



Research Article

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The existing pipeline asset and spillover effect: The economic perspective of pipeline sharing

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ABSTRACT

A spokes model is established to analyze how the existing pipeline asset and its spillover effect will influence the corporate profit. It shows that if the existing pipeline assets among oil and gas companies are symmetrical, their product prices, demands and profits are also symmetrical; if there is a large existing pipeline asset gap among oil and gas companies, the optimal strategy for the company with pipeline advantage is to decrease its pipeline assets' spillover effect, i.e. preponderant company will not share its pipelines, and the disadvantaged companies with relatively few pipelines have to construct pipelines by themselves, or degenerate into suppliers of the preponderant company. It implies the reason why oil and gas companies are unwilling to share their pipelines is that sharing pipeline will decrease the monopoly power of the preponderant company. Therefore, in order to encourage oil and gas companies to share pipelines, the government needs to formulate a reasonable charge scheme of pipeline use fee. Besides, if the government plans to realize the reorganization and independence of pipelines, the government needs to consider the opportunity fair, and compensate the loss of dominant company caused by pipeline independence. In addition, facilitating the cooperation of upstream and downstream industries among different companies is also a feasible way to alleviate the problem of repeated pipeline construction.

Keywords: Existing pipeline assets, Spillover effect, Pipeline sharing

INTRODUCTION

The repeated pipeline construction is a knotty problem in P R. China. Worse still, many pipeline resources are idle, and cause numerous potential security risks. Many scholars attribute this problem to owner's system and diversified investors in pipeline construction. Naturally, they suggest the government to implement a centralized management for pipeline. One primary method is to centralize the pipeline's management right from each company to the central government, and the other method is to establish an independent pipeline company to manage the countrywide pipeline. If the problem of repeated pipeline construction mainly results from the defects of policies and institutions, the government-led centralized management for pipelines is the best solution undoubtedly. However, we shouldn't ignore the for-profit nature of the three state-owned oil and gas companies, which manage most of the pipelines in P R. China. Every decision they make is for profit. Therefore, to find out the economic reason for the behavior of repeated pipeline construction is necessary. The research results will perfect the current pipeline policies.

Pipeline asset is one of the most important factors to constitute oil and gas companies' core competence, because companies can monopolize oil and gas transportation with the help of pipelines. Therefore, nature monopolized pipeline is the vital resource for oil and gas companies to form differentiation and improving their competitiveness in downstream consumer market. However, the construction cycle of pipeline is very long. Hence, only the existing pipeline assets actually count in company's decision. It is well known that pipeline's investment income determines pipeline's construction mode. In order to find out the economic reason for the repeated pipeline construction, it is very helpful to analyze how the existing pipeline assets influence corporate profit.

The economics literature on product differentiation originates from the seminal paper of Hotelling [1]. The Hotelling model considers a market with two stores located symmetrically on a line and consumers are uniformly distributed on the line. Hotelling model uses the transportation costs to represent the difference between the two stores' products, and presents an explanation for the differentiation. For a long while, the Hotelling model has become a standard tool in oligopoly analysis [2]. As research continues, it is important to develop a new model which can be used to analyze more than two firms. Salop presents the circle model which allows an arbitrary number of differentiated oligopoly firms [3]. Although the circle model is powerful on the localized competition, it is powerless on the nonlocalized competition. As to the development of nonlocalized competition model, Chamberlin and Edward [4], Schulz and Stahl [5], Dixit and Stiglitz [6], Perloff and Salop [7], etc. all make outstanding contributions. Chen and Riordan present the Spokes model which extends the Hotelling model to allow an arbitrary number of differentiated oligopoly firms on nonlocalized competition [2].

Nowadays, the three state-owned oil and gas companies, i.e. CNPC, Sinopec and CNOOC, monopolize the oil and gas market of P R. China. One prominent manifestation of their differentiation is their different monopoly power in downstream consumer market which derives from their different existing pipeline asset scale. Therefore, based on Spokes model, this paper analyzes how the various structure of existing pipeline asset influence companies' pipeline sharing strategy and investment strategy. Finally, we present an economic explanation for repeated pipeline construction.

