T.C. Dokuz Eylül Üniversitesi İktisadi ve İdari
Bilimler Fakültesi Dergisi, Cilt:4, Sayı:1-2, Yıl:1989

# MEASURING THE PRODUCTIVE EFFICIENCY OF LICENCE TRANSFERRED TECHNOLOGY:THE CASE OF TURKISH CHEMICAL FIRMS(*)

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## SUMMARY

**This study attempts to measure the productive efficiency of the technology imported to the Turkish chemical industry through license agreements in the form of licensed process and the production techniques. The measurement method involves an indirect approach based on interfirm efficiency comparisions between selected groups of Turkish firms which operated with transfered technology (TT firms) and a sample of Turkish firms which has used indigenous technology (IT firms). The findings suggest that as the IT firms were more efficient in the use of labor, the TT firms have performed better in both capital and total factor productivities.**

## I. INTRODUCTION

Authorities have long recognized that the transfer of technology is at the heart of the process of economic growth and that the progress of developing countries depends partly on imported technology. Accordingly over the years Turkey has been importing technology in various ways but mainly through foreign investment, joint ventures with minority foreign eguity, and license agreements. Particularly the technology transfer historically has been viewed as an inevitable device for closing the country`s techno-

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(*) The author, who was a visiting professor at University of Florida, Gainesville, is grateful to Dr. David Denslow and an anonymous referee for helpfull comments.

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logical and production gap as it modernizes and industrializes. (1) The popular view is that as the country has relied more on this transfer mechanisms,the technological gap has not narrowed but has widened instead.( 2) These developments have fueled the debate on the role of imported technology in affecting the nation`s technological and productive capacity.(3)

Some analysts attribute the widening technological gap to inefficiency of the imported technologies as well as to inability to produce a compatible indigenous technology, ineffective utilization of imported technology due to lack of an adequate adaption mechanism, and unacceptable terms and conditions imposed by the transferor party.

Among the various forms of transfer channels in Turkey, while the foreign direct investment has been the most effective alternative in the acguisition of the needded technology, License agreements have been the most popular mechanism. (4) This study attempts to measure the productive efficiency of the technology imported to the Turkish chemical industry through license agreements in the forms of licensed process and production technigues (know-how).It is hoped that the study will contribute to the diagnosis of the roots of the technological gap which, in turn, may eventually help lead to taking the necessary steps to close the gap.

## II. LIMITATIONS ON THE WORK

Measurement of the productive efficiency of license agreements in particular and that of other various channels is a complex task:

First, since technological progress has long been recognized as probably the most important source of economic growth and modernization, there exists a substantial empirical and theoretical literature on technological change, technological innovations and their measurements compared to that on technology transfer in the industrialized-Western world. The subject of technology transfer, and in turn its measurement, has come to the attention to the industrialized world relatively recently, especially after Japan`s and late comer South Korea`s overwhelming successes importing Western technology.

Second, the literature on the technology transfer mostly deals with issues confronting enterprises in industrialized countries. Studies and data on the transfer of technology to developing countries such as Turkey are very limited and scarce(5).

Third, although foreign investment has been commonly regarded as he most effective way to transfer technology, it is almost infeasible to de-

termine statistically its contribution in terms of technology and managerial know-how. This has directed attention to other channels, especially to license agreements, in most of the discussions on technology transfer to developing countries. Nevertheless, most of the works on license agreements facus on the related problems and general issues such as the legal-technical arrangements, commercial and regulatory terms, and acquisition and adaption mechanisms. However, among the few works about the measurement of imported technology through license agreements, the significant contributions by Balasubramanyam(1973), Telesio(1979), Mytelka(1985), Cortes and Bocock(1984) and Contracto(1985) warrant mention.

Finally, the limitation most directly impeding the measurement issue lies in the identification of the guantifiable variables reflecting the extent and the guality of imported technology in general and obtaining statistical data about them which adds another problem in developing countries in particular. Only a few developing countries have data on licensing being collected and analysed. It has been claimed that one such country is India (6). Gaining access to statistical data in Turkey, from my personal experiences, which is likely to be similar to that in most developing countries, poses a very frustrating problem in the form of either the non-availability of the data reguried or difficulties in obtaining them(7).

