



Munich Personal RePEc Archive

# **Infrastructure integration and incomplete contracts: natural gas in the Southern Cone**

Navajas, Fernando H.

Fundacion de Investigaciones Economicas Latinoamericanas(FIEL),  
Argentina, Universidad Nacional de La Plata, Argentina

January 2008

Online at <https://mpra.ub.uni-muenchen.de/31025/>  
MPRA Paper No. 31025, posted 23 May 2011 19:16 UTC

# **Infrastructure Integration and Incomplete Contracts: Natural Gas in the Southern Cone\***

*Fernando H. Navajas*

*Fundación de Investigaciones Económicas Latinoamericanas (FIEL)  
&  
Universidad Nacional de La Plata (UNLP), Argentina.*

*January 31, 2007*

---

\* Published in *Integration and Trade*, N°.28 January-June, 2008, pp.25-48. A previous version of this paper was presented at the 2nd Annual Meeting of the Latin American/Caribbean - Asia/Pacific Economic and Business Association (LAEBA), Seoul, Korea, November 17, 2006. While still responsible for remaining errors, I acknowledge useful comments received from Paulina Beato, Ricardo Carciofi, Antoni Estevadeordal, Mauricio Mesquita-Moreira and other participants at the LAEBA meeting.

## 1. Introduction

Regional infrastructure can be seen as a platform to support exchange of inputs or final goods and services in an expanded economic area. The regional public goods perspective to regional infrastructure provision has characterized many challenges that normally have to do with coordination failures related to the construction and governance of large projects that usually have multidimensional externalities.<sup>1</sup> However, active private sector participation in many integration projects show that contractual arrangements and provisions, under the umbrella of good legal and regulatory frameworks, can cope with those difficulties. Absence of or insufficient supply of infrastructure projects has not been a problem in the recent experience, among others, of southern cone natural gas integration. At the same time, the exchange supported by infrastructure comes in long term contracting format, particularly in energy sectors such as natural gas where proven reserves need to guarantee that sunk investment in pipelines will be recovered through appropriate use of capacity and that sunk elements of reserves development need also be recovered. Besides, domestic market conditions and the prevalence of domestic supply reliability objectives can in principle make exchanges contingent on domestic imbalances, that in turn can be due to shocks or to policy failures, such as inconsistent pricing or energy planning decisions. Foreseeing, perfect or imperfectly, such problems amount to precautionary decisions by exchange participants, that can be included in contractual formats. On the other hand, unforeseen contingencies or the inability of agents to incorporate them in written contracts, make contracts intrinsically incomplete. Therefore, there is an interdependency between private contracting of energy exchanges, energy planning (in the form of a balanced domestic market) and infrastructure provision, that critically makes infrastructure integration workable or not.

The significant infrastructure integration of natural gas that emerged in the 90s in the southern cone on Latin America fits well into this problem. The evidence of the leading role played by the private sector has been used to argue that in energy sectors, so called infrastructure-related-regional-public-goods can be easily supplied in a decentralized fashion with rather low public intervention, mainly in the form of “minimally” compatible rules across countries. Indeed, around the mid 90s about ten large to medium scale projects were put in place to transport natural gas in significant amounts, relative to domestic markets. Long term contracts of natural gas supply were part of this framework with embedded provisions for a reasonable exchange environment. Among these, gas producers in Argentina and electricity generators or distribution companies in Chile signed contracts under the umbrella of a trade protocol by both countries.

However, in 2004 an imbalance in Argentina led to a restraint of exports, within a generalized shortage of gas deliveries, and to a claim and concern by Chilean authorities. At the private sector level, some litigation processes were triggered, particularly by those Chilean buyers (particularly electricity generators) that took the brunt of the cuts, against upstream gas producers on the Argentine side. The demand rested on the basis that the “major force” provision contemplated in the contract (as argued by Argentine gas suppliers) should not apply in the case, despite the indication that the Argentine market was under severe policy

---

<sup>1</sup> See, for example, Ruffin (2004).

intervention, given that the Argentine regulators did not directly intervene in gas contracts and rather allowed gas exports whenever a provision of equivalent energy (in fuel oil) were delivered to end users (mainly electricity generators). In any case, deliveries were seriously reduced and the foreseen scenario gave rise to pessimism on the strategy of integrated infrastructure to deal with long term reliable provision of energy.

This paper looks at the intersection between energy infrastructure integration and contractual perspectives. It argues that in many cases imbalances in domestic markets related to shocks or to policy decisions make incomplete contracting of the exchange (to be supported by the infrastructure) the center stage of problem. This in turn implies the need for contract design to govern relationships among private participants and, at the policy level, some form of supra-national coordination of decisions that affect exchanges, including energy planning.

The structure of the paper is as follows. Section 2 reviews the conceptual framework provided by applied contract theory to natural gas trade and inquires into sources of incompleteness in international exchanges. The discussion points to some dimensions that justify the quest for empirical evidence used in the paper. Section 3 describes central features of natural gas infrastructure integration in the Southern Cone, evidence on recent underperformance related to the Argentine energy imbalance and the policy decisions that followed since then. Section 4 looks at the likely reasons for the generalized restrictions of supply to Chile as a form to discern between competing explanations of broken exchanges that are essential to understand the likely source of contract incompleteness and to qualify contending views in recent litigations. Section 5 moves to the scant but interesting evidence of contractual conflict and adaptation between private sector participants. Section 6 discuss lessons for contractual design and regional cooperation that are particularly relevant in view of recent major developments on natural gas infrastructure integration between Argentina and Bolivia. Finally Section 7 draws the main conclusions.

## **2. Contract Theory Perspectives in Natural Gas Trade**

Natural gas contracts usually come in long-term format depending on many dimensions at play. Early literature in applied contract theory stressed, among various dimensions affecting contract design, the sunkness of decisions chiefly related to pipeline infrastructure investments and the development of gas fields. The characterization provided came within the framework of transaction cost economics and complete contracting. A complete contract is a long term contractual relationship where related parties in a transaction (buyer-seller) make provisions to cope with opportunistic ex-post behavior from each other in face of idiosyncratic investments from each side.

Long-term formatting predetermines the level (or sequence) of quantities and prices involved in a time trajectory and includes several contractual provisions to avoid opportunistic behavior against sunk investments. Chiefly among them is the minimum bill or take-or-pay or delivery-or-pay provisions, identify in early literature applied to natural gas contracts (see Marsten, 1988). “Pay” in those provisions does not necessarily involve cash payments but rather the obligation to take or deliver what it was written in the contract and in the case of gas deliveries may simply imply the requirement to find at the seller expense the quantities of natural gas required in the contract.

Studies that focused on natural gas were also interested not only in what determines observed contractual provisions, but also on how they change with the economic (regulation and competition) environment (e.g. Marsten and Crocker, 1985; Crocker and Marsten, 1988). Dimensions such as contract length were shown to (negatively) depend on the degree of competition in natural gas trade, with evidence coming from American markets given the relevance of the issues and the availability of data for large number transactions.