2. The Spokes Model On Existing Pipeline Assets

Based on the basic spokes model presented by Yongmin and Michael (2005), this paper introduces another two variables, i.e. the existing pipeline asset and its spillover effect. We use pipeline's spillover effect to describe the pipeline's sharing level among oil and gas companies here. In other words, spillover effect describes the convenience for companies to use other companies' pipelines.

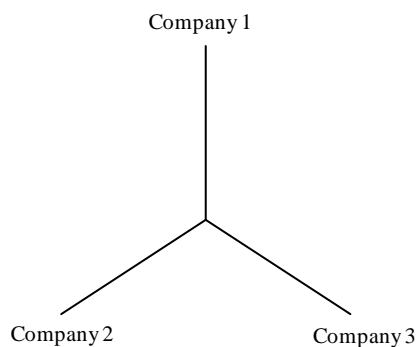


Fig.1 Spokes model

There are three oil and gas companies presenting identical products in the market. Each company is presented by a point that is the origin of a line with its length being $\frac{1}{2}$, as it is shown in fig.1. Obviously, the market is constituted of three spokes with a common core. We let i denote company, then we have $i=1,2,3$; l_i denote the spoke where company i is located on; I_i denote the existing pipeline asset of company i ; α_{ij} denote the spillover effect of company i , where $\alpha_{ii}=1, 0 \leq \alpha_{ij} \leq 1$; the company i 's cost function of pipeline investment is $\frac{1}{2}\psi I_i^2$, where $\psi > 0$ denotes the marginal cost of pipeline investment [8,9]. Let c denote pipeline maintenance cost, a denote pipeline's charge for use, and we assume $a=c$. The variable cost of production is normalized to 0.

Consumers are uniformly distributed on the spokes network, and the total mass of consumers is normalized to unity. A consumer's location on the network is fully characterized by a vector (l_i, x_i) , meaning that the consumer is on l_i at a distance x_i to company i (the origin of l_i). Consumer pays p_i for unit product bought from company i , and consumer's utility is v ; while consumer's utility is zero if he doesn't buy any product. Any consumer must travel on the spokes to reach any firm where he wishes to purchase the product, incurring positive transportation costs. The unit transportation cost, t , is normalized to unity.

Company i chooses a price strategy $p_i(x_i | \sum I_i)$, and customers choose to buy from the company providing the good

at the lowest price. Naming X as the set of customers' location x_i over the spokes network, then the demand function of company i , q_i , is: $q_i(p_i, p_{-i}) = \{x \in X, s.t. p_i(x|\sum I_i) \leq \min\{p_{-i}(x|\sum I_i)\}\}$.

$$\text{Then we have } q_i = \frac{1}{3} \left(1 + \frac{\sum p_{-i} - 2p_i}{2} + \frac{2\alpha_{ii} - \sum_{j=i} \alpha_{ij}}{2} I_i + \sum_{j=i} \frac{2\alpha_{ji} - \alpha_{jj} - \alpha_{jj}}{2} I_j \right).$$

Obviously, part of q_i benefits from the pipeline investment of company $-i$, and company i should pay for this part of q_i . We define the part of q_i which benefits from other companies' pipeline investment as the pipeline's transmission capacity which company i purchases. Similarly, we define the demands of other companies which benefit from company i 's pipeline investment as the pipeline's transmission capacity which company i sell.

Therefore, the amount of pipeline's transmission capacity which company i purchases is $\frac{1}{3} \sum_{j=i} \alpha_{ji} I_j$, and the amount of pipeline's transmission capacity which company i sell is $\frac{1}{3} I_i \sum_{j=i} \alpha_{ij}$.

