_k) show them to be jointly significant (k is the number of estimated coefficients). All reported standard errors are heteroskedasticity-consistent. The first and second lags of the wage were not significant and so they were not retained. WG in column 2 differs from OLS-levels in column 1 in controlling for fixed efficiency effects at the industry-state level (a_{is}). Comparison across these columns demonstrates that the levels-OLS estimate of every parameter carries a substantial heterogeneity bias. The within groups (WG, column 2) and first-difference (FD, column 3) estimates are fairly similar, the slightly smaller estimates of β and μ in the latter case being consistent with measurement error in K and H and with the resulting bias being larger under FD than under the WG transformation (e.g., Griliches and Hausman, 1986). Griliches and Hausman (1986) show how the WG and FD estimates can be combined to

[13] Since the specifications in Table 1 are only exploratory, only the final specifications are shown for the consumer wage model, and these are in Table 2. Corresponding estimates of production functions without any wage term are presented in Bhalotra (1996b), where the alternative estimators are discussed in more detail.

provide consistent estimates in the presence of measurement error. Let $x=x^* + u$, where x is the observed value of x^*, u is measurement error, T is the length of the panel, and x=N, K, H. Then

$$\beta_x = [2\beta_{x(WG)}/\mathrm{var}(\Delta x) - (T-1)\beta_{x(FD)}/(T\ \mathrm{var}(x_{WG}))] \ / \ [2/\mathrm{var}(\Delta x) - (T-1)/(T\ \mathrm{var}(x_{WG}))] \tag{32}$$

The corrected estimates are shown in column 4. However, if the WG and FD estimates are subject to endogeneity bias in addition to measurement error bias, then this approach will not recover the true coefficients. Therefore an instrumental variables estimator is used. Column 5 presents GMM estimates which rely on the second to the fourth lags of $\ln N_{ist}$, $\ln K_{ist}$, $\ln H_{ist}$, $(\ln W_{ist} - \ln W_{st})$ and $\ln P^c_{st}$ as instruments. Since there is no evidence of second-order serial correlation in the differenced residuals, these instruments are not invalid (also see Sargan statistics in Table 1). The results suggest that productivity shocks are positively correlated with employment and negatively correlated with capital, hours and the wage. Note that the wage coefficient behaves rather similarly to the hours coefficient as it responds to corrections for different sorts of bias. Column 6 presents the two-step estimates which use the residuals from the one-step estimates in column 5 to create the asymptotically optimal weighting matrix in the presence of heteroskedasticity. While the two-step estimates are asymptotically more efficient, they appear to have spuriously small standard errors in small samples (Arellano and Bond, 1991). Indeed, standard errors on our two-step coefficients are about a third of those on the one-step coefficients. Therefore the estimates in column 5 are preferred. In view of the discussion in Section 6.2, we are only concerned with its size in the GMM models.

7.2. Investigating Restrictions

Table 2 reports one-step GMM estimates for the relative wage ($\ln W_{ist}$-$\ln W_{st}$) and the consumer wage ($\ln W_{ist}$-$\ln P^c_{st}$) models. Wald tests of restrictions are reported in Notes to the Table. Column 1 in each panel shows the unrestricted estimates corresponding to column 5 in Table 1. In the other columns, constant returns to scale are imposed since this is data consistent and is a clean way of dealing with measurement error in K, the effects of which are not guaranteed to be taken care of using lags of K as instruments. Columns 2 impose the additional restriction, common in the literature, that the coefficient on hours equals that on employment. The relevant α is then the coefficient on total person-hours. An advantage of this specification is that a test of the efficiency wage condition (γ=α) is robust to the problem that firms varying employment incur adjustment costs. While this provides a useful check on the model, we prefer the estimates in columns 3 where the coefficient on hours is restricted to equal unity. The Wald tests of the alternative restrictions on hours greatly favour the μ=1 restriction. Scaling output by hours is also theoretically appealing since, when a worker puts in an additional hour, capital services, fuel and other inputs will typically be utilised for the additional hour. Both restrictions buy us greater efficiency which is fairly important with GMM estimates.

7.3. Testing the Efficiency Wage Hypothesis

Across a range of estimators and, irrespective of restrictions, the wage has a significantly positive effect on productivity. In every GMM model in Table 2, the efficiency wage condition, α=γ, cannot be rejected (t-statistics in Table 2). There is thus fairly compelling evidence that efficiency wages are paid and that these pay for themselves. For further discussion, we shall take columns 3 as the *preferred model.*

With regard to the significance of the relative wage, it is worth recalling that the evidence presented here pertains to the factory sector, which is the primary or `formal' manufacturing sector. It includes all of the relatively big firms, in which moral hazard and other information problems are likely to be relatively severe. In addition, these tend to be relatively capital and technology intensive firms, the output of which may be more sensitive to effort variations than is the case in very small firms. It is the tendency for such enterprises to select themselves into the primary or formal sector labour market that gives rise to formal-informal sector wage dualism (Akerlof, 1982). Significance of the consumption wage supports the "enable" hypothesis. Although the average production worker in the Indian factory has crossed the subsistence level of income, food still claims almost two-thirds of the family budget (Chatterji, 1989). Increments to their wages might therefore be associated with visible increases in well-being. For example, the worker might consume higher quality foods, or avoid a long commute to work[14]. Bhalotra (1995b) discusses the relevance of the alternative efficiency wage models to the Indian setting.