More recently research spread across the Atlantic as European markets developed and allowed for data size to inquire on contractual response to liberalization. Recent econometric evidence on natural gas imports finds contract duration related to the competition regime, asset (project) specificity and volumes (Neumann and Hirschhausen, 2006). Further explanations of the choice of contractual length along these lines have been explained by structural elements such as the “perceived” elasticity of demand in the long run, where suppliers take advantage to lock-in exchanges (Neuhoff and Hirschhausen, 2005).

The interesting feature of these results is that they are taken from international or cross-border transactions in an integrated (by infrastructure) market and thus are more rich and relevant for our setting. However, beyond the econometric evidence on general contract characteristics there are no details on actual contractual performance, conflict or adaptation and the absence of case studies is due to the difficulties of getting access to explicit contractual formats made available for research.

Given this shortcomings it is understandable that issues of incomplete contracting, and in more general terms contractual governance of unforeseen contingencies, are not addressed by the received literature. To begin with, it is not at all clear why contracts should be intrinsically incomplete in the setting studied by previous papers, and what verifiable features make them incomplete. Perhaps a key feature in cross-border exchanges is the commitment of national governments not to intervene in dimensions agreed-on previously at a coordinated supra-national level. These are precisely features that may have low relevance in the European integration experience. Nevertheless, exchanges in Europe do not come within the realm of the European Union and recent episodes of gas deliveries between Russia and neighbors cast doubts on the reliability of natural gas and led some governments to address questions of security of supply.

A contract is incomplete if at the moment of writing there are contingencies that may affect the exchange later on and cannot be incorporated either because they are unforeseen or difficult to describe, observe or quantify.<sup>2</sup> Unforeseen contingencies may be due to fundamental shocks in supply or demand structures or in policy variables that either affect them or hit at the exchange described in the contract. Answers to incompleteness in practice range from court “completion” in litigation procedures (which is, rather, third party “arbitration” and is subject to the same difficulties to discern phenomena that the original contractual parties faced) to “governance” frameworks agreed and incorporated into the contractual format. Contract theory in economics explores governance mechanisms while applied contract law studies focuses on court behavior.

---

<sup>2</sup> See Tirole (1994) and Salanie (1997) for technical surveys of theoretical issues and modeling strategies.

A simple framework to describe the potential sources of incompleteness in cross-border contracts of natural gas is provided with the help of the notation given by following identity, that expresses feasible exports for firm  $i$  ( $X_i^E$ ) as a difference between production ( $X_i^S$ ) and domestic demand ( $X_i^D$ ).

$$X_i^E \leq X_i^S(p, I^S(p^e), \theta^S) - X_i^D(p, I^D(p^e), \theta^D) \quad (1)$$

Production  $X^S$  depends on prices ( $p$ ), current and past investment (denoted by  $I^S$ ) which in turn depends on expected prices ( $p^e$ ) and a state-contingent variable ( $\theta^S$ ) that represents supply (including geological) conditions. Domestic Demand depends on prices ( $p$ ), current and past investment in natural gas-using equipment ( $I^D$ , a function also of  $p^e$ ) and a state-contingent variable ( $\theta^D$ ) representing demand conditions (including growth and energy-use patterns).

A contract is a sequence of volumes and prices ( $X_i^{CE}, p^{CE}$ ) that is individually feasible when written. That is to say that proven reserves of natural gas guarantee agreed volumes and also condition (1) across the time span of the contract. Opportunistic behavior of a hold-up nature is controlled by specifying fixed quantities and prices (so these cannot be renegotiated or subject to ex-post bargaining). Moreover, if  $p, \theta^S$  or  $\theta^D$ , create an imbalance, such that (1) cannot be met, then suppliers or “sellers” in the contract have normally to “buy” enough quantities to sustain the agreed delivery at the given price (path) or compensate “buyers” in another form, depending on what was originally agreed.

Aggregate consistency requires that adding up both sides of (1) also holds, even when it may not individually hold for some particular contracts. A stronger requirement for consistency is that individual contracts should satisfy (1) and, given other contracts, should also satisfy the adding-up condition. If aggregation of (1) across firms or contracts do not hold, then there will not be enough natural gas to satisfy exports and domestic markets at the same time, and individual contracts that cannot meet (1) will not be able to cover the quantities required in the contract, by borrowing or buying natural gas from other producers. Aggregate consistency is normally supervised by the government, in the form of authorizations (conditional on observed balances and what is perceived in terms of risks), as a regulatory function to avoid the externalities created by individual decisions. In certain scenarios of abundant natural gas resources, the government –judging that there is no risk of aggregate imbalances- may follow an “automatic” export authorization policy (AEAP), leaving to the private sector to evaluate the individual consistency of the project and granting permits once the private evaluation has passed.

In this context, contract incompleteness are unforeseen contingencies given by realizations of the state-contingent variables  $\theta^S$  and  $\theta^D$  and by the price policy ( $p, p^e$ ), that cannot be anticipated at the time of writing the contract. Either (uncommitted) price policy decisions or shocks in supply and demand, or both, may violate aggregate consistency and render contracts incomplete insofar as there will be a generalized gas shortage, and contractual provision to back-up deliveries with borrowed gas will not be feasible.

In this paper we distinguish between two competing hypothesis that have been commented elsewhere (Navajas, 2006) to address the natural gas shortage in Argentina and that are related

to the sources of incompleteness address before. The first hypothesis is that by the late 1990s and the early 2000s a shock in supply and demand conditions ( $\theta^S$ ,  $\theta^D$ ) not properly anticipated by producers or by government (i.e., in the context of an AEAP) led to individual and aggregate inconsistencies of export decisions, compounded by a slow response in investment decisions. The second hypothesis is that the price policy ( $p$ ,  $p^e$ ) followed by the government created an aggregate imbalance, particularly on the demand side but probably also on supply investments, that render exports contracts unfeasible. We explore the evidence related to these hypothesis in section 4, after a reviewing the rise and fall of recent natural gas integration in the southern cone.

### 3. Natural Gas Integration in the Southern Cone: From Success to Crisis

Important discoveries of natural gas in the 70s along with a new paradigm of private sector participation and regulatory regime in the late 80s and early 90s raised business climate and prompted several exports projects to Chile, Brazil and Uruguay. At a supranational level, several protocols were signed under the ALADI framework and authorizations to built pipelines were granted. **Table 1** summarizes the status of natural gas infrastructure integration in the southern cone.

