Econometric analysis of Jordanian phosphate industry

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Abstract. The aim of this study is to assess the competitiveness of the Jordanian extractive phosphate industry using the econometrics analysis, i.e., a common integration approach and error correction model, as well as to appraise some of the competitiveness indicators of the Jordan Phosphate Mines Company (JPMC) for the period (1990-2018), on the basis of Porter's index of comparative advantage, technical efficiency, as well as allocative efficiency. The results pointed out that the Jordanian extractive phosphate industry has a comparative advantage, moderate technical efficiency and decreasing returns to scale. However, the results of the econometrics analysis showed that there is no significant long-term statistical relationship between the company's performance and the variables affecting it. Moreover, the results revealed that the profitability of the company fluctuates during the studied period. On that account, the study presented a set of recommendations, including raising the technical efficiency and efficiency of scale through the optimal use of resources, opining new export markets, using modern technologies, in addition to expanding exploration and extraction areas in order to boost productivity, profitability and competitiveness.
Keywords: competitiveness, comparative advantage, technical efficiency, allocative efficiency, co-integration, vector error correction model.

1. Introduction

Competitiveness has been regarded as a principal tool for economic development economy in globalization, liberalization of markets and global co-integration. Hence, a higher degree of competitiveness improves country's per capita GDP, standard of living and welfare economy due to the optimal utilization of resources, high degrees of quality and superiority over other similar countries and global market penetration.

The importance of the competitiveness of companies in general and Jordanian extractive phosphate industry, in particular, is that it leads to the achieve-

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ment of many advantages that reflect on the well-being of the people. This is because that competitiveness leads to overstepping the domestic market by expanding exports, supplying the state with foreign currencies, creating new job opportunities and localizing high-tech technologies by attracting foreign investment, which improves efficiency and productivity levels.

Phosphate mining in Jordan is one of the most important components of the mining sector, which contributed 0.08 of GDP in 2017. Phosphate was discovered in Jordan in 1908 and invested for the first time in Russeifa in 1935. Fourteen years later, the Jordan Phosphate Mines Company (JPMC) in order to exploit phosphate ores in the fertilizer industry. The company has the fifth largest phosphate reserves in the world by about 3.7 billion tons. It is the sixth largest producer of phosphate in the world with a production capacity of more than seven million tons per year.

Phosphate is used in many industries such as detergent industry and the chemical fertilizer industry.It is used in agriculture to feed the plant. It is one of the inputs of the manufacturing industry like extraction of uranium.In the nineties of the last century, the Indian-Jordanian Chemical Company was established to manufacture high-quality phosphoric acid with a production capacity of 224,000 tons per year, and the Japanese-Jordanian Fertilizer Company to produce compound fertilizers with a production capacity of 300,000 tons per year. During the period (2007-2010), the company was invested in several allied companies such as PetroJordan, the Jordanian Indian Company, Jordan Industrial Ports Company and others.

The importance of studying the competitiveness of phosphate metal, as it is linked to global food security, and the increasing global demand for the production of agricultural crops, for which phosphate fertilizers and other fertilizers are important elements. The demand for phosphate is increasing because of the limited global stock of this precious metal and the continuous increase in the world population.

1.1 Problem statement

The dependence of the phosphate sales on export calls for policies to improve international competitiveness. The export of phosphate and the related fertilizers is closely linked to the global market conditions of supply, demand and exchange market of the global fertilizer market, in addition to droughts in agricultural seasons in many regions of the world,competition from countries with cheap energy sources, as well as competition between the prices of compound fertilizersand natural gas-based nitrogen fertilizers.

Consequently, fluctuations in the sale prices of raw phosphate products and compound fertilizers exported to the world market are reflected in the performance and profitability of JPMC, hence, its efficiency and competitiveness. Accordingly, the problem of the study signifies the extent of the ability of JPMC to face global competition by improving its efficiency, maximizing its profits, raising its competitiveness and absorbing external shocks. Basically, the study seeks to answer the following questions:

1. What is the comparative advantage of JPMC in exporting crude phosphate?

2. Is there a technical competence enjoyed by JPMC?

3. Does the company benefit from economies of scale to reduce costs and raise efficiency?

4. Is there a long-term relationship between the company's performance and profitability with its production and costs?

1.2 Study objectives

The study aims to shed light on:

1. Sources of competitiveness and the challenges facing the Jordanian phosphate industry.

2. The comparative advantage that JPMC possesses according to the Port Competitiveness Index.

3. The competitiveness of JPMC using the efficiency indicators such as technical efficiency and scale efficiency according to the method of production function of cobb- Douglas and translog function

4. Using the co-integration approach and error correction model in exploring the long and short term causal relationship between the JPMC's performance, production and costs in order to measure the allocative efficiency.

