CAN THE PREVIOUS YEAR UNEMPLOYMENT RATE AFFECT PRODUCTIVITY? A DPD CONTRAST*

Rosario Sánchez**

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ABSTRACT

This paper presents evidence that sector productivity level increases when either relative wage or the level of unemployment rises. It can be established that value added depends not only on present unemployment rate, but also on the level of unemployment of the previous year. Both facts are consistent with the efficiency wage model. Moreover there is support for the idea that an increase in sector's wage with respect to the previous year level, also increases productivity. The empirical evidence has been obtained using a Dynamic Panel Data estimation.

KEY WORDS: Wage, rigidity, panel.

RESUMEN

Este documento presenta evidencia que el nivel de productvidad del sector se incrementa, cuando aumenta el salario relativo o el nivel de desempleo. Se establece que el valor añadido depende no solamente de la tasa de desempleo actual, sino también de la tasa del año anterior. Ambos hechos son consistentes con el modelo de eficiencia salarial. Es más, se sostiene la idea que un aumento en el salario del sector con respecto al del año anterior también incrementa la productividad. La evidencia empírica se obtiene a través de una estimación de panel dinámico de datos.

PALABRAS CLAVE: Salarios, rigidez, panel.

0.- Introduction.

In this paper I attempt to test some of the predictions of the efficiency wage model through a labour augmenting production function where the factor of augmentation, the effort, is specified as a CES function. According to the fair wage hypothesis, workers proportionately withdraw effort as their actual wage falls short of their fair wage[1]. As well, the shirking model is tested through the introduction of the unemployment rate as an explanatory variable of the CES effort function.

The economics consequences depend on how the fair wage is determined. There are three natural possibilities: individuals may compare themselves with others in similar occupations in the same firm, with those in dissimilar occupations in the same firm, or with individual in other firms (Akerlof and Yellen, 1990). Another possibility is to suppose that workers do not merely compare their wage with outside opportunities, but they also allow their comparison standard to rise with past achievements. In this sense, an increase in the real wage this year has to be compared with last year increases.

The traditional Shirking model is based on the imperfect information that firms have concerning the effort of their employees. Monitoring individual performance is assumed to be impossible or very costly and the punishment for low performance is limited by legal constraints. As an incentive for workers to work instead of shirking, firms may find it profitable to rise wages. This attitude increases the cost of job loss in two ways. First, because this wage is higher than the wage paid by other firms. Secondly, this wage is above the market clearing level and thus will generate involuntary unemployment. In the simplest version, according to Shapiro and Stiglitz (1984) workers and firms are assumed to be homogeneous. And as a firms are identical, they would all find it profitable to raise wages. Relative wage will keep constant, and only unemployment will act as a discipline device.

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[1]For more explanation see Akerlof, A. and Yellen, J.L. (1990).

Some firms do care about their quality of their labor force; they are worried about providing incentives to their workers (in the competitive paradigm, the firm could not care less whether some workers decide to work or not since there is a competitive supply of workers readily available to perform any service; workers who do not do what they have been contracted to do are replaced by ones who will).

In general, by paying higher wages, firms obtains a higher quality labor force (Stiglitz, 1976; Weiss 1980). Thus, firms could have two different strategies equally profitable that are: to pay more with a reduced labour force or pay less and increase the number of workers, to obtain a given level of production. In both cases the workers are paying for themselves.

In the Literature there exist three studies that use a methodology similar to that of this paper, and augment standard production function with measures of relatives wages. J. Straka finds that when industry had wage growth greater than that industry's trend value, it also had growth in total factor productivity above its trend (1989). S. Wadhwani and M. Wall, using U.K. financial data, find that firms increase their average wage increase productivity (1988). D. Levine finds that business units that increase relatives wages for workers of similar human capital have productivity gains approximately large enough to pay for the wage increases.

The novelty of this work is that here the direct test, about the efficiency wage hypothesis, has been done through the estimation of a production function where the effort is included as an additional input. Beside this, the effort is defined as a CES function, depending on the relative wage, on the unemployment rate and on a dummy variable that reflects changes in the real wage paid by the sector with respect to previous year.

To avoid simultaneity bias a standard instrumental variable estimator provided by the Dynamic Panel Data computer program due to M. Arellano and S. Bond will be used.

1.- The Model.

