Production Function Analysis of The New Kufa Cement Plant For The Period (2004-2020)

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Introduction

The cement industry is an essential manufacturing industry that effectively enhances national income and achieves sustainable economic development. Its front and backlinks with various industrial sectors, and the importance of this industry is increasing in all countries alike. Extensive facilities to cover their need for this product and export the surplus. This industry is significant in Iraq due to the government's wars, which destroyed many infrastructures and disrupted the wheel of development. So, it became necessary to promote this industry again to push the wheel of reconstruction and infrastructure development forward. Given the importance of the new Kufa Cement Factory and its role in providing the local product as well as its contribution to promoting economic growth and employment of many human resources, as well as its contribution to strengthening and increasing the national development in terms of providing the product locally in the required quantities and quality, As well as concerning maintaining the balance of payments and providing foreign currency by closing the door to imported products that have always occupied the largest share of the Iraqi market in this aspect, it has been highlighted in this research.

Research problem

Despite the great importance that the new Kufa Cement Factory enjoys in terms of its location among the factories of the General Company for Southern Cement and its importance in promoting development at the level of the country as a whole. It suffers from the presence of a large group of deviations in economic performance that eventually led to a group of real problems represented by Low production capacity and not reaching the planned capacity as well as the available or designed capacity. It resulted from the low productivity of the labor and capital elements, the high amount of costs, low profits, obsolescence of equipment, frequent stops due to maintenance, high numbers of employees) and other problems.

Research hypothesis

The research starts from the hypothesis that although the Kufa Cement Factory suffers from a significant decrease in the actual energy level from the design, it is not the most prominent factor in its low productivity and that the process of analyzing the production

function will help to detect deviations and know their details to treat them with the great capabilities available at the factory that helps to make the optimal use of his available economic resources and productive forces.

Research Objectives: The research aims to achieve several objectives, the most important of which are:

1- Determine the performance level of the Kufa Cement Factory and ensure that it uses the available resources with high efficiency.
2- Studying the reality of the factory and showing the relationship of costs to production and sales and measuring the contribution of the labor and capital elements in particular to the amount of production and other data, and identifying the factors affecting the quantity of its production.
3- Knowing the productive method used in the factory, whether it is labor-intensive or capital-intensive.

Research Structure
To achieve the desired objectives in this research, it was divided into three paragraphs:
The first paragraph dealt with an overview of the new Kufa Cement Factory, while the second paragraph touched on production functions and acquaintance in detail with the Cobb Douglas function. The third paragraph dealt with the estimation and analysis of the production function of the Kufa Cement Factory, and the research concluded with conclusions and recommendations.

First: About the Kufa Cement Factory

The new Kufa factory is one of the factories of the Southern General Company. It is located south of the city of Kufa, (7) km from the city center. It operates with a design capacity of (2) million tons annually. It was established in 1977 and implemented by the Danish Company F.L.S. The production began in 1984, and its production method is the wet method. It produces ordinary Portland cement and achieved 103% of clinker production compared to the company's factories during 2009. It is one of the eight production factories associated with the Southern General Company for Cement. (1)

The Production departments in Kufa Cement Factory(2)

The new Kufa Cement Factory has a number of production departments, which are as follows:

(1) The official website of Kufa Cement Factory, https://icsc.site
(2) Karrar Abd al-Ilah Arair al-Khalidi, the target cost technique as a tool for strategic cost management, an applied study in the new Kufa cement factory, a master's thesis submitted to the Council of the College of Administration and Economics, University of Kufa, 2010, p. 107.

• Quarry Department:
This section is located 25 km from the factory in the Bahr Al-Najaf region, where the first cement manufacturing operations begin, represented by the provision of raw materials, which are limestone and dirt, which is a mixture of sulfates of some minerals, carbonates, and silicates.

• Rubber Conveyor Department:
The rubber conveyor belt is the link between the quarry and the factory, and its task is to transport the stone from the quarry to the stone storehouse in the factory. This distance is in stations. The 35 stations operate with an electronic control system that ensures the flow of materials through the stations so that each station unloads its cargo to the next station in a smooth and gradual manner(3).

• Raw Materials Mills Department:
The task of this section is to grind the mixture consisting of soil, water, and limestone to produce a well-mixed clay material to facilitate its burning.

• Ovens Department:
This section is of great importance in the clinker production process, and its mission is to burn the paste formed in the previous section in a rotary kiln to produce clinker. The kilns section contains four rotary kilns, each of which is 175 m long and 5.25 m in diameter and has a production capacity of (1500 tons/day) for each.

