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Quasi-Rents and Pricing Gas in Mexico

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Abstract

In 1997, the Comisión Reguladora de Energía of Mexico implemented a netback rule for linking the Mexican natural gas price to the Texas price. At the time, the Texas price reflected a reasonably competitive market. Since that time, there have been dramatic increases in the demand for natural gas and there are various bottlenecks in the supply of natural gas. As a result, the price of natural gas in Texas now reflects the quasi-rents created by these bottlenecks.

This paper addresses the optimality of the netback rule when the price of gas at the Texas market reflects the quasi-rents created by bottlenecks in the supply of natural gas to the United States pipeline system. In this paper, it is shown that it is optimal for the Mexican government to use the netback rule based on the Texas price of gas to set the price natural gas in Mexico even though the Texas market cannot be considered a competitive market, and the Texas price for natural gas reflects quasi-rents created by various bottlenecks.

The indirect welfare function approach used in this paper can be extended to address the problem of pricing gas when there are multiple sources of imported gas from LNG terminals.

Resumen

En 1997, la Comisión Reguladora de Energía (CRE) implementó la regla netback para ligar el precio del gas natural en México al precio en Texas. En ese entonces, el precio en Texas reflejaba un mercado razonablemente competitivo. A partir de ese año, se ha incrementado dramáticamente la demanda de gas natural y se han originado varios cuellos de botella en el suministro de gas natural. Como resultado, ahora el precio del gas natural en Texas refleja las cuasi-rentas creadas por tales cuellos de botella.

Este documento aborda la optimalidad de la regla netback cuando el precio del gas en el mercado de Texas refleja las cuasi-rentas creadas por los cuellos de botella en el suministro de gas natural en el sistema de gasoductos de Estados Unidos. En este trabajo se muestra que es óptimo para el gobierno mexicano utilizar la regla netback basada en el precio del gas en Texas para fijar el precio de gas natural en México, aun cuando el mercado Texano no sea considerado un mercado competitivo y el precio del gas en Texas refleje las cuasi-rentas creadas por varios cuellos de botella.

La función de bienestar indirecta utilizada en este documento puede ser extendida para abordar el problema de fijación del precio del gas cuando existan múltiples fuentes de gas importado a terminales de GNL.

Introduction

The Comisión Reguladora de Energía (CRE) has implemented the netback rule that uses the price of gas in Texas to set the price of gas in Mexico adjusting for transportation costs since 1996.[1] At that time, the price gas in Texas was viewed to be the result of a competitive market. Using the netback rule meant that Pemex became a price taker in the gas market and lost monopoly power with respect to setting prices. The equilibrating mechanism in the natural gas market was the supply of gas; prices were fixed by the Texas price and the movement of gas within Mexico and between Texas and Mexico insured that the supply of gas equaled the demand for gas. The Mexican gas market would also have the characteristics of a competitive market as long as there were no constraints to the flow of gas and gas was able to move to equilibrate supply and demand. The price of gas to a Mexican consumer was the Texas price corrected by transport costs. It should be noted that the netback rule allows Pemex and Mexican consumers to have access to the Texas forward gas markets so as to diversify risk.

The pricing rule based on the Houston Ship Channel price was an implementation of the Little-Mirrlees proposal for pricing traded goods. (See Brito and Rosellón, 2002, 2005.) When the Little-Mirrlees rule was first implemented, the price gas in the United States was on the order of $2.00 to $.2.50 per thousand cubic feet and since the gas market in the United States was viewed as close to competitive, using the Little-Mirrlees netback rule with a Texas benchmark was a reasonable methodology to price gas.[2]

Since then, conditions have changed. The increase in the demand for gas has resulted in various bottlenecks in the supply of natural gas. The price of gas in the United States now reflects the quasi rents to these bottlenecks.[3] The current pricing policy in Mexico is now imputing these economic rents to the gas produced at Ciudad Pemex. This note is a reexamination of the optimality of the netback rule when the base price of gas reflects quasi rents to such bottlenecks.

