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Economic and Productivity Impacts of Natural Gas in South Khorasan

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Natural gas is a critical energy source that substantially contributes to meeting national energy demand. Iran possesses the world's second-largest natural gas reserves. In South Khorasan province, natural gas coverage is extensive, reaching 100% of urban households, 99.9% of rural households, and a large proportion of industrial facilities. This study examines the effects of natural gas supply to agricultural and production centers on production efficiency and economic profitability. The research is applied and employs a descriptive–survey design with a mixed-methods approach, combining structured questionnaires and expert interviews. The sample consisted of 165 respondents from the agricultural sector and 150 respondents from the production sector. Results indicate that supplying natural gas to agricultural and production centers enhances resource utilization, reduces energy costs, improves operational efficiency, and diminishes air pollution and greenhouse gas emissions.

Keywords: *Gas supply, production efficiency, economic profit.*

1. Introduction

Energy is a primary driver of both economic development and environmental sustainability. Given its central role, reducing consumption and improving energy efficiency are essential strategies for advancing national development. Fossil fuels, particularly oil and gas, continue to play a pivotal role in satisfying global energy demand and retain strategic importance; therefore, their optimal use and the minimization of energy losses are crucial for fostering sustainable growth and long-term development (Paji et al. [9]).

Natural gas, in particular, constitutes a critical component of the national energy mix and has seen substantial increases in consumption owing to its advantages (Qian et al. [11]). Iran holds the world's second-largest natural gas reserves. In South Khorasan Province, natural gas coverage is effectively universal: 100% of urban households, 99.9% of rural households, and a substantial portion of industrial units are now connected to the gas network.

Below is a revised, more fluent and academically styled version of your passage. I preserved citations and key findings while improving cohesion, clarity, and formal tone.

A central concern in both agricultural and industrial domains is how the supply of natural gas affects production efficiency. Natural gas, characterized by relatively low emissions and favorable combustion properties, can enhance productivity by improving operational processes and energy performance. However, excessive dependence on natural gas also entails environmental risks.

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extraction, processing, and consumption activities may contribute to air pollution and the depletion of natural resources (Zhou et al. [15]).

Economically, natural gas can materially influence the viability of agricultural and industrial enterprises. As a comparatively clean and cost-effective energy source, it lowers operating expenses and raises energy efficiency, thereby strengthening profitability and long-term sustainability (Qiu et al. [12]). At the same time, adopting gas technologies often requires substantial upfront investments in infrastructure and installation, which can temporarily depress profitability for farms and industrial units. Thus, a balanced and comprehensive assessment of both the benefits and the costs of natural gas supply on production efficiency and economic viability is necessary.

Extant literature increasingly documents the positive role of gas supply in improving sectoral performance. Upgraded infrastructure and wider access to natural gas have been associated with higher output, reduced operating costs, and better energy utilization. In agriculture, gas access has been linked to enhanced crop yields, reduced dependence on more polluting fuels, and improved environmental outcomes through lower emissions and more efficient resource management. Najafabadi et al. [8] report a positive correlation between robust gas supply networks and agricultural productivity. In industry, Brown et al. [2] show that gas-enabled technological improvements accelerate production, reduce downtime, and increase operational efficiency. Fu et al. [4] further identify infrastructure reliability, technological integration, and process compatibility as critical determinants of productivity in gas-supplied settings.

From an economic standpoint, Povellato et al. [10] demonstrate that efficient gas utilization significantly reduces operational costs and enhances financial resilience within the agricultural sector. Gerarden et al. [5] highlight the returns on investment from gas infrastructure, documenting cases of marked profitability improvements. At the macro level, Ayres et al. [1] provide evidence of broader economic benefits, employment generation, income growth, and contributions to national development, stemming from expanded gas supply to agricultural and manufacturing sectors.

In sum, while natural gas offers substantial operational, environmental, and economic advantages, policy and investment decisions should account for associated environmental risks and the capital intensity of infrastructure deployment. Rigorous, context-specific evaluations are required to identify strategies that maximize productivity and sustainability while mitigating adverse impacts.

In addition, comparative studies focusing on gas supply to agricultural and industrial centers across China, Russia, the United States, Nigeria, and India have yielded valuable insights into the diverse effects of natural gas utilization. These studies explore how gas access influences production efficiency, cost optimization, and broader economic outcomes. A summary of these investigations, highlighting their primary objectives and findings, is presented below.

