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Iran-Pakistan-India Gas Pipeline—An Economic Analysis in a Game Theoretic Framework

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Over the last four decades world economy has experienced several wide swings in energy prices. These swings have very serious repercussions for countries of Asian, in general, and South Asian regions, in particular; the latter having tremendous economic potential. Rapidly growing economies like India, China and Pakistan will face serious energy crisis if they do not plan well for future needs. Energy is one of the most critical inputs to several variety of production function. And we have very limited ability to replace it by other means in the short run, without having serious setback to our GDP.

Energy conservation is a topic that has been discussed over a long period of time. Energy conservation is not a local issue but a global one, affecting the strategic planning and policy making of the governments worldwide. Energy conservation is proving as a catalyst for globalisation and international trade of energy.

There are number of challenges for the South Asian region. Energy is at the forefront and has not kept pace with rapid economic expansion. This analysis is about transporting gas from Iran to Pakistan and then possibly to India. The so called Iran-Pakistan-India (IPI) gas pipeline has been named as peace pipeline in the jargon of political language because this will be the most credible confidence building measure (CBM) between India and Pakistan. Both countries have high stakes involved in this pipeline project.

An economically viable project might suffer due to geo-political scenario of all the three countries involved. One of the main players of this game is United States which is aimed at isolating Iran on both economic and political front. How US pursue its policies for this IPI pipeline and response of two beneficiaries Pakistan and India is not merely an economic issue but a political issue as well but we shall not cover this aspect in our paper.

Main objective in this paper will be on economic analysis of IPI pipeline. We shall develop different scenarios of Iranian gas export to Pakistan and India in the presence of different strategic behaviours on the part of each player. We shall model both cooperative and non-cooperative behaviour of these players.

To the best of our knowledge, this is the pioneering effort of modelling the IPI pipeline under game theoretic framework. Many newspaper articles have been written on the IPI pipeline but no formal effort of modelling the whole scenario under some theoretical reasoning has been carried out.

1. INTRODUCTION

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Almost three-quarters of the world's natural gas reserves are located in the Middle East and Eurasia. Russia, Iran, and Qatar combined accounted for about 58 percent of the world's natural gas reserves as of January 1, 2007. Iran is the second largest producer of natural gas with its major natural gas fields at South and North Pars, Tabnak, and Kangan-Nar. According to *Oil and Gas Journal*, Iran has an estimated 974 trillion cubic feet (Tcf) in proven natural gas reserves, about 15.8 percent of world's total (see Appendix-I). Of all the natural gas fields in Iran, the most yielding one is the offshore South Pars field, which is estimated to have 450 trillion cubic feet of natural gas reserves accounting for about 47 percent of Iran's total natural gas reserves [Energy Information Administration (2007)]. Since the discovery of South Pars field, in 1990, Iran has been proposing for a pipeline project that can transport the Iranian gas to Pakistan and India.

The US $7.4 billion Iran-Pakistan-India (IPI) line is expected to transport Iranian natural gas south to the Asian subcontinent, with a proposed 1724 miles and a 5.4 Billion cubic feet (Bcf) capacity [Energy Information Administration (2007)]. From South Pars, a pipeline will stretch over 1,100 kilometres within Iran before entering Pakistan, travelling through Khuzdar. One section will run through Karachi, the main section going through Multan to the Indian border (760 kilometres), thereafter travelling 860 kilometres to Delhi.

Pakistan and Iran signed a preliminary agreement in 1995 for the construction of a natural gas pipeline linking Karachi with the South Pars natural gas field. Iran and India signed an agreement for an overland natural gas pipeline in 1993, and in 2002 Iran and Pakistan signed an agreement on a feasibility study for such a pipeline. Iran later proposed an extension of the pipeline into India, with Pakistan standing to benefit from transit fees. The pipeline would supply both countries with gas: India with 90 million cubic meters per day and Pakistan 60 million cubic meters per day [United Press International (2008)]. In April 2008 Pakistani president Pervez Musharraf met his Iranian counterpart Ahmedinejad in Pakistan; among several other issues IPI has been a main gist. It is believed that Iran and Pakistan have resolved all issues regarding the IPI pipeline project and the final agreement may be inked soon. During the meeting, Iranian president Ahmedinejad stated "Pakistan and Iran are like one soul in two bodies". In response to Pakistani proposal for allowing China to receive gas from the IPI from Pakistan, Iran showed a positive response, which indicates that in case the project materialises, even without India's participation, Pakistan can still enjoy the status of a transit country.

