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Economies of Scale in the Egyptian Industry

(The Case of Steel and Fertilizers)

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Contents

	Page
Introduction	1
I. Definition of Economies of Scale	2
II. The Comparative Cost Method of Measuring Economies of Scale	6
III. The Production Function Method of Measuring Economies of Scale	9
III.I, Data Used	12
III.2. Empirical Results	13
A. Fertilizers Industry	13
B. Textiles Industry	15
C. Steel Industry	15
D, Limitations of Results	16
E. Corrections of the Basic Data for the Steel Industry	17
F. Final Remarks	19

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Introduction

The aim of this paper is to apply the Concept of Economies of Scale to the Egyptian industry. Three activities were selected: textiles, Steel, and fertilizers. For these same industrial activities, we have tried, in a previos paper, to identify the relationship between wages, productivity, and cost of living [1][2]. we felt that a partial analysis is not enough . A detailed survey of each industty is needed to discover the bottlenecks to efficiency . This has been done for the steel industry and a Rationalization program is suggested [3]. The rationalization program dealt accidently with the concept of economies of scale. The present paper concentrates on the concept of economies of scale . we were fortunate to have detailed data on costs for the steel industry but not for textiles and fertilizers . It will be seen from the text that in such cases of scanty data on costs, one could use other sources of information for gauging the degree of economies of scale . we chose the aggregate concept of a production function . Explicitly, two methods are suggested :

1. The comparative cost method, and
2. The production function method .

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(1)&(2) El Sayed Nassef:"Determinants of Wages in the Egyptian Industry (The Textiles Case),"Institute of National Planning, Memo , 1982. " Determinants of wages in the Egyptian Industry-A Comparative study(The Case of Textiles, Steel, and Fertilizers)," INP, Memo ( ),1982 .

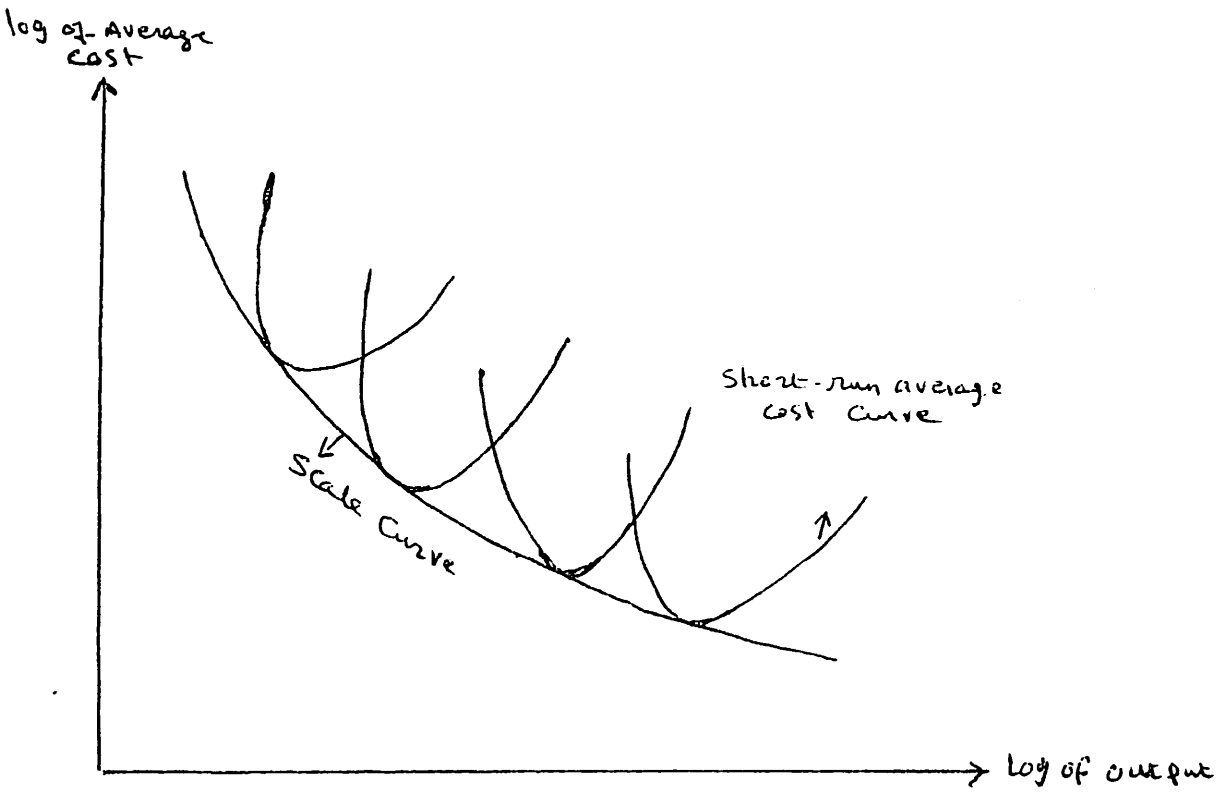
(3) El Sayed Nassef:"A Program of Action Rationalize the performance of the Egyptian steel Industry,1975-1985",INP,Memo( ),1982.

