The Analysis of Labor Productivity in the Copper Industry: Case Study of Iran

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Abstract

According to the **USGS¹,** Iran allocated ranks 12 of the world's copper output. Copper industry is the second largest source of income and foreign exchange after oil industry. In terms of production, productivity is one of the key factors in efficient use of available resources. In this paper, labor productivity in the copper industry and Sarcheshmeh copper company will be discussed. Due to foreign exchange restrictions on the import of new technologies, one of the most important factors that affect the level of production is labor productivity. So, the aim of this study, is measuring labor productivity and its influencing factors in the Sarcheshmeh copper company. Data was obtained from the Statistical Yearbook of Iran Mines between 1984 to 2013 period. The data have been considered for the panel and TSLS OLS method of labor productivity was examined. Results shown that, labor productivity have been increased during the years under review. Also, labor productivity growth was the main factor in copper production growth during the mentioned period.
**USGS¹:** United State Geological Survey

1. Introduction

Starting of copper industry in Iran since 1972, began with exploitation and exploration operations in Sarcheshmeh .In this industry like many industries, production is dependent on two components: first, technology and related industries with copper industry and second, workforce in this industry. In many case studies, emphasized only to technology and feed supply requirements of copper industry and about of labor, only investigates to the time and quantity of work [1] [2]. In this article try to discuss an important and basic factor that called labor productivity which consecutive years in developed countries in all fields including industry focused on improving it while high rates of economic growth in these countries is related to labor productivity [3]. In this article, we try to measure the labor productivity and its evolution. Evolution of copper production in Iran has mostly incremental flow.

As can be seen in figure (1) the process of copper production in Iran for many years has been upward. According to the Deputy Economy of the Central Bank of Iran about the economic productivity from 1988 to 2007 that includes the labor productivity , capital productivity and total factor productivity , Labor productivity in mining group based on the 1997 base year (index 100) in 2001 at a rate of 85.2 in 2004 to 101.2 in 2007 the number was 97.5 that represents the continuous changes in labor productivity in the mining sector and in comparison to total productivity growth in the economy have slowly growth [4].
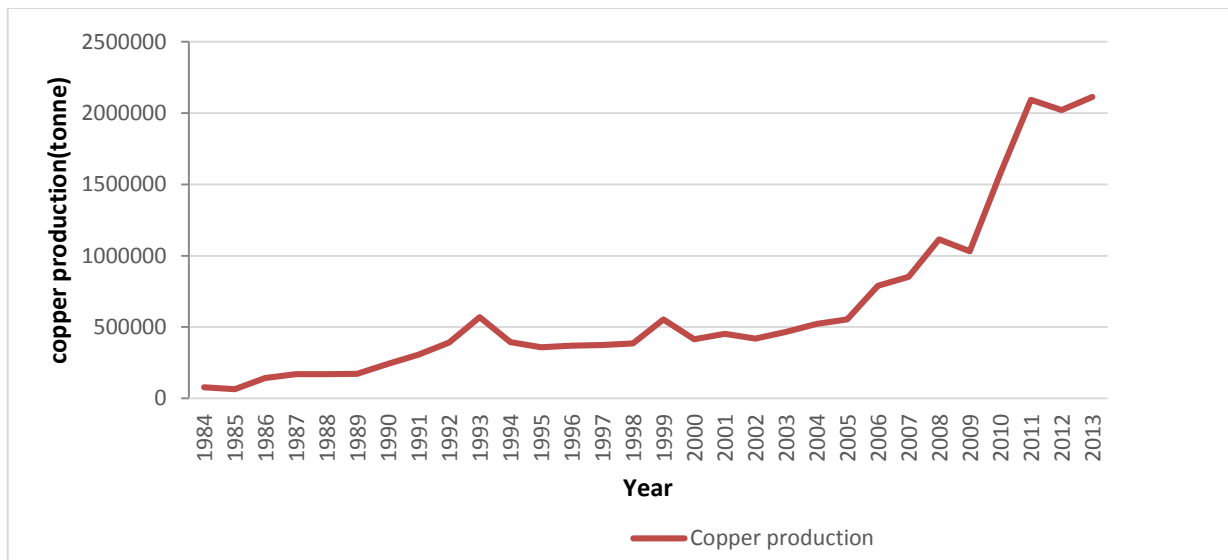
Fig. 1: the process of copper production from 1984 to 2013
Source: Statistical Center of Iran, 2015.
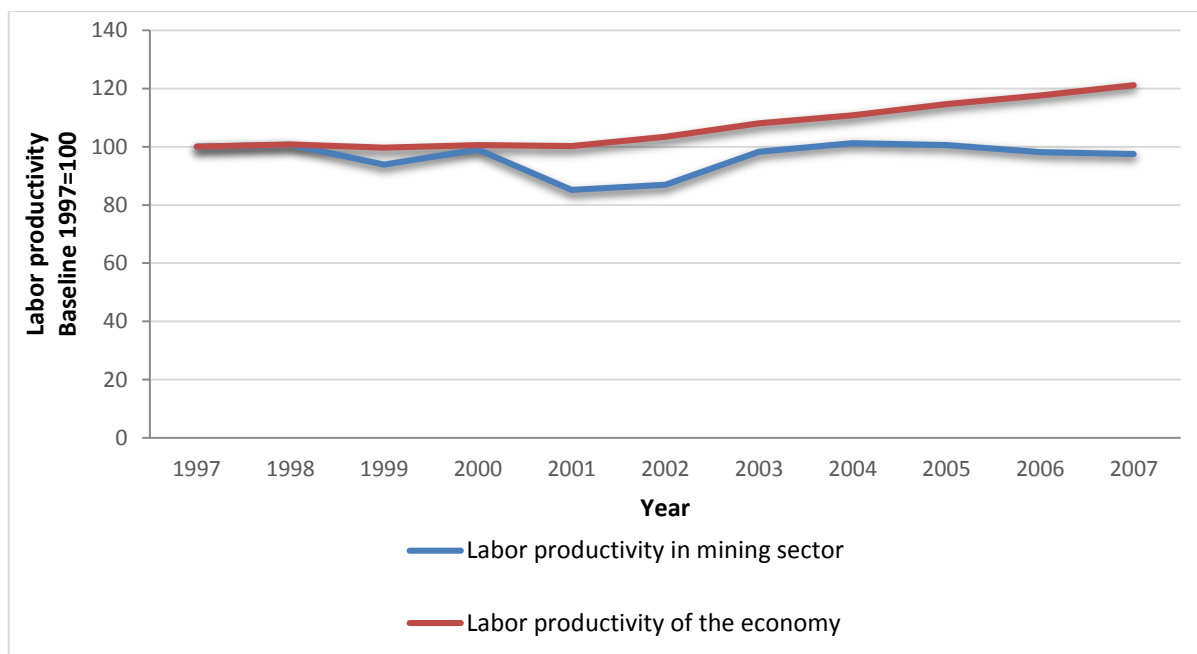
Fig. 2: Labor productivity index based on the 1997 base year
Source: Deputy Economy of the central bank of Iran, 2010.