1.3 Study hypotheses

Three key hypotheses were postulated in the current study.

1. The company has a comparative advantage in the extraction and production of crude phosphate qualifiesit for exporting phosphate to the world market.

2. The company has a technical efficiency in the extraction and production of crude phosphate, as well as economies of scale increase its competitiveness in global markets.

3. The performance of the company is affected by the size of its production and the value of its costs through a short and long-term causal relationship.

1.4 Data sources

The study was based on annual time series data for the indicators of net profit, production volume, total cost, number of employees and capital size during the period studied (1990-2018). Data were collected from the published annual reports of JPMC and unpublished data issued by the company. Secondary data sources were books, researches and scientific papers published in refereed journals.

1.5 Data processing methods

The descriptive-analytical method was used to apply some indicators such as Porter's comparative advantage index and quantitative analytical analysis to estimate the production function on crude phosphate by Douglas function to determine the type of returns to scale in the Jordanian phosphate industry.Using the Douglas production function for the half-normal distribution and the translog function for truncated-normal distribution to measure the technical efficiency achieved in the Jordanian phosphate industry using frontier 4.0 Software.

The econometric analysis was also used to measure the allacative efficiency in the Jordanian phosphate industry through a co-integration approach, in order to avoid the false results that result from using ordinary least squares method for unstable time series. This methodology was applied by E–views using the following steps:

• First, the stability of time series test. The test was used to ensure long-term stability of time series data for the variables of the study through the null hypothesis test (H0), which assumes unit root presence in the time series versus the alternative hypothesis (H1) which indicates that the time series is stationary using Augmented Dickey–Fuller(ADF). The null hypothesis is rejected if the absolute statistical ADF values are greater than the critical(tabular) value, and if the probability value is less than 0.05. The ADF test is performed in three cases: no constant and no trend, constant and no trend, constant and trend. This is at a level less than 0.05 for the original chains (level). If the chains are not stable at that level, the first differences are taken until they stabilize and integrate from the same degree.

• Second: Determination of the appropriate number of lag. The appropriate lag interval for time series is determined for its direct impact on the results of subsequent tests. Vector autoregressive (VAR) model is applied to select the appropriate length of time slack based on the results of five tests: LR-test, (AIC), (SC), (HQ), and (FPE).

• Third: The Johansen Test for Co-integration (1988). In order to test the existence of a long-term equilibrium relationship between the variables of the study, and to determine the number of vectors and equilibrium relationships in the long term, Johansen test of co-integration will be used, which aims to test the extent of harmony between the variables under study. Johansen proposed two tests. The first one is the impact test, to test the null hypothesis (H0), which states that the number of co-integrated equations is less than or equal to the rank of the matrix (r = 0) versus the alternative hypothesis that there are several alternatives for co-integration. The second test is the Max Eigen value test, which tests a specific alternative. It tests the null hypothesis (H0), which states that the number of the co-integrated equations equals the rank of the matrix (r = 0) versus the alternative hypothesis that there is a number (H1) of co-integrated trends. Commonly, the null hypothesis is accepted if the impact and the Max Eigen values are less than the critical value at a level of less than 0.05.

• Fourth: Error Correction Models (ECM). In case of co-integration, there is a long-term relationship between the variables. This suggests that there is a causal relationship in at least one direction, so ECM is used to determine the short and long-term causality of the variables under study shown by the results of the co-integration test, and to estimate the speed of reaching long-term equilibrium.

• Fifth: Granger Causality Test. If one of the variables causes the other, the relationship is one-way. In the case of each of the variables causes the other, the relationship is reciprocal. There may be no causal relationship between variables, and the causality test is based on the F-test.

Theoretical framework and Literature Review. Since the 1970s, the concept of competitiveness has been linked to international trade and evolved to relate to the technological policy of countries since the 1990s. In the present century, the concept of global competitiveness has been linked to the state's superiority over its peers in economic activity and raising the standard of living of its citizens. The British definition of the company's competitiveness refers to the ability to produce the right goods and services of good quality, at the right price and at the right time, and that means meeting the needs of consumers more efficiently than other enterprises (Oughton, 1997). Measuring the competitiveness of the enterprise economy is linked to a set of indicators including profitability, cost of manufacture, total factor productivity and market share.

