IS THE EFFICIENCY WAGE HYPOTHESIS VALID FOR DEVELOPING COUNTRIES?

EVIDENCE FROM THE TURKISH CEMENT INDUSTRY

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Abstract

The efficiency wage hypothesis is tested by using one of the recently developed methods to measure technical efficiency. We use panel data on 40 Turkish cement plants for the period 1980-1995. The predictions of the efficiency wage hypothesis are tested in two ways: estimation of wage augmented production frontiers and the simultaneous estimation of a production function together with inefficiency effects. Our empirical analysis shows that the wage level is one of the significant factors contributing to the output and technical efficiency of plants in the cement industry in Turkey.

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1. Introduction

Recent empirical findings show that two of the main characteristics of the labour market are involuntary unemployment and large differences in wages for workers in similar occupations. One explanation for these phenomena is the efficiency wage hypothesis which states that if work effort depends positively on the wage level, a profit maximising firm would find it profitable to pay above the market clearing level. If the linkage between wages and effort differs across firms and industries, then the optimal wage will differ across firms and industries. Consequently, there will be differences in wage levels for workers with similar abilities and occupations with similar characteristics.

There are four main ways of rationalising the benefits of paying higher wages.[1] In the shirking version, higher wage payments reduce shirking by increasing the cost of losing the job (Solow, 1979; Shapiro and Stiglitz, 1984). In the turnover version, higher wage payments reduce labour turnover costs (Salop, 1979). The adverse selection version states that offering a higher wage will increase the average quality of the job applicants, and thus raise the average quality of the worker that the firm hires (Weiss, 1980). Finally, the sociological version states that a higher wage can build loyalty among workers and hence increase workers' effort (Akerlof, 1982).

Although there are a number of empirical studies testing efficiency wage models, very few have attempted to test directly the effect of wage increases on the performance of a firm.[2]

[1] See Yellen (1984), Katz (1986) and Akerlof and Yellen (1986) for literature surveys.
[2] For a survey of the methodology and results of previous empirical studies, see Katz (1986). The evidence suggests that a rise in the relative wage level: increases productivity (Wadhwani and Wall, 1991; Levine, 1992; Orszag and Zoega, 1996); increases firms' market share (Konings and Walsh, 1994); increases job satisfaction (Akerlof *et al.*, 1988); reduces disciplinary dismissals (Cappelli and Chauvin, 1991), reduces supervisory costs (Leonard,

Instead, most previous empirical studies find supportive evidence for the efficiency wage hypothesis by examining wage differentials across industries, firms and occupations. However, the findings from such studies have been criticised on the grounds that such tests are indirect, and that differences in wages for workers can be largely attributed to compensating differentials or unobservable worker quality (Weiss, 1986).

In view of this criticism, we directly test the effect of the wage level on a firm's performance in two different ways. In the first, following Wadhwani and Wall (1991) and Levine (1992), the efficiency wage hypothesis is tested by using a wage augmented composed-error production frontier. In the second, we consider the wage level as a determinant of the inefficiency effects in the production frontier. The second method differs from the first in that it uses the estimated firm level technical (in)efficiency as the performance measure and investigates whether the wage is a significant determinant of the firm's inefficiency.

This paper has two distinctive features. Firstly, although the efficiency wage model originated from work in less developed countries (Leibenstein, 1957[3]), almost all of the previous empirical studies have been confined to developed countries.[4] The efficiency wage model is particularly important for developing countries since, if valid, it raises important questions regarding the effectiveness of stabilisation and structural adjustment policies (for detailed

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1987), turnover costs (Krueger and Summers, 1988), hiring and training time and the job vacancy rate; and attracts experienced and productive workers (Holzer, 1990), and more applicants (Holzer *et al.*, 1991).

[3] By observing the agricultural sector of less developed countries, Leibenstein (1963) identified the positive link between nutrition and workers' productivity.