The basic framework of a standard efficiency-wage model starts assuming that wages, "w", affect worker efficiency, "e". In the implementation of this hypothesis worker efficiency is assumed to be labour augmenting, and enters in the production function as an additional input. In order to test the efficiency wage hypothesis, it can be assumed a Cobb-Douglas production function with only two inputs: effective labour "E", and capital "K".

$$Y_{it} = A_i K_{it}^{\alpha} E_{it}^{\beta} \exp(\mu t) \exp(u_{it}) \tag{1}$$

$$E_{it} = e_{it} L_{it} \tag{2}$$

$$e_{it} = (a_1 \, RW_{it}^{-\rho} + a_2 \, TU_t^{-\rho})^{-1/\rho} \exp(vwd_{it}) \tag{3}$$

Where:

Y_{it}:	Value added of sector i in year t.
A_i :	A sector-specific fixed effect.
E_{it}:	Effective labor force of sector i in the year t.
K_{it}:	Capital stock of sector i in year t.
t :	Denotes a time trend.
u_{it}:	An error term which is assumed to be normally distributed with mean zero, and variance σ^2.
e_{it}:	Average efficiency of the labour force of sector i in year t.
L_{it}:	Employment of sector i in year t.
RW_{it}:	Relative wage paid by sector i year t.
TU_t :	The unemployment rate of the year t.
vwd_{it}:	Is a dummy variable that takes value 1 if real wage has increases with respect to previous years.

The novelty that this work incorporates is the specification of an effort function. The CES effort function was chosen because it is more general than a Cobb-Douglas effort function. The efficiency wage theories that have been considered above imply that the relative wage and unemployment should be included as additional explanatory variables in (3).

The general conditions that have to apply to any effort function are that: $e_w > 0$ and $e_{ww} < 0$, in words the effort function has to be concave with respect to wages. To check it the expression (3) can be differentiated totally, and then:

$$\frac{\delta e}{\delta WR} = a_1 \gamma^{-\rho} \; e_{it}^{1+\rho} \; WR_{it}^{-1-\rho} \tag{4}$$

$$\frac{\delta e}{\delta WR^2} = - a_1 \gamma^{-\rho} (1-\rho^2) \; e_{it}^{\rho} \; WR_{it}^{-2-\rho} \tag{5}$$

From (5) it can be obtained that the effort function will be concave when "ρ" (the substitution parameter)[2] is smaller than 1.

A major problem with the CES function is that unlike the Cobb-Douglas it cannot be transformed into a linear in parameters form by operation such as taking logarithms. Using a Cobb-Douglas effort function is rather more restrictive than a CES where the elasticity of substitution between wage and unemployment is 1/1+ρ. In order to facilitate estimation I use the log-linear approximation suggested by Kmenta (1967) and thus the effort function becomes:

$$\log e = a_1 \log WR + a_2 \log TU - 1/2\, \rho a_1 a_2 \,[\log WR/TU\,]^2 + a_3 vwd \tag{6}$$

In fact, the squared logarithm of the wage unemployment ratio is added to the Cobb-Douglas log-linear regression, and this last term indicates the

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[2]It can be shown that the CES effort function reduces to the Cobb-Douglas as $\sigma=1$ then $\rho=0$.

departure from an unit elasticity of substitution. The regression coefficients yields estimates of the four parameters.

Substituting (6) in (2), and (2) in (1) and taking logarithms the simplest equation that I seek to estimate is of the form[3]:

$$\boxed{\begin{aligned} y_{it} = {} & a_i + \tau_1\, wr_{it} + \tau_2\, tu_t + \tau_3\, wrtu_{it} + \tau_4\, vwd_{it} + \\ & + \tau_5\, k_{it} + \tau_6\, l_{it} + \mu t + u_{it} \end{aligned}} \qquad (7)$$

The value of ρ is held in parameter τ_3 and indicates the degree of substitution between the real wage and the unemployment rate. High unemployment not only raises effort, but also reduces the effect of wages upon effort.

The case where the effort (e) enters multiplicatively with the labour factor (L) corresponds to the form which is most often used in the theoretical literature. However I will use, also, the alternative form that consist in allowing β to depend on effort instead of entering multiplicatively with L[4].