## III. MEASUREMENT METHOD

The method employed in this work, in attempting to measure the productive efficiency of the imported technology through license agreements used by Turkish chemical firms involves an indirect approach which is based on interfirm efficiency comparisons. This requires a comparison of growth in the productive efficiency of a sample of firms in a particular sector which use transferred technoloy with that of a group of firms which operates with indigenous technology in the same sector over a given period. A similar approach has been used by J.H.Dunning(8) in his work comparing the effiency of U.S. and U.K. manufacturing firms,by V.N. Balasubramanyam(9) in assessing the impact of technical collaboration agreements in Indian industrial productivity, and by F.J.Contractor(10) and P.Telesio(11) in their separate works on comparing licensing versus foreign direct investment in determining U.S. corporate strategy.

Application of the above method to the two groups of firms is carried out in two stages. At the first stage, the comprative efficiency of each group of firms is calculated by the utilization of well known productive efficiency indicators such as labor, capital and total factor productivity ratios.

At the second stage, Cobb-Douglas production functions are estimated for each sample of firms in the respective industry.

Even though this approach has some shortcomings which will be mentioned later, it success in providing some results on the subject largely depends on the degree of accuracy in the selection of the sample firms in the two groups and the accesibility to solid statistical data about the efficiency variables. It is particularly crucial to stick to the following criteria in the choice of sample firms:

1.The products produced by the sample of firms in the two respective groups should be similar with respect to their brands and qualities.

2.The firms included in the sample should have a considerable weight within a given setor in terms of their production capacity and employment level.

3.The groups of firms should not differ much from each other with respect to size, the business environment and the market structure in which they operate but differ only in terms of technology they employ.

One should keep in mind that it is extremely difficult to find a sufficient number of firms satisfying these selection criteria in each industrial sector and it even may become infeasible in same sectors.In other words, there is a trade off between the degree of conformity to the criteria and sample size.The more restriction is put on the selection of firms between which comparisons are to be made, the smaller will be the sample size.

## IV. APPLICATION OF THE METHOD

This section deals with an exercise in interfirm productive efficiency comparisons between selected groups of Turkish firms which operated with transferred technology (TTfirms) and a sample of Turkish firms which has used indigenous technology (IT firms) over the period 1982-86 in the chemical industry.Actually at first it was the intention of this work to include not only firms in chemical industry but also in electronics, electrical and non-electrical industries. But this was not possible(12).The acquisition of foreign technology in Turkey through license agreements usally takes place on an entrprise-to enterprise basis.Turkish firms, as in most developed countries, seek specific know-how covered by patents or trade marks rather than for compositeor package technology(13). The latter type of transfer is common for developing countries in both the estaplishment and the operation of industrial enterprises(14). On the basis of the most re-

cent data available Turkey`s license agreements are concentrated in chemical products, petro-chemical products, rubber products, electrical appliances and electronic products, machinery and metal products. The leading contractual countries are W. Germany followed in order by the U.S., Italy, Switzerland, and the U.K(15).

Selection of Sample Firms

The sample of firms in each group of the chemical manufacturing firms has been selected from 56 major firms which have operated in the Turkish chemical industry for the years 1982 to 1986. After careful scrutiny only 13 firms in the group of the IT firms and 11 firms in the group of the TT firms were found to satisfy the selection criteria mentioned earlier. The main source of information for classifying each group was the National Survey of The Technical Conditions of Turkish Manufacturing Firms carried out by the Turkish Scientific Research Center. On the other hand, the sources of information in obtaining statistical data on the variables needed for the implementation of the above method were the Annual Reports on the Performance of Turkish Firms issued by the Istanbul Chamber of Industry and the Capacity Reports on Turkish Manufacturing Firms supplied by the Federation of Turkish Chambers of Commerce and Industry.

Table 1 shows the accessible data in aggregate terms for the 13 IT firms and the 11 TT firms for the years 1982 and 1986.

On the basis of the gross output, a common indicator of firm size, the two groups of firms can be thought of almost the same size. But judged on averege employees per firm, the IT firms seem to be bigger than the TT firms. Over the years the IT firms have registered significantly higher percentage increases in both gross output and number of total employees but almost the same percentage rise in total assets the TT firms have performed.