There would be two alternative candidates to the netback rule for pricing gas in Mexico. The first is the intertemporal opportunity cost of gas. Mexico produces non-associated gas, so at the margin Mexico faces the tradeoff between consumption of gas in the present, and consumption of gas in the future. The opportunity cost of finding non-associated gas reserves reflects that margin. The cost of acquiring non-associated gas reserves should

[1] See Comisión Reguladora de Energía, 1996.

[2] Little and Mirrlees (1968) proposed the use of the world prices for traded goods, not necessarily because theses prices are more rational, but rather because these prices reflect the terms under which a country can trade. Thus, the price of gas in Texas is a measure of the opportunity cost to Mexico of consuming the gas rather than exporting it to the United States.

[3] See Hartley and Medlock (2006).

reflected the value of the gas when it is consumed in the future. Hartley and Medlock (2006) suggest that in a five to ten year horizon as the bottlenecks on LNG are eliminated the price of gas should be in the $3.50 to $4.50 range. The question is whether the optimal price for gas in Mexico should use the price implied by the intertemporal price or should the current price of gas in Mexico reflect the quasi-rents associated with the various bottlenecks that exist in the gas market.

The other candidate for pricing natural gas in Mexico would be the price of alternate fuels in the production of electricity. There are many gas contracts where the price is based on the price of alternate fuels, so the optimality properties of this pricing methodology have to be addressed.

To see the problem, suppose that Mexico was an isolated economy that was neither importing nor exporting gas. Assume that as a result of some intertemporal maximization there was a well-defined price that was a correct measure of the opportunity cost of discovering and producing gas. In a dynamic programming problem, this would be the costate variable associated with non-associated gas reserves. This costate variable is the value to Mexico of adding or subtracting on unit of gas at that time. It is easy to show that the correct price of gas for gas is that intertemporal price. At the margin Mexico should be indifferent to consuming a unit of gas or adding it to its non-associated gas reserves. Now suppose that Mexico is now linked to an external market where there is a different price of gas. Further assume that this different price reflects quasi-rents caused by some temporary bottlenecks. Using the netback rule to set the price of gas in Mexico would mean that Mexico would stop using the price of gas that correctly measures the tradeoff between the consumption of gas now and the consumption of gas in the future. The surprising result that we obtain in this paper is that,even in this case, the netback rule is optimal. The simple intuitive argument is that Mexico could capture some of the quasi-rents by reducing its consumption, and exporting gas.

2. Model

The model is intended to address the question of the netback rule when there are quasi-rents in the market from which gas is being imported or exported. This means that the netback rule no longer gives the Mexican gas market the characteristics of a competitive market. We will show that, given that most of the gas consumed in Mexico is produced in Mexico, is it optimal to impute the quasi-rents in the Texas market to gas produced in Mexico.

To address this problem we must include certain essential elements in our model. First, since the net revenue from sale of hydrocarbons by the state-owned monopoly, Pemex, goes to the government and the government captures the quasi-rents from natural gas, it is necessary for the model to have a private good and a public good to justify a role for government revenues. It will be assumed that government has two sources of revenue: taxation of individuals, T, and and the revenue from the sale of oil and gas.[4] The purpose of government is to provide a public good. In the one sector model we will assume that the government does not tax to redistribute income.

Electricity is one of the most important uses of natural gas in Mexico. Since one of the alternatives for pricing natural gas we are studying is to use the price of fuel oil used in the generation of electricity as a way of pricing natural gas, electricity and natural gas are included in the utility function. However, since we will assume that the price of oil is set on the world market, oil will be treated as an input in the production of electricity and not as consumption good. Thus, it will be assumed that utility depends on consumption of a private good, X, natural gas, G_1, electricity, Y and a public good Z. Government provides the public good, Z and the price of Z will be normalized to 1. The planner is assumed to control the domestic price of gas, p_1 and the price of electricity p_2. The price of the private consumption good is q_3. It is assumed that this price is set on the world market.

Mexico is a large country and transportation is an important component in the cost of gas. Mexico could be importing and exporting gas. For example, if the Burgos fields in the north of Mexico live up to their expected promise,[5] Mexico could be exporting gas into Texas while it is importing LNG in the Pacific. Movements of gas within Mexico, and the cost of transporting gas, would be the equilibrating factors. Since this paper is abstracting from such detail we will assume that the import price of gas is equal to the export price of gas.[6] Similarly, we are going to assume that in the oil market the domestic price of oil is equal to the world price of oil.