• Cement Mills Department:
The task of the department is to grind the clinker produced after it leaves the kilns and cools down, and the grinding is done according to specific standard specifications. The department contains a group of three mills, the dimensions of each of them are (13 * 4.2)m, and the production capacity of each is (120 tons/hour)(4).

The department's mission is to fill the final product of cement in large storage silos, five of which are in the factory, with a storage capacity of each of them up to (25,000) tons. The department contains six packing machines with a production capacity of (100 tons/hour). The paper is responsible for manufacturing cement packing bags and

(3) Maqdis Abdul-Kadhim Abbas, The possibility of applying the project resource planning system to enhance the competitive advantage, an exploratory study in the Kufa Cement Factory, a master's thesis submitted to the College of Administration and Economics, University of Kufa, 2012, p. 122.
(4) Marwa Abdul-Karim Al-Zuhairi, The role of critical success factors and organizational citizenship behavior in reducing organizational collapse, an exploratory study in the Southern Cement General Company, a master's thesis submitted to the Board of the College of Administration and Economics at the University of Kufa, 2010, p. 130.

preparing them for the factory, where it operates with a production capacity of (100,000 bags/day) with two work shifts per day.

Second: Production Functions: Cobb - Douglas Function

It is one of the most widespread production functions, as it was used for the first time by the two scientists named after them in 1928 in an attempt to adapt data on American industry to determine and measure the extent to which labor and capital contribute to production and their impact on industrial output in America, which is the main title of the American Economic Association [(5)], Since this mentioned year, this function has been used more frequently than other functions for its ease of estimation [(6)], and it is the most common model in the application due to its simplicity and ease of dealing with it mathematically [(7)], as it is used in many practical studies of cross-sectional data due to its ease of calculation, Knowing the elasticity of production directly through the value of the exponent, and knowing the cases of volume return directly through the total elasticity, as well as it shows the features of diminishing returns with respect to volume using a specific number of degrees of freedom, and the total of the elasticities in it expresses the degree of homogeneity of the function [(8)], as it is considered the tool that enabled economists to build several models and helped discover other functions that in turn contributed to a remarkable development in the methods of economic analysis [(9)]. In this function, the flexibility of substitution is equal to one, which means that there is a constant substitution between labor and capital to reach a certain level of productivity [(10)], and this function is considered the intermediate state between linear functions and fixed ratios, and it is an estimated relationship used in solving problems of choosing between

(5) Cobb – Charles W., Douglas, Paul H., Theory of Production, American Economic, Review, Vol. 18 March, 1928, P 65-135.
(6) David L. Debertin, Agricultural Production Economics, Bibliography : p, Library of Congress Cataloging in Publication Data, Second edition, 2012, p172.
(7) A. Koutsoyiannis, Modern Microeconomics, 2nd, Macmillan press LTD, London, 1975, P 75.
(8) Habi Abdel-Latif, Al-Ahsan Rafik, Analysis of the production function, productivity and technical change in the cement industry in Algeria, Journal of the New Economy, Vol. 10, No. 1, 2019, p. 531.
(9) Lutfi Makhzoumi, Economic Analysis of the Production Function (Cobb-Douglas) of Potato Crop in El Wadi State, Journal of Economic and Financial Studies, No. 5, 2012, pp. 73-74.
(10) Emad Abdel Masih Shehata, The Role of Technological Change in the Demand for Agricultural Labor in Egypt, The Egyptian Journal of Agricultural Economics, Volume 16, No. 4, 2006, p. 5.

technical methods of production or technological combination [(11)], and expresses the economic behavior of the production process, whether at the aggregate level or at the level of the sector and economic unit, and depends in its analysis on only two elements of production, namely, labor and capital, and it is expressed in the following mathematical formula [(12)]:

$Q= f(K,L) = A\ k^{b1}\ L^{b2}$

$L>0\ ,\ K>0\ ,\ 1<b1,b2>0\ ,\ A>0$

Whereas A represents the technological efficiency coefficient, while b1, b2 represents the elasticities of labor and capital in relation to the output, and this function is employed to estimate the elasticity of substitution between the elements of production. The relative contributions of the factors of production do not change when significant changes occur in the prices and ratios of the factors of production because changes in prices that result from technological updates lead to changes in the relative contributions of the factors of production in the same quantity but in the opposite direction [(13)].