7.3. Robustness

We have already investigated robustness of the positive wage effect on productivity to alternative estimators and alternative data-consistent restrictions on the production function parameters. The $(k\text{-}n)^2$ term implied by both a Taylor series approximation to a CES technology, and the Translog function under CRS is insignificant on this data sample, as are lags of the regressors (see Bhalotra, 1996b). Therefore, in this sample, the Cobb-Douglas model provides a reasonable approximation to the actual technology. By virtue

[14] Myers (1958:49-50) cites company officials in Indian industry in 1954 as saying that the Indian worker would be as efficient as any, were it not for poor nutrition and bad living conditions at home and unsympathetic supervisors at work. Living standards of factory workers have improved since 1954. Whether the real consumption wage had any impact on productivity in the 1980s merits investigation.

of controlling for *actual hours*, the specification distinguishes the output effects of observed worker effort (or utilization) from those of unobserved effort. Having time dummies rather than a trend affords a flexible characterization of *aggregate productivity growth*. As mentioned earlier, the GMM estimates are expected to be clear of biases arising from unobserved heterogeneity, endogeneity, and measurement error. Taking care of endogeneity of the wage is particularly important since it eliminates any concern with the efficiency wage effect being conflated with a *rent-sharing effect* working in the opposite direction[15]. Note also that our measure of output is real value added. In studies that use the nominal output of firms, a positive wage-productivity correlation can arise from rent sharing whence an increase in prices and wages following an increase in market share (e.g., Levine, 1992).

However, interpretation of a positive wage coefficient in the production function as an efficiency wage effect is still subject to the criticism that the positive wage effect arises from inadequate controls for *skill shifts*. If there are industry-specific changes in skill-composition over time, then industries that

[15] In the long run, industry productivity growth may be expected to be passed on to the wider population as lower product prices. In developed countries, this typically implies a rise in the consumer wage and so it could account for reverse causality *in the absence of insider wage push*. However, in agrarian economies like India, the consumer price index is largely determined by agricultural prices, making this connection more tenuous. Therefore, a productivity impact on wages relies upon rent-sharing or efficiency wage models.

are raising skill levels will probably exhibit increases in wages and productivity even in the absence of an efficiency wage mechanism. So as to control comprehensively for skill shifts, the production function is re-estimated with a full set of interaction terms between industry and time dummies ($\lambda_i \tau_t$). The 136 additional terms are included on the strength of the regional variation in the data. Relative to columns 3 of Table 2, the employment coefficient increases by one standard error and the relative wage coefficient falls by less than a standard error. In the alternative specification with the consumer wage, both the employment and the wage coefficients increase, but both changes are insignificant. Since GMM estimates of the model with industry-time dummies are not very precisely determined, the model was also estimated by within groups. The changes in the wage and employment coefficients were even smaller. Therefore it appears unlikely that the wage effect is proxying a skill effect.

There is no reason for either of the output-effort or the effort-wage functions to be common across sectors but suitable disaggregate data are unavailable. To investigate this matter, we estimate a model with *industry-specific wage coefficients*. Since 17 additional terms need to be instrumened, GMM is very inefficient. Within-groups estimates produce a significant positive wage effect in half of the eighteen industries in the sample[16]. It would be interesting to explain the industry differences in terms, for example, of differences in the sensitivity of output to variations in effort, firm size and monitoring costs, location and regional unemployment, or union power. This is beyond the scope of the present study but provides an interesting avenue for research with more disaggregate data.

So far, worker effort has been permitted to depend either on the relative wage or on the consumer wage. A third possibility, the *adaptation hypothesis*, is that effort depends on current income relative to past income (see Goodman (1974), Akerlof (1982)). This is proxied here by $\Delta(w_{ist}-p^c_{st})$, and it turns out to be insignificant. Finally, the production function is estimated with the nominal wage (w_{ist}), the alternative wage (w_{st}) and the consumer price index (p_{st}^c) appearing as three independent terms. The point of this exercise is to determine the *"natural" denominator for the nominal wage.* The nominal wage acquires a significant coefficient (t=2.1) of 0.55. The coefficient on w_{st} is exactly equal and opposite in sign but it is insignificant. The coefficient on the index, p_{st}^c, is

[16] In the specification with the relative wage, these are Chemicals, Basic metals, Machinery, Non-metallic minerals, Petroleum and rubber, Paper and publishing, Tobacco and beverages, Textile products, and "Other" (the residual industry). In the model with the consumer wage, a positive efficiency effect is found in the same set of industries with the exception of Basic Metals.

significant but it is much larger than on w_{ist}. These results do not have an unambiguous interpretation.

In conclusion, there is robust evidence that efficiency wages are paid and that these pay for themselves. In different specifications, the data support both the relative wage and the consumer wage. The profit-maximising condition, that α and γ are identical, cannot be statistically rejected.

8. Investigation of Near Rationality in Wage-Setting

Given that we cannot reject rationality, it is not strictly necessary to investigate near rationality. The methods outlined may be more fruitfully applied to a data set that does reject the null of rationality, and this section may be regarded as merely illustrative[17]. Since the point estimates of α and γ are their most likely values, we use the fact that they are not identical to investigate the curvature of the profit-wage function. Estimates used here are those in columns 3 of Table 2.

[17] Note that, if the two-step GMM estimates are favoured over the one-step estimates, then we *can* reject the null of equality of α and γ. However, since simulations suggest that the two-step GMM estimates are spuriously well-determined in small samples, and since this is the "conservative" strategy in this context, we have chosen to concentrate on the one-step estimates.