The value added production function in the second case can be defined as:

$$Y_{it} = A_i K_{it}^{\alpha} L_{it}^{\beta} \exp(\mu t) \exp(u_{it}) \qquad (8)$$

$$\beta = \beta_0 + \beta_1 \log e_{it} \qquad (9)$$

The equation to be estimated in this second form is obtained substituting (9) in (8), and taking logs:

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[3]Lower case letters denote logarithms.

[4]This second form was primarily propose by Wadhwani and Wall (1988), but in their work they do not define an effort function.

$$y_{it} = a_i + \tau_1 \; wr_{it} l_{it} + \tau_2 \; tu_t l_{it} + \tau_3 \; wrtu_{it} l_{it} + \tau_4 \; vwd_{it} l_{it} + \tau_5 \; k_{it} + \tau_6 \; l_{it} + \mu t + u_{it} \tag{10}$$

The advantage of the equation (10) with respect to equation (7) is that here differences are introduced through sectors in the returns of the labour factor. The disadvantage here is that the elasticity of the production with respect to the wage cannot be computed directly.

2.- The Empirical Implementation.

The Data used for estimation is the Industrial Inquiry for 89 sectors of the Spanish industrial economy and carried on by the National Institute of Statistics (INE) and Fundación Empresa Pública. The information used to make the sectors has been obtained from a random sample of companies. One of the difficulties of this data source is the degree of aggregation. For this kind of estimation firm level data is more appropriate, but in this case the data available was made for a sector level. The years to be used in the estimation are from 1978 to 1988.

The Dynamic Panel Data (DPD) is a program written in the Gauss matrix programming language to compute estimates for dynamics models from panel data. A number of estimators are available, including the generalized method of moments (GMM) technique developed in Arellano and Bond (1988), as well as instrumental variable procedures. Lagged and first-differenced series are easily constructed. Standard errors and test statistics that are robust to the presence of heteroskedasticity are provided. Test for serial correlation and instrument validity are automatically computed. If the model has been transformed to first differences, first-order serial correlation is to be expected but not second order.

3.- The Results.

In Tables 1 and 2 the results appear of the different estimations of the value added production function for the industrial sectors of Spain for the period (1978-1988). Equation (7) has been estimated in regressions 1 and 3, and equation (10) in regressions 2, 4 and 5. A common practice in this type of regressions is to estimate the first difference form to remove the fixed effect component, the regressions have been carried out in this way and by using instrumental variables estimates.

In general the coefficients of the variables were as expected. In Table 1 the estimation of both equations has been produced without taking into account the lag of the unemployment rate. In Table 2 the lag of the unemployment rate is introduced and equation (10) is estimated considering the effort function as a Cobb-Douglas instead of a CES, the results are reported in the instrumental variables estimates (5).

The relationship between effort and relative wage (RW) has to be positive in a efficiency wage model. In this context, sectors pay above the market clearing level to increase productivity. To construct the relative wage the average wage of the enquire has been used. It can be considered the average wage acts as a "proxy" of the opportunity wage of the sector's labour force. The value of the coefficients of this variable are insignificantly different from zero in the most part of the cases with the exception of the estimate reflected in (5), that are significantly different from zero at 1% level of significance.

The relationship between unemployment (TU) and effort has to be positive in an efficiency wage framework. In the most part of the estimation the coefficient of the unemployment rate is positive and significantly different from zero at 1% level of significance. In Table 2 the lag of the unemployment rate (TU (-1)) has been introduced. With this variable I try to reflect the idea that for workers not only can be important the actual unemployment rate if not also the evolution of this rate. In Spain the unemployment rate has been increased in the last years, then the workers know that it is quite difficult to find a job when they have been fired and this is a strong concept precisely because it happens year after year. In the results it can be checked that the coefficient of the lag of the unemployment rate are significantly different from zero at 1% level of significance in two of the three estimations.

With the variable WRTU the substitution parameter "ρ" can be obtained. The coefficient of this variable is positive, and as it can be seen in equation (6), it means that the parameter ρ is negative as it can be expected in an efficiency wage context. If the wage is kept constant then an increase in the unemployment rate has to raise the level of effort; or alternatively if the unemployment rate raises thus to keep the effort constant the real wage can be smaller. In all the regressions the value of ρ is bigger than 1, this result implies that the effort function is not concave; besides, the coefficient of this variable in the estimation (5) is insignificantly different from zero at 5% level of significance.