The empirical content of this paper will concentrate on the second method since the first method can easily be applied using the information of our detaild study on steel industry . For the completement of exposition, the theoritical definition of the economies of scale concept is presented in Section one and the measurement problems of the comparative cost method is discussed in the Second Section . The Third Section deals with the choice of the production function, presents the empirical evidence, and evaluates the reults .

I. Definition of Ecomomies of Scale

Economies of scale can be defined as reductions in average costs due to increases in scale either by changing the level of output in one plant and then comparing the unit cost for every level of output,or by comparing different unit costs in different plants which produce the same product but plants differ in output level (scale). Small and large plamts are examples of different scales : small scales and large scales .

The different levels of output are associated with the level of capacity utilization . Here a differentiation between long-and short-term costs is pertinent . The short-term cost curve is a relationship between average costs and the level of capacity utilization . Then, if there are economies of scale, the elasticity of average costs to output level is a negative figure which means that as output level increases, efficiency requires that production is undertaken at minimum cost . The long-term average costs curve is the curve that traces the minimum cost points of the short-term cost curves as depicted in the following figure .



Figure(1): Short-and long-term Average Cost Curves

Of course, minimum costs are not a function of output level only; they are influenced by the technology used in production . Old technology is associated with higher costs compared with new technology . Because of the vagaries of substantiating the role of techniques of production on costs, it is usually assumed that plants use the same technology at different levels of operations .

Another influence on costs comes from factor prices . If one assumes that technology is given , this means that the combination of the factors of production , i.e. technical coefficients are given and remain constant irrespective of scale . To neutralize the influence of prices , a similir assumption should be made . To give an example , if we increase the level of output and use more labor , it should be assumed that the additional labour is paid the same wage rate prevailing before the increase in employment . In other words, we assune that the supply of factors of production is infinitely elastic .

Backward/forward linkages in the industrial structure affect costs . Production of (X) is used by firm (Y) . The latter's product is used by firm (2) and so on . External economies should be assesed apart form the internal economies . Internal economies are our point of investigation . The above mentioned factors affecting costs are just examples. A long list of sources of economies of scale can be enumerated including the overall business environment in which a given plant is operating . But we limit ourselves to the more salient factors amenable to empirical quantification .

On the other hand, there are two reasons behind diseconomies of scale as reflected in increases in unit costs :

(1) The supply of factors of production is not infinitely elastic so that as output increases, costs of factors increase . In other words, there are limitations on factors' avilability .

(2) Productivity of factors of production declines when increased quantities of factors of production are used. It could be seen that the first reason is violating an important assumption when measuring economies of scale, but the second reason is par excellence a source pf inefficiency or diseconomies of scale . A careful measurement of costs alleviates biases in historical cost data when calculating unit costs .