This paper discusses the probability of achieving competitiveness by JPMC through a number of indicators including:

1. Revealed Comparative Advantage: This measure of competitiveness is based on the share of economic activity in the international market (Porter, 1990). The indicator can be computed based on the following equation: (State exports of economic activity / total exports of the State) ÷ (World exports of economic activity / total world exports). When the value of the index is greater than the unit, the state has an apparent comparative advantage for the product (Ghazali, 2003).

2. Allocative Efficiency: Pearce (1992) defined allocative efficiency as "the optimal mix of output resulting from the best efficient mix of inputs." It was measured in this study by estimating net profit as a dependent

variable, via analyzing the time series of the phosphate mines company between (1990-2018), stability test, co-integration and error correction model in the regression model, where the determinants of the company's profitability represented by production and total cost.

3. Technical Efficiency: It represents the ratio of actual output to the maximum potential output. A company achieves its technical efficiency if the output is increased using a specific set of inputs. The technical competence of the JPMC was measured by the Maximum Likelihood Method, estimation of the cobb- Douglas production function (a) assuming the half-normal distribution and estimation of the translog production function (b) assuming truncated-normal, respectively.

   (a) $LnYi = A + B1LnLi + B2LnKi + (ui - vi) \ldots$ (Douglas production function);

   (B) $LnYi = A{+}B1LnLi{+}B2LnKi{+}B3(LnLi){+}B4(LnKi){+}B5[(LnLi){*}LnKi)] + (ui - vi)$.

4. Scale Efficiency: When the company selects a level of production appropriate to the cost conditions, where the average costs fall, production volume increases and the company achieves economies of scale.

1.6 Competitiveness aspects of JPMC

Four key aspects of JPMC Competitiveness were elucidated:

1. The company owns Al-Shidia mines with a production capacity of five million tons annually, Al-Hasa mine with a production capacity of half a million tons annually, and Wad-Alabyad mine with a production capacity of 1.5 million annually.

2. The company has a number of allied companies such as Indian Fertilizer Company, Jordan Industrial Ports Company, Manajemfor Mining Development, Al-Abyad Company for Fertilizers and Jordan Chemicals and others.

3. Jordanian exports of crude phosphate in 2017 constituted 375.7 million dollars, i.e., 0.122 of the global exports of crude phosphate, and ranked second after Morocco, where the value of world exports of phosphates equal 3076.7 million.

4. The company was able to reduce production costs per ton of crude phosphate by about 10 dollars in 2018, equivalent to 0.20 of production costs for 2017.

1.7 Challenges facing the competitiveness of Jordanian crude phosphate:

1. The fluctuation in the selling prices of raw phosphate products and fertilizers exported to the global market, which reflects on the performance and profitability of the company.

2. The Low production capacity of the company due to the depreciation achieved in mining equipment, crushing equipment, in addition to the periodic maintenance required for these devices.

3. The high extraction costs associated with the high costs of clearance back to the layer where the concentration of phosphate ores.

4. High costs of global shipping, and their effect on the marketing of phosphate products.

5. Little spending on promotional activities to market the company's products in international markets, especially in the world markets that have not been penetrated.

6. The global competition that the company's exports face, as the company lost some of its export markets for crude phosphate in some years, which increases the challenges facing the company.

7. The high volume of unjustified expenses and the absence of a rational policy to control expenditures, in order to increase the company's profits and competitiveness.

2. Literature Review

Al-Dabbagh's (1992) study aimed at comparing the productivity of the Jordanian phosphate mining company and the Jordanian cement factories, and found that both the average labor and capital productivity in the phosphate company are greater than in the cement company, and that the overall productivity of the phosphate company was characterized by fluctuation due to increased production costs. This result is consistent with the findings of this study that the company's performance fluctuates during the study period. It also found a positive relationship between profitability and a number of independent variables of total productivity and capital productivity. Studying Jordan's phosphate exports, Azhar (2000) discussed the contribution of the phosphate industry to Jordanian exports, where it maintained its market share in the global market. The study reviewed the places of abundance of raw phosphate in Jordan, such as Alwadi Alabiadh, Rusaifeh, Ras Al-Naqab, Al-Hasal and Al-Qatraneh. Furthermore, the phases of the development of phosphate production have been discussed since the company's establishment.

