Efficiency Wage and Labor Discipline Models: Matched-Panel Evidence from Brazilian Construction Industry

(Preliminary Version)

Luiz A. Esteves[§]

Universidade Federal do Paraná and Università di Siena

This Version: 23 March 2007

Abstract: The aim of this paper is to test the relationship between wage and workers' labor effort for the Brazilian construction industry. This relationship is stated by both the shirking and the labor discipline versions of efficiency wage models. Actually workers' labor effort is neither verifiable nor available for empirical tests, so the most of the empirical tests for this theory are performed by testing the trade-off between wages and supervision, and the trade-off between wages and the workers' probability of termination. This paper provides empirical tests for both relationships, and the efficiency wage model hypothesis is empirically supported by this paper.

Keywords: Efficiency Wage Models, Cross-sectional Models, Panel Data Models, Matched Employer-Employee Data.

JEL Codes: J31, J41,C21,C23.

[§] Email: esteves@ufpr.br.

Introduction

The efficiency wage hypothesis argues that wages, at least in some markets, are determined by more than simply supply and demand. Specifically, it points to the incentive for firms to pay their employees more than the market-clearing wage in order to increase their productivity or efficiency. There are different versions of efficiency wages models, but in this paper I am mainly interested in the shirking version of efficiency wage model. This version states that higher wages are paid by firms in order to extract higher levels of intensity from workers.

The most important theoretical papers on the shirking version of efficiency wages were developed by Shapiro and Stiglitz (1984), Bowles (1985) and, Bulow and Summers (1986). A common characteristic of these papers is to formalize the relationship between employers and employees as a agency problem. It is well known that the principal-agent problem arises under conditions of incomplete and asymmetric information when a principal hires an agent.

In the shirking model the principal-agent problem arises because of the employers´ impossibility to obtain complete information about the effort level workers´ decision. On the other hand, the firm product level is known by the both parts. This impossibility is justified by the employers´ imperfect monitoring of workers´ labor effort, and the high costs that this supervision task requires.

In this way, it is impossible to design a contract of selling and buying of labor effort intensity. So, the alternative option is to design a incomplete contract of employment which hours and wages are bargained, but the intensity of labor effort to be performed by workers are not considered in their clauses.

Given the incompleteness of the employment contracts, and the role of workers´ effort intensity in the production function, and performance firms, it becomes necessary to the

employers to control and to supervise workers in order to extract higher levels of labor effort of them.

The shirking version of efficiency wage model states that employers manipulate incentives and penalties (carrots and sticks) in order to persuate workers to work hard which wages premiuns works as incentives, and dismissals (or probability of employment contract termination) works as penalties

In this paper are presented two different versions of shirking models. The first one was developed by Shapiro and Stiglitz (1984) which the well known non shirking condition is derived. The second one was developed by Bowles (2004) which a probability of termination equation for workers is derived in fuction of the wage rate.

Empirical evidence for both theoretical models are given by using cross section and panel data econometric estimations, and the outcomes provided in this paper support the efficiency wage hyphotesis.

This paper is composed in the following way: (i) the first section presents the theoretical models to be tested; (ii) the second section presents the data, descriptive statistics, and the outcomes of the econometric analysis; and (iii) the third and last section presents the conclusion.

1. Theoretical Issues

1.1. The Shirking Model

The model assumes a fixed quantity of similar workers with a utility fuction *U=(w-e)*, where *w* means the wage rate, and *e* means the labor effort. The labor effort workers´ choice is restricted in two values: *e*=0 (*shirker*), and *e*>0 (*non-shirker*).

Workers who labor effort is *e*>0 will always be employed at wage rate *w*. On the other hand, workers who labor effort is *e*=0 are exposed to be caught shirking, and to be fired at probability *q* in each period of time. Unemployed workers receive a income (insurance) *b*.

A shirker worker alternates between periods of employability and unemployment where θ is the fraction of time which these workers remain employed. The utility function for non-shirker and shirker workers is, respectively:

$$U^N = (w - e) \qquad (1)$$

e

$$U^S = \theta w + (1 - \theta) b \qquad (2)$$

In order to extract positive levels of labor effort from their workers, firms choose a wage rate *w* which $U^N > U^S$ (the non shirking condition):

$$w > b + \frac{1}{1+\theta} e \qquad (3)$$

Given that *q* is the probability of a shirker worker to be caught and fired in each period of time, the expected time of employment for this worker will be 1/*q*. If ρ is the probability of an unemployed worker to find a job in each period of time, so the expected time of unemployment for this worker will be 1/ ρ.