Illustrative Wage Deviations

Using (30), we compute the profit loss that would arise if the wage were to deviate by 1, 2, 5 and 10 per cent. The relative wage and the consumer wage models produce the same result since the estimate of α is basically the same in the two models (Table 2). We do not know δ but do know that $0<\delta<1$[18]. In fact, (14) implies the smaller range, $0<\delta<(\gamma/\alpha)$[19]. The results in Table 3 and Figure 1 show that the profit function is very flat in the neighbourhood of the optimum. A deviation of 1% in the wage results in no more than 0.002-0.006% of optimal profit being lost, and a 10% deviation in the wage results in a profit loss in the region of 0.2-0.6%. These are trivial losses by most standards. Notice that, *for a given wage deviation, profit loss is decreasing in* δ (see (30)). Intuitively, the larger is δ, the greater is the effort-return to increasing the wage, and this mitigates the profit lost from paying too much.

Wage Deviations Implied by the Data

Table 4 presents estimates of profit loss based on imputing rather than assuming the percentage deviation of the wage from its optimum. The results are plotted in Figures 2a and 2b for the relative wage and the consumer wage

[18] This is a strict inequality. If $\delta=0$ then effort is not wage dependent. If $\delta=1$ then the effort-wage relation is linear but the more plausible situation is that there are decreasing effort returns to increasing the wage or that the relation is concave to the origin.

[19] Suppose $1>\delta>(\gamma/\alpha)$. Simple rearrangement shows that this implies $(-1)>(\alpha-\gamma)/(\gamma-\alpha\delta)>(-\infty)$ or, by (14), $(-1)>\Delta\omega/\omega^{*}>(-\infty)$. The first inequality in this expression implies $\omega<0$, which is absurd. At $\delta=(\gamma/\alpha)$, $\Delta\omega/\omega^{*}=\infty$.

respectively. Equation (14) shows that $\Delta\omega/\omega^*$ can be inferred from the point estimates of α and γ if, as before, we assume different values for δ. In our sample $\gamma<\alpha$ and it is evident from (14) that the wage deviation is positive or firms tend to pay *more* than the efficiency wage. A natural scenario consistent with this is one in which unions are involved in wage-setting. The wage deviation, and therefore the profit loss, is increasing in δ.

The results make two striking points. First, the α and γ estimated on our data, while statistically insignificantly different from one another, are consistent with fairly large wage deviations. Thus the wage deviates by at least 14% in the relative wage model and at least 23% in the consumer wage model. Second, the profit losses are relatively small. To be more precise, one needs to define what one considers as small. Like significance levels that, by convention, may lie between 1% and 10%, we might suppose that profit losses upto 10% are "small"[20]. Then our estimates for the relative wage model are consistent with near rationality. However, the consumer wage model may appear to violate near rationality *if* δ is larger than about 0.45. In this case we have the apparently counter-intuitive result that, while rationality is not

[20] This is just for expositional convenience. The reader can, of course, reinterpret Table 4 using any alternative definition of "small". As mentioned in the Introduction, a "small" loss may correspond in size to transactions or information costs or other costs (like those imposed by unions) associated with moving to the optimum. Alternatively, they may be the sorts of losses that firms incur on account of "everyday" mistakes, or else losses that firms in competitive environments can survive.

statistically rejected, near rationality, which relies upon a different metric is. However, it is important to note that the exercise resulting in Table 4 involves the point estimates of α and γ which we know to be uncertain, and that the profit loss calculations grow unreliable as the wage deviations grow larger since they rely upon a Taylor series approximation of second-order[21].

The following conclusions emerge. While the relevant elasticities (α=0.57, γ=0.50 when $\omega=W/W^a$ or α=0.58, γ=0.47 when $\omega=W/P^c$) are statistically not significantly different, their point estimates imply that firms pay wages considerably higher than the efficient wage. *This is useful information with which to complement the standard statistical metric applied to testing the predictions of economic models.* Using UK company data, Wadhwani and Wall (1991) find α=0.65, γ=0.39 and reject $\alpha=\gamma$ in favour of $\alpha<\gamma$, which is consistent with union bargaining leading to wages higher than the efficiency wage. In contrast, Levine (1992) finds, on U.S. company data, that α=0.27, γ=0.46. The point estimates suggest that companies pay less than the efficiency wage but the data cannot reject $\alpha=\gamma$. Clearly, point estimates may diverge considerably more than they do on the Indian data and yet be statistically consistent with the notion that firms are operating at an optimum.

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[21] While this digresses from the main concern of the paper, it may be worth pointing out that a deviation in the wage from its optimal level implies a deviation in employment of the opposite sign. There has been considerable concern in India regarding the slow growth in manufacturing employment (see Bhalotra, 1998).

The second result from our analysis is that the profit function is remarkably flat. It suggests that, even though wage increases beyond the efficient wage do not pay for themselves, they stimulate enough effort to mitigate the resulting profit loss. *Thus in environments where effort is a positive function of the wage, the profit-wage function will be flatter than otherwise.* This makes some sense of the fact that such large deviations are sustained. It might seem surprising that firms can sustain *any* loss in profit loss without, for instance, incurring takeover (e.g. Cochrane, 1989). However, Indian manufacturing in the 1980s was sufficiently protected from competition to make it possible for firms to live with some degree of slack.

