Eskişehir Osmangazi Üniversitesi Mühendislik ve Mimarlık Fakültesi Dergisi 26(3), 107-116, 2018

The Journal of Engineering and Architecture Faculty of Eskisehir Osmangazi University 26(3), 107-116, 2018

TOTAL PRODUCTIVITY AND PROFITABILITY ANALYSES OF TURKISH BORON MINING

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DOI : http://dx.doi.org/10.31796/ogummf.404467

Makale Geliş : 12.03.2018
Makale Kabul : 24.04.2018
Araştırma Makalesi

Article Received : 03.12.2018
Article Accepted: 04.24.2018
Research Article

Türkiye Bor Madenciliğinin Toplam Verimlilik ve Karlılık Analizleri

Öz

Verimlilik, işletme performanslarını belirlemek için kullanılan temel göstergelerden biridir. Türkiye'de Bor Madenciliği sektöründe kârlılığın yüksek olması verimlilikle ilgili çalışmaların göz ardı edilmesine yol açmıştır. Bor pazarının yapısı ve ürün gamının birbiriyle ikame edebileceği kalitesinden ötürü, rekabetten kaynaklanacak gelecekteki muhtemel fiyat düşüşleri verimlilik ölçüm ve değerlendirme çalışmalarına dikkat çektiği düşünülmektedir. Bu çalışmada, Fisher Ideal Index kullanılarak "Toplam Verimlilik ve Karlılığın Analizi için Toplam Endeks (AIPR)" adı verilen model yeniden yapılandırılmıştır. Geliştirilen model, verimlilik açısından mevcut durumu görmek ve üretkenliği artırmak için hangi noktalara odaklanılacağını belirlemek amacıyla, 1980 ve 2001 yılları arasında Türkiye Bor Madencilik Sektörüne uygulanmıştır. Sektörün kârlılık ve verimlilik düzeyinin temel yıla göre yüksek olduğu ve teknolojik değişimin yüksek verimlilikte lider rolü oynadığı saptanmıştır. Ayrıca bu çalışmada, Türkiye Bor Madencilik Sektörünün girdi parametreleri ile verimlilik ve karlılık endeksleri arasındaki ilişkiyi belirlemek için istatistiksel analizler yapılmıştır.

Anahtar Kelimeler : *Verimlilik Analizi, Bor Madenciliği, AIPR Modeli, Karlılık, Fisher İdeal İndeksi.*

Total Productivity and Profitability Analyses of Turkish Boron Mining

Abstract

Productivity is one of the primary indicators used to determine enterprise performances. The fact that profitability is high in Turkey Boron Mining sector has led to undervaluing the studies related to productivity. Due to the structure of the boron market and the product range's quality to be able to substitute for each other, the potential future price drops to be caused by competition is considered to draw attention to productivity measurement and assessment studies. In this study, the model called as "Aggregate Index for the Analysis of Total Productivity and Rentability (AIPR)" was restructured by means of Fisher Ideal Index. The developed model was applied to Turkey Boron Mining Sector between the years 1980 and 2001 in order to see the current position with regard to productivity and to determine which points to focus on to increase productivity. It was established that the sector's profitability and productivity level according to the base year was high and that technological change played the leading role in achieving high productivity. Also in this study, statistical analyses were carried out in order to determine the relation between the input parameters of Turkey Boron Mining Sector and indices of productivity and profitability.

Keywords : *Productivity Analysis, Boron Mining, AIPR Model, Rentability, Fisher Ideal Index.*

1. Introduction

Mining is one of the main industries, which not only contributes with resources to country's development, but is also globally recognized (Solminihac et al., 2018). Boron is one of the most important minerals that Turkey

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possesses. Boron minerals contain boron oxide (B_2O_3) at various levels and the common boron minerals found in Turkey are tincal, cholemanite and ulexite. Boron minerals can be used as raw material in some industries and they present a wide range of practical use after being transformed generally into refined boron compounds and end products. Having a wide range of practical use from glass industry to soap and detergents, from fertilizers and pesticides to flameproof materials and nuclear applications, boron products have a key position in today's technology. As the actual function in the end use of boron products is their B_2O_3 contents, various boron products can substitute for each other. In other words, a product of boron can be a commercial rival for another (Eti Mine, 2003). Turkey, has 73% of the world boron reserves by 3.3 billion tons. In 2016, Eti Maden refined boron production capacity was 2.7 million tons and its sales amount was approximately 1.8 million tons. Approximately, 95% of the boron mine produced in our country is used in the production of refined boron products, and about 97% of the produced refined boron products are exported (Eti Mine, 2016). It is suggested that the potential future price drops due to the competition caused by the structure of the boron market and the product range's quality to be able to substitute for each other will eventually draw attention to productivity measurement and assessment studies.

Productivity is the relation between an output received from a system and the inputs used to obtain that output (Sink, 1985). The method to determine if productivity is low or high is productivity measurement. Productivity measurement is the most essential and first step in both determining and improving productivity. Productivity is a key factor for success for all types of organizations. Productivity measurement conducted at enterprise basis allows monitoring productivity development in an enterprise throughout years and making a comparison with other rival enterprises in terms of productivity.

