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Effects of International Barriers and Limitations on Natural Gas Production in Iran

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ABSTRACT

The enforced international limitations and sanctions against Iran have affected all stages of natural gas extraction from gas reservoirs. In this study, the effects of various situations on natural gas extraction from the Iranian operating oil reservoirs have been examined. Thus, this study aimed to study the role and effects of imposed international sanctions on Iran's gas extraction and production. Outcome of the study provides appropriate solutions to recognize such situation and cope with the resulting circumstances. Regarding methodology of the research, quantitative data were collected and analyzed by using the statistical panel model. Results show that gas extraction from natural gas reservoirs has been decreased significantly in the period of international sanctions and limitations were imposed. To achieve the previous desired gas extraction level according to the initial developing plans and the existing potentials as well as to be able to cope with hardship of international circumstances, it is necessary to improve implementation system of the respective projects, attain technological knowledge and take serious steps towards resilient economy to enhance the domestic abilities through knowledge-based advancement especially in producing strategic equipment and goods required by such a large scale projects while the existing internal rules and regulations should be reformed and be more flexible.

1. Introduction

Iran has the fourth and the second rank in the world in terms of oil and gas reservoirs, respectively. Moreover, the oil industry of Iran having more than hundred years history is a huge and vastly developed industry. The Ministry of Petroleum (MoP) is authority of all the affairs related to the oil, gas and petrochemical issues (including: exploration, exploitation, refining, maintenance, distribution, import, export, etc.). It is obvious that such a large and complicated organization with many different responsibilities and duties at the national and international levels requires very exact and precise action plans to develop its programs, meet the growing needs of the oil and gas industry, and help the economy of Iran. It had been decided

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that the country should become the leader producer and exporter of natural gas which could redefine the economy and play a determining role in the global energy landscape.

The sanctions imposed to Iran put it in difficult situation and caused many problems such as being prohibited from energy exports and money transfers and not coming the foreign vessels to the Iranian ports. One of the major effects was that big and famous companies, particularly, those dominant and key players in the oil and gas industry refused to sign contracts in order to invest and operate in the Iranian oil and gas industry. In the next sections of the paper, we will discuss oil and gas projects of Iran and will review and analyze the consequences of the international limitations and sanctions.

2. Background of the Research

The Energy Information Administration (EIA) has issued its report on 19th June 2015 and mentioned: "… Iran holds the world's fourth-largest proven crude oil reserves and the world's second-largest natural gas reserves as well. Despite the country's abundant reserves, Iran's crude oil production has been substantially declined, and the growth of natural gas production has been slower than expected values over the past few years. International sanctions have profoundly affected Iran's energy sector and have prompted a number of cancellations or delays of upstream oil and gas projects".

With a storage volume of 27 trillion cubic meters, Iran has the first rank in the gas reservoirs among the global gas reservoirs in terms of the natural gas volume. These reserves may be often found in gas reservoirs, oil caps, or together with oil in the oil fields. The South Pars Gas Reservoir is the largest gas reservoir of Iran having an in-situ storage of approximately 507 trillion cubic feet including Qatar share (North Dome). Nearly one third of Iran's total gas storage is accumulated in this extra huge reservoir.

The major gas reservoirs of Iran are as follows:

3. Southern Gas Reservoirs:

3.1 Aghar Gas Field (AGF)

This field is located in the southeast of Shiraz in Fars Province, Iran. Discovered in 1972, Aghar Gas Field (AGF) has 16 wells, of which 13 ones are productive. Gas production at AGF has been initiated since 1998. The natural gas and its condensate are transmitted for processing through two separate pipelines (90 km length) to Farashband Gas Refinery.

Moreover, AGF is equipped with wellhead facilities, four gas recovery centers, flow pipeline transmitting gas from wells to central facilities and finally to Farashband Gas Refinery. There is also a recovery and separation center including a slug catcher, two-phase and three-phase node separators, control room, pumping stations and pigging systems. The daily production capacity of AGF is 95.22 million cubic meters of natural gas. This field also produces 4,300 barrels of condensate per day.

3.2 South Pars Gas Field (SPGF)

South Pars Gas Field is the world's largest gas field. This field covers an area of 9,700 square kilometers, of which 3,700 square kilometers is in Iranian territorial waters, while 6,000 square kilometers is in the Qatari territorial waters. The volume of recoverable gas along with natural gas condensate at SPGF is equivalent to 230 billion barrels of crude oil. The Iranian section holds 13.3 trillion cubic meters of in-situ gas as well as 19 billion barrels of gas condensates containing approximately 50% of Iranian gas reserves and 8% of world gas reserves. Moreover, the dry gas recoverable in the Iranian sector amounts to 8.1 trillion cubic meters.