Li (2008) evaluated the competitiveness of phosphate fertilizer producers and compound fertilizer producers in China, and provided a way to explore the quantitative assessment of the competitiveness of Chinese fertilizer enterprises. The overall economic strength of fertilizer and phosphate producers in China was analyzed by the establishment of a targeted economic valuation system according to the distinctive feature of phosphate and compound fertilizer producers. Alrawashdeh (2008) examined the competitive behavior of the State Mining Corporation (the case of JPMC) and showed that the growth of state-owned companies was reflected in the expansion of JPMC to reduce the current account deficit. One of the determinants of the expansion of exports of JPMC is its role in paying off the external debt obligations of the Jordanian economy.

AL-Sukkar (2010) examined the competitiveness analysis of the JPMC (Case Study of the Least Developed Countries) in order to identify the factors affecting the competitiveness of the Jordanian phosphate industry in the global market, and compare the Jordanian phosphate company globally. Alrawashdeh and Sukkar (2010) investigatedfactors affecting the competitiveness of JPMC and concluded that although some markets were lost in Eastern and Western European countries, new markets had been gained in South Asia. The study showed the company outperformed some of its competitors against lower performance compared to other competitors. Furthermore, Alrawashdeh and Thyabat (2012) measured the links of the mining industry in the Jordanian economy and examined the challenges facing the mining industry in Jordan. It concluded that mining had strong forward and backward linkages to the entire economy, and that there was a significant increase in the fertilizer income multiplier from 2.8 to 6.67. Using Porter analysis,Alrawashdeh (2013)explored the competitiveness of JPMC viaa questionnaire and found that JPMC has a comparative advantage in the bargaining power of suppliers, and does not have a comparative advantage in negotiating ability among buyers.Alrawashdeh and Maxwell (2013) used the MMSD method to identify the variables that most affect the economy and showed that the Jordanian economy was not affected by the Dutch disease.

On the other hand, Al-Thyabat (2014) dealt with the determinants of demand for Jordanian phosphate through time series analysis for the period (1980-2010). Jordan's demand for crude phosphate exports was estimated using time series analysis and a co-integration approach to ensure a long-term equilibrium relationship. The results confirmed the existence of such a relationship between the variables of the study, and recommended the need to raise the competitiveness of the JPMC. In order to identify opportunities and threats facing the mining sector in Jordan, Altarawneh (2016) showed that the importance of crude phosphate as one of the most important elements of the sector's competitiveness, and provided recommendations regarding expanding investment in the mining industries.

Irshad and Xin (2017) examined the determinants of export competitiveness and an applied testof the comparative advantage index in the external sector of Pakistan. It concluded that there was a concentration of exports of Pakistan in specific markets and products, and recommended the need to diversify exports.The comparative advantage index of the metal commodity in Pakistan recorded 1.22 and 1.58 during the years 2012 and 2014, respectively.

Using logistic and Gompertz model,Al-Titi et al (2019) found that the peak production of the phosphate in Jordan will be in 2044-2048, where it is expected that the production volume will reach (15.2) million tons in 2048 according to Gompertz model.

On the basis of the above-mentioned literature, this study is characterized one of micro-economic studies that analyzethe institution's economy, while highlighting the economic impact at the macro level through the analysis of competitiveness indicators. Moreover, the study uses various methods of quantitative econometrics analysis to measure competitiveness in extractive industries in the Jordanian economy, according to the best of the researchers' knowledge.

3. Results

1. Using the Porter Relative Advantage Index: The index was calculated according to the available global data for 2017 and 2018.If the value of this index exceeds one, the country has a comparative advantage in the studied commodities.If it were less than 1, it lacks comparative advantage. According to the formula of Porter's comparative advantage index, which indicates : (State exports of economic activity / total exports of the State) ÷ (World exports of economic activity / total world exports). The value of this index for Jordanian crude phosphate was 350, 136.9 for the years 2017 and 2018, respectively. This indicator shows that Jordan enjoys a high comparative advantage in the production and export of crude phosphate.This result is consistent with the position of the Jordanian Phosphate Mines Company as the sixth largest producer and exporter of phosphate in the world with a production capacity of more than 7 million tons annually.

