Infrastructure investments and incentive regulation

Juan Rosellón

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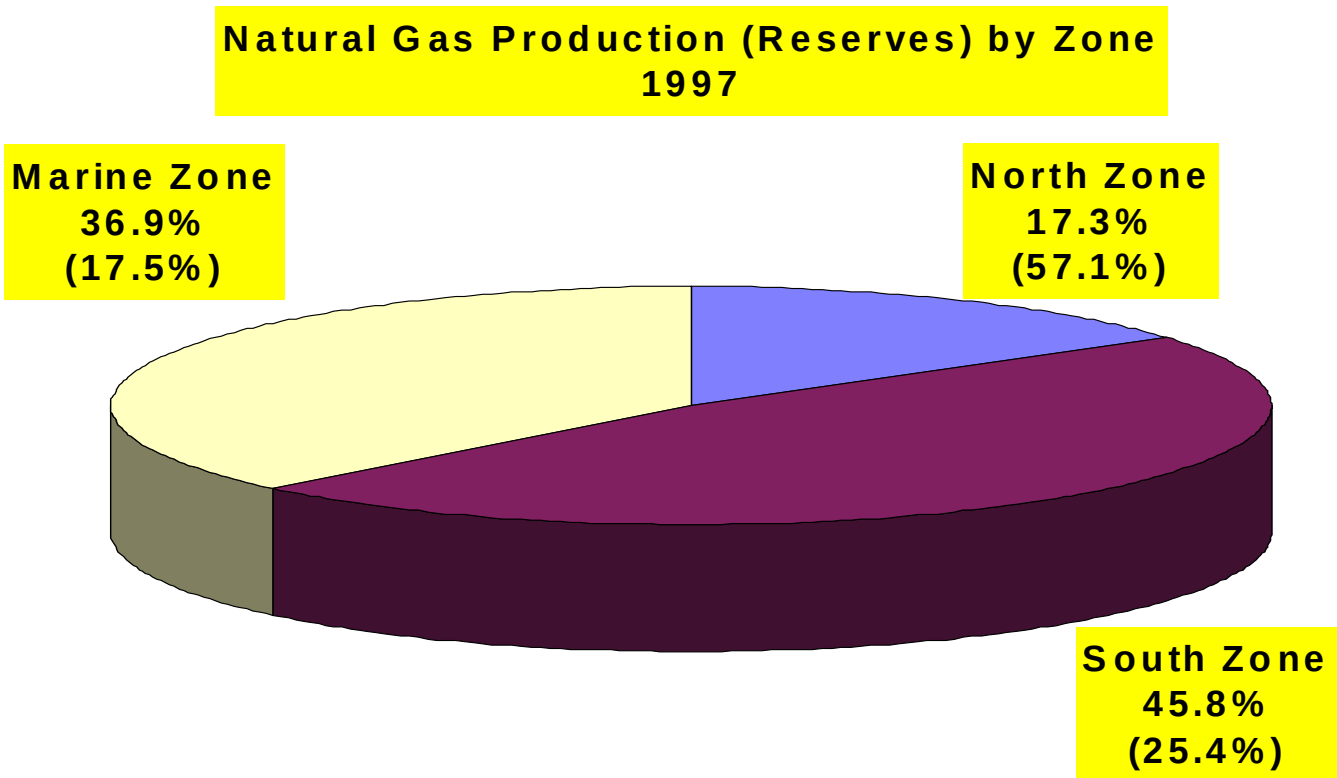
- Incentive regulation concepts
- Incentive regulation and its effects on infrastructure investment:
  - Distribution
  - Transportation
  - Production
- Conclusions

Regulatory reform process of the natural gas industry

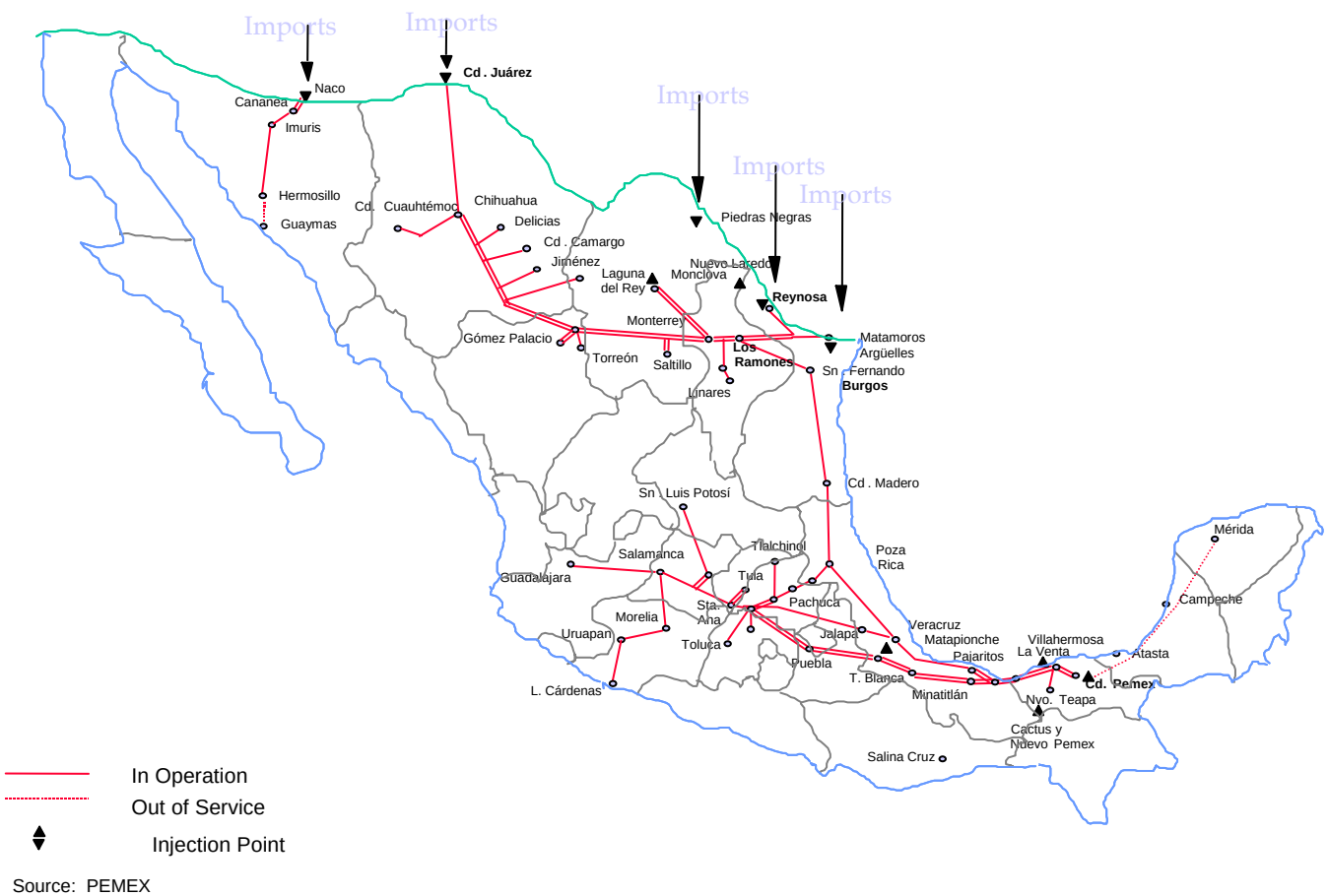
REGULATORY REFORM

- Make Pemex invest more in production and development of reserves, and keep in good shape the already existing pipeline transportation network.
- Attract private investment to develop infrastructure in distribution systems, new transportation pipelines as well as in gas marketing.
- All these through a regulatory-reform process that implied regulatory decisions regarding industrial structure and incentive regulation (prices, auctions, etc.).