3.3 North Pars Gas Field (NPGF)

North Pars Gas Field is located 4,000 meters below seabed covering an area of 21×19 square kilometers. NPGF is dome-shaped with a gentle slope less than 20 degrees. NPGF's reserves hold about 59 trillion cubic feet, of which 72% has been located in the upper reservoir known as Kangan and Upper Dalan, while the remaining 28% is in the lower reservoir known as Lower Dalan. There have so far been 17 wells and 26 offshore platforms installed in NPGF. The study and development plan have estimated the production of 3,600 million cubic feet per day of dehydrated sour gas in four 900-million-cubic-feet phases feeding LNG plants by as much as 20 million tons per year.

3.4 Sarkhun Gas Field (SGF)

This field is located in Hormozgan Province, averagely, have 75.27 km long and 5.7 km wide. 17 wells have been excavated at SGF, of which 16 are currently in operation.

The gas products from SGF are transmitted to Sarkhun Gas Refinery for processing goals and to south-eastern provinces for domestic and industrial consumption as well as gas plants. The daily production capacity of SGF is about to 15.2 million cubic meters of gas and 11,490 barrels of natural gas condensate. At the moment, three wells have been completely excavated and are ready for extractions.

3.5 Ferdowsi Gas Field (FGF)

This gas field is located in Bushehr and Persian Gulf offshore. So far, many developmental operations have been done in FGF.

3.6 Farzad Gas Field (A)

Farzad Gas Field is one of the Iranian gas fields located along with several other gas fields in the Iranian block of Persian Gulf. So far, many developmental operations have been done in this field.

3.7 Farzad Gas Field (B)

Farzad Gas Field (B) is one of the Iranian gas fields discovered in 2012. The production of natural gas and gas condensate has been initiated since 2013. The volume of reserves in FGF (B) is about to 21.7 trillion cubic feet, of which about 60% is recoverable. The field's production capacity is about 1.1 billion cubic feet per day.

4. West Gas Fields:

4.1 Tange Bijar Gas Field (TBGF)

TBGF is located in Ilam Province. The processing capacity of fluid separation center is 7 million cubic meters of gas per day at the first phase.

The first phase of TBGF was initiated with a daily capacity of seven million cubic meters of gas. In the first phase, the facility is equipped with five wells, central Tangebijar Central Facility (TCF) and flow pipelines from wells toward facilities, power systems including emergency batteries, medium voltage switchgear, low voltage switchgear and two power stations. Accordingly, two gas pipelines with a total length of 43 km and condensate pipelines with a total length of 43 km transmit the products from the recovery center to Ilam Gas Refinery. The power transmission lines, telecommunications lines, and power network are serving to all construction and operation facilities. After the processing stage, the TCF gas is transmitted to Ilam Separation Center through an 18 inch pipeline, and then to Ilam Gas Refinery. Similarly, the natural gas condensate is transmitted to Ilam Refinery through a 6 inch pipeline.

5. Central Gas Fields:

5.1 Sarajeh Gas Field (SGF)

Sarajeh Gas Field is located on 40 km far from south-east of Qom, 140 kilometers far from Tehran. SGF has 9 wells.

6. North and Northeast Gas Field

6.1 Khangiran Gas Field (KGF)

Khangiran Gas Field is an Iranian gas field located 25 km northwest of Sarakhs and 180 km northeast of Mashhad.

6.2 Gonbadli Gas Field (GGF)

Gonbadli Shared Gas Field has a daily production capacity of 700 thousand cubic meters of sweet gas. This field is commonly operated with Turkmenistan at a distance of 25 km southwest of Sarakhs near Turkmenistan border. The exploration of the first well at GGF dates back to 1969, which didn't lead to natural gas discovery. In the next excavations in 1981, the gas reserves was discovered at GGF. Finally, the operation of this shared reservoir has been initiated since 1986 by Iran-Turkmenistan. By possessing about 13 independent and 6 shared reservoirs of the 35 reservoirs discovered in the Persian Gulf, Iran has a considerable portion of marine resources. Iran shares Forouzan, Arash, Salman, Hengam, Mobarak, Esfandiar and the large South Pars reservoirs with Persian Gulf countries and has not been able to deservedly utilize these shared reservoirs so far and gain its right in the utilization of these reservoirs.

Although Iran benefits largely from various oil and gas fields, but could not have been utilizing effectively and efficiently from such resources because of lack of knowledge, technology and sufficient fund. International

limitations and sanctions restricted getting access to these requirements and made the situation more complicated resulting to wasting of resources, as Albawaba News on 9th May 2016 reported that "… Under-Deputy Oil Minister of Iran told in a meeting in Tehran that the country loses at least 28 million cubic meters of natural gas flowing alongside extracted crude in oilfields." This amount is approximately 3.5 billion dollars in waste of money each year…". Below, the facts and figures of natural gas flaring countries have been shown.