Given these conditions, it is possible to write θ in the following way:

$$\theta = \frac{1/q}{1/q + 1/\rho} \qquad (4)$$

By substituting the equation (4) in (3), we have:

$$w > b + \left(1 + \frac{\rho}{q}\right)e \qquad (5)$$

It is possible to note a positive correlation between the labor effort (*e*) and the wage rate (*w*) in the equation (5), but an empirical test of this equation is not possible since that the labor effort is not a verifiable variable.

On the other hand, it is possible to verify a trade-off between the wage rate (*w*) and the probability of shirker worker be caught and fired (*q*). If *q* is positively related with the firm intensity of monitoring, so it is possible to infer about a trade-off between wage rate and supervision intensity too.

Empirical tests of the shirking model use the trade-off between wage rate-intensity of supervision as hypothesis. The main problem of these empirical tests is the choice of proxy variable for intensity of supervision. The empirical works on this subject uses two different proxy variables: (1) the size of the firm; and (2) the supervisors/staff ratio (span of control).

In this paper I use the supervisors/staff ratio (span of control) as proxy variable for intensity of supervision.

1.2. The Labor Discipline Model

The labor discipline model is developed in Bowles (1985, and 2004). In this model is assumed that the employer know the best-effort response of workers, *e(w,m,z)*, given the wage rate, *w*, the level of monitoring, *m*, and the exogenous fallback option, *z*.

In the beginning of each time period the employer select and announces: (a) a probability of termination, *t(e,m)* $\epsilon[0,1]$ com $t_e<0$ e $t_m>0$; (b) a wage rate, *w*; and (c) a monitoring level for each hour of labor hired, *m*.

The worker utility function in each period of time is $u=u(w,e)$ with $u_w \geq 0$ e $u_e \leq 0$. The worker varies *e* in order to maximize the present value of his expected utility, given his time preference rate, *i*. The present value of the expected utility can be written in the following way:

$$v = \frac{u(w,e) + [1 - t(e)]v + t(e)z}{1+i} \qquad (6)$$

Alternatively, by using the stationarity hypothesis:

$$v = \frac{u(w,e) + iz}{i + t(e)} + z \qquad (7)$$

The worker will select an effort level, *e*, which $v_e=0$, it implies that:

$$u_e = t_e(v - z) \qquad (8)$$

Supposing that the worker utility function has the following specification:

$$u = w - \frac{a}{1-e} \qquad (9)$$

Where a is a positive constant. Suppose that the firm does not incur in costs to monitor workers[1]. This simplification allows specifying the probability of termination function in the following terms:

$$t = 1 - e \quad (10)$$

Supposing that i and z are zero, these simplifications allow re-writing the equation (7) in the following way:

$$v = \frac{u(w,e)}{t(e)} = \frac{w - a/(1-e)}{(1-e)} \quad (11)$$

Let us remember that workers will select an effort level e which v_e=0 and u_e=t_e(v-z). From equation (10) is known that t_e=-1, so the effort level which maximizes the expected utility function of workers will be:

$$e = 1 - \frac{(1+a)}{w} \quad (12)$$

It is possible to verify in the equation (12) that firms can not extract positive levels of effort (e) from their workers if the wage rate (w) paid is not superior to 1+a (non shirking condition).

[1] Bowles disagrees with the argument that incomplete information arises because the costs and imperfect monitoring. The author suggests that "Incomplete information occurs when some information relevant at the outset of interaction is not revealed to at least one party. It is sometimes suggested that asymmetric information is the source of contractual incompleteness. But this is not quite right. What counts for the feasibility of a complete and third-party-enforceable contract is not only whether the relevant information is known, but also whether information is verifiable, that is admissible in a court of law or some other body that is capable of enforcing its terms".