**Table 1**  
**Natural Gas Pipelines in the Southern Cone**

Pipeline	Year	Capacity MM m3 day	Distance Km	Current use (Jan-Aug 2006) MM m3 day	Initial Investment in millions USD	Initial Shareholders of Project
<b>Chile</b>						
Norandino	1999	5	380	1.7	400	Tractebel and Southern Electric
GasAndes	1997	10	313	5.3	350	AES Gener (13%), Metrogas (13%), CGC (17,5%), Total Gasandes (10%), Total Gas and electricidad Chile S.A. (46,5%),
Gasoducto del Pacifico	1999	3.5	530	0.6	342	TransCanada, 30%; YPF, 10%; Gasco, 20%; El Paso Energy, 21,8%; and Enap; 18,2%
Atacama	1999	8.5	531	1.5	380	CMS Energy and Endesa (50-50)
Metanex YPF	1999	2.0	8	2.0	6.5	na
Metanex SIP	1999	1.2	12	1.1	na	na
Metanex PAE	1997	2	48,5	1.7	na	na
<b>Bolivia</b>						
Tarija-Campo Durán	1972	7.7	5	5.5	na	na
<b>Brazil</b>						
TGM	2000	2.8	450	0.9	250	Techint, CGC, TransCanada International, Petronas Argentina SA, CMS Gas Argentina, Repsol-YPF, Petrobras, Sulgas and AES.
<b>Uruguay</b>						
Cruz del Sur	2002	6	200	0.2	170	ANCAP (20%), British Gas (40%), Pan American Energy (30%), Wintershall Energía S.A. (10%)
Del Litoral	1998	0.7	15	0.1	na	na

Source: From several private and public sources and internet sites

All projects except one were designed to transport gas from Argentina to neighbors, are relatively recent and became operative in the second half of the 1990s. Pipelines were built in this period with a capacity to deliver up to 42 MM m3 day, which represents a sizeable share (about a third) of the production capacity in Argentina. Albeit incomplete from data restrictions, Table 1 suggests important initial investment efforts, of about 2 billion dollars.

The legal and regulatory framework for this exchanges is summarized in **Table 2**, describing a period of ten years from the Gas Law in Argentina to the starting of the domestic contractual

crisis in early 2002. Crucial to this framework were the bilateral protocols signed with Chile, the authorization mechanism for exports, the Mercosur Memorandum of Understanding on gas exchanges, the move towards an AAEP in 2001 and the measures taken immediately after the crisis in Argentina in 2002 pointing to objectives of priority of domestic supply.

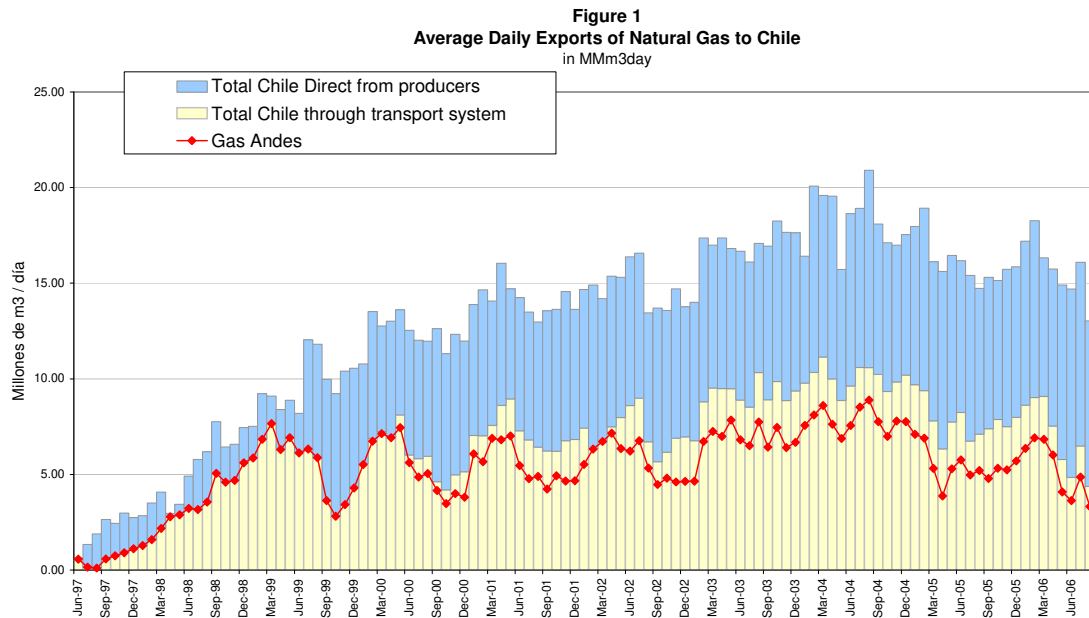
**Table 2**

**Framework for Natural Gas Exports: Pre-Crisis**

- Gas Law (1992) formally allows exports
- Bilateral Protocol (1995) sets norms that regulate supply and interconnection between Argentina and Chile.
- Secretary of Energy (SE) resolution (1998) set exports permits mechanism, requiring proven reserves and ability/commitment to maintain supply to domestic market
- Authorizations proceed on an individual and discretionary basis
- Mercosur' Memorandum of Understanding (1999) on gas exchanges.
- Competition Commission studies mergers and indirectly oversees state of exports supply
- SE resolution (2001) makes authorizations automatic after a period without observations
- After 2002 macro crises, domestic contracts frozen in pesos and export contracts not intervened (stay in US dollars). Again, requirements for domestic supply are stressed.
- Bilateral Protocol (2002) on information about "market conditions" and on "decisions" related to exchanges

Source: Official sources and Cafiero et.al. (2004)

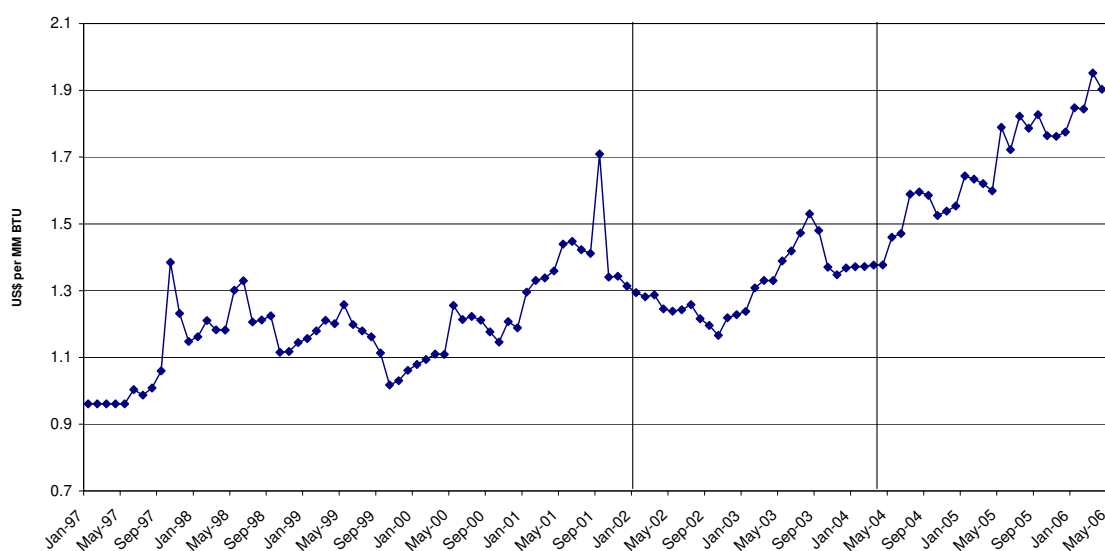
In this environment, exports of natural gas to Chile increased substantially from 1997 as the projects became mature. **Figure 1** shows a sharp increase from nil in 1997 to a peak of more than 20 MM m<sup>3</sup> day, equivalent to about 17% of domestic demand, in 2004 and a drop since then. As contracted capacity was expanding and additional shipments were expected, the observed fall points to a deliverability problem explained below.