According to Figure 2, Labor productivity in the mining sector lower than the productivity in the total economy. For the economic growth purpose, must be considered the factors that affecting on labor productivity mining as one of the components of the transition effects in this section [4].

2. Literature Review

About the importance of productivity, French Economist; Francois Quesnay (1750) invented for the first time in a scientific manner the idea and says: The power of any government depends on increase productivity in the agriculture sector. In the process of economic and industrial transformation productivity of the factors that always considered by the leading characters and various organizations [5]. In this regard, investigating the effect of political promotion incentives on the labor investment efficiency of firms in China show that: 1) promotion incentives of local politicians significantly increase firm-level employment growth and decrease labor investment efficiency. 2) Causality is established

using the number of death toll in local mining accidents to isolate exogenous shocks on the promotion incentives of local politicians, and placebo tests further confirm the causality. 3) For under-hiring firms, promotion incentives only increase the employment of low human capital, thus distorting human capital structure and decreasing labor investment efficiency. 4) Our findings are robust to alternative specifications [6].

Also, studying mining productivity in Chile by relying on two indicators: measure of the total factor productivity (TFP) using the traditional Solow methodology, and labor productivity, since 2000, indicated a decrease in TFP, and explained mainly by the participation of capital as well as diverse factor adjustments to labor and capital inputs. Average labor productivity also decreases 42% from 1999 to 2010, a decrease explained by four determinants: real mining wages, electricity prices, copper prices and mineral grade [7].

The result of the study of Joaquín et al [8] show that better deposits and operational factors are important, but not enough to explain labor productivity improvements in the copper mining industry, and instead, company specific efforts and wide industry changes, such as technology and management innovations, are as important as the evolution of the reserve base or geological features of the operations [8]. Furthermore, according to a growth accounting approach for OECD and G20 Countries for the 1990–2013 to decompose a pollution-adjusted measure of output growth into the contributions of labour, produced capital and natural capital, the main findings suggested that growth in OECD countries has been generated almost exclusively through productivity gains, while BRIICS countries have drawn largely on increased utilization of factor inputs to generate additional growth [9].

Hamit et al in their article about the industry in America between 1975 and 1995 pointed out that there have been impact of labor productivity on the production but this impact has been limited [10]. Patricio Garcia et al express that Copper industry can be considered as one of the highest sources of revenue for the economy for example in Chile copper industry to be allocated between 32 to 52 percent of annual revenue from exports of Chile and between 6 to 9 percent of per capita GDP [11].

Shah Abadi [12] estimated the rate of the value added of industries and mines according to labor productivity and capital productivity. In this paper investigate the growth rate of labor productivity, capital productivity, and total factor productivity in the industries and mines sector. To show the growth rate of the value added of industries and mines used the model:

$$G_r(VA_{ind}) = G_r(A_{ind}) + MP_{Kind} * \left(\frac{K_{ind}}{VA_{ind}}\right) * G_r(K_{ind}) + MP_{Lind} * \left(\frac{L_{ind}}{VA_{ind}}\right) * G_r(L_{ind}).$$

That in this equation Gr(X), MP_{Kind}, MP_{Lind} indicate growth rate of X variable , marginal productivity of physical capital and marginal productivity of labor force in mining and industries sector . The left side of the equation represents the rate of value-added industries and mines. By analyzing the mentioned model it follows that the average annual growth rate of total factor productivity industries and mines during the first, second and third after the revolution (1979) respectively, 8.2, 2.6 and 5.9 percent and the annual growth rate of total factor productivity growth in value added of industries and mines during the first to third respectively 67.5, 71.6 and 59.9 percent [12].

Basiri and Nabiyan Javardy in their study investigates the strategically and economical ranking method for investment promotion in Iran. In these article discuses about the strategic indicators needed for ranking minerals. These indicators include the rate of the value added of each sector, the mining sectors share in GDP, labor productivity, the coefficient of employment in any sector, the ratio of capital to labor in each sector and the mining expert practitioners share of the total mining workforce. Labor productivity index is measured according to the model: $LPI = \frac{VM}{LI} * 100$ .That in this equation VM indicate the value added for each sector of mining in terms of thousand rials to constant prices 1997 and the LI is the total labor force employed in the mining sector (people). By analyzing indicators conclusion that mines iron ore, copper, lead and zinc Iran in order of priority investments in the field of economic indicators and strategies are relatively high. LPI labor productivity index for iron ore, copper, lead and zinc is respectively 2.360, 2.119 and .887 [13].

Finally, Amini studies the factors that affecting on total factor productivity in industry and mine sectors. In this case, he measured the index of labor productivity, capital, energy and total factor productivity in industry and mining form 1967 to 2002 [5]. The annual growth rate of this indexes have been respectively 5.2% , 1% , 3% , 2.5% and the share of total factor productivity in promoting production growth was around 32.4% . To calculate direct TFP index used this methods: first is Kendrick method that is based on the weighted average of capital and labor and second is division index that is for aggregation of inputs. Indirect methods of calculating TFP index are including first Solow residual method that is equal to the difference between the weighted average growths of production factors. Second Solow method that is in this method production function is based on this assumption that technological progress is neutral or neutral-type of Hicks. Factors that affecting on labor productivity are including human capital, technological progress, human capital quantity, quality workforce in terms of level of education, skills, physical abilities and health [5].

In the following of this article, we are investigating these cases: theoretical foundations, the concept of labor productivity and factors affecting it, methodology, models and variables, analyze changes in productivity based on the model introduced and finally discussion of results.