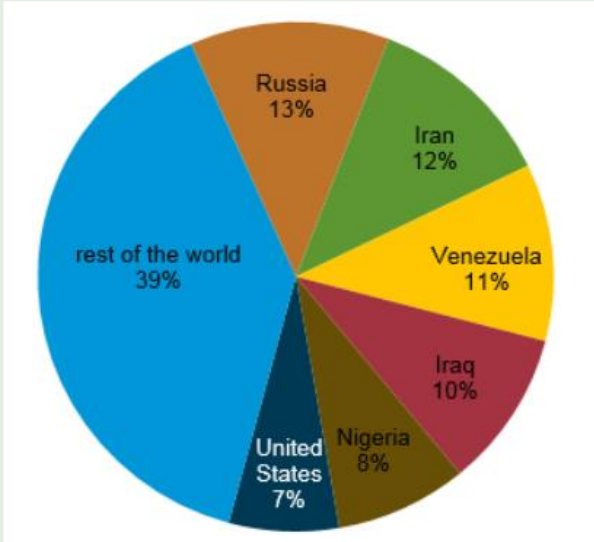

Fig1: world's top five natural gas flaring countries (2014). Source: US Energy Information Administration, based on Cedigaz and OPEC annual statistical bulletin (2015).

7. Statement of the Problem

Whereas international circumstances can affect all implementation stages of gas extraction projects from the Iranian gas reservoirs, this paper aims to investigate the effect of these various situations on gas extraction in a specific period of time and provide suitable solutions to deal with such circumstances and similar ones. The reason lies in the fact that identifying this effect can prevent the wasting of limited resources and optimize the consumption and sale of the produced gas while the final implementation cost of such projects and other similar ones can be minimized. The optimal implementation of the respective projects prevents the imposing extra costs. Use of research results in other similar projects constitutes the rationale for this research. The fundamental question will be examined in this study within the framework of a suitable hypothesis is as follows: Is there any significant relationship between natural gas extraction from gas reservoirs of Iran and international circumstances of the respective period of time? To do so, the main hypothesis is posed as follows and it is analyzed afterward: "Natural gas extraction from Iranian gas reservoirs at the time of international sanctions is significantly less than its value at the time when there is no sanction".

8. Literature Review

The failure of financial markets and the international banking system have overshadowed the global economy. No rule or regulation of the global banking system could determine and modify the defects and problems of financial markets. Some banks were not willing to give loans to high-risk and risky companies according to the Second Basel Accord and were sought to maintain no-risk assets heightening the financial crisis, itself. The crisis demonstrated that financial regulations involve defects. That is why the Third Basel Accord was developed and implemented in 2013. Will this accord prevent another financial crisis like that of 2008? How will this accord affect the financial markets and the financing of oil projects? After the 2008 crisis, financial markets faced with a shortage of money supply and the difference between the loan rate and deposit rate were increased indicating the crisis. Broad and Javadi (2009) addressed performance measuring challenges and limitations surrounding a system. The shortage of money supply in the financial market and its effect on economic growth and the failure of the commodity market resulted in a decreased money supply in the oil and gas section. However, this section could overcome this problem due to its powerful aggregate balance (Derakhshanno, 2014).

Oil and gas companies could invest in bond and stock markets because such sectors can benefit the strong support of Chinese demand along with other emerging markets (Bagheri, 2011). The oil and gas section published 200 billion dollars of bonds in 2009. The balance sheet and turnover of the oil and gas industry is in very favorable circumstances after increasing prices in the commodity market and the demands of non-industrial countries. This situation allows industry to be more prepared for absorbing capital compared with other sections.

The projects undertaken by international and national companies in the oil and gas industry require a

huge amount of capital from various markets. Despite the fact that industry needs this amount of capital, the capital and money supply of the banks may become limited leading to increased cost of capital. High and roughly stable price of the oil and gas, which are supported by ever increasing demand of the emerging markets is a factor for absorbing of capital by the oil and gas industry (Hausman, 2013).

New financial regulations affect the banks profoundly; however, they have low effect on the oil and gas industry (Nguyen and Bhatti, 2012). The oil and gas industry section is in enviable circumstances, but we should not think that we passed all threats. The brittle global economy as well as the debts of Western governments and their poor economy are still threats to future. Therefore, it can be concluded that the high profit margin of the oil and gas industry is so high to overcome over crises easily and absorb the capitals toward itself.

Hafbauer and Schott[1] (2012) started to work on economic sanctions since late 1970s. The outcome of their work during 25 years has been published in the third edition of the book "Economic Sanctions Reconsidered". Hafbauer, Schott, Elliott and Oegg (2007) have studied the history of more than 100 years of economic sanctions. In addition to publishing this book, they directly reflected their opinions to the US government and congress in certain cases by gathering information pertaining to 174 sanctions in the 20th century. They have also conducted interviews regarding the economic sanctions of Iran.

