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Econometric Analysis of Some Competitiveness Indicators in the Jordanian Potash Industry: Evidence from the Arab Potash Company

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Abstract: This research conducted an economic analysis of competitiveness indicators within the Jordanian potash industry from 1990 to 2022. Utilizing ARDL, FMOLS, DOLS, and CCR econometric methods, the study aimed to assess volume efficiency, operational efficiency, and allocative efficiency along with their determinants. Findings indicated decreasing returns to scale in the Jordanian potash industry. The ARDL model revealed a long-term equilibrium relationship between operational efficiency and its determinants. Moreover, a direct association between exports and profits was observed, along with an inverse relationship between profits and both costs and production volume. Lastly, Granger causality analysis indicated a unidirectional causal relationship from profits to production.

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1. Introduction

The global population surge is increasing the demand for food, necessitating a heightened need for agricultural commodities, especially fertilizers like potash. This growing demand is concurrently raising fertilizer costs, crucial for effective food cultivation. Potash fertilizers play a vital role in nourishing plants, strengthening roots, and activating enzymes. They facilitate nutrient absorption, extend crop storage, and optimize physiological reactions, ultimately boosting crop yields and quality, particularly in soils with potassium deficiency (Gautam et al., 2022). In an industrial context, potash comprises chlorides, sulphates, nitrates, and potassium oxide. Its applications extend to the manufacturing processes of glass, soap, gunpowder, as well as serving as a component in animal feed and certain pharmaceutical formulations (PalladianPublications, 2021). Industrial development propels national economic growth. Jordan's potash industry is a crucial extractive sector, noted for its employment generation, economies of scale, and foreign revenue attraction. Leveraging the Dead Sea's resources, Jordan strategically established the Arab Potash Company in 1956, granted a 100-year franchise (1958-2058) for exclusive extraction, production, promotion, and investment rights in Dead Sea salts and associated minerals. With the extractive industry being a cornerstone of Jordan's national revenue, enhancing the competitiveness of the potash sector, especially given Jordan's global ranking as the tenth-largest producer, becomes pivotal. This study contributes as one of the pioneering investigations into the competitiveness of Jordan's potash industry through the application of econometric analysis.

Competitiveness indicators, pivotal metrics within management, offer insights into both the operational efficiency and market positioning of an organization (Rosário & Dias, 2023). These metrics facilitate informed decision-making, strategy optimization, and responsive adjustments to evolving market conditions (Basu et al., 2023). Utilizing competitiveness indicators is imperative for attaining sustained success and long-term growth.

This study employs various econometric techniques to assess the competitiveness of Jordan's potash sector. It focuses on evaluating scale efficiency, returns to scale, and factors influencing operational and allocative efficiency. The research analyses the enduring equilibrium relationship between operational efficiency and its determinants. Additionally, it examines the factors influencing allocative efficiency and utilizes the Granger test to explore the cause-and-effect connection between profitability and its drivers. The competitiveness of a corporation is influenced by its economic activities, including supply, production, and sales (Ivanova et al., 2018). This document is structured into six sections: Section 1 encompasses the introduction, Section 2 reviews pertinent literature on the subject, Section 3 explores the theoretical framework, Section 4 delineates the data and methods employed, Section 5 presents the empirical results and ensuing discussion, and finally, Section 6 provides the concluding remarks.

2. Literature Review

In a study conducted by Al-Naif & Al Shra'ah (2019), the financial performance of companies within Jordan's extractive and mining industry was investigated. The research specifically focused on the interrelation between working capital management and profitability within this sector, with potential implications for the Jordanian economy. Employing panel data analysis, the researchers assessed the financial performance of nine publicly traded companies over the period from 2000 to 2016. According to the random effect model, the findings revealed a robust inverse relationship between elements of working capital management and company profitability. Furthermore, a negative correlation was observed between the debt ratio and company profitability, while a positive correlation was identified between company size and profitability.

Al Tarawneh (2016) examined Jordan's mining sector and its impact on the economy. He also invested in feldspar, clay, limestone, gypsum, zirconium, uranium, copper, and rare earth elements. The report examined the sector's opportunities, risks, and critical issues and made crucial suggestions to the Jordanian government to encourage investment.

In a study by Akinsemolu (2020), an analysis is conducted on the historical and contemporary influence of extractive industries on the social and economic advancement within the Middle East and North Africa region. The author asserts that the extractive industry in this region possesses the capability and potential to substantially contribute to the achievement of all sustainable development objectives. However, despite the sector's diversity, it is noted that the extractive activities in the Middle East and North Africa region hinder the support of sustainable development goals by contributing to environmental degradation.

Numerous studies have scrutinized the economic efficiency and financial performance of the Arab Potash Company (APC). Notably, Abu-Hamatteh & Al-Amr (2008) conducted an analysis focused on the operational efficiency of APC in mineral extraction from the Dead Sea, encompassing the production of agricultural potash, industrial potash for chemical sectors, industrial salt, bromine, and NPK fertilizers (comprising nitrogen, phosphorus, and potassium). These investigations have also delved into strategies aimed at enhancing the company's competitiveness by optimizing energy and production costs. Optimal efficiency in terms of halite elimination and carnallite retrieval was achieved, with influential factors including pulp density, reagent quantity, conditioning duration, temperature, pH, and the presence of additives. The findings suggest the potential for reducing both loss and total costs, thereby enhancing overall productivity.

Kim et al. (2020) investigated the financial performance of the Arab Potash Company. The study revealed significant effects on both profitability and liquidity metrics. The company demonstrated rationality in operational expense management, leading to fluctuating ROA, ROE, and Profit Margin over time due to varying resource utilization. Sales cost, total cost, and revenues exhibited variations across different periods, while working capital turnover and current ratio remained relatively consistent.

In a related study, Qaisi (2020) explored the influence of compensation and perks on the net operating income before tax. The findings emphasized the notable impact of Board of Directors' membership fees on financial performance, resulting in increased expenditures. The study underscores the importance of establishing a direct correlation between remuneration for Board members and the company's production, sales growth, and annual net profit or loss.

As per Al-Kasasbeh, Khasawneh, & Alzghoul (2023), energy conservation and rationalization within the Arab Potash Company hold noteworthy importance due to their competitive implications. Positioned as a significant consumer of energy in Jordan's industrial sector, the company annually consumes approximately 125,000 TOE, drawing from various sources such as heavy fuel oil, electricity, and diesel. Notably, the company's energy-related expenditures constitute approximately 22% of its overall operational expenses. The study advocates various energy conservation strategies, encompassing immediate, short-term, and long-term measures, with the overarching goal of enhancing the efficiency of equipment and systems, consequently reducing operational costs.