3. Theoretical Foundations

Competitiveness of products and diverse industries worldwide has made countries to stay in the competition use from techniques and methods in addition to improving the inputs and technology that the most important is to promote productivity. Productivity can be defined as a factor that established an effective communication between the data and level of products such that achieved the greater efficiency and output needless to increase the level of input and advances in technology. The evolution of productivity in the world can be found in the years after World War II through the creation of institutions and organizations around the world looked efficiency. Among the most important productivity center that have international aspects can be enumerate the APQC[1] , EPA[2] and APO[3] . Iran in 1965 without having productivity organization entry to APO and from 1992 ministry of heavy industries of Iran equipped and triggered the National Iranian Productivity Organization that the main objective of this organization including the interaction with other countries to promote and creation consulting services in order to improve productivity in various industries . Studies show that increasing productivity in work forces cause growth and overall development in the key areas of economic and industry. If we want to consider the definition for labor productivity can measured as real GDP value that generated by an hour labor force. Productivity from a systematic perspective can be measured as the efficiency of combination of factors in the production process. OECD statistics directorate defines productivity as the output ratio to a factor of production that the factor can be included capital, labor, raw material, energy and other items. Overall productivity can be seen as a combination of efficiency and effectiveness. Efficiency means doing is correct and associated with the beneficial use of resources, that's mean obtain the maximum output from minimum input. Effectiveness means doing the right thing that's mean in addition to producing more products and increase the quantity, quality of manufactured products is also high. Many countries do not have diverse natural resources but aim of these countries is improve the situation of economy and achieve to suitable economic growth. Some Percent of this growth is realized by increasing in efficiency work force as labor productivity. Currently most prestigious and most common set of definitions and concepts and measurement methods are presented by OECD[4]. As defined by this organization, productivity defined as the ratio between the volume of production and volume of raw material input. In other words, productivity represents the effective use of production inputs in order to achieve a certain level of production in various sectors [14] [15].

Productivity measure can be classified into two categories : first , productivity as a single factor that's mean the size of production relative to a measured like labor productivity and second productivity as a

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[1] American Productivity & Quality Center
[2] European Productivity Agency
[3] Asian Productivity Organization
[4] Organization for Economic Co-operation and development

multi factorial that's mean the size of production relative to set of measured input like multi factorial productivity. In Iran also offered a similar definition of productivity: productivity is a culture, a rational attitude to work and live which aims to cleverly the activities for access to a better life (NIPO[5]). If we be done compare the two types of productivity of capital and labor in a mine it can be seen influencing factors on capital productivity is often related to economic and financial aspects. Updated technology in the extraction, refining and processing product can dramatically increase the efficiency of this part of the production. On the other hand we are dealing with work force that has economic and psychological aspects. Therefore to increase productivity of this factor of production must attention to two aspects. Economic aspects most related to discussion about the wages and benefits and psychological aspects related to factors that affecting on individual behavior in the workplace , for example the essential training to work in various sectors(as extraction of copper ore, doping section of copper and other sectors) , rationalization each sector workers in line with company , organization and national goals. To achieve the aims of high growth in the mining sector should identify and apply factors that affecting on the productivity of factors of production. Behaviors such as participation of employees and workers on issues related to determine purpose and programs, clarification of the laws and regulations, open duties in activity sectors for workers and such these. This factors can be effect on increase in productivity and consequently increase growth and production in each sector and then on the allover of mineral collection. In Figure 3 expressed these factors in graphical form for a mine. In addition to these cases, we provided indicators such as measuring the efficiency of laws, physical resources and human resources that can affect on improved economic growth.

4. Methodology

In many production target the productivity human resources affect as a key factor in achieving desired results of economic experts whether within the government or within a company. Therefore in this study obtained the results of quantitative of this productivity with using conventional formulas and equations of labor productivity. With obtained the results can be compared the data with the other countries and countries that are leading in the copper industry and with determine of appropriate rate of productivity as a target in addition to the use of new technologies can be by applying methods and behavior within the structure of the labor force of Iran causes increase growth in mining sector. The question that arises is that with despite the abundant mineral resources such as copper Iran has been able to create competitive power in terms of labor productivity in return other countries? Are despite the rise in production has also increased labor productivity? With study of global mine production, policies must move in what direction? Capital productivity, labor productivity or a combination of both.

The model used in this study is written based on the effect of time and scale of production. The equation used in this study are as follows [16]:

$$\text{Ln} \left(\frac{Q_{it}}{L_{it}} \right) = \tau_t + \alpha_i + F(\ln Q_{it}) + \varepsilon_{it} \qquad (1)$$

The left side of equation (1) represents changes in production quantities to changes in the labor force that used in the mine that is the definition of labor productivity. α_i represents the value of productivity at constant time (or zero time) , represents particular geological attributes and technical characteristics of mine that obtained by providing a basic level of the log of labor productivity for the mine. Effect time (τ_t) represent the common effect of all changes in particular year like the usual progress of technology, the effects of input prices and executive regulations for each group of mines. Time effect can be expressed as a function of the wages and the price of copper. Disturbing element ε_{it} represents other special features of labor productivity which is normally distributed with zero mean and constant variance. A non-parametric method of function $F(\ln Q_{it})$ is acceptable because of this assumption that the best approximation to a polynomial obtained from logarithm of the value of production.