The results obtained with the variable WRTU has induced the alternative estimation of the value added production function with the specification of a Cobb-Douglas production function; the values of these estimates are reported in (5). The last regression in table 2 report the best results for the coefficients of all the explanatory variables, in this case the coefficient of the relative wage has to be smaller than one to fulfill that the effort function is concave with respect wages. The value of this coefficient can be obtained dividing the value of the coefficient reflect in (5) by the coefficient of the labour force, and as it can bee seen this condition applies.

The variable VWD reflects the effect of an increase in real wage with respect to previous year. Efficiency wage models assume that workers compare themselves either with others in a similar position, or with their expected opportunities if they left the sector. There is evidence that people become accustomed to a certain state, good or bad and, therefore, tend to be influenced by events that are better or worse than normal. In this case this variable picks up the treatment of the sector in the actual year and in this context it has to be positive. The VWD(-1) reflects the previous year treatment and thus it has to be negative in the sense that this year increases have to be higher than last years, to positively affect effort. Otherwise the worker does not feel that he is receiving a gift in the sense of Akerlof (1980). Both variables have the correct sign and are significantly different from zero at 1% level of significance, but in both cases the value of the coefficient is small implying that the effect on effort is not relevant.

The best results are obtained with regression (5). All the coefficients of the explanatory variables have the correct sign and are significantly different from zero, with the exception of the variables TU and VWD, on the other hand these variables with one lag are significant at 1% level.

In general the results obtained are in favor of the existence of the efficiency wage model. In regression (5) it can be observed constant return to scale, that is a plausible result. The coefficients of the long run solution when all the dynamics have been solved can easily be obtained with the value of VA(-1). The value of the effort elasticity with respect to the wage is 0.28, then it is clear that the Solow's Condition does not hold. However it is possible to have production function with a lower effort-wage elasticity in the case of wage bargain with unions or when there are more than one factor affected with the same effort function[5]. The effort elasticity with respect to the unemployment rate is 0.12 and for the lag unemployment rate is 0.29 indicating that the effect of increases in the unemployment rate on effort are significant.

In the work due by Sánchez et all (1993) about the existence of wage premium in Spain with the same Inquire, they obtain that the Solow's condition hold for the sectors that seems to pay wage premium. In that paper the estimation was carried out separately for the real wage paid by the sector and for the average wage paid by a group of sector with the same characteristics.

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[5]For more information see Akerlof and Yellen (1986) pp 14-15.

On the other hand in that work the variable that picked up changes in the employment was insignificantly different from zero. Here, instead of changes in the sectorial employment, the aggregate unemployment rate has been used and it is positive and significantly different from zero a 1% level of significance, as it is predicted by theory.

4.- Alternative Explanations for the Wage-Productivity Relation.

The fundamental predictions of efficiency-wage models are supported by these results. Increases in relatives wages (controlling for differences in quality of labour among sectors)[6] lead to increases in productivity but not large enough to pay for the wage increases because the Solow's condition does not hold.

The positive correlation between productivity and wages is consistent with rent-sharing theories. Rent-sharing and efficiency wages theories are also complementary, because the efficiency wage effects reduce the cost of sharing rents. If workers share rents as in the Insider-Outsider models of wage determination, then high productivity in this sectors will cause high relatives wages. A problem in interpreting these results is not likely because internal instrumental variable estimates have been used.

Another reason to have this positive relation is the existence of differences in labour quality not observable to the econometrician. I attempt to control for this possibility by allowing a sector specific fixed effect.

[6] All the sectors used for regressions have the same proportion of "blue collar" workers and "white collar" workers. The blue collar worker represents the eighty per cent of the labour force of the Inquire.

While differences in human capital may account for positive influence of wages on productivity it is less likely to explain why variations in unemployment would improve productivity. In an efficiency wage model the unemployment acts as a discipline device and then if it increases it could be expected a higher effort and thus a higher value added.

5.- Conclusions.

Evidence has been found in favor of the efficiency-wage models. It has been obtained that sector-level value added increases when either the relative wage rises or the level of unemployment rises. The estimated effort-wage elasticity for the long run is around 0.28, this implies that increases in productivity are not large enough to pay for increases in wages. The effort-unemployment elasticity for the unemployment rate is around 0.12, while the elasticity of the effort-unemployment lagged one year is 0.29. As it has been shown for the industrial sectors of Spain the unemployment rate has a higher effect on productivity than the relative wage. These results can easily be explained by efficiency wage considerations. Spain has a long tradition in high unemployment rate then the cost to be fired are, perhaps, higher for the difficulties to be rehired in alternative sectors.