Table 1 Gross Output, Employees, Wages and Salaries and Fixed Assets in Chemical Manufacturing Firms, 1982 and 1986*

| | IT Firms | | | TT Firms | | |
|---|---|---|---|---|---|---|
| | 1982 | 1986 | Percentage İncrease | 1982 | 1986 | Percentage İncrease |
| Number of firms | 13 | 13 | | 11 | 11 | |
| Total gross output | 72,577 | 329,324 | 353,7 | 80,219 | 288,087 | 259,1 |
| Total employees | 13,124 | 16,162 | 23,1 | 4,227 | 4,984 | 17,9 |
| Total wage bill | 3,149 | 11,637 | 269,4 | 1,522 | 4,187 | 175,1 |
| Total assets | 99,904 | 320,099 | 220,4 | 57,467 | 175,018 | 204,6 |

*All the variables expect total employees are given in millions of Turkish Lira.

## Adjusted Productivity Indicators

As Table 1 shows the data employed in this study deviate from the conventionally used or ideal variables for estimating productivity indicators and Cobb-Douglas production function. For instance, the market value of gross output instead of value added has been used for the numerator of productivity ratios due to our inaccessibility to the selected firm`s production costs. This should not be taken as a serious shortcoming. Even thought net producitivity has begun to attract more attention in recent years.(16)

For the estimation of labor productivity the number of employees(L) and that of total factor productivity the wagessalary bill (LW) have been taken to represent labor input.

In the case of capital, we were compelled to utilize the book values of assets (K) as supplied by the relevant firms for the capital variable. Ideally as Balasubramanyam cited it would make more sense to take the current replacement costs of assets(17). Alternatively the insurance valuation of the fixed assets of the firms may be employed as J. H. Dunning did in his work on interfirm efficiency comparisons(18). Unfortunately these data are not available for the Turkish firms.

All the variables used in this study in estimating the productivity indicators are valued at current or historic prices, that is, in terms of undeflated values. This was done for two reasons. First, utilization of undeflated values of variables should be deemed as legitimate in such studies which require comparisons over time(19), as is the case in this work. Secondly, no proper deflator for all these variables exists.

In accordance with the defined variables the labor productivity index (Q/L) calculated in this work for the differend groups of firms is the gross output per employee. On the other hand, the capital productivity index(Q/K) is estimated in terms of output per unit of total assets(K).Further, the ratio of total assets to the number of employees(K/L) are taken as the indicator of capital intensity.

When labor productivity and capital productivity show divergent trends neither alone provides an adequate indicator of overall productive efficiency. This leads to the need to take into account to total factor productivity index(TEP) which relates the combined impact of all inputs to output. Thus TEP index could be utilized as a more sound proxy indicator for overall efficiency of the firms(20). There are several methods available to estimate this index. We have adapted the method employed by N.E.Terlecky j in the form of following expression:(21)

$$TEP = \frac{Q}{LW + rK}$$

Q= gross value of output

LW= total wages and salary bill
r= rate of return on capital
K= gross value of total assets

The method of Kendrick and others is very similar to the above method used in this study except it uses the base year price for labor and capital to calculate their shares or weights in total output. The above method employes current year prices for labor as its weight and uses an assumed rate of return on capital for the capital price or its weight. Moreover, in calculating the TFP, we used 60 per cent rate of return on capital which was suggested to be a reasonable rate by Turkish State Investment Bank in reflecting the nominal rate at which the Turkish entreprises can borrow or the highest gross profit that can be earned on total assets.

## Unrestricted Cobb-Douglas Production Function

In evaluating the relative productive efficiency of the two groups of firms, the second approach quoted earlier was the application of Cobb-Douglas production functinos to the respective groups.However, the type of Cobb-Douglas production function at below adapted for this study is called unrestricted Cobb-Douglas production function which differ from the basic one with respect to dropping the assumption ofconstant return to scale, and perfect competitive factor and commodity markets(22)

$$Q = A L^a K^b$$

The following logarithmic transformation of this function were estimated by least squares for the two groups of firms for the years 1982 and 1986.

$$\text{Log } Q = \log A + a \log L + b \log K$$

Where

Q= gross outputs of the firms,
A= an indeks of total factor productivity,
a= the elasticity of output with respect to labor,

b= the elasticity of output with respect to capital,
L= total employees of the firms,
K= total assets of the firms,

**Application Results**

The results concerning with the application of the productive efficiency indicators to the selected groups of IT and TT firms in Turkish Chemical Industry are given in Table 2. This table shows the annual average percentage rate of growth ( average % growth rate ) over the five-year period in the various productivity indicators and the estimated five-year averages for these indicators for the two groups of the firms. The final column shows the "t" statistics to test statistical significance of the difference in the five-year averages between the two groups. The statistical importance was tested at 5 percent significance level and those statistically significant carry asterisk sign.