Assume that the utility function of the representative agent is given by:

(2.1) $$u(G_1, X, Y, Z)$$

The representative agent maximizes (2.1) subject to the budget constraint:

(2.2) $$F(T) = p_1 G_1 + q_3 X + p_2 Y + Z$$

[4] We have looked at the problem of the redistributive impact of the netback in the context of a two-sector model. The result that the netback rule is optimal does not depend on the structure of the welfare function and the two-sector model is more complicated. Results depend on the assumption made about the curvature of the underlying utility functions. We decided to use the more general and simpler model to illustrate the result.

[5] The U.S. Geological Survey estimated a mean of 6.2 billion barrels of undiscovered oil (with 7.4 trillion cubic feet of associated gas), a mean of 0.52 billion barrels of undiscovered natural gas liquids, and a mean of 12.9 trillion cubic feet of undiscovered nonassociated gas in the Burgos Basin Province of northeastern Mexico (see USGS, 2004).

[6] See Brito and Rosellón (2002) for details on the netback price mechanism. The Mexican gas network is going to become more complicated as new LNG terminals come on line, and there will be multiple sources of gas. Some of this gas will be indexed to different reference markets such as Henry Hub. This structure can be added to our model by including the new gas sources in the constraint set. The indirect welfare function can be generalized to include multiple points of consumption.

Recall that *T* is the tax. We will define

(2.3) $$v\left[p_1, p_2, T, Z\right] = \max\ u(G_1, X, Y, Z)$$

as the indirect utility function. Note that we are not including the price of the consumer good, q_3, as an argument of the indirect utility function as it is a parameter whose value is determined by the world market. We will assume that the goal of the planner is to maximize the utility of the representative agent.

Pemex produces Q amount of oil; of this oil, Q_1 is exported and Q_2 used in Mexico to produce electricity. Thus

(2.4) $$Q = Q_1 + Q_2 .$$

There is a flow constraint on the production of oil so that

(2.5) $$Q \le \bar{Q}$$

Associated gas, G_2 is produced jointly with oil. The production of Mexican associated gas is given by

(2.6) $$G_2 = \alpha Q$$

where α is a technological parameter that links the production of oil to the production of associated gas . Mexico also produces non-associated gas, G_3 and there is a flow constraint. $\bar{G}_3$ on the production of non-associated gas.

(2.7) $$G_3 \le \bar{G}_3$$

Gas is also exported to or imported from the United States. Denote imported gas by G_4 and exported gas by G_5. In summary, the sources of gas in Mexico are associated gas, G_2, non-associated gas, G_3 and imported gas, G_4. Gas is used for consumption, G_1, exports, G_5, and the production of electricity, G_6.

(2.8) $$G_2 + G_3 + G_4 = G_1 + G_5 + G_6$$

Electricity, Y, is produced by burning oil or gas. The production function for producing electricity when using oil is

(2.9) $$Y_1 = \beta_1 Q_2 .$$

The production function for producing electricity using gas is given by

(2.10) $$Y_2 = \beta_2 G_6 ,$$

where β_1 and β_2 are the heat rates associated with oil and natural gas respectively. Total electricity is given by

(2.11) $$Y = Y_1 + Y_2$$

It will be assumed that there are capacity constraints,

(2.12) $$Y_1 \le \bar{Y}_1$$

and

(2.13) $$Y_2 \le \bar{Y}_2$$

for generation capacity. The price of electricity is p_2.

We will assume that Pemex has solved the intertemporal planning problem associated with the production of oil and non-associated gas. The dual variables associated with this optimization give the marginal value to Mexico of the oil and non-associated gas stocks. This is the marginal value to Mexico of adding or selling oil or non-associated gas. As mentioned above the dual variable that corresponds to non-associated gas is a possible candidate for a Mexican price for natural gas. Let π_1 be the dual associated with non-associated gas, and π_2 be the dual associated with oil.[7]

Define p_1 as the domestic price of gas and q_1 as the prices of imported and exported gas. Let p_2 be the price of electricity, and q_2 be the price of oil. It will be assumed that all prices, except the price of natural gas in Mexico and electricity are given and fixed.