Substituting the outcome of the equation (12) in to the probability of termination function (equation 10), we have:

$$t = \frac{(1+a)}{w} \qquad (13)$$

This outcome states a trade-off between the probability of termination and wages, which *t* will tend to 1 if the firm pay a wage rate equals 1+a, and *t* will tend to 0 if the firm pays a infinite wage rate. This hypothesis – the trade-off between wages and probability of termination – will be empirically tested in the following sections of this work.

2. Empirical Issues

2.1. Data

The data set used in this paper is RAIS which one uses to cover the period 2003 and 2004. RAIS (Annual Social Information Report) is an annual census of all firms and their employees in Brazil. There is detailed information about each employee (wages, hours worked, education, age, tenure, gender, and occupation) and each firm (industry, region, size, establishment type, etc), including a unique identifier for each firm and each establishment.

This sample uses individual information about 637,527 workers in 2003, and 635,121 workers in 2004. Individual information is also available for employers – 12,329 firms in 2003, and 12,082 firms in 2004. This sample corresponds to the total formal labor force employed in the construction industry located in the cities of Belo Horizonte, Porto Alegre, Recife, Rio de Janeiro, Salvador e São Paulo.

The choice of construction sector analysis is justified for three reasons: (1) the sector has specific statistics of unemployment for each city of the sample; (2) when compared with other industrial sectors, this sector presents higher incidence of workers fired by fair

reason; (3) different from other industrial sectors, the intensity of supervision in the construction industry is exclusively performed by human work, so it is possible to infer that the span of control is a more realistic proxy for intensity of monitoring in this case.

Descriptive statistics of variables used in this paper are reported in the table 1. Statistics are presented for each year of the sample, separately.

2.2. Econometric Tests for the Shirking Model

In this section the shirking model version of efficiency wage is tested by different econometric estimators. In this specific test one only uses information about blue collar workers. Given the occupational code for each worker, it is possible to calculate an accurate measure of span of control for each firm of the sample.

The first step is to test the model through cross section analysis. The specification of the econometric model to be tested is:

$$\ln w_i = \beta_0 + \beta_1 X_i + \beta_2 Z_i + \beta_3 S_i + \varepsilon_i \quad (14)$$

Where lnw_i is the *ln* of worker *i* hourly wage, X_i is a vector of worker *i* attributes, Z_i is a vector of variables related to the firm where the worker *i* is employed, S_i is the ratio supervisors/staff (span of control) in the firm where the worker *i* is employed, β´s are parameters to be estimated, and ε_i is an error.

It was mentioned in the previous sections that shirking model states a negative relationship between wages and monitoring – in terms of the equation (14), it implies a negative value for the parameter β_3.

In order to test this hypothesis, one ran an OLS regression for each period available in the sample. The outcomes are reported in the table 2. In the second column of the table 2 it is

possible to find the parameter β_3 estimated for the 2003, and in the third column the value of β_3 estimated for the 2004. In the both cases the estimated value of β_3 present negative values - -0.0025 for 2003, and -0.00015 for 2004 **-,** but parameter of β_3 for the 2004 is not statiscally significant.

Given the availability of identifier for each firm, an alternative way to test the shirking model is by exploring the panel characteristics of the sample. The specification of the econometric model to be in the panel approach is:

$$\ln w_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 S_i + u_i + \varepsilon_{it} \quad (15)$$

Where u_i is a disturbance that does not varies across the time. There are two hypotheses for relationship between u_i and the other regressors of the equation (15): they are correlated (fixed effect models) or not (random effect models).

The outcomes of these tests are reported in the table 2. Outcomes for random effect model are reported in forth column, and outcomes for the fixed effect model are reported in the fifth one. In the both cases the estimated value of β_3 presents negative values - -0.0050 for random effects model, and -0.0055 for fixed effects model.

In general, the outcomes presented in this section have corroborated the efficiency wage model hypothesis, but it is important to mention some limitations of this section: (1) it is expected that wages and supervision are simultaneously determined, so the estimations obtained here may be biased, and the instrumental variables estimations would be necessary; (2) the panel has only two years; (3) fixed effects estimation is performed only for firms – it would be interesting obtain identifiers for workers in order to control the unobservable heterogeneity of workers.

2.3. Econometric Tests for the Labor Discipline Model

In this section the labor discipline model version of efficiency wage is tested by different econometric estimators. Different from the last section, in this specific test one uses information about blue and white collar workers.