[4] There are two previous empirical studies which have tested the validity of the efficiency wage hypothesis in developing countries. Downes and Leon (1994) find that the wage rate has no direct impact on labour productivity in Barbados. Riveros and Bouton (1994) report the results of D.I. Robbins who finds supportive evidence for the efficiency wage hypothesis by analyzing wage differentials across firms in the manufacturing sector in Sao Paulo, Brazil.

discussion, see Riveros and Bouton, 1994). This study tests the validity of the efficiency wage hypothesis by using firm level data from a developing country, namely Turkey. Secondly, our methodology permits us to decompose productivity growth into technological progress and changes in efficiency. This separation is important since workers' effort is expected to be translated into efficiency gains rather than technological progress.[5] Our study confirms the predictions of the efficiency wage hypothesis. We find that the wage level is a significant factor in determining efficiency at the firm level in the Turkish cement industry.

The remainder of the paper is organised as follows. Section 2 and section 3 describe the estimation method and data respectively. The empirical findings are presented in section 4 and, finally, the conclusions are summarised in section 5.

2. Estimation Methods

There are a variety of measures that can be used to assess the performance of a country or sector or firm. Partial or total productivity are commonly used performance measures. In recent years, the frontier production function with composed errors has been increasingly used by researchers (see, for example, Caves, 1992; Perelman, 1995; Battese *et al*., 1996). The most important advantage of this method over the more traditional methods is that it takes into account the distinction between the two main sources of productivity growth, namely technological progress and efficiency change. This approach explicitly recognises the fact that some plants do not use their resources efficiently, i.e. they operate inside the production

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[5] Various factors have been suggested to account for technological progress: market structure, human capital, R&D expenditures, investment etc. Largely depending on the nature of technology, a rise in the wage level especially of unskilled workers may create incentives for firms to substitute capital for labour which may lead to capital deepening technological progress.

frontier defined by the "best practice" technology. In this respect, the production frontier corresponds to the set of maximum attainable output levels for a given combination of inputs and technology, and technical efficiency refers to the ability to produce a given amount of output by using the minimum level of inputs that the production technology allows.

The stochastic frontier production function for the measurement of technical efficiency was first proposed by Aigner *et al*. (1977) and Meeusen and van den Broeck (1977). In their survey articles, Lovell (1993) and Greene (1993) summarise contributions to the econometric modelling of production frontiers and the estimation of technical efficiency.[6]

The basic proposition of the efficiency wage hypothesis is that beside factor inputs, workers' effort should also be regarded as contributing to the output level of a firm. Accordingly, effective labour input is a combination of physical labour input and workers' effort. The effort of workers is assumed to be increasing in the real or relative wage. Furthermore, under the assumption that the effective labour input is the *product* of effort and employment, it can be shown that the elasticity of effort with respect to the wage level is unity (Solow, 1979). Empirically, this so-called "Solow condition" implies that the estimated coefficients of the wage level and physical labour input in the production function should be the same. In other words, the output elasticity of physical labour and the wage level should be equal.

2.1 Wage Augmented Production Frontiers

A wage augmented Cobb-Douglas frontier production function can be written as follows:

$$\ln y_{ft} = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln x_{ift} + \beta \ln w_{ft} + \gamma T + (v_{ft} - u_{ft}) \qquad (1)$$

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[6] See also Førsund *et al*. (1980), Schmidt (1986) and Bauer (1990).

where f indexes plants (or firms), t denotes time, y is output, x_i represent factor inputs and w_{ft} is the wage level. The time trend T is included to capture technical progress. We also estimate the Translog version of equation (1).[7]

We specify a composed error structure for the stochastic term as suggested by Battese and Coelli (1993). In equation (1), v_{ft} are random effects which are assumed to be independent and identically distributed with zero mean and variance σ_v^2, and are independently distributed of u_{ft}. The u_{ft} are non-negative random variables to account for technical inefficiency, and are assumed to be independently distributed and drawn from a truncated (at zero) normal distribution with variance σ^2. Intuitively, the v_{ft} represent random disturbances to production such as weather conditions, while u_{ft} have an asymmetric distribution and represent the deviations of production from the frontier due to technical inefficiencies.