Fig. 1. Iran-Pakistan-India (IPI) Pipeline

Source: U.S. Government.

Pakistan has always been enthusiastic to start IPI project but India has whether explicitly or implicitly shown reluctance to join the project. The IPI project has been pending due to many geo-political, geo-strategic and geo-economic factors, but concentrating on the geo-economic ones, mainly due to the transit fee issues. Pakistan has been demanding transit fee of US 50 cents per million British Thermal Units (MBTU), while India wants it to be US 15 cents per MBTU.

It is interesting that other countries especially China has shown interest in joining this IPI project. China told Pakistan that Beijing is keen on importing 1.05 billion cubic feet of gas from Iran through the pipeline if India does not participate in the project [Press TV 11 February (2008)]. Indian officials did not attend the last few meetings on the pipeline, citing their problems with pricing.

Rapidly growing countries; China and India have great dependence on energy import and it continues to be an issue of immense importance for the sustainable growth rate of 7-9 percent for both the countries. The question is that, how Iranian gas reaches Pakistan and India? In the case of the former, issue of gas import from Iran is not a serious problem because the two countries have their common borders. For India it's an issue economic-cum geo-political. India can import Iranian gas through Pakistan the most viable economic route but politically fragile one given the past history of both the countries. Both countries lack confidence in each other. Nevertheless, many assume that Pakistan will never sabotage this project because it has its own economic interest in form of transit fee of about $700 million per year.

Iran seems to be interested in gas exports mainly because of its transition economy where unemployment is rising and budget deficits have been a chronic problem. About 18 percent of the Iran's population lives below the poverty line and unemployment rate is about 11 percent [CIA world Factbook (2007)]. Iran has abundant resources of natural gas and crude oil, oil and natural gas meet 40 percent and 49 percent, respectively, of the Iran's energy demands (Energy Information Administration). Beyond the geo-economic factor another geo-political point of view is that Iran can make India and Pakistan, and possibly China as its allies in the South Asian region and thus the so called monopoly of the US, in the region, can be endangered. US has been opposing the materialisation of the IPI project mainly because it fears that Iran can play a vital role in South Asia once it becomes a gas supplier for the two major countries of the region i.e., India and Pakistan. Iran has been working to develop nuclear weapons and is supporting international

terrorism; that is what believed by the US government. Iran has been assuring on several occasions that it is interested in IPI pipeline for general economic development and not for consolidating its nuclear weapons.

India is also facing energy crises that may catch momentum if not addressed timely. Regarding natural gas, in the International Energy Outlook 2007 (IEO) reference case, natural gas consumption in the non-OECD countries grows more than twice as fast as in the OECD (Organisation for Economic Cooperation and Development) countries. Led by demand in China and India, natural gas consumption in non-OECD Asia is projected to expand by 4.6 percent per year on average from 2004 to 2030. India's natural gas consumption is projected to rise rapidly in the mid-term, growing by 6.2 percent per year on average from 2004 to 2015 [Energy Information Administration (2007)].

In economic horizon *Pakistan's Interest in IPI* is vivid as it is an energy deficient country, though not as much as is India or China. Energy consumption in Pakistan has grown significantly over the last few decades due to a rapidly growing economy. Energy shortfall seems to be one of the hurdles in the quest towards economic growth of Pakistan. In its second quarterly report for fiscal year 2006, State Bank of Pakistan indicated that the energy demand-supply gap was 47 percent in 2006. Major gas fields are very mature and supplies will decline from 2010. Energy shortage is badly affecting the economic growth of Pakistan. It is expected to moderate to 6.3 percent in financial year 2008 and then pick up slightly to 6.5 percent in financial year 2009, underpinned by consumption expenditures. These forecasts are lower than the average 7 percent growth rate of recent years, as the ongoing power and gas shortages caused by an aging energy infrastructure, chronic underinvestment in expansion and maintenance, and unsustainable pricing regimes slow production and constrain domestic and foreign investment. [Asian Development Bank (2008)].

Natural gas and oil meet 51 percent and 28 percent, respectively, of the Pakistan's energy demand [Pakistan Energy Yearbook (2006)]. The total production of natural gas is 1.40 Trillion Cubic Feet (Tcf) at the rate of 900Btu. If Pakistan has to decrease the energy demand-supply gap then it has to devise its energy policy efficiently.