2. Technical efficiency measurement: The technical efficiency of JPMC was measured using Stochastic Frontier (SF) model and Cobb-Douglas production function with the assumption of half-normal and the translog function assumed by truncated–normal and using Frontier 4.0 software. The results revealed that the technical efficiency using half-normal for Cobb-Douglas production function was 0.75 and the technical efficiency using truncated-normal for translog output function was 0.71.This result indicates that phosphate producers can increase their production by 0.029 without increasing the economic resources used in the production process.Stochastic Frontier method of measuring technical competence has been used by many researchers including (e.g., Battese and Coelli, 1995). This result is consistent with the findings of Ajibefun (2007) when mea-

suring technical competence in metal industries in a number of regions of Nigeria where it reached 0.82.

3. Measuring the efficiency of Scale : The efficiency of Scale in the Jordanian phosphate industry was measured according to the Cobb-Douglas production function. It was found that:
   - There is no effect of labor and capital elements on production. This is shown by the estimated parameters of labor and capital elasticity of production, as it came very low as shown in the estimated equation.
   - The results showed that production depends on exports, as most of the crude phosphate production is exported globally.
   - The overall explanatory power of the model was appropriate by testing the determinant coefficient and the overall significance of the model was accepted according to F-test.
   - The statistical significance according to the T test was acceptable with the exception of the labor parameter, and the results revealed that there was no problem of Auto correlation.
   - The results showed that there are decreasing returns to scale in the phosphate industry, where the value of production elasticity is less than 1, where the value of returns to scale is about 0.31, it should be noted that the most of the returns come from exports, because the work component was restructured in the company, so that the number of workers decreased significantly since 1990, it was decreased from 5135 workers to 2570 in 2018.
   - The company can benefit from economies of scale if it makes good use of the available elements of production, and expanded in the extraction and processing of phosphate in order to raise the efficiency of scale and thus improve competitiveness.

     $LogQ = LogA + B1LogL + B2LogK + B3Logx + (ui - vi).$

     $LogQ = 6.38 + 0.0001LogL + 0.0007LogK + 0.30Logx + e.$

     t 9.23 1.66 2.15 3.82

     $R^2 = 0.52$, D.W = 2.06, F = 6.27, P-Value = 0.004

4. Measuring the allocative efficiency: By detecting a long-term relationship between net profit and its determinants, allocative efficiency will be measured based on a co-integration approach and error correction, assuming thatnet profit as a dependent variable is influenced by the volume of crude phosphate production and total costs.In addition to assuming that the net profit as a dependent variable is affected by the value of crude phosphate exports and total costs. Because of the linear interdependence between production volume and the value of exports, it was estimated separately.

- Test the stability of the time series of the study variables: net profit, production volume, export value, total costs. It is clear from the results shown in Table 1 that the values of MacKinnon (1996) calculated for the ADF test for all study variables that there is a fixed limit and a and a general trend less than the critical value at a level less than 0.01, and thus the null hypothesis was accepted, which indicates that the time series suffers from the problem of a unit root, as it is unstable at the level.The series must be converted to the first differences to make sure that the series are stable and static at the first differences where all ADF test values are greater than their critical value, and that all probability values are less than 0.01.Therefore, we reject the null hypothesis and accept the alternative hypothesis that there is no unit root in the series.

- The results of the optimal lag length test: The results of the unrestricted directional gradient vector test, based on the most commonly used Akaike information criterion (AIC) that the length of the appropriate lag time are two periods between the net profit and its determinants.

- Johnson co-integration test:The test is used to discover long-term relationships. The results of the Johansen test for the co-integration of the variables of the study represented by the first equation: net profit, as a dependent variable, affected by the volume of production and total costs.The existence of a single vector for the integration of these variables at the level of 0.05, in contrast, the test results according to the second equation: net profit is a dependent variable and is affected by the value of exports and total costs indicated that there are two vectors for the co-integration between those variables at the level of 0.05. Therefore, the null hypothesis that there is no co-integration at 0.01 level will be rejected. This indicates a long-term relationship in the model, where the statistical values of both the trace test and the maximum-Eigen test were greater than the critical value in both equations, andthe probability is less than 0.05. Based on these results, the short- and long-term relationship will be estimated using the error correction vector (VECM).