The technical efficiency for plant f at time t is defined as:

$$TE_{ft} = \exp(-u_{ft}) \qquad (2)$$

Given the distributional assumptions on the error terms, equations (1) and (2) can be estimated by the Maximum Likelihood (ML) method.

There are two related previous studies in the literature. Using data on 219 UK manufacturing companies over the period 1972-82, Wadhwani and Wall (1991) test the efficiency wage hypothesis by including a relative wage measure and the unemployment rate into a standard

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[7] A standard Translog frontier production function with composed errors can be defined as:

$$\ln y_{ft} = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln x_{ift} + \tfrac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln x_{ift} \ln x_{jft} + \gamma_0 T + \tfrac{1}{2}\gamma_1 T^2 + \sum_{i=1}^{n} \delta_i T \ln x_{ift} + (v_{ft} - u_{ft})$$

production function. Similarly, Levine (1992) estimates a production function using data on North American manufacturing companies for the period 1970-85. The results of both of these studies confirm the predictions of efficiency wage theory, that higher wages are associated with higher levels of output. However, both studies employ a conventional production function, rather than the theoretically more appealing production frontier as utilised in this study.

2.2 Inefficiency Effects Model

Recently, Battese and Coelli (1993, 1995) proposed an extension to the traditional stochastic production frontier in which the technical inefficiency of a production unit is considered as a function of a set of explanatory variables. That is, the efficiency term, u_{ft}, in equation (1) is now assumed to arise from the truncation (at zero) of a normal distribution with mean $z_{ft}\delta$ and variance σ^2, where z_{ft} is a vector of explanatory variables associated with the technical inefficiency of a firm *f* at time *t* and δ is a vector of unknown coefficients. More formally, the inefficiency effects model can be written as equation (1) with:

$$u_{ft} = z_{ft}\delta + \eta_{ft} \tag{3}$$

and thus technical efficiency for plant *f* at time *t* is defined as:

$$TE_{ft} = \exp(-z_{ft}\delta - \eta_{ft}) \tag{4}$$

Thus, the level of inefficiency depends upon a variety of factors such as firm-specific accumulated knowledge, organisation of production and market structure. In particular, the efforts of managers and workers can be allowed to determine the level of inefficiency (Aigner *et al*. 1977) and, accordingly, the efficiency wage hypothesis can be tested by including the wage level amongst the set of variables determining the level of inefficiency.[8]

3. Data and Definition of Variables

Our analysis uses unbalanced panel data for 40 plants from the Turkish cement industry for the period 1980-1995. The main sources of data used are the returns from our questionnaire and the Turkish Cement Producers' Association (TCPA) cement and clinker statistics. Due to their different nature, clinker grinding and parcelling plants are excluded from the analysis and we concentrate on cement plants only. Since some of the plants started cement production after 1980, and/or reported information only for more recent years, data for the whole period are available only for 22 plants. Variable definitions and summary statistics are given in Table 1 and a detailed description of the key variables is provided in the Appendix. Estimation of the production frontier utilises four factor inputs - capital (K), labour (L), energy (E) and raw materials (R) - together with a time tend (T) to proxy technical progress and a variable indicating the "quality" of output (Q). To test the validity of the efficiency wage hypothesis, we investigate the impact of two different measures of wages: the wage level relative to average wages in the cement industry (WIND) and the wage level relative to other cement plants in the same region (WREG).

In the inefficiency effects model, it is important to control for other factors that may contribute to the performance of a plant. We use a number of control variables in order to isolate the effect of the wage level. These variables can be grouped into: ownership structure (PRIVATE, EXPUBLIC, FOREIGN); market structure (DEMAND, MKTSHARE, EXPORTS),

[8] Estimation of both the wage augmented production frontier and the inefficiency effects model is by FRONTIER Version 4.1 program (Coelli, 1994).

technology (AGE, TECHAGE, TECj, R&D); organisational status (OS); and location (REGk).