In the presence of such conditions, Pakistan is bound to streamline the issue of natural gas and electricity shortage. There may be various courses of action, while considering the gas import. Gas reserves are not expected to meet the supply shortfall and IPI project may prove a doorstep in converting Pakistan as economic tiger of the region.

Iran may be one of the potential exporters of natural gas to India. India has three options to acquire natural gas from Iran (i) in the form of LNG (liquefied natural gas), using LNG fleets through the Arabian Sea (ii) through a deep sea pipeline or (iii) through land route. The land-based option seems quite cheaper than all other options even after including transit fee payments to Pakistan.

2. IRAN-PAKISTAN-INDIA IN A GAME THEORETIC PERSPECTIVE

Hirschhausen, *et al.* (2005) has carried out an analysis, of the transportation of Russian gas to Western Europe. Our model is different in structure and implications than the Hirschhausen, *et al.* (2005) model. Before we specify the model of the IPI gas

pipeline we identify the fundamental difference between the cooperative and non-cooperative strategy with reference to countries involved.

Let

(i) p denotes the price of imported gas in Pakistan,
(ii) p_{LNG} denotes the price of liquefied natural gas in Pakistan,
(iii) x denotes the total amount of gas exported by Iran, through IPI pipeline, to Pakistan and India,
(iv) y denotes the total amount of gas imported by Pakistan,
(v) B denotes the benefits that Pakistan will earn from the IPI pipeline ($B = p_{LNG} - p$),
(vi) c_I and c_P denote the respective constant per unit cost of Iran and Pakistan,
(vii) $y(p)$ denotes the gas import function for Pakistan with $y(p) \geq 0$ and $[\partial y(p) / \partial p] < 0 \; \forall \; p \geq 0$,
(viii) Assume that IPI pipeline is the only way of transporting Iranian gas to Pakistan and India.

For Iran and Pakistan we define the following strategies:

- Non-Cooperative strategy: Iran and Pakistan independently determine the export quantity (or the final price for gas) and benefits so as to maximise their respective profits.
- Cooperative strategy: Iran and Pakistan determine the profit-maximising amount of imported gas and share the total benefits.

Furthermore, let us denote;

- $\pi^I_{nc}(*) = (p - c_I)x$ as Iran's profits for the non-cooperative strategy and $x^*_{nc} = \text{argmax}_{x\geq 0} \{\pi^I_{nc}(p)\}$ or $p^*_{nc} = \text{argmax}_{p\geq 0} \{\pi^I_{nc}(p)\}$ as solution for Iran's profit-maximisation problem;
- $\pi^p_{nc}(*) = (B - c_p)x$ as Pakistan's profits for the non-cooperative strategy and $B^*_{nc} = \arg\max_{b\geq 0}\{\pi^p_{nc}(b)\}$ as solution for Pakistan's profit-maximisation problem;
- $\pi_{nc}(*) = \pi^I_{nc}(*) + \pi^P_{nc}(*)$ as aggregate profits of the non-cooperative strategy
- $\pi_c(*) = (p + B - c_I - c_P)x$ as total profits of the cooperative strategy and $x^*_c = \arg\max_{x\geq 0}\{\pi_c(x)\}$ or $p^*_c = \arg\max_{p\geq 0}\{\pi_c(x)\}$ as solution for Iran's and Pakistan's joint profit maximisation problem.

Finally, we assume that all the above profit functions are continuous and quasiconcave (so that x^*_{nc}, p^*_{nc}, B^*_{nc}, x^*_c and p^*_c exist and are unique).

Then using results of Hirschhausen, *et al.* (2005), we have,

Proposition 1: *Profits of the cooperative strategy are always greater than or equal to aggregate profits of the non-cooperative strategy:* $\pi_c(*) \geq \pi_{nc}(*)$. *Furthermore, the*

transit quantity (or the gas price) is always greater (lesser) or equal in its level in the non-cooperative strategy: $x_c^* \geq x_{nc}^* (p_c^* \leq p_{nc}^*$.