II.The Comparative Cost Method of Measuring Economies of &cale

When cost data are available and accurate, the calculation of unit costs is a straightforward exercise : total costs divided by output level . Change the output level then costs per unit will change and are either decreasing (economies of scale) or increasing (diseconomies of scale) . But when biases in cost data are detected, they should be corrected in line with standard economic calculations . Examples of the kind of problems encountered in this respect are given below . we concentrate on the major items of costs .

A. Material Costs

In some industries, material costs represent a substantial percentage of costs (e.g. around 70 % in Egyptian steel industry). Costs of materials on the base of market prices are used straightforwardly for calculations when materials are obtained from other firms (supplying industries) . Exceptions are when the firm obtains materials at favourable conditions, then prices paid are used . To asses the probable economies of scale internal to the supplying industries but external to the using industries, one could allow for this effect by backward calculation for economies of scale in the supplying industries(e.g. iron ore used by the steel industry). A short cut way is to use previous knowledge on this respect and to spare the effort of generating the data . Another way is to exclude raw materials from calculating economies of scale . In other words, one could concentrate on costs of resources used for production : capital and labor .

B. Capital Charges

Charges on capital are composed of two componets : depreciation and interest on the capital fund sinked in the physical investment . For depreciation, the scrap value of the asset should be deducted from the book value (or the replacement value?) in order to phase out the depreciation charge over the lifetime of the asset . It is arguable whether to use the book value or the replacement value . The merit of the latter value is to care for obsolescence ,i.e. to account for imptovements in new capital that have taken place since the purchase of the scrapped asset . The last issue is to decide for a constant (straightline method of calculating depreciation) or a variable instalment. All this issues in estimating depreciation are to be settled in case the economist suspects any biases in the data available.

On the other hand, interest charges differ according to the conditions in the capital market . Somtimes it is easy to get funds and somtimes the market is tight . It is usually argued whether to use a norm (shadow interest rate) or to use the market interest rate . The estimate of a shadow interest rate (profitability of capital) is not without difficulties , In practice, a rate of interest of 10-15% is used .

C. Labor Costs

This item does not present any difficulties . Wages and salaries paid are the costs of labor . Only when a rationalisation Policy pendent upon measuring economieso of scale, the appropriate wzge rate is problematic[1]. In such cases, the focal point is related to the appropriate wage policy .

The identification of the cost of a unit of production is no problem in the process industries where the product is more or less homogeneous; that is, the technical specifications of the product are simple like a meter of textiles or a ton of steel . When products become diversified or/ and the same product is highly differentiated such as in machine industry, it becomes difficult to identify the unit cost . A detailed study on the workshop level is needed .

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(1) This point is much dicussed in our study on steel industry: Ibid .

Cost data are considerd highly confidential . In such Cases, other methods for measuring economies of scale, Like the production function method, could be used. The level of aggregation becomes higher and is acoompanied by the fomiliar problems of èconometric measrement . This brings us to the third section .

III. The Production Function Method of Measuring Economies of Seale

The most familiar type of a production function is the socalled Cobb - Douglas function . It is Controversial whether this function is Linear homogeneous or exhibit increasing (decreasing) returns to scale . Homogeneity and Linearity of first order mean that hte elasticity of output with respect to factors of production is unity . So doubling the level of inputs leads to doubling the level of output. this is the case of constant Returns to scale : If we denote by ( ) and (B) the elasticity of output (Y) to the most familiar inputs, Capital (K) and labor (L) respectively , the cobb- Douglas function in its simplest form is :

$$Y = A\,K\quad L^{B} \qquad (A = \text{Constant})$$

In this form, Increasing returns to scale do exist if the sum of (α) and (β) are greater than unity. In this case, if you double both the factors of production, output will be more then doubled . For example, if the sum is 1.3 , this means that an increas in inputs by 100% leads to an increase in output by 130% , i.e. current output will be 230% of the previous level ; more than doubled .