Production and reserves

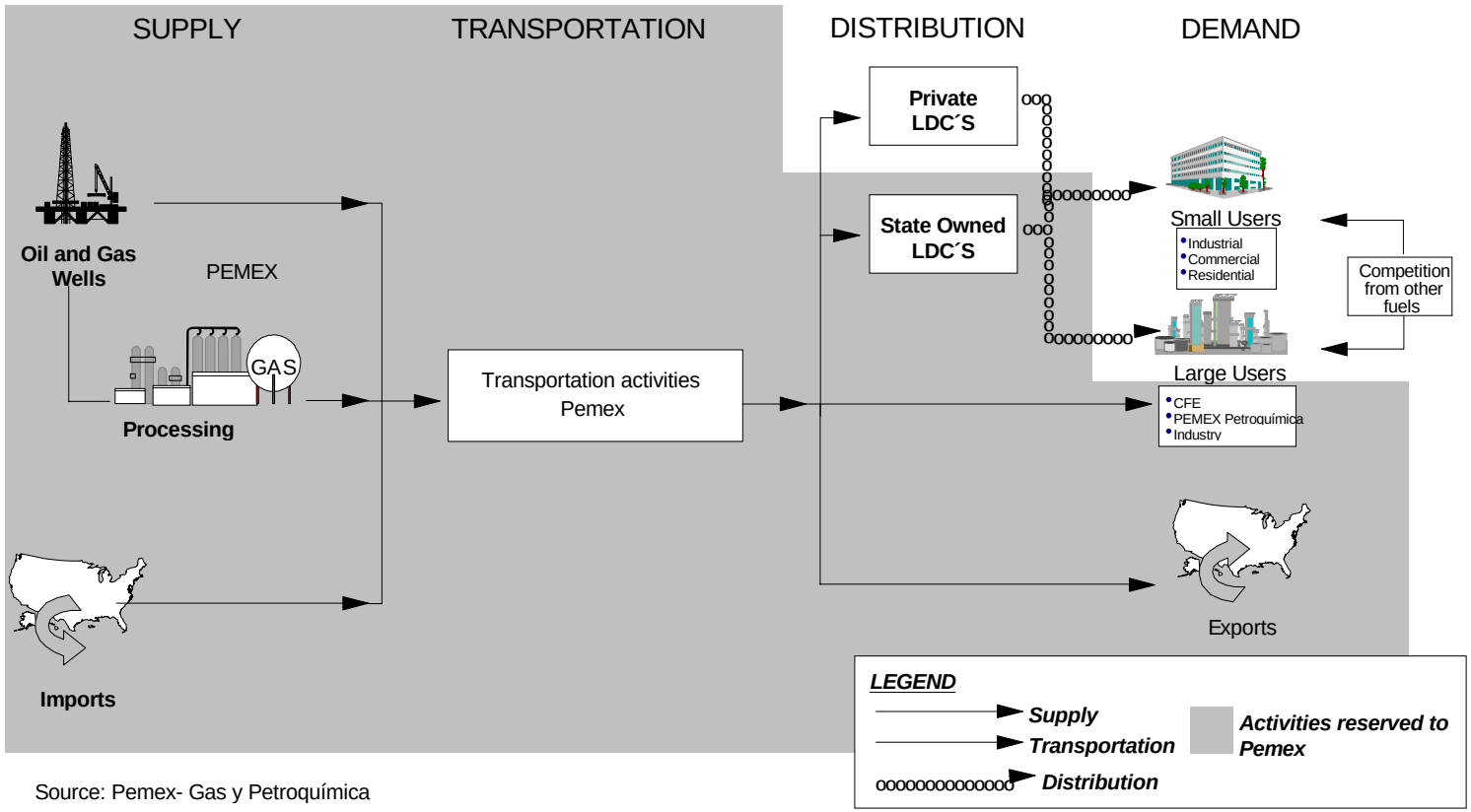


PIPELINE SYSTEM



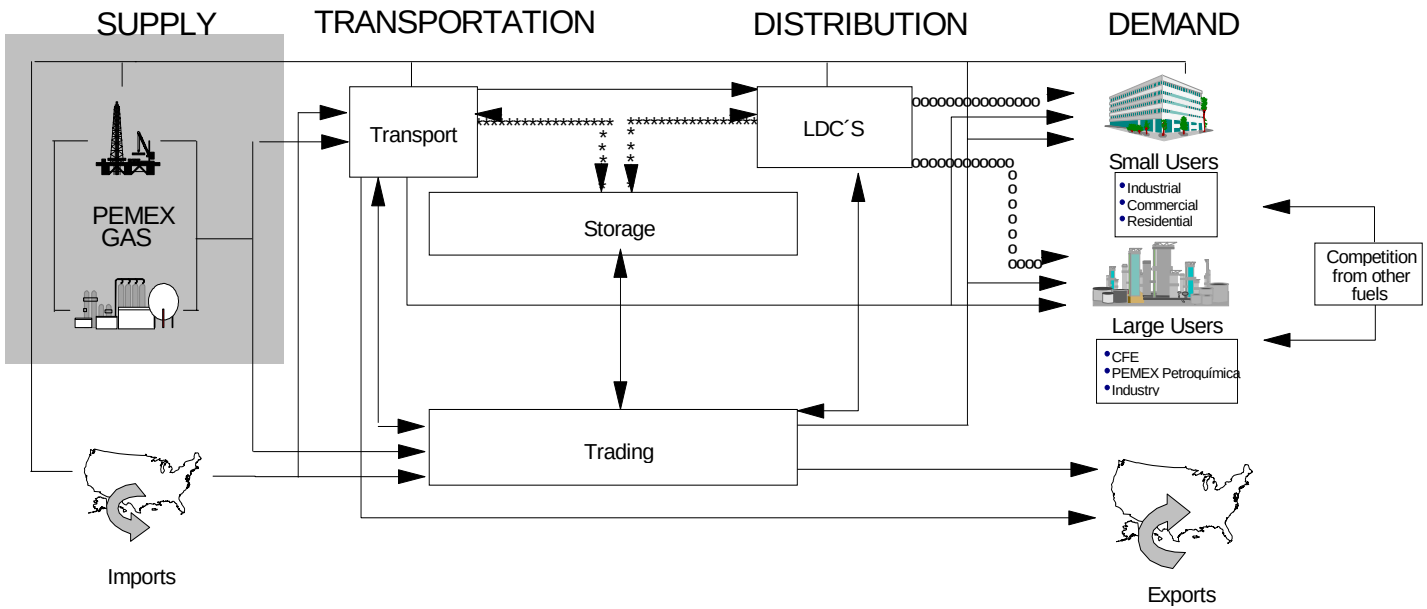
Source: PEMEX

Industry Structure Before 1995



Source: Pemex- Gas y Petroquímica

Expected Evolution



Source: Comisión Reguladora de Energía

Policy decisions

EXCLUSIVITY

- Transportation: no exclusivity.
- Distribution: Twelve-year exclusivity for each LDC project.
- Commercial bypass from day one. Physical bypass gradually implemented.