Several studies have focused on sustainability, employing econometric analyses to predict future potash reserve availability and export volumes. Al-Abbadi (2013) utilized the Box-Jenkins methodology to project declining potash exports, highlighting the need for strategic marketing approaches and exploring new markets. Al Rawashdeh (2020) assessed the long-term viability of global potash reserves, pinpointing the projected peak in potash production around 2057, spanning from 2029 to 2095. To ensure sustained potash accessibility, it is imperative to establish markets for sustainable potash fertilizers derived from excrement, manure, and food waste.

Numerous studies have scrutinized fertilizer firms' competitiveness and the economic implications of potash trade. Ponomarenko & Sultani (2010) crucially assessed the competitiveness of potassium companies in Russia and Belarus, focusing on exclusive potassium salt deposits contributing to over 40% of global potassium fertilizer production. Sakamornsnguan & Kretschmann (2016) investigated the distribution of potassium deposits in Thailand, revealing that manufacturing 1.1 million tonnes of potash fertilizer annually reduces import reliance. Wang & Kong (2019) employed a network model to analyse global potassium salt trade, affirming Canada's prominence and endorsing international competitive advantage development. Vîrjan et al. (2023) analysed Romania's competitiveness pre- and post-COVID-19, emphasizing sustainable development, energy costs, efficiency, macroeconomic indicators, labour productivity, and economic growth to enhance market and export share and return on capital for improved living standards.

Conversely, alternative research endeavours have focused on evaluating technical efficiency and quantifying inefficiency using parametric tests like Stochastic Frontier Analysis (SFA) and non-parametric tests such as Data Envelopment Analysis (DEA). DEA, a non-parametric technique widely used in operations research and economics, is employed to estimate production frontiers. Zamanian, Shahabinejad, & Yaghoubi (2013) assessed the levels of technological competence in agriculture across MENA nations during the 2007-2008 period, utilizing DEA and Stochastic Frontier Approaches Analysis (SFA). Their findings revealed that overall efficiency rates were as follows: DEABCC (0.770) > DEACCR (0.744) > SFA (0.479).

Khan (2017) investigated the competitiveness of Indian fertilizer firms by evaluating their production-oriented technological efficiency from 1993-1994 to 2012-13, utilizing a stochastic frontier technique. The data reveals an average technical efficiency of 57 percent in the industry, signifying potential for improvement. The results further demonstrate that private sector fertilizer enterprises display superior efficiency levels compared to their public sector counterparts. Additionally, well-established corporations with substantial expertise exhibit higher efficiency in contrast to smaller and recently established enterprises.

In their investigation, Yadava (2023) evaluated the technical inefficiency across 28 Indian states concerning the utilization of chemical fertilizers and the plausible reduction in fertilizer usage while preserving agricultural productivity. The study employed the DEA approach to quantify the effectiveness of employing chemical fertilizers and their impact on agricultural productivity. The results suggested a higher potential for reduction in potassium fertilizer usage, followed by phosphorus and then nitrogen. This contributes to reducing dependence on chemical fertilizers during production, thereby enhancing farmers' income through input supply strategies.

Jaber et al. (2022) evaluated the operational effectiveness of Jordan's mining and extraction industry using DEA, specifically employing BCC models for efficiency assessments and comparisons between input-output models. The study examined sector-wide efficiency, identifying strengths and weaknesses within companies, and observed performance variations over time within organizations using dynamic BCC models. The efficiency of the Jordanian extractive industry was influenced by GDP growth and return on assets.

Competitiveness studies, exemplified by Husain & Islam (2016) focus on analysing productivity, scale efficiency, and economies of scale. They employed the Cobb-Douglas production function to identify top industrial enterprises in Bangladesh's southwestern region, assessing correlations between inputs and outputs, marginal productivity, allocative efficiency, and returns to scale. The findings indicated diminishing returns to scale for cement, jute, and textiles, while fertilizer and seafood manufacturers experienced increasing returns to scale.

Lavrenko & Shishlyannikov (2021) investigated the mechanized production of potash, attributing underwhelming technological performance to low machine productivity in moving the mine area, with a mean productivity coefficient of 0.29. The results also highlighted elevated values of the energy efficiency coefficient, aligning with the machine's productivity meeting design specifications.

In a comparable vein, certain studies have investigated the determinants of operational efficiency, technical efficiency, and allocative efficiency. For instance, Ajibefun & Daramola (2003) explored the factors influencing allocative and technical efficiency in small businesses within the Nigerian economy, revealing significant variations in efficiency levels among firms. The study underscored the pivotal role of the educational background of enterprise owners in shaping the efficiency levels of microenterprises. Al-Qubaisi & Ajmal (2018) conducted research on the determinants of operational efficiency in the oil and gas sector in the UAE, emphasizing the importance of incorporating new knowledge and continuous learning into daily operations. This approach, perceived as an investment rather than an expense, is deemed crucial for enhancing the company's future. Organizations are encouraged to adopt a learning-oriented approach and foster learning cultures. In a related context, Hung & Cuong (2023) analysed the technical efficiency and allocative efficiency in the cultivation of lotus roots in Soc Trang Province, Vietnam. Survey results reveal that expanding households achieve an average production of 8.29 tonnes per hectare, with an average profit of VND 49,357,143 per hectare. The average revenue-to-cost ratio is 174%, the profit-to-cost ratio is 73%, and the profit-to-sales ratio is 42%. Notably, research demonstrates that lotus root exhibits superior economic efficiency compared to other crops.

In a related context, Anthony et al. (2023) assessed the profitability, technical efficiency, and allocative efficiency of watermelon production in Nigeria. Findings highlighted the significant influence of seeds, NPK fertilizer, Urea fertilizer, and chemical fertilizer on overall watermelon yield. The study also identified gender, marital status, educational level, occupation, and family size as key factors influencing technical inefficiency. Additionally, determinants of allocative inefficiency included age, gender, and educational attainment of farmers. The study recommends enhancing productivity by providing farmers with improved seeds, financial resources, chemicals, and fertilizers at reduced prices.

In addition, research has been done on how to diagnose the potash fertilizer business. Farias et al. (2021), for example, did a strategic diagnosis of the Brazilian potash fertiliser business. This is because Brazil is the fourth-biggest fertiliser user in the world. There are problems with the industry's infrastructure, access to raw materials, and barriers that make it hard for new companies to start up. Because of this, it is very important for the government to make rules that will help the business grow by taking advantage of Brazil's consumer market advantages. The study's goal is to find out how Brazil's situation compares to that of its better competitors, mainly Canada, Russia, and Belarus. In 2011 and 2016, the writers Al-Rawashdeh et al. put out papers.

