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Luis F. López Calva and Juan Rosellón

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THE REFORM OF THE MEXICAN NATURAL GAS MARKET: EFFECTS ON PRODUCTION AND DISTRIBUTION.*

Luis F. López-Calva
El Colegio de México

and

Juan Rosellón
Centro de Investigación y Docencia Económicas

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Abstract

One of the main objectives of the reform of the natural gas sector in Mexico was to develop a formerly underdeveloped market of this product. This paper shows clear econometric evidence of structural change in the series of production of natural gas in Mexico after the reform period. When compared to the case of a complete deregulation of the sector, as in the case of Argentina, we can see the type of gains Mexico could have achieved through a more aggressive deregulation. The paper also discusses the concession contracts awarded for distribution of natural gas because of the overwhelming recent evidence of renegotiation of concession contracts around the world. Some potential room for renegotiation in the future is discussed.

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1. Introduction

The Mexican government recently deregulated its natural gas sector. This deregulation, however, differs from other reform programs in this sector due to specific political and legal constraints, as described below. It is important to assess the effect such reform has had on the evolution of the natural gas market after the reform because of the potential impact this might have on consumers´ welfare and the growth potential of the economy in the long run. The latter is the main theme of this study. The paper aims at analyzing the existing evidence and assessing the effects of the reform to the natural gas sector in Mexico in 1995. Also, it sheds some light on the challenges the regulator faces and potential problems to be solved. The main result is that the reform has been successful in terms of attracting investment at the distribution stage, expanding significantly production and creating the basis for a formerly almost non-existent gas market.

2. Background

In the Mexican energy sector, state companies had historically controlled energy activities: Petróleos Mexicanos (Pemex) in the oil sector, and Comisión Federal de Electricidad (CFE) and Luz y Fuerza del Centro (LFC) in the electricity industry. Some reforms to power generation were carried out in 1992 and a more ambitious reform in natural gas was achieved in 1995. Notwithstanding, reform decisions in terms of gas production, oil extraction, production of petrochemicals, and the structural reform of the complete electricity sector have been postponed.[1]

[1] See Rosellón and Halpern (2000).

The reform to the natural gas sector of 1995 allowed for private investment in new transportation projects, and in distribution and marketing but kept the Pemex' monopoly in production. The institutional reform created an independent regulatory body, the Energy Regulatory Commission (CRE), and issued newly designed bylaws, the *Reglamento de Gas Natural Natural* (Natural Gas Regulations).

Natural gas is one of the most important sources of energy these days because its use provides us with economic and technical advantages, in addition to the fact that it is environmentally friendlier than other sources of energy. After a period of intervention by the government in the energy sector, countries in Asia, Europe, and North and South America are introducing reforms to promote efficiency and attract investment to their natural gas industries.

The liberalization of this sector is complex since the natural gas market combines naturally monopolistic with potentially competitive activities. Pipeline transportation and distribution have natural monopoly characteristics and require regulation of price and non-price behavior. Production is a contestable market, even though in Mexico it was maintained as a state monopoly. Marketing of gas is also contestable but the regulator must make sure that there are no entry barriers to this activity. Market architecture decisions - such as degree of vertical integration, horizontal structure, and regional development – are also crucial.

Gas production in Mexico is mainly associated to oil extraction in the southeast of the country and the offshore zone. Of total associated natural gas extracted, 11.7% is vented. Mexico has approximately 78 trillion cubic feet of gas reserves (14 th place in the world) and the reserve-to-production ratio is 45 years. Until very recently, natural gas production had not increased due to poor investment in exploration and drilling. In recent years, over 38 trillion cubic feet of gas reserves have been discovered near Burgos in the northeast of Mexico.

A picture of the situation of natural gas consumption in Mexico is given by gas penetration rates in the energy matrix. Natural gas represents 25% of the total energy consumption in Mexico. In fact, this weight is similar to the US one (27%) but much smaller than in Argentina (53%). In 1999, Pemex was the main consumer using 42% of the available gas, while the remaining consumption was shared by industry (31%), electricity generation (22%) and residential and commercial customers (6%). This structure might be compared with the US one where natural gas used for oil production represents 8.9%, industrial purposes 40%, residential consumption 37.6%, and electricity generation 13.5 %.[2] So one main difference between Mexico and the US is that natural gas is not much utilized in Mexico for residential consumption. LPG is used instead with a subsidized price and with a fairly good distribution in large cities.

After the Mexican economic crisis of the 80's it became evident that some sectors, such as infrastructure, needed major reforms in order to foster economic growth. It was thus necessary to implement a structural reform program which was eventually carried out in several sectors and included a deregulation plan to eliminate artificial entry and exit barriers in contestable markets such as transport, ports and telecommunications. The reform included privatization of state-owned enterprises, including the telephone company, deregulation in potentially competitive sectors and, in 1995, the opening to private investment in the natural gas sector.[3]

3. Main aspects prior to the reform

Natural gas has some economic and technical advantages as a source of energy, but it is especially important because of its environmentally friendly properties. Estimates indicate that between 1998 and 2007, the share of natural gas in energy consumption will attain 58.1% for

[2] Rosellón and Halpern (2000).

thermal power generation, 70% for industrial use and 25% for distribution systems serving residential, commercial and municipal users.

Before 1995 PEMEX had the monopoly over production and transportation in natural gas. Even though PEMEX carried out a gross rationalization program cutting half of its excess labor force, it just did not invest in this "strategically unimportant" sector. At that time PEMEX itself functioned as an owner, operator and regulator.

Mexican fuel oil is the main natural gas substitute for industrial consumption. Since 1997 this source of energy has been cheaper than natural gas. The former is, however, very polluting due to its high sulfur content. Due to the enormous growth in demand for natural gas (9% per year in the next decade), important changes in industry structure, price, tariff regulation, and permits regime have been introduced in order to attract private investment in natural gas pipeline transportation distribution, storage and commercialization.[4]

In 1992 the first steps in energy sector reform took place when private investment was allowed in power generation. In October 1993 the Energy Regulatory Commission was created to regulate the electric sector only in auto-consumption, cogeneration, and independent power projects (IPP) which were forced to sell any generation surplus to the Federal Commission of Energy (CFE). Two years later, the reform of the natural gas market initiated with the opening to private participation in transportation, distribution and marketing projects. The liberalization of this market was especially complex since it combined natural monopoly as well as potentially competitive activities. Production was protected as a monopoly, even though

[3] A detailed discussion of the deregulation of the natural gas sector is Rosellón (1997). An interesting reference related to the privatization process is Rogozinski (1998).
[4] The expected rate of growth in 1995 for the demand in natural gas was 42% from 1997 to 1999 and 10% annually from 2000 to 2007.

competition is possible from a technical point of view. Gas transportation and distribution were left as natural monopolies and the marketing of gas was recognized as a contestable market.

To establish the general principles for developing the natural gas industry in 1995 the gas Law was amended. The *Reglamento de Gas Natural* became the regulatory framework that specified the organization, operation and regulations of the industry with a long-term perspective. The most important market players in the sector are transporters, operators of storage facilities, distributors, marketers, consumers and PEMEX, which still participates as a state monopoly gas supplier due to political, historical and cultural reasons.