Dorri and Hamzei (2010) conducted a case study on North Azadegan Oil Field using AND technique. They investigated risk management for adopting a proper solution in project management in order to confront the risks and incidents occurring in an industrial project. In this research, the main project risk was determined by using Arena software as the risk of existing limitations in the supply of goods and equipment. The "cash payment" strategy was also specified by Super Decision software and the pair comparisons pertaining to the developed model as the best strategy to deal with the main risk.

Mirmoghadam and Ghazinoory (2017) identified elements in the institutional setting affecting technological learning outcomes in large socio - technical systems. They did a field study and used empirical evidence from oil and gas industry of Iran. They discovered that institutional regime of this section jeopardizes technological learning scenarios through four overarching aspects: Cost, Time, Risk and Management structure called "CTRM square".

9. International Limitations and Sanctions against Iran

The UN Security Council has imposed four rounds of sanctions against Iran subsequently in 2006, 2007, 2008 and 2010. The UN Security Council approved Resolution 1696 on July 31, 2006, to set the first round of sanctions against the Islamic Republic of Iran under Article 40 of the UN Charter against the peaceful nuclear activities of the Islamic Republic of Iran. These sanctions covered sensitive nuclear materials and froze the assets of Iranian natural and legal entities associated with the nuclear program.

Paragraph 5 of the draft resolution states: "[The UN Security Council] Calls upon all States, in accordance with their national legal authorities and legislation and consistent with international law, to exercise vigilance and prevent the transfer of any items, materials, goods and technology that could contribute to Iran's enrichment-related and reprocessing activities and ballistic missile programmes".

In line with the first round of sanctions against Iran, the Security Council adopted Resolution 1737 on December 27, 2006, against the peaceful nuclear activities of the Islamic Republic of Iran. Paragraph 3 of this resolution states: "[The UN Security Council] Decides that all States shall take the necessary measures to prevent the supply, sale or transfer directly or indirectly from their territories, or by their nationals or using their flag vessels or aircraft to, or for the use in or benefit of, Iran, and whether or not originating in their territories, of all items, materials, equipment, goods and technology which could contribute to Iran's enrichment-related, reprocessing or heavy water-related activities, or to the development of nuclear weapon delivery systems, weapon delivery systems".

Moreover, Paragraph 12 of resolution states: "[The UN Security Council] Decides that all States shall freeze the funds, other financial assets and economic resources which are on their territories at the date of adoption of this resolution or at any time thereafter, that are owned or controlled by the persons or entities designated in the Annex, as well as those of additional persons or entities designated by the Security Council or by the Committee as being engaged in, directly associated with or providing support for Iran's proliferation sensitive nuclear activities or the development of nuclear weapon delivery systems, or by persons or entities acting on their behalf or at their

[1] The two experts of the US Secretary of the Treasury (as one of the two departments responsible for dealing with economic sanctions together with the US Department of State).

direction, or by entities owned or controlled by them, including through illicit means, and that the measures in this paragraph shall cease to apply in respect of such persons or entities if, and at such time as, the Security Council or the Committee removes them from the Annex, and decides further that all States shall ensure that any funds, financial assets or economic resources are prevented from being made available by their nationals or by any persons or entities within their territories, to or for the benefit of these persons and entities".

According to Paragraph 17, all States were requested to exercise vigilance and prevent specialized teaching or training of Iranian nationals, within their territories or by their nationals, of disciplines which would contribute to Iran's proliferation-sensitive nuclear activities and development of nuclear weapon delivery systems.

The Security Council adopted Resolution 1747 on March 24, 2007, against the peaceful nuclear activities of the Islamic Republic of Iran and the second round of sanctions initiated targeting new weapons and financial sanctions. This period of sanctions against Iran aimed at freezing assets owned by over 28 natural and legal entities involved in supporting sensitive nuclear activity or development of ballistic missiles.

Paragraph 6 calls upon all States to exercise vigilance and restraint in the supply, sale or transfer directly or indirectly from their territories or by their nationals or using their flag vessels or aircraft of any battle tanks, armored combat vehicles, large-caliber artillery systems, combat aircraft, attack helicopters, warships, missiles or missile systems as defined for the purpose of the United Nations Register on Conventional Arms to Iran, and in the provision to Iran of any technical assistance or training, financial assistance, investment, brokering or other services, and the transfer of financial resources or services, related to the supply, sale, transfer, manufacture or use of such items in order to prevent a destabilizing accumulation of arms. In Paragraph 17, all states and international financial institutions are requested not to enter into new commitments for donations, financial assistance and concessional loans to the Government of Islamic Republic of Iran.

The Security Council adopted the third round of economic sanctions against the peaceful nuclear activities of the Islamic Republic of Iran on March 3, 2008. This resolution intensified the travel and financial restrictions on naturals and companies. These sanctions extended the partial ban on trading items either civilian or military used to cover the sale of nuclear technology to Iran.