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[5] National Iranian Productivity Organization
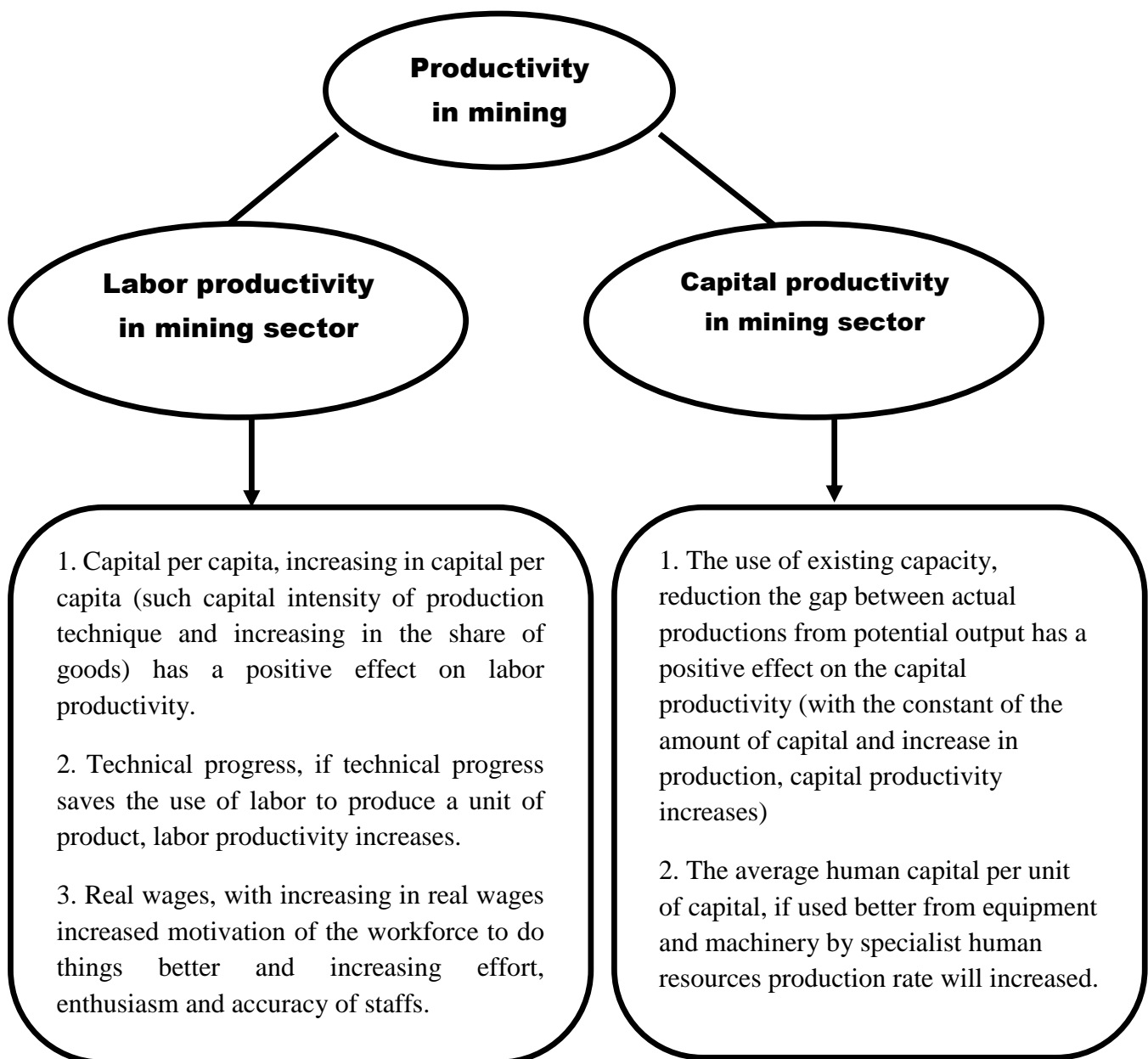
Fig. 3: Factors affecting on productivity in the mining sector
Source: Collection economic research of the central bank of Iran.

In framework of panel model equation (1), logarithm degree polynomial for mining production achieved through least squares cross validation[6]. The result of this validation is that copper mining could well describe by a polynomial of three of the log production by name the scale effect as follows:

$$F(\ln Q_{it}) = \beta_1 \ln Q_{it} + \beta_2 (\ln Q_{it})^2 + \beta_3 (\ln Q_{it})^3 + \varepsilon_{it} \qquad (2)$$

As the it can be seen scale effect measured as a third grade function of the logarithm of the amount of copper during any given year. In the form of panel data, time effect τ_t, represent the effect of all variables that change over time, but at the same time are equal for all mines. According to equation(1) and to evaluate the effect of copper on labor productivity expressed this time effect based on prices and actual wages in a separate equation of equation(1) is called the equation of time effect which is shown as follows:

$$\tau_t = k + \theta_p \ln P_t + \theta_w \ln W_t + \rho_t \qquad (3)$$

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[6] For further reading also see : among many others , green and Silverman , 1994

In equation (3), P_t represent copper price and W_t represents wages paid to employees and staff copper. θ_p display the elasticity of labor productivity consider to changes in the price of copper and θ_w represent the elasticity of labor productivity due to the changes in paid wages.

Changes in productivity indicators by separation of the sources of change

Due to the use of time series in explaining model of equation (1) before estimating regression should first examined the stagnation variable of model with advanced Dickey-Fuller test. After reviewing the stagnation and regression, equation (1) will be discussed to study the factors affecting on labor productivity. To understand the impact of various forces on labor productivity and that how change each of this forces over time expressed the model that involved all elements that affecting on labor productivity. This model expressed as follows [16]:

$$\frac{\sum_i Q_{it}}{\sum_i L_{it}} = \frac{\sum_i L_{it} \exp(ln\frac{Q_{it}}{L_{it}})}{\sum_i L_{it}} = \frac{\sum_i L_{it} \exp(\hat{\tau}_t)\exp[(\hat{\alpha}_i + \hat{F}(lnQ_{it}) + \hat{\varepsilon}_{it}]}{\sum_i L_{it}} \tag{4}$$

The equation (4) obtained from multiply the numerator and denominator at total labor in mining and also achieve the exponential function of the logarithm of productivity (equation 1). The second part of the right side of equation (4) investigate the equation (1) that can be extracted the effective impact on labor productivity. Can be breakdown equation (4) into elements that each of which impose certain changes on labor productivity that it generalized form by using the equations related to effects of scale and time is as follows:

$$\frac{\sum_i Q_{it}}{\sum_i L_{it}} = \exp(\hat{k} + \hat{\theta}_p lnP_t + \hat{\theta}_w lnW_t) \exp(\hat{\rho}_t) \frac{\sum_i L_{it} \exp(\hat{\alpha}_i + \hat{F}(lnQ_{it}) + \hat{\varepsilon}_{it})}{\sum_i L_{it}} \tag{5}$$

Using equation (5) can defined the effect that affecting on labor productivity in indicator form that each of these indicators has components. This indicator include: price effect index , Residual time effect index , scale effect index , fixed effect index and Residual Micro heterogeneity index that examined the components of each of these indicators in the following :

Price effect index
$$Z_t = \exp(\hat{k} + \hat{\theta}_p lnAP_t + \hat{\theta}_w lnW_t) \tag{6}$$