Proof: For the non-cooperative strategy, maximum aggregate profits are

$\pi_{nc}(*) = \pi_{nc}^I(*) + \pi_{nc}^P(*) = \max_{x\geq 0} \pi_I(x) + \max_{b\geq 0} \pi_P(x) = (p_{nc}^* - c_I)x_{nc}^* + (B_{nc}^* - c_P)x_{nc}^*$

$= (p_{nc}^* - c_I + B_{nc}^* - c_P)x_{nc}^*$

or $x_{nc}^* = \max_{x\geq 0} \pi_I(x) + \max_{b\geq 0} \pi_P(x) = (p_{nc}^* - c_I + B_{nc}^* - c_P)x_{nc}^*$. However, because x_{nc}^* (or p_{nc}^*) and B_{nc}^* are chosen within two separate problems, aggregate profits $\pi_{nc}(*)$ cannot exceed maximum profits for the cooperative solution in which x_c^* is directly chosen to maximise the same expression $x_c^* = \arg\max_{x\geq 0}\{\pi_c(x)\} = (p + B - c_I - c_P)x_c^*$. Now the regularity condition of quasi-concavity imposed on $\pi_{nc}^P(*) = (B - c_P)x$ requires that $(\partial x / \partial B) \leq 0$. Thus if Pakistan gains zero benefits from the IPI project in the cooperative strategy and shares total profits with Iran then $\pi_{nc}(*)$ cannot exceed maximum profits for the cooperative solution. Because if $\pi_{nc}(*)$ exceeds x_c^* then $c_I > p$. Hence it is proved that $x_c^* \geq x_{nc}^*$ or $p_c^* \leq p_{nc}^*$.

Now we shall extend this general result to a specific situation.

1. Non-cooperative Strategy (Two Players)

Under prevailing circumstances Iranian gas can reach Pakistan through LNG method or through a pipeline. In geo-economic aspect the pipeline may benefit Pakistan if $B > 0$. Symbolically speaking, we can say that Iran being the main supplier of gas to Pakistan, sets an export quantity x to maximise its profits $\Pi^I = (p - c_I)x$. It is assumed that the relationship between p and x is direct, so that the function $p(x)$ is increasing and $\frac{\partial p(x)}{\partial x} < 0$. It is plain to envisage that the two players Iran and Pakistan have almost same bargaining power;

Iran is very wholehearted to start the IPI pipeline project to pace up its collapsing economy and to defend itself against the embargoes and trade restriction imposed by countries like United States and United Kingdom. It also wants to develop friendly ties with two important countries of the region i.e. Pakistan and India. India is reluctant on their part due to the US pressure and fears of US that Iran may become a strong country through its nuclear energy programme. Iran has to keep an inviting tone rather than dictating one with reference to IPI pipeline project. Pakistan is enthusiastic for IPI because of energy shortfall that it is facing. Pakistan is also interested because of the transit benefits and lower cost it can enjoy (when compared with prevalent LNG prices). All in all Iran the supplier needs foreign exchanges to support the economy. So both Iran and Pakistan do not have much bargaining power on the IPI pipeline issue.

The First Order Condition (FOC) for Iran's profit maximisation problem requires that the optimal price of exported gas (x) to be so as to ensure

$$\frac{\partial \prod_I}{\partial p} = x + (p - c_I)\frac{\partial x}{\partial p} = 0, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Pakistan problem is to enjoy maximum benefits from importing x units of gas from Iran through IPI pipeline. Since benefits of Pakistan are portrayed by the quantity B, which is the price differential between price of gas through IPI pipeline and price of gas otherwise (where we have attributed LNG to be the other source). *Cetris Peribus* the benefits of Pakistan will increase as the amount of gas imported increase. The underlying mechanism is that if the price differential is B_i (say) for i units of import through IPI pipeline then $B_{i+1} \geq B_i$, where B_i is the benefits to Pakistan on importing i units of gas from Iran through IPI pipeline. The highest possible benefits will be earned when Pakistan imports gas from Iran on the minimum price. But Iran will set the price not at the minimum but at the optimum level ensuring the optimum volume of trade x. So benefits of Pakistan are directly dependent on x that is to say $B = B(x)$. With this prior setup and background information, the FOC for Pakistan is;

$$\frac{\partial \prod_P}{\partial B} = x + \frac{\partial x}{\partial B}(B - c_P) = 0,$$

$$B_{opt} = -\frac{x}{\sigma} + c_P, \text{ where } \sigma = \frac{\partial x}{\partial B} < 0. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Assume that if quantity imported/demanded by Pakistan increases, suppliers shall offer higher prices. Therefore the gas imports function for Pakistan, is given by

$$y(p) = x + x_0 = a\,p, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where x_0 is the gas imported by Pakistan from any other source and $a > 0$ is an exogenous parameter.