Productivity is divided into three main categories which could be listed as total productivity, total factor productivity and partial productivity (Stainer, 1996, 1997; Sumanth 1998; Schreyer, 2001; Hannula, 2002; Ghebrit, 2004). There are three approaches for measuring the improvement in productivity: index number approach, parametric approach and non-parametric approach (Mongia and Sathaye, 1998; Hailu and Veeman, 2001). The studies conducted in mining sector on productivity have generally been applied in coal mining (Szwilski, 1988; Darmstadter, 1997; Flynn, 2000; Kulshreshtha and Parikh, 2001) due to the fact that data can be collected more easily in this sector. However, there seems to be no productivity measurement study on the boron sector according to the researches of present authors. In this study, the model suggested by Kurosawa (1991), which is based on index number approach and called AIPR, was taken as the basis. The primary reasons why this model was chosen are its suitability for productivity measurement at sectoral and firm level and the conveniences it presents in adapting economic data to the model. Due to the fact that the index numbers this model uses contain error at certain levels, the model was restructured with index number approach, which is commonly used in economic analysis calculations and called "Fisher Ideal Index", and a new productivity measurement model was developed. The implementation of this study was carried out on Turkey Boron Mining Sector between 1980 and 2001 in order to see the current position in terms of productivity and to determine which points to focus on to increase productivity.

2. Indexation of Productivity Measurement Parameters

Index number is a statistical indicator which represents the proportional change of a variable or a set of variables in time and space (Comlekci, 1994). In index number approach used in productivity measurement, a general productivity index can be calculated by means of Equation 1 (Mawson et al., 2003).

$$P_t=O_t/I_t \quad (1)$$

Where ;

P_t : Productivity index,

O_t : Index of output quantities,

I_t : Index of input quantities,

t : Time period.

Although it is quite easy to calculate productivity index after determining output and input quantities, the hardest challenge encountered is to determine the accurate productivity index. An input or output quantity index can be formed by adding various inputs and outputs produced in economic conditions. Index formulas with many and various weighing were devised to solve this major problem (Mawson et al., 2003).

Generally four basic index numbers are used in productivity measurement methods: Laspeyres, Paasche, Törnqvist and Fisher index (Diewert, 1993; Rogers, 1998; Mawson et al., 2003; Ahn and Abt, 2005). However, the index form called "Fisher Ideal Index" has been used commonly over the recent years because of the reasons mentioned below.

Laspeyres and Paasche are forms that were devised to compare the changes in price and quantity over a given period of time. Laspeyres index form was established as base year weighed. The expression base year weighed requires the use of a specific year as the reference year over the whole analysis time period. This situation may yield some prejudiced results for analyses varying over a long interval. Paasche and Fisher indices could be

suggested as index forms which are used commonly and can eliminate this problem. (Ahn and Abt, 2005).

The price of the comparison year in addition to the price and quantity of the base year is used when establishing price index in Laspeyres form. The margin for error could be reduced to a minimum if the assessment is conducted by including the quantity of the comparison year in price index calculations. Therefore, using Paasche or Fisher index, which contain the quantity of the comparison year as well in price index calculations, can yield more accurate results (Diewert and Fox, 1998).

As Laspeyres and Paasche forms both take the weighing factor of the base year into consideration when the weighing factor between the compared and base years is high, they approach economic productivity measurements in quite a prejudiced way. Using the approach called Fisher form and calculated by taking geometric mean of Laspeyres and Paasche forms in order to avoid these negative approaches carries a more realistic meaning in practice (Kurosawa, 1991; Mawson et al., 2003; Ang et al., 2004; Balk, 2004).

Requiring less data in comparison with Fisher index, Törnqvist index allow performing calculations more easily, which leads to an easier application of the index in practice. However, although both index types present similar theoretical features and yield similar results, Fisher index has found a significant area of practical application particularly in conducting economic analyses. While especially the U.S. Bureau of Labor Statistics uses Törnqvist index in workers productivity measurements, the U.S. Bureau of Economic Analysis and the International Monetary Fund (IMF) use Fisher Index (Dumagan, 2002; Reinsdorf et al., 2002; Hansson, 2002).

Fisher price index is calculated by taking the geometric mean of Laspeyres and Pasche price indices and represented by Equation 2. Similarly, Fisher quantity index is calculated by taking the geometric mean of Laspeyres and Pasche quantity indices and represented by Equation 3 (Mawson et al., 2003; Balk, 2004; Ang et al., 2004).

$$P_F = (P_L . P_P)^{1/2} = \left(\frac{p_1 q_0}{p_0 q_0} \frac{p_1 q_1}{p_0 q_1} \right)^{1/2} \quad (2)$$

$$Q_F = (Q_L . Q_P)^{1/2} = \left(\frac{p_0 q_1}{p_0 q_0} \frac{p_1 q_1}{p_1 q_0} \right)^{1/2} \quad (3)$$

where,

p_0: Price of base year,

p_1: Price of current year,

q_0: Quantity of base year,

q_1: Quantity of current year.