It can be converted into a linear production function by taking the natural logarithm of both sides of the function to be in the following form:

$Ln\ Q = Ln\ A + b1\ Ln\ L + b2\ Ln\ K + U$

Third: Analysis of the Production Function of the New Kufa Cement Factory

The production function is considered as one of the measures of total productivity and expresses the mathematical relationship between the factors of production and the final product, and it is used to calculate the relative contribution of the production factors used in the production process. The Cobb-Duclas function is considered as one of the commonly used functions, and it is expressed in the following form:

$Y= A\ L^{b1}\ K^{b2}$ ……. (1)

(11) Laith Demi Al-Anzi, Iskandar Hussein Ammi Al-Qaisi, Economic Analysis of the Production Functions of Barley Crop in Wasit Governorate for the Year 2014, Iraqi Journal of Agricultural Sciences, Volume 48, No. 4, 2017, p. 1045.
(12) Tchibozo Guy, Microeconomie approfondie, Paris, Armand Colin, 1997, p19.
(13) Batoul Matar Abbadi, The Application of the Constant Deflection Elasticity Model in the Jordanian Economy, A Standard Study for the Period 1970-1997, Al-Qadisiyah Journal of Administrative and Economic Sciences, Volume 7, No. 4, 2005, p. 65.

Y: production quantity
L: labor element
K: capital element
b1: elasticity of production due to the change of labor
b2: elasticity of production due to the change of capital
A: Technical Proficiency Coefficient
To estimate this function, it is converted to linear by taking the logarithm of both sides

LogY= Log A + b1 Log L + b2 Log K ..... (2)

Table 1 Data of the New Kufa Cement Plant for the Period 2003 - 2019

Year	K / million Iq D	L	Y / ton
2003	30,909	1402	222,440
2004	40,850	1489	435,424
2005	52,751	1669	304,171
2006	62,087	2252	299,880
2007	57,854	2235	429,100
2008	63,831	2187	470,839
2009	81,045	2307	208,319
2010	18,132	2031	477,268
2011	14,061	1999	401,248
2012	68,829	2034	386,727
2013	71,469	1897	687,691
2014	75,753	1978	638,795
2015	68,321	2038	618,942
2016	61,600	2094	945,794
2017	56,191	2084	849,204
2018	87,269	1981	663,690
2019	49,815	1924	812055
2020	48,293	2003	744723
Growth Rate	% 2.51	% 2	% 6.94

*/ Kufa Cement Factory / Accounts Department

For the purpose of estimating the production function of the Kufa Cement Factory, the data in Table (1) was used for the purpose of estimation, using the computer and the E-views program, and based on the data allocated to the Kufa Cement Factory mentioned in Table (1), the following equation was estimated to measure the impact of both capital and labor on production:

$$\hat{Log}\ Yi = -2.9 + 0.86\ Log\ L + 0.253\ Log\ K \ldots\ldots\ldots\ldots\ (3)$$

$$t = (1.94) \qquad (2.03)$$

$$F = 4.678 \qquad R^2 = 25\%$$

$$D.W = 1.62373$$

While the tabular values of (DW, T, F) parameters were obtained from the custom tables where the tabular values are

$$t^*_{(0.05)} = 1.86 \qquad F^*_{0.05} = 4.46$$

$$DL = 0.772 \qquad DU = 1.255$$

The average productivity of labor

The average productivity of labor can be found through the data mentioned in Table (1) by dividing the quantity of production by the number of workers:

$$APL = Y/L$$

The marginal productivity of labor

It is the addition to the total product resulting from adding one unit of labor to the production process. Depending on the amount of the average product of labor and the following equation, the marginal product of labor can be obtained:

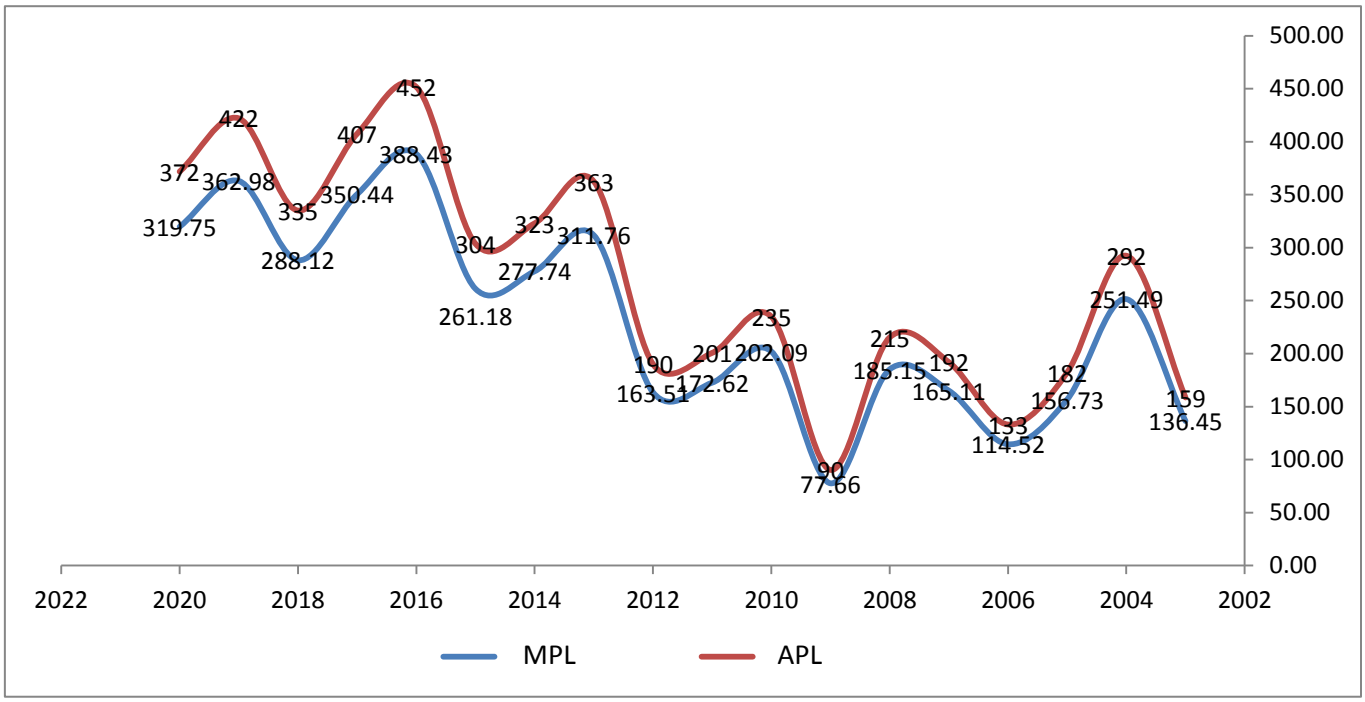
$$MPL = 0.86 * APL$$

Table 2 the Average Productivity and Marginal Productivity of Labor

Year	Y	L	APL	MPL
2003	222,440	1,402	159	136.45
2004	435,424	1,489	292	251.49
2005	304,171	1,669	182	156.73
2006	299,880	2,252	133	114.52
2007	429,100	2,235	192	165.11
2008	470,839	2,187	215	185.15
2009	208,319	2,307	90	77.66
2010	477,268	2,031	235	202.09
2011	401,248	1,999	201	172.62
2012	386,727	2,034	190	163.51
2013	687,691	1,897	363	311.76
2014	638,795	1,978	323	277.74
2015	618,942	2,038	304	261.18
2016	945,794	2,094	452	388.43
2017	849,204	2,084	407	350.44
2018	663,690	1981	335	288.12
2019	812055	1924	422	362.98
2020	744723	2003	372	319.75

* Source // The table is from the researcher's work based on the data of the Iraqi General Company for Cement / Southern Cement Association / Planning and Production Control Department / Kufa Cement Factory.

Figure. 1 the Average Productivity and Marginal Productivity of Labor



The average productivity of capital

The average productivity of capital can be found through the data mentioned in Table (1) and by dividing the quantity of production by the capital:

APK=Y/K

The marginal productivity of capital

It is the addition to the total product resulting from adding one unit of capital to the production process. Depending on the amount of the average product of capital and the following equation, the amount of marginal product of capital can be obtained:

MPK=0.253 * APK

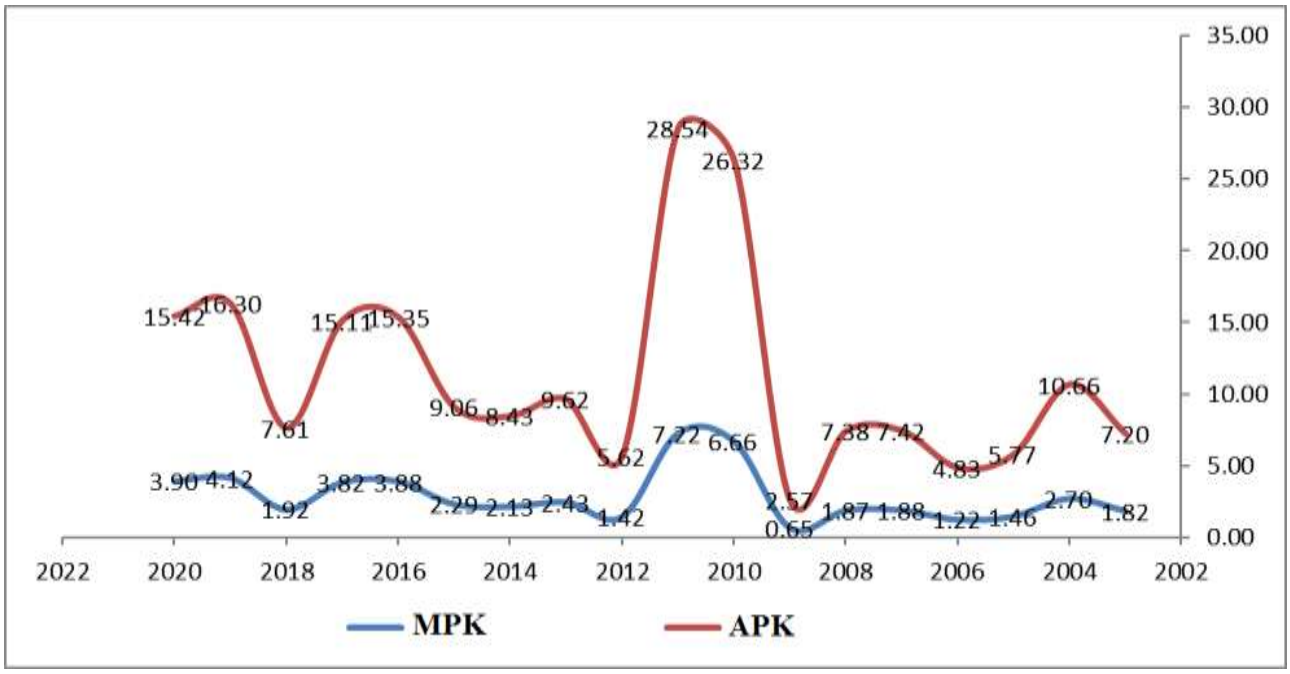
Table 3 Average Productivity and Marginal Productivity of Capital

Year	Y / ton	K / Million IQ D	APK	MPK
2003	222,440	30,909	7.20	1.82
2004	435,424	40,850	10.66	2.70
2005	304,171	52,751	5.77	1.46
2006	299,880	62,087	4.83	1.22
2007	429,100	57,854	7.42	1.88
2008	470,839	63,831	7.38	1.87

2009	208,319	81,045	2.57	0.65
2010	477,268	18,132	26.32	6.66
2011	401,248	14,061	28.54	7.22
2012	386,727	68,829	5.62	1.42
2013	687,691	71,469	9.62	2.43
2014	638,795	75,753	8.43	2.13
2015	618,942	68,321	9.06	2.29
2016	945,794	61,600	15.35	3.88
2017	849,204	56,191	15.11	3.82
2018	663,690	87,269	7.61	1.92
2019	812055	49,815	16.30	4.12
2020	744723	48,293	15.42	3.90

* Source // The table is from the researcher's work based on the data of the Iraqi General Company for Cement / Southern Cement Association / Planning and Production Control Department / Kufa Cement Factory.

Form 2 Average Productivity and Marginal Productivity of Capital



3-5 Analysis of the Production Function:

The function is analyzed in the following order:

First: the Statistical Aspect

t. test

Through the comparison, we find that the calculated t-test statistic for both labor and capital (1.94, 2.03) is greater compared to the tabular t-statistic of (1.86) at the level of significance (0.05), which means rejecting the null hypothesis and accepting the alternative hypothesis that is, accepting the significance of the estimated parameters.

Coefficient of Determination R^2

Or the interpretation coefficient. It is used to decide what the independent variables explain about the changes that occur in the values of the dependent variable. It expresses the amount of explanatory power of the estimated model. Its value has reached (0.25), meaning that the change in the independent variables explains 25% of the change in the dependent or dependent variable, which is production (Y). The remaining percentage (75%) is due to other variables that were not included in the estimated model and can be called a random variable.

F. test

This test is used to verify and know the significance of the entire model. The calculated test statistic value reached (F = 4.678), which is greater than the tabular value (F0.05 = 4.46), which indicates the rejection of the null hypothesis and acceptance of the alternative hypothesis that indicates the significance of the model or the estimated relationship and the presence of an effect For the two variables (labor, capital) in the dependent variable production.

Second: the Standard Aspect

Autocorrelation analysis

It is one of the common tests for autocorrelation, which includes calculating the statistical tests based on the remainder of the regression process. Through observation, it was found that the value of the statistic (DW) is (1.62373), which is greater than the Durban Watson tabular value, whether the minimum value (DL), which amounted to (0.772) or the higher value (DU), which reached (1.255) and this estimated value for the case of Kufa Cement Factory is located in the region of no autocorrelation because it lies between (DU < 1.62373 < 4-DU). The mentioned value indicates that there is no autocorrelation of the first degree, being close to the number 2.