There are incentives for firms to invest because of the autonomous regulatory institution that implements the regulatory instruments, CRE. The Ministry of Energy (SE) became the head of the Nation's energy resource policy, as before, while PEMEX was restricted in its activities and the CRE was separated from the SE.

4. Key policies in the *Reglamento*

In this section we analyze the main policies articulated in the *Reglamento*, namely: permit regime, vertical integration, international trade, marketing activities and open access. Permits are granted for thirty years and are renewable. In order to get one, parties have to present a technical project, and then market decides which project is carried out. Transportation, storage and distribution permits are issued in a different manner. This kind of regulatory instrument has been successful since it ensures more uniform technical and economic characteristic of the projects across the country, and therefore provides certainty to investors.

In the case of transportation, policy makers decided that access of parties to the transportation and storage systems must be open when there is enough capacity. Distributors must allow open access to their distribution network (commercial bypass). This measure

ensures competitive conditions in the provision of goods and services along natural gas industry. 21 distribution permits and 66 transportation permits have been granted to date with pipeline lengths of 28, 042 kilometers and 11, 478 respectively. Many of the tranportation permitsserve to supply gas to the new independent power production plants.

Due to the dominant role of PEMEX, the *Reglamento* permits some degree of vertical integration for other market participants. However the vertical integration between transportation and distribution is not allowed unless transportation (distribution) permit is necessary for a distribution (transportation) project. In terms of international trade the *Reglamento* established a measure that permits free imports of natural gas from the US without an import license or duties.

Regulation of domestic gas first-hand-sale price and distribution

It is well known that welfare increases as transportation and distribution networks are better designed, and as prices and tariffs are lower. After considering the main aspects of the Mexican natural gas sector and that the main goal was to maximize the social welfare, policy makers focused on the regulation of domestic gas price and development of distribution systems.

Policy makers confronted a serious problem when they decided how to regulate the price of the natural gas. After considering the international experience they chose among three well-analyzed alternatives to set the price according to the international benchmark. This benchmark is given by the regulated price of domestic price of domestic gas plus the regulated tariffs for transporting and storing gas. This instrument seems not to be very innovative because PEMEX used something similar before, but it has served to try to introduce competition into the Mexican market. The only problem of using this methodology is that Mexican consumers were

to be affected according to the externalities of the US market implying in some cases consumers' bills increases. [5]

After five years of the liberalization process, on February 2000, CRE finally issued the directive on first hand sales of natural gas. Since PEMEX vertical integration has been an obstacle to the introduction of competition into the market, the directive obligates PEMEX to present information of all the operations it is doing. It also has to offer the same price to power generators located in the north or south, this will allow power generators to compete in technical and financial concerns. The directive assumption on first hand sales is that PEMEX will remain as a monopoly in gas marketing so it must be regulated, but regulation of commercialization activities has proven to be difficult, therefore competitive evolution of the Mexican gas industry will not be easy to attain.

Economic entry barriers to the construction of a distribution network explain in a certain manner the natural monopolies that have characterized the distribution sector. However, regulators in Mexico considered very important the harmonic development of distribution systems.From international experience Mexico learned that the exclusivity period for a distributor plays a fundamental role because short periods do not allow the firms to recover investment costs so they are obligated to set high tariffs, but long periods are not necessary due to natural-market barriers. In Mexico they were many opinions about the optimal length of the exclusivity period. The decision was to grant an exclusivity period of 12 years in conjunction with the initial distribution bidding. But exclusivity only refers to gas conduction. Physical by-pass was to be gradually implemented and commercial by-pass was accepted immediately.

The international experience has shown that marketing activities are important in promoting competition through price arbitration. Mexico put in place this idea by permitting

[5] Natural gas prices suffered increases of more than 100% in the winter of 1996, and in the summer an fall of 2000.

marketers to buy gas, transport and sell it to distributors or to consumers directly connected to the transportation system gas within a franchise area. In order to get a franchise, parties have to present an economic and technical project, then CRE choose one of them and defines the distribution geographical zone and the consumer target that it has to covere by the end of the first five years. Since the first franchise granted to Mexicali, 21 distribution permits have been awarded. The distribution infrastructure that belonged to PEMEX and CFE in the distribution zones was privatized. Distributors have made investment commitments of around 1 billion dollars, therefore one can say that this regulation has been successful.

To protect captive consumers an acquisition-price regulation was chosen. This methodology establishes the maximum price that can be passed through to the final user by the distributor resulting from costs of gas purchase, transportation, distribution and storage services. Distributor is able to transfer the cost as long as it is less than or equal to a predetermined benchmark.

In order to regulate distribution (and transportation) tariff level policy makers chose a combination of two instruments: cost-of-service and price caps. At the beginning of every five-year period , a price cap is determined on a cost of service basis. To regulate distribution tariff structure Mexico decided to use two variations of price cap, namely, tariff basket regulation and average–revenue regulation. During the first five-year period average-revenue regulation is used because this instrument gives more flexibility to overcome unexpected changes in prices that characterize the first stage of the distribution network, it also permits to the firm to choose each year its relative prices at the beginning of the year making forecasts on the volume that will be demanded at the end of the year. After five years the tariff basket regulation is used

because it permits firms to maximize consumer surplus and at the same time recover its fixed costs.[6]

At this time it is not possible to make a deep comprehensive evaluation of the regulatory decisions because during the small period of time of the reform the CRE has onlybeen concerned with issuing permits, promoting distribution and transportation projects and incorporating PEMEX into the regulatory framework. One of its last task was to work on a arrangement with the National Institute of Ecology (INE) and the Water Commission (CAN) to simplify the process that LDC's have to meet. For the same purpose federal and local regulatory authorities are working to establish agreements of coordination with the states and municipalities.

Domestic production of natural gas increased by 33% from 1994 to 1998. Policy makers expected a supply growth rate of 4.5% from 1998 to 2007. Demand for natural gas was expected to grow at about 9% per year specially for electricity generation and because higher environmental standards are pushing firms to change fuel oil for natural gas. Comparing current production trends with expected consumption it is evident that a huge deficit willprevail in the near future. To diminish this deficit, it was recently announced in a "Gas Strategic Plan" that the government will increase its investment in natural gas production: PEMEX will invest around 12.5 billion US dollars in hydrocarbon extraction during the next fifteen years. This is difficult to believe because PEMEX' has not historically shown efficiency in production in the gas sector, but also because PEMEX' budget is determined by the Mexican Congress. To exploit its natural gas resources rather than increases the natural gas imports, Pemex should establish new arrangements for risk sharing with experienced private companies with associated changes in licensing, taxation and audit policies and practices.

[6] For a detailed analysisi of the impacts of this methodology on consumer surplus see Ramírez and Rosellón (2000).

Among the distribution companies that were granted permits, the results in terms of investment and prices are as expected. Some of these firms are actually publicly traded (see Table 1) and the performance of its shares in the market denote that the public has good expectations about the market, and perhaps more important, that the regulatory regime is credible.