Using (3) and (1), we get

$$p_{opt}\left(\frac{x_0 + c_I(a - \sigma_0)}{2a - \sigma_0}\right), \sigma_0 = \frac{\partial x_0}{\partial p} < 0. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

This optimum price depends purely on the cost structure of the Iran and the exogenous parameters of the gas import functions of the gas in Pakistan. Finally using (4) as Pakistan best-response function (given in (2)) the optimum benefits that Pakistan ought to enjoy are,

$$B_{opt} = -\frac{1}{\sigma}\left(\frac{x_0 + c_I(a - \sigma_0)}{2a - \sigma_0}\right) + c_p, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

This solution is termed as non-cooperative as it does not assume partnership between the two major players Iran and Pakistan

2. Cooperative Strategy (Two Players)

In the cooperative strategy, Iran and Pakistan jointly maximise the aggregate profits (benefits) and then share it between themselves. It is important that we can utilise the aggregate profit function under non-cooperation, given by $\pi_c(*) = (p + B - c_I - c_P)x$. Simply maximising this aggregate profit function w.r.t x will provide an estimate of the optimal quantity of gas that should be exported by Iran to Pakistan.

However, another more formal approach is to use the Nash Product. Let the joint profit (or benefit) be distributed among Pakistan and Iran according to Nash bargaining criteria. For two players, the Nash product is defined as the product of each player's profit under cooperative environment after deduction of the profit under non-cooperative environment.

Let NP_{IP} denote the Nash product, when two players Iran and Pakistan are considered. Then NP_{IP} is given by,

$$NP_{IP} = \left(\prod_{I_{coop}} - \prod_{I_{non-coop}}\right)\left(\prod_{P_{coop}} - \prod_{P_{non-coop}}\right). \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

If Iran and Pakistan play under cooperation then Iran's profits are characterised by the function,

$$\prod_{I_{coop}} = \prod_I - B_{P_{coop}} = px - x(c_p - c_I) - B_{P_{coop}}, \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

Where $B_{P_{coop}} = B * x$ is the fixed benefits offered to Pakistan by Iran, under cooperation agreement.

Since both Pakistan's and Iran's supreme interest is not to stall the mega IPI pipeline so we assume that non-cooperation can only occur if India remains reluctant to start the IPI pipeline. In that case Pakistan may become the only potential customer of the Iranian gas and then Pakistan can play a role of monopolistic customer. Similarly, Iran can be a monopolistic supplier if Pakistan has no options of imports other than that of Iran. Several other assumptions can be stated before we assume monopoly of Iran and Pakistan, but we shall not go into intricate geopolitical details of the issue.

Coming back to the identification of the profits of Iran and Pakistan under non-cooperation, we say that $\prod_{I_{Monopoly}}$ and $\prod_{P_{Monopoly}}$ are the respective profits of Iran and Pakistan. Therefore, the Nash product in (8) can be restated as:

$$NP_{IP} = \left(\prod_I - B_{P_{coop}} - \prod_{I_{Monopoly}}\right)\left(B_{P_{coop}} - \prod_{P_{Monopoly}}\right) \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Now, we shall seek the optimal benefits that Pakistan should gain, to maximise the aggregate profits under joint venture (cooperation). Maximising the Nash product in (10) w.r.t $B_{P_{coop}}$ yields;

$$\frac{\partial NP_{IP}}{\partial B_{P_{coop}}} = -\left(B_{P_{coop}} - \prod_{P_{Monopoly}}\right) + \prod_I - B_{P_{coop}} - \prod_{I_{Monopoly}} = 0, \quad \ldots \quad \ldots \quad (11)$$

which implies that

$$B_{P_{coop}}^{opt} = \frac{\Pi_{P_{Monopoly}} + \Pi_I - \Pi_{I_{Monopoly}}}{2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

Thus optimum benefits for Pakistan are 50 percent of the profit-maximising surplus in the Nash product solution.