INTERNATIONAL TRADE

- Any person can import natural gas without import license.
- Elimination of the import tariff

VERTICAL INTEGRATION

- Vertical integration between transportation and distribution: only when a transportation permit is necessary for a distribution project or vice versa.
- Producers, transporters, operators of storage facilities and distributors can be marketers.
- All vertical integrations permitted providing there is one subsidiary for each activity. Subsidiaries at arm’s length. Unbundling.

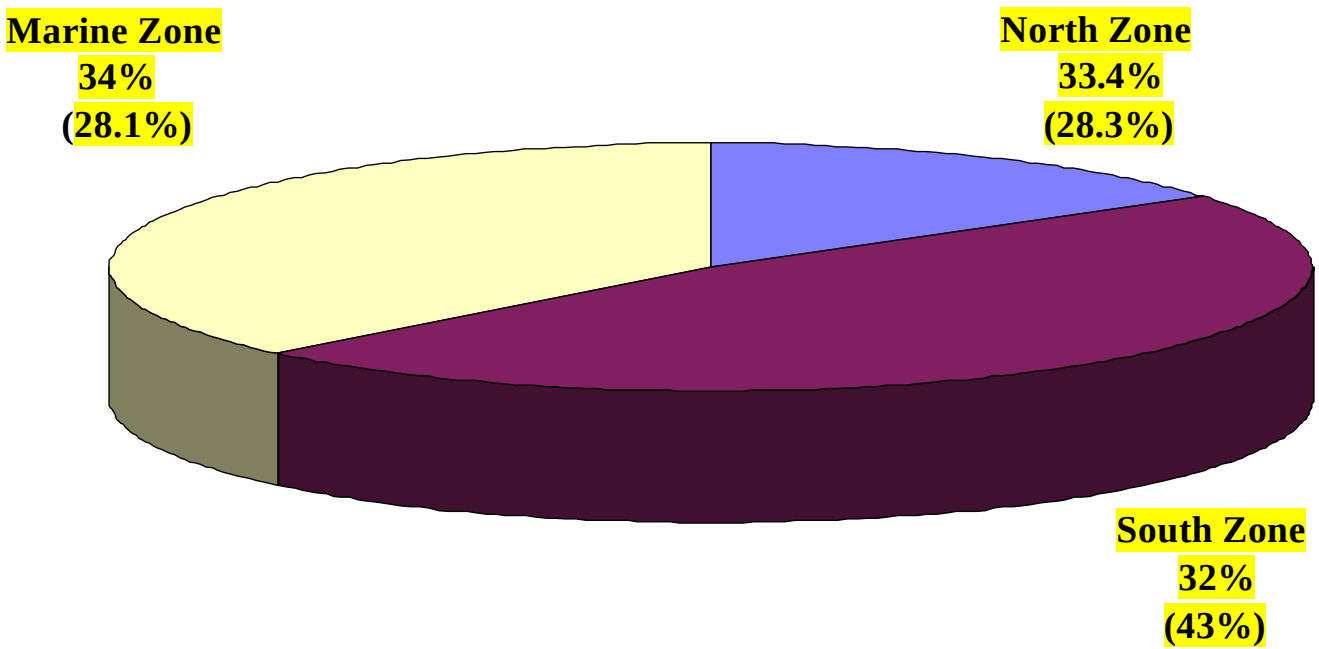
MARKETERS

- Marketers need no permit to operate.
- Marketers can buy gas and sell it to distributors or consumers connected to the transportation system.
- Marketers can sell gas to consumers within the distribution area.
- Marketers can buy and sell pipelines' capacity (secondary market).

PIPELINE ACCESS

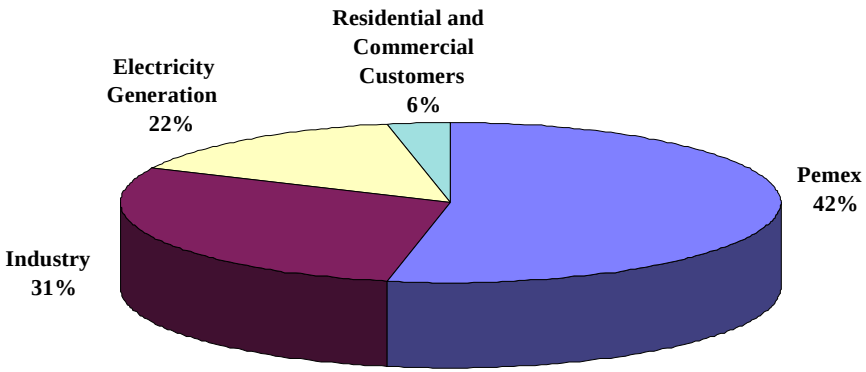
- Open access to transportation and storage.
- Distribution: Commercial bypass from day one