Although the index types mentioned are used by many international organizations, it is considered that using Fisher Ideal Index would be more appropriate especially in economic analysis calculations due to the reasons mentioned above. Therefore, the relative and absolute value systems where the model suggested by Kurosawa and called AIPR is used were restructured based on Fisher Ideal Index.

3. Calculation of Productivity and Profitability with Fisher Ideal Index

Relative value system is formed by using indices and represents price and quantity changes proportionally. Absolute value system, on the other hand, represents the effect of price and quantity changes in monetary terms.

Productivity is a relative concept. Making comparisons is required when discussing the productivity of an enterprise, sector or economy. These comparisons can be made between another enterprise, another country or a previous month or year. Expressing productivity merely in numbers is not meaningful and sufficient to make an interpretation. Instead of that, productivity comparison is made based on a term chosen.

The system established is based on profitability's relation with productivity and price recovery. Profitability is defined as the proportion of sales to costs. While costs are the multiplication of inputs and input prices, sales equal the multiplication of output quantities and output prices. Profitability can be expressed as the following equation:

Profitability = (Output prices × Output quantities)/ (Input prices × Input quantities) (4)

The equation above can be rewritten as two ratios:

Profitability =(Output prices / Input prices)*(Output quantities / Input quantities) (5)

The first part of the equation is price recovery which is the ability to maintain a favorable relation between prices paid for input and prices charged to costumers. The second part of the equation is productivity (Stainer, 1997; Ghebrit, 2004). Relative value system, which is based on the relation of profitability with productivity and price recovery and formed by using Fisher Ideal Index (Onder, 2006), can be given as in Equation 6.

$$I_\pi = \left(\frac{I_{p(F)}}{I_{P(F)}} \right) * \left(\frac{I_{q(F)}}{I_{Q(F)}} \right) \quad (6)$$

In Equation (6);

(F) : Fisher index,

$I_{p(F)}$: Index of price of products,

$I_{P(F)}$: Index of price of input factors,

$I_{p(F)/P(F)}$: Index of relative price,

$I_{q(F)}$: Index of total output of products,

$I_{Q(F)}$: Index of total input factors,

$I_{q(F)/Q(F)}$: Productivity index,

$I_{\pi} = \pi_t/\pi_0$: Profitability index,

$$\frac{\sqrt{\frac{\sum p_1q_1}{\sum p_0q_1}\cdot\frac{\sum p_1q_0}{\sum p_0q_0}}}{\sqrt{\frac{\sum P_1Q_1}{\sum P_0Q_1}\cdot\frac{\sum P_1Q_0}{\sum P_0Q_0}}}\cdot\frac{\sqrt{\frac{\sum p_0q_1}{\sum p_0q_0}\cdot\frac{\sum p_1q_1}{\sum p_1q_0}}}{\sqrt{\frac{\sum P_0Q_1}{\sum P_0Q_0}\cdot\frac{\sum P_1Q_1}{\sum P_1Q_0}}}=\frac{\frac{\sum p_1q_1}{\sum P_1Q_1}}{\frac{\sum p_0q_0}{\sum P_0Q_0}} \quad (7)$$

In Equation (7);

p : Price of product,

q : Quantity of product,

P : Price of input factors (raw material, labour force, machine etc.),

Q : Quantity of input factors,

π_0 : Cost profitability at base year,

π_t : Cost profitability at comparison year.

Equation 6, formed based on Fisher ideal index, can be established in the following way so as to make it more suitable for practical uses:

0 : Base year,

1 : Current year.

In absolute value system, on the other hand, the multiplication in relative value system is expressed as addition, and the division as subtraction (Kurosawa, 1991). The absolute system compatible with Fisher ideal index in relative value system expressed in ratios in Equation 7 is as the following represented in Equation 8:

$$\left[\frac{1}{2}\left[\left(\sum p_1q_1-\sum p_0q_1\right)+\left(\sum p_1q_0-\sum p_0q_0\right)\right]-\frac{1}{2}\left[\left(\sum P_1Q_1-\sum P_0Q_1\right)+\left(\sum P_1Q_0-\sum P_0Q_0\right)\right]\right]+$$
$$\left[\frac{1}{2}\left[\left(\sum p_0q_1-\sum p_0q_0\right)+\left(\sum p_1q_1-\sum p_1q_0\right)\right]-\frac{1}{2}\left[\left(\sum P_0Q_1-\sum P_0Q_0\right)+\left(\sum P_1Q_1-\sum P_1Q_0\right)\right]\right]$$
$$=\left[\left(\sum p_1q_1-\sum P_1Q_1\right)-\left(\sum p_0q_0-\sum P_0Q_0\right)\right] \quad (8)$$

In equation 8;

$\left[\left(\sum p_1q_1-\sum P_1Q_1\right)-\left(\sum p_0q_0-\sum P_0Q_0\right)\right]$: represents the effect of profitability,