The government sets the price of natural gas, the price of electricity and the tax rates. The government also chooses the inputs into the production of electricity, and the level of exports of oil and imports of gas.

The budget constraint of government is

(2.14) $$T + q_2Q_1 + p_1G_1 + q_1G_5 + p_2Y = q_1G_4 + Z .$$

Government revenue is tax revenue plus the revenue from the sale of domestic gas, plus oil and gas exported. Government expenditures are the cost of imported gas plus the cost of the public good.

3. Optimality Conditions

If the government is maximizing welfare, the Lagrangian is given by

(3.1) $$\begin{aligned} L = {} & V\left(p_1, p_2, T, Z\right) + \lambda_1\left(G_2 + G_3 + G_4 - G_1 - G_5 - G_6\right) + \lambda_2\left(Q - Q_1 - Q_2\right) \\ & + \lambda_3\left(Y_1 + Y_2 - Y\right) + \lambda_4\left(\beta_1 Q_2 - Y_1\right) + \lambda_5\left(\beta_2 G_6 - Y_2\right) + \lambda_6\left(\alpha Q - G_2\right) \\ & + \delta_1\left(\bar{G}_3 - G_3\right) + \delta_2\left(\bar{Q} - Q\right) + \delta_3\left(\bar{Y}_1 - Y_1\right) + \delta_4\left(\bar{Y}_2 - Y_2\right) \\ & + \gamma\left(T + q_2Q_1 + p_1G_1 + q_1G_5 + p_2Y - q_1G_4 - Z\right) - \pi_1 G_3 - \pi_2 Q \end{aligned}$$

The first order conditions are:

A. Choice of prices, p_1, q_2, T and Z

(3.2) $$\frac{\partial V\left(p_1, p_2, T, Z\right)}{\partial p_1} + \gamma\left(G_1 + G_5\right) = 0$$

[7] Given that Pemex is investing in capital to augment the stock of gas and oil reserves, one would expect that they have computed the marginal value to Mexico of adding to the stock of oil or non-associated gas. If it had been a result of this paper that the value of the duals associated with these stocks should be used to price natural gas, then the validity of the assumption that Pemex has solved the planning problem of production of oil and non-associated gas could be questioned. However, it turns out that it is not correct to use the duals to price gas, so the accuracy of the duals used for planning is not an issue.

(3.3) $$\frac{\partial V\left(p_1, p_2, T, Z\right)}{\partial p_2} + \gamma Y = 0$$

(3.4) $$\frac{\partial V\left(p_1, p_2, T, Z\right)}{\partial T} + \gamma = 0$$

B. Extraction and Exports G_3 Q and Q_1

(3.5) $$\lambda_1 - \delta_1 - \pi_1 \leq 0;\ \ G_3\left[\lambda_1 - \delta_1 - \pi_1\right] = 0$$

(3.6) $$\lambda_2 - \delta_2 - \pi_2 + \lambda_6\alpha \leq 0;\ \ \mathrm{Q}\left[\lambda_2 - \delta_2 - \pi_2 + \lambda_6\alpha\right] = 0$$

(3.7) $$-\lambda_2 + \gamma q_2 \leq 0;\ \ Q_1\left[-\lambda_2 + \gamma q_2\right] = 0$$

Allocation of gas, G_1, G_4 and G_5

(3.8) $$-\lambda_1 + \gamma p_1 \leq 0;\ \ G_1\left[-\lambda_1 + \gamma p_1\right] = 0$$

(3.9) $$\lambda_1 - \gamma q_1 \leq 0;\ \ G_4\left[\lambda_1 - \gamma q_1\right] = 0$$

(3.10) $$-\lambda_1 + \gamma q_1 \leq 0;\ \ G_5\left[-\lambda_1 + \gamma q_1\right] = 0$$

C. Choice of Electricity inputs G_6 and Q_2

(3.11) $$-\lambda_1 + \lambda_5\beta_2 \leq 0;\ \ G_6\left[-\lambda_1 + \lambda_5\beta_2\right] = 0$$

(3.12) $$-\lambda_2 + \lambda_4\beta_1 \leq 0;\ \ \mathrm{Q}_1\left[-\lambda_2 + \lambda_4\beta_1\right] = 0$$