Paragraph 9 calls upon all States to exercise vigilance in entering into new commitments for public provided financial support for trade with Iran, including the granting of export credits, guarantees or insurance, to their nationals or entities involved in such trade, in order to avoid such financial support contributing to the proliferation-sensitive nuclear activities, or to the development of nuclear weapon delivery systems, as referred to in resolution 1737 (2006).

In Paragraph 10, all States are asked to exercise vigilance over the activities of financial institutions in their territories with all banks domiciled in Iran, in particular with Melli Bank and Saderat Bank, and their branches and subsidiaries abroad, in order to avoid such activities contributing to the proliferation-sensitive nuclear activities, or to the development of nuclear weapon delivery systems, as referred to in resolution 1737 (2006).

According to Paragraph 11, all States are asked, in accordance with their national legal authorities and legislation and consistent with international law, in particular the law of the sea and relevant international civil aviation agreements, to inspect the cargoes to and from Iran, of aircraft and vessels, at their airports and seaports, owned or operated by Iran Air Cargo and Islamic Republic of Iran Shipping Line, provided there are reasonable grounds to believe that the aircraft or vessel is transporting goods prohibited under this resolution or resolution 1737 (2006) or resolution 1747 (2007).

Following the third round of sanctions against Iran, the Security Council approved Resolution 1835 on September 27, 2008, against the peaceful nuclear activities of the Islamic Republic of Iran. Containing four Paragraphs, this resolution only stressed the previous resolutions.

The Security Council adopted Resolution 1929 on June 9, 2010, against the peaceful nuclear activities of the Islamic Republic of Iran. Regarding the fourth round of Security Council sanctions, this resolution calls for measures against new Iranian banks abroad suspected in connection with the Iranian nuclear and missile programs. The UN arms embargoes against Iran extended by putting on the black list three companies affiliated to Islamic Republic of Iran Shipping Line (IRISL) and Army of the Guardians of the Islamic Revolution (AGIR).

According to Paragraph 8, the Security Council "Decides that all States shall prevent the direct or indirect supply, sale or transfer to Iran, from or through their territories or by their nationals or individuals subject to their jurisdiction, or using their flag vessels or aircraft, and whether or not originating in their territories, of any battle tanks,

armored combat vehicles, large-caliber artillery systems, combat aircraft, attack helicopters, warships, missiles or missile systems as defined for the purpose of the United Nations Register of Conventional Arms, or related material, including spare parts, or items as determined by the Security Council or the Committee established pursuant to resolution 1737 (2006). The Security Council "decides further that all States shall prevent the provision to Iran by their nationals or from or through their territories of technical training, financial resources or services, advice, other services or assistance related to the supply, sale, transfer, provision, manufacture, maintenance or use of such arms and related material, and, in this context, calls upon all States to exercise vigilance and restraint over the supply, sale, transfer, provision, manufacturing and use of all other arms and related material".

In Paragraph 23, Security Council "calls upon States to take appropriate measures that prohibit in their territories the opening of new branches, subsidiaries, or representative offices of Iranian banks, and also that prohibit Iranian banks from establishing new joint ventures, taking an ownership interest in or establishing or maintaining correspondent relationships with banks in their jurisdiction to prevent the provision of financial services if they have information that provides reasonable grounds for believing that these activities could contribute to Iran's proliferation-sensitive nuclear activities or the development of nuclear weapon delivery systems.

In Paragraph 24, the Security Council "calls upon States to take appropriate measures that prohibits financial institutions within their territories or under their jurisdiction from opening representative offices or subsidiaries or banking accounts in Iran if they have information that provides reasonable grounds for believing that such financial services could contribute to Iran's proliferation-sensitive nuclear activities or the development of nuclear weapon delivery systems."

On January 23, 2012, the European Union urgently banned any new contracts to be signed to import, purchase or transport of Iranian crude oil and petroleum products. However, the EU members can, in their discretion, purchase oil and petroleum products from Iran until July 2012. The EU officials agreed to freeze the assets of Iranian Central Bank as well as to ban the trade of gold and other precious metals with Iranian banks and state-run institutions.

It should also be mentioned that after the Islamic Revolution in 1975, there have always been different types of pressures and sanctions on Iran, particularly on behalf of the US. The above mentioned studies and articles historically and empirically show how international limitations and sanctions targeted and affected Iran's economy and technology, especially the oil and gas industry.

10. Theoretical Foundation

Economic sanction is an instrument which the sanctioning countries try to affect the policies of the under sanction country compelling it to accept their demands by exerting economic pressure (Economic Sanctions Reconsidered, Hafbauer and Schott, 2012) and Derakhshanno (2011). Economic sanction is oftentimes considered as substitute for war and military force. What is denoted by economic ties is all types of economic relationships including commercial and financial ones. Different countries make use of limited economic sanctions for their political purposes against target countries. However, this type of sanction has generally had little effect. Comprehensive sanctions by international organizations have also been rarely imposed.