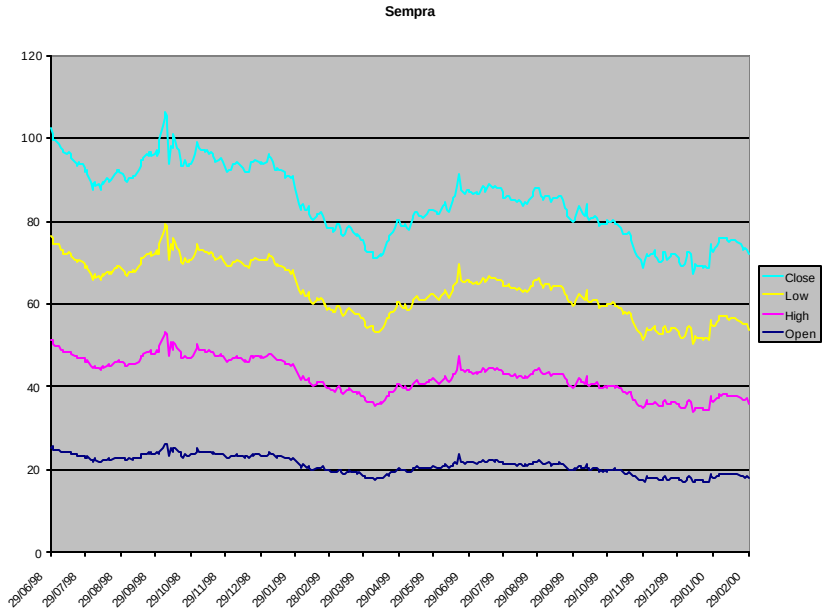
Table 1
Distribution Companies that are Publicly Traded

Distribuidora de Gas Natural de Mexicali	Proxima Enova-San Diego Gas & Electric Pacific Enterprises
Compañía Mexicana de Gas (Piedras Negras)	
DGN Chihuahua	Próxima Gas Enova Internacional- San Diego Gas & Electric (Actualmente Sempra Energy) Pacific Enterprises- Southern California Gas.
Gas Natural México (Saltillo)	Repsol
Gas Natural del Noroeste	KN Energy Inc. KN Energy International Grupo Marhnos.
Gas Natural de México (Toluca)	Repsol
Compañía Mexicana de Gas (Monterrey)	Grupo Diavaz Enserch de México. Subsidiaria de National Pipeline Company (Enserch Corporation)
Gas Natural de México (Nuevo Laredo)	Repsol
Gas Natural de Juárez	
Gas Natural del Río Pánuco	Corporación Gutsa NorAm Energy de México.(Actualmente Reliant Energy) Actualmente quien posee el permiso es Tractebel (Belgica)
Tamauligas	Bufete industrial Gaz de France
Gas Natural de México (Monterrey)	Gas Natural SDG (Repsol)
Distribuidora de Gas Natural del Estado de México (D.F.)	Grupo Diavaz 15% Lone Star Gas International (Enserch Cop.)70% Controladora Comercial e Industrial 15%
Consorcio Mexi-Gas (Valle Cuautitlán-Texcoco)	Grupo Bufete Industrial Construcciones 25% Gaz de France 26% Mexigas 49%
Distribuidora de Gas de Querétaro	Tractebel
Gas Natural de México (Bajío)	Gas Natural SDG (Repsol)
DGN de la Laguna-Durango	Sempra Energy International
Distribuidora de Gas de Occidente	

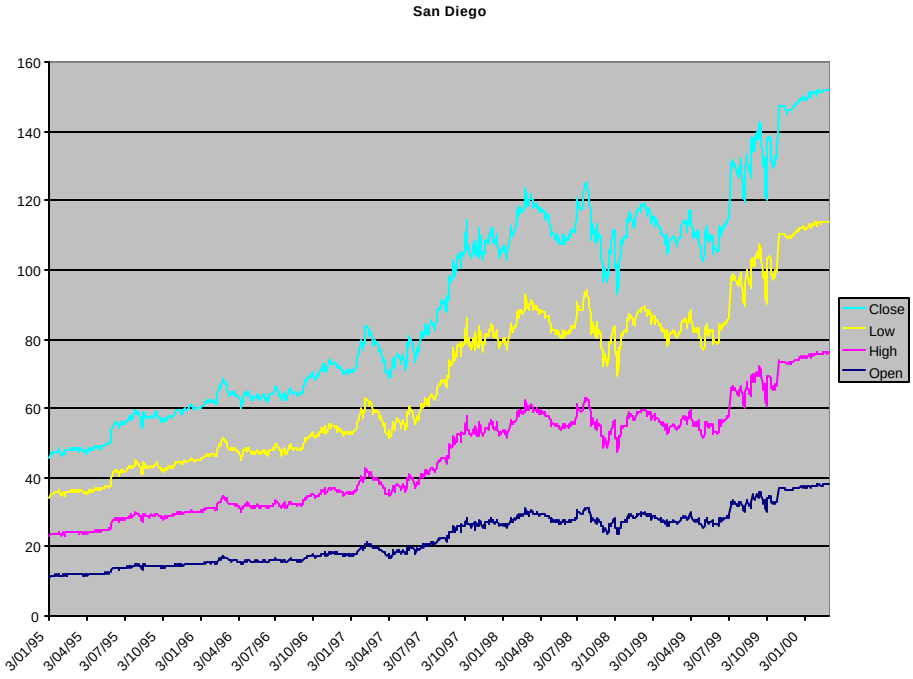
(Cananea)	
Puebla - Tlaxcala	Gaz de France

The market performance of the shares of Repsol, Sempra and San Diego gas & Electric is shown in graphs 1-3. As can be seen, the market performance is, on average, very good.

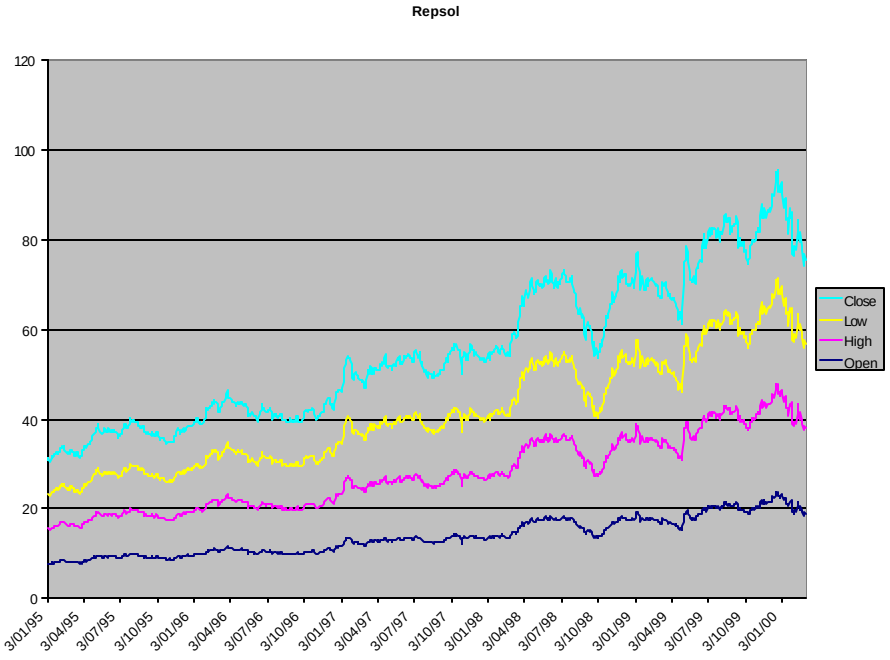
Graph 1
Market Performance: Sempra



Graph 2
Market Performance: San Diego



Graph 3
Market Performance: Repsol



Some of the relevant questions to be answered regarding the reform in the sector are:

i) Has the reform resulted in a more dynamic natural gas market?