Moreover, alternative research has centred on investigating the environmental impacts of potash mining on the atmosphere, surface water, and groundwater. In their investigation, Ushakova et al. (2023) scrutinized the repercussions of potash mining on various environmental components, encompassing the atmosphere, surface water, groundwater, soil, and vegetation cover. It is recommended to employ the most effective strategies to mitigate the adverse environmental effects of potash mining in the Verkhnekamskoe deposits. This can be achieved through the hydraulic effect, which reduces the necessity for mine room backfilling, provides protection against floods, and diminishes the volume of potash tailings.

In their investigation, Dmitrieva, Ilinova, & Kraslawski (2017) explored the competitive advantage of Russian mining and chemical firms amid substantial environmental disturbances, revealing the industrial characteristics of mining within an oligopolistic market. Mining and chemical enterprises have developed both sustainable and unsustainable competitive advantages in response to significant environmental disruptions.

Similarly, Oktavilia & Damayanti (2023) examined the association between fertilizer raw materials and environmental degradation using Granger causality and cointegration tests. The analytical findings indicate the absence of a bidirectional relationship between these variables. However, a unidirectional relationship is observed where environmental deterioration influences the pricing of potash and phosphate fertilizer.

Research Gap

This research scrutinized the economic analysis of competitiveness within the Jordanian potash industry, characterized by a monopoly market structure operating under a government franchise. The existing body of literature within the Jordanian extractive industry sector lacks comprehensive examinations of competitiveness and neglects the application of econometric analysis models for such assessments. The distinctiveness of this study lies in addressing this critical gap in the literature pertaining to the Jordanian economy. It accomplishes this by conducting research that integrates micro and industrial economics, coupled with the application of econometric models to analyse competitiveness (Chikán et al., 2022).

3. Theoretical Framework

3.1 World Potash Industry

Potash, a vital mineral abundant in potassium, holds significance within the extractive industry and concurrently plays a pivotal role in the manufacturing sector, where it undergoes transformation into various fertilizer types. As per the World Trade Organization's (2021) report, the mining industry, inclusive of potash, constituted 10% of the overall Gross Domestic Product (GDP) in the year 2020, as reported by the WTO in collaboration with the United States government agency.

The global potash market is characterized by an oligopolistic structure, characterized by a limited number of participants at the international level. The escalating demand for agricultural production, driven by the rising global population and the concomitant aging demographic due to advancements in healthcare and increased income levels, contributes to the increasing consumption of potash worldwide. The annual growth rate of potash consumption is approximated at 2.9% (Al Rawashdeh, Xavier-Oliveira, & Maxwell, 2016).

The global economy faces ongoing challenges such as the Russian-Ukrainian war, COVID-19-related closures, a surge in inflation rates, increased interest rates, geopolitical uncertainties, extreme weather events, and escalating commodity prices. These factors contribute to heightened risks of a significant decline in global economic activity. The fertilizer market, particularly potash, has experienced successive price increases due to these factors, with the US Geological Survey reporting a reduction in global potash consumption from 40.6 million tons in 2021 to an estimated range of 35-39 million tons in 2022. Despite this, the global potash production reached 40 million metric tons in 2020, and projections suggest an increase in global potash capacity to 66 million metric tons by 2025 (U.S. Geological Survey, 2023).

Table 1: Global Production of Potash (million tons) during the years 2018 and 2022.

Country	Production 2022	Production 2018
North America	22.8	23.2
Russia	9.5	11.8
Belarus	6.2	12.1
Israel/UK/Spain	4.7	4.9
China/Laos/Uzbek	9.2	7.9
Jordan	2.7	2.4
Germany	4.6	4
Latin America	1.7	1.9
Total	61.4	68.2

Source: APC's Annual Report 2022.

The global production of potash experienced a decline in 2022, totalling 61.4 million tons, as opposed to 68.2 million tons in 2018. This reduction can be attributed to the Russian-Ukrainian conflict, resulting in a significant decrease in Russia's potash exports. Notably, economic sanctions imposed by the European Union and the United States, including import quotas on Russian potash, contributed to the decline in Russia's production. Belarus, a significant potash producer, witnessed a 50% reduction in production levels compared to 2018. North America, specifically Canada, claimed the top position globally in potash production, accounting for 37.1% of the total global production in 2022. China secured the third position globally in potash production for the same period (Arab Potash Company, 2022).

Table 2: Potash Shipments and Demand (million tons) during the years 2018 and 2022.

Region	2022	2018
Asia & Oceania	27	30.6
North America	7.9	10
Europe	5.3	6.2
Latin America	14.5	13.2
ME and Africa	2	2.5
CIS	4.3	4
Grand Total	61	66.5

Source: APC's Annual Report 2022.

Global potash shipments in 2022 declined to approximately 61 million tons, marking a reduction of 5.5 million tons compared to 2018 levels. Decreases in potash shipments were observed in Brazil, the United

States, and Europe, with the latter ceasing imports of Russian and Belarusian potash due to reduced consumption. Notably, numerous compound fertilizer and potash sulphate fertilizer plants globally curtailed potash consumption, citing elevated prices and non-competitive final product prices, compounded by sluggish consumer markets. The diminished global demand for potash in 2022 results from constrained supply, stemming from reduced contributions from Russia and Belarus, declining agricultural crop prices, heightened fertilizer inventories, adverse weather conditions, elevated energy prices, and the strengthened U.S. dollar against currencies of fertilizer-importing nations (Arab Potash Company, 2022).

3.2 The Jordanian Potash Industry and Its Contribution to the Jordanian Economy

The potash industry in Jordan is characterized by a singular entity, the Arab Potash Company, which holds an exclusive monopoly granted through a government concession from the Hashemite Kingdom of Jordan for a century-long period spanning from 1958 to 2058. Additionally, there exist several subsidiaries and affiliates associated with the company. The primary operations involve the extraction of salts and chemicals from the Dead Sea or the designated concession area, leading to the establishment of derivative industries. The Arab Potash Company and its affiliated entities collectively engage in the production of a diverse range of products, encompassing potash, potassium nitrate, bromine, various forms of sodium chloride, chlorine, hydrochloric acid, magnesium oxide, among others.

The company played a role in the Kingdom's economic modernization plan, contributing to the targeted growth rates of the Jordanian economy. In 2022, its payments to the Kingdom's treasury totalled 404 million Jordanian dinars, covering income tax, mining fees, road and port fees allowance, lease of concession lands, and anticipated dividends (Arab Potash Company, 2022). Through its sales, along with those of subsidiaries and affiliates, the company bolstered the Kingdom's hard currency reserves by a total of 2.39 billion US dollars in 2022. Over the past decade, the company's potash sales constituted 10% of the overall value of Jordanian national exports. By the end of the third quarter of 2022, its sales represented 13% of the value of national exports.