Table 1: Results Augmented Dickey -Fuller Statistical test (ADF)

Variables	% level		First differences (1%)		Result
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
Profit	-2.99 (0.04)	-3.02 (0.14)	-6.02 (0.000)	-5.91 (0.0003)	I(1) stationary
Quantity	-1.62 (0.45)	3.73 (0.04)	-5.3 (0.0002)	-5.31 (0.0011)	I(1) stationary
Cost	-0.29 (0.91)	-2.5 (0.33)	-7.54 (0.000)	-7.46 (0.000)	I(1) stationary
Export	-1.68 (0.42)	-2.63 (0.27)	-6.43 (0.0000)	-6.28 (0.0001)	I (1) stationary
critical value	-3.68	-4.32	-3.71	-4.36	

Source: authors' own elaboration and the numbers in parentheses represent the probability.

Table 2: Results of co-integration between net profit, production volume and total costs of JPMC

Hypothesis	Eigen	Trace test			Max Eigen		
		p-value	C.V (5%)	t-stat	p-value	C.V (5%)	t-stat
Non*	0.573	0.02	29.8	33.40	0.03	21.13	22.14
At most 1	0.347	0.19	15.5	11.26	0.15	14.26	11.08
At most 2	0.006	0.67	3.84	0.18	0.67	3.84	0.18

Source: authors' own elaboration. * Null hypothesis is rejected at 5%.

Table 3: Results of the test of the co-integration between the net profit, the value of exports and the total costs of JPMC

Hypothesis	Eigen	Trace test			Max Eigen		
		p-value	C.V (5%)	t-stat	p-value	C.V (5%)	t-stat
Non*	0.64	0.0001	29.8	48.76	0.006	21.13	26.97
At most 1*	0.567	0.005	15.5	21.79	0.003	14.26	21.79
At most 2	0.002	0.989	3.84	0.0002	0.99	3.84	0.0002

Source: authors' own elaboration. Two vectors for co-integration at 5%.

- Results Error Correction Vector Model estimation:In order to determine the direction of the causal relationship in the short and long term, and to estimate the speed of reaching the long-term equilibrium, the error correction model is tested. The appendix (3) shows the results of estimating the error correction vector according to the first equation, where the net profit is affected by the volume of production and costs. The coefficient of error correction was (0.145). Contrary to the expected, the value was positive in addition to the absence of statistical significance, which indicates the absence of a long-term equilibrium relationship from production quantities and costs to profits. The appendix (4) also shows the results of estimating the error correction vector according to the second equation, where the net profit is affected by the value of exports and costs. The error correction coefficient was (-0.325), which means that 32.5% of the imbalance is treated in the subsequent period after any shocks in the independent variables and affects the dependent variable. So, the company's net profit variable needs 32.5% each year to return to equilibrium. It is interesting to note that the correction coefficient lacks statistical significance at a level less than 5%, indicating that the long-term equilibrium relationship that moves from the value of exports and costs to net profit is not significant, which means a weak long-term relationship between net profit and its determinants. We can attribute the presence of the positive signal in the first equation, and the lack of the second equation of statistical significance to several reasons, the most important of which are the large fluctuations in the company's profits over (1990-

2018), the company's reliance on export contracts, the loss of the company for important export markets, in addition to severity competition between global prices of compound fertilizers that based on phosphate products and nitrogen fertilizers which based on natural gas and oil. It should be noted that the JPMC has recorded losses in various years during the studied period, including 1993, 1999, 2016, and 2017. In contrast, during 2008, the company recorded profits of 238.6 million JDs. The company has many projects and future plans to increase production, maximize profits and improve competitiveness.

The direction of the causal relationship of the variables in the short term:

Based on the first equation where the net profit is affected by the volume of production and costs, and based on the Granger causality test (F test) and Chi Square-basedWald's test, the short-term relationship between the variables was as follows:

- There is a short-term relationship between profits and the volume of production in one trend. The increase in profits stimulates the company to produce and extract more phosphate in a number of undiscovered areas. In the contrast, the increase in the volume of production does not cause profits because the profits depend on demand, especially export sales and global demand.

- There is no short-term causal relationship between costs and profits in both trends according to the F-test. This result contradicts the economic theory, but there is a statistically significant relationship between both profits and production in influencing the costs according to Wald's test. Increased profits motivate the company to purchase high-tech exploration and extraction machinery and equipment, thereby reducing costs.

- The existence of a short-term causal relationship in one trend between the volume of production and the costs, since the lower costs, causes an increase in the volume of production, and according to F-test, the high volume of the production does not cause a decrease in costs. This result is consistent with our results on the declining returns to scale in the phosphate industry. Based on the second equation, where net profit is affected by the value of exports and costs, and based on the Granger causality test, the results indicated that there is no short-term or long-term relationship between net profit and its determinants.