D. Production of Electricity Y, Y_1 and Y_2

(3.13) $$-\lambda_3 + \gamma p_2 \leq 0;\ \ Y\left[-\lambda_3 + \gamma p_2\right] = 0$$

(3.14) $$\lambda_3 - \lambda_4 - \delta_3 \leq 0;\ \ Y_1\left[\lambda_3 - \lambda_4 - \delta_3\right] = 0$$

(3.15) $$\lambda_3 - \lambda_5 - \delta_4 \leq 0;\ \ Y_2\left[\lambda_3 - \lambda_5 - \delta_4\right] = 0$$

4. Optimality of Little-Mirrlees Rule

Proposition 1

If the Texas market price for natural gas reflects quasi-rents to a scarce factor, it is still optimal to use the Texas price to set the price of gas in Mexico and the Little-Mirrlees Rule is optimal.

Proof

The Kuhn-Tucker conditions for gas imports, G_4, and exports, G_5, given by (3.9) and (3.10) can be written as

(4.1) $$\lambda_1 - \gamma q_1 \leq 0$$

(4.2) $$\lambda_1 - \gamma q_1 \geq 0$$

These two conditions can only be satisfied if both hold as equalities and

(4.3) $$\lambda_1 = \gamma q_1 .$$

If gas is consumed in Mexico, $G_1 > 0$, then the Kuhn-Tucker condition given by (3.8) must also hold as an equality

(4.4) $$-\lambda_1 + \gamma p_1 = 0$$

and using (4.3)

(4.5) $$p_1 = \frac{\lambda_1}{\gamma} = q_1 .$$

It follows immediately from the Kuhn-Tucker conditions that if gas is consumed in Mexico the Little-Mirrlees Rule is optimal.

The economic intuition behind the result is very straight-forward. The Lagrange multiplier λ_1 is the shadow price of gas in utils, and the term γq_1 is the cost of gas to Mexico in utils. If Mexico is importing gas then the condition, $\lambda_1 = \gamma q_1$, must hold as λ_1 is the value to Mexico of one unit of gas and γq_1 is what Mexico has to give up to import one unit of gas. These two must be equal if Mexico is maximizing.

The government of Mexico chooses the domestic price of gas to maximize welfare. Recall that γp_1 is the marginal value of a cubic foot of gas. If the government of Mexico sets the domestic price of gas p_1 such that $\gamma p_1 > \lambda_1 = \gamma q_1$, then welfare can be improved by lowering price, and importing more gas as the gain, γp_1, is greater than the loss γq_1. Similarly, if the government of Mexico sets the domestic price of gas p_1 such that $\gamma p_1 < \lambda_1 = \gamma q_1$, then welfare can be improved by raising price and importing less gas as the gain, γq_1, is greater than the loss γp_1.

5. Alternative Methodologies for Pricing Gas

Having established that the Little-Mirrlees Rule is optimal, let us consider the two other candidates for pricing domestic gas in Mexico. The first candidate is the costate variable associated with non-associated gas reserves in Mexico. Inasmuch as this is the value to Mexico of adding to or subtracting from its gas reserves, the costate variable seems like an obvious candidate. If gas is consumed in Mexico, $G_1 > 0$ and from (3.8)

(5.1) $$\lambda_1 = \gamma p_1$$

Since we have shown that the Little-Mirrlees Rule is optimal

(5.2) $$\lambda_1 = \gamma q_1 .$$

If Mexico is producing non-associated gas, $G_3 > 0$, then the Kuhn-Tucker condition for the production of non-associated gas given by (3.5) must hold as a equality and

(5.3) $$\lambda_1 - \delta_1 - \pi_1 = 0 .$$

where δ_1 is the dual associated with the constraint on the production of non-associated gas.

The condition $\gamma p_1 = \lambda_1 = \pi_1$ can hold only if the production constraint is not binding, and $\delta_1 = 0$. This means that the costate variable that corresponds to non-associated gas is correct value to use in determining the domestic price of gas in Mexico only if there is sufficient production capacity in Mexico to bring the Houston and Mexican markets into equilibrium at the price implied by the costate variable or, trivially, that the Houston price happens to be the same as the value of the costate variable and Mexico is indifferent between buying gas in Houston and producing gas.