Moreover, the company actively engages in social responsibility initiatives by establishing training centres to enhance the qualification and skills of the workforce in Jordan. It extends support to the education sector by backing official educational institutions and contributes to the health sector. Notably, the company allocated 7 million Jordanian dinars for private spending on social responsibility endeavours in the year 2022. Furthermore, the company operates in alignment with sustainability standards, embracing principles targeted at achieving carbon emissions cessation, evaluating the influence of green technology advancements on the fertilizer sector through renewable energy, and exploring the utilization of hydrogen as an energy source.

3.3 Jordanian Potash Production and Sales in 2022

In 2022, the Arab Potash Company achieved a production volume of 2,684,000 tons, marking the highest level in the company's history since its inception. This notable achievement can be attributed to the implementation of substantial projects by the company, which played a pivotal role in enhancing production efficiency.

Table 3: Arab Potash Company's Production in 2022 by Type (ton).

Type	Quantity	Ratio
White standard potash	1,202,054	45%
White fine potash	1,140,676	42%
Red granular potash	299,230	11%
White granular potash	42,040	2%
Total	2,684,000	100

Source: APC's Annual Report 2022.

In 2022, China emerged as the leading importer of Jordanian potash, constituting 26% of the total, with subsequent positions held by India and Malaysia. The export destinations for Jordanian potash expanded to encompass the Americas, Europe, Asia, and Africa, alongside domestic sales. Notably, the Arab Potash Company successfully entered new markets, notably Brazil, introducing and selling novel varieties of red, granular, and standard potash.

Table 4: APC's Top Ten Markets Sales Distribution in 2022 (Ton).

Country	Quantity	Ratio
China	538,154	26%
India	476,125	21%
Malaysia	245,533	11%
Egypt	218,890	10%
Jordan	215,666	10%
Americas	161,533	7%
Indonesia	142,935	6%
Netherlands	87,450	4%
Finland	67,000	3%
Saudi Arabia	56,687	2%
Top Ten Total	2,209,973	100
% of Total Sales	2,620,966	

Source: APC's Annual Report 2022.

3.4 Aspects of the Competitiveness of the Potash Industry in Jordan

Despite intense global competition, including rivals with expansive production capabilities and lower costs, the Arab Potash Company navigated the 2022 world's geopolitical uncertainty, leveraging flexibility in production to meet surging potash demand and achieve unprecedented profits. Concurrently, the company focused on diversification, introducing new product varieties, including standard white potash, fine white potash, granular, and standard red potash. Sales of red potash constituted 11.9% of the company's 2022 net profits at 71.5 million dinars. Additionally, the company strategically managed production and sales costs, optimizing global shipping through transitions between bulk and container shipping and utilizing large vessels for economies of scale. Efforts to boost production volume played a key role in reducing fixed costs per ton.

The company has undertaken numerous water and energy projects as part of its strategic initiatives to optimize production costs, thereby bolstering its global competitiveness and fostering sustainable long-term growth. Moving forward, the company envisages several strategic initiatives, including a ten-year energy strategy, drilling strategy, marketing strategy, digital transformation strategy, human resources strategy, and growth strategy. Furthermore, the company is expanding its global presence by establishing representative offices in Brazil, India, and Malaysia (Arab Potash Company).

The ensuing table delineates paramount indicators instrumental in augmenting the competitive prowess of the potash industry in Jordan, exemplified through the performance of the Arab Potash Company, its subsidiaries, and affiliated entities. The focus is directed towards optimizing performance efficiency, cost reduction, and elevating product quality.

Table 5: Indicators Performance Arab Potash Company, Aspects of the Competitiveness.

Factor	Amount
The highest profit volume in the companies since the establishment of the company	601 million JD
The volume of net revenues is the highest since the establishment of the company	1.27 Billion JD
The company provided the Kingdom's treasury with foreign currencies, which is the highest since the company was established.	2.39 billion American Dollar
The company's share of the profits of the affiliate companies	95million JD
The company's sales of granular red potash	295, 000 ton

Source: APC's Annual Report 2022.

The company successfully expanded its product portfolio and accessed international markets through the exportation of products facilitated by its subsidiaries and affiliated companies, as outlined below:

Subsidiaries Companies:

1. Arab Fertilizers and Chemicals Industries (KEMAPCO) : In the fiscal year 2022, the company achieved sales totalling approximately JOD 124 million, with a net profit of around 17 million dinars.
2. Numeira Mixed Salts and Mud Company: The company engages in the extraction and utilization of raw materials sourced from the Dead Sea, involved in the manufacturing of cosmetics and personal care products.
3. The Dead Sea Chemicals and Fertilizers Company: The company is undertaking a new initiative to implement a project for the production of specialized fertilizers in the Ghor Al-Safi region.

Affiliates Companies:

1. Jordan Bromine Company (JBC): Jordan Bromine Company specializes in the production of bromine and its derivatives. The marketing of JBC's production is handled by Albemarle Holdings Limited and Arab Potash Company.
2. Jordan Industrial Ports Company (JIPC): Established as a central hub for fertilizer trade, the company integrates potash production and exports, providing maritime and land connections. Strategic initiatives have reduced shipping costs and facilitated entry into new global markets.
3. Nippon-Jordan Fertilizers Company (NJFC): It produces compound fertilizers (NPK), (MAP) and (DAP).

Table 6: Challenges, Risks, and Control Mechanisms.

Challenges and Risks	Control and Confrontation Mechanism
Geological nature of the Dead Sea region	capital investments. Increasing efficiency in the exploitation of extracted natural resources.
Increasing electricity prices and scarcity of water	Generation of electricity from solar energy and natural gas. Increase consumption efficiency and efficient water use
Environmental, social, and seasonal effects.	Applying sustainability Criteria (ESG)
Price fluctuations In Global Markets.	Penetrating new markets and diversifying products.
The demand for potash of all kinds varied in the global markets.	-Production of granular and normal red potash. - Transforming fine potash into granular.

Source: APC's Annual Report 2022.