Consequently, analyzing the time series according to the co-integration approach in order to measure the allocative efficiency, it was clear that there is no long-term causal relationship between the net profit and its determinants of the JPMC, which means that the company has low allocative efficiency as a measure of competitiveness

4. Conclusion

JPMC has many forms of competitive strength, represented in the production capacity of mines, allied and affiliated companies and the volume of its exports to international markets. However, the company suffers from some challenges such as fluctuating prices of selling raw fertilizer and phosphate products, high extraction costs associated with high landfill costs, high international shipping costs as well as international competition in the company's exports. The Porter Index showed in the revealed comparative advantage that the Phosphate Mines Company has a comparative advantage in the production of raw phosphate, exceeding one, as the index recorded 137 in 2018. The results of the competitiveness measurement showed that the crude extractive phosphate industry has a moderate technical efficiency of 73%, and presence decreasing returns to scale in the phosphate industry. The results of the measurement of allocative efficiency using the co-integration approach and the error correction model indicated that there is no long-term equilibrium relationship moving from production quantities and costs to profits. The results showed that there is no statistically significant long-term relationship between the net profit and its determinants, due to various reasons, including fluctuations in the company's profits, global competition, and the company's dependence on export contracts, which contributes to the weakness of the allocative efficiency enjoyed by the company as a measure of competitiveness. The causality test showed that there is a short-term relationship between production volume and costs in one trend, as well as between profits and production volume.

In the light of the findings of this study, it is recommended to face the challenges facing the company and focus on increasing production capacity and the use of modern machinery and equipment in extraction, mining, and crushing. As well as spending on promotional activities to market the products of Jordan Phosphate Mines Company in international markets, in addition to participating in international exhibitions.

The study recommends the necessity of rationalizing the current and capital expenditures of the company and controlling its disbursements, raising the technical and scale efficiency of the company through optimizing the available production elements and improving the company's performance by opening new markets to the company's exports, in addition to expanding phosphate mining and exploration to cover new target areas in order to increase productivity and maximize profitability.

Finally, the study recommends strengthening the company's hedge fund with financial reserves to meet global developments, uncertainty conditions and unexpected losses.

Appendix 1. *Granger causality test results between net profit, total costs and production volume of Jordan Phosphate Mines Company.*

Null hypothesis	F	Prop.	Results
Production volume doesn?t cause profits	0.147	0.86	Supported
Profits do not cause production	5.93	0.0087	Rejected
Total costs do not cause profits	0.8	0.83	Supported
Profits do not cause total costs	1.1	0.35	Supported
Costs do not cause production volume	8.07	0.002	Rejected
Production volume does not cause costs	0.93	0.4	Supported

Appendix 2. *Short-term causality according to Wald test*

Dependent	Decision	Null- Hypothesis	Chi-Square	Probability	Excluded
D(profit)	Accept	C(4)=c(5)=0	2.53	0.28	D(Quantity)
	Accept	C(6)=c(7)=0	3.03	0.21	D(COST)
D(quantity)	Accept	C(10)=c(11)=0	1.22	0.54	D(Profit)
	Accept	C(14)=c(15)=0	0.67	71	D(COST)
D(cost)	Reject	C(18)=c(19)=0	8.27	0.01	D(Profit)
	Reject	C(20)=c(21)=0	8.14	0.01	D(Quantity)

Source: authors' own elaboration based on e-views results.

Appendix 3. *Co-integration Equation between Profit and quantity, cost.*

Co-integrating Eq:	CointEq1		
PROFIT(-1)	1		
QUANTITY(-1)	0.080283		
	-0.02497		
	[3.21504]		
COST(-1)	-0.658383		
	-0.16097		
	[-4.09021]		
C	-280.9747		
Error Correction:	D(PROFIT)	D(COST)	D(QUANTITY)
CointEq1	0.145038	0.549194	-4.171196
	-0.21616	-0.24169	-2.51237
	[0.67097]	[2.27228]	[-1.66026]
D(PROFIT(-1))	-0.05354	-0.821832	-2.484471
	-0.38751	-0.43328	-4.50388
	[-0.13816]	[-1.89678]	[-0.55163]
D(PROFIT(-2))	-0.595467	-1.245379	3.420935
	-0.41519	-0.46422	-4.82555
	[-1.43421]	[-2.68272]	[0.70892]