Now let us consider the use of the marginal rate of substitution between fuel oil and gas as a mechanism for the pricing of gas. If oil is exported, the condition (3.7) is

(5.4) $$-\lambda_2 + \gamma q_2 = 0 .$$

If gas and fuel oil are both used in the production of electricity, then the Kuhn-Tucker conditions for the fuel choice, (3.11) and (3.12), can be written as

(5.5) $$-\lambda_1 + \lambda_5 \beta_2 = 0$$

(5.6) $$-\lambda_2 + \lambda_4 \beta_1 = 0 .$$

The Kuhn-Tucker conditions (3.14) and (3.15) for the production choice must hold as

(5.7) $$\lambda_3 - \lambda_4 - \delta_3 = 0$$

(5.8) $$\lambda_3 - \lambda_5 - \delta_4 = 0 .$$

If neither technology is facing a capacity constraint, then $\delta_1 = \delta_2 = 0$, $\lambda_4 = \lambda_5$ and from

(5.9) $$\lambda_1 = \frac{\beta_2}{\beta_1} \lambda_2$$

or using (5.4)

(5.10) $$\lambda_1 = \frac{\beta_2}{\beta_1} \gamma q_2 .$$

Recall that

(5.2) $$\lambda_1 = \gamma q_1$$

is a necessary condition for optimality. Thus (5.10) can hold only if the cost of producing electricity is the same for both fuels when natural gas in Mexico is priced at the Texas price.

(5.11) $$\frac{\beta_2}{q_1} = \frac{\beta_1}{q_2} .$$

Suppose that $\frac{\beta_2}{q_1} > \frac{\beta_1}{q_2}$, then if the fuel oil generation capacity is sufficient to meet the requirements, only fuel oil would be used to produce electricity.

Suppose that one of the technologies for producing electricity had a capacity constraint. Then the assumption that $\delta_1 = \delta_2 = 0$ and $\lambda_4 = \lambda_5$ would not hold. We will show that, in that case, the technology that has the less expensive fuel earns rents.

Suppose that fuel oil is less expensive in the production of electricity, but the fuel oil generation capacity is not sufficient to meet the requirements. Then gas would also be used to produce electricity. $G_6 > 0$ implies that (3.11) must hold as

(5.12) $$-\lambda_1 + \lambda_5 \beta_2 = 0$$

If the gas generation capacity is not binding then $\delta_4 = 0$ and (3.15) must hold as

(5.13) $$\lambda_3 - \lambda_5 = 0$$

From (3.11) and (5.1)

(5.14) $$\lambda_5 = \frac{\lambda_1}{\beta_2} = \frac{\gamma p_1}{\beta_2}$$

and from (5.13)

(5.15) $$\lambda_3 = \lambda_5 = \frac{\gamma p_1}{\beta_2}$$

Then $Y > 0$ implies that (3.13) must hold as

(5.16) $$\lambda_3 = \gamma p_2$$

so combining (5.15) and (5.16) the price of electricity is given by

(5.18) $$p_2 = \frac{p_1}{\beta_2}.$$

From (5.4) and (5.6)