4. Data and Methodology

The data for this study primarily derives from the annual reports of the Arab Potash Company spanning the study period from 1990 to 2022, complemented by data provided by the Central Bank of Jordan. Various econometric methods were employed to elucidate facets of competitiveness within the Jordanian potash industry. The study utilized the Cobb-Douglas production function approach to assess scale efficiency and ascertain returns to scale in the potash sector. Additionally, the research delved into the determinants of operational efficiency in the Jordanian potash industry, scrutinized the long-term equilibrium relationship between operational efficiency and its determinants, and employed an error correction model to rectify short-term deviations and restore them to their long-term equilibrium trajectory.
The study employed an ARDL to analyse operational efficiency, utilizing variables such as operating profit margin, cost-to-asset ratio, and asset benefit as determinants. The choice of the ARDL model was based on its suitability for experimental studies, considering specific characteristics that align with the research objectives:

1. Utilized to establish the long-term relationship between series exhibiting varying orders of integration, the study incorporates a combination of integration at the level and first difference. I (0), I (1).
2. It is feasible to illustrate the cointegrating vectors in situations involving multiple cointegrating vectors.
3. The estimators derived from this model exhibit unbiasedness and efficiency.
4. This model is particularly apt for small-scale and constrained sample data.
5. Pesaran, Shin, & Smith (2001) demonstrated that the ARDL model adequately addresses both residual serial correlation and endogenous regressor issues simultaneously. Hence, the ARDL model is well-suited for handling internal homogeneity, with the assumption that all variables are endogenous Nkoro & Uko (2016).

The representation of the ARDL model is as follows:

$$\Delta Yt = \alpha o + \sum_{i=1}^{m} Bi\Delta Yt - i + \sum_{i=0}^{n} \theta i\Delta Xt - i + \gamma 1\, Yt - 1 + \gamma 2Xt - 1 + \varepsilon t$$

$\gamma 1, \gamma 2$: Parameters Relationship in the Long run.
θ, β : Parameters Relationship in the short run.
Δ: $The\ first\ difference\ for\ variables.$
n,m : lag period for variables.
εt: $Error\ term.$

In contrast, this study assesses allocative efficiency within the Potash industry, utilizing profits as the dependent variable and considering total costs, exports, and production volume in million tons as explanatory variables. The research aims to ascertain the presence of a long-term equilibrium relationship between profits and their determinants for the Arab Potash Company. The analysis employs the single equation method of cointegration regression, utilizing three efficient estimation methods: Fully Modified OLS (FMOLS) , (Phillips & Hansen, 1990), Dynamic OLS (DOLS), (Saikkonen, 1992), and Canonical Co-integrating Regression (CCR), (Park, 1992). Phillips & Hansen (1990) posit the existence of a singular cointegrating vector linking all variables. Both the Engle-Granger test and the Phillips-Ouliaris test utilize residuals for testing purposes. In the case of the Engle-Granger test application (EG), the model is estimated as follows:

$\Delta \cup\hat{}\ 1t = (p-1) \cup\hat{}1t = 1 + \sum_{j=1}^{p} \delta j \Delta \cup\hat{}1t = j + \cup t$ equation (1)

$$\tau\hat{} = \frac{P\hat{} - 1}{Se(P)\hat{}}$$

$$Z\hat{} = \frac{\tau\,(P\hat{} - 1)}{1 - \sum j\delta\hat{}j}$$

Where Se (P^) is the standard error of the parameter P^

As for a test Phillips-Ouliaris (PO)), It is based on the estimation of the following model:

$\Delta \cup\hat{}1t = (P-1) \cup\hat{}\ 1t-1 + Wt$ equation (2)

5. Empirical Results and Discussion

5.1 Scale Efficiency

The measurement of scale efficiency was conducted based on the Cobb-Douglas production function.

LNQ= LN A + LNL + LN K+U

LnQ= -1.83 + 0.17 LnL + 0.22Lnk

T -0.65 0.44 3.36

Sig t 0.52 0.66 0.00

R^2= 0.34, F-Statistic= 7.58, Sig F= 0.002

The labour and capital factors contributed (0.39), indicating that a 1% change in these factors results in a 0.39% change in production. This implies a decreasing return to scale in the potash industry, where the increase in production is lower than the inputs. The cost elasticity, calculated as the reciprocal of production factor elasticities, is (2.56), signifying that a 1% increase in production leads to a 2.56% rise in costs. This outcome aligns with Moosavian's (2015) investigation of returns to scale in the mining industry in Iran, which reported a value of 0.85, indicating a state of decreasing returns to scale. While there are direct associations between production and inputs like labour and capital, the augmentation of labour may not necessarily boost production, especially for roles with consistent productivity rates like saline workers, engineers, and technicians. Additionally, the expansion of certain fixed assets, such as dams, may not directly enhance production due to the dependency of the production process on the heating and evaporation system. This situation results in a reduction in sea levels, causing water in the Salinas to rise and impeding the efficient functioning of the dams.

5.2 Measures Operation Efficiency

Operational efficiency refers to the effectiveness of profit generation in relation to operating costs. Higher operational efficiency corresponds to increased profitability or return on investment for the company. In a business context, operational efficiency signifies the capability to attain desired outcomes with minimal effort and resource wastage. It serves as an indicator of an organization's overall functioning. The primary objective of operational efficiency is to streamline operations and minimize waste, thereby enhancing the effective utilization of resources (Olarewaju & Obalade, 2015). The study aims to elucidate the factors anticipated to impact operational efficiency within the Jordanian potash industry. Additionally, it delves into examining the long-term equilibrium relationship between operational efficiency and its determinants.

5.2.1 Clarifying the Variables Used to Explain Operational Efficiency

Operational Efficiency: Operational efficiency is quantified as the ratio of total revenues to total expenses, serving as a metric for the costs incurred in a specific economic or financial undertaking. A higher ratio signifies greater efficiency due to lower costs.

Profit Margin: It evaluates the efficiency and managerial control over all cost components related to an activity. This metric is articulated as the ratio of net income to total revenues, providing an indication of cost efficiency.

Cost to revenue ratio: It is represented by the ratio of overall costs to total revenues, serving as an indicator of cost efficiency.

Assets Utility: It signifies the productivity of assets, denoting optimal asset utilization. Expressed as the ratio of total revenues to total assets, this measure conveys profit efficiency.

Table 7: Stationary test (Augmented Dickey -Fuller Test).

	First Difference				Level			
Variable	Intercept +Trend		Intercept		Intercept +Trend		Intercept	
	Sig t	t-stat	Sig t	t-stat	Sig t	t-stat	Sig t	t-stat
Efficiency (TR/Texp)	0.01	-4.118	0.000	-8.58	0.01	-4.05	0.003	-4.150
Profit Margin (PM)	0.0005	-5.47	0.0001	-5.33	0.24	-2.69	0.18	-2.29
Cost/Return (CR)	0.000	-6.64	0.000	-6.55	0.11	-3.19	0.03	-3.09
Assets Utility (AU)	0.0001	-6.01	0.000	-6.04	0.31	-2.53	0.32	-1.91

*All variables have Sig at 1%.