From the viewpoint of international trade principles, any sanction is deemed as an imperative intervention in free trade and causes "trade distortion," which involves certain costs imposed often on both parties. Prohibition of import or export to a country makes the import and export more expensive. That is why it is said that sanction imposers aim to increase trade costs and create trade deviation in the target country. However, the cost of sanction differs depending on the countries involved and the section on which sanction is being imposed.

In financial sanctions, the sanction imposing country refuse financial transactions, transfer of money and investment. It also exercises influence on international financial institutions to disrupt any financial relationships or technical assistance or even attempts to freeze the assets of the target country. The effectiveness of unilateral sanctions is usually insignificant unless the imposer is economically more powerful than the target country and there is a tight interdependence between two countries.

There was a total of 176 target countries banned by other countries from 1914 to 1990. According to estimations, however, 66% of cases, the sanction-imposing countries never achieved their goals, and only 34% were reasonably successful. The USA has been employed the sanctions more than any other country. The Clinton's administration alone put 35 countries under unilateral sanctions. These 35 countries covered 42% of the world's population consum-

ing 19% of world exports. The USA has suffered from major losses due to such sanctions. According to estimations of the Heritage Foundation, economic sanctions against 26 countries decreased the US exports by $19 billion and eliminated 200 thousand jobs in export sector while the employees in this section have experienced about one billion dollars in losses.

Strategic economic sanctions differ from those aimed at other non-strategic or economic interests. Since the strategic sanctions are an alternative option to war, the economic costs will be far lower than war and fully justified to the imposing country or countries. Any economic sanction for strategic purposes usually involves four stages:

A) Encouraging the target country privately through mutual negotiations;

B) Public request from the target country and public announcement;

C) Consulting with allies for subsequent actions and military measures if needed;

D) Initiating non-economic sanctions.

Failing in domestic manufacturing the fundamental equipment used in the extraction of natural gas from gas reservoirs in the past two decades has caused the Iranian oil industry to be substantially dependent on foreign-manufactured equipment. The enforcement of international sanctions against Iran caused foreign vendors to be either unwilling or not permitted to sell this equipment to Iran. As a result, this has led to create a considerable dependence and delay in the important and strategic projects of gas reservoirs. Moreover, lack of a comprehensive, expert plan, lack of support and failing to pay special, practical attention by the respective institutes and organizations have unfortunately caused extra costs to be imposed on the interested projects leading to their unfavorable progress. All these factors have caused delay in implementation of development and operation projects of Iran's gas reservoirs. In light of the fact that some of these reservoirs are shared with neighboring countries, the disadvantages of failing to extract natural gas has been imposed on Iran.

11. Research Methodology and Model Estimation

There are two methods for efficiency measurement: Parametric and Non-parametric methods. The Data Envelopment Analysis (DEA) is a non-parametric method, while the Stochastic Frontier Analysis (SFA) is a parametric method which uses econometric models. The appropriate estimation technique having the mentioned features is the Maximum Likelihood Estimation (MLE) method with panel data, which is estimated in SFA. The model adopted in the present study is as the following equation

$$Y\_ij=f(Xij)+V(ij)+U(ij) \quad (1)$$

$$V\sim N(0.\sigma v) \quad (2)$$

$$U\sim |N(0.\sigma u)| \quad (3)$$

Where i indicates different modes of project execution and different executors of the project and j indicates 65 stages of project implementation. Furthermore, V is usual stochastic component (disturbance term) in econometrics with normal distribution. U denotes inefficiency that its distribution is generally considered as half-normal. The f(X) is production function. In the present study on the amount of gas production, frontier production function is of interest. The investigated model for production is defined as follows:

$$Ln(Yij)=f(Xij)+\ln(Vij)+\ln(Uij) \quad (4)$$

In fact, stochastic frontier analysis (SFA) was adopted in this research, whereas this method is a structural method to study efficiency. Today, the application of frontier models is rapidly increasing. Firstly, nature of these models is in agreement with the principles of the economic theory of optimal behavior. Secondly, deviation from conceptual natural frontier functions is a criterion for efficiency on the basis of which economic units regulate their