Export prices are reported in **Figure 2**, and represent average values from trade statistics in Argentina. One important feature of these prices is that they reflected the (quasi-strong) nature of integration between Argentina and Chile, since they were co-integrated with domestic prices.<sup>3</sup> The reason behind this result is that export contract design made the sequence of export prices (normally indexed to reference fuels) constrained by the evolution of domestic prices. This feature shows that a one-price for both domestic and exports was at the heart of the integration design with Chile, very much unlike what it has been recently witnessed in the case of Bolivian exports of natural gas to Brazil and Argentina. Still, and despite this evidence of quasi-strong integration there were some regulatory problems concerning open access issues and pricing of transport as reported in Beato and Benavidez (2004).

Figure 2  
AVERAGE PRICE OF NATURAL GAS EXPORTS TO CHILE



The post devaluation (2002) environment was relatively normal insofar as contracted deliveries, beyond certain yellow lights turned on in 2002 and referred to at the end of Table 2. The crisis erupted in April 2004, when after a log and hot summer with –strangely enough– shortages of natural gas, Argentina entered into a gas-constrained regime in domestic markets.<sup>4</sup> In what was going to be the first moves in an unprecedented sequence of resolutions,

<sup>3</sup> This was so until the Argentine mega-devaluation in January 2002, where domestic prices were frozen in pesos and exports continued being denominated in dollar terms. Two vertical lines in Figure 2 indicate January 2002 when the devaluation took place and March 2004, when the domestic crisis led to export constraints. The upward adjustment of export prices shown in the figure since 2004 may depend on contracts changes (addendum) given the Argentine situation but it should also depend on indexation conditions given the link with fuels, and indirectly with the price of oil in international markets. Still, the raise in prices is less than what has been observed in other fuel-indexed export contracts in South-America, such as the Gas Sales Agreement between Bolivia and Brazil, and its level in mid 2006 is comparatively much lower, reflecting that prices (and its sequence) were favorably negotiated by Chilean buyers, which looked for prices similar to those observed in the domestic market. This situation changed dramatically in June 2006 as Argentina imposed a substantial export tax that was shifted to the Chilean buyers.

<sup>4</sup> See Cont and Navajas (2004) for an early analysis of the episode.

the Secretary of Energy (SE) in Argentina first suspended the automatic exports authorizations (that is, reverted the “AAEP” adopted in 2001) and then moved openly to an invocation of the rule of priority to serve domestic markets.<sup>5</sup> After an initial and temporary suspension of exports to “redirect” gas to domestic markets, the government then moved into perfecting the mechanisms through several resolutions by SE that stated that what it was sought was to require additional injections to serve domestic markets.<sup>6</sup> Thus instructions were given to producers –amid accusations of negligence for not keeping investment efforts- for additional injections determined by SE on an individual basis. In this new framework, and given the burden imposed on Chilean demand –rapidly voiced at the highest level-, it was stressed that exports were not prohibited per-se “if” the required additional injections to domestic markets could be met directly with physical gas or with an equivalent fuel.

The magnitude of the constraints that emerged from the mandatory supply to domestic markets resulted in “additions” that were equivalent in 2005 to about 37% (on average for all basins) of total exports measured in January 2004 (that is, in a month previous to the crisis that reflects normal shipments). **Table 3** shows these numbers for the three basins, where it can be seen that the “Neuquina” basin (the main source of exports to Chile) received the largest requests relative to exports.

**Table 3**

Exports before the crisis and "required additions" to supply domestic markets in 2005 at the different basins					
Basin	Daily average exports in Jan 2004 MMm3d	Share in Exports	Required Additions to Domestic Market daily average 2005 MMm3d	Share in required additions to Domestic Market	Additions in 2005 / Exports in Jan 2004
Neuquina	9.84	51.4%	5.32	74.6%	54%
Austral	4.57	23.9%	1.21	16.9%	26%
NorthWest	4.73	24.7%	0.61	8.5%	13%
<b>All Basins</b>	<b>19.14</b>		<b>7.14</b>		<b>37%</b>

Source: Aggregate estimates from the Secretary of Energy

Memo item: Total Production in all basins= 141.3 in MMm3d for 2005; Neuquina had a 59% share.

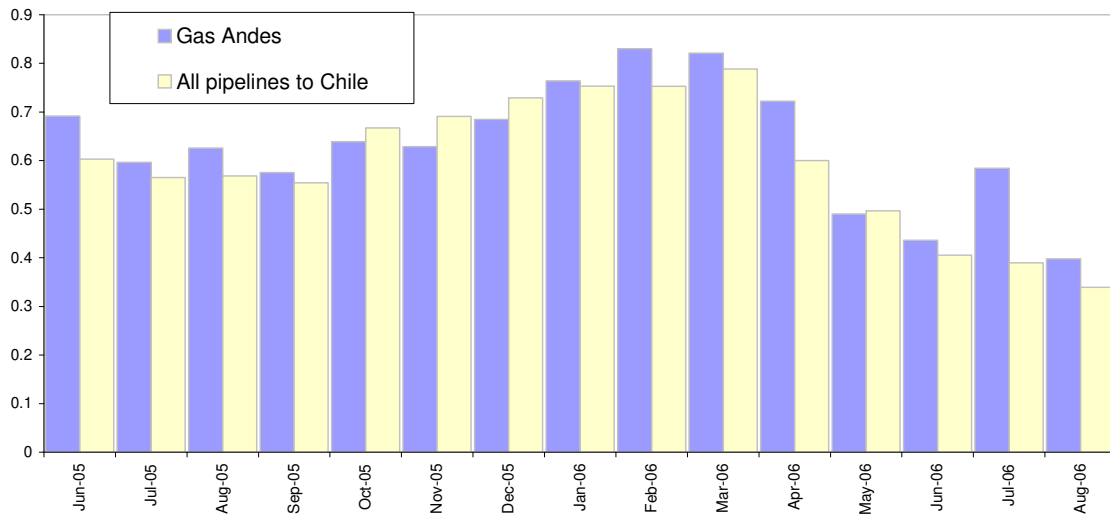
The previous Table suggest that producers in all basins suffered the same effect and that the picture is of a general shortage rather than a basin-located or individual producer one. In fact, this view is enlarged by the evidence shown in **Figure 3**, comparing the ratio of the actual exports to contracted export capacity in one of the main pipelines (Gas Andes, see Table 1 and Figure 1) with that observed for all pipelines. The Gas Andes pipeline, exporting from the

<sup>5</sup> Resolution SE 265/2004 of March 24, 2004 took this initial steps, including the suspension of Resolution 133/2001 of automatic authorizations and in fact of export permits at all. Export permits were later on “restated” in Resolution SE 833/2005. All resolutions quoted are available from [www.infoleg.gov.ar](http://www.infoleg.gov.ar)

<sup>6</sup> The “genealogic tree” of resolutions here starts in Resolution SE 659/2004 to the more recent Resolution 1886/2006.

Neuquina basin, is important for its size and location and, as it will be shown below, for being the center of one important contractual conflict that arose after the 2004 crisis.