(5.19) $$\lambda_4 = \frac{\lambda_2}{\beta_1} = \frac{\gamma q_2}{\beta_1}.$$

Since (3.14) must hold as as an equality

(5.20) $$\delta_3 = \lambda_3 - \lambda_4$$

If we use (5.16), (5.18), and (5.19) we get

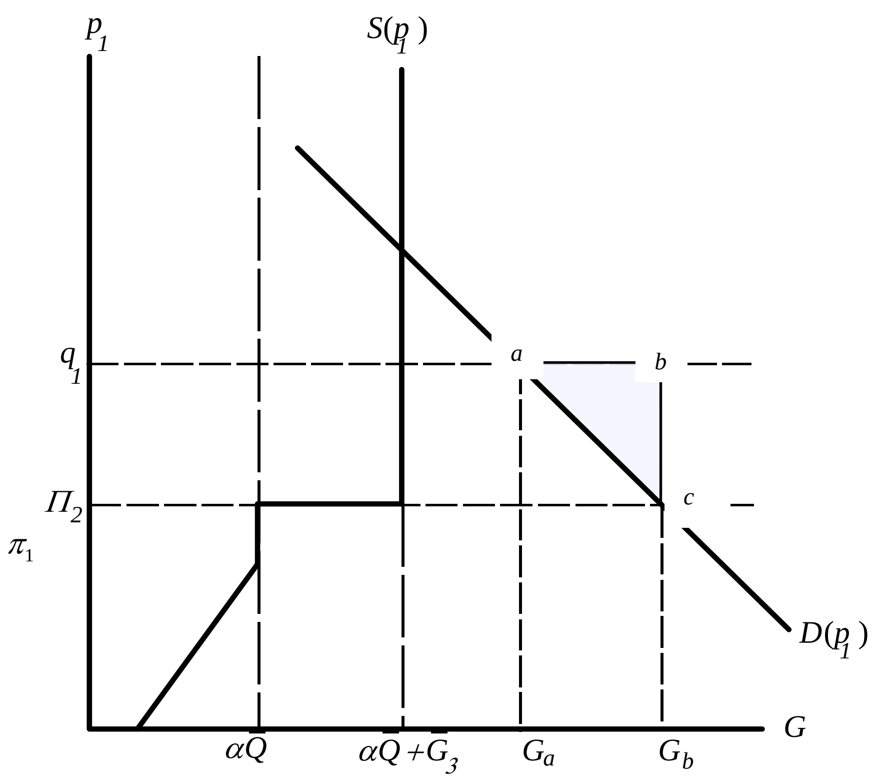
(5.21) $$\delta_3 = \gamma\left(\frac{p_1}{\beta_2} - \frac{q_2}{\beta_1}\right)$$

so the fuel oil generation capacity is allocated the rents associated with being the less expensive fuel.

6. Supply and Demand Analysis of Problem

The result that it is optimal to set the price of natural gas in Mexico to the Texas price follows directly from the formulation of the technological structure of the problem and the Kuhn-Tucker conditions given by (3.9) and (3.10). The result is very strong and robust to various assumptions about the objective function. It is just necessary that gas be a good. Unfortunately, the result might not be very intuitive for individuals who do not regularly work with duality and nonlinear programming. In this section we are going to explain the results intuitively using supply and demand curves.

FIGURE 1



The domestic supply curve for gas in Mexico, $S(p_1)$, is depicted in Figure 1. The lower part of the supply curve comes from associated gas. Inasmuch as gas had to be flared if it is not used, the intercept at $p_1 = 0$ could be positive. Pemex has internal demand for gas, but the supply is likely to be increasing as the price goes up. When all associated gas has been sold, the supply curve becomes vertical. This will continue until the price of gas reaches the replacement cost of non-associated gas, π_1. At that point the supply of gas will increase to the capacity constraints and become vertical again. When the price of gas reaches the Texas price, q_1, Mexico faces a horizontal supply and demand curve at that price since Mexico can export or import gas at q_1. In Figure 1, the demand curve for gas is such that the demand for gas at a price π_1 is $G_b > \alpha\bar{Q} + \bar{G}_3$. Mexico has to import gas. If Mexico sets the domestic price of gas equal to π_1, the demand will be equal to G_b. If Mexico sets the domestic price of gas equal to q_1, the demand will be equal to G_b. If Mexico wants to consume more than domestic production, $\alpha\bar{Q} + \bar{G}_3$, it must pay the Texas price, q_1 for the additional gas. The demand curve represents the value of the marginal unit of gas so if Mexico consumes more gas than G_a, it must pay q_1 for that gas, but the value of that gas is given by the demand curve so for all consumption of gas greater that G_a, the marginal value of the gas is less than the price. The shaded triangle a-b-c represents the welfare loss. Reducing the consumption of gas to the point supported by the Texas price eliminates the welfare loss, so if Mexico is importing gas, it is optimal to set the price of gas in Mexico to the Texas price.

The Mexican gas network is going to become more complicated as new LNG terminals come on line and there will be multiple sources of gas to the system. Some of this gas will be indexed to different reference markets such as Henry Hub. This more complicated structure cannot be analyzed using simple supply and demand analysis. However, multiple import points and multiple pricing references can be added to this model by including this structure in the constraint set. The indirect welfare function can be generalized to include multiple points of consumption.