Third: the Economic Aspect

The used test shows that the model passed the economic criteria because the calculated amounts and the indications of the parameters correspond to the principles of economic theory, as the estimated value of the statistics expresses the production elasticities for each variable. The production elasticity of labor of 0.86 is directly related to the value of the output. If the labor increases by 100%, the value of output increases by 86%, with all other factors held constant. As for the elasticity of production for capital, it reached (0.253), and it is directly related to the value of the output. If the capital increases by 100%, the value of the output will increase by 25.3%. In order to find out the total productive elasticity of the elements of production, the following is adopted:

$b1 + b2 = 0.86 + 0.253 = 1.113$

Through the above result, it is clear that the cement industry in the Kufa Cement Factory enjoys an increase in volume yield. When the production elements increase by 100%, the output increases by 111.3 in the case of the stability of the level of technical progress. The work share of the value of the output is identified by dividing the production elasticity of labor by overall flexibility

$W= b1/(b1+b2) * 100 = 0.86/1.113 * 100 = 77.27$

Whereas the share of capital in the value of output is measured by dividing the elasticity of production of capital by the total elasticity

$W= b2/(b1+b2) * 100 = 0.253/1.113 * 100 = 22.73$

The results show that the share of labor in the value of the output is twice greater than the share of capital in the value of production, and the elasticity of production for labor will be divided by the elasticity of production for capital. If the output is greater than one, the industry is labor-intensive, but if it is less than one, it is capital-intensive

$b1/b2 = 0.86/0.253 = 3.4$

This result indicates that the company is labor-intensive, and this reason is attributed to the nature of the cement production process, as well as the old factory and the failure to keep pace with modern technology and techniques that were followed in the cement production process.

Effect of Labor on Production with the Stability of Capital

To measure the effectiveness of the amount of labor on production with the stability of capital, the following equation will be used:

$\hat{Log}\ Yi = -2.9 + 0.86\ Log\ L + 0.253\ Log\ K$

And by taking the anti-logarithm of both sides to get the following equation:

$Yi = 0.00129 * L^{0.86} * K^{0.253}$

And by using the data from Table (4) and substituting the median value for the capital by dinar, the equation becomes as follows:

$Yi = 0.00129 * (56{,}058{,}923{,}017)^{0.253} * L^{0.86}$

$Yi = 0.676078044 * L^{0.86}$ ……. (4)

$APL=Y/L$ ……. (5)

$MPL=APL * 0.86.$ ……. (6)

And by using the data in Table (4) and substituting it in equations (4, 5, 6), the following data was reached, represented by the effect of labor on production with the stability of capital

Table 4 Total Productivity, Average Productivity and Marginal Productivity of Labor

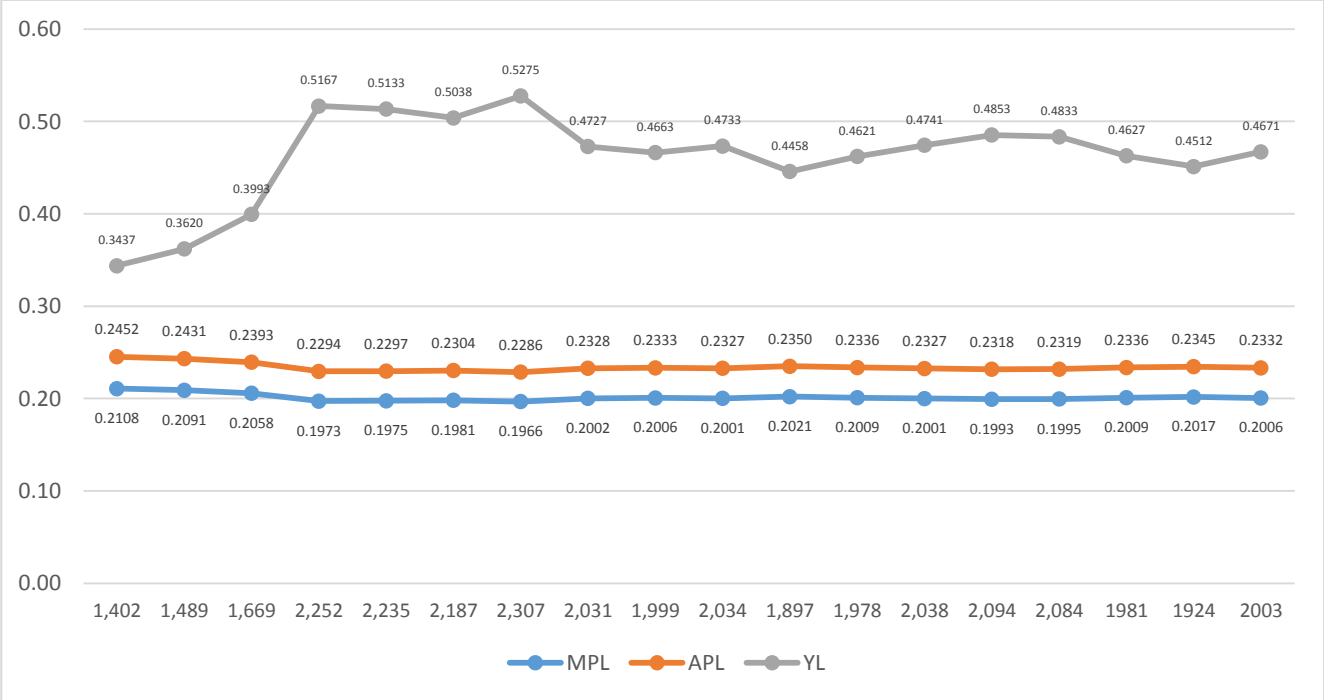
L	YL	APL	MPL
1,402	343.716	0.245161	0.210839
1,489	361.981	0.243104	0.209069
1,669	399.309	0.239251	0.205755
2,252	516.661	0.229423	0.197304
2,235	513.305	0.229667	0.197513
2,187	503.810	0.230366	0.198115
2,307	527.494	0.228649	0.196639
2,031	472.745	0.232765	0.200178
1,999	466.333	0.233283	0.200623