**Figure 3**  
Ratio of Observed Exports to Contracted Capacity  
2005-2006



#### 4. Competing Views of Broken Exchanges

The previous section shows evidence pointing to a generalized shortage more akin to aggregate than individual inconsistency of export contracts. Thus it seems that aggregate explanations are in order and following the conceptual framework used in section 2 these explanations must be related to aggregate (non-price related) supply shocks, inconsistent domestic pricing policy or autonomous (non-price related) demand shocks. We submit two competing, albeit not mutually exclusive, explanations. The first one is related to evidence connected to a supply shock, while the second one has to do with domestic imbalances caused by distorted pricing. The role of autonomous demand shocks is seen within this second hypothesis (i.e. whether demand growth is due to price or non-price factors). Of course, both hypothesis involved unobservables and therefore are only partially addressed by the available evidence. This is true for the researcher but also for the courts, besides the fact that both explanations may be concurrently present in the evidence and it may become difficult to chose the dominant one. In fact this is a pervasive problem from the perspective of incomplete contracting, since otherwise third party arbitration could easily complete contracts ex-post.

The first hypothesis is related to a shock that may have operated in the form of structural “fatigue” in supply, perhaps due to geological reasons and/or related also to required investment efforts, that was not properly anticipated by producers and the government alike.<sup>7</sup> This shock would render contracts incomplete if it was unforeseen early on or, alternatively, may lead to arguments of negligence of some producers concerning investment provision

<sup>7</sup> In the statements contained in Resolution SE 133/2001, the government argued that the level of reserves in Argentina and the recent discoveries in Bolivia created enough margin to proceed with automatic export permits (so called “AAEP” in the terminology of section 2).

given that it could have been foreseen. An obvious problem with this hypothesis is that it depends on unobservable, or difficult to verify, assertions about supply conditions. Additionally, another conceptual difficulty is that in order to fit into observed results, of a generalized or coordinated failure or negligent behavior by producers (and the government).

This hypothesis has, nevertheless, some foundation in conclusions and comments obtained from an early energy study on Argentina, performed by a World Bank mission in 1989 (see World Bank, 1990). One conclusion from that study is a sort of warning about the dynamics of supply efforts to sustain the evolution of domestic demand and to avoid reaching a critical Reserve/Production ratio (underlying and italics are mine).

*“The urgent need for an accelerated exploration and development program is clearly shown by the trend in the [Reserves/Production] R/P ratio. In 1987, the...R/P ratio in Argentina was 20 years, comfortably above the critical level of 15 years.....Even if a substantial exploration program is undertaken immediately, and all of the probable and possible reserves are actually discovered, the critical R/P ratio... [for Demand Management]... will be reached by the year 2002.” (op. cit. p.101)*

A second remark of the study was directly related to the export policy on natural gas and the risks for the reliability of supply for domestic users (underlying and italics are mine).

*“In the case of all three projects exports now being considered...the buyer who must make a significant investment in pipelines (e.g. Chile) will insist on a long term supply contract and probably require that adequate reserves be explicitly dedicated to their project. None of the proposed export projects would impose a limit on near-term gas availability... but they would reduce availability over the long term...Discussions should be continued with potential buyers of Argentine gas; however, the national long term supply base should be assured before long-term export commitments are made.”(op. cit. p.111)*

Concerning the first quotation, the actual evolution of production and proven reserves in Argentina coincides with pessimist expectations. As Shown in **Figure 4**, the Reserves/Production ratio reached 15 years in 2002<sup>8</sup>, with reserves falling since 2001, suggesting that exploration results could not match the speed of production. Even though this does not mean an exact forecast by the study (given that many changes in Argentina happened in the 12 year period) it fits exactly as a qualitative comment that suggest that supply risks existed and had been mentioned before by authoritative sources. In Navajas (2006) this argument is complemented by historical data (1970-2005) taken from the energy balances published by the Secretary of Energy (2006) which shows a very intensive pattern of natural gas use.

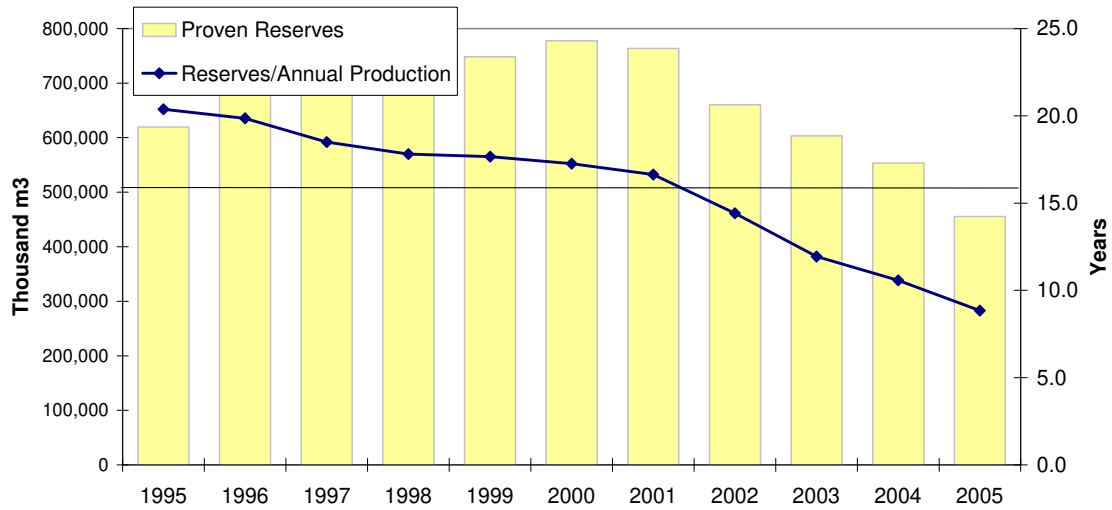
Concerning investment efforts to sustain the R/P ratio above the critical level, given the dynamic demand pattern, there is also some evidence showing a sluggish exploration effort after 1999. This is shown in **Figure 5** where the number of wellheads explored fell sharply compared to the previous decade. Nevertheless, the evidence shows that new wellheads for development or production did not suffer such a drop, suggesting that production efforts were still high and that the problem was rather related to exploration results. Reasons for the drop in 1999 cannot be attributed to a deteriorated contractual environment, as it may be argued for 2002 onwards. Low oil prices and a recession in Argentina might explain a wait-and-see

---

<sup>8</sup> The reasons for suggesting a ratio R/P of fifteen years are explained in the study, since the chosen figure depends on the characteristics of the Argentine up-stream sector including geological considerations.