Finally, we attempt to address two important criticisms of the efficiency wage hypothesis. The first is that any observed positive correlation between wages and output is due to unmeasured individual ability; more skilled and educated workers, receiving higher wages, are more productive. To account for this possibility, we construct a human capital variable (SKILLED) as the share of engineers, technicians and qualified workers in total employment.[9] The second criticism that we wish to address is that the theory of rent-sharing also predicts a positive relationship between wages level and productivity. However, according to this model, the causality is reversed and goes from productivity to wages due to the rent-sharing considerations of trades unions. Therefore, in order to mitigate this effect, we control for the unionisation rate (UNION). Unionised workers in the Turkish cement industry belong to the same labour union, namely, CIMSE-IS, but the rate of unionisation differs across the plants and over time mainly due to the different number of sub-contractors' workers in each plant.

4. Estimation Results

4.1 Wage Augmented Production Frontier

Table 2 presents the ML estimates of conventional and wage augmented Cobb-Douglas and Translog frontier production functions. Columns (1) and (4) present the basic specifications. A simple log-likelihood test indicates that the restrictions imposed by the Cobb-Douglas production function are not supported by the data. Furthermore, with regard to the specification of the error term, the estimation results show that the traditional production

[9] The number of qualified workers depends entirely on the judgement of plant managers.

function specification should be rejected in favour of the composed error production frontier specification.[10]

In columns (2) and (5), we augment the production frontier by the wage relative to the industry average, WIND. Its positive sign indicates that output is positively correlated with the wage, confirming the primary prediction of the efficiency wage hypothesis. In columns (3) and (6), we use the alternative definition of the relative wage variable, that of the wage relative to the regional average, WREG. Again the coefficient is positive although only significant in the Translog specification. Once again, comparing the Cobb-Douglas with the Translog rejects the former over the latter in both cases.

Our estimation results indicate that the Solow condition does not hold since the coefficients of the relative wage level are significantly less than the coefficients of the employment variable. This implies that the estimated elasticity of effort with respect to wages is less than one. Finally, the test of the degree of returns to scale in production at the bottom of the table indicates that there are significantly increasing returns in every case.

4.2 Inefficiency Effects Model

Results for the inefficiency effects model are given in Table 3. Since the restrictions imposed by the Cobb-Douglas production frontier are always rejected, only the Translog specification results are reported. As in the case of the augmented production frontier in Table 2, the composed error specification is not rejected by the data.

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[10] The relevant test is simply a test of H_0: $\gamma = \sigma^2/\sigma_s^2 = 0$.

Results from three different models are reported in Table 3. In the first column, all available variables which are considered as possible factors affecting the efficiency level of a plant except the wage are included in the model. Note that the coefficients on both SKILLED and UNION are insignificantly different from zero. Thus the two alternative explanations, namely human capital differences and rent-sharing theories, would appear to be rejected as explanations for the observed positive correlation between wages and productivity.

It can be seen that ownership structure significantly affects the level of efficiency in cement plants. The results suggest that the efficiency of public sector cement plants is significantly lower than in private and privatised plants. Moreover, it is estimated that plants owned by foreigners operate less efficiently than others, *ceteris paribus*[11]. The regional market power variable (MKTSHARE) shows that dominant plants outperformed smaller ones or large scale plants were technically more efficient on average. It is reasonable to consider that regionally dominant plants may protect themselves by manipulating the market during fluctuations in regional cement demand. Similarly, the sign of the coefficient of the export intensity variable (EXPORTS) indicates that those plants that export cement and (or) clinker intensively achieved a higher level of technical efficiency. This may be an indication of the fact that the possibility of selling in foreign markets may provide a cushion against any downturn in domestic demand. Plants that are located in Mediterranean, Aegean and Marmara regions are estimated as more efficient than those that are located in East and Southeast Anatolia (REG1 and REG2). Differences in inputs and especially the deficiency in regional demand may explain the poor performance of plants located in East and Southeast Anatolia regions.

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[11] However, Saygili and Taymaz (1996) suggest that low technical efficiency levels in these plants is mainly due to their geographical location rather than ownership. Moreover, privatisation did not result in a significant improvement in efficiency levels of public plants.