Therefore, the profit function of company i is:

$$\pi_i = \frac{1}{3} \left(1 + \frac{\sum p_{-i} - 2p_i}{2} + \frac{2\alpha_{ii} - \sum_{j=i} \alpha_{ij}}{2} I_i - \frac{\sum_{j=i} (\alpha_{ij}) I_j}{2} \right) (p_i - c) + \frac{1}{3} \left(\sum_{j=i} \alpha_{ji} I_j \right) (p_i - a) + \frac{1}{3} I_i \sum_{j=i} \alpha_{ij} (a - c) - \frac{1}{2} \psi I_i^2.$$

Calculate the first-order derivation of π_i , and let $\frac{\partial \pi_i}{\partial p_i} = 0$, then we have:

$$p_i = 1 + \frac{2\alpha_{ii} - \sum_{j=i} \alpha_{ij}}{5} I_i + \sum_{j=i} \frac{2\alpha_{ji} - \alpha_{jj} - \alpha_{jj}}{5} I_j + c - \frac{3}{5} \psi \left(3I_i + \sum_{j=i} I_j \right);$$

$$q_i = \frac{1}{3} \left(1 + \frac{2\alpha_{ii} - \sum_{j=i} \alpha_{ij}}{5} I_i + \sum_{j=i} \frac{2\alpha_{ji} - \alpha_{jj} - \alpha_{jj}}{5} I_j \right) + \frac{3}{5} \psi \left(2I_i - \sum_{j=i} I_j \right).$$

3. The Example And Analysis

Let $a = c = 3$, and $\psi = 0.01$. The results are in Table 1 which is grouped by spillover effect and divided into four groups. Then we use Table 1 to analyze how the structure of existing pipeline asset and its spillover effect influence the pipeline sharing strategy and investment strategy.

Table 1: the prices, demands and profits of different structures of existing pipeline asset and its spillover effect

groups	I1	I2	I3	p1	p2	p3	q1	q2	q3	π_1	π_2	π_3
(1) $\alpha_{ij} = 1$	4	4	4	3.880	3.880	3.880	0.333	0.333	0.333	0.213	0.213	0.213
	6	6	6	3.820	3.820	3.820	0.333	0.333	0.333	0.093	0.093	0.093
	8	8	8	3.760	3.760	3.760	0.333	0.333	0.333	-0.067	-0.067	-0.067
(2) $\alpha_{ii} = 1$ $\alpha_{ij} = 0$	4	4	4	3.880	3.880	3.880	0.333	0.333	0.333	0.213	0.213	0.213
	6	6	6	3.820	3.820	3.820	0.333	0.333	0.333	0.093	0.093	0.093
	8	8	8	3.760	3.760	3.760	0.333	0.333	0.333	-0.067	-0.067	-0.067
(3) $\alpha_{ij} = 1$	4	0	0	3.928	3.976	3.976	0.349	0.325	0.325	0.244	0.318	0.318
	6	0	0	3.892	3.964	3.964	0.357	0.321	0.321	0.139	0.310	0.310
	8	0	0	3.856	3.952	3.952	0.365	0.317	0.317	-0.007	0.302	0.302
(4) $\alpha_{ij} = 1$ $\alpha_{1j} = 0$	4	0	0	5.528	3.176	3.176	0.883	0.059	0.059	2.151	0.010	0.010
	6	0	0	6.292	2.764	2.764	1.157	-0.079	-0.079	3.630	0.019	0.019
	8	0	0	7.056	2.352	2.352	1.432	-0.216	-0.216	5.488	0.140	0.140

Groups 1 and 2 describe the condition where the existing pipeline assets among oil and gas companies are symmetrical. In group 1, pipeline's spillover effect is 1, and the three companies' product prices, demands and profits are also symmetrical. As their existing pipeline assets increase, their product prices and the profits become lower and lower, while the demands remain unchanged. In group 2, pipeline's spillover effect is 0, and the result is

same to group 1's, because we assume $a=c$. Group 1 and 2 indicate that when the existing pipeline assets among oil and gas companies are symmetrical, pipeline's spillover effect makes no difference on product prices, demands and profits of the three companies. It means that whether companies share their pipeline makes no difference. Besides, each company can't make full use of its pipelines, and pipelines keep high cost to operate. Therefore, the more pipelines a company has, the lower profit it earns.