Natural Gas Production (Reserves) by Zone
2005

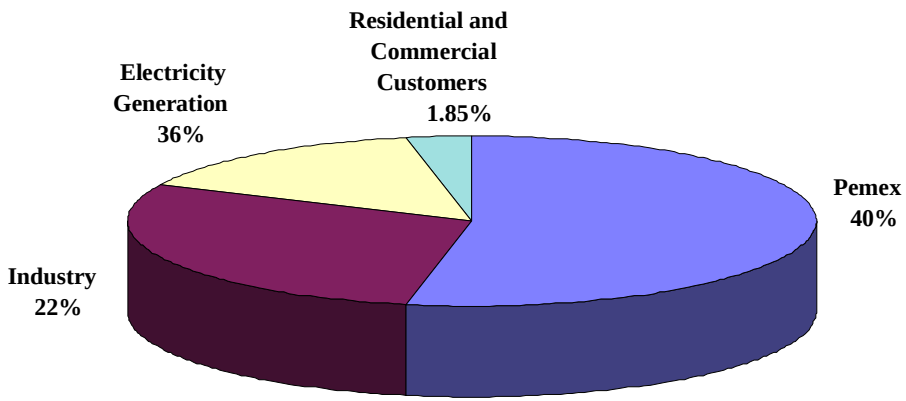


Demand

Mexican Natural Gas Consumption. 1999



Mexican Natural Gas Consumption. 2004



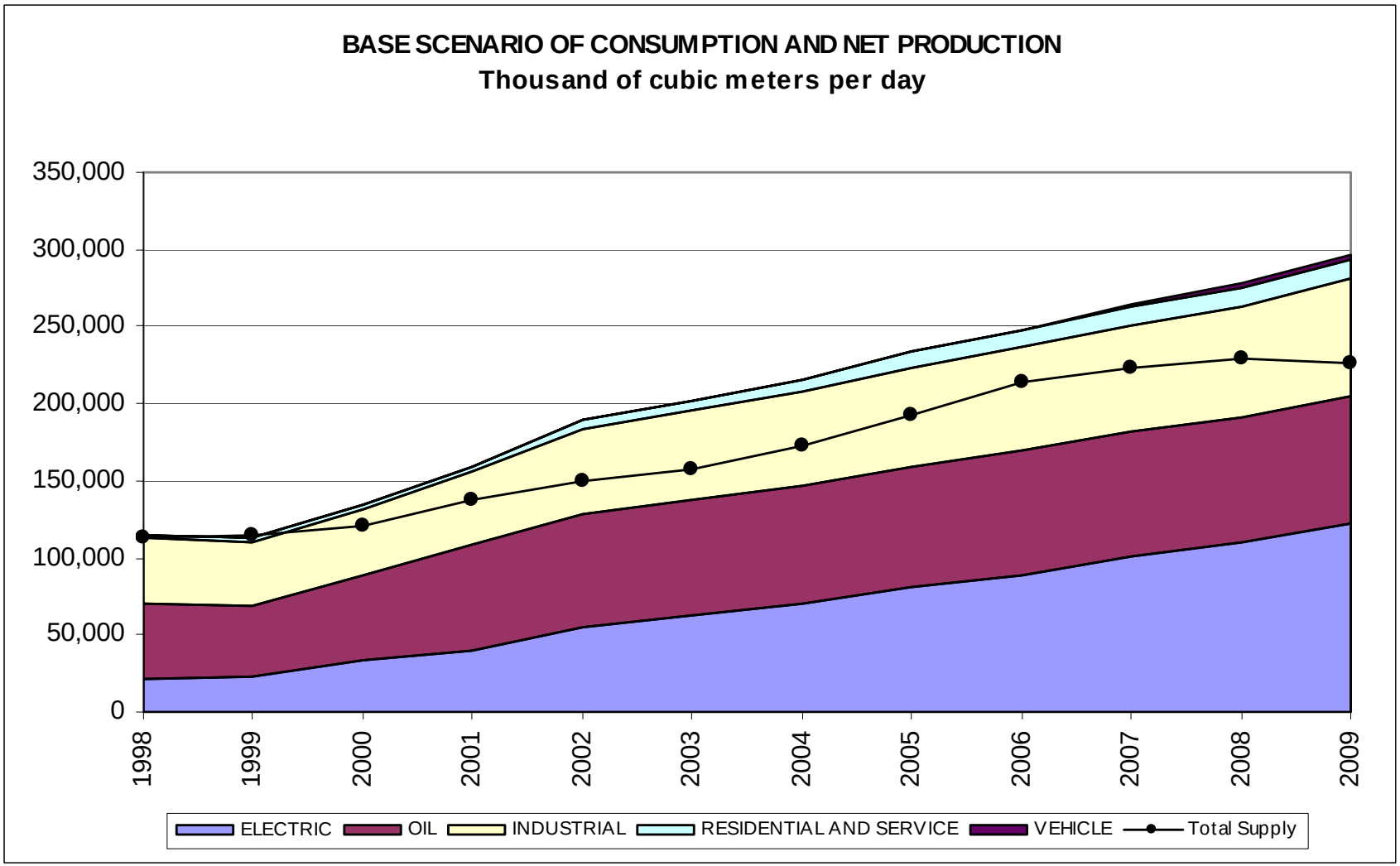

BASE SCENARIO OF CONSUMPTION AND NET PRODUCTION
Thousand of cubic meters per day
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
ELECTRIC
OIL
INDUSTRIAL
RESIDENTIAL AND SERVICE
VEHICLE
Total Supply

Table 7
Characteristics of Natural-Gas Distribution Permits

Concessionaire	Location	Granting Date	Length* (km)	Capacity mm3/d	Users Coverage
DGN de Mexicali, S. de R.L. de C.V.	Mexicali	27/09/96	402.69	708.00	25,346.00
Cía. Nacional de Gas, S.A. de C.V.	Piedras Negras	20/03/97	336.00	197.00	25,608.00
DGN de Chihuahua, S. de R.L. de C.V.	Chihuahua	20/05/97	1,196.00	1,451.00	51,453.00
Gas Natural México, S.A. de C.V. (Saltillo)	Saltillo-Ramos Arizpe-Arteaga	20/06/97	656.00	744.00	40,027.00
Gas Natural del Noroeste, S.A. de C.V.	Hermosillo	9/06/97	505.00	430.00	26,250.00
Gas Natural México, S.A. de C.V. (Toluca)	Toluca	3/09/97	595.30	1,931.00	47,279.00
Cía. Mexicana de Gas, S.A. de C.V.	Monterrey	9/09/97	921.00	3,254.00	50,079.00
Gas Natural México, S.A. de C.V. (Nuevo Laredo)	Nuevo Laredo, Tamaulipas	17/11/97	366.00	182.00	25,029.00
Gas Natural de Juárez, S.A. de C.V.	Ciudad Juárez	2/12/97	1,828.00	996.00	129,045.00
Gas Natural del Río Pánuco, S. de R.L. de C.V.	Río Pánuco	19/12/97	334.68	1,459.00	28,338.00
Tamauligas, S.A. de C.V.	Norte de Tamaulipas	27/03/98	451.00	1,020.36	36,447.00

Table 7

Characteristics of Natural-Gas Distribution Permits

Concessionaire	Location	Granting Date	Length* (Km)	Capacity mm3/d	Users Coverage	Investment* (US$ Million)
Gas Natural México, S.A. de C. V. (Monterrey)	Monterrey	24/04/98	7,239.00	3,500.00	557,052.00	184.10
Distribuidora de Gas Natural del Edo. de México, S.A. de C.V.	Distrito Federal	3/09/98	2,619.00	4,300.00	439,253.00	109.04
Consorcio Mexi-Gas, S.A. de C.V.	Valle Cuautitlán-Texcoco	3/09/98	3,517.00	7,600.00	374,698.00	199.70
Distribuidora de Gas de Querétaro, S.A. de C.V.	Querétaro	10/12/98	870.08	2,446.56	50,001.00	47.20
Gas Natural México, S.A. de C.V. (Bajío)	Silao-León-Irapuato	15/01/99	788.00	3,974.40	72,384.00	27.10
DGN la Laguna-Durango, S. de R. de C.V.	Torreón-Gómez Palacio-Ciudad Lerdo-Durango	18/06/99	1,075.03	1,150.36	50,084.00	35.40
Distribuidora de Gas de Occidente, S. A. de C.V.	Cananea, Sonora	9/08/99	4.63	104.77	6,684.00	35.40
	Puebla-Tlaxcala	28/01/00	800	2,600.00	68,196.00	34.80
Gas Natural (Bajío Norte)	Bajío Norte	22/02/00	719	1,200.00	55,715	34.55
Total			**23,704.41**	**35,448.45**	**2,035,057.00**	**868.45**

(*) At the fith year of the permit.