An ADF test was conducted to assess the presence of a unit root and prevent spurious regression. Table 7 presents the results of the unit root test. The efficiency variable is deemed stationary at a specific level when both the intercept and the intercept with trend are included in the ADF test equation. However, all explanatory factors exhibit stationarity after undergoing first-order differencing, with a significant p-value of 1 percent. These results indicate that all variables are stable and do not manifest random walk behaviour. According to Pesaran, Shin, & Smith (2001), potential co-integration is proposed among a combination of integrated variables with mixed orders (I(0) and I(1)). It is crucial to note that the concept of co-integration does not apply to I(2) or higher orders. The E-Views-12 program automatically determined the optimal number of lag periods that minimizes the Akaike Information Criterion (AIC). For model 401 in Figure 1, the optimal number of lag periods is (1,3,4,4).

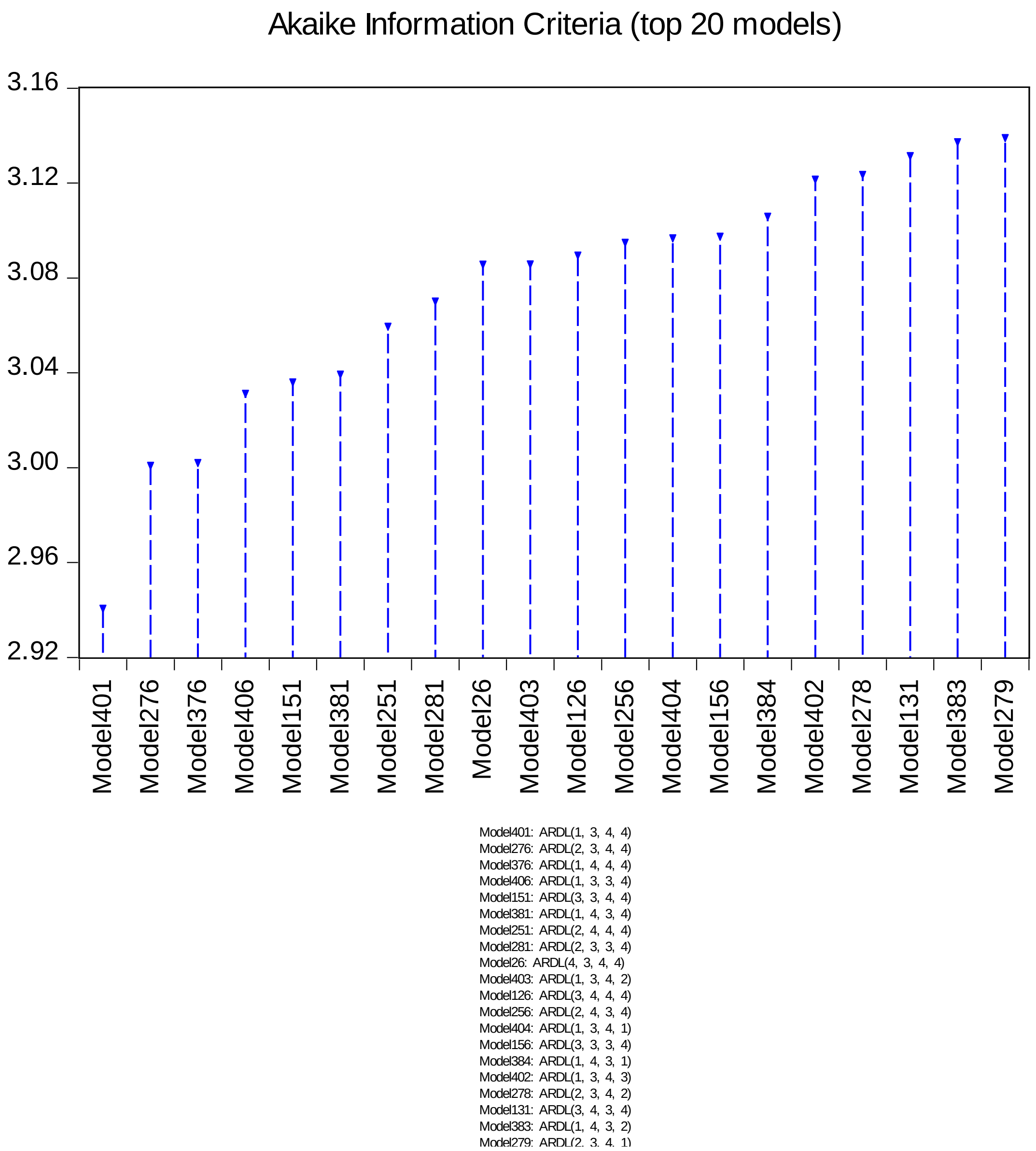

Figure 1: The Optimal Number of Lags is Determined Based on the AIC.

The ARDL co-integration boundary tests results in Table 8 show an F-statistic value of 5.02, exceeding the upper and lower threshold values at a 5% significance level. The rejection of the null hypothesis indicates a significant and stable relationship over time between efficiency and its influencing factors. Variable K in the ARDL boundary test table represents the count of explanatory variables included in the cointegrating equation, and lagged differences in the equation denote the number of time periods separating the variables.

Table 8: Boundary Tests – Co-Integration Test using (ARDL –Bound Test).

F-Bounds Test		Null Hypothesis:	No levels relationship	
Test Statistic	Value	Significant level	I(0) Lower levels	I(1)Upper Levels
F- Statistics	5.02		Asymptotic: n=1000	
k	3	10%	2.37	3.2
		5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
			Finite Sample: n=35	
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816
			Finite Sample: n=30	
		10%	2.676	3.586
		5%	3.272	4.306
		1%	4.614	5.966

Source.: E-views -12 Program

Table 9: Results of Estimating the Model Parameters in the Long Term for the (ARDL).