Groups 3 and 4 describe the condition where the existing pipeline assets among oil and gas companies are asymmetrical. Particularly, we let the existing pipeline assets of company 2 and 3 is 0. In group 3, pipeline's spillover effect is 1. For product price, the more pipeline assets company 1 has, the lower product prices the three companies will claim, but the company 1 suffers a bigger price falling range than the other two companies. For product demand, as the existing pipeline assets increase, company 1's demand increases, while company 2 and 3's demands decrease. For profit, the three companies' profits are negatively related to the existing pipeline assets. Besides, the profit of company 1 is lower than company 2 and 3's. The reason is that pipeline's spillover effect is 1, and it makes pipeline assets no difference among the three companies. The existing pipeline assets of company 1 should have been its important competitive edge in downstream consumer market. However, because of pipeline's spillover effect being 1, company 1 loss its pipeline advantage. What's worse, company 1 has to afford the cost of pipeline investment by itself, and company 1 suffers a higher cost, because $a=c$. In group 4, pipeline's spillover effect is 0. As the existing pipeline assets increase, the product price, the demand and the profit of company 1 increase. However, the other two companies' product prices and demands decrease, but their profits also increase like company 1. Note that when company 1's existing pipeline assets are 6 and 8, the demands of the other two companies are negative. It implies that company 2 and 3 will abandon the downstream consumer market, and turn to suppliers of company 1. It means that company 2 and 3 provide company 1 with oil and gas products and gain profits. Meanwhile, company 1 monopolizes the downstream consumer market completely, depending on its pipeline advantage. Group 3 and group 4 show the significance of pipelines in the downstream consumer market.

CONCLUSION

Based on the Spokes model, we analyze how the existing pipeline asset and its spillover effect influence the corporate profit. Afterwards, we obtain the Eq.s of product price, the demand and profit, and present an example to illustrate the model result. The primary conclusions are as follows:

- (1) When the existing pipeline assets among oil and gas companies are symmetrical, their product prices, demands and profits are also symmetrical. Besides, pipeline's spillover effect makes no difference.
- (2) When there exist companies with absolute pipeline advantage over other companies, pipeline's spillover effect will have a significant influence on product prices, demands and profits: if pipeline's spillover effect is 1, the dominant company will be trapped in a negative situation in the downstream consumer market; however, if pipeline's spillover effect is 0, the dominant company will monopolize the entire market gradually, as its existing pipeline assets increase, and the disadvantaged companies have to turn to suppliers of dominant company.

Therefore, the three oil and gas companies' pipeline sharing and investment strategies are:

- (1) The dominant company will try to keep the lowest spillover effect to enhance its monopoly power in the downstream consumer market, i.e. the dominant company will not share its pipelines with other companies.
- (2) The disadvantaged companies have two strategies: constructing pipelines to bridge the gap of pipeline, or becoming the suppliers of dominant company.

In P R. China, CNPC is the first company to realize the importance of pipeline assets. As a consequence, CNPC has an absolute pipeline advantage. One of the evidences is that its pipeline company has been the dominant professional company in pipeline transportation domain in P R. China. As the dominant company, the optimal strategy is to keep the lowest spillover effect, i.e. CNPC will not share its pipelines. Sinopec and CNOOC are very late to start constructing pipelines, and they are disadvantaged companies in fact. However, because Sinopec and CNOOC are integrative companies, they do not abandon the downstream consumer market, definitely. Therefore, they prefer to construct pipelines to bridge the pipeline gap. Obviously, it will lead to a repeated pipeline construction. Besides, according to the first conclusion, the cooperation on pipeline is relatively easy to come true between Sinopec and CNOOC, because their pipeline assets are alike.

The most intuitionistic solution to the repeated pipeline construction is to found an independent pipeline company to manage the countrywide pipelines. However, we should note that if the government can promise that sharing pipeline will not deteriorate the dominant company's competitive edge, the dominant company will not refuse sharing pipeline. In practice, some alternative plans are more moderate for government to solve the problem.

(1) The government adopts a reasonable charge scheme of pipeline use fee to encourage dominant company sharing pipelines with other companies.

The core problem is to design a reasonable pipeline charge scheme. Based on the model's results, the pipeline use fee is not only involving pipeline maintenance cost, but also the pipeline construction cost. In practice, we should also take the comprehensive capital cost rate, the business tax and pipeline's service life into consideration.