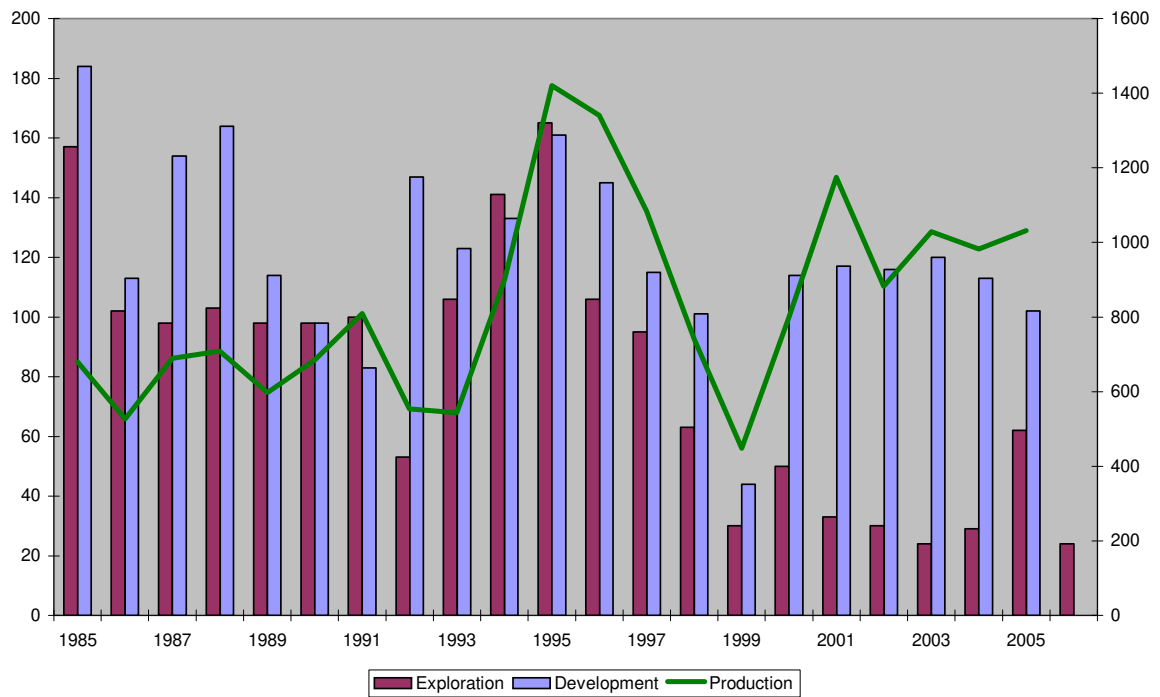
policy that was later on compounded or reinforced by a contractual intervention and a freeze on prices.

**Figure 4**  
**Argentina: Natural Gas Reserves and R/P Ratio**  
 1995-2005



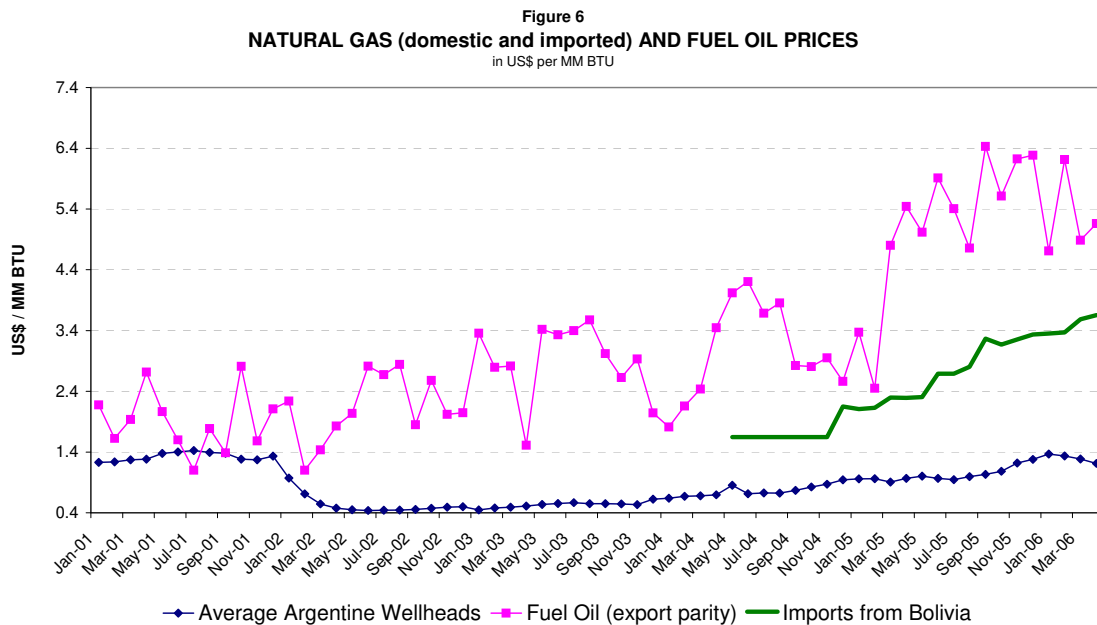
Source: Scheimberg (2006)

**Figure 5**  
**Number of Wellheads: Exploration, Development (left axis) and Production (right axis)**  
 1985-2006



Source: Scheimberg (2006)

The second hypothesis relates the observed imbalances with a policy-induced distortion in domestic markets after a freeze in domestic prices that, along with a rapid recovery, created a large increase in demand while depressed incentives to producers. The main evidence for this view is provided by the divorce between natural gas prices and benchmark substitute fuels, particularly in transport. This excess demand for direct use of natural gas was reinforced by a similar freeze in end-user prices of electricity, a large user of natural gas.<sup>9</sup> **Figure 6** shows the sequence of prices of natural gas for domestic users, the price of imports of natural gas from Bolivia<sup>10</sup> and the price of fuel oil (as a benchmark substitute in thermal generation of electricity). In general liquid fuels such as gasolines (relevant for substitutions towards natural gas in transport)<sup>11</sup> followed a pattern similar to the fuel-oil price described in Figure 6.



That prices are divorced from opportunity costs does not mean that the actual shortages follow simply from this direct observation. Rather we need some measurement that first decomposes the imbalances in supply and demand factors and then proceeds to explore the role of prices. This exercise was performed in Cont and Navajas (2004) and an up-date to the first part of 2006 is summarized in **Figure 2.7**.<sup>12</sup> The right hand side bars of the panel show factors

<sup>9</sup> Prices for industrial users both in gas and electricity began to adjust in 2005 and 2006, while they still remain frozen for residential and small commercial user. Prices of GNC were also partially adjusted in 2006.

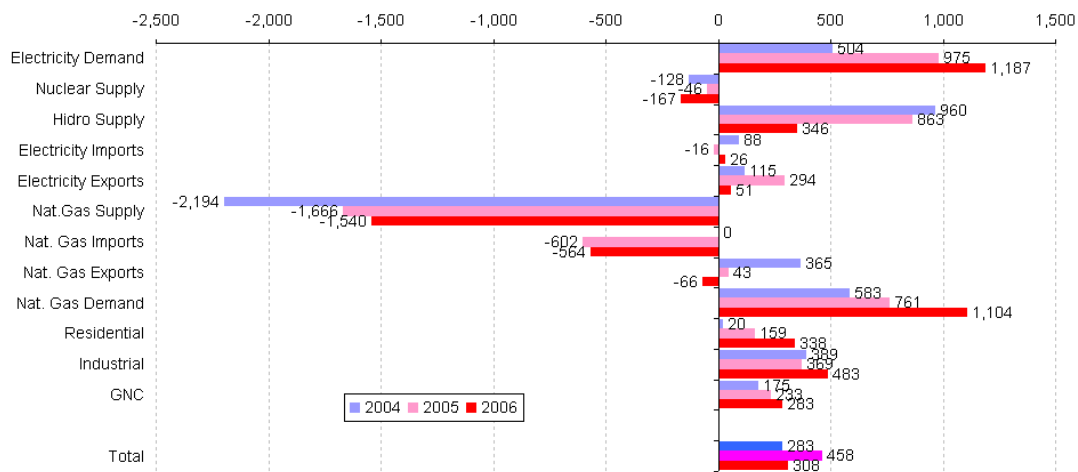
<sup>10</sup> In the recent long term contract signed between Argentina and Bolivia the base price (chosen for the first quarter of 2007) is 5 dollars per MM BTU.