Source: Comisión Reguladora de Energía.

Incentive regulation concepts

- Few market niches with legal or natural monopolies (e.g.: transmission and distribution of natural gas and electricity).

- Regulation of monopolies is important since they are vertically interrelated with other competitive sectors.

“HISTORY” OF OPTIMAL PRICES

- First Best: marginal cost (70´s).
- Second best: Ramsey prices (80´s).
- Third best: Revelation principle/Laffont-Tirole (93).
- Fourth best: Theoretical models under practical restrictions (nowadays).

DESIRABLE PROPERTIES OF APPLIED MECHANISMS

- Pareto superiority.
- Efficiency improvements.
- Two basic concepts:

- Price level.
- Price structure.

Price-level regulation

ALTERNATIVES

- Cost-of-service regulation.

- Price caps. Adjustment factors (*RPI*, *X*, etc.).
- “Yardstick” regulation.
- Hybrid regulation.

Price-structure regulation

ALTERNATIVES

- Fully distributed cost pricing.
- Price bands.
- Restricted flexibility:
  - Average revenue.
  - Tariff basket.

AVERAGE REVENUE REGULATION

- Sets a cap on revenues per unit.
- Does not set fixed weights that limit tariff rebalancing.

TARIFF-BASKET REGULATION

- Cap set over an index.
- Fixed weights

$$\mathrm{I(p)} = \sum_{i=1}^{h} w_i \, p_i$$

TYPES OF WEIGHTS

- Chained Laspeyres.
- Paasche weights.
- Fixed Laspeyres.
- Ideal weights.
- Flexible weights (average revenue).

POLICY OPTIONS

- Price level regulation: Cost of service or incentive regulation?
- Price structure regulation: Tariff basket or average revenue?

INCENTIVE REGULATION

- Promotes productive and allocative efficiency.
- Light-handed regulatory intervention.
- Captures virtues of both price cap and cost of service methodologies:
  - Limits firm’s risk.
  - Provides incentives for cost reduction.
  - Protects consumers.

Incentive regulation and its effects on infrastructure investment

Distribution

- The regulatory reform process in distribution combined the design of auctions for exclusivity in distribution geographical areas (competition for the market), as well as incentive regulation for distribution tariffs, so as to attract investment.
- Auction design sought to reach a balance in the trade-off between risk management (through the granting of exclusivity) and incentive provision (implicit competition between the LDCs and Pemex).
- The design of price regulation tried to reach equilibrium in the trade-off between investment attraction to *greenfield* projects (average-revenue incentive regulation) and consumer-surplus maximization (through tariff-basket incentive regulation and competition for the market).

CRE´S PLAN

- Competition for the distribution market. Greenfield projects. Biddings grant 12-year distribution exclusivity.
- Average-revenue regulation used during the first five-year period. Tariff-basket is used later on.
- Prices must be set at the start of the period based on a forecast of $Q_{t.}$
- Need of a correction factor to adjust for estimation errors.
- Average revenue regulation provides the needed flexibility in tariff rebalancing during the initial stages of greenfield projects.

LITERATURE REVIEW. THREE RESULTS

1. Under stable cost and demand functions, and myopic profit maximization the chained Laspeyres index induces convergence to Ramsey prices.
2. Assuming stable cost and demand functions, and myopic profit maximization, average revenue regulation causes divergence from Ramsey prices.
3. In a dynamic setting with changing cost and demand functions --and/or non-myopic profit maximization-- the chained Laspeyres index generates prices that may diverge from the Ramsey structure.

LITERATURE REVIEW: POLICY RECOMMENDATIONS

- Chained Laspeyres index should be used under cost and demand stability.
- Under risk and uncertainty there is no reason that justifies the use of the Laspeyres index.
- Average-revenue regulation is a softer constraint than the chained Laspeyres index. It helps to attract investment.
- Under changing demand conditions, what are the effects of average-revenue regulation on consumer surplus?

The Model

Ramírez, J.C. and J. Rosellón, (2002), "Pricing Natural Gas Distribution in Mexico," Energy Economics

- Under changing demand conditions, what are the effects of average-revenue regulation and competition for the distribution market on consumer surplus?
- Two effects: strategic effect and stochastic effect.
- Solution: set usage charge close to zero while fixed charge strategically set to bear burden of misprediction.
- Stochastic effect alone: Consumer surplus decreases (increases) as the firm is more risk loving (averse) and when there is less (more) demand uncertainty.

Average-Revenue Constraint

- Static constraint: $\left\{ p \,/\, \sum_i Q_i(p_i)\, p_i \;\le\; p_0 \sum_i Q_i(p_i) \right\}$

- Dynamic constraint: $AR_t = p_t + \dfrac{F_t}{Q_t}$

$$E(AR_t) = p_t + \frac{F_t}{E(Q_t)} \le M_t$$

$$F_t \le E(Q_t)\left[M_t - p_t\right]$$

DYNAMIC CONSTRAINT

$$M_{t+1} = K_t + M_t$$

$$M_t = M_0 + k_1 + \ldots\ldots k_{t-1}$$

DYNAMIC CONSTRAINT

- K_t will be positive, zero or negative whenever $AR_t < M_t$, $AR_t = M_t$ or $AR_t > M_t$, respectively.

- The strategic effect:

$$E(Q_t) = Q_t : \quad F_t \leq Q_t\left[M_t - p_t\right]$$

DYNAMIC CONSTRAINT

The stochastic effect: Q_t stochastic $\Rightarrow$ $E(Q_t) \neq Q_t \Rightarrow AR_t \neq M_t \Rightarrow K_t \neq 0$ and, therefore, more (or less) flexibility to set F_{t+1}.

The Stochastic Model

$$\max_{p_t, F_t} \; E\left\{ \sum_{t=1}^{T} \beta^t \left(p_t Q_t - c(Q_t) + F_t \right) \right\}$$

subject to

$$Q_{t+1} = Q_t(p_t) - K_t$$

$$F_t \le E\left\{ Q_t (M_t - p_t) \right\}$$

$$Q_T \ge N$$

$$\beta^t \in [0,1]$$

SOLUTION

- Static scenario: set the usage charge *P* close to zero and set fix charge *F* to the level that satisfies the average-revenue and cumulative constraints.
- Dynamic scenario with strategic pricing: The usage charge in period *t* (P_t) is kept close to zero while the fixed charge in period *t+1* (F_{t+1}) is strategically set so as to bear all the burden of misprediction

SOLUTION

- Dynamic scenario with no strategic pricing: the static-case solution is applied in each period.
- However, we proceed to isolate the effect of the stochastic effect alone on consumer surplus. We assume the fixed fee is kept constant in each period and study how the firm manipulates its expected profits subject to the average revenue and cummulative constraints, and under the stochastic behavior of the correction factor *K.*

SIMULATION

$$\max_{pt} E\left\{\sum_{t=1}^{T} \beta^t \left(M_t[a - bp_t] - [F + cp_t]\right)\right\}$$

subject to

$$Q_{t+1} = a - bp_t - K_t$$

$$Q_T \geq N$$

SIMULATION RESULTS

- Results obtained under the assumption of no strategic behavior.
- Consumer surplus tends to decrease (increase) as the firm is more risk loving (averse) and when there is less (more) demand uncertainty.