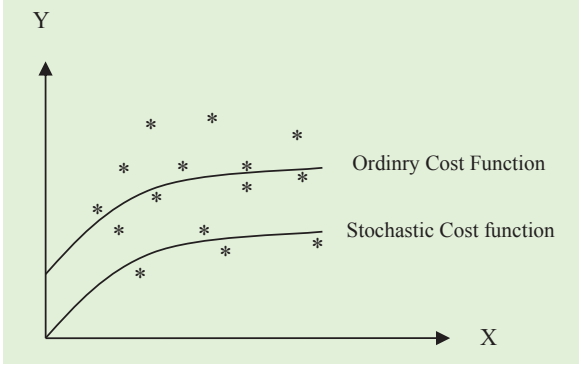

Figure 2: Stochastic and Ordinary Cost Functions

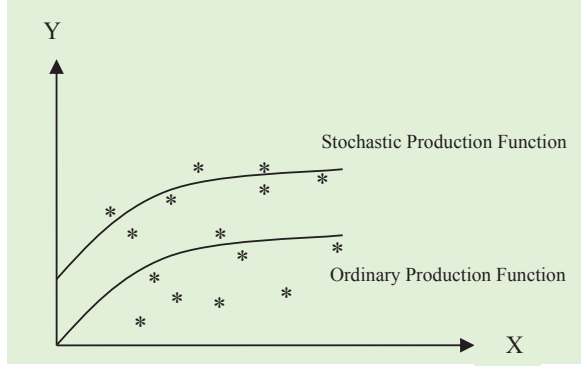

Figure 3: Stochastic and Ordinary Production Functions

technical and behavioral goals. Thirdly, the information related to frontier functions and the efficiency of economic units has many policy-related applications.

It is noteworthy that what is of importance from the standpoint of policy making is the measurement of efficiency for each of the sample enterprises. In the present study, the efficiency of gas production in the period of sanctions has been measured and compared with that in the period before sanctions. The following two diagrams illustrate both stochastic frontier analysis and ordinary estimation and it shows their differences clearly.

A comparison of the above two diagrams clearly in-

Table 1: Regression of Frontier Cost Function for Capital Costs

Time-invariant inefficiency model — Number of obs = 127
Group variable: contractor — Number of groups = 2

Obs per group: min = 62, avg = 63.5, max = 65

Wald chi2(5) = .
Log likelihood = -236.4332 — Prob > chi2 = .

ln_capex	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
component1	-.3510823	.3232888	-1.09	0.277	-.9847168	.2825522
component2	.1762347	.0746718	2.36	0.018	.0298807	.3225888
component3	-.0197783	.0066009	-3.00	0.003	-.0327159	-.0068407
component4	.0009315	.0002842	3.28	0.001	.0003745	.0014884
component5	-.0000215	6.37e-06	-3.37	0.001	-.0000339	-8.97e-06
component6	2.39e-07	7.16e-08	3.35	0.001	9.92e-08	3.80e-07
component7	-1.04e-09	3.18e-10	-3.26	0.001	-1.66e-09	-4.13e-10
/mu	-5.81e-11	1.12333	-0.00	1.000	-2.201686	2.201686
/lnsigma2	1.150139	.1302841	8.83	0.000	.8947873	1.405492
/ilgtgamma	-1.302319	.	.	.	.	.
sigma2	3.158633	.4115197			2.446815	4.077531
gamma	.2137751	.			.	.
sigma_u2	.675237	.			.	.
sigma_v2	2.483396	.			.	.

Table 2: Regression of Frontier Cost Function for Non-Capital Costs

Time-invariant inefficiency model — Number of obs = 127
Group variable: contractor — Number of groups = 2

Obs per group: min = 62, avg = 63.5, max = 65

Wald chi2(5) = .
Log likelihood = -252.88955 — Prob > chi2 = .

ln_noncapex	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
component1	-.1181303	.3967327	-0.30	0.766	-.895712	.6594514
component2	.1129055	.0829196	1.36	0.173	-.049614	.2754249
component3	-.0137651	.0070919	-1.94	0.052	-.027665	.0001349
component4	.0006762	.0003007	2.25	0.025	.0000868	.0012656
component5	-.000016	6.69e-06	-2.39	0.017	-.0000291	-2.88e-06
component6	1.81e-07	7.47e-08	2.43	0.015	3.48e-08	3.28e-07
component7	-7.91e-10	3.30e-10	-2.40	0.017	-1.44e-09	-1.44e-10
/mu	4.14e-10	.	.	.	.	.
/lnsigma2	1.025651	.149285	6.87	0.000	.7330582	1.318244
/ilgtgamma	-2.262546	.	.	.	.	.
sigma2	2.788911	.4163425			2.081436	3.736855
gamma	.0942728	.			.	.
sigma_u2	.2629184	.			.	.
sigma_v2	2.525993	.			.	.

dicate their performance based on inputs and outputs (or based on the cost and production, respectively).

12. Data Analysis

As it mentioned in the previous section, a number of sixty five stages of project implementation were recognized and categorized in 5 different modes based on project execution and different executors of the project. The aim is to find out cost of which contractor is more and which one is less, and what the role of efficiency is. Results of SFA estimation are illustrated in the following tables.