9. Conclusions

We cannot reject the hypothesis that efficiency wages are paid in Indian factories. The wage effects are sizeable, the elasticities being about 0.5. In independent specifications, effort appears to be stimulated by increases in the relative wage and in the absolute consumption wage. Significance of the relative wage affords support for the "recruit-retain-motivate" class of models which is consistent with informational deficiencies in the relatively large and capital intensive firms in the factory sector. Significance of the consumption wage supports the "enable" hypothesis.

The profit function is remarkably flat in the neighbourhood of the optimum. A deviation of as much as 10% from the efficiency wage results in a profit loss of, at most, 0.6%. The wage deviations implied by our estimates of the production function parameters are a good bit larger than 10% but the resulting profit loss is relatively small. This suggests two things. First, that, on average, Indian factories do pay more than the efficiency wage, possibly on account of union intervention in wage-setting. Second, this deviation from the optimum does not cost them very much, presumably because positive productivity gains from increasing the wage beyond its efficient level compensate the profit loss to some degree. Thus, near rational behaviour in a pure efficiency wage model is indistinguishable from rational behaviour in a model in which efficiency wage considerations and union wage bargaining coexist.

The popular view that factory wages incorporate substantial rents arising from imperfect competition in product markets and extracted through union and government intervention is undermined. While unions may have some influence on wage-setting, curbing union power is not guaranteed to generate lower wages and higher employment in factories; and it would seem to be technology rather than unionism that separates the informal from the formal manufacturing sector.

These results would, of course, be more convincing if they emerged from investigation of firm-level data. This was not available. In general, firm data for developing countries are still scarce. Were the necessary detail available, it would also be interesting to investigate efficiency wage setting in public versus privately owned firms, in union versus non-union firms and in large versus small firms. Further work is also desirable on the question of *why* efficiency wages are needed to elicit effort. Important questions of the health and nutrition standards of workers at the one hand, and of job security on the other are potentially tied in with an understanding of this: Do firms need to pay efficiency wages because workers are *unable* to work hard unless they are paid uncompetitively high wages, or because they all shirkers in the knowledge that their jobs are secure?

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Table 1
Production Functions Incorporating the Relative Wage
ALTERNATIVE ESTIMATORS

	(1) Levels-OLS	(2) Within Groups	(3) First Differences-OLS	(4) Griliches-Hausman adjustment	(5) GMM: one step estimates	(6) GMM: two step estimates
employment	0.98 (31.4)	0.61 (5.8)	0.71 (5.7)	0.50	**0.42 (2.4)**	0.45 (7.6)
capital stock	0.03 (3.1)	0.27 (6.1)	0.25 (4.5)	0.30	**0.43 (5.1)**	0.42 (19.6)
hours	0.81 (7.1)	0.48 (4.2)	0.44 (3.7)	0.67	**0.87 (2.9)**	0.81 (6.2)
relative wage	0.73 (10.3)	0.27 (3.7)	0.20 (2.6)	0.50	**0.54 (2.0)**	0.67 (7.1)
R^2	0.89					
NT	2381	2113	2113		**2113**	2113
Wald (θ_t)	99.7/8 (0.0)	42.9/8 (0.0)	43.9/8 (0.0)		**26.7/8 (0.0)**	85/8 (0.0)
Wald (RHS)	2318/4 (0.0)	226/4 (0.0)	106/3 (0.0)		**91.1/4 (0.0)**	4744/3 (0.0)
σ^2 (levels)	0.337	0.140	0.120		**0.133**	0.133
serial corr(1)			-6.63 (0.0)		**-6.70 (0.0)**	-7.02 (0.0)
serial corr(2)			0.35 (0.72)		**0.63 (0.53)**	0.66 (0.51)
Sargan (χ^2)					**92.7/87 (0.29)**	92.7/87 (0.29)

Notes: Dependent variable=log(real value added). θ_t are time dummies, σ^2 is an estimate of the variance of the levels equation error; ε_{ist} in FD and GMM, $(\varepsilon_{ist}-\varepsilon_{is})$ in WG and $(\varepsilon_{ist}+\mu_{is})$ in the OLS equations. Fig. in parenthesis are absolute t-ratios except for the test statistics, where they are p-values. The figure following the slash (/) is the number of estimated coefficients for the Wald test and the degrees of freedom for the Sargan test. Instruments are $n_{ist}(2,4)$, $k_{ist}(2,4)$, $h_{ist}(2,4)$, the product wage $(w_{ist}-p_{it})(2,4)$ and the consumer price index, $p_{st}^c(2,4)$, where x(a,b) denotes $x_{t-a}, x_{t-a-1}, .., x_{t-b}$.