$\frac{1}{2}\left[\left[\left(\sum p_1q_1-\sum p_0q_1\right)+\left(\sum p_1q_0-\sum p_0q_0\right)\right]-\left[\left(\sum P_1Q_1-\sum P_0Q_1\right)+\left(\sum P_1Q_0-\sum P_0Q_0\right)\right]\right]$: represents the relative price effect,

$\frac{1}{2}\left[\left[\left(\sum p_0q_1-\sum p_0q_0\right)+\left(\sum p_1q_1-\sum p_1q_0\right)\right]-\left[\left(\sum P_0Q_1-\sum P_0Q_0\right)+\left(\sum P_1Q_1-\sum P_1Q_0\right)\right]\right]$: represents the total effect of productivity change.

This effect representing the value of output increase is productivity change defined in a wider sense. In this analysis, productivity effect is represented in absolute value and caused by technological change and aggregated input scale effect. Technological change denotes the aggregated result of improvement and progress in hardware (such as tools, machines, apparatus, new materials/energy sources, etc.) and software (such as the business organizational situation, the managerial scheme, industrial engineering, etc.). Scale economy effect, on the other hand, represents output increase caused by increasing input quantity

(Kurosawa, 1991). Productivity effect can be established as the following so that it represents technological change effect (TCE) and the aggregated input scale effect (SE):

$$TCE = \frac{1}{2}\left[\left(\sum p_0 q_1 - \pi_0 \sum P_0 Q_1\right) + \left(\sum p_1 q_1 - \pi_{10} \sum P_1 Q_1\right)\right] \quad (9)$$

$$SE = \frac{1}{2}\left[\left(\pi_0 \sum P_0 Q_1 - \sum p_0 q_0\right) - \left(\sum P_0 Q_1 - \sum P_0 Q_0\right)\right] + \left[\left(\pi_{10} \sum P_1 Q_1 - \sum p_1 q_0\right) - \left(\sum P_1 Q_1 - \sum P_1 Q_0\right)\right] \quad (10)$$

In equation 9 and 10, π_0 and π_{10} can be calculated as follows;

$$\pi_0 = \sum p_0 q_0 \Big/ \sum P_0 Q_0$$

$$\pi_{10} = \sum p_0 q_1 \Big/ \sum P_1 Q_0$$

4. Measurement of Turkey Boron Mining Productivity and Profitability

The model established according to Fisher ideal index was implemented between 1980 and 2001 by using the data from Turkish Statistical Institute (TSI). Between these years, wholesale price index, published by TSI was used and revenues and costs were calculated with the constant prices of the year 1980 so that the inflation effect in the revenues and costs of boron sector could be eliminated. The calculated values were evaluated with the model developed and the graphs presented below were formed. The price index in the boron sector based on years and the change in the number of workers are given in Figure 1.

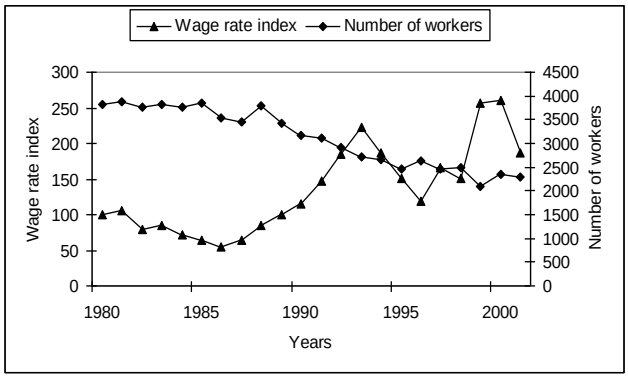

Figure 1. The price index in boron sector based on years and the change in the number of workers.

When Figure 1 is examined, it can be seen that there is a drop in workers' wage between 1980 and 1990, whereas there is a rise in workers' wage after 1990 in comparison with 1980. While there is a decrease in the number of workers on a yearly basis, this decrease seems to be a dramatic one after 1990 and to be 40% less in 2001 than 1980. On the other hand, it is observed that workers' wage rises although the number of workers decreases.

The price indices of material and capital in boron sector based on years are presented in Figure 2.

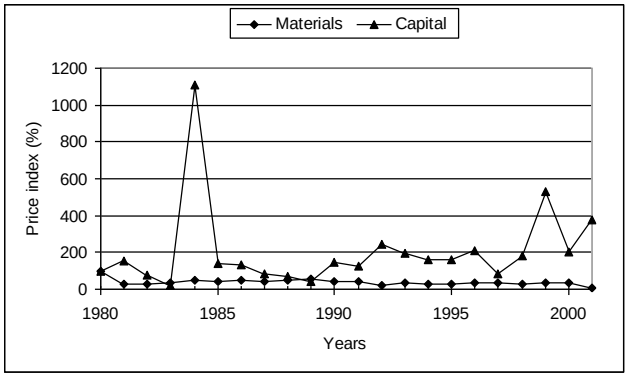

Figure 2. The price indices of material and capital in boron sector based on years

As can be seen in Figure 2, there are not considerable fluctuations in the price index of material except for the year 1980. Considering the price index of capital, it can be seen that there are investments in the sector on a larger scale in 1984 (the investment on I. Boron derivatives facility in Kırka) and in 1999 (the investments in Emet cholemanite enterprise and Kırka boron enterprise, though not big ones) in comparison with other years.