Now, incorporating the optimum benefits from (12) into the Nash product (10), the Nash product can be restated as follows,

$$NP_{IP} = \left(\Pi_I - \frac{\Pi_{P_{Monopoly}} + \Pi_I - \Pi_{I_{Monopoly}}}{2} - \Pi_{I_{Monopoly}} \right)$$

$$* \left(\frac{\Pi_{P_{Monopoly}} + \Pi_I - \Pi_{I_{Monopoly}}}{2} - \Pi_{P_{Monopoly}} \right),$$

$$= \left(\frac{P(ap - c_0) - (c_P + c_I)(ap - x_0) - \Pi_{P_{Monopoly}} - \Pi_{I_{Monopoly}}}{2} \right)^2 \quad \ldots \quad \ldots \quad (13)$$

Maximising (13) w.r.t p, yields the optimum selling price of gas for Iran (purchase price for Pakistan).

$$p_{opt}^{coop} = \frac{x_0 + (c_P + c_I)(a - \sigma_0)}{2a - \sigma_0}. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

This optimum price depends purely on the cost structure of the players and the exogenous parameters of the gas import functions of the gas in Pakistan and India. In cooperative strategy the optimum benefits of Pakistan are independent of marginal impact of Pakistan's benefits, whereas reverse is the case in non-cooperation. Furthermore, as stated in proposition (1), the total benefits of the cooperative strategy are always greater than the total benefits of the non-cooperative strategy. Iran and Pakistan have relatively friendly ties and Pakistan can plausibly cooperate with Iran.

3. IPI IN THREE-PLAYERS SET-UP

Now we introduce India as a third player of the mega IPI game and develop the three players' scenario, by using following notations

Let

(i) p_{PA} denotes the price of imported gas in Pakistan,
(ii) p_{IN} denotes the price of imported gas in India,
(iii) p_{LP} denotes the price of liquefied natural gas in Pakistan,
(iv) p_{LI} denotes the price of liquefied natural gas in India,
(v) t denote the transit fee Pakistan may earn on transiting gas from IPI to India,
(vi) y_{PA} denote the amount of gas imported by Pakistan by Iran,
(vii) y_{IN} denote the amount of gas imported by India,
(viii) y_{IO} denote the gas imported by India from sources other than Iran,
(ix) y_{PO} denote the gas imported by Pakistan from sources other than Iran,

(x) y_{tot} (= y_{IN} + y_{PA}) denotes the total amount of gas exported by Iran, through IPI pipeline, to Pakistan and India,

(xi) B_{PA} denotes the benefits that Pakistan will earn from the IPI pipeline (B_{PA} = $p_{PA} - p_{LP} + t$),

(xii) B_{IN} denotes the benefits that India will earn from the IPI pipeline (B_{IN} = $p_{IN} - p_{II}$),

(xiii) c_{IR} and c_{PA} and c_{IN} denote the respective constant per unit cost of Iran, Pakistan and India ,

(xiv) x_P denotes the demand function of Pakistan for gas imports with $x_P \geq 0$ and $(\partial x_P / \partial p) < 0 \ \forall \ p \geq 0$, such that the inverse demand function $p = p_x \geq 0$ exists with $(\partial x_P / \partial p) < 0$,

(xv) x_I denotes the demand function of India for gas imports with $x_I \geq 0$ and $(\partial x_I / \partial p) < 0 \ \forall \ p \geq 0$, such that the inverse demand function $p = p_x \geq 0$ exists with $(\partial x_I / \partial p) < 0$,

(xvi) Assume that IPI pipeline is the only way of transporting Iranian gas to Pakistan and India.

For each of the three players we define the following strategies:

- Non-cooperative strategy: Iran, Pakistan and India take independent decisions to maximise their individual profit functions. Iran determines the final price and amount of gas that it allows to be exported, Pakistan determines the allowable transit quantity and India determines the quantity it imports through IPI and both Pakistan and India set their own prices.
- Cooperative strategy: Iran, Pakistan and India determine the joint profit-maximising values of final price, amount of gas, transit quantity and quantity of imported gas through IPI.

Furthermore, let us denote;

- $\phi_{nc}^{IR}(*) = (p_{PA} + p_{IN} - c_{IR}) y_{tot}$ as Iran's profits for the non-cooperative strategy and $\phi_{nc}^{*} = \arg\max_{x \geq 0}\{\phi_{nc}^{IR}(y)\}$ or $p_{nc}^{*} = \arg\max_{p \geq 0}\{\phi_{nc}^{IR}(p)\}$ as solution for Iran's profit-maximisation problem;
- $\phi_{nc}^{PA}(*) = (B_{PA} - c_{PA}) y_{PA}$ as Pakistan's profits for the non-cooperative strategy and $\left(B_{PA}\right)_{nc}^{*} = \arg\max_{b \geq 0}\{\phi_{nc}^{PA}(b)\}$ as solution for Pakistan's profit-maximisation problem;
- $\phi_{nc}^{IN}(*) = (B_{IN} - c_{IN}) y_{IN}$ as India's profits for the non-cooperative strategy and $\left(B_{IN}\right)_{nc}^{*} = \arg\max_{b \geq 0}\{\phi_{nc}^{IN}(b)\}$ as solution for India's profit-maximisation problem;
- $\phi_{nc}(*) = \phi_{nc}^{IR}(*) + \phi_{nc}^{P}(*) + \phi_{nc}^{IN}(*)$ as aggregate profits of the non-cooperative strategy