In columns (2) and (3) we exclude the insignificant variables from column (1) and include the two relative wage terms as additional determinants of the efficiency effects. The coefficients on the relative wage are negative and significant, indicating that higher wages are associated with lower technical inefficiency at the plant, *ceteris paribus*, which conforms with the predictions of the efficiency wage hypothesis.[12] Note that the test for returns to scale at the bottom of Table 3 indicates marginally decreasing or constant returns to scale, in contrast to the wage augmented production frontier results reported in section 4.1 which always exhibit increasing returns to scale. One possible interpretation of this result is that the increasing returns in production derive, at least in part, from the higher technical efficiency of plants paying higher wages.

5. Conclusion

In this study, we test the implications of the efficiency wage hypothesis for the Turkish cement industry in two different ways. In the first, we find that wages have a positive impact on output in a wage augmented production frontier. In the second, having controlled for a variety of factors which may affect efficiency, we estimate the effect of the wage on the technical efficiency of cement plants. Our results support the predictions of efficiency wage theories in that there appears to be a significant positive link between wages and the output and technical efficiency of Turkish cement plants.

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[12] We also experimented with retaining all insignificant variables, and with alternative definitions of the relative wage (for example, defined relative to the average manufacturing wage, or whole economy wage). All specifications produced similar results - in that the wage is significantly negatively related to the level of technical inefficiency at the plant.

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Table 1: Variable Definitions and Summary Statistics

Variable	Definition	Mean	Standard Deviation
	Variables in Production Function		
Y	Output (Tons)	578626	447114
K	Capital (Million TL, in 1993 prices)	968997	587408
L	Employment	392	145.6
E	Cost of energy (Million TL, in 1993 prices)	120782	77729
R	Cost of raw and intermediate inputs (Million TL, in 1993 prices)	45317	73638
T	Time trend	9.3	4.46
Q	Type of cement produced (%)	16.3	30.9
	Inefficiency Explanatory Variables		
PRIVATE‡	Ownership dummy variable (1 for private sector, 0 for others)	0.30	0.458
EXPUBLIC‡	Ownership dummy variable (1 for privatised plants, 0 for others)	0.51	0.500
FOREIGN	Ownership dummy variable (1 for foreign owner, 0 for others)	0.12	0.323
DEMAND	Changes in the level of regional cement demand	0.07	0.122
MKTSHARE	Share of plant in total regional cement sales	0.18	0.104
EXPORTS	Share of exports in total production	0.07	0.139
AGE	Age of plant (years)	26.7	15.76
TECHAGE	Age of manufacturing technology in use (years)	17.9	8.73
TEC1	A dummy variable for the type of manufacturing technology (1 for dry and semi-dry manufacturing process, 0 for others)	0.79	0.409
TEC2	A dummy variable for the type of manufacturing technology (1 for pre-calsination method, 0 for others)	0.12	0.329
R&D	Level of technological activity (share of R&D expenditures in total costs) (%)	0.09	0.532
OS	A dummy variable for organisational status (1 for plants that belong to any holding and 0 for others)	0.83	0.377
REG1*	Regional dummy variable (1 for plants located in SE Anatolia or E. Anatolia and 0 for others)	0.26	0.439
REG2*	Regional dummy variable (1 for plants located in Mediterranean, Aegean or Marmara regions and 0 for others)	0.38	0.485
SKILLED	Proportion of qualified workers	0.48	0.187
UNION	Unionisation rate	0.77	0.132
WIND	Wage of plant relative to cement industry	1.00	0.244
WREG	Wage of plant relative to plants in the same region	1.00	0.203

Notes: ‡ Public Sector plants are the omitted category.
* Central Anatolia and Black Sea regions are the omitted regions.