ii) What have been the incentives to increase production?

iii) Is there room for higher gains if the regime were changed in some stages of the chain?

iv) Is there room for renegotiation in the distribution contracts in detriment of consumers?

v) What is the connection between the reform in the natural gas sector and the success in other related sectors like electricity?

All these questions are addresses in the sections to follow.

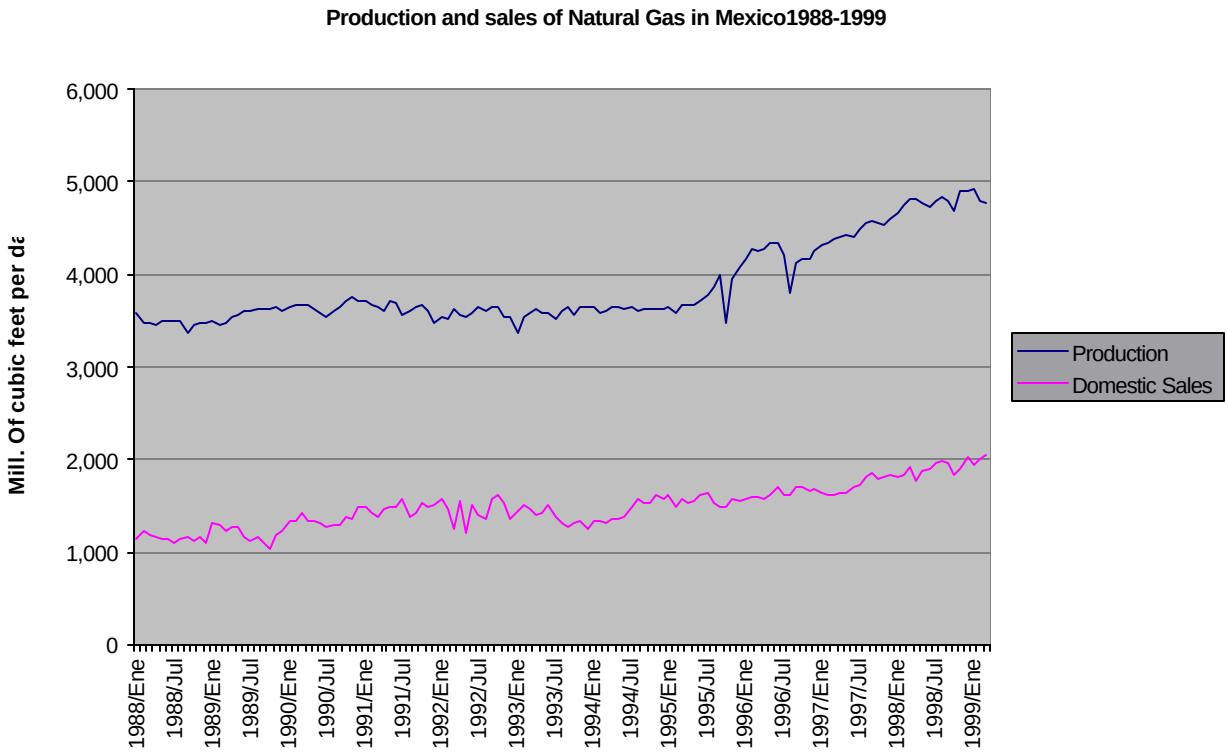
5. Production and Sales of Natural Gas in Mexico 1988-1999

Series behavior in the period

This analysis uses monthly series for production and sales of natural gas in millions of cubic feet between January 1988 and March 1999.As can be seen in Graph 4, natural gas production showed an upward trend from 1988 to November 1995. The behavior is similar after that date, but the rate of growth seems to be steeper. Between 1988 and 1999 the average annual rate of growth was 0.25% while the rate of growth during the whole period was 31.18%.

When we observe sales and production of natural gas it becomes evident that sales behavior was more homogeneous during the whole period. Domestic sales, however, showed higher variability than production. The average monthly rate of growth for sales was 0.62% and its rate of growth in all the period was 78.87%. The interesting question that arises is whether there exists a structural change in these series after the reform.

Graph 4



Tests of structural change

Economic series are generally non-stationary. Thus, integration tests must be carried out. The Integration order of a series is the number of times it has to be differentiated to make it stationary. Regressions with non-stationary series could results in spurious relationships and that is why the Integration order of a series becomes important before any type of statistical analysis of time series

As we noted in the previous section, production and domestic sales of natural gas show an upward trend in this period. Augmented Dicky Fuller (ADF) and Phillips Perron tests (PP) are carried out to verify the integration order of theses series. Results are presented in Tables 1a and 1b.

Table 1a
Unit Root Tests[7]

Variable	Phillips Perron (4 lags) (t statistic)
lprod	0.0118
Dlprod	-16.2148
lcons	1.1295
Dlcons	-17.6209

Note: Phillips-Perron test suggests four lags taking into account possible correlation. This results does not include a trend nor a constant, however if we carry out the test with a trend or a constant the integration order does not change.

Table 1b
Dickey Fuller Test (levels)

Augmented Dickey-Fuller Test Equation (levels)
Dependent Variable: D(LP)
Sample(adjusted): 1984:06 1999:03
Included observations: 178 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LP(-1)	0.014582	0.018850	0.773560	0.4403
D(LP(-1))	-0.298892	0.079131	-3.777197	0.0002**
D(LP(-2))	-0.228403	0.081994	-2.785599	0.0059**
D(LP(-3))	-0.136428	0.081264	-1.678827	0.0950*
D(LP(-4))	-0.094608	0.077863	-1.215063	0.2260
C	-0.117953	0.155098	-0.760504	0.4480

R-squared	0.093298	Mean dependent var	0.001180
Adjusted R-squared	0.066940	S.D. dependent var	0.024125
S.E. of regression	0.023304	Akaike info criterion	-4.647289
Sum squared resid	0.093406	Schwarz criterion	-4.540038
Log likelihood	419.6088	F-statistic	3.539681
Durbin-Watson stat	1.991680	Prob(F-statistic)	0.004517
ADF Test Statistic	0.773560	1% Critical Value[a]	-3.4682
		5% Critical Value	-2.8777
		10% Critical Value	-2.5753

* 90% level of significance
** 95% level of significance
[a] MacKinnon critical values for rejection of hypothesis of a unit root.