<sup>11</sup> Gasification of the private transport fleet (mainly cars) in Argentina has been substantial since the early 1990s but it suddenly accelerated after 2002 in reaction to relative prices. According to national energy balances natural gas accounted in 2005 for almost 20% of the use of energy in transportation.

<sup>12</sup> We developed a decomposition of the gas shortage from a computable identity that matches the natural gas required by electricity generators with the disposable natural gas. This two parts are expressed in equivalent natural gas units and result, respectively, from the excess demand for electricity (when hidro and nuclear generation is subtracted) and the excess supply of natural gas (when demand components different from

contributing to the shortage, while the left hand side are those compensating the shortage. In 2004 when the shortage erupted (to an equivalent of 2.4 MM m3 per day, on average for the January-April period) the explaining factors were the fall in hydro-generation (due a long dry cycle), the increase in the demand for electricity and natural gas and to a lesser extent the growth in natural gas exports. On the other hand natural gas supply reacted positively (even though not rapid enough to meet demand). The situation changed in 2005 and 2006, were demand factors became more important in the explanation of the shortage. For instance the sharp increase in the demand for GNC between 2003 and 2006 was equivalent to 90% of the observed shortage.

**Figure 7**  
**Decomposition of Natural Gas Shortage**  
 January-April 2004, 2005 and 2006 vs. 2003 (Units: MM m3)



Source: Up-dated from Cont and Navajas (2004)

While the evidence shows that demand growth played a leading role in the imbalances, it has been said that this may be due to GDP growth or to an output-mix effect that, for instance in industrial demand, shifted output to energy (gas and electricity) intensive sectors after devaluation in 2002. However some scrutiny of these arguments with available data suggest that their role is not fundamental. Income (growth) effects were netted out in Cont and Navajas (2004) using available income elasticities from econometric evidence and they do not represent a large effect given that the economy was in fact recovering previous output levels. Concerning the output-mix effect, Navajas (2006) performed simulations of observed shifts in aggregate and in industrial production since 2002 and used available input-output coefficients to approximate changes in energy intensity. The result was that this sort of changes were small

electricity are subtracted). International trade in natural gas and electricity is also included in both sides. This decomposition allows to explain the observed shortage of natural gas, in relation to a “normal” year (2003) in terms of several components, to test whether supply or demand (an of what type) are dominant explanations and to proceed to test the role of prices (versus growth or output mix changes that affect energy intensity) in the demand side.

and happened between 1998 and 2002, so they cannot be attributed to the observed policy changes.

To sum up, addressing likely causes of observed shortages we find that rather casual evidence in favor of a supply shock, possibly not properly anticipated by producers and the government (leading to a less dynamic supply response to demand challenges) coexist with evidence of induced price distortions and demand factors. While the data suggest that demand factors are primarily responsible for the observed shortages, one cannot deny that a sluggish supply and low investment exploration efforts were underlying factors operating before the 2002 crisis. Observed shortages of natural gas are immediately explained by demand factors and point to a policy intervention effect. But the extrapolation of the observed reduction in the Reserves/Production ratio along with warnings expressed several years before suggests that sooner or later the intervention was going to be effected. This contending evidence is what makes third party arbitration procedures precisely so difficult to implement.

## **5. Contractual Conflict at the Gas Andes Pipeline**

Immediately after the restrictions on natural gas deliveries began to bite on the Chilean side, communications and negotiations started at the highest official level, with obvious claims from the Chilean side on the basis of protocols signed in 1995 and other further agreements. The response from and position of the Argentine government was made clear in several critical dimensions arguing that (i) there was an umbrella (protocols) but not an official commitment to exports, (ii) exports permits were wrongly decided by previous administration, (iii) legislation (and protocols) were clear concerning priority of domestic markets, (iv) decisions to supply exports were private decisions, possibly mistaken, (v) Observed natural gas shortages in general were explained by insufficient investment in upstream, (vi) exports are not prohibited if suppliers can deliver substitute fuels to domestic end-users. At the same time the Argentine government stated an unwritten commitment to maintain supplies whenever possible and to avoid cutting residential demand for urban areas such as Santiago. A new conflict emerged in mid 2006 when Argentina introduced an export tax within an operation to balance an increase in the price of its imports from Bolivia, with a substantial effect in final prices.

The interruptions also triggered contractual conflict at a private level between buyers of natural gas in Chile that had participated in the pipeline projects and producers in Argentina. One important case is related with deliveries through the Gas Andes pipeline (see Chart 1) in a conflict that started early on in 2004. The importance of looking at this case is that it is relevant because is a major transaction (about 2.5 MM m<sup>3</sup> day, representing 12% of total exports to Chile at the time of the interruptions) on the larger pipeline to Chile.<sup>13</sup>

The contract involved in this conflict had originally being signed in 1996 by “Buyers” (two generators and a Distco) and “Sellers” (about five gas producers operating areas at the

---

<sup>13</sup> This is not the only case but it may be the largest one. Other conflicts emerged in transactions using the Gasoducto del Pacífico (see Table 1) between trading companies (delivering gas to industrial users) in Chile and Repsol-YPF in the Neuquina basin, while similar demands were evaluated by electricity generators in the North of Chile, using the Noradino Pipeline, against producers in the Northern basin.



Neuquina basin). The qualitative features of the contract are all expected arrangements from the perspective of contract theory surveyed in section 2. The contract (i) was a long-term one (17 years) in line with the nature of the exchange and the sunk investments involved; (ii) had fixed quantities (with enlargement provisions) from a gas field committed exclusively to this export activities; (iii) had prices indexed by fuels but constrained to domestic pricing at the basin; (iv) was a take-or-pay contract, with flexible clauses for Buyers that may reflect demand uncertainty and contemplated outside opportunities (for the “untaken” gas) to Sellers; (v) was a delivery-or-pay contract with no flexibility, reflecting perhaps very low uncertainty of supply; (vi) had a “Force Majeur” provision contemplating for instance a case of direct government intervention; (vii) had an arbitration mechanism of disputes.

These features provided a seemingly reasonable design of contractual base given the nature of the exchange, investment in both sides and the stage of development in (gas to gas) market competition. Rigid elements of this contract, compared to what has been depicted by the evidence in the US and Europe (Neumann and Hirschhausen, 2006), can be understood given structural elements. However, the contract had apparently a weak management of unforeseen contingencies, such as problems with overall gas availability. One critical element in contract design was that the inability to deliver gas was supposed to be covered with natural gas from other producers, rather by an alternative fuel (such as was the condition imposed by the Argentine government to allow exports). This is to say that the contract did not contemplated a massive bottleneck in gas deliverability from Argentina to Chile and therefore the ex-post resolution of impeded exchanges were treated as a commercial risk from Buyers or Sellers defaulting individually.