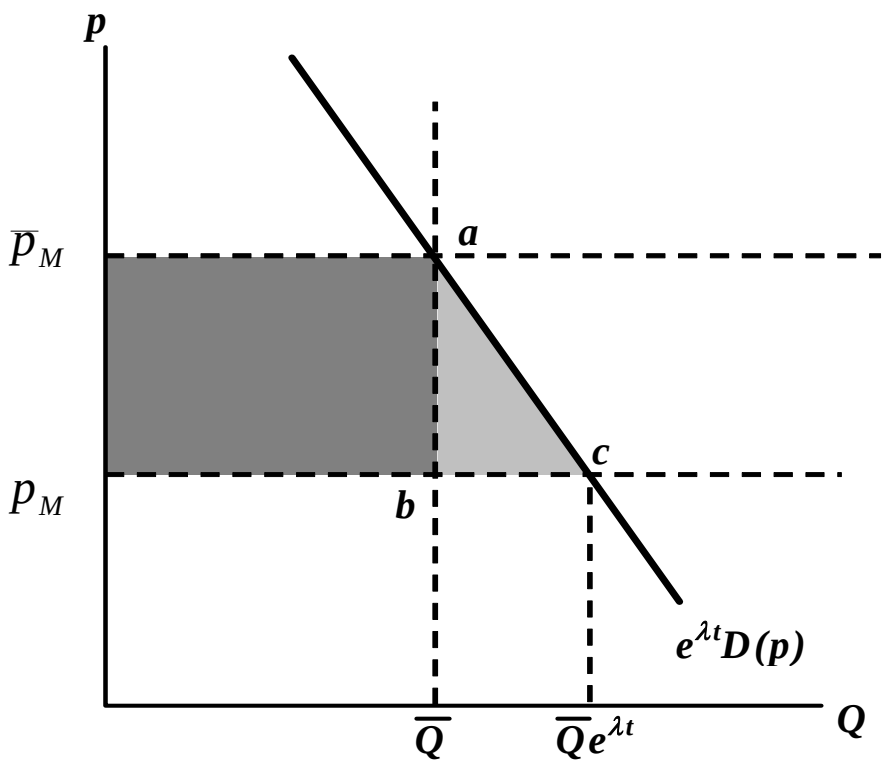
Incentive regulation and its effects on infrastructure investment

Transportation

- A regulatory scheme that provides incentives for the development of the transportation network is been sought.
- A first structural basic problem is of course Pemex' vertical disintegration. Pemex has incentives to congest the pipeline network so as to get congestion rents, evade price regulation, and deter the entrance of competitors in gas marketing activities.
- In the case of vertical disintegration, several incentive regulatory alternatives are analyzed so as to attract private investment.
- Two proposals:
  - **Brito, D. L. and J. Rosellón**, (2005), "Implications of the Elasticity of Natural Gas in Mexico on Investment in Gas Pipelines and in Setting the Arbitrage Point," in Repsol YPF-Harvard Kennedy School Fellows 2003-2004 Research Papers, William Hogan, editor, Cambridge, MA, Kennedy School of Government, Harvard University, April, http://www.ksg.harvard.edu/m-rcbg/repsol_ypf-ksg_fellows/03-04_research_papers.pdf
  - **Vogelsang, I.,** (2001), "Price Regulation for Independent Transmission Companies," *Journal of Regulatory Economics*, vol. 20, no. 2, September.

FIRST PROPOSAL

- Sufficient investment in pipeline capacity so that bottlenecks do not develop.
- A policy that makes sure that there is always sufficient pipeline capacity so that the gas market can always clear should be followed.
- Such a policy would generate sufficient savings to the consumers of gas that they will be willing to pay for such investment in the rate structure. Consumers would be willing to pay for this capacity.


p
$\overline{p}_M$
a
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c
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$e^{\lambda t}D(p)$
Q
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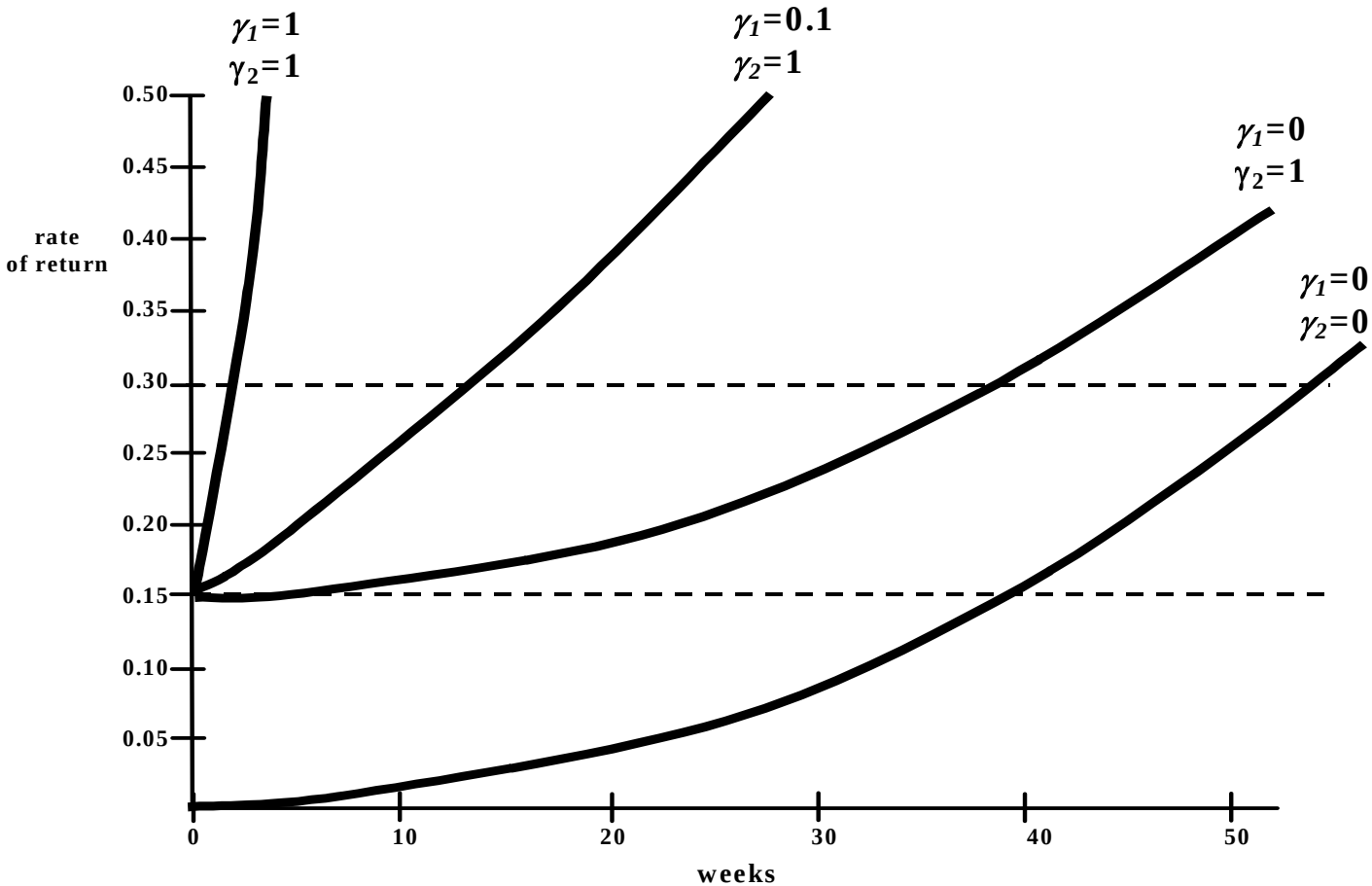
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$\gamma_1=0$
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$\gamma_1=0$
$\gamma_2=0$
rate
of return
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
10
20
30
40
50
weeks