- $\phi_c(*) = (p_{PA} + p_{IN} + B_{PA} + B_{IN} - c_{IR} - c_{PA} - c_{IN})x$ as total profits of the cooperative strategy and $x_c^* = \arg\max_{x \geq 0}\{\phi_c(x)\}$ or $\phi_c^* = \arg\max_{p \geq 0}\{\phi_c(x)\}$ as solution of for Iran's and Pakistan's joint profit maximisation problem.

Finally, we assume that all the above profit functions are continuous and quasiconcave.

Using *Proposition 1* (stated in 3.1), in three players' setup, the profits of the cooperative strategy will be greater than the profits in non-cooperative strategy.

1. Non-cooperative Strategy (Three Players)

In three players setup Iran, India and Pakistan have almost equal standings, as far as bargaining on IPI is concerned; Iran is eager to find buyers of its gas and both India and Pakistan are amid energy crisis. Pakistan being the transit country may have an added benefit in the form of transit fee.

Pakistan's interest is to maximise with respect to benefits it can gain through IPI. Pakistan wants to enjoy maximum benefits from importing x units of gas from Iran through IPI pipeline. Since benefits of Pakistan are portrayed by the quantity B_{PA}. *Cetris Peribus* the benefits of Pakistan will increase as the amount of gas imported increase. The underlying mechanism is that if the price differential is (B_{PA}) (say) for i units of import through IPI pipeline then $(B_{PA})_{i+1} \geq (B_{PA})_i$, where $(B_{PA})_i$ is the benefits to Pakistan on importing i units of gas from Iran through IPI pipeline. The highest possible benefits will be earned when Pakistan imports gas from Iran on the minimum price and maximum transit fee. Following the inverse demand convention, Pakistan may charge a higher rate of transit fee if the volume of gas transit to India is high. It implies that transit fee, and consequently benefits of Pakistan, are dependent on the volume of trade y_{tot}, that is to say $B = B(y_{tot})$. With this prior setup and background information, the FOC for Pakistan is;

$$\frac{\partial \Phi_P}{\partial B_{PA}} = y_{tot} + \xi(B_{PA} - c_P) = 0,$$

Where $\xi = \frac{\partial y_{tot}}{\partial B_{PA}} < 0$, then

$$(B_{PA})_{opt} = -\frac{y_{tot}}{\xi} + c_{PA}. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

Now, concentrating on Iran's profit maximisation, profits are supposed to be maximised with respect to the optimum prices of imported gas in India and Pakistan, through IPI.

The Pakistan's gas import function is given by,

$$w = y_{PA} + y_{PO} = bp_{PA}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

where $b > 0$.

India's gas import function is given by,

$$z = y_{IN} + y_{IO} = cp_{IN}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

where $c > 0$.

Maximisation of Iran's profit function w.r.t p_{PA}, yields

$$\left(p_{PA}\right)_{opt} = \frac{c_{IR}(b-\sigma_1) - p_{IN}(b+c-\sigma_1) + y_{PO} + y_{IO}}{2b-\sigma_1}, \sigma_1 = \frac{\partial y_{PO}}{\partial p_{PA}} < 0. \quad \ldots \quad (18)$$

Substitution of (18) in Iran's profit function and then maximising w.r.t p_{IN} yields

$$\left(p_{IN}\right)_{opt} = \frac{-k_4}{k_3}, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (19)$$

$$\sigma_2 = \frac{\partial y_{IO}}{\partial p_{IN}},$$

$$k_1 = \frac{c_{IR}(b-\sigma_1) + y_{PO} + y_{IN}}{2b-\sigma_1},$$

$$k_2 = \frac{b+c-\sigma_1}{2b-\sigma_1},$$

$$k_3 = 2c - 2ck_2 - 2bk_2 + 2bk_2^2 - \sigma_2 + \sigma_2 k_2,$$

$$k_4 = bk_1 - y_{PO} - y_{IO} - 2k_2k_1b + k_2y_{PO} + k_2y_{IO} + k_1c - k_1\sigma_2 - cc_{IR} + bc_{IR}k_2 + c_{IR}\sigma_2.$$

2. Cooperative Strategy (Three Players)

Just like two players setup we use the Nash Product. Let the joint profit (or benefit) be distributed among Iran, Pakistan and India according to Nash bargaining criteria. Iran and Pakistan negotiate a fixed value of transit fee for the quantity, y_{IN}, to be transported to India through Pakistan. In this way benefits of Pakistan are also fixed mutually by Iran and Pakistan.