Other types of production function can be used such as the CES (Constant Elasticity of Substitution) function . Empirical evidence is available for such specification of the technical process of production in many industrial activities in Egypt(1). The empirical evidence provided by this type of fuction shows that the elasticity of substiution between labor and capital is not different from unity(2). This means that a C-D production function can be used as well since a characteristic of this function is that the elasticity of substitution is unity . Then, a comparison of results derived from different types of functions can be carried out . But the important point is that if the technical procese used in production (technology) changes as the scale of output changes, the very notion of a production function loses all analytical and operational significance .

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(1)&(2) Maurice Girgis:"Aggregation and Mis-specification Biases in Estimates of Factor Elasticity of Substitution: the case of Egypt", Weltwirtschaft Archiv, 110, 1974, no.I.

The method of estimation of the parameters of the C-D function is the Least Squares Method . Multicollinearity and the least squares bias (or autocorrelation) are among the defects of this method . The first problem will show itself into higher standard errors of the estimated parameters . This problen could be mitigated by using the restricted version of the C-D function in which constant returns to scale are assumed :

$$Y/L = A\ (K/L)^{\beta}$$

In this form, the two explanatory variables with uni - directional trend overtime are expressed as a ratio of each other . Since this form excludes (Ex Ante) the possibility of economies of scale, it will not be used . The second problem can be eliminated by using a complete model comprising output, labor, and capital as three independent variables; a task beyond the scope of this paper . Thus, we will accept the least squares method of estimation, knowing its defects , pending upon its results .

III.I. Data Used

For the three industries, time series data are used. The number of observations are eight from which three Parameters are estimated to be left with five degrees of freedon . Decidedly, the sample is very small . Except for the steel industry, no data were available on the firm level . Cross-sectional analysis could be performed for the steel industry . This has not been done because the available data on capital represent the balance sheet paid-up capital which is per se an accounting concept. we preferred to constrict capital to machinery and equipment foresaking other types of capital such as buildings . The chosen concept of capital has been used for steel and fertilizers . Whenever data were missing for machinery and equipment, an estimated figure is compiled by adding current investment to the stock of machinery and equipment in the previous year. This is done to estimate machinery and equipment in years 1972 and 1975 for the fertilizers industry . We could not do that for the textiles industry because the stock of machinery and equipment was not available for the first two years of the time series . We felt that the above mentioned manipulation will distort the time series . Thus, it was decided to work with total capital .

The other two variables of the production function are labor and value added . They do not represent any difficulty; the labor variable is the total number of employees and the product variable is gross value added. Basic data are reported in the Appendix .

III.2.Empirical Results

A. The Fertilizers Industry

The estimated function is as follows :

$$Y = 0.4699\, K^{-0.0350}\, L^{1.6040} \quad (s.e.=0.1895, R=0.9958)$$

$$(1.2562) \quad (1.4397)$$

The exponents of capital and labor represent the elasticity of output to changes in the two factors of production respectively. The standard errors of the estimated coefficients are reported below the estimated function , On the right hand side, the standard error of the estimated function (s.e.) and the correlation coefficient (R) are given . The same way of presentation is used for subsequent industries .

The sum of the elasticities is positive and more than one. The industry shows increasing returns of the order of 0. 569. It can be seen that the elasticity of output to changes in capital is negative. This result is no surprise to us since the industry is plagued with idle capacity of machinery and equipment . In that case, additions of labor will be useless as far as output is concerned unless idle capacity is reactivated. This is a basic assumption of the production function : full employment. Activation of idle capacity will be reflected heavily as increases in labor productivity. If this interpretation is valid, the economies of scale will be captured by the elasticity of output to changed in labor. This does not mean that reactivation of idle capacity will create emploment drive . Only disguised unemployment will be phases out . To test this possibility, one need to know the rate of excess capacity and the rate of disguised unemployment to correct the basic data of the production function and to come closer to the full employment assumption . Lack of this information for the fertilisers industry restricted this type of correction to the steel industry alone .