Variable	Coefficient	S.E	T- Statistics	Probability
Profit Margin (PM)	39.33689	12.26789	3.206493	0.0069
Cost/Revenue (CR)	32.26494	9.111462	3.541137	0.0036
Assets Utility (AU)	-9.573757	3.128247	-3.060423	0.0091
C	-22.71959	8.918639	-2.547428	0.0100

Source: E-views -12 Program

Table 9 elucidates the outcomes of estimating the long-run model parameters in the ARDL model. All coefficients exhibit statistical significance at the 1% level. The results indicate a positive long-term association between profit margin and operational efficiency, with a 1% increase in profit margin corresponding to a 39% increase in operational efficiency. The profit margin ratio reflects management's efficiency in controlling costs related to mining activities, including potash extraction and fertilizer manufacturing. Additionally, the findings reveal a positive relationship between the cost-to-revenue ratio and operational efficiency, suggesting that the Arab Potash Company will expand production and bear increasing costs in the long term. However, the company experiences diminishing returns to scale and diseconomies of scale in the long run, aligning with economic theories of cost behaviour. In contrast, the utility of assets exhibits an inverse relationship with operational efficiency, indicating that as profitability improves, the operational efficiency ratio decreases. This negative correlation can be explained by the cost structure of mining operations, where fixed costs remain relatively constant, leading to a lower operating efficiency ratio even with increased profitability. In the mining sector, prioritizing profitability over operating efficiency may result in higher total return to total assets but a lower operating efficiency ratio.

Table 10: Error Correction Model and Short Run Coefficients.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PM)	2.389573	5.596313	0.426991	0.6764
D(PM(-1))	-15.25937	5.551387	-2.748748	0.0166
D(PM(-2))	-17.79670	4.217895	-4.219331	0.0010
D(CR)	4.198918	2.386977	1.759094	0.1021
D(CR(-1))	-18.20679	3.951912	-4.607085	0.0005
D(CR(-2))	-12.98966	3.142585	-4.133430	0.0012
D(CR(-3))	-3.481951	1.590825	-2.188770	0.0475
D(AU)	-0.724742	2.322459	-0.312058	0.7599
D(AU(-1))	4.174446	2.948249	1.415907	0.1803
D(AU(-2))	1.893053	2.437822	0.776535	0.4513
D(AU(-3))	6.235654	2.263890	2.754398	0.0164
CointEq(-1)*	-0.932882	0.162810	-5.729891	0.0001
R-squared	0.817871	Mean dependent var	-0.006897	
Adjusted R-squared	0.700024	S.D. dependent var	1.445953	
S.E. of regression	0.791950	Akaike info criterion	2.664866	
Sum squared resid	10.66214	Schwarz criterion	3.230644	
Log likelihood	-26.64056	Hannan-Quinn criterion	2.842061	
Durbin-Watson stat	2.163744			

Table 10 presents the outcomes of estimating short-run coefficients and the error correction model within the ARDL framework. The model comprises twelve parameters, including twice-differenced lags (PM), third-differenced lags (CR), third-difference lags (AU), first differences of the explanatory variables, and the error correction model coefficient. Most variables exhibit statistically significant estimates, with significance levels below 5%. In contrast, D(PM), D(AU), D(AU(-1)), D(AU(-2)) demonstrate poor significance, with values exceeding 5%. The error correction coefficient parameter is negative and highly statistically significant for the studied variables, indicating the speed at which deviations in the short term adjust to return to their long-term equilibrium. The results from the short-run coefficients and the error correction model highlight the significant short-term effects of changes in the explanatory variables on operational efficiency.

5.2.2 Diagnostic Tests

Table 11: Diagnostic Tests.

Diagnostic tests	Type of test	value	P-value
Jarque -Bera	Normality test	0.3634	0.8338
Breusch-Godfrey	Serial Correlation (LM)	F-Statistics = 0.4310	0.66
		Chi-square = 2.107	0.35
Breusch-Pagan-Godfrey	Heteroskedasticity	F-statistic= 1.166	0.39
		Chi-Square=16.63	0.34
Ramsey REST-Test	Functional shape	F-statistic= 0.148589	0.71

Source: E-views -12 Program

The Diagnostic tests encompass four statistical assessments employed to scrutinize various aspects of a regression model. The Jarque-Bera test supports the null hypothesis of normality, as evidenced by the p-value exceeding the 5% significance threshold. The Breusch-Godfrey test investigates the presence of serial correlation or autocorrelation in the error terms. The test statistic for the Lagrange Multiplier (LM) in the Breusch-Godfrey test is F=0.43, with a corresponding p-value of 0.66. Additionally, the Chi-square test produces a value of 2.107. Elevated P-values suggest the absence of serial correlation in the residuals. However, the outcomes indicate the absence of heteroskedasticity, signifying that the variance of the error components varies across observations. This observation is clarified by employing the Breusch-Pagan-Godfrey test. Finally, the Ramsey RESET-Test illuminates the functional structure of the regression model, assessing whether crucial variables have been omitted. The high precision probability value for this test necessitates that the original model is accurately specified without any variables being overlooked.

5.2.3 Structural Stability Test

The structural stability assessment comprises two tests: the Cumulative Sum of Residuals Test (Cusum) and the Cumulative Sum of Residual Squares Test (CUSUMSQ). These tests ascertain whether any alterations in the data's structure occurred over time. Figures 2 and 3 illustrate that the regression line lies within the critical region's boundary lines, indicating the model's stability within a significant 5% limit. Consequently, it can be inferred from the figures that the estimated coefficients of the utilized ARDL model exhibit structural stability, thereby elucidating stability among the study variables.

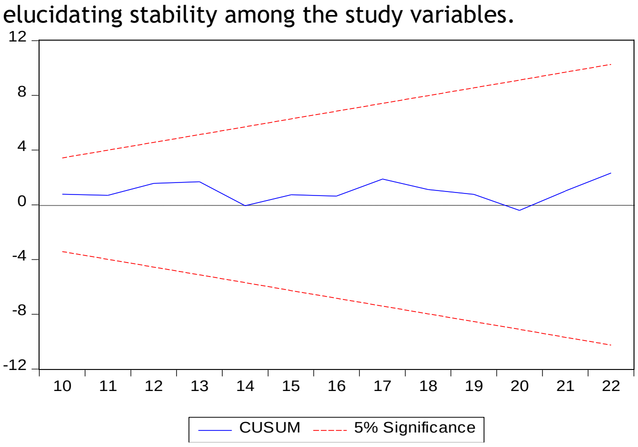

Figure 2: Structural Stability Test: Cumulative Sum of Residuals Test (Cusum).

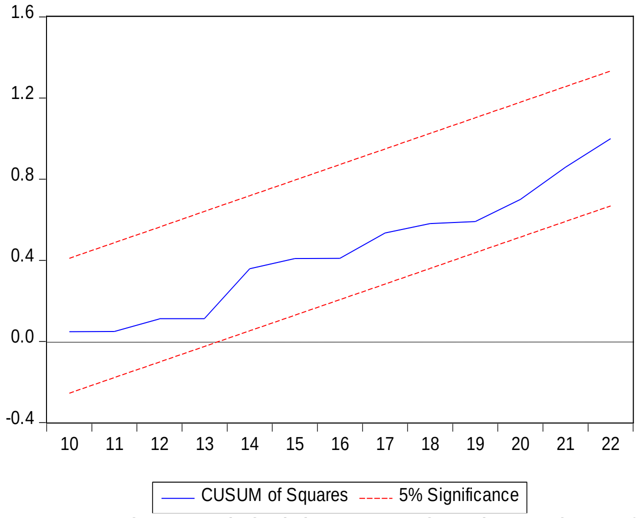

Figure 3: Structural Stability Test: Cumulative Sum of Residual Squares Test (CUSUMSQ).