Let NP_{IPI} denote the Nash product, when three players Iran, Pakistan and India are considered. Then NP_{IPI} is given by,

$$NP_{IPI} = (\Phi_{IR_{coop}} - B_{PA_{coop}} - \Phi_{IR_{monopolyB}})\,(B_{PA_{coop}} - \Phi_{PA_{monopolyB}}). \quad \ldots \quad \ldots \quad (21)$$

Now, we shall seek the optimal benefits that Pakistan should gain, to maximise the aggregate profits under joint venture (cooperation). Maximising the Nash product in (21) w.r.t $B_{PA_{coop}}$ yields;

$$\left(B_{PA_{coop}}\right)_{opt} = \frac{\Phi_{PA_{Monopoly}} + \Phi_{IR} - \Phi_{IR_{Monopoly}}}{2}. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (22)$$

Now, incorporating the optimum benefits from (22) into Nash Product in (21), the Nash product can be restated as

$$NP_{IPI} = \left(\frac{\Phi_{IR} - \Phi_{IR_{monopolyB}} - \Phi_{PA_{monopolyB}}}{}\right)^2,$$

$$= \left(\frac{p_{IN} y_{IN} + p_{PA} y_{PA} - y(c_{IN} + c_{PA} + c_{IR}) - t\, y_{IN} - \Phi_{IR_{monopolyB}} - \Phi_{PA_{monopolyB}}}{2} \right)^2, \quad (23)$$

Using (16) and (17) and maximising (23) w.r.t p_{IN}, yields the optimum quantity of gas exports to India.

$$(p_{IN})_{opt} = \frac{y_{IO} + (c - \sigma_2)(c_{IN} + c_{PA} + c_{IR}) - t(c - \sigma_2)}{c(1 - \sigma_2)}. \quad \ldots \quad \ldots \quad \ldots \quad (24)$$

Similarly optimum value of p_{PA} may easily be found.

It may be noted that, in a three player setup, under cooperative strategy the optimum prices are dependent on the exogenous parameters of the gas import functions of India and Pakistan, the cost structures of the players and the amount of gas imported by India and Pakistan from sources other than Iran.

4. CONCLUSIONS

We have explored the IPI gas pipeline benefits to Iran, Pakistan and India under two different scenarios cooperation versus non-cooperation. All three countries can enjoy economic growth and prosperity by materialising IPI pipeline project. The whole scenario of profit-maximisation has also been studied under three players setup. In both the cases cooperative strategies are beneficial for all three countries. We have ignored geo-political aspects of the project which can be considered by some political economy student in some other paper. One limitation in our paper is the lack of any data on the variables we have included in our model and therefore, we have not been able to carry out any simulation analysis of the results which would have helped in finding out the magnitude of the benefits all the three countries will reap. Last but not the least IPI gas pipeline project in no way implies that Pakistan and India can afford to take risk of not exploring other means of energy both domestic and international.

APPENDIX-I

Table 1

World Natural Gas Reserves by Country as of January 1, 2007

Producers	Reserves (Trillion Cubic Feet)	% of World Total	Producers	Reserves (Trillion Cubic Feet)	% of World Total
Russia	1680	27.17	Kazakhstan	100	1.617
Iran	974	15.75	Indonesia	98	1.584
Qatar	911	14.73	Norway	82	1.326
Saudi Arabia	240	3.881	China	80	1.293
UAE	214	3.461	Malaysia	75	1.213
USA	204	3.299	Uzbekistan	65	1.051
Nigeria	182	2.943	Egypt	59	0.954
Algeria	162	2.620	Canada	58	0.938
Venezuela	152	2.458	Kuwait	55	0.889
Iraq	112	1.811	Rest of World	581	9.396

Turkmenistan	100	1.617	World's Total	6183	100.00

Energy Information Administration, Report #:DOE/EIA-0484 (2007), Release Date: May 2007.

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