Table 2: Estimates of the Frontier Production Function[13]

	Cobb-Douglas						Translog					
	Column (1)		Column (2)		Column (3)		Column (4)		Column (5)		Column (6)	
	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*
Constant	0.233	*(19.05)*	0.279	*(17.02)*	0.289	*(17.62)*	0.290	*(13.66)*	0.254	*(10.95)*	0.256	*(11.41)*
K	0.390	*(11.72)*	0.367	*(10.02)*	0.388	*(10.71)*	0.357	*(8.82)*	0.327	*(7.96)*	0.372	*(9.07)*
L	0.241	*(5.53)*	0.286	*(5.96)*	0.252	*(5.35)*	0.406	*(7.31)*	0.486	*(8.33)*	0.405	*(6.91)*
E	0.331	*(12.30)*	0.313	*(10.10)*	0.319	*(9.94)*	0.325	*(8.79)*	0.316	*(8.32)*	0.302	*(8.11)*
R	0.161	*(9.85)*	0.152	*(8.96)*	0.164	*(9.80)*	0.155	*(9.26)*	0.136	*(7.84)*	0.147	*(8.69)*
T	0.023	*(6.78)*	0.025	*(6.81)*	0.023	*(6.13)*	0.028	*(7.07)*	0.033	*(7.76)*	0.027	*(6.50)*
Q	0.002	*(5.49)*	0.002	*(5.93)*	0.002	*(5.71)*	0.002	*(5.35)*	0.020	*(4.68)*	0.002	*(4.71)*
WIND	-		0.157	*(3.11)*	-		-		0.172	*(3.21)*	-	
WREG	-		-		0.028	*(0.58)*	-		-		0.123	*(2.13)*
K^2	-		-		-		0.042	*(0.49)*	0.062	*(0.72)*	0.066	*(0.78)*
L^2	-		-		-		-0.270	*(1.80)*	-0.215	*(1.28)*	-0.213	*(1.39)*
E^2	-		-		-		0.014	*(0.27)*	0.061	*(1.10)*	0.036	*(0.67)*
R^2	-		-		-		-0.024	*(1.28)*	-0.019	*(0.97)*	-0.019	*(1.04)*
T^2	-		-		-		-0.001	*(2.04)*	-0.001	*(1.29)*	-0.001	*(1.76)*
$WIND^2$	-		-		-		-		0.435	*(2.29)*	-	
$WREG^2$	-		-		-		-		-		0.547	*(2.68)*
K*L	-		-		-		0.098	*(0.54)*	0.100	*(0.54)*	0.099	*(0.55)*
K*E	-		-		-		-0.053	*(0.49)*	-0.105	*(0.95)*	-0.095	*(0.86)*
K*R	-		-		-		0.093	*(1.67)*	0.042	*(0.74)*	0.056	*(0.99)*
K*T	-		-		-		-0.002	*(0.16)*	-0.003	*(0.22)*	-0.001	*(0.03)*
K*WIND	-		-		-		-		0.366	*(1.68)*	-	
K*WREG	-		-		-		-		-		0.506	*(2.30)*
L*E	-		-		-		0.087	*(0.57)*	0.012	*(0.07)*	0.061	*(0.39)*
L*R	-		-		-		-0.058)	*(0.80)*	-0.108	*(1.40)*	-0.071	*(0.96)*
L*T	-		-		-		-0.075	*(4.22)*	-0.073	*(3.72)*	-0.075	*(4.07)*
L*WIND	-		-		-		-		0.160	*(0.71)*	-	
L*WREG	-		-		-		-		-		0.098	*(0.45)*
E*R	-		-		-		-0.076	*(1.66)*	-0.001	*(0.03)*	-0.044	*(0.96)*
E*T	-		-		-		0.033	*(4.05)*	0.030	*(3.38)*	0.032	*(3.70)*
E*WIND	-		-		-		-		-0.486	*(2.96)*	-	
E*WREG	-		-		-		-		-		-0.428	*(2.65)*
R*T	-		-		-		0.001	*(0.03)*	0.003	*(0.62)*	0.001	*(0.26)*
R*WIND	-		-		-		-		-0.116	*(1.35)*	-	
R*WREG	-		-		-		-		-		-0.017	*(0.20)*
T*WIND	-		-		-		-		-0.006	*(0.31)*	-	
T*WREG	-		-		-		-		-		-0.010	*(0.55)*
σ_s^2	0.414	*(5.63)*	0.143	*(10.89)*	0.150	*(11.04)*	0.137	*(11.50)*	0.124	*(10.90)*	0.134	*(11.32)*
γ	0.958	*(69.30)*	0.900	*(32.16)*	0.913	*(35.76)*	0.921	*(40.91)*	0.901	*(31.63)*	0.925	*(40.62)*
CRS	1.123	*(4.07)*	1.275	*(4.57)*	1.151	*(4.14)*	1.243	*(5.76)*	1.265	*(5.69)*	1.226	*(3.11)*
Mean Eff.	0.767		0.774		0.768		0.776		0.786		0.777	
LogL	7.10		12.6		7.83		36.8		50.0		46.3	