[7] The variables are: *lprod* = natural logarithm of production, *Dlprod* = first difference of the previous production series, *lcons* = natural logarithm of the sales series, and *Dlcons* = the first difference of the previous series.

Table 1b
Dickey Fuller Test (differences)

Augmented Dickey-Fuller Test Equation (differences)
Dependent Variable: D(LP,2)
Sample(adjusted): 1984:07 1999:03
Included observations: 177 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LP(-1))	-1.671141	0.235829	-7.086246	0.0000**
D(LP(-1),2)	0.384269	0.204823	1.876100	0.0623*
D(LP(-2),2)	0.169814	0.167486	1.013898	0.3121
D(LP(-3),2)	0.059732	0.123837	0.482342	0.6302
D(LP(-4),2)	-0.013497	0.076574	-0.176258	0.8603
C	0.002231	0.001766	1.262824	0.2084

R-squared	0.633913	Mean dependent var	0.000186
Adjusted R-squared	0.623209	S.D. dependent var	0.037766
S.E. of regression	0.023182	Akaike info criterion	-4.657551
Sum squared resid	0.091898	Schwarz criterion	-4.549885
Log likelihood	418.1933	F-statistic	59.22037
Durbin-Watson stat	2.011638	Prob(F-statistic)	0.000000
ADF Test Statistic	-7.086246	1% Critical Value[a]	-3.4684
		5% Critical Value	-2.8778
		10% Critical Value	-2.5754

* 90% level of significance
** 95% level of significance
[a] MacKinnon critical values for rejection of hypothesis of a unit root

In Tables 1a and 1b we can see that *t* statistics of the unit root tests (ADF) and PP for *lprod* y *lcons* series are neither negative nor statistically significant so it is not possible to reject the null hypothesis of the unitary root. This means that series are non stationery (see Maddala and Kim, 1998). To determine if a series is integrated of order one, *I(1)*, the same tests are carried out using first differences. Results lead us to conclude that production and sales of natural gas are non-stationary processes *I(1)*.

Structural break tests are carried out as a next step. The main idea of the stability test in the parameters is that at any date in time T_1 it is believed that a structural change has occurred. There are several ways to carry out structural change tests. Before doing so, the specification of the time series process has to be done. In this case, after several specification tests we found that the process can be modeled as a *ARIMA*(10,1,1) process. The results are shown in Table 2.

Table 2
Modeling the Series

Dependent Variable: DLP
Sample(adjusted): 1984:12 1999:03
Included observations: 172 after adjusting endpoints
Convergence achieved after 11 iterations
Backcast: 1984:11

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000378	0.001486	0.254621	0.7993
DE	0.005457	0.002925	1.865625	0.0638*
AR(10)	0.172472	0.076048	2.267941	0.0246**
MA(1)	-0.381160	0.071814	-5.307589	0.0000**

R-squared	0.140597	Mean dependent var	0.001592
Adjusted R-squared	0.125251	S.D. dependent var	0.024179
S.E. of regression	0.022614	Akaike info criterion	-4.717533
Sum squared resid	0.085912	Schwarz criterion	-4.644336
Log likelihood	409.7079	F-statistic	9.161548
Durbin-Watson stat	1.851577	Prob(F-statistic)	0.000012
Inverted AR Roots	.84	.68 -.49i	.26 -.80i
	.68+.49i		
	.26+.80i	-.26 -.80i	-.26+.80i
	-.68+.49i		
	-.68 -.49i	-.84	
Inverted MA Roots	.38		

* 90% level of significance
** 95% level of significance

Thus, production of natural gas follows an *ARIMA* (10,1,1) process.[8] However, the normality test shows unexpected results, which could be due to the structural change that seems to have occurred.

Natural gas sales follow an *AR*(2) process. The series also shows normality problems. The residuals of the models are stationary (See Table 3).

Table 3

Unit Root Tests

Variable	Augmented Dickey Fuller (four lags) (t statistic)	Phillips Perron (four lags) (t statistic)
Residual production model	-6.4007	-12.0085
Residual sales model	-5.0673	-10.8330

One common structural break test is due to Chow. The structural break point proposed is November 1995. The idea is to prove the null hypothesis of non structural change. The main results are shown in Table 4.

Table 4
Natural Gas Production
Chow Forecast Test: Forecast from 1995:11 to 1999:03

F-statistic	2.425678	Probability	0.000239
Log likelihood ratio	98.96503	Probability	0.000001

Gas Sales

Chow Forecast Test: Forecast from 1995:11 to 1999:03

F-statistic	0.437056*	Probability	0.99802
Log likelihood ratio	24.14935*	Probability	0.983246

* Significant at a 99% level.

[8] After doing the specification tests on the errors we found that there are neither heteroskedasticity nor autocorrelation problems (see appendix 1).

From these results it is possible to state that the natural gas production series shows a structural change in November 1995 but the gas sales series does not show such a change. The null hypothesis is rejected in the case of production but not in that of sales. In order to verify the robustness of this result is performing an alternative test of structural change. This is done by using a dummy variable after the reform period and checking for its "redundance". The models are then modified and the results are shown in the following Tables:

Table 5a
Test of Redundance in the Model with a Constant

Redundant Variables: DE				
F-statistic	3.298747	Probability		0.071115
Log likelihood ratio	3.344559	Probability		0.067428
Dependent Variable: DLP				
Sample: 1984:12 1999:03				
Included observations: 172				
Convergence achieved after 11 iterations				
Backcast: 1984:11				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001748	0.001407	1.242722	0.2157
AR(10)	0.201679	0.074592	2.703770	0.0076**
MA(1)	-0.355878	0.072084	-4.937014	0.0000**
R-squared	0.123723	Mean dependent var		0.001592
Adjusted R-squared	0.113353	S.D. dependent var		0.024179
S.E. of regression	0.022767	Akaike info criterion		-4.709716
Sum squared resid	0.087599	Schwarz criterion		-4.654818
Log likelihood	408.0356	F-statistic		11.93067
Durbin Watson	1.871145	Prob (F-statistic)		0.000014
Inverted AR Roots	.85	.69+.50i	.69 -.50i	.26 -.81i
	.26+.81i	-.26 -.81i	-.26+.81i	-.69+.50i

	-.69 -.50i	-.85
Inverted MA Roots	.36	

** 95% level of significance

Table 5b
Redundance Test without a Constant

Redundant Variables: DE			
F-statistic	4.761321	Probability	0.030487
Log likelihood ratio	4.778835	Probability	0.028812
Dependent Variable: DLP			
Sample: 1984:12 1999:03			
Included observations: 172			
Convergence achieved after 10 iterations			
Backcast: 1984:11			
Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(10)	0.210309	0.074508	2.822647	0.0053**
MA(1)	-0.334959	0.072407	-4.626081	0.0000**
R-squared	0.116048	Mean dependent var		0.001592
Adjusted R-squared	0.110849	S.D. dependent var		0.024179
S.E. of regression	0.022799	Akaike info criterion		-4.712624
Sum squared resid	0.088366	Schwarz criterion		-4.676025
Log likelihood	407.2857	Durbin-Watson stat		1.888135
Inverted AR Roots	.86	.69+.50i	.69 -.50i	.26 -.81i
	.26+.81i	-.26 -.81i	-.26+.81i	-.69+.50i
	-.69 -.50i	-.86		
Inverted MA Roots	.33			