According to equation (5) can be obtained two index by estimating equation (3):
The first index that determine in equation (6) represents change in average prices and wages and the effects of these two factors on labor productivity. The second indicator that shown in equation(7) obtained by estimate remaining equation(3) and in equation(5) display this index by the common logarithm of the residual estimate of the time effect($\exp(\hat{\rho}_t)$). This index reflects the combined effects of all variables in specific year (time effect) except to the components of the average wage and price. This index named residual time effect index and its equation is as follows:

$$M_t = \exp(\hat{\rho}_t) \tag{7}$$

Typically can be expressed the common time pattern according to these two factors Z_t and M_t. In the following study the effects of technical and geological characteristics of the ore during each year. These effects are included: scale effect index, fixed effect index and Residual Microheterogeneity index. The first indicator is scale effect. This index refers to change in labor productivity associated with change in size of the mining operation. Change in the size of the operation and production caused by factors such as the increase in the development and creation the contraction in the average of production. Scale effect index is shown follows:

$$SC_t = \frac{\sum_i L_{it} \exp[\hat{F}(lnQ_{it})]}{\sum_i L_{it}} \tag{8}$$

After indicator is fixed effect index which represents the basic level of productivity for the mine. This index indicates that factors such as existing technology used in mining and management style is

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effective. Due to different types of reserves mine and also geographical location not only affect on size, purity and form of stone extraction rather affect on issues related to metallurgy and geotechnical over time. Fixed effect index shown as follows:

$$FE_t = \frac{\sum_i L_{it} \exp(\hat{\alpha}_i)}{\sum_i L_{it}} \tag{9}$$

Next index represent the residual effect. This indicator represents the residual effect that pays to measure features and assess heterogeneity that no measurable by regression of the initial panel. This effect is shown as component error for mining in the other words the residual index including total unexplained component regression. The equation is shown as follows:

$$RE_t = \frac{\sum_i L_{it} \exp(\hat{\varepsilon}_{it})}{\sum_i L_{it}} \tag{10}$$

As is determined factors that affecting on labor productivity due to different levels of indicators that each in turn have a significant impact on labor productivity. That in this paper refers only to economic factors. Therefore can be gain labor productivity with multiplied equations (6) to (10) as follows:

$$PR_t = SC_t * FE_t * RE_t * Z_t * M_t \tag{11}$$

Indicators that shown in equation (11) divided labor productivity into various components that included price effect, time effect, scale effect, fixed effect and residual effect. The data in this study contains the average of copper price, copper production, wage of labor force and number of workforce. These data have been collected from institutions and organizations of mining, library of statistics agency of Iran, books and world websites that written about copper mine from 1984 to 2013. Copper price achieved from global copper market, copper production of Sarcheshmeh copper company achieved from library of Iranian copper company, wage of labor force and number of labor force achieved from library of statistics agency of Iran [17] [18] [19] [20].

5. Econometric and empirical results

The variables used in equation (1) are time series therefore before regression estimates need to investigate the static variables. For this purpose investigates static variables with augmented Dickey-fuller test. The results of stability offered according to the following table 1.

Table 1: Evaluation stationary of variables equation (1)

Parameter	Examination quantity with fixed component			Optimum lag	Degree of difference
	Statistics	Critical value	Critical level		
LNPR	-1.7403	-2.9677	%95	0	-
DLNPR	-4.3151	-2.9762	%95	1	1
LNAP	-.8661	-2.9677	%95	0	-
DLNAP	-3.6762	-2.9918	%95	3	2
LNW	.2983	-2.9677	%95	0	-
DLNW	-3.2123	-2.9810	%95	2	1
LNQ	-1.0463	-2.9677	%95	0	-
DLNQ	-4.1647	-2.9762	%95	1	1
$(LNQ)^2$	-.7806	-2.9677	%95	0	-
$D(LNQ)^2$	-4.0102	-2.9762	%95	1	1
$(LNQ)^3$	-.5168	-2.9677	%95	0	-
$D(LNQ)^3$	-3.8774	-2.9762	%95	1	1

Source: Author(s).

As can be seen, the absolute value of the coefficient obtained by the augmented Dickey-fuller test are larger of critical value for all variables that can be concluded all coefficient used are stable. For example variable LNAP without having to lag and consider the degree of difference the variable is not sustainable after the third lag and the second degree of difference the variable LNAP become stable. After reviewing

static will be discussed regression estimates. With estimating equation (1) can be obtained coefficients required to obtain the component of labor productivity of the equation related to effects of time and scale. For this purpose, the equations (2) and (3) that are affecting on productivity are written separately as follows:

$$\text{Ln}\left(\frac{Q_{it}}{L_{it}}\right) = \alpha_i + \beta_1 \ln Q_{it} + \beta_2 (\ln Q_{it})^2 + \beta_3 (\ln Q_{it})^3 + \varepsilon_{it} \tag{12}$$

$$\text{Ln}\left(\frac{Q_{it}}{L_{it}}\right) = k + \theta_p \ln P_t + \theta_w \ln W_t + \rho_t \tag{13}$$

Equation (12) defines the scale effect that written as a cubic function of logarithm production. To estimate this model used TSLS method that results are as follows (Table 2):

Table 2: The results of estimating the scale effect equation (12)

Variables name	Mathematical symbol	Coefficient	t-statistics	Probability
Fixed component	α_i	-88.534	-2.614	.0147
Log of production	LNQ	44.985	2.459	.0209
Square log of production	$(LNQ)^2$	-7.557	-2.302	.0295
Cubic log of production	$(LNQ)^3$	.431	2.207	.0363

Source: Author(s).

The estimated coefficients for equation (12) are as follows:

$$F(LNQ) = 44.985\ LNQ - 7.557\ LNQ^2 + .431\ LNQ^3 \tag{14}$$

The equation (14) represents the scale effect. Coefficients obtained for this model is indicative of the changes in labor productivity associated with changes in production. Such that for one unit increase in log production , the productivity increase amount of 44.985 units , for one unit increase in square logarithm of production productivity is reduced to amount of 7.557 units and for one unit increasing in cubic logarithm of production the productivity increase amount of .431 units. Equation (13) indicates the time effect that is a function of copper price and amount of wages. For estimating this effect used the OLS method that results are as follows:

Table 3: The results of estimating the time effect equation (13)

Variables name	Mathematical symbol	Coefficient	t-statistics	Probability
Fixed component	K	-.819	-1.332	.1938
Log of copper price	LNAP	.428	1.754	.0907
Log of wage	LNW	.317	4.179	.0003

Source: Author(s).

Coefficients obtained for this model represents the changes in labor productivity due to changes in copper prices and wages. Obtained coefficient for copper price indicate meaningless of these effect on labor productivity. For each unit increase in the level of wage labor productivity increase to amount of 0.317 units. The estimated coefficients for equation (13) are as follows:

$$\tau_t = -.819 + 0.428\ \ln AP_t + 0.317\ \ln W_t \tag{15}$$

With obtain the coefficient of scale effect and time effect can be achieved the amounts as to changes in productivity indicators in equation (6) to (10) during the studied years.