<u>Notes:</u> 1. $\sigma_s^2 \equiv \sigma_v^2 + \sigma^2; \gamma \equiv \sigma^2 / \sigma_s^2$.

2. CRS is a test for constant returns to scale in production. The t-ratio is for the test for H_0: RTS = 1.

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[13] Except for T and Q, all variables in the production frontier are expressed in logarithms.

Table 3: Estimates of the Translog Inefficiency Effects Model

Variables	Column (1)		Column (2)		Column (3)	
	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*	Coeff.	*|t-ratio|*
			Production Function			
Constant	0.362	*(10.33)*	0.298	*(11.29)*	0.235	*(13.09)*
K	0.356	*(11.17)*	0.346	*(10.73)*	0.345	*(11.04)*
L	0.159	*(3.19)*	0.272	*(5.60)*	0.303	*(6.48)*
E	0.233	*(7.70)*	0.237	*(7.84)*	0.274	*(8.58)*
R	0.056	*(4.02)*	0.050	*(3.40)*	0.075	*(4.72)*
T	0.040	*(11.98)*	0.044	*(14.08)*	0.037	*(10.97)*
Q	0.001	*(1.99)*	0.001	*(2.95)*	0.001	*(3.48)*
K^2	-0.147	*(2.01)*	-0.117	*(1.64)*	-0.064	*(0.87)*
L^2	-0.180	*(1.76)*	-0.248	*(2.28)*	-0.225	*(2.13)*
E^2	0.014	*(0.32)*	0.016	*(0.38)*	0.051	*(1.16)*
R^2	-0.003	*(0.18)*	-0.006	*(0.37)*	-0.007	*(0.45)*
T^2	-0.002	*(2.45)*	-0.001	*(0.37)*	-0.001	*(2.20)*
K*L	0.216	*(1.46)*	0.181	*(1.21)*	0.148	*(0.97)*
K*E	0.059	*(0.66)*	0.054	*(0.61)*	-0.014	*(0.15)*
K*R	0.012	*(0.26)*	0.040	*(0.90)*	0.022	*(0.48)*
K*T	0.038	*(3.66)*	0.031	*(2.96)*	0.017	*(1.55)*
L*E	-0.014	*(0.12)*	0.023	*(0.19)*	0.043	*(0.37)*
L*R	-0.022	*(0.41)*	-0.036	*(0.73)*	-0.055	*(1.07)*
L*T	-0.045	*(3.42)*	-0.051	*(3.74)*	-0.043	*(3.18)*
E*R	0.028	*(0.75)*	0.018	*(0.49)*	0.024	*(0.61)*
E*T	-0.009	*(1.24)*	-0.006	*(0.76)*	0.006	*(0.71)*
R*T	-0.003	*(0.58)*	-0.003	*(0.62)*	-0.001	*(0.19)*
			Inefficiency Effects			
Constant	1.080	*(7.09)*	0.839	*(13.55)*	0.717	*(7.47)*
PRIVATE	-0.385	*(7.21)*	-0.374	*(4.87)*	-0.655	*(4.93)*
EXPRIVATE	-0.195	*(5.27)*	-0.214	*(5.03)*	-0.238	*(3.98)*
FOREIGN	0.135	*(2.92)*	0.118	*(2.47)*	0.079	*(0.92)*
DEMAND	-0.250	*(2.84)*	-0.293	*(2.80)*	-0.321	*(2.13)*
MKTSHARE	-2.332	*(18.47)*	-2.385	*(15.59)*	-3.117	*(9.73)*
EXPORTS	-0.474	*(3.42)*	-0.552	*(3.89)*	-0.702	*(2.99)*
AGE	-0.002	*(1.57)*	-		-	
TECHAGE	-0.001	*(0.62)*	-		-	
TEC1	-0.015	*(0.51)*	-		-	
TEC2	-0.031	*(0.60)*	-		-	
R&D	-0.022	*(1.07)*	-		-	
OS	-0.210	*(0.43)*	-		-	
REG1	0.364	*(8.84)*	0.360	*(8.13)*	0.525	*(7.36)*
REG2	-0.176	*(5.07)*	-0.242	*(5.74)*	-0.406	*(6.32)*
SKILLED	-0.131	*(1.82)*	-		-	
UNION	-0.003	*(0.02)*	-		-	
WIND	-		-0.258	*(2.92)*	-	
WREG	-		-		-0.351	*(2.43)*
σ_s^2	0.029	*(14.35)*	0.033	*(12.01)*	0.065	*(9.32)*
γ	0.450	*(12.14)*	0.494	*(10.95)*	0.801	*(28.41)*
CRS	0.806	*(6.97)*	0.904	*(2.23)*	0.997	*(1.14)*
Mean Eff.	0.725		0.767		0.814	
LogL	226.8		226.8		202.5	