In Table 2 the IT firms showed much lower labor productivity at the five year average although they performed a moderately higher annual avarege rate of the growth in the respective productivity compared to the TT firms. On the other hand, the TT firms registesed a significantly highes capital productivity but in term of the annual average growth rate they fell much behind that of the IT firms. Moreover, the capital intensity indicator (K/L) for both of the two groups of firms are found to be statistically insignificant. Thus this make it difficult to explain the differences in labor and capital productivities of these groups of firms on the basis of the factor intensity. Neverthless, the much higger labor productivity of the TT firms may largely attributed to the nature of the technology they have transferred and partly the relatively higher capital intensity of their operation. In the other words, increasing application of capital, necessitated by the imported know-how, may have accompanied by a growth in domestic skills and the efficiency required to operate the transferred technology.

Table 2

Productivity Indicators of the IT Firms and the TT Firms

| | IT Firms | | TT Firms | | |
|---|---|---|---|---|---|
| | Average % growth over 1982-86 | fi.e year average | Aver. % growth over 1982-86 | five year average | Estimated "t" value |
| Q/L | 38.36 | 13 72 | 29.22 | 39.98 | 2.20* |
| Q/K | 5.87 | 0.96 | 2.55 | 1.58 | 4.83* |
| K/L | 22.88 | 14.34 | 22.63 | 25.24 | 1.65 |
| TFP | 4.89 | 1.39 | 2.43 | 2.37 | 5.37* |

On the other hand, the higher capital productivity experience also by theTT firms may be expleined by the more efficient utilization of capital rather than the differences in factor intensity which is already found to be insignificant.

In terms of total factor productivity, which is considered to be the indicator of overall productive efficiency, while the TT firms registered higher total productivity the TT firms recorded a much higher growth rate in the respective productivity over the years. The relatively much higher growth rate in capital productivity and slightly better growth rate in labor productivity experienced by the IT firms do not seem to have compensated for the poor performances of both capital and labor productivities over the years. Thus, in short the TT firms appear to have performed better with respect to the relative overall efficiency.

The results of the estimated-unrestricted Cobb-Douglas production functions for the two groups of firms for the years 1982 and 1986 are shown in Table 3.

The estimated results based on cross-sectional data in general are quite gratifying, in that the percentage variation in output explained by the independent variables ($R^2$) is quite high in all equations, the estimated coefficients in most cases are statistically significant and almost all of their signs are consistently positive, as anticipated.

In terms of the 1982 functions while the IT firms appear to have been more efficient in the use of labor, the TT firms seem to have performed better in capital use. Among other things this may be attributed to the different nature of technology used by each group, that is, the labor intensive technology of the IT firms and the capital intensive technology of the TT

firms. The capital coefficient in the case of the IT firms and the labor coefficient with respect to the TT firms are found to be insignificant in explaining the variation in the outputs of the respective firms. On the other hand, the estimated function for the year 1986 show more meaningful results for comparison of their efficiency. That is mainly because both of the functions carry more improved $R^{2'}$s and more variables have become statistically significant with the exception of labor coefficient in the TT function bearing and unanticipated negative sign. In comparing with the 1982 functions as the IT firms have also become efficient in the use of capital, the TT firms have experienced inefficient use of labor with improved efficiency in the use of capital. Further, the difference between capital coefficients of these two groups of firms, at almost 152 percent is higher than the difference bet ween the labor coefficients, at 109 percent.