Pipeline capacity

WELFARE LOSS FUNCTION

$$\varphi = \int_0^T e^{-rt} \left\{ \frac{\overline{Q}\left(e^{\lambda t} - 1\right)\left[\theta\left(\overline{Q}\, e^{\lambda t}\right) - \overline{p}_M\right]}{2} + \gamma_1 \overline{Q}\left[\theta\left(\overline{Q}\, e^{\lambda t}\right) - \overline{p}_M\right] - \gamma_2 \varphi \right\} dt + e^{-rT} C_0$$

F.O.C.

$$\frac{\dfrac{\overline{Q}\left(e^{\lambda T} - 1\right)\left[\theta\left(\overline{Q} e^{\lambda T}\right) - \overline{p}_M\right]}{2} + \gamma_1 \overline{Q}\left[\theta\left(\overline{Q} e^{\lambda T}\right) - \overline{p}_M\right] - \gamma_2 \varphi}{C_0} = r$$

SECOND PROPOSAL

- Vogelsang's suggestion for regulating price structure in electricity transmission considers congestion problems (short run) and capacity problems (long run).

- Two-part tariff cap:

- Usage fee solves congestion problems.
- Fixed fee recovers capital costs.
- Rebalancing between usage fee and capacity fee provides investment incentives.
- Transmission quantities are used as weights.

VOGELSANG'S MODEL

$$max \prod^t = p^t q^t + F^t N - c(q^t, k^t)$$

subject to:

$$\sum_i p_i^t q_i^w + \sum_j F_j^t \delta_j^w \leq (\sum_i p_i^{t-1} q_i^w + \sum_j F_j^{t-1} \delta_j^w)(1-X)$$

$$F^t \leq F^{t-1} + \left(p^{t-1} - p^t\right) q^w / N$$

$$q^t \leq k^t$$

Incentive regulation and its effects on investment

Production

- Regarding natural gas production, price regulation seeks to provide incentives for productive efficiency by making Pemex another competitor in the North American natural gas markets.
- However, this regulation presents a problem in its structure of incentives. Pemex has incentives to decrease investment in gas production and processing, to flare gas, and to deviate production from the regulated market to its own internal market (so as to bring down the arbitrage point).
- Likewise, Pemex has incentives to congest its transportation pipelines so as to increase the domestic natural gas price as well as to strategically use the pipeline capacity to preserve its monopoly in gas marketing and evade the netback price regulation.

- The proposed regulatory measures to deal with these problems are:
  - Close regulatory monitoring of Pemex' production, processing and gathering (flaring) activities. Fixing the arbitrage point in the short run.
  - Pemex should be charged for the gas it uses and the gas it flares.
  - Open acess to gas pipelines and investment in the network.
  - Pemex' vertical disintegration or (at least) not letting Pemex to market gas inside Mexico.

The Little-Mirrlees rule

Little and Mirrlees propose using the world prices for traded goods because these prices reflect the terms under which a country can trade. The pricing rule based on the Houston Ship Channel price is an implementation of the Little-Mirrlees proposal. The price of gas in Houston is the opportunity cost of using gas in Mexico rather than exporting it to the US

NETBACK FORMULA

- Price cap of Mexican natural gas: price in Southeast Texas plus transport costs from Texas to the arbitrage point less transport costs from the arbitrage point to Ciudad Pemex

ARBITRAGE POINT

- Place where northern and southern gas flows meet
- Price of northern and southern gas is the same
- It moves north (south) as imports decrease (increase)
- Currently located at “Los Ramones”

The Model

Brito, D. L. and J. Rosellón, (2002), "Pricing Natural Gas in Mexico; An Application of the Little Mirrlees Rule," The Energy Journal, Vol. 24, No. 3.

- Effects of investment in production facilities, and technical export restrictions on natural gas pricing
- Implications of the regulatory framework on Pemex´marketing activities
- Forward markets and pipeline capacity