- **Infrastructure Development–China:** China's expansive gas infrastructure has significantly enhanced agricultural efficiency, underscoring the role of modern energy systems in boosting productivity (Zhang et al. [14]).
- **Resilience Enhancement–Russia:** In regions with severe climatic conditions, natural gas plays a crucial role in meeting agricultural energy demands, highlighting its strategic importance for ensuring food security (Dzyuba et al. [3]).
- **Sustainability Alignment–United States:** The United States is integrating natural gas into its agricultural practices to support sustainability objectives, emphasizing the synergy between energy efficiency and environmental stewardship (Haggerty et al. [6]).
- **Environmental Commitment–Nigeria:** Nigeria's emphasis on cleaner gas alternatives reflects its dedication to international environmental standards and sustainable development goals (Umeh et al. [13]).
- **Technological Integration–India:** India's adoption of advanced technologies for gas distribution in agriculture illustrates the transformative potential of innovation in achieving sustainable energy use (Haggerty et al. [6]).

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The remainder of this article is structured as follows: Section 2 outlines the research methodology; Section 3 presents the findings; and Section 4 offers a discussion of the results and concluding remarks.

2. Research method

This study utilized a library-based approach to collect information from both printed and electronic scientific sources. Complementary statistical data were obtained via a structured questionnaire; the instrument's specifications are described below.

Questionnaire design and administration

- Purpose: To assess the effect of natural gas supply on production centers with respect to production efficiency and economic profitability. A corresponding instrument was developed to evaluate these same dimensions in agricultural centers.
- Structure: Each questionnaire comprised 33 items organized into the two principal constructs—production efficiency and economic profit.
- Response scale: Items were rated on a five-point Likert scale (1 = Strongly disagree to 5 = Strongly agree).
- Data collection: The questionnaires were administered to respondents in the relevant sectors

To assess the reliability of the instruments, Cronbach's alpha and composite reliability indices were calculated. The results, summarized in Table 1, indicate high internal consistency across all components:

Table 1. Reliability Results of the Questionnaires

Component Description	**Cronbach's Alpha**	**Composite Reliability**
Increasing Production Efficiency (Agricultural Centers)	0.94	0.95
Enhancing Economic Profit (Agricultural Centers)	0.89	0.91
Increasing Production Efficiency (Production Centers)	0.96	0.96
Enhancing Economic Profit (Production Centers)	0.93	0.95

Based on the results of Table 1, the questionnaire demonstrated excellent internal consistency across all measured constructs. Cronbach's alpha coefficients ranged from 0.89 to 0.96, well above the conventional threshold of 0.70, indicating that each item set reliably captures its intended dimension. The highest reliability was observed for the "Increasing Production Efficiency (Production Centers)" construct ($\alpha = 0.96$), reflecting near-perfect item homogeneity.

Composite Reliability (CR) values, which ranged from 0.91 to 0.96, corroborated the Cronbach's alpha results and further supported the precision and stability of the measurement model. The close correspondence between Cronbach's alpha and CR across constructs suggests minimal measurement error and strong construct reliability and validity. These findings indicate that the instrument is suitably calibrated for inferential analyses of the effects of natural gas supply on economic and operational outcomes. Moreover, the uniformly high reliability across both agricultural and production questionnaires supports valid sectoral comparisons.

In collaboration with the South Khorasan Gas Company, the study targeted manufacturing and agricultural enterprises in South Khorasan Province that had access to natural gas. Official records identified 252 manufacturing companies and 292 agricultural companies as the population frame.

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Using Morgan's sampling table, a representative sample was drawn: 150 manufacturing firms and 165 agricultural firms completed the questionnaire. Data were collected via an online survey platform to enhance accessibility and data-collection efficiency.

3. Computational Results

The demographic information of the study sample is summarized as follows. Within the agricultural sector, 41.2% of respondents were aged between 30 and 40 years, while 58.8% were over 40 years old. The majority of participants held a master's degree or higher, indicating a well-educated respondent base. Additionally, 80.6% of the participants were male. The frequency distribution of respondents based on work experience is detailed in Table 2.

Table 2. Frequency Distribution of Demographic Characteristics in the Production Sector by Work Experience

Work Experience	Frequency	Percentage
Less than 5 years	6	3.6%
5 to 10 years	72	43.6%
10 to 25 years	49	29.7%
More than 25 years	38	23%
Total	165	100%

In the production sector, 44% of participants were aged between 30 and 40 years, while 56% were over 40 years old. The majority of respondents held a bachelor's degree, and 88% were male. The distribution of participants based on work experience is presented in Table 3.