In face of the events and the lack of response by Sellers to the request by Buyers of the contractually agreed deliveries, these initiated an arbitration demand on damages for the undelivered natural gas, within the terms of the contract. The process of litigation, under the umbrella of the ICC, is in process with resolution pending for 2007 and we obviously had no access to the material related with this legal procedure.

But some comments on the strategies followed by the parties are in order, given what has been presented in this paper. Sellers argued a “Force Majeure” situation given the constraints imposed on them in Argentina. However, this position apparently resulted difficult to sustain in court. From the evidence commented before it results clear why this might have been so. First of all, exports were not explicitly prohibited and could in principle be allowed if an alternative substitute (fuel-oil) is delivered to the domestic market, even though this might have been a strategy by the Argentine government to shift the burden to producers, knowing before hand that the proposed mechanisms for export authorization would be non implementable for all cases.<sup>14</sup> Nevertheless some evidence exists that the mechanism was used in specific and isolated cases or events.<sup>15</sup>

---

<sup>14</sup> Of course, for suppliers the problem with this proposal was not the availability of alternative fuels but the uncertainty about the price to be recognized by the Secretary of Energy, given the difference in prices between natural gas and fuel oil (see Figure 6). Expected losses and legal implications over pending contracts went against participation. Beyond this lack of incentive, which resulted in negligible acceptance of the mechanism, there is the hypothetical but interesting case that the announced condition for an export permit (i.e. supply an alternative or equivalent amount of fuel-oil) while valid for a single transaction, may not be feasible in the event that all exporters accept the offer, given the inability of the domestic users to for example run thermal units with such an

Second, and perhaps more problematic to Sellers, to invoke “Force Majeure” and avoid this being seen as an excuse for negligence, Sellers need to show that they had no way to anticipate the imbalances that occurred in Argentina after 2002. However, against this position is the evidence commented in section 3 related to signals of “supply fatigue”, lack of exploration efforts before 2002 and the warnings written in the World Bank report of 1990, concerning the balance between gas availability vis a vis dynamic demand.

On the other hand, Buyers argued for plain or outright contractual negligence rather than “Force Majeure” or unforeseen contingencies. From this angle the argument was simply the lack of investment or provisions that should have been foreseen by Sellers to keep supply given the evolution of domestic demand in Argentina. In the end, this argument by Buyers resembles, or rather exactly matches, the official Argentine explanation of the imbalances and shortages.<sup>16</sup> However, this line of argumentation has also several problems vis a vis the evidence presented in this paper. First of all, the generalized, rather than individual, partial interruptions of deliveries (see Table 3 and Figure 3) goes against the view that this was an individual negligence case. In terms of the framework presented in section 2, it was not only individual but also aggregate consistency that was violated in the case, with evidence that shocks in supply, demand or price policy ( $\theta^S$ ,  $\theta^D$ ,  $p$ ,  $p^e$ ) have been interacting. Given that “aggregate negligence” is a rather difficult argument, this may nevertheless motivate research behind aggregate inconsistency or perhaps coordinated tacit behavior among producers that could have led to a generalized shortage.<sup>17</sup> But this is an issue that goes beyond the narrow and focused bilateral case that will be addressed by the arbitration court.

A second problem for the Buyers demand is the evidence of government intervention in post 2002 and the imbalances created in the domestic market, particularly the role of demand vis a vis supply in explaining domestic market disequilibrium, that cast doubts on the simple and lineal argument of the Argentine government that it was due to lack of supply and investment efforts. Evidence for an exacerbated pattern of natural gas use at disequilibrium prices suggest

---

amount of fuel. To my knowledge no one has tested if an unanimous acceptance of the condition to export violates the maximum (reasonable) fuel constraint of the dispatch of thermal units in Argentina or imposes logistic costs (of fuel delivery) that are unreasonable .

<sup>15</sup> Indeed this was used by the Buyers who participated once in the mechanism and complaint that this was a proof that the Sellers had used the “Force Majeure” argument to disentangle themselves from obligations on how to manage the problem, particularly given their position and knowledge of the Argentine market to organize such exchanges.

<sup>16</sup> This may sound strange given the voice expressed by the Chilean authorities about the crisis, and the suggestion that it was necessarily connected with regulatory decisions taken after 2002. But this was what Chilean Buyers, or their lawyers, argued and need not be congruent with official arguments or explanations. For the Chilean authorities it became clear that the contracts were a private concern and that there could not be an official legal claim against Argentina.

<sup>17</sup> For coordinated or tacit behavior of export decisions it is required that decisions taken by individual producers in the Argentine market be “strategic complements” (i.e. raise the marginal benefit of the same actions of others), in the expectation that domestic prices would accommodate to clear domestic markets. Given that exports contracts were designed so as to adjust prices in line with domestic market prices, a rise in export prices is guaranteed establishing the link for actions (export decisions) to be strategic complements. This problem was to my knowledge never discussed in Argentina. The only intervention by competition authorities in relation to exports to Chile had to do with some proposed mergers or acquisitions of producers participating in the export projects, that led to an evaluation of the cases but not to problems of conduct such as those hypothesized above.

an excess demand scenario, with supply lagging behind after years of low investment efforts that were even more paralyzed by the price policy ( $p, p^c$ ) faced by all Sellers alike.

The impression from this analysis is that it will be a hard job for the arbitration court to “complete” the contract and that, despite claims on the contrary by Buyers, the incomplete nature of the contract lies in the fact that it was not prepared to face events of the nature and magnitude of those experimented years after.

## **6. Issues and Lessons for Contract Design and Regional Cooperation**

There are two areas of analysis and policy making where the topics discussed in this paper contribute directly or indirectly. One is the field of contract design for international exchanges of energy that are supported by infrastructure investments. The second one belongs to issues of regional cooperation and coordination of policies among participant countries.

Given the evidence that existing contracts did not include provisions that were targeted to the aggregate inconsistency of export decisions, there seems to exist room for improving design. Efforts in this direction should be concentrated at the study of contractual provisions related to the presence of aggregate energy imbalances on both sides, but particularly on suppliers. This is so because the later can take investment efforts, autonomous or in response to policy decisions that may jeopardize the sustainability of contracts. Ex ante clauses to govern contingencies are difficult to write down, but provisions can help at providing some back-up for these circumstances. The back-up provisions apparently present in existing contracts assume that the Seller can find alternative sources of supply and therefore do not properly address a generalized shortage. Explicit inclusion of deliveries of substitute fuels (that is, the back up fuels that will be finally used by Buyers) could work better than assuming that natural gas will be available elsewhere.

Rather than reflecting past experiences, these issues are relevant for very recent transactions between Argentina and Bolivia. In fact, the ENARSA-YPFB contract signed in 2006 between both firms is a big project to supply up to 27 MM m<sup>3</sup> day from the southern Bolivian basin that involves, according to preliminary estimates, a major infrastructure investment in pipelines of about 1.2 billion US dollars and additional investments in Bolivia to develop the gas fields of