Table 2
GMM Estimates of the Production Function
INVESTIGATING RESTRICTIONS

	The Relative Wage			**The Consumer Wage**		
	(1) Unrestricted	**(2) Impose CRS and $\mu=\alpha$**	**(3) Impose CRS and $\mu=1$**	**(1) Unrestricted**	**(2) Impose CRS and $\mu=\alpha$**	**(3) Impose CRS and $\mu=1$**
employment	0.42 (2.4)	0.62 (8.2)	**0.57 (7.2)**	0.45 (2.6)	0.61 (7.4)	**0.58 (6.9)**
capital stock	0.43 (5.4)			0.42 (4.9)		
hours	0.84 (3.1)			0.82 (2.8)		
wage	0.55 (2.1)	0.54 (2.1)	**0.50 (2.0)**	0.52 (2.1)	0.48 (2.0)	**0.47 (2.0)**
Wald (θ_1)	26/8 (0.0)	27.7/8 (0.0)	**23.3/8 (0.0)**	22.9/8 (0.0)	21/8 (0.0)	**20.8/8 (0.0)**
Wald (RHS)	103/4 (0.0)	70.3/2 (0.0)	**52/2 (0.0)**	107/4 (0.0)	55/3 (0.0)	**47/2 (0.0)**
σ^2 (levels)	0.133	0.126	**0.135**	0.131	0.125	**0.133**
serial corr(1)	-6.70 (0.0)	-6.94 (0.0)	**-6.88 (0.0)**	-6.72 (0.0)	-7.00 (0.0)	**-6.91 (0.0)**
serial corr(2)	0.61 (0.54)	0.50 (0.62)	**0.79 (0.43)**	0.61 (0.54)	0.46 (0.65)	**0.80 (0.42)**
Sargan (χ^2)	105/99 (0.31)	106/101 (0.34)	**106/101 (0.36)**	91/86 (0.33)	92/88 (0.36)	**90/88 (0.43)**
$\lvert \mathbf{t} \rvert$ ($\alpha=\gamma$)	**0.39**	**0.29**	**0.28**	**0.22**	**0.54**	**0.48**

Notes: See notes to Table 2. *NT*=2113. The *dependent variable* is y_{ist} in col.1 & 4, $(y_{ist}-k_{ist})$ in col.2 & 5, and $(y_{ist}-k_{ist}-h_{ist})$ in col.3 & 6. *Wald tests of the restrictions* are as follows. In the relative wage model, CRS (1.0), $\mu=\alpha$ (1.68) and $\mu=1$ (0.04). In the consumer wage model, CRS (0.94), $\mu=\alpha$ (1.36) and $\mu=1$ (0.22). *Instruments* common to every column are $n_{ist}(2,4)$, $k_{ist}(2,4)$, $h_{ist}(2,4)$, $p_{st}^c(2,4)$, and time dummies. Additional instruments are $(w_{ist}-p_{it})(2,4)$ and $(w_{st}-p_{it})(2,4)$ in col. 1-3, and $(w_{ist}-p^c_{st})(2,4)$ in col. 4-6.

Table 3

Profit Loss Incurred by the Wage Deviating from the Efficiency Wage

(1) Curvature of Effort Function [δ]	(2) Wage Deviation=1%	(3) Wage Deviation=2%	(4) Wage Deviation=5%	(5) Wage Deviation=10%
0.1	0.006	0.024	0.149	0.597
0.2	0.005	0.021	0.133	0.530
0.3	0.005	0.019	0.116	0.464
0.4	0.004	0.016	0.099	0.398
0.5	0.003	0.013	0.083	0.331
0.6	0.003	0.011	0.066	0.265
0.7	0.002	0.008	0.050	0.199

Notes: Columns 2-5 (in %) are derived using $\Delta\pi/(\pi(\omega^*)) = -[\alpha(\delta - 1)/2(1 - \alpha)](\Delta\omega/\omega^*)^2$, where $\alpha=0.57$, $0<\delta<(\gamma/\alpha)$, and $(\Delta\omega/\omega^*)^2$ is assumed to take the values 1%, 2%, 5% and 10% respectively. These data are plotted in Figure 1.