The index of price of products in boron sector based on years is presented in Figure 3.

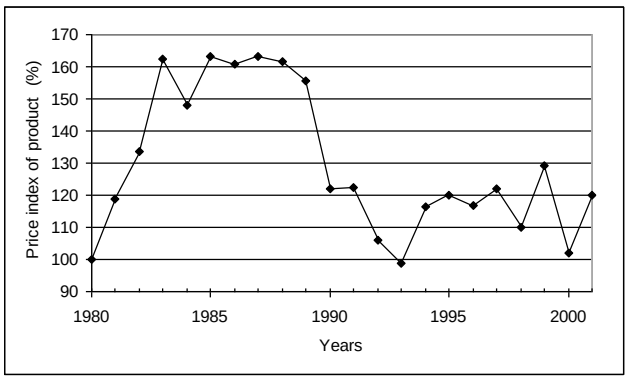

Figure 3. The index of price of products in boron sector based on years

Figure 3 points out a noticeable rise in sale prices of products till 1988 but a drop after this year. The drop in product prices due to competition and the price structure of the market could be the reasons behind this situation.

Product sale prices are directly related to enterprise revenues. In order to be able to increase enterprise revenues, the variety of the products that offer a high sale price and added value for the country should be increased as well. In boron sector, Turkey has a share of more than 95% of the unrefined boron export market in 2000. 75% of the world market in boron, the yearly volume of which is around 1.2 billion $, is owned by Eti Holding Company and US Borax. However, although the shares of Eti Holding Company and US Borax in the world production are 34% and 40% respectively, the percentages of the revenues earned from the boron market are 20% and 70 respectively. The reason for this situation is that the yearly refined boron sale of Eti Holding company is 350 000 tons, whereas US Borax realizes a yearly sale of 1 300 000 tons of refined products (TMMOB, 2002). What is needed in Turkey boron mining sector to increase the revenues to be earned from the boron market is to focus on the production and sale of refined and end products with high sale price instead of unrefined boron with low sale price.

In addition to the graphs given above, it possible to examine relative price change, which is defined as the proportion of the change of product sale prices to the change of total input prices. The relative price indices between 1980 and 2001 were examined and presented in Figure 4.

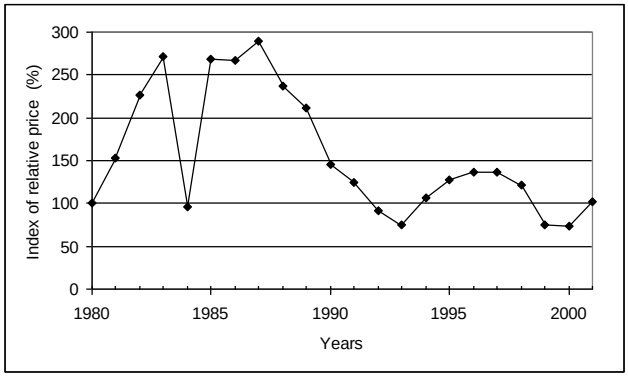

Figure 4. Relative price index in boron sector based on years.

When Figure 4 is evaluated by taking the graphs given previously into account, it is seen that relative price index presents an increase till 1988 except for 1984. The high product sale prices despite the lack of a noticeable increase in labor, material and capital costs might be the reason for this situation. On the other hand, the increase in constant capital investments could be suggested as the reason behind the dramatic fall in 1984. The fact that there is a decrease in product sale prices due to the reasons mentioned above and an increase in labor costs although there is not a sharp rise in material and capital costs could be regarded as a major cause of the fall of relative price index after the year 1988.

The productivity change in Turkey boron mining sector was examined and given in Figure 5. The productivity index was obtained by proportioning production quantity index to input quantity index (Equation 7).

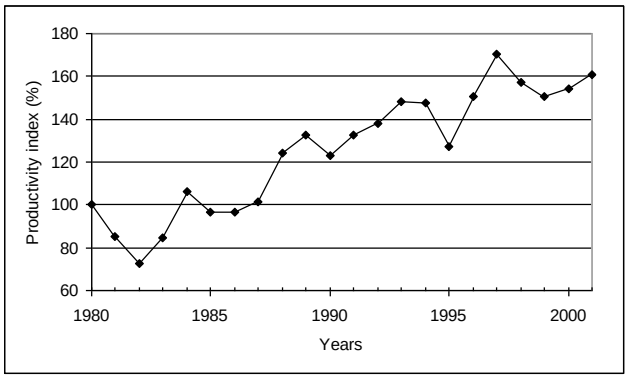

Figure 5. Productivity index in boron sector based on years.