** 95% level of significance

From this analysis we can again conclude that the natural gas production series in Mexico show a structural change in November 1995. This result, we hereby argue, is due to the reform carried out at that time. The increase in production does not have a counterpart on the side of sales, a series which already had an increasing trend before the reform. A plausible explanation

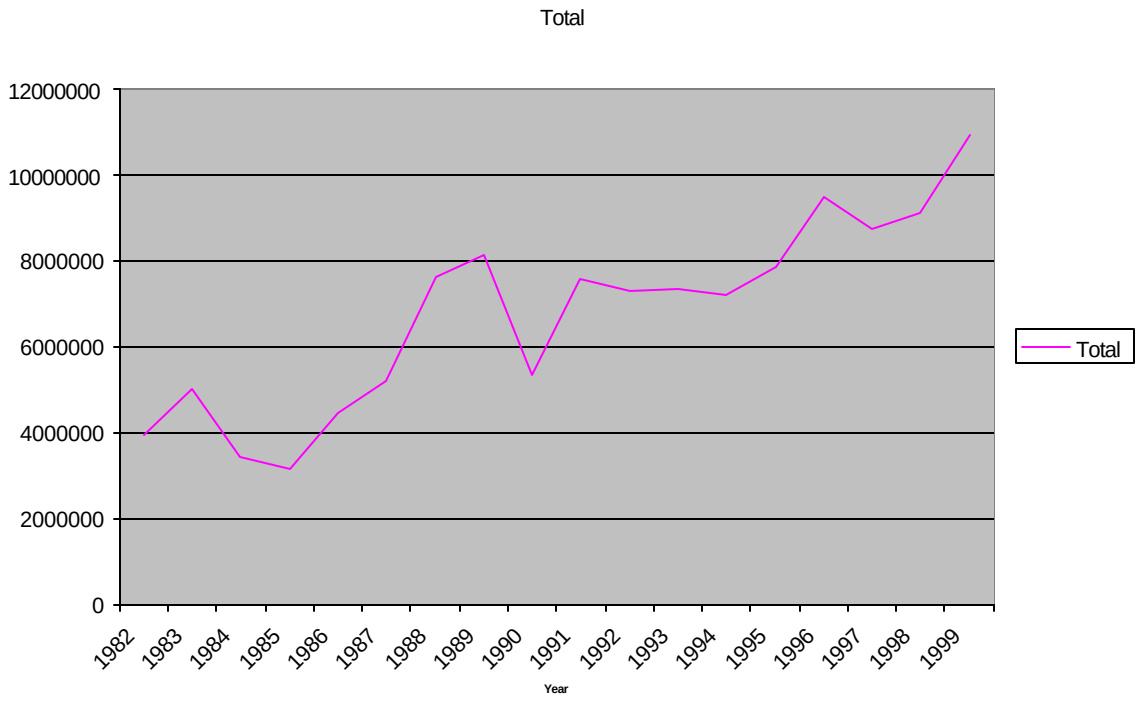
is that the demand for natural gas was already growing at high rate and the structural change in production was needed just to match the demand dynamics.

Even though the increase in production shows a positive effect of the reform on the market, a new question that arises is whether the change could be larger if a complete liberalization, without monopoly in production had taken place. In order to pursue such investigation, an imperfect, though useful, method shall be used: the same tests are carried out for a case in which the liberalization was complete, as in the case of Argentina. Proving that the Argentinean market had a larger response could indicate that the reform in Mexico was indeed limited by the historical constraints on the production side. This is so especially because the natural gas market in Argentina was more developed than its counterpart in Mexico even before the reform, so it cannot be argued that a smaller response in Mexico was due to a smaller deficit at the moment of the policy change.

6. Full Liberalization: Argentina

The series analyzed show an upward trend with abrupt changes. The average monthly rate of growth after the reform was 8.61% and the rate of growth during the period was 176%. This means a much higher rate of growth as the one in Mexico, shown above.

Graph 5



Structural Change

We proved the integration order of the series using Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) tests. As we can see in Table 6 this series has an integration order of one, *I(1)*. This result is taken from the statistical values of the *t*-test, *ADF* and *PP*.

Table 6

Unit Root Test[9]

Variable	Augmented Dickey Fuller (2) (t-statistic)	Phillips Perron (2) (t-statistic)
Largen	1.7817	1.4699
Dlargen	-3.3653	-4.6284

Note: Phillips Perron taste suggests two lags taking into account possible manifestations of correlation. This results does not include a trend or a constant, but when they are included the integration order does not change.

[9] The variables are *Largen* = natural logarithm of the production series in Argentina, and *Dlargen* = first differences of the previous series.

The best model that fits the series is as follows:[10]

$$largen_t = 1.0043\ largen_{t-1} + 0.9346\ MA(2)$$
$$(944.41) \qquad (-23.507)$$

This series follows an *ARIMA* process (1,2,1).[11] The residuals of this model have constant mean and variance, so they are stationary. ADF and PP tests are presented in the next table.

[10] Numbers in brackets are t-test values

[11] Testing for the specification of the errors, heteroskedasticity, autocorrelation or non-normality problems are ruled out.

Table 7

Unit Root Tests

Variable	Augmented Dickey Fuller (two lags) (t-statistic)	Phillips Perron (two lags) (t-statistic)
residual	-2.3741	-6.3711

Note: Phillips Perron taste suggests two lags taking into account possible manifestations of correlation. These results do not include a trend or a constant, but when they are included the integration order does not change.

The year 1992, i.e., the year of the reform, is taken as a potential structural break. The idea is again to prove the null hypothesis of no-structural change. The results are shown in Table 8.

Table 8
Chow Test
Argentina

Chow Forecast Test: Forecast from 1992 to 1999

F-statistic	0.744797	Probability	0.657808
Log likelihood ratio	10.46914	Probability	0.733629

From these results we can conclude that the null hypothesis is rejected, so there was a structural change in production in 1992. We now follow the dummy procedure to check the robustness of the result. The model becomes:

$$\underset{}{largen_t} = \underset{(406.32)}{1.0068\ largen_{t-1}} \underset{(-22.8006)}{-0.9367\ MA(2)} \underset{(-2.1320)}{-\ 0.06622\ dummy}$$

From this analysis we conclude that the series does show a structural change in 1992.