2,034	473.346	0.232717	0.200136
1,897	445.795	0.235	0.2021
1,978	462.116	0.233628	0.20092
2,038	474.146	0.232653	0.200081
2,094	485.330	0.231772	0.199324
2,084	483.336	0.231927	0.199457
1,981	462.719	0.233579	0.200878
1,924	451.246	0.234535	0.2017
2,003	467.135	0.233218	0.200567

* Source // The table is from the researcher's work based on the data of the Iraqi General Company for Cement / Southern Cement Association / Planning and Production Control Department / Kufa Cement Factory.

For the purpose of representing the results graphically, the Excel program was used, as well as the division of production (Y) by (1000) to make the graphs in one graph.

Form 3 Production Function, Total Productivity, Average Productivity and Marginal Productivity of Labor



Effect of Capital on Production with the Stability of Labor

To measure the effectiveness of the amount of capital on production with the stability of labor, the following equation will be used:

$\hat{\text{Log}}\ Yi = -2.9 + 0.86\ \text{Log}\ L + 0.253\ \text{Log}\ K$

And by taking the anti-logarithm of both sides to get the following equation:

$Yi = 0.00129 * L^{0.86} * K^{0.253}$

And by using the data from Table (5) and substituting the median value for the labor, the equation becomes as follows:

$Yi = 0.00129 * (1{,}978)^{0.86} * K^{0.253}$

$Yi = 0.88174 * K^{0.253}$ ……. (7)

$APK = Y/K$ ……. (8)

$MPK = APK * 0.253$ ……. (9)

And by using the data in Table (5) and substituting it in equations (7, 8, 9), the following data was reached, represented by the effect of capital on production with the stability of labor

Table 5 Total Productivity, Average Productivity and Marginal Productivity of Capital