As can be seen in Figure 5, the general trend in productivity is upwards. Between 1980 and 1987, the fall in production quantities despite the rise in input quantities caused productivity index to be low. Although there are some falls after 1987, productivity index is high compared to 1980. After the year 1987, input and production quantities increased, but productivity also increased as the increase in productivity quantities was higher than that of input quantities. Within this change, while the production quantity index in 1982 fell by 27.56% compared to 1980, the input quantity index in the same year increased by 0.08% and therefore the sectoral productivity fell by 27.61% and the lowest productivity rate was obtained. In 1997, on the other hand, the production quantity index increased by 85.26% compared to 1980, the input quantity index increased by 8.56%; and because the increase in production quantity index was higher than that of input quantity index, the sectoral productivity increased by 70.65% and therefore the highest productivity rate was achieved.

The graph given in Figure 6 was drawn so that the effects technological change (Equation 9) and scale effect (Equation 10) in productivity change could be examined.

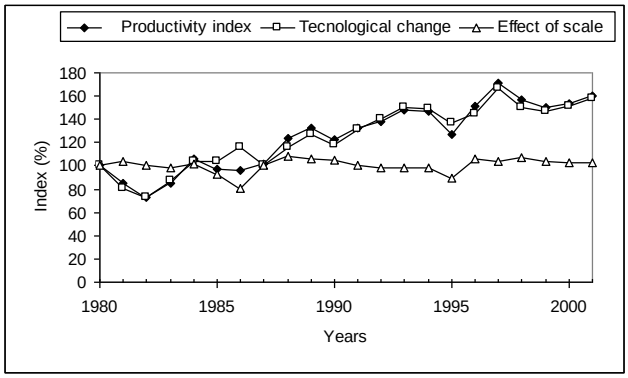

Figure 6. Productivity index, technological change and scale effect changes in boron sector based on years.

It can be seen in Figure 6 that technological change is parallel with productivity change, but the share of scale effect in productivity change is less. Considering the whole of the studies conducted in Turkey boron mining sector, it was determined that while technological change plays the key role in productivity increase, the marketing policies implemented also contribute to productivity increase to a certain extent.

The profitability change in Turkey boron mining sector was examined and presented in Figure 7.

As can be seen in Figure 7, the lowest profitability occurred in 1980 by 248.67% and the highest one in 1988 by 630.36%. The sector operates with over 100% profitability in general. Considering the fact that unrefined boron sale in the sector is high, Eti Holding Company possesses 95% of the world unrefined boron export market and the refined boron sale is low, it could be suggested that increasing refined boron sales would boost profitability rate.

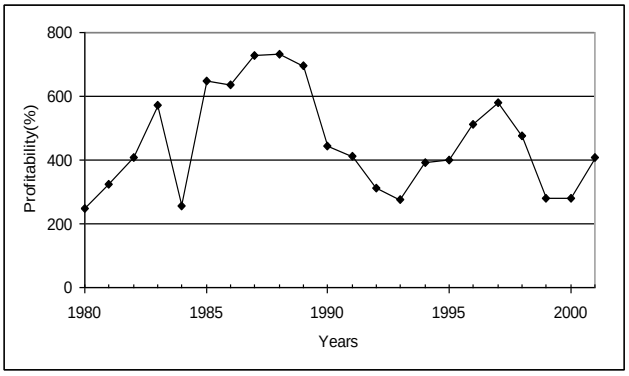

Figure 7. Profitability change in boron sector based on years.

5. The Effect of Input Parameters on Productivity and Profitability

Linear regression-correlation analysis and variance analysis were carried out in order to determine the relation between Turkey Boron Mining Sector input parameters and productivity and profitability indices. In the statistical analysis conducted between the productivity indices and input parameters of Turkey Boron Mining Sector, productivity index (PI) was taken as the dependent variable, index of workers wage (WI), price index of materials (MI), price index of capital (CI), and number of workers (N) were taken as the independent variables. The results are shown in Table 1.

Table 1. The statistical analysis conducted between productivity indices and input parameters

Variables		Regression coefficents		Correlation coefficent r	Variance analyse	
Dependent Y	Independent X	Constant a	Slope b		Calculated F (F_c)	Relation between variables
PI	WI	78.560	0.349	0.760	27.266	Significant
PI	MI	146.608	-0.549	-0.333	2.488	Insignificant
PI	CI	122.896	0.012	0.101	0.205	Insignificant
PI	N	251.793	-0.041	-0.881	69.204	Significant

In variance analysis, Ft = 4.38 at 95% reliability level and when Fc > Ft, relations are considered to be significant but insignificant when Fc < Ft. According to the analysis results in Table 1, it was determined that the parameters having an effect on productivity change are the number of workers and workers wages in order of the greatness of their correlation coefficients. On the other hand, it can be seen that price index of capital and price index of material do not have an important effect on productivity index. The more index of workers wages increases and the number of workers decreases, the more productivity index rises.