Table 3

Regression Estimates of Cobb - Douglas Production Functions for the IT firms (Standart errors in paranthesis)

| | IT Firms | | | | | | TT Firms | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costant | Log L | Log K | $R^2$ | N | | Costant | Log L | Log K | $R^2$ | N |
| 1982 (1) | 1.607 | 0.712 (7.495*) | 0.032 (0.444) | 0.89 | 13 | (3) | 0.571 | 0.090 (0.176) | 0.823 (3.626*) | 0.74 | 11 |
| 1986 (2) | 1.940 | 0.312 (4.010*) | 0.376 (7.301*) | 0.95 | 13 | (4) | 0.499 | 0.028 (0.077) | 0.948 (4.017*) | 0.76 | 11 |

Thus the TT firms appear to have been relatively a higher overall productive efficiency in the use of both inputs taken together.

Finally the following regression equation is estimated in order to test the contribution of the two factors of production to the growth in gross output of the two groups over the periodsof 1982-1986:

$$\log\left(\frac{Q_{86}}{Q_{82}}\right) = \log A + \alpha \log\left(\frac{L_{86}}{L_{82}}\right) + \beta \log\left(\frac{K_{86}}{K_{82}}\right)$$

The log of the ratio of gross output of 1986 to that of 1982 for each of the firms is regressed on the log of the ratio of the total employees of 1986 to 1982, and the Log of the ratio of the valve of total assets of 1986 to 1982.

The above function estimated for the IT firms are given below in equation 5 and for the TT firms in equation 6:

$$\log\left(\frac{Q_{86}}{Q_{82}}\right) = 0.531 + 0.502 \log\left(\frac{L_{86}}{L_{82}}\right) + 0.130 \log\left(\frac{K_{86}}{K_{82}}\right) \qquad (5)$$

$R^2$ 0.23 (0.462) (0.203)

$$\log\left(\frac{Q_{86}}{Q_{82}}\right) = 0.349 - 0.173 \log\left(\frac{L_{86}}{L_{82}}\right) + 0.485 \log\left(\frac{K_{86}}{K_{82}}\right) \qquad (5)$$

$R^2$ 0.43 (1.078) (0.262)

The above estimates may indicate cross-sectional differences in the long term growth of the firms over the period 1982-1986. Obviously the estimated functions as an indicator of long-term growth seem to have yielded very poor results. That is mainly because in both functions not only the $R^{2}$`s extremly low but also almost all of the estimated coefficients are statistically insignificant. Therefore, it is not possible to draw any plausible conclusion about the trend of the relative growth in the productive efficiencies of the respective groups of firms on the basis of obtained poor results. However, the relatively better fit for the TT firms may indicate that these firms experienced a decline in labor productivity but a significant rise in capital productivity over the years. The coefficient of -0.173 for labor imlies a 10 percent increase in the ratio of total employees in 1986, ceteries paribus, leads to a 1.73 percent decrease in the ratio of gross output over the same period. On the other hand, the coefficient of 0.485 for capital indicates a 10 percent increase in the ratio of total capital in 1986 to that of 1982, ceteris paribus, results in 4.85 percent rise in the ratio of gross output over the same period.

The sum of the two coefficients of 0.312 percent increase in the ratio of each of the inputs would produce a 3.12 percent increase in gross output.

That means, in terms of long-term growth, the significant increase in capital productivity appears to have been sufficient to offset the decline in labor productivity.

## V. CONCLUSION

On the basis of the results reached in this study, the following preliminary conclisions can be drawn:

1) A comparative analysis of the productivity indicators suggest that in terms of the five-year average productivity the TT firms appear to have been more efficient than the IT firms with respect to all of the three productivity indicators, namely labor, capital and total factor productivities. In the case of productivity growth over the years, the IT firms appear to have performed better than the TT firms especially in terms of labor and total factor productivity but no fast enough to catch up with the respective average productivities of the TT firms over the same years.

2) On the other hand, the production function estimates indicate the followings: First, in the case of the IT firms both labor and capital inputs but with respect to the TT firms only capital input are found to be significant variables in explaining variation in total outputs. Second, as the IT firms were significantly more efficient in the use of labor with improved efficiency in the use of capital later, the TT firms have experienced an inefficient use of labor but a clear superiority in the productive use of capital which eventually led them to have a higher overall productive efficiency. In other words, the TT firms have experienced a higher total factor productivity over the period 1982-1986 mainly owing to their ability to utilize capital input much more efficiently despite their ineffcient use of labor input. In the final analysis, both the productivity indicators and production function estimates suggest that in terms of relative efficiency in the use of labor, the TT firms have performed better in both capital and total factor productivities.