FIGURE 2

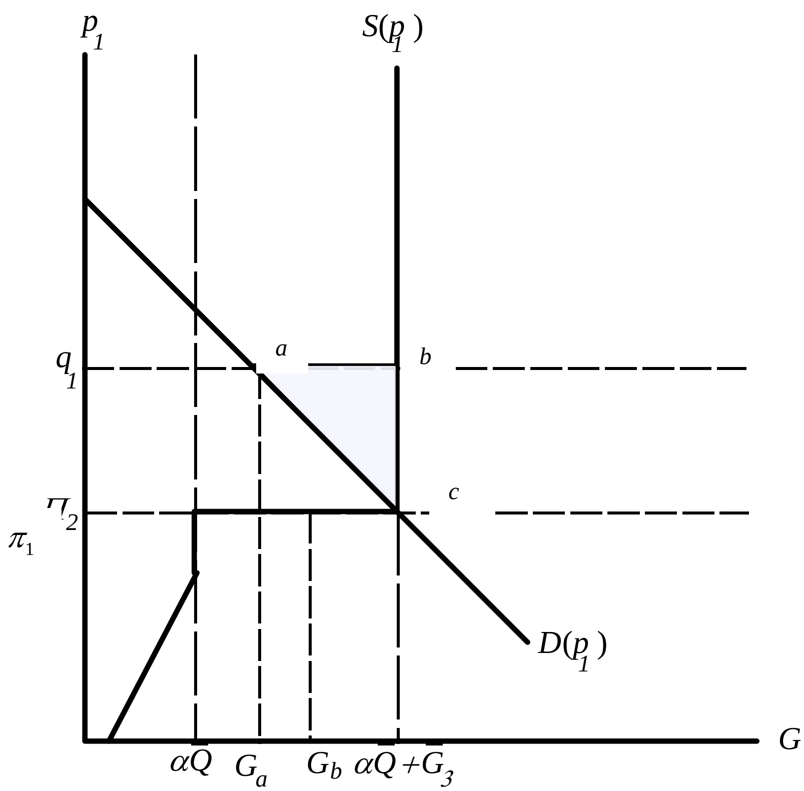


Figure 2 above represents the case where Mexico is producing just enough gas to meet its demand a price equal to the opportunity cost of non-associated gas, π_1. Supply and demand could support a price less than the Texas price q_1. However, that is not optimal. Mexico can sell gas at the Texas price q_1. For all amounts of gas greater than G_a, the value of gas to Mexico as given by the demand curve for gas is less than the export price. The welfare loss is depicted by the shaded triangle a-b-c.

Conclusions

When the CRE introduced the netback rule to price of gas in Mexico, the policy could be justified as linking the Mexican market to what was a competitive market for gas in Texas. Linking the Mexican market to the Texas market made Pemex a price taker and as long as gas was free to move the Mexican gas market had most of the attributes of a competitive market.

At the present time however, the increase in the demand for gas has resulted in various bottlenecks in the supply of natural gas. The price of gas in the United States now reflects the quasi rents to these bottlenecks. The question is whether the using the Texas price is still a good way to price gas in Mexico. The obvious alternative candidate is the shadow price of non-associated gas, since that reflects the intertemporal tradeoff Mexico faces between the price of gas in the present, and the price of gas in the future. It is not obvious why this is not the correct margin as opposed to the price of gas in Texas.

The formal analysis in this paper shows that this argument is not correct. The opportunity cost of natural gas to Mexico is the price of natural gas in the Texas market. If Mexico is importing gas, the Texas price is the opportunity cost of consuming gas and if Mexico is exporting gas, the Texas price is still the opportunity cost of consuming gas. It is what Mexico has to give up to consume that marginal amount of gas.

The result is best illustrated in the case, discussed in Section 6, where the demand for gas and the supply of gas is equal at the intertemporal price. The intertemporal price can equilibrate supply and demand in Mexico, but if the Texas price is higher than the intertemporal price, then it is optimal to reduce consumption of gas in Mexico and export gas to Texas.

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