Analysis indicators of change in productivity
Fixed effect (FEt):
 Fixed effect showing the level of productivity of each mine therefore index FE_t represent evolution of this effect over years to mine survey. This effect achieved with fixed taking into amount other factors that affecting on labor productivity. Factors that affecting on this index are include: The mining

technology used in different processes leading to the production of copper and Management styles , difference in management styles of public and private companies affecting on the initial level of productivity mining. Changes of this effect from 1984 to 2013 is as follows:
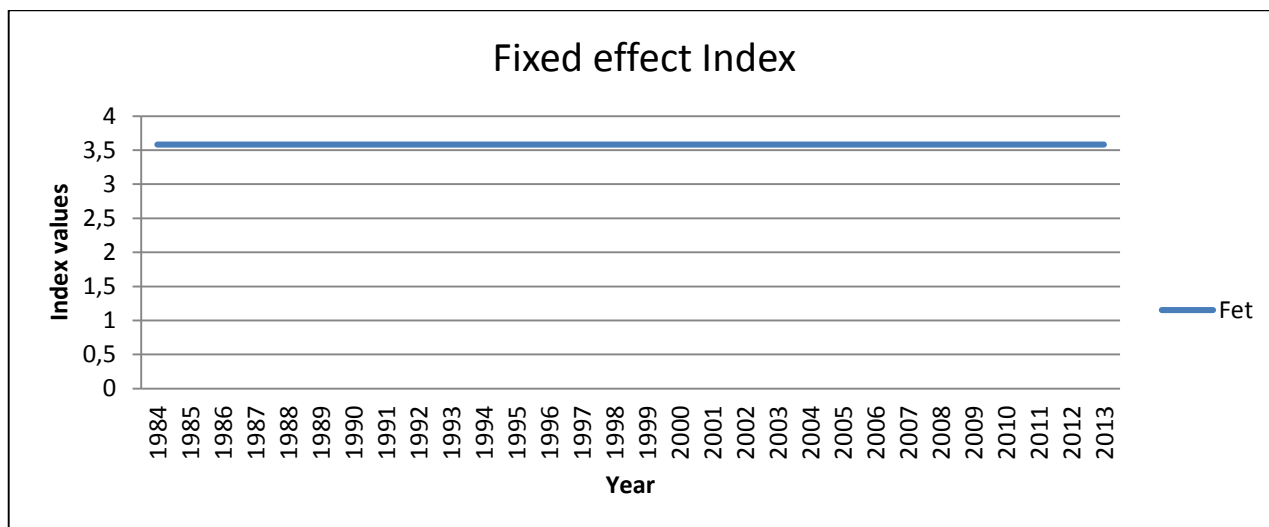
Fig. 4: Change in fixed effect in Sarcheshmeh copper company 1984 to 2013
Source: Author(s)

Scale effect (SCt):
Scale effect index SCt represent the changes on labor productivity associated with change in the optimal size of production performance. By comparing the graphs related to labor productivity and scale effect can be realized direct relationship between these two indices. Fig.5. represent changes in scale effect for Sarcheshmeh copper company that this index have decreasing trend in the early years of study (1984 to 2013) and then has been rising at a gentle slope. Changes in the scale effect index is same direction with labor productivity index that represents the positive impact of this index on labor productivity. Changes in scale effect from 1984 to 2013 is as follows (Figure 5):
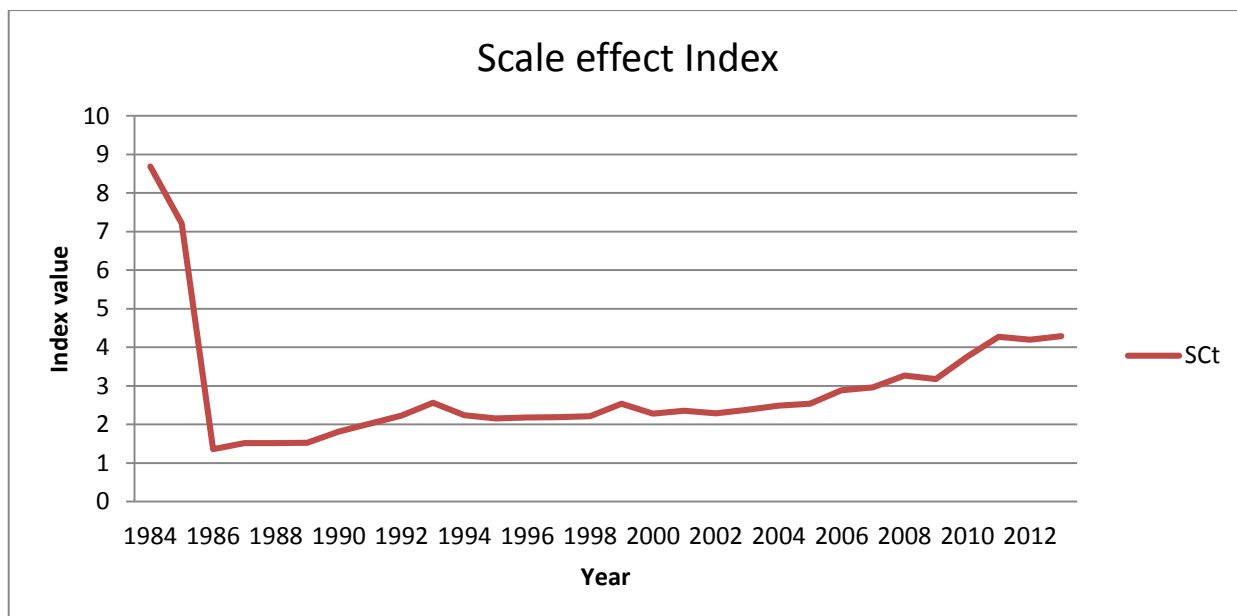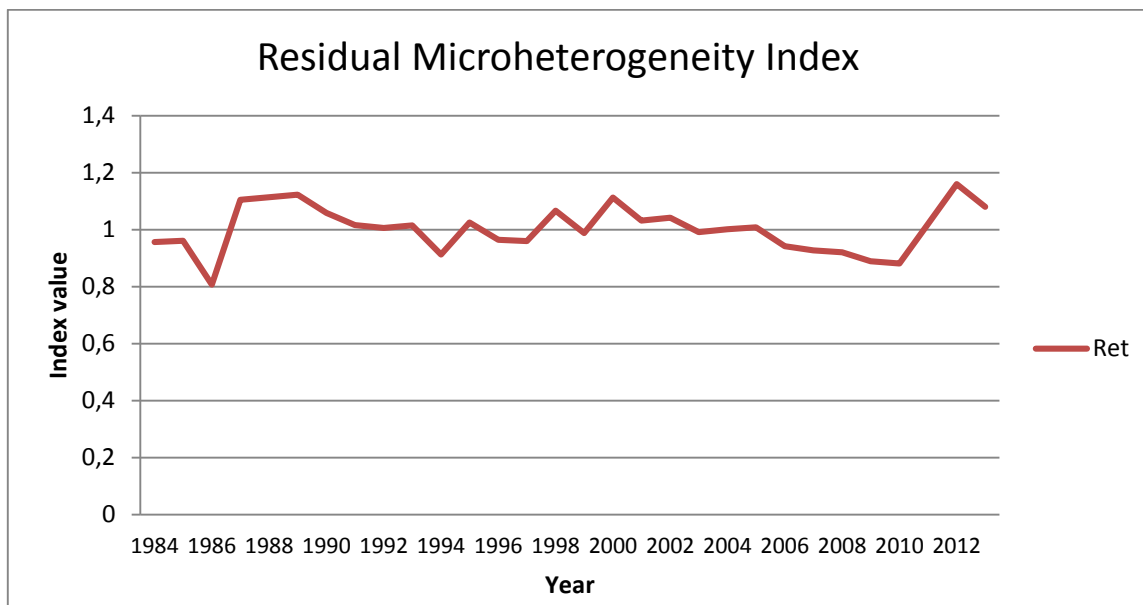