Similar to the last section, the first step is to test the model through cross section analysis. The specification of the econometric model to be tested is:

$$y_i = \beta_0 + \beta_1 \ln w + \beta_2 X_i + \beta_3 Z_i + \beta_4 U_i + \varepsilon_i \quad (16)$$

Where y_i is a dummy variable (y_i=1 if the worker was fired by fair reason, otherwise y_i=0), *ln*w_i is the *ln* of worker *i* hourly wage, X_i is a vector of worker *i* attributes, Z_i is a vector of variables related to the firm where the worker *i* is employed, U_i is the rate of unemployment in the city where the worker *i* is employed, β´s are parameters to be estimated, and ε_i is an error.

An important point to mention is about the expect values for the coefficients β_1 and β_4. The negative relationship between probability of termination and wages has just been discussed in the previous sections. The relationship between probability of termination and unemployment depends, as argued by Campbell (1997), from the nature of the labor contract termination.

Different from that cases which terminations were caused by layoffs (in this case it is expected a positive relationship between termination and unemployment), the expected relationship between fair reason terminations and unemployment rate is negative, since that it is expected that higher unemployment rates reduces the incentives for shirking – it means that unemployment rate is a discipline device on the labor force.

The model specified by the equation (16) was estimated by three different methods: (1) Logit, (2) Probit, and (3) OLS-Linear Probability Model. The outcomes obtained by Probit estimations are reported in the table 3. The second (third) column reports 2003 (2004) outcomes.

The cross sectional outcomes corroborates the theoretical arguments which β_1 and β_4 are negatives. In the case of β_1 the outcomes are -0.1427 for 2003, and -0.0426 for 2004. In the case of β_4 the outcomes are -2.2474 for 2003, and -3.7974 for 2004.

Alike the econometric tests of the shirking model, the cross section outcomes have supported the efficiency wage theory too.

Following the econometric strategy from the previous section, the next step of this work is to explore the panel characteristics of the sample by using fixed effects estimators. The last test is to obtain parameters for β_1 and β_4 by using conditional logistic for fixed effects model.

The results from the fixed effects conditional logistic model are reported in the last column of table 3. After controlling for the heterogeneity of firms, the outcomes remain supporting the trade-off between probability of termination and wages (-0.3448), but the negative relationship between probability of termination and unemployment rate is not supported by the estimated value for β_4 (4.2494). Although the value of β_4 is positive, it is not statiscally significant.

The outcomes presented in this section have corroborated the efficiency wage model hypothesis again, but it is important to mention that these outcomes suffer from the same limitations discussed before (endogeneity, and workers omitted variables). So, it is important to the reader take to account these problems and to interpret the outcomes with some caution.

Final Comments

The aim of this paper was to test the shirking, and the labor discipline versions of the efficiency wage model. A rich data set with detailed information about workers and firms from Brazilian construction industry was used in this way.

Specificities of the sample allow me to use different econometric methods to test the theoretical models presented along of this work. The econometric results supported the efficiency wage hypotheses in all used specifications (cross section, and panel analysis).

It was commented along this paper about the limitations of the tests. Controls for endogeneity, and for unobservable heterogeneity of workers would be very important to provide more robustness for the results – they are the next steps of this preliminary work.

References

Bowles, S. (2004). Microeconomics: Behavior, Institutions and Evolution. New Jersey. Princeton University Press.

Bowles, S. (1985). The production process in a competitive economy: Walrasian, neo-Hobbesian and Marxian models. *American Economic Review*, 75: 16-36.

Brown, C. & Medoff, J. (1989). The employer size-wage effect. *Journal of Political Economy,*97: 1027-1059.

Brown, S. & Sessions, J. (2001). Wages, Supervision and Sharing: An analysis of the 1998 Workplace Employee Relations Survey, *Discussion Papers n.02/7*, Department of Economics, University of Leicester.

Bulow, J. and Summers, L.(1986). A theory of dual labor markets with application to industrial policy, discrimination, and Keynesian unemployment, *Journal of Labor Economics*, 4:376-414.

Campbell, C. (1997) "The Determinants of Dismissals, Quits, and Layoffs: A Multinomial Logit Approach." *Southern Economic Journal*, 63: 1066-1073.