In the statistical analysis conducted between the profitability indices and input parameters of Turkey Boron Mining Sector, profitability index (PRI) was taken as the dependent variable, index of workers wage (WI), price index of materials (MI), price index of capital (CI), and number of workers (N) were taken as the independent variables and the results are shown in Table 2.

Table 2. The statistical analysis conducted between profitability indices and input parameters

Variables		Regression coefficents		Correlation coefficent r	Variance analyse	
Dependent Y	Independent X	Constant a	Slope b		Calculated F (F_c)	Relation between variables
PRI	WI	654.862	-1.485	-0.572	9.737	Significant
PRI	MI	442.916	0.325	0.035	0.024	Insignificant
PRI	CI	525.194	-0.338	-0.486	6.175	Significant
PRI	N	205.187	0.080	0.309	2.113	Insignificant

According to the analysis results in Table 2, it was determined that the parameters having an effect on profitability index are index of workers wages and price index of capital in order of the greatness of their correlation coefficients. On the other hand, it can be seen that price index of material and the number of workers do not have an important effect on productivity index. Profitability index increases as index of workers wage and price index of capital decreases.

Productivity and profitability indices have showed dramatic rises in Turkey Boron Mining Sector in comparison with the year 1980. What have been influential in productivity increase are the decrease in the number of workers and the rise in workers wages. While the rise in workers wages was expected to cause productivity to decrease, recruiting qualified personnel and reducing the number of unqualified workers over the recent years caused the wages to rise, which resulted in a contribution to productivity increase. On the other hand, it was determined that profitability index would rise even more if index of workers wage and price index of capital decrease.

6. Conclusion and Suggestions

In this study, AIPR productivity measurement model was restructured based on Fisher index number so that it could eliminate the errors caused by Laspeyres and Paasche indices. By using the model developed, the productivity of Turkey boron mining sector was measured and evaluated. The results gained from the study are given below:

It was determined that there was an increase in product sale prices in Turkey boron mining sector till 1988 but a decrease after that year. The fall in product prices due to competition and the pricing structure of the market could be suggested to be the causes of the decrease in prices. Also, another reason may be the fact that the prices in the boron market are actually artificial prices decided by supply and demand monopolies by taking the product and market conditions as well as the short, medium and long term interests of companies into consideration.

A decrease is observed in workers wages between 1980 and 1990 compared to 1980, but there seems to be an increase in workers wages after 1990. While the number of workers came down based on years, this decrease occurred on a larger scale after the year 1990 and in 2001 it turned out to be 40% compared to 1980. On the other hand, despite the decrease in the number of workers, workers wages seem to go up.

It was determined that there was not a serious fluctuation in price index of material except for the year 1980 and, considering price index of capital, there were investments in the sector on a larger scale in 1984 and 1999 (though not big ones) in comparison with other years.

It was determined that the general trend in productivity in Turkey boron sector is upwards. In 1982, the sectoral productivity fell by 27.61% leading the lowest productivity rate. In 1997, on the other hand, the production quantity index increased by 85.26% compared to 1980, the sectoral productivity went up by 70.65% and therefore the highest productivity rate was achieved.

Considering all the operations carried out in Turkey boron sector, it was determined that technological change played the leading role in the increase in productivity. Improvement operations in several facilities (e.g. renewing equipment) might be considered as a reason for this situation. It was also determined that the abundance of machinery and equipment due to the great size of the sector and the marketing policies implemented over the recent years to increase market share contributed to productivity increase to an extent.

When profitability change was examined, it was determined that the lowest profitability occurred in 1980 by 248.67% and the highest one in 1988 by 630.36%. The sector operates with over 100% profitability in general. Considering the fact that unrefined boron sale in the sector is high, Eti Holding Company possesses 95% of the world market in unrefined boron export and the refined boron sale is low, it could be suggested that increasing refined boron sales would boost profitability rate.

Productivity and profitability indices have realized dramatic rises in Turkey Boron Mining Sector in comparison with the year 1980. The decrease in the number of workers and the rise in workers wages have been influential in productivity increase. While the rise in workers wages was expected to cause productivity to decrease, recruiting qualified personnel and reducing

the number of unqualified workers over the recent years caused the wages to rise, which resulted in a contribution to productivity increase. On the other hand, it was determined that profitability index would rise even more if index of workers wage and price index of capital decreased.

In light of these results gained from the study, the following suggestions can be made:

An important aspect of the issue is carrying out scientific and technological production in addition to trying to increase the revenue to be earned from sales. The market shares of the industrial sectors using boron minerals as raw material are far more than the boron market itself. Therefore, the focus should be on research and development activities in order to shift towards end product market.

It's a fact that Eti Mining, which has the larger share in production but less share in the revenue earned in the world market in boron, operates in the regions where US Borax exports boron less. It is essential that Eti Mining do a detailed research into the current situation in the markets to which it exports boron and into the potential of those markets where it has no export activities. Making investments in increasing refined product capacity and product range, reviewing the current marketing strategies and setting up more efficient distribution networks might yield positive results for increasing the market share and get a chance to compete in the regions where the rival company operates as well.