Fig. 5: Change in scale effect in Sarcheshmeh copper company 1984 to 2013
Source: Author(s)

Residual Micro heterogeneity (Ret):
By calculating this index can be compared heterogeneity in productivity between the mines. There are differences between different mines that these differences are not determined by primary regression. The

effect of these differences on labor productivity can be achieved in terms of error for each mine. In other words Ret index represent the detail that is not considered in the regression. Fig.6. represent the fluctuations of this index in the study period years that demonstrate the positive and negative effectiveness of labor productivity in the mines so that in some periods these effect have been in order to decrease the productivity and in some periods in order to increase the productivity. Changes in residual micro heterogeneity effect from 1984 to 2013 are as follows:

Fig. 6: Change in Residual Micro heterogeneity effect in Sarcheshmeh copper company 1984 to 2013
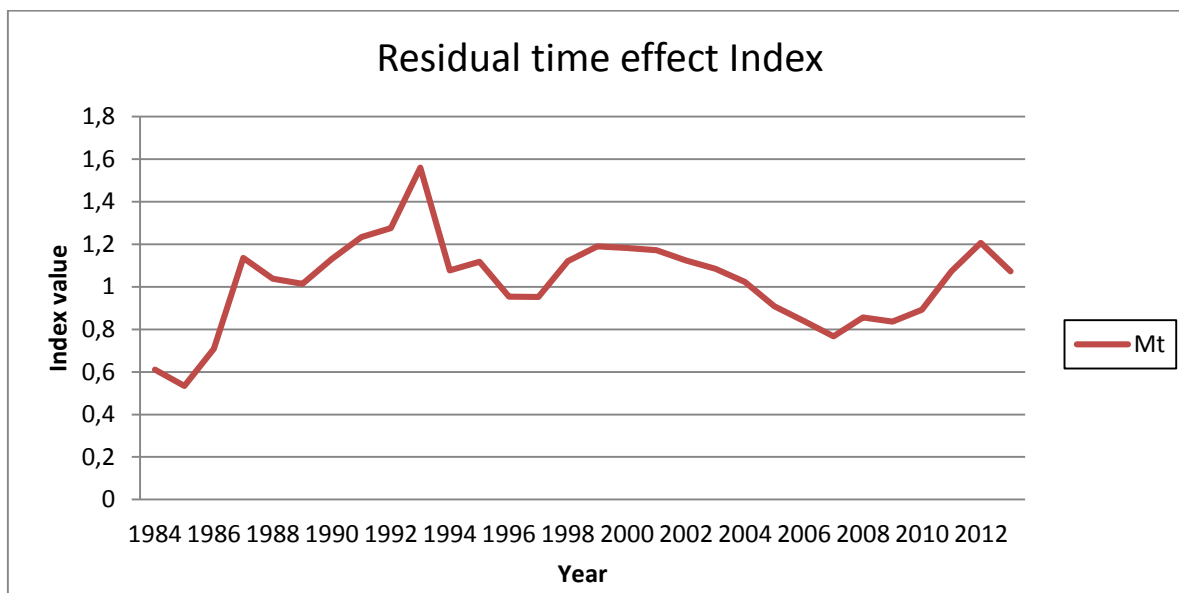Source: Author(s)