From the statistical point of view, the estimated function explains 99% of the variation in the independent variable (R= 0. 9958) so that the standard error of the residuals (s.e.) is only 0. 1895. Apart from the standard error of the estimated parameters, no further significance test is carried out since we were discouraged by finding that they are bigger or nearly equal to the estimated parameters.

B. The Textiles Industry

The difficulties in composing the proper variables for the textiles industry are reflected in the empirical results, Both the elasticity of output to capital and labor are negative. They are (- 1.075) and (-1,656) respectively . On the face of these results,the industry shows diseconomies of scale of the order of (2. 731) .

A previous study on labor productivity in textiles gave negative elasticity of output to labor during the same period (-0.76), but the industry shows constant returns to scale when the positive elasticity of output to investment is added to the negative elasticity of labor mentioned above [1]. The results of the present study and the previous one are incomparable due to differences in methodology . If one has to decide on the merits of the results of the two studies, we doubt the results of the present one and so is discarded . Further work is needed as the issue of economies of scale is concerned .

C. The Steel Industry

The estimated function is as follows :

$$Y=0.3957\ \underset{(1.5814)}{K^{-0.1852}}\ \underset{(4.4860)}{L^{1.5690}} \qquad (s.e.=0.3043, R=0.9870)$$

(1) El Sayed Nassef : Op. Cit.

The industry is characterised by increasing returns to scale . The scale of increasing returns is 0.38. This is captured by the elasticity of output to labor .In this regard, what has been said for fertilisers can be applied for the steel industry; both are characterised by excess capacity and redundant employment . A rationaliaation study for the steel industry has shown that[1]:

(1) Workers are overpaid in comparison with productivity . Ex Post, the average wage exceeds the marginal rate by 37% .

(2) Excess capacity ranges between 47 and 64% .

Out suggested program of action to rationalize the performance of the industry centerd around the probable efficiency which could result from better allocation of resources to make the industry comes closer to full employment. The rationalization study serves its puropses . It has been sited here to warn against the biases in our basic data and to show that the assumptions of the production function should be fulfilled if empirical results would have any meaning . For now, the best we can say is that there are limitations of the above empirical results .

D. Limitations of the Results

The three basic assumptions on the basis of which a Cobb-Douglas production function is formulated are :

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(1) EL. Sayed Nassef : OP . Cit .

(1) Perfect competition in the product and factor markets,

(2) Full employment; i.e. no excess capital capacity and no underemployment of labor, and .

(3) Substitutability between capital and labor is such that the elasticity of substitution is unity .

since the first two assumptions are exposed to great doubts, the results should be corrected as far as the rate of capital utilization and as for the redundancy of labor. Some data on capacity utilization and an estimated rate of overemployment are available for the steel industry only. The production function of the steel industry is re-estimated after correcting the basic data as regards excess capacity and underemployment of labor ,

E. Corrections of the Basic Data for the Steel Industry

The basic data been corrected as follows :

(1) capital (machinery and equipment) has been deflated by the rate of utilized capacity (excess capacity ranges between 47 and 64% .)

(2) The number of workers has been reduced by 37% (the rate of overremuneration).

The corrections are not done for each year because data were not available. The only thing we have done is to apply a unfform factor of correction : this is 0.44 for machinery and 0.63 for labor . The former is the average figure for utilized capacity and the latter is the wage rate equivalent to productvity for year 1978 . To estimate the Productive wage rate is a complicated exercise that should be repeated for each year.(1) For that reason , we worked the figure for only 1978. Obviously, the corrections have thier limits too. But we have put them explicity for further work .