Continue table in Appendix 3

D(QUANTITY(-1))	-0.009686	-0.032609	0.256072
	-0.01925	-0.02152	-0.22371
	[-0.50323]	[-1.51520]	[1.14466]
D(QUANTITY(-2))	-0.024071	-0.041989	-0.371883
	-0.01649	-0.01844	-0.19167
	[-1.45960]	[-2.27717]	[-1.94021]
D(COST(-1))	-0.4619	-0.008659	-2.573768
	-0.27179	-0.30389	-3.15892
	[-1.69946]	[-0.02849]	[-0.81476]
D(COST(-2))	-0.017998	0.902218	-1.046856
	-0.29341	-0.32806	-3.41017
	[-0.06134]	[2.75015]	[-0.30698]
C	9.245993	0.286902	165.8472
	-14.5141	-16.2283	-168.692
	[0.63703]	[0.01768]	[0.98314]
Error Correction:	D(PROFIT)	D(COST)	D(QUANTITY)
R-squared	0.475073	0.531263	0.529365
Adj. R-squared	0.270935	0.348976	0.34634
Sum sq. resids	58180.29	72734.7	7859270
S.E. equation	56.85278	63.56742	660.7769
F-statistic	2.327216	2.914438	2.892311
Log likelihood	-137.1641	-140.0666	-200.9408
Akaike AIC	11.16647	11.38974	16.07237
Schwarz SC	11.55357	11.77685	16.45948
Mean dependent	1.207692	16.65769	105.9231
S.D. dependent	66.58382	78.78367	817.295
Determinant resid covariance (dof adj.)	1.25E+12		
Determinant resid covariance	4.14E+11		
Log likelihood	-458.417		
Akaike information criterion	37.33977		
Schwarz criterion	38.64625		

Appendix 4. *Co-integration Equation between Profit and Export, cost.*

Co-integrating Eq :	CointEq1		
PROFIT(-1)	1		
Export (-1)	-1.562126		
	(0.18101)		
	[-8.62998]		
COST(-1)	0.745785		
	(0.08741)		
	8.53224		

Continue table in Appendix 4

C	7.213026		
Error Correction:	D(PROFIT)	D(COST)	D(export)
CointEq1	0.439396	-0.759038	-0.325961
	-0.53294	-0.56414	-0.43986
	[0.82447]	[-1.34548]	[-0.74105]
D(PROFIT(-1))	-0.553529	0.432789	0.396314
	(0.71290)	(0.75464)	(0.58840)
	[-0.77645]	[0.57351]	[0.67355]
D(PROFIT(-2))	-0.016331	0.759763	0.356945
	(0.79733)	(0.84400)	(0.65808)
	[-0.02048]	[0.90019]	[0.54241]
D(COST) (-1))	-0.216702	0.084871	-0.316696
	(0.36833)	(0.38989)	(0.30400)
	[-0.58834]	[0.21768]	[-1.04177]
D(COST) (-2))	0.024851	0.410273	-0.150246
	(0.29916)	(0.31667)	(0.24691)
	[0.08307]	[1.29557]	[-0.60850]
D(EXPORT) (-1))	0.304948	-0.938009	-0.478195
	(0.71855)	(0.76061)	(0.59306)
	[0.42440]	[-1.23323]	[-0.80632]
D(Export) (-2))	-0.53254	-1.228862	-0.763207
	(0.66807)	(0.70718)	(0.55139)
	[-0.79714]	[-1.73770]	[-1.38415]
C	7.870440	28.22875	20.71450
	(18.8756)	(19.9806)	(15.5790)
	[0.41696]	[1.41281]	[1.32964]
Error Correction:	D(PROFIT)	D(COST)	D(EXPORT)
R-squared	0.368598	0.368658	0.462642
Adj. R-squared	0.123053	0.123135	0.253669
Sum sq. resids	87430.26	97966.48	59558.17
S.E. equation	69.69388	73.77386	57.52206
F-statistic	1.501144	1.501525	2.213886
Log likelihood	-142.4589	-143.9381	-137.4684
Akaike AIC	11.57376	11.68755	11.18987
Schwarz SC	11.96087	12.07465	11.57698
Mean dependent	4.326923	16.65769	1.207692
S.D. dependent	74.42316	78.78367	66.58382
Determinant resid covariance (dof adj.)	4.28E+09		
Determinant resid covariance	1.42E+09		
Log likelihood	-384.6532		
Akaike information criterion	31.66563		
Schwarz criterion	32.97211		

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Accepted: May 05, 2020