Price effect (Zt):
To estimate the effect of time effect in equation (3) it can be divided into two parts: The first part is related to changes in the price of inputs and outputs (price effect index Zt) and second part that not determined by estimating the first part is residual time effect(Mt). First investigate the price effect index. This index influences from two factors the price and wage. Fig.7. represent Changes in price effect index between 1984 to 2013 for Sarcheshmeh copper company as observed changes on price effect is same direction with change on labor productivity that represent the positive effect of this index on labor productivity. Changes in price effect index from 1984 to 2013 are as follows:
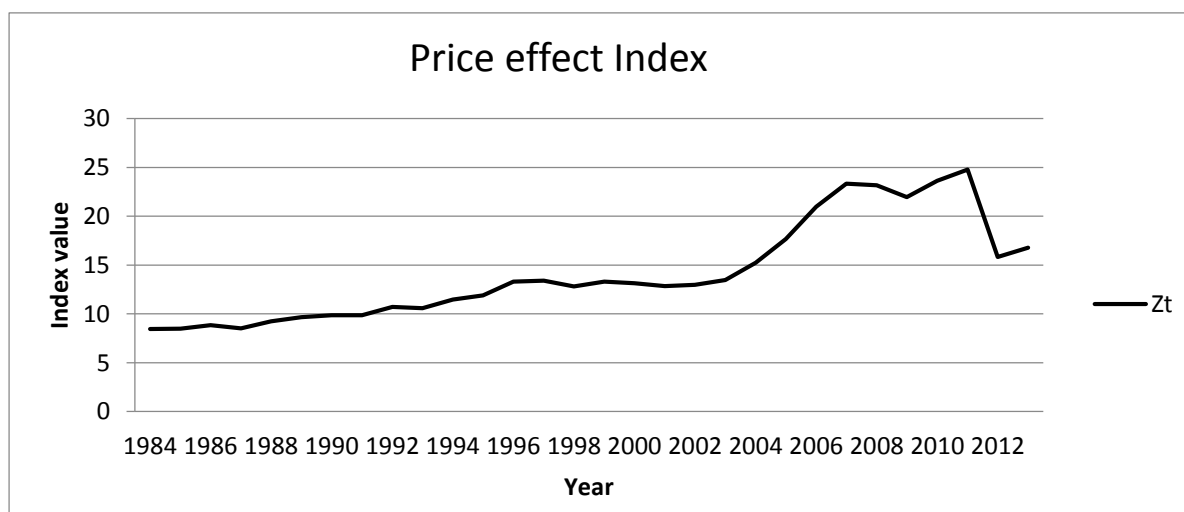
Fig. 7: Change in price effect in Sarcheshmeh copper company 1984 to 2013
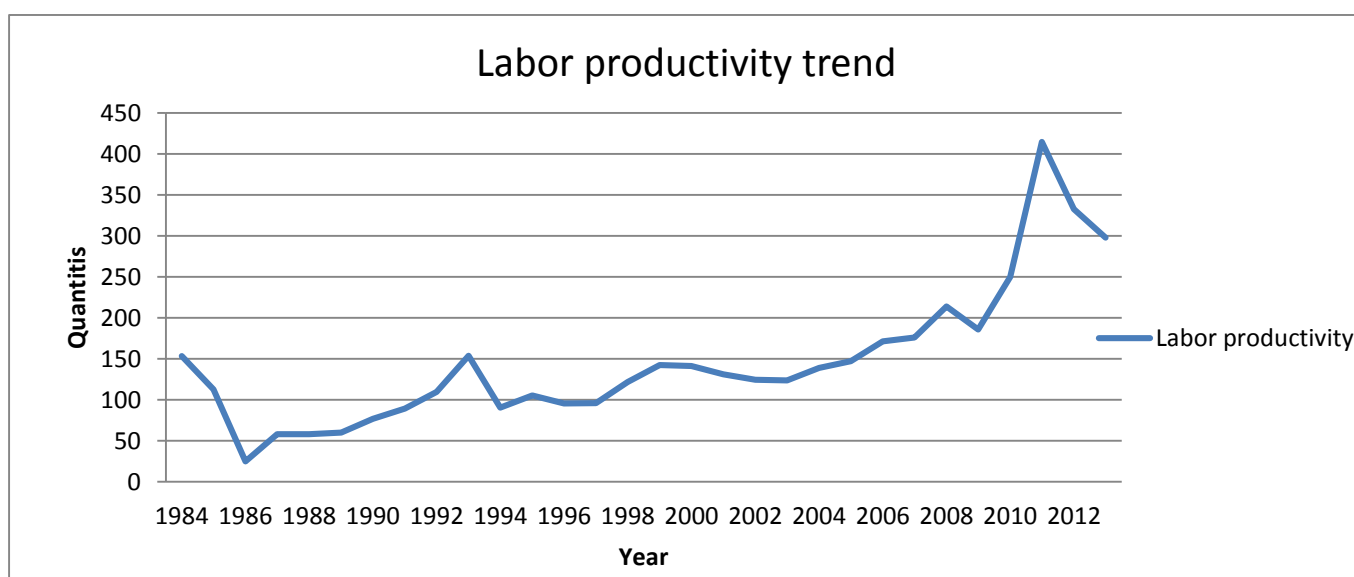Source: Author(s)

Residual time effect (Mt):
Residual time effect is second part of time effect that not determined by estimating the price effect. This index can be related to technology improvements and change in laws related to the mining sector. Fig.8. represents that variation range for this index oscillation in nearly numbers about one. Changes in this index are same direction with labor productivity but in some years this changes was contrary to changes of labor productivity for example 2003 to 2007 years. Changes in residual time effect from 1984 to 2013 is as follows:

Fig. 8: Change in residual time effect in Sarcheshmeh copper company 1984 to 2013
Source: Author(s)

By examining the factors that affecting on labor productivity and put amount of these factors in the equation (11) can be studies the trend of labor productivity. Fig.9. represents the labor productivity has been increased between1984 to 2013. With comparing between the process of copper production in figure (1) and the trend of labor productivity in figure (9) conclude that there is a positive relationship between copper production and labor productivity that explanatory the positive effect of labor productivity as one of the factors affecting on copper production. According to equation (11) trend changes for labor productivity is as follows:

Fig. 9: Trends change on labor productivity for Sarcheshmeh copper company in 1984 to 2013 years
Source: Author(s)

Conclusions

This article investigates the labor productivity in Sarcheshmeh copper company. It uses from TSLS method for estimate the scale effect and OLS method for estimate the time effect. Referring to data from statistical center and central bank of Iran can be observed that copper production had an increasing trend and labor productivity in all mines of Iran had a stable trend. In literature review studies the effect of productivity on economic factor such as production, employment and etc. in some countries that results indicates there is a relationship between this factors and productivity. This relationship in developed countries decreased and in developing countries has increasing trend.

Based on the methodology used model for this article (equation 1) include components that affecting on labor productivity that divided into two factors: scale effect that shows in equation (2) indicate the impact of production changes on productivity and time effect that shows in equation (3) represent the common effect of all changes in particular year that include the copper price and wages. To evaluate the impact of different forces uses from equation (4) that include details affecting on labor productivity. The equation (4) shows the components affecting on labor productivity that include price effect index , Residual time effect index , scale effect index , fixed effect index and Residual Micro heterogeneity index. Investigates the effects that affecting on labor productivity for Sarcheshmeh copper company represents the positive impact of scale effect index (SC_t) and price effect (Z_t) on labor productivity while residual time effect (M_t) and residual micro heterogeneity (Re_t). These effects in some periods have positive impact and in some periods have negative impact on labor productivity. By comparing the changes in trend of labor productivity (Fig.9) and trends of copper production (Fig.1) represents the direct relationship between these two factors. By identifying that affecting on labor productivity to separate the components companies operating in the fields of mining can be consider this components to increase the labor productivity that causes rising in copper production. Also can be considered as the motive factor on labor productivity. Therefore, the methodology and models that used in this article can be the subject of future researches.

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