It should be kept in mind that productivity measurements indicates a firm's technichal efficiency but not overall economic efficiency. On the other hand, to transfer and make efficienct use of imported technology undobtedly requires considerable "technological mastery" or technological capacity. The technology has to be adapted to local conditions, and to differences in the quality/avilability of various factors, in goverment regulations, market conditions and so on. Japan's successful development in the twentieth century compared to other technology importing countries not only lies in her heavy use of Western technology and its nature but also her capability in adapting transferred technology (23).

## FOOTNOTES

[1] This statement has been repeatedly quoted in each issue of the Fifth-Five Year Development Plan of Turkey since 1963 in reference to "Technological Policy".

[2] See the Turkish Mechanical Engineers Union(1980, p.3).

[3] Despite the continuous controversy over this issue, we dare to say that in Turkey there exists a very limited number of works, almost none, based on the observed facts toward the objective evaluation of this subject. Most of the assessments have grown out of emotions and ambiguous data.

[4] See The State Planning Organization of Turkey (1978, p.228).

[5] See UNIDO (1973, p.1).

[6] See UNIDO (1973, p.1).

[7] It is a chronic problem which most researchers and academicians often face in Turkey especially in the case of carrying out research about the activities of business firms. The business firms not only are very reluctant and mainly uncooperative but also "Protection of Busines Secrecy" code empovers them not to reveal any business data against their will.

[8] See the work of Dunning(1970, pp.345-400) for interfirm economic efficiency comparisons.

[9] See the work of Balasubramanyam(1970, pp.92-137) for the relative productive efficiency comparisons, that is more directly related to our study.

[10] See the work of Contractor(1985, pp.277-319) for determing U.S. Corporate Strategy between licensing and foreign direct investment alternatives.

[11] See Telesio's study(1979, pp.66-103) on comparing the economic benefits of the technological license agreements with that of controlled foreign direct investments of multinational entreprises.

12 In these sectors it was unfortunately impossible to come up with an adequate sample size in each group consistent with the given sample selection criteria, especially with respect to the two different kinds of technology. Also, it was infeasible to gather statistical data about them in spite of our intensive efforts.

13 See The Ministry of Turkish Industry and Technology(1981, p.16).

14 See UNIDO (1973, p.4).

15 See The Turkish Mechanical Engineers Union (1980, p.32).

16 On this view see Dovrin (1987, p.134), Gollop and Jurgenson (1980, pp. 124-136), and Christenson(1975, pp.900-915).

17 See Balasubramanyam(1973, p.96).

18 See Dunning(1970, p.366).

19 For a discussion on this topic see Dovrin(1987, pp.169-176), Kravis(1984, pp.1-39), and Marris(1984, pp.40-57).

20 For the detailed discussion see Silver(1984, pp.3-11).

21 See Kendrick(1961, p.6), Silver (1984, p.15) and Terlecky (1982, p.69).

22 The same equation has been applied by Katz (1969, pp.27-28), by Silver (1984, p.14), and others.

23 See the Annals of The American Academy of poitical and Social Science(1981, p.10

## LİSANS ANLAŞMALARI KANALIYLA YABANCI TEKNOLOJİ KULLANAN FİRMALARIN VERİMLİLİKLERİNİ ÖLÇÜLMESİ : TÜRK KİMYA ENDÜSTRİSİNDE BİR UYGULAMA

Bu çalışma, Türk Kimya Endüstrisi'nde lisans anlaşmaları kanalıyla ithal ya da transfer edilen teknolojinin verimliliğini ölçmeye yöneliktir. Ölçüm metodu, ülkemiz kimya endüstrisinde yerli teknoloji kullanan bir grup firmayla, yine aynı alanda transfer edilmiş yabancı teknoloji kullanan firmaların dolaylı olarak verimliliklerinin karşılaştırılması esasına dayanır. Çalışmanın bulguları, yerli teknoloji kullanan firma grubunda işgücü faktörünün daha verimli kullanılmasına karşın; ithal edilen yabancı teknoloji kullanan firma grubunda ise, sermaye girdisi ve toplam faktörlerin daha verimli kullanıldığını göstermektedir.

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