DATA APPENDIX

VA: Value added in real terms and logarithms.

VA(-1): The lag of the Value added.

WR: Relative wage in real terms and in logarithms. The average wage of the enquire has been taken as a "proxy" for the opportunity wage of the labour force.

WRL: Is the log of relative wages multiplied by the log of the labour force in the sector.

L: Is the logarithm of the labour force for the sector.

T: Time trend.

TU: Unemployment rate in logs.

TU(-1): The lag of the unemployment rate.

TUL: Is the log of the unemployment rate multiplied by the log of the labour force in the sector.

K: The log of the Stock of capital in real terms.

WRTU: Is equal to $[\log WR/TU]^2$.

WRTUL: Is WRTU multiplied by the log of the labour force.

VWD: Is a dummy variable that takes value 1 if the real wage has increased in the sector this year.

VWD(-1): Is a dummy variable that takes value 1 if the real wage has increased in the sector the previous year.

VWDL: Is VWD multiplied by the log of the labour force in the sector.

VWDL(-1): Is VWD(-1) multiplied by the log of the labour force in the sector.

TABLE 1

VALUE ADDED PRODUCTION FUNCTION (1978-1979)

VARIABLES	INST.VARIABLE(1)	INST.VARIABLE(2)
Constant	-0.040707 (-0.3789)	-0.071942 (-0.7334)
VA(-1)	0.329226 (3.3689)	0.607777 (6.52840)
WR	0.027224 (0.9792)	—
WRL	—	0.042277 (1.5760)
L	0.284357 (2.1670)	0.466058 (3.2294)
T	0.003847 (0.2961)	0.010529 (0.9767)
TU	0.347837 (3.8992)	—
TUL	—	0.045642 (1.2204)
K	0.455674 (1.2852)	0.170812 (0.7539)
WRTU	0.876615 (4.2152)	—
WRTUL	—	0.020079 (1.7634)
VWD	0.09892 (1.8860)	—
VWD(-1)	-0.12298 (-2.2805)	—
VWDL	—	0.005177 (1.4646)
VWDL(-1)	—	-0.006263 (-2.1352)
T.WALD	175.68(9)	434.58(9)
T.SARGAN	22.14(26)	29.78(26)

Notes: a) t-student between brackets.
b) Dependent variable VA (Value added).

TABLE 2

VALUE ADDED PRODUCTION FUNCTION (1978-1979)

VARIABLES	INST.VARIABLE(3)	INST.VARIABLE(4)	INST.VARIABLE(5)
Constant	-0.067878 (-0.5709)	-0.261636 (-1.6483)	-0.314898 (-2.4595)
VA(-1)	0.348105 (2.7749)	0.631364 (6.27977)	0.413541 (4.97319)
WR	0.021382 (0.7074)	___	___
WRL	___	0.015520 (0.55811)	0.055397 (2.36119)
L	0.354105 (2.8183)	0.734146 (4.0198)	0.333046 (1.85679)
T	0.007582 (0.5168)	0.030428 (1.7665)	0.038915 (2.53835)
TU	0.358155 (4.1042)	___	___
TU(-1)	-0.051710 (-0.4373)	___	___
TUL	___	0.055730 (1.4799)	0.025569 (0.80280)
TUL(-1)	___	0.052860 (1.7913)	0.058485 (2.80816)
K	0.523912 (1.3889)	0.105291 (0.3849)	0.763162 (3.87253)
WRTU	0.801064 (3.7110)	___	___
WRTUL	___	0.011861 (1.0354)	___
VWD	0.094640 (1.6740)	___	___
VWD(-1)	-0.116240 (-2.0104)	___	___
VWDL	___	0.007395 (2.1146)	0.004000 (0.44067)
VWDL(-1)	___	-0.007151 (-2.3182)	-0.002592 (-3.4696)
T.WALD	200.06(10)	311.04(10)	423.09(9)
T.SARGAN	23.11(25)	29.03(25)	26.83(26)

Notes: a) t-student between brackets.
b) Dependent variable VA (Value added).

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