The comparison between the Mexican and the Argentina case was meant to contrast a situation of partial liberalization, with monopoly at the production stage, and a case of full liberalization. Potential gains seem to have been foregone in Mexico in this respect. Also, as

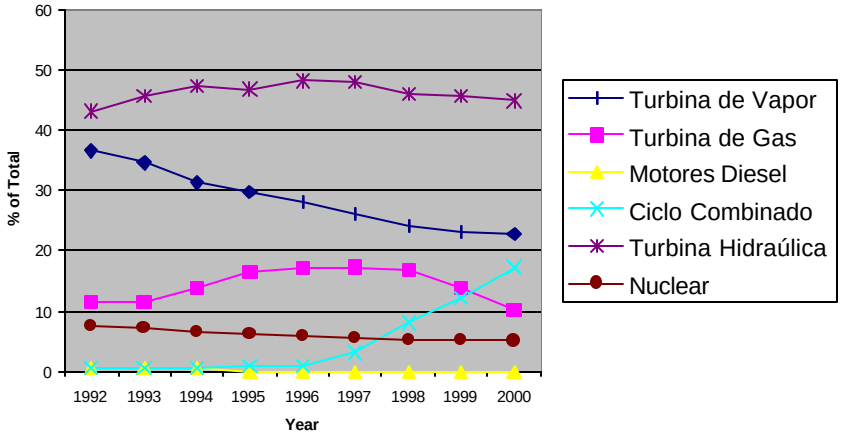
discussed in Rosellón and Halpern (2000), some regulatory problems still persist and may explain efficiency losses. These are related to PEMEX´s virtual vertical integration and the incentives it sometimes has to reduce production and to congest the transport pipelines. Brito and Rosellón (2000) propose that PEMEX should not be allowed to commercialize, and that such measures would result in higher efficiency gains in the natural gas market.

7. The importance of Natural Gas for the Development of the Electricity Markets

One of the key factors in the development of the natural gas sector is its importance in the development of another crucial energy market: electricity. As an example, in Argentina the use of the combined cycle technology –natural gas-based – after the reform has gained importance as a source of energy. In graph 6 we can see that in Argentina the combined cycle technology has gone from being almost unimportant as a source of electricity generation to representing around 20% of total installed capacity. This figure can tell us the relevance of a well-functioning natural gas market as a pre-condition for a competitive electricity market.

Graph 6
Argentina

Sources of Energy as Percentage of Total Capacity



Among the reasons for the importance of the combined cycle technology in electricity generation is its relatively low cost and its environmentally friendly characteristics. Table 9 below shows the ranking of different technologies in electricity generation by components. The data are for generation plants in Mexico, as reported in 1997. Combined cycle plants were ranked as the cheapest.

Finally, when one looks at the composition of the generation capacity, 59% of the total is carried out from hydrocarbons. Out of that 59%, only 12% comes from combined cycle technologies (see Graph 7). There seems to be indeed a large potential for the development of this generation technology with its implicit cost reductions and environmental benefits. A well-functioning natural gas market, however, is a pre-condition for such a change.

Graph 7

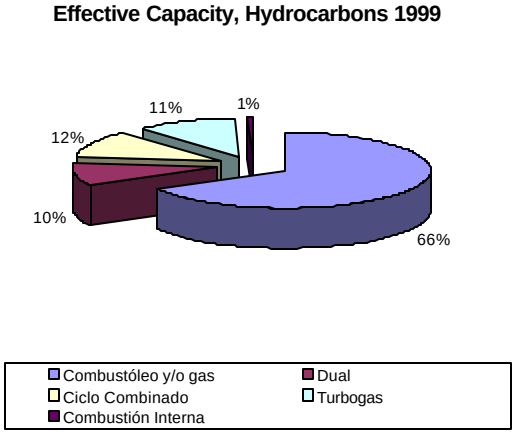


Table 9
Total Costs of Generation and Ranking
(1 = Cheapest)
(Average Prices 1997)

Ranking	Plant	Power	Investment		Fuel		Maintenance		Total	
			P	$/MWH	P	$/MWH	P	$/MWH	Indice	$/MWH
1	Combined Cycle	1*532	1	49.06	14	135.53	7	16.6	57	201.19
2	Combined Cycle	1*268	2	58.17	15	136.39	8	24.38	62	218.94
3	Carbon	2*350	6	150.92	11	85.92	10	26.30	74	263.14
4	C. dual with sulfur	2*350	7	151.85	12	93.52	11	26.94	79	281.67
5	C. dual without sulfur	2*350	11	186.57	13	102.88	17	43.92	91	324.01
6	La Amistad	2*33	15	272.41	8	9.94	18	44.99	92	327.34
7	Chicoasen	5*300	17	329.51	3	3.20	1	8.76	96	341.47
8	Thermal	2*350	3	103.31	23	236.34	5	14.93	100	354.58
9	Bacurato	2*46	18	335.82	5	5.41	13	31.55	105	372.78
10	Penitas	4*105	19	348.24	9	17.11	3	12.44	107	377.79
11	Comedero	2*50	20	368.79	7	7.03	14	31.80	115	407.62
12	Termal 2	2*160	4	138.68	24	244.95	9	25.33	115	408.96
13	Diesel	2*38.6	9	178.56	16	169.85	22	63.26	116	411.57
14	Geotermoeléctrica	1*25	12	196.86	18	182.75	19	45.90	120	425.51
15	Diesel	5*5.65	5	151.19	20	192.80	27	122.02	131	466.01
16	Nuclear	1*1356	16	318.26	10	68.17	23	85.98	133	472.41
17	Termal 3	2*84	8	157.39	25	283.40	15	32.63	134	473.42
18	Diesel	2*13.5	13	208.67	17	179.76	24	92.01	135	480.44
19	Turbogas	1*175	14	257.89	21	205.95	21	63.35	140	498.03
20	Agua Milpa	3*120	23	496.30	4	4.33	4	14.17	145	514.80
21	Caracol	3*200	22	494.76	6	6.17	6	15.81	146	516.74
22	Termal 4	2*37.5	10	186.48	26	302.53	20	62.40	156	551.41
23	Zimapan	2*146	26	645.40	2	0.99	2	10.26	185	656.65
24	Turbogas 2	1*70	21	400.79	22	223.51	21	63.35	194	687.65
25	Agua Prieta	2*120	27	683.31	1	1.16	12	28.55	201	713.02
26	Turbogas 3	1*141	24	506.51	19	192.18	25	107.34	227	806.03
27	Turbogas 4	1*41	25	519.17	27	349.33	26	118.08	278	986.58

Source: CFE

8. Distribution Concessions and the Potential Room for Renegotiation

A final issue to be discussed is the effectiveness of the bidding process for the distribution concessions in order to determine whether modifications should be made in this regard. Given the available data, it is possible to run an OLS regression, using a Heckman correction for

selection bias given that we only observe the maximum income in the bid for those who are the winners.[12] Our interest is to assess whether there is a systematic component in the bidding process to draw some policy recommendations. First, before looking at the regression results, we see a simple negative correlation before the maximum income (lowest bid) offered by the winner company and the number of firms competing in the bidding process. This is consistent with the theory and tells us that the more competitive the bidding process, the lower the maximum income offered and thus the higher the benefits for the consumers (see Graph 8). The regression analysis is useful, however, to verify these results.