5.3 Measures Determinants Allocative Efficiency

The investigation employed numerous variables to gauge the determinants of allocative efficiency. These variables encompassed the following: Net profit after tax, serving as the dependent variable measured in million dinars, and a set of explanatory variables, which included Export value (measured in million dinars), Total costs (measured in millions of dinars), and Production volume (measured in million tons).

5.3.1 Econometric Analysis Methods:

The research employed various methodologies to elucidate the determinants of allocative efficiency, which will be delineated in Table 12.

Table 12: Cointegration Regression Model Estimates Using Different Methods.

var	Method	export	cost	Q	Constant	$\tau(EG)$	Z(EG)	$\tau(PO)$	Z(PO)	R^2
	FMOLS	0.828	-0.39	-31.4	22.5	-4.8	-50.1	-4.1	-19.9	
	t- statistic	22.9	-7.5	-2.8	1.3					0.97
	Prob	0.000	0.00	0.00	0.22	0.02	0.000	0.08	0.15	
	DOLS	0.52	-0.01	-64.1	68.4	-4.8	-50.1	-4.1	-19.9	
	t-statistic	5.7	-0.13	-4.9	3.3					0.97
	Prob	0.00	0.89	0.00	0.004	0.02	0.00	0.08	0.15	
	CCR	0.68	-0.22	-37.8	33.8	-4.77	-50.1	-4.1	-19.9	
	t- statistic	7.8	-2.2	-3.1	1.7					0.95
	Prob	0.00	0.03	0.00	0.09	0.02	0.000	0.08	0.15	

Source: E-views -12 Program
EG is the Engle- Granger test for cointegration.
PO is the Phillips-Ouliaris test for Cointegration.

The findings, derived from various estimation methods such as the fully modified least squares method, the dynamic least squares method, and the CCR method, unveiled several significant relationships. Firstly, a positive direct correlation between exports and profitability emerged, reflecting the Arab Potash Company's reliance on exporting raw potash and diverse fertilizers globally. Conversely, the results underscored a negative inverse correlation between costs and profits, aligning with established economic theories. Additionally, a negative correlation between production and profits surfaced, indicating that the expansion of production leads to price declines. This inverse relationship stems from diverse factors, including the company's provision of commercial discounts to domestic and international clients for bulk purchases, competitive pressures inducing price reductions, and the operation of the law of diminishing marginal returns.

The outcomes derived from the aforementioned methodologies demonstrated that the explanatory variables exhibited statistical significance at the 1% level, with the exception of the costs parameter, which did not demonstrate statistical significance based on the DOLS method. The overall explanatory efficacy of the models proved substantial, as evidenced by the coefficient of determination and the modified coefficient of determination, both surpassing 95%. Additionally, the outcomes of the Engle-Granger (EG) and Phillips-Ouliaris (PO) tests suggested the presence of a cointegration relationship among the study variables, determined by the computation of values for τ and Z in equations (1) and (2) respectively. Although the Z (PO) test did not yield statistical significance, the (EG) and τ (PO) tests were statistically significant, implying the rejection of the hypothesis positing the absence of a long-term relationship between profitability and its determinants.

5.3.2 Granger Causality Test

Table 13 presents the outcomes of the Granger causality examination concerning the profitability of the Arab Potash Company and its scrutinized determinants: exports, total costs, and production volume. The findings indicate a neutral association between profitability and both exports and total costs. Moreover, a unidirectional causal relationship emerges from profits towards the augmentation of production volume, suggesting the company's reinvestment of profits into expanding extractive operations and production. Conversely, the results demonstrate a unidirectional causal linkage from exports to production volume, signifying that heightened export levels correspond to increased production volumes to satisfy rising export demands.

Table 13: Pairwise Granger Causality Tests (1990 2022).

Null-Hypothesis	F-Statistic	Prob.
Cost does not Granger Cause Profit	0.64030	0.5352
Profit does not Granger Cause Cost	0.92710	0.4084
Export does not Granger Cause Profit	0.86706	0.4320
Profit does not Granger Cause Export	0.72313	0.4947
Q does not Granger Cause Profit	0.89491	0.4209
Profit does not Granger Cause Q	6.84727	0.0041
Export does not Granger Cause Cost	2.83057	0.0772
Cost does not Granger Cause Export	0.85350	0.4375
Q does not Granger Cause Cost	0.63888	0.5360
Cost does not Granger Cause Q	1.99591	0.1562
Q does not Granger Cause Export	0.59154	0.5608
Export does not Granger Cause Q	8.97023	0.0011

Source: E-views -12 Program

6. Conclusion

The Jordanian economy relies heavily on the extractive sector for reducing unemployment and creating employment opportunities. This sector significantly enhances the trade balance and balance of payments by increasing export volumes and attracting foreign currency. Moreover, Jordan's extractive industry is pivotal for economic development, fostering productivity, economic efficiency, and technological advancement, thus enhancing competitiveness. Jordan ranks seventh globally in potash production, a key extractive industry alongside potassic fertilizer production. This study examines the competitiveness of Jordan's potash industry using various econometric methods, addressing the scarcity of research in this area and its global importance in agriculture and food security. The Cobb-Douglas production function, commonly utilized to assess scale efficiency in the Jordanian potash industry, indicates diminishing returns to scale owing to economies of scale and escalating costs. Employing the ARDL model, the study scrutinized factors influencing operational efficiency in the potash sector, revealing a long-term equilibrium connection between operational efficiency and its determinants. Profit margin and expense-to-revenue ratio serve as indicators of cost efficiency, while asset utilization gauges profit efficiency. Through FMOLS, DOLS, and CCR methods, the study evaluated allocation efficiency. Results delineated positive correlations between exports and profits, while production volume and expenses exhibited negative correlations with profits, elucidating elements influencing profitability in Jordan's potash industry. The Granger causality test disclosed a unidirectional causal link from profits to production and neutral causal relationships between profits and both exports and expenses. Recommendations include cost rationalization, adoption of cost-effective manufacturing techniques, reduction of expenditure associated with output expansion, and augmentation of exports by creating goods that meet international market demands.

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