Table 3. Frequency Distribution of Demographic Characteristics in the Production Sector by Work Experience

Work Experience	Frequency	Percentage
Less than 5 years	6	4%
5 to 10 years	54	36%
10 to 25 years	30	20%
More than 25 years	60	40%
Total	150	100%

The central hypothesis of this study posits that the supply of natural gas to agricultural and production centers contributes to improved operational conditions within these sectors. To evaluate this hypothesis, a one-sample t-test was employed, comparing the observed mean values against a benchmark value of 3.67. As shown in Table 4, the significance level (p-value) is less than 0.05, and the calculated mean values exceed the reference threshold of 3.67. These results indicate a statistically significant improvement, thereby supporting the hypothesis that gas supply positively influences the condition of agricultural and production centers.

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The primary hypothesis of this study asserts that the supply of natural gas to agricultural and production centers leads to improved operational conditions in these sectors. To evaluate this claim, a one-sample t-test was conducted, comparing the observed mean values against a benchmark value of 3.67.

Table 4. One-Sample t-Test Results for the Main Hypothesis

Sector	Mean	Standard Deviation	t-Statistic	Significance Level (p-value)
Agricultural Sector	4.16	0.50	12.49	0.000
Production Sector	3.84	0.72	2.89	0.005

The significance levels of the one-sample t-tests conducted for each of the study's subsidiary hypotheses are summarized in Table 5. As indicated, the highest mean value pertains to the component addressing changes in energy usage and the reduction of energy costs within the agricultural sector. Conversely, the lowest mean is associated with production growth in manufacturing and industrial centers.

Table 5. One-Sample t-Test Results for Research Variables

Variable	Mean	Standard Deviation	t-Statistic	Significance Level (p-value)
Agricultural production efficiency	4.21	0.48	14.51	0.000
Production efficiency of the manufacturing sector	3.89	0.71	3.87	0.000
Economic profit of the agricultural sector	3.97	0.64	6	0.000
Economic profit of the manufacturing sector	3.70	0.8	2.88	0.003
Agricultural production growth	4.17	0.52	12.18	0.000
Production growth of the manufacturing sector	3.88	0.72	3.62	0.000
Changes in energy use and reduction of energy costs in the agricultural sector	4.46	0.51	19.72	0.000
Changes in energy use and reduction of energy costs in the manufacturing sector	4.05	0.83	5.58	0.000
Environmental impacts of the agricultural sector	4.19	0.48	13.93	0.000
Environmental impacts of the manufacturing sector	3.86	0.69	3.52	0.001
Economic impacts on livestock production and animal husbandry in the agricultural sector	3.96	3.61	6.08	0.000

Based on the results presented in Table 5, the following conclusions can be drawn regarding the subsidiary hypotheses:

- The supply of natural gas to agricultural and production centers contributes to increased production efficiency.
- Gas supply enhances economic profitability across both sectors.

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- Access to gas infrastructure stimulates production growth in manufacturing and agricultural domains.
- Gas supply leads to changes in energy consumption patterns and reduces energy-related costs.
- The use of natural gas has positive environmental implications, including reductions in air pollution and greenhouse gas emissions.
- In agricultural contexts, gas supply positively influences economic outcomes in livestock production and animal husbandry.

4. Discussion and Conclusion

The supply of natural gas affects production efficiency both directly and indirectly. Modernizing gas infrastructure and ensuring reliable delivery to machinery and equipment improve operational performance and, consequently, production efficiency. Efficient transmission systems also reduce energy losses and lower energy costs, further supporting productivity gains. Environmental benefits accompany these economic and operational advantages. Substituting cleaner, lower-emission gases for conventional fossil fuels reduces air pollution and greenhouse gas emissions, which in turn fosters more sustainable and efficient production processes. In agriculture, access to natural gas increases output and productivity, decreases operating costs, and promotes environmental sustainability. Together, these effects enhance farm profitability and enable more efficient use of natural resources and energy inputs.

Statistical analysis in this study indicates that natural gas supply positively influences production efficiency, economic profitability, energy cost reduction, and environmental outcomes in both agricultural and manufacturing sectors. The greatest impact was found on reducing energy costs in agriculture, while the smallest impact concerned production growth in manufacturing.

The study was limited to South Khorasan province; despite a representative sample, results may not generalize to other regions or industries. Moreover, reliance on self-reported questionnaire data may introduce response bias.

Future studies should cover additional provinces and industrial sectors to assess generalizability. Policymakers should prioritize investment in modern gas infrastructure and transmission networks to realize efficiency gains. Integrating renewable energy with natural gas systems could further improve sustainability and reduce environmental risks.

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