According to Table 5, foreign (external) contractors or companies (before international limitations and sanctions) have been more efficient than internal contractors (after international limitations and sanctions). It also shows cost of external contractors had been less than internal ones. It shows contractor type and international conditions causes inefficiency and imposes higher expenses at the time of running the projects.

Table 3: Regression of Frontier Cost Function for the Total Costs

```
Time-invariant inefficiency model                 Number of obs      =       127
Group variable: contractor                        Number of groups   =         2

                                                  Obs per group: min =        62
                                                                 avg =      63.5
                                                                 max =        65

                                                  Wald chi2(5)       =         .
Log likelihood  = -247.95359                      Prob > chi2        =         .
```

ln_total	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
component1	-.1512372	.4022099	-0.38	0.707	-.9395541	.6370798
component2	.121214	.0826211	1.47	0.142	-.0407204	.2831483
component3	-.0145484	.0070196	-2.07	0.038	-.0283066	-.0007903
component4	.0007099	.0002966	2.39	0.017	.0001286	.0012911
component5	-.0000167	6.58e-06	-2.54	0.011	-.0000296	-3.83e-06
component6	1.89e-07	7.34e-08	2.58	0.010	4.55e-08	3.33e-07
component7	-8.27e-10	3.24e-10	-2.55	0.011	-1.46e-09	-1.92e-10
/mu	3.31e-10	.	.	.	.	.
/lnsigma2	1.020257	.1452078	7.03	0.000	.7356548	1.304859
/ilgtgamma	-1.882273	.	.	.	.	.
sigma2	2.773907	.4027928			2.086848	3.687168
gamma	.132128	.			.	.
sigma_u2	.3665107	.			.	.
sigma_v2	2.407396	.			.	.

Table 4: Regression of Frontier Cost Function for the Execution Time

```
Time-invariant inefficiency model                 Number of obs      =       130
Group variable: contractor                        Number of groups   =         2

                                                  Obs per group: min =        65
                                                                 avg =        65
                                                                 max =        65

                                                  Wald chi2(5)       =         .
Log likelihood  = -210.52751                      Prob > chi2        =         .
```

ln_time	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
component1	-.7336034	.2678288	-2.74	0.006	-1.258538	-.2086687
component2	.1429125	.0593656	2.41	0.016	.026558	.2592669
component3	-.0118396	.0051715	-2.29	0.022	-.0219756	-.0017036
component4	.0004818	.0002211	2.18	0.029	.0000485	.0009151
component5	-.0000101	4.94e-06	-2.05	0.040	-.0000198	-4.58e-07
component6	1.06e-07	5.54e-08	1.91	0.056	-2.58e-09	2.14e-07
component7	-4.35e-10	2.46e-10	-1.77	0.077	-9.16e-10	4.68e-11
/mu	-1.19e-11	2.360865	-0.00	1.000	-4.62721	4.62721
/lnsigma2	1.644676	.1281784	12.83	0.000	1.393451	1.895901
/ilgtgamma	.8985487	.	.	.	.	.
sigma2	5.179332	.6638788			4.028729	6.658547
gamma	.7106512	.			.	.
sigma_u2	3.680698	.			.	.
sigma_v2	1.498634	.			.	.

Table 5: Efficiency Comparisons

Foreign company		Internal Contractor		Cost Function
Inefficiency	Inefficiency log	Inefficiency	Inefficiency log	
1/760	0/341	1/464	0/706	Capital expenditure
2/160	1/085	3/152	1/578	Non-capital expenditure
2/703	1/628	3/969	2/291	Total Costs
1/601	0/022	3/031	1/518	Execution time

13. Summary of Findings and Conclusion

Iran has the second rank in the world in term of gas reservoirs. These storages can be often found in gas reservoirs, oil caps, or together with oil in the oil fields. At this time, Iranian gas storage is estimated equaled to 27 trillion cubic meters. The effect of the different circumstances on gas extraction has been investigated in a certain period of time and proper solutions have been offered in order to cope with such situations and similar ones. Based on the results obtained in this study, limitations have increased total costs of gas projects. Furthermore, the amount of gas production has been reduced significantly. Therefore, in light of the rapid and extensive advancements in the upstream sector of the oil industry and need of the country to access to the newest scientific and technical innovations and findings, the international mutual collaborations with leader companies is a vital and undeniable necessity. This study provides historical facts and figures as well as the effects and consequences of international economic limitations and sanctions. It also elaborates on petroleum ministry's mission, vision and efforts during limitations including activities, international relations and collaborations, and other major issues related to the oil and especially gas extraction and production. The present research also addressed the effect of international sanctions on the amount of natural gas extraction from Iranian gas reservoirs. The results indicate that the amount of natural gas extraction from Iranian gas reservoirs has significantly decreased in the period of international sanctions. It finally added to the body of knowledge by taking into the account of sanctions on a critical sector of a country which has not been previously touched.

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