Esteves, L. (2006) Uma nota sobre intensidade de supervisão nas indústrias brasileiras. *Revista Brasileira de Economia*, 60 (3): 235-246.

Rebitzer, J. (1995). Is there a trade-off between supervision and wages? An empirical test of efficiency wage theory. *Journal of Economic Behavior and Organization*, 28: 107-129.

Shapiro, C. and Stiglitz, J. (1984). Equilibrium unemployment as a worker discipline device. *American Economic Review*, 74: 433-444.

Table 1. Descriptive Statistics

Variables	Mean (Standard Deviation) Year 2003	Mean (Standard Deviation) Year 2004
Wage (in minimun wages)	2.96	2.93
Gender (male=1; female=0)	0.94	0.94
	(0.23)	(0.23)
Schooling (years)	6.34	6.50
	(3.38)	(3.39)
Age of Worker	35.67	35.80
	(10.85)	(10.89)
Firm Size (Employees)	54.19	57.45
	(331.60)	(278.09)
Unemployment Rate	0.095	0.076
	(0.021)	(0.016)
% Fired Workers (Fair Reason)	0.0028	0.0028
	(0.053)	(0.053)
Supervisors-staff ratio	0.13	0.129
(span of control)	(1.62)	(1.90)
Number of workers	637,527	635,121
Number of Firms	12,329	12,082

Table 2. Regressions *Shirking Model*

Dependent variable: ln hourly wage

Independent Variables	Cross Section 2003 coefficient (t-student)	Cross Section 2004 coefficient (t-student)	Panel Random Effects Firms coefficient (z)	Panel Fixed Effects Firms coefficient (t-student)
Constant	-5.1700	-4.2203		-4.7356
	(-243.73)	(-195.29)		(-478.74)
Age of Worker	0.0040	0.0038	0.0029	0.0029
	(50.83)	(50.71)	(65.23)	(64.51)
Gender	0.0689	0.0807	0.0566	0.0574
	(7.86)	(8.42)	(10.28)	(10.39)
Schooling	0.0140	0.0122	0.0064	0.0064
	(43.24)	(40.29)	(28.52)	(28.65)
Ln Firm Size	0.0475	0.0389	0.0045	0.0035
	(95.04)	(82.99)	(3.56)	(2.26)
Supervisors-staff ratio	***-0.0025***	***-0.00015***	***-0.0050***	***-0.0055***
(span of control)	***(-8.12)***	***(-0.73)^{NS}***	***(-7.17)***	***(-7.35)***
Controls occupations.	Yes	Yes	Yes	Yes
Controls industries.	Yes	Yes	Yes	Yes
Controls local.	Yes	Yes	Yes	Yes
Observations	352,017	357,348	709,365	709,365
R^2	0.3478	0.3450		
F-Statistic	11,042.32	11,072.40		
Nr. Groups			10,378	10,378

Table 3. Regressions *Labor Discipline Model*

Dependent variable: Fired worker fair reason=1; Otherwise=0

Independent Variables	**Probit 2003 Model coefficient (z)**	**Probit 2004 Model coefficient (z)**	**Conditional Logit Fixed Effects Firms Coefficient (z)**
Constant	-3.0954	-2.8388	
	(-13.21)	(-10.22)	
Ln hourly wage	**-0.1427**	**-0.0426**	**-0.3448**
	(-6.41)	**(-1.76)**	**(-7.29)**
Age of Worker	-0.0021	-0.0027	-0.0107
	(-2.67)	(-3.20)	(-5.52)
Gender	0.1829	0.1194	0.6702
	(3.39)	(2.15)	(4.89)
Schooling	0.0016	-0.0096	0.0101
	$(0.50)^{NS}$	(-3.01)	$(1.13)^{NS}$
Ln Firm Size	-0.0312	-0.0324	0.1029
	(-7.11)	(-6.86)	$(1.38)^{NS}$
Local Unemployment	**-2.2474**	**-3.7974**	**4.2494**
	(-6.13)	**(-8.32)**	$\mathbf{(1.16)^{NS}}$
Controls ocuppations.	Yes	Yes	Yes
Controls industries.	Yes	Yes	
Observations	601,072	598,143	1,199.215
Wald Chi	444.98	703.74	260.29
Log pseudolikelihood	-11,047.66	-10,961.30	-14,393.12
Hausman			37.97