MAJOR RESEARCH FINDINGS

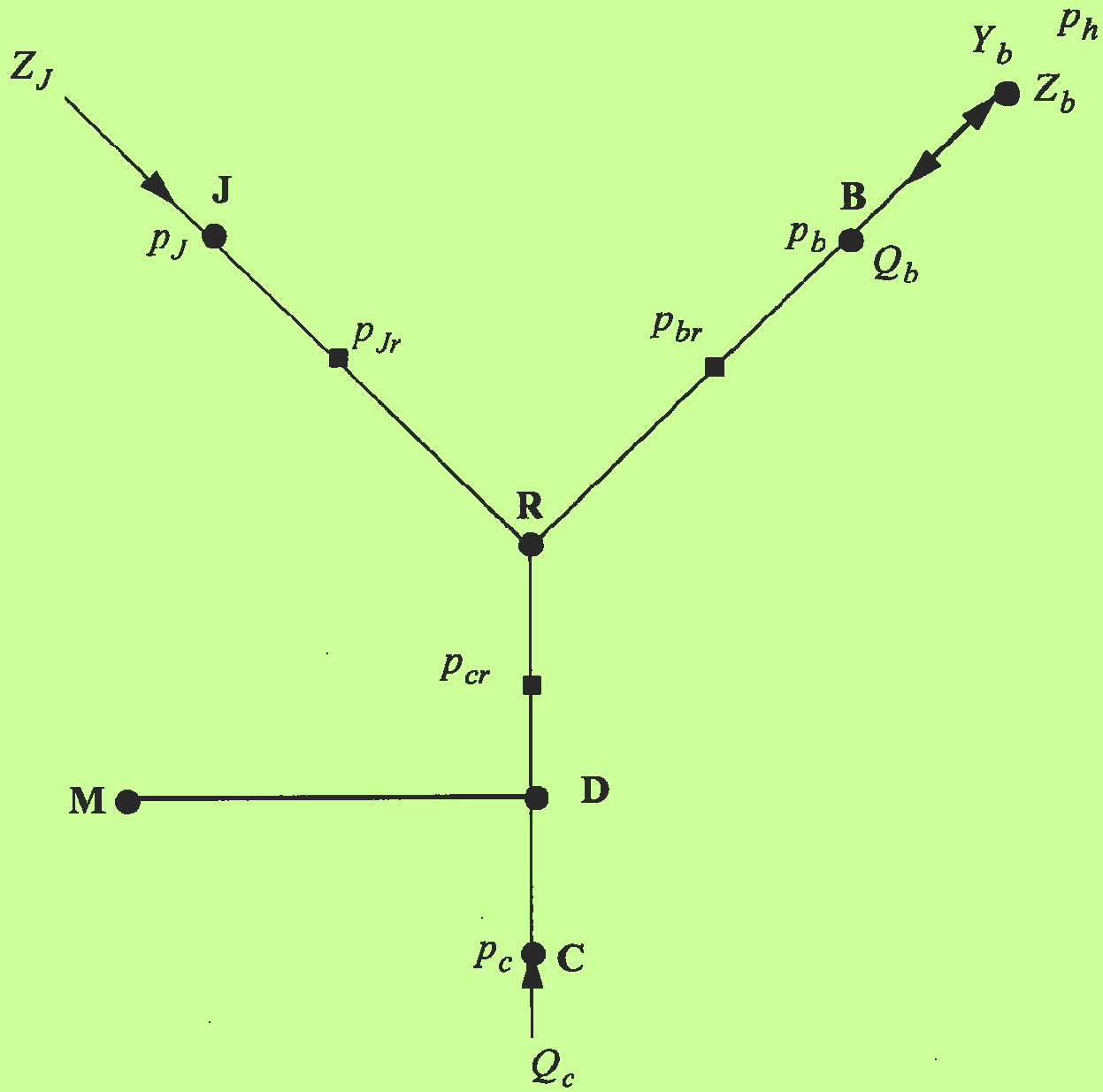
- Netback formula derives from the solution of the problem of a regulator that maximizes welfare subject to resource constraints in the pipeline network.
- Netback formula is an application of the Little-Mirrlees principle, and relies on the fact that the Houston hub is has a competitive market.
- The formula can also lead to incentives to increase the price of domestic natural gas by diverting production from the regulated market.
- Optimal to develop new gas sources closest to the arbitrage point rather than to the center of consumption

MAJOR RESEARCH FINDINGS

- The netback policy is critically conditional on the existence of adequate pipeline capacity. If there is insufficient capacity, the movement of gas will not clear markets and it will be impossible to implement the netback rule.
- Pemex should not be permitted to discount the price of gas from the Houston netback price because it can carry out several strategies (such as cross subsidies) and evade regulation.
- In an open economy where agents can chose between gas and alternative fuels the netback rule is Pareto optimal .
- There is evidence that pipeline network capacity restrictions in Texas preclude the arbitrage between the LNG import price and the Houston natural gas price. Therefore, the use of a net present lower benchmark price might be justified.

RESEARCH TRANSLATED INTO POLICY ANALYSIS

- Open access regulation as well as the monitoring investment in pipeline capacity
- PEMEX' vertical disintegration
- Short-term regulatory measures to provide PEMEX incentives to increase supply in the domestic regulated market include fixing the arbitrage point at a level that forces Pemex to increase production and investment, and setting a price based on the netback rule for internal gas transactions among PEMEX' subsidiaries.
- The use of the South Texas price relies on the assumption of competitive conditions in the Texas natural gas market. The recent increasing trend in the gas price and the expected future increase of LNG might give reason for the use of an alternative benchmark price.


Z_J
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p_c
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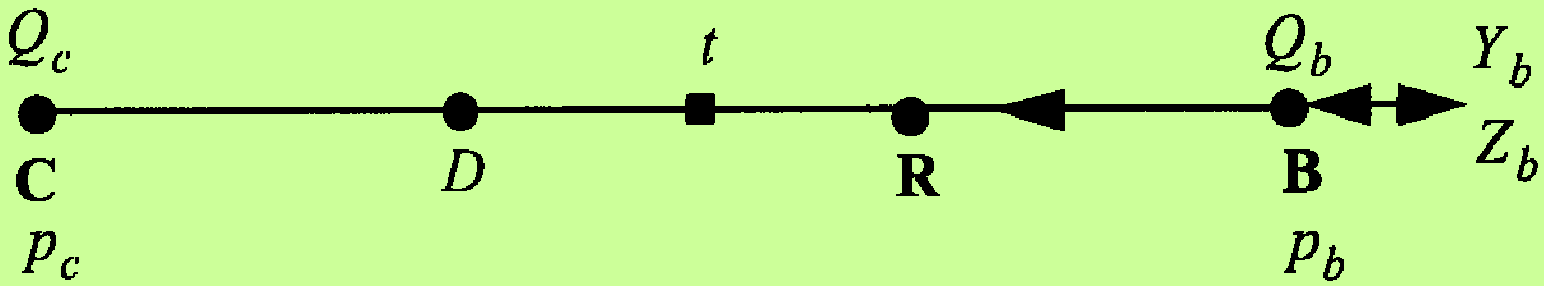
Q_c


Q_c
t
Q_b
Y_b
Z_b
C
D
R
B
p_c
p_b

- Choice variables: exports (Y_b), imports (Z_b), amount of consumption, and the arbitrage point t

- Variables of interest: the arbitrage point, price of gas at Burgos (p_b) and Ciudad Pemex (p_c)

Maximize

$$\int_0^1 v([q(n)], n)dn - \int_0^t q(n)cn\,dn - \int_t^1 q(n)c(1-n)dn - (p_b + \bar{c})Z_b + (p_b - \bar{c})Y_b$$

subject to

$$Q_b + Z_b - Y_b - \int_t^1 q(n)dn = 0,$$

$$Q_c - \int_0^t q(n)dn = 0$$

$$p_c = p_h + c - 2ct - \bar{c}$$

$$p_c = p_h + c - 2ct + \bar{c}$$

$$\frac{\partial p_c}{\partial t} = -2c$$

$$Q_c - \int_0^t \hat{q}(n)dn = 0$$

Conclusions

MAIN LESSONS

- The policy design of incentive regulation to attract investment should consider the effects of industry-structure and vertical integration decisions on defining a level playing field for all market players.
- Decisions on price regulation should consider reaching equilibrium in at least two trade-offs:
    1. Risk management vs. Incentives
    2. Investment attraction vs. Consumer-surplus maximization.