The specification of the model is:

$$Price = a_0\, emp + a_1\, inver + a_2\, usua + a_3\, partic + u$$

Where

Price = maximum income bid of the winner,

emp = number of firms in the bidding process

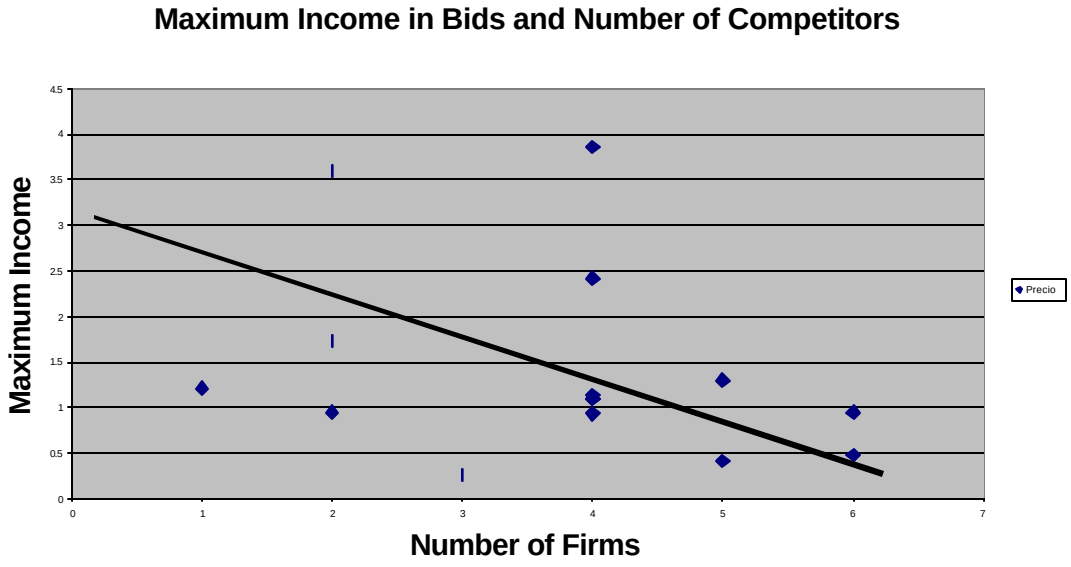
inver = required investment by the 5th. year

usua = number of consumers by the 5th. year

partic = a dummy variable, 1 if the winner has public participation in its home country
u = error term with usual properties

[12] The data is taken for the concession awards information available in the CRE webpage: http://www.cre.gob.mx

Graph 8



The econometric results show that the most important variable is systematically the number of potential users by the 5th year (Tables 10-11). The coefficient is always positive and significant, which is related to the fact that the firms incur higher costs by having to supply a larger number of residential consumers.

Table 10
Econometric Analysis of the Bidding Process

Dependent Variable: PRICE
Sample: 1 15
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FIRMS	-0.399284	0.192149	-2.057132	0.0318
C	2.170767	0.768596	2.824328	0.0143

R-squared	0.076419	Mean dependent v.	1.426774
Adjusted R-squared	0.005374	S.D. dependent var	1.071573
S.E. of regression	1.068689	Akaike info criterion	3.094309

Sum squared resid	14.84726	Schwarz criterion	3.188715
Log likelihood	-21.20732	F-statistic	2.075643
Durbin-Watson stat	1.948736	Prob(F-statistic)	0.031858

Table 11

Dependent Variable: PRICE
Sample: 1 15
Included observations: 15

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PART	-0.125745	0.087302	-1.544033	0.1381**
FIRMS	-0.206572	0.202826	-1.018467	0.3303
USERS	3.20E-06	1.56E-06	2.054907	0.0644*
C	1.774362	0.749200	2.368343	0.0373

R-squared	0.353678	Mean dependent var	1.426774
Adjusted R-squared	0.177409	S.D. dependent var	1.071573
S.E. of regression	0.971882	Akaike info criterion	3.004014
Sum squared resid	10.39010	Schwarz criterion	3.192827
Log likelihood	-18.53010	F-statistic	2.006465
Durbin-Watson stat	1.702842	Prob(F-statistic)	0.171542

*95% Significance
** 85% Significance

The number of firms participating in the process is always negative, as predicted by the theory, though it becomes statistically non-significant when the number of users is added to the model. Required investment is never significant, even when it is included as investment per capita (divided by number of potential users). Perhaps one of the most important results is that

the fact that the winner has public ownership in its home country affects negatively the maximum income required by the firms.[13] This means that those firms are systematically able to offer lower bids. A warning should be made in this respect in the sense that those firms might potentially be more likely to renegotiate, unless they have subsidies in their home countries that allow them to bid sustain lower prices or have more technical capabilities than the rest. The former is more likely to be the case. Guasch (1999) has shown the incidence of renegotiation in concession contracts around the world, showing the common aspects of concession contracts that are renegotiated around the world. We propose hereby that the fact that firms have public ownership in their home countries should be taken into account in such analysis.[14]

Final Remarks

The structural Reform in Mexico´s gas industry has been successful in inducing a significant increase in production as a response to demand. The regulator has faced important challenges in terms of choosing the right institutional framework and incentives in an environment of asymmetric information and short history of a regulatory culture in the country. The econometric evidence, however, clearly shows the structural change in production induced from 1995, when the reform took place. All the challenges ahead notwithstanding, the route chosen seems to be strengthening the development of a natural gas market in Mexico. The comparison with a completely liberalized market –Argentina—has shown that there might still be room for gains in Mexico. The lower response of production as compared to the full-liberalization scenario could be interpreted as the price to be paid for maintaining a

[13] Firms with public ownership are from France *(Gaz de France)*, and Spain *(Repsol)*.
[14] Formal analysis by the authors has looked at the potential risk of renegotiation and the potential bargaining power of firms with public ownership in their home countries. The contracts designed by CRE in Mexico seem to have incorporated clauses to protect the consumers from renegotiation by the distributors.

monopolistic structure at the distribution level. Two fundamentals problems are to be solved, however, the problem of vertical integration of Pemex and its possible advantage against potential competitors in the deregulated stages, and the potential danger of renegotiation of the distribution companies, even though the contractual arrangements seem to be prevent that possibility and have done so thus far.

Appendix 1

Correlation Tests
Production Series

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.211753	Probability	0.042802
Obs*R-squared	6.407526	Probability	0.040609

Dependent Variable: RESID
Presample missing value lagged residuals set to zero

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.93E-05	0.001465	0.013163	0.9895
DE	0.000249	0.002886	0.086173	0.9314
AR(10)	-0.001698	0.075130	-0.022604	0.9820
MA(1)	-0.655171	0.493501	-1.327597	0.1861
RESID(-1)	0.718741	0.485930	1.479104	0.1410
RESID(-2)	0.100434	0.203427	0.493711	0.6222

R-squared	0.037253	Mean dependent var	-2.47E-05
Adjusted R-squared	0.008255	S.D. dependent var	0.022415
S.E. of regression	0.022322	Akaike info criterion	-4.732243
Sum squared resid	0.082712	Schwarz criterion	-4.622447
Log likelihood	412.9729	F-statistic	1.284659
Durbin-Watson stat	1.996163	Prob(F-statistic)	0.272863

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