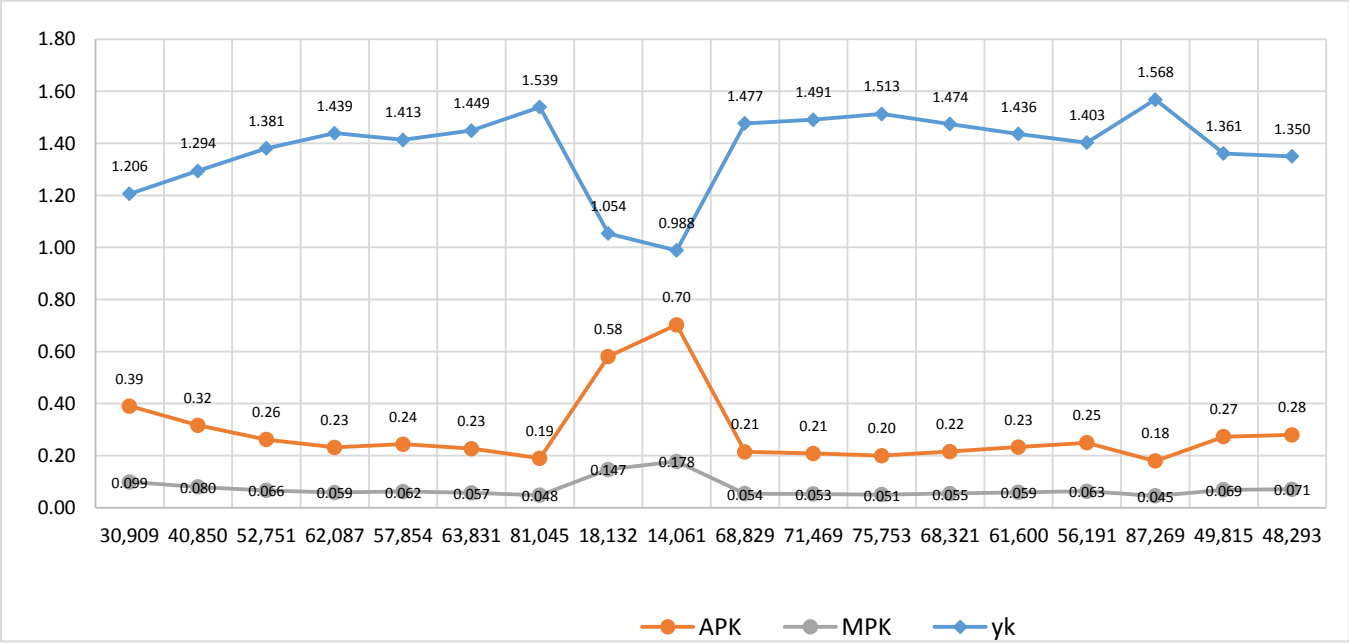
K/ Million IQ D	YK	APK	MPK
30,909	12.060	0.39	0.099
40,850	12.941	0.32	0.080
52,751	13.806	0.26	0.066
62,087	14.387	0.23	0.059
57,854	14.132	0.24	0.062
63,831	14.488	0.23	0.057
81,045	15.390	0.19	0.048
18,132	10.537	0.58	0.147

14,061	9.881	0.70	0.178
68,829	14.767	0.21	0.054
71,469	14.909	0.21	0.053
75,753	15.130	0.20	0.051
68,321	14.740	0.22	0.055
61,600	14.358	0.23	0.059
56,191	14.028	0.25	0.063
87,269	15.681	0.18	0.045
49,815	13.607	0.27	0.069
48,293	13.501	0.28	0.071

* Source // The table is from the researcher's work based on the data of the Iraqi General Company for Cement / Southern Cement Association / Planning and Production Control Department / Kufa Cement Factory.

For the purpose of representing the results graphically, the Excel program was used, as well as the division of production (Y) by (10) to make the graphs in one graph.

Form 4 Function of Total Productivity, Average Productivity and Marginal Productivity of Capital



Fourth: Conclusions and Recommendations

First: The Conclusions:

Through the available data and information that were relied upon in the process of evaluating the performance efficiency of the new Kufa Cement factory, the following conclusions were reached:

1- The low rate of exploitation and operation of energies in the factory, which lost a lot of contribution to the Iraqi gross domestic product.

2- The factory faces many difficulties and challenges represented by the obsolescence of equipment and the lack of optimal utilization of resources, as well as the interruption of electrical power before the establishment of a power station for the factory, the last of which is the economic and political fluctuations that it experienced throughout the duration of this study.

3- Through the marginal and average product of labor, it was noted that the marginal and average production of labor fluctuated between years and started low in the first years and then increased in the last years, and the marginal and average production of capital was not immune to fluctuation, as it continued throughout the years of study.

4- When analyzing the production function with a simple regression between capital and production, it was observed that there was a relationship in each of the following statistical tests (t, f, R2), And the absence of self-correlation in the standard tests, as well as the compatibility of the model with the economic theory, so that capital is directly related to production, and it is in the second stage of production, that is, the stage of increasing yields.

5- When analyzing the production function with a simple regression between work and production, it was noticed that there was a relationship in each of the following statistical tests (t, f, R2) much higher than it is with the capital, And the absence of self-correlation in the standard tests, as well as the compatibility of the model with the economic theory, so that labor is directly related to production, and it is in the second stage of production, that is, the stage of increasing yields.

Second: Recommendations:

1- The necessity of adopting an effective incentive system, in which wages are linked to productivity to motivate workers and encourage them to produce skillfully, leading to rising production efficiency and achieving planned goals.

2- Encouraging research and development in a way that leads to improving the entire production process and setting several priorities in this aspect, including reducing costs,

increasing production, raising quality, innovating new products, and developing equipment in a way that accelerates the pace of production.
3- Due to the decrease in the design capacity to less than half, it is necessary to prepare the capital needed to rehabilitate the production lines and raise the level of energy therein to what it was, in addition to replacing the obsolete equipment that cannot be developed yet, and adding new production lines, and this must be done after conducting economic feasibility studies for each process separately.
4- Activating the principle of preventive and periodic maintenance to avoid stops that occur as a result of malfunctions according to a specific timetable.

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