The mainly variables of pipeline charge scheme are, i , the company; S , the total pipeline construction cost; a , the pipeline maintenance cost's percent of the total construction cost; t , the business tax rate; r , the comprehensive capital cost rate; n , the pipeline's service life; Y , the annual pipeline use fee; b , the lease term; z , the number of lessees. Obviously, company i prefers to share its pipelines, if and only if the pipeline construction cost is less than pipeline's leasing cost [10]. That is: $S + a\%S \sum_{i=1}^n \frac{1}{(1+r)^i} - zY(1-t) \sum_{i=1}^b \frac{1}{(1+r)^i} \leq Y \sum_{i=1}^b \frac{1}{(1+r)^i}$. Then we have

$$Y \geq \frac{\left(1 + a\% \sum_{i=1}^n \frac{1}{(1+r)^i}\right) S}{\left[z(1-t) + 1\right] \sum_{i=1}^b \frac{1}{(1+r)^i}}.$$

Based on company's historical data, all variables can work out particular values. If the

annual pipeline use fee is very low, none of the companies will construct pipelines or share pipelines. However, if the annual pipeline use fee is very high, all companies will prefer to construct pipelines by themselves. Only a reasonable and modest pipeline use fee can encourage companies to cooperate for pipelines. Therefore, a modest Y

is that $Y = \frac{\left(1 + a\% \sum_{i=1}^n \frac{1}{(1+r)^i}\right) S}{\left[z(1-t) + 1\right] \sum_{i=1}^b \frac{1}{(1+r)^i}}.$

(2) According to the pipeline's distribution, that the government facilitates the cooperation of industry chains belonging to different companies is an effective way to solve the problem of repeated pipeline construction.

Based on group 4's analysis, the dominant company will monopolizes the downstream consumer market completely, depending on its pipeline advantage. Meanwhile, other companies will abandon the market and turn to the suppliers of the dominant company. It is a promising cooperation mode, and can reach a win-win result. Actually, this cooperation mode is a transformation of the conventional pipeline-sharing mode. A typical example is the comprehensive cooperation of Sinopec and CNOOC in natural gas market in south China. As to the pipeline assets, Sinopec is superior to CNOOC. However, CNOOC has more natural gas resources than Sinopec. Therefore, CNOOC becomes the supplier of Sinopec, and Sinopec is responsible for the market. CNOOC need not to construct pipelines and Sinopec doesn't worry about the natural gas supply. Their cooperation is not only good for themselves, but also good for customers.

(3) If the government must found an independent pipeline company, the government must protect the legitimate rights and the interests of companies which own the property right of pipeline.

The second conclusion has elucidated the important role which pipelines play for oil and gas companies in the downstream consumer market. Therefore, if the government must separate pipelines with oil and gas companies, the government should offer enough compensation to oil and gas companies. Besides, from the perspective of opportunity fair, the government should provide additional compensation to the dominant company, because the dominant company will lose its competitive edge.

In the end, we discuss the policy that the government centralizes the pipelines from oil and gas companies to an independent pipeline company, which is called 'pipeline independence' by Chinese scholars, briefly. Obviously, pipeline construction has made great progress in P R. China. However, compared with the United States and Russia, it still falls behind. Nowadays, Chinese pipeline industry is still in investment-construction stage, and needs a lot of capital. Relatively speaking, the income from pipeline investment is low, while the investment cycle is lengthy. Nonetheless, Chinese oil and gas companies still maintain a high enthusiasm to construct pipelines. They even use the profits from their upstream industries to support the pipeline construction. The reason is that companies are all firmly believe the principle that only the people who invest will benefit from their former investment. If the government allocates the pipelines to a pipeline company, then the pipeline company will be responsible for pipeline

construction. The first severe dilemma which pipeline company will face is to finance for pipeline construction. Firstly, national finance can't be invested to pipeline construction, definitely. Secondly, private capital is hardly introduced to pipeline industry for its low income and long investment cycle. The only capital source of pipeline company is the pipeline use fee. Compared with the pipeline investment scale, it is insufficient. In order to raise fund, the only way for the pipeline company is to raise pipeline use fee. But it will lead to a higher oil and gas price, and it is the ordinary consumers that bear the rising price pressures, actually. Therefore, the oil and gas companies are the most appropriate organization to construct pipelines. In a word, founding a pipeline company represents the general trend, but it is not the right time now.

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