The last variable that should be corrtcted is Value added. The corrections center around eliminating the biases in prices of intermediate inpute and final products. This work has been done in the rationalization study (Ex Ante) for 1985. It could be done Ex Post . But that is a tremendous work beyond the scope of this dtudy. So the value added figure is left as it is during the period of study (1971- 1978).

The re-estimated finction is as follows;

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(1) J.K. Boon : "Technology and Sector Choice in Economic Development " , Sijthoff & Noordhoff international Publishers, 1978 .

$$V = 0.7410 \; K^{-0.2072} \; L^{1.6082} \qquad (s.e.=0.3717,\ R=0.9844)$$
$$(1.7328) \qquad (4.8977)$$

In our opinion , the correction does not add to the significance of the results. The only merit it gives is an assurance of the goodness of fitness of the previous estimated function .The statistical coefficients are very close in both cases and the order of economies of scake is nearly the same (0.40).

F.Final Remarks

This paper has suggested two methods to estimate economies of scale: a micro -level approach and a macro- leval approach. The first deals with cost-comparisons and the difficulties of cost estimation are exposed in the second section of this paper. This method has been applied inter alia in our rationalization Study on steel. The second approach formulates a production function for the industry as a whole either by using time series or cross - firm data . The difficulties of this approach has been the corner stone of this paper. The empirical evidence showed that there are economies of scale in the Egyptian steel and fertillizers industries . This is in line with the only source known to us. Prof. Maurice Girgis estimated the degree of economies of scale in the ferrous metals industry as equal to 0.38.(2) If this

(2) Maurice Girgis: Op.Cit. &
_______________ "Industrialization and Trade Patterns in Egypt". (Kieler Studien), Tubingen , 1977.

result is challenged, further work is welcomed. If there are limitations to the statistical approach or to the basic data, they are explicitly elucidated and refinements are invited.

There are few rigorous empirical studies on the Egyptian industrial problems apart from the DRC (Domestic Resource Cost) type of studies which has serious limitations.[1] Explicitly, the DRC method lacks a dynamic efficiency content. We believe that our rationalization study is the first to cope with this dynamic efficiency content. The present study is complementary to rationalization studies in general. It is hoped that our series of studies on the Egyptian industry will motivate a long search for measuring efficiency and its determinants (Ex ante and Ex Post) in the Egyptian industry.

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(1) Bent Hansen and K. Nashashibi : " Foreign Trade Regimes and Economic Development ", National Bureau of Economic Research, New York, 1975.

Appendix

Table(1): Steel Indusry(Original Data)

Year	Capital (machinery) (mln LE)	Labor in (1000)	Value Added (mln LE)
1971	26.5	24.2	19.6
1972	28.7	26.2	27.6
1973	31.8	28.5	32.2
1974	32.3	31.1	23.6
1975	107.4	40.1	21.7
1976	113.3	44.7	30.8
1977	116.5	44.5	48.3
1978	126.2	44.6	61.3

Table(2) : Steel Industry(Corrected Data)

	Capital (mln LE)	Labor in (1000)	Value Added (mln LE)
1971	11.7	15.2	19.6
1972	12.6	16.5	27.6
1973	14.0	18.2	32.2
1974	14.2	19.6	23.6
1975	47.3	25.3	21.7
1976	49.8	28.2	30.8
1977	51.3	28.0	48.3
1978	55.5	28.1	61.3

Table(3) : Fertilizers Industry

Year	Capital (machinery) (mln LE)	Labor (in 1000)	Value Added (mln LE)
1971	36.3	8.4	11.5
1972	40.0 *	8.0	11.7
1973	35.8	7.5	6.3
1974	37.2	7.7	9.3
1975	59.0 *	8.8	11.0
1976	58.8	11.6	13.2
1977	59.7	11.8	16.6
1978	63.9	13.5	23.0

* Estimated by adding current investment to previous stock of machinery and equipment .