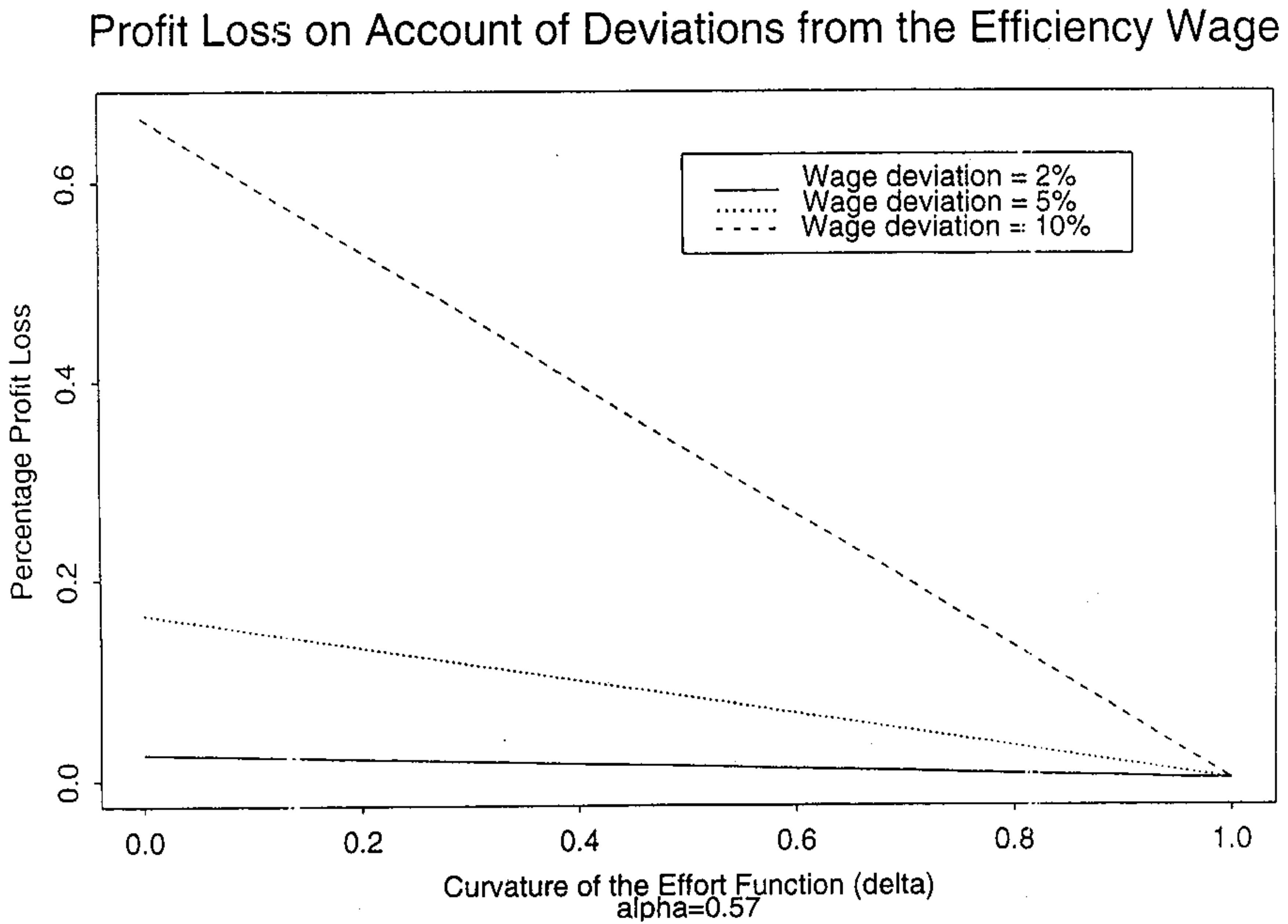
Table 4

Profit Loss Incurred by the Wage Deviating from the Efficiency Wage

	The Case of the Relative Wage		The Case of the Consumer Wage	
(1) **Curvature of Effort Function** [δ]	(2) **Wage Deviation** [$\Delta\omega/\omega^*$]	(3) **Profit Loss** [$\Delta\pi/\pi(\omega^*)$]	(4) **Wage Deviation** [$\Delta\omega/\omega^*$]	(5) **Profit Loss** [$\Delta\pi/\pi(\omega^*)$]
0.10	15.8	1.49	26.7	4.43
0.20	18.1	1.74	31.1	5.33
0.30	21.3	2.10	37.2	6.67
0.40	25.7	2.63	46.2	8.85
0.50	32.6	3.51	61.1	12.9
0.55	37.5	4.20	73.3	16.7
0.60	44.3	5.20	90.2	22.5
0.65	54.1	6.78	118.3	33.8

<u>**Notes**</u>: In columns 2-3, [α=0.57, γ=0.50], in columns 4-5, [α=0.58, γ=0.47]. Figures 2a and 2b plot the data in columns 2-3 and 4-5 respectively. In column 1, $0<\delta<(\gamma/\alpha)$. Columns 2-5 are derived using $\Delta\omega/\omega^* \approx (\alpha - \gamma)/(\gamma - \alpha\delta)$ and $\Delta\pi/\pi(\omega^*) = - [\alpha (\delta - 1) / 2(1 - \alpha)] (\Delta\omega/\omega^*)^2$. These are presented in percentages. Refer to Section 9 for details. Note that, for alternative values of δ, the wage deviation is *implied* by our estimates of α and γ.

FIGURE 1



Profit Loss on Account of Deviations from the Efficiency Wage
Wage deviation = 2%
Wage deviation = 5%
Wage deviation = 10%
Percentage Profit Loss
0.0
0.2
0.4
0.6
0.0
0.2
0.4
0.6
0.8
1.0
Curvature of the Effort Function (delta)
alpha=0.57