APPENDIX

Description of Variables in Production Function

Output (Y): We cannot simply use the volume of cement produced as the dependent variable (output) of the production function since there is also a considerable amount of clinker trade between plants. Clinker is an intermediate form of the final product, which, when finely ground, is the basis of cement. Thus, if net purchases of clinker are positive, we define the clinker as a raw material *input* into the production process, whereas if net purchases of clinker are negative, we define this as an output from the production process. The volume of clinker is transformed into equivalent measures of input or output using suitable price indices.

Capital (K): Two alternative measures for capital input are available. Firstly, we have clinker grinding capacities in tonnes for a long period for each plant. Secondly, we have a measure of the fixed capital stock in money terms for 1992 from the TCPA statistics. Given that annual fixed capital investment was collected in our survey, we can use this 1992 figure as a base for a perpetual inventory method in which, by adding and subtracting investment and depreciation, we can construct a fixed capital stock variable for every year. Our previous production function estimates indicate that these two alternative measures of the capital stock produce similar estimates (Saygili, 1996). In this analysis we used the second, constructed, measure, expressed in 1993 prices.

Employment (L): Total number of production workers and administrative personnel.

Energy (E): By using suitable price deflators, nominal expenditures on electricity, oil and coal were transformed into 1993 prices and aggregated.

Raw and Intermediate Inputs (R): By using the price index of non-metallic mineral products sector as a deflator, expenditures on raw materials, auxiliary materials and operational inputs were aggregated in 1993 prices.

Type of Cement Produced (Q): In order to reduce production costs, it is possible to blend Portland cement with natural cements such as slag, fly-ash or pozzolan (a volcanic material) (Bianchi, 1982:8). In Turkey, by the end of 1995, only a small part of total production (*circa* 14%) was pure Portland cement while the remainder comprised various kinds of blended cements. Therefore, the share of a blended cement, Trass TC 325, in total cement output is also used as a control variable in the estimation of the production function. Trass TC 325 accounted for 39% of total cement output in 1995.

Definition of the Wage Level Variables (WIND and WREG):

1. *Wage level Relative to Cement Industry*: $WIND_{it} = W_{it} / WC_t$ where W_{it} is the wage level for plant i at time t and WC_t is the average wage level for cement industry at time t.

2. *Wage level Relative to Other Cement Plants in the Same Region*: $WREG_{it} = W_{it}/WR_t$ where WR_t is the average wage across cement plants in the same region at time t.