The fact that profitability is high has resulted in neglecting the studies related to productivity. However, because there is a limited number of producers in the boron market and the items in the product range can substitute for each other, the potential future price drops to be caused by competition will highlight productivity measurement and assessment studies. Thus, it is suggested that the productivity measurement and assessment studies concerning the subject are bound to gain importance.

Conflict of Interest

No conflict of interest was declared by the authors.

References

Ahn, S., and Abt, R.C., (2005). Productivity measurement with improved index numbers: Application to the sawmills and planing mills industry of the U.S.: 1947-2000. Forest Policy and Economics, 8, 323-335.

Ang, B.W., Liu, F.L., Chung, H-S., (2004). A generalized Fisher index approach to energy decomposition analysis. Energy Economics, 26, 757-763.

Balk, B.M., (2004). Decompositions of Fisher indexes. Economics Letters, 82, 107-113.

Comlekci, N., Basic Statistic. Science&Technics Publishing House, Istanbul, 1994.

Darmstadter, J., (1997). Productivity Change in U.S. Coal Mining. Resources For The Future, Discussion Paper 97-40.

Diewert, W.E., (1993). Fisher Ideal Output, Input and Productivity Indexes Revisited. Essays in Index Number Theory, Volume I, Elsevier Science Publishers, Chapter 13, pp.317-357

Diewert, W.E., and Fox, K.J., (1998). The measurement of inflation after tax reform. Economic Letters, 61, 279-284.

Dumagan, J.C., (2002). Comparing the superlative Törnqvist and Fisher ideal indexes. Economics Letters, 76, 251-258.

Eti Mine, (2003). Eti Mine Works General Management. Annual Report. Ankara. 2003.

Eti Mine, (2016). Eti Mine Works General Management. Annual Report. Ankara. 2016.

Flynn, E.J., (2000). Impact of Technological Change and Productivity on the Coal Market. Energy Information Administration, Issues in Midterm Analysis and Forecasting, 10 p.

Ghebrit, K.S., (2004). The Impact of management practices on productivity in the Eritrean fishing industry. Dissertation, University of Pretoria, 224 p.

Hailu, A., and Veeman, T.S., (2001). Alternative methods for environmentally adjusted productivity analysis. Agricultural Economics, 25, 211-218.

Hannula, M., (2002). Total productivity measurement based on partial productivity ratios. International Journal of Production Economics, pp.57-67.

Hansson, K., (2002). Reconcilliation of Quarterly and Annual National QNA. 27th General Conference of The International Association for Research in Income and Wealth Djurhamn (Stockholm Archipelago), Sweden 18 to 24 August 2002.

Kulshreshtha, M., and Parikh, J.K., (2001). A study of productivity in the Indian coal sector. Energy Policy, 29, 701-713.

Kurosawa, K., Productivity Measurement and Management at the Company Level: The Japanese

Experience. Elsevier Science Publishing Company, 1991.

Mawson, P., Carlaw, K.I., and McLellan, N., (2003). Productivity measurement: Alternative approaches and estimates. New Zealand Treasury, Working Paper 03/12.

Mongia, P., and Sathaye, J., (1998). Productivity Growth and Technical Change in India's Energy Intensive Industries, A survey, LBNL-41840.

Onder, S., Productivity Analyses of Turkish Boron Mining. PhD Thesis. Eskisehir Osmangazi University, Eskisehir, Turkey (Turkish text), 2006.

Reinsdorf, M.B., Diewert, W.E., and Ehemann, C., (2002). Additive decompositions for Fisher, Törnqvist and geometric mean indexes. Journal of Economic and Social Measurement, 28, 51-61.

Rogers, M., (1998). The Definition and Measurement of Productivity. Melbourne Instute of Applied Economic and Social Research, The University of Melbourne, Melbourne Instute Working Paper, No:9/98.

Schreyer, P., (2001). The OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity. Number Two, Spring 2001, pp. 37-51.

Sink, S.D., Productivity Management: Planning, Measurement and Evaluation, Control and Improvement. John Wiley&Sons, New York, 1985.

Solminihac, H., Gonzales, L.E., and Cerda, R., (2018). Copper mining productivity: Lessons from Chile. Journal of Policy Modeling, 40 (1), 182-193.

Stainer, A., (1996). Productivity, performance measurement and management in logistics. Asia Pacific Journal of Marketing and Logistics; 8 (2), ABI/INFORM Global, pg. 46.

Stainer, A., (1997). Capital input and total productivity management. Management Decision, 35 (3), 224-232.

Sumanth, D.J., Total Productivity Management A systemic and Quantitative Approach to Compete in Quality, Price and Time. St. Lucie Press, 1998.

Szwilski, A.B., (1988). Significance and Measurement of Coal Mine Productivity. Mining Science and Technology, 6, 221-231.

TMMOB, (2002). "The Importance on National Science and Technology Policy in Utilization of Turkish Boron Reserves", Proceedings of the 1st International Boron Symposium, The Board of Directors of Chamber of Mining Engineers of Turkey, pp. XIII-XVI.