FIGURE 2

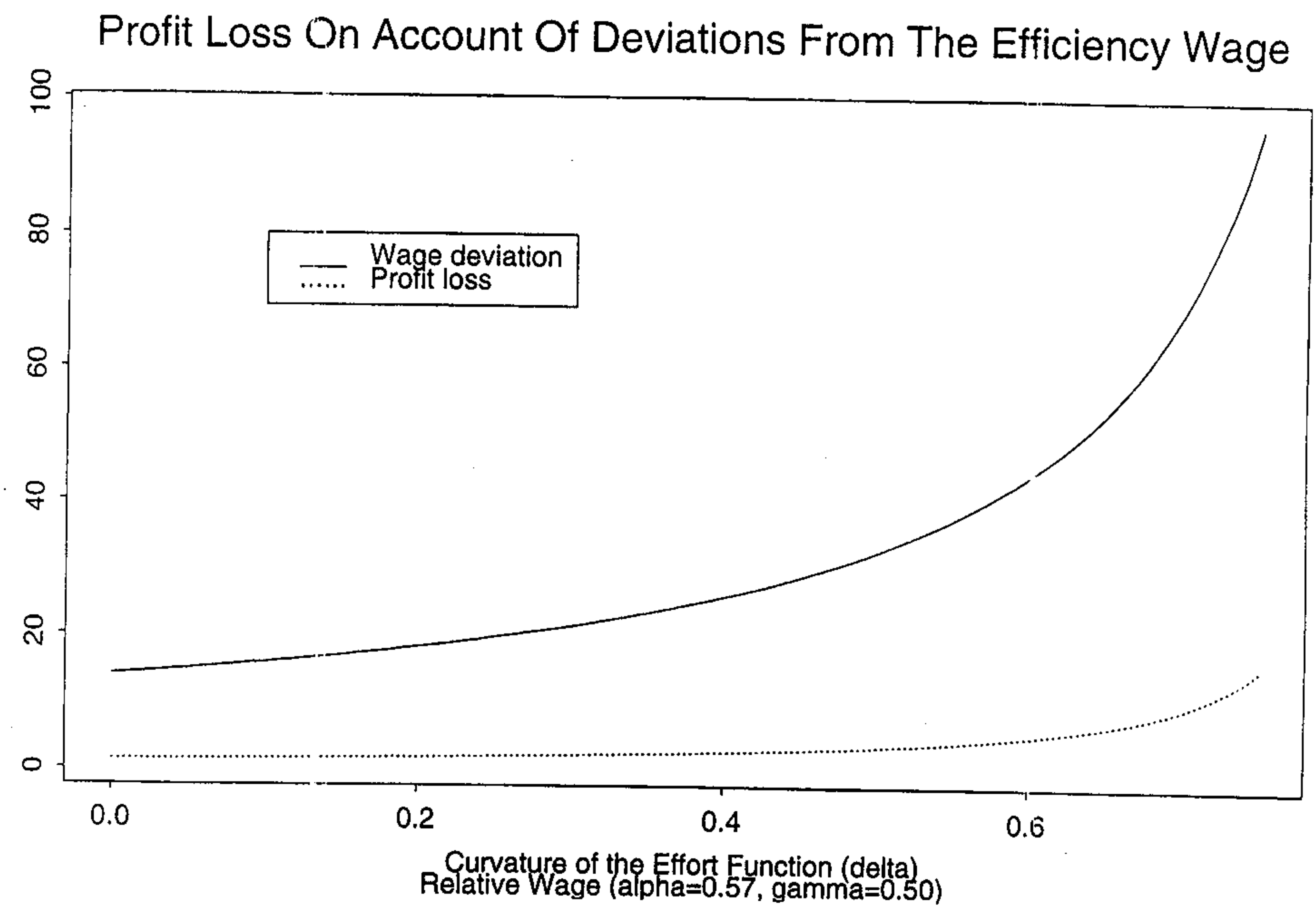
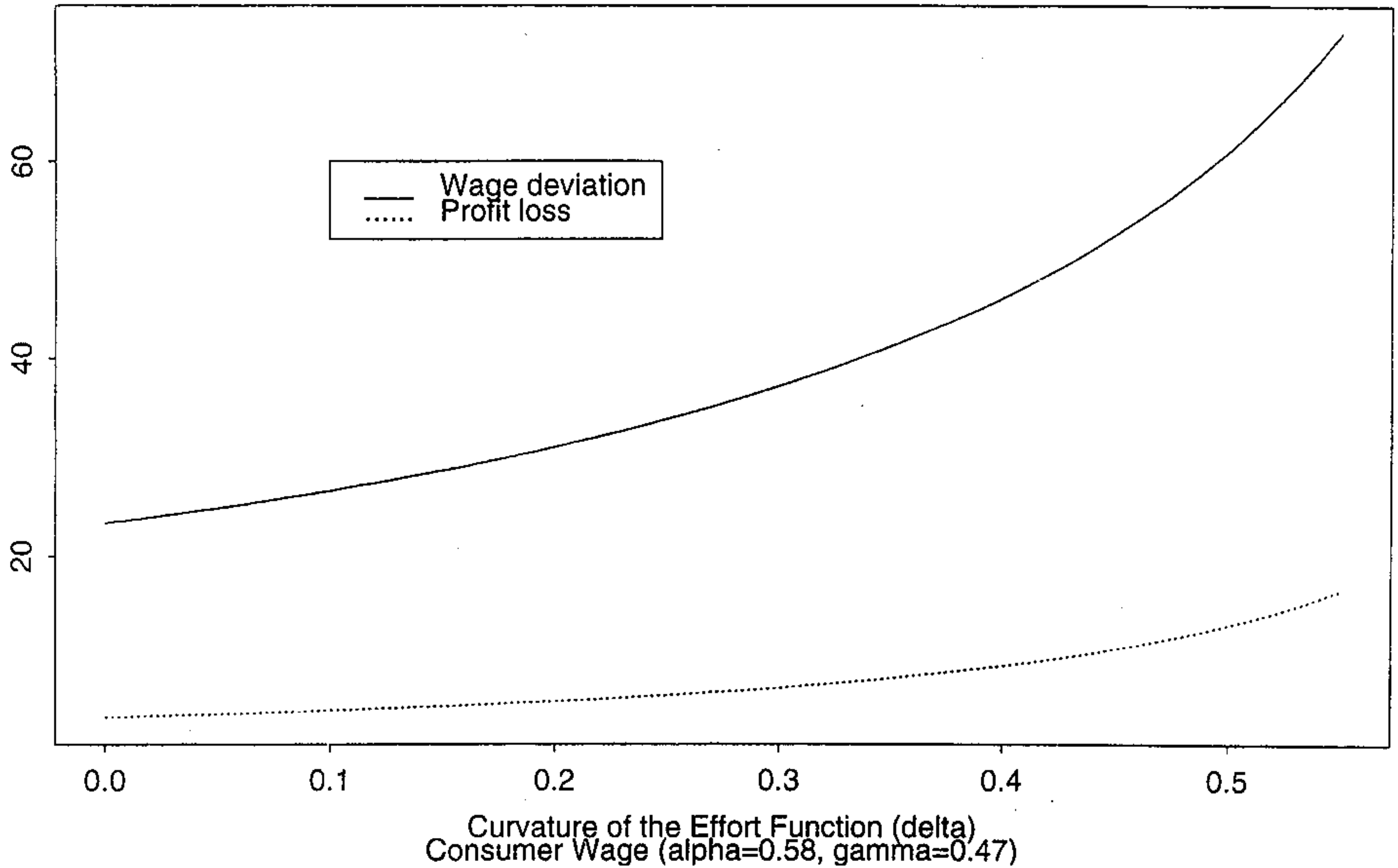

Profit Loss On Account Of Deviations From The Efficiency Wage
Wage deviation
Profit loss
0
20
40
60
80
100
0.0
0.2
0.4
0.6
Curvature of the Effort Function (delta)
Relative Wage (alpha=0.57, gamma=0.50)

FIGURE 3

Profit Loss On Account Of Deviations From The Efficiency Wage



Appendix 1

Approximate Log Linearisation of the Production Function

A logarithmic transform of the production function in (4) is

$$y = \alpha \ln N + \alpha \ln [-\theta + \omega^{\delta}] \tag{1}$$

Since (1) is nonlinear, the following approximation is used. Let $\omega = \omega^0 + \Delta\omega$, where ω^0 is any wage around which there is a small deviation, $\Delta\omega$, in the sample. Substituting for ω in (1) gives, to first-order,

$$y = \alpha \ln N + \alpha \ln [-\theta + (\omega^0)^{\delta} + \delta(\omega^0)^{\delta-1} \cdot (\Delta\omega)] \tag{2}$$

Taking $[-\theta + (\omega^0)^{\delta}]$ common,

$$y = \alpha \ln N + \alpha \ln ([-\theta + (\omega^0)^{\delta}] [1 + \delta(\omega^0)^{\delta-1}(\Delta\omega)[-\theta + (\omega^0)^{\delta}]^{-1}) \tag{3}$$

Since $\alpha \ln[-\theta + (\omega^0)^{\delta}]$ is a constant, and $\ln (1+z) \approx z$ for small z, this implies

$$y = \text{constant} + \alpha \ln N + \alpha\delta(\omega^0)^{\delta-1}(\Delta\omega)[-\theta + (\omega^0)^{\delta}]^{-1} \tag{4}$$

But $\alpha\delta(\omega^0)^{\delta}[-\theta + \omega^{\delta}]^{-1} = \gamma$ (see (9)). Substituting in (4),

$$y = \text{constant} + \alpha \ln N + \gamma(\Delta\omega/\omega^0) \tag{5}$$

Using $z \approx \ln(1+z)$ where $z=(\Delta\omega/\omega^0)$ and $\omega = \omega^0 + \Delta\omega$, (5) implies $y=\text{constant} + \alpha \ln N + \gamma \log (\omega/\omega^0)$. Since $\gamma \log \omega^0$ goes into the constant,

$$y = \text{constant} + \alpha \ln N + \gamma \log \omega \tag{6}$$

This establishes that, for reasonably small changes in the wage, the production function can be approximated by a loglinear equation in which α and γ are estimable parameters.

Data Appendix

DEFINITIONS AND SOURCES OF VARIABLES

Note: Italics indicate that the variable is defined in this Table.

VARIABLE	DEFINITION
capital stock (K_{ist})	Gross fixed stock at replacement prices; Aggarwal (1991), ASI and Chandhok *et al* (1990).
consumer price index (P^c_{st})	State-level index of prices of food, tobacco, fuel and housing for industrial workers. There are separate indices for urban non-manual employees and for agricultural labourers; Chandhok *et al* (1990).
earnings$_{ist}$	Annual income per worker (wage-bill/*employees*); ASI.
employees (N_{ist})	Production *workers* plus supervisory staff. Defined as `total persons engaged' until 1980; ASI. There is no information on the age, sex, education and skill composition of the work force.
hours (H_{ist})	*`Manhours'* actually worked per worker; ASI. Hours averages overtime and undertime both across workers and temporally (over the course of a year) and it need not equal official hours. This variable will register an increase when, for example, workers begin to work more than one shift per day, annual holidays are reduced, or there is a lower incidence of work stoppages, whether on account of power shortages, materials bottlenecks, machine faults or industrial disputes.
manhours (M_{ist})	Total hours *actually* worked by all workers; ASI. The available variable is mandays, defined as `days worked rather than days paid for, obtained by adding up the number of persons attending in each shift over all shifts worked on all days, working and non-working' (CSO, 1987/88). A manday is standardized as an 8 hour block and so it is effectively an hours variable.
price of output (P_{it})	Wholesale price index at the 2-digit industry-level; Chandhok *et al* (1990).
skill (S_{ist})	Ratio of *employees* to *workers*, proxies skill composition; ASI.
value added (Y_{ist})	Nominal difference of value of outputs and inputs. Gross preferred to net because depreciation figures are unreliable. Deflated by the output price, P_{it} (see *price*), in absence of industry value added deflators; ASI.
wage (W_{ist})	Hourly wage (*earnings/ manhours*), deflated by P_{it} to give the product wage. Averaging across industries gives the *state wage*, W_{st}.
workers$_{ist}$	Production workers; ASI. This includes regular, casual and contract workers.

Notes: ASI=Annual Survey of Industries (several issues), CSO=Central Statistical Organisation, India. Variables pertain to the factory sector for which data other than P_{it} are available at an industry-state-year level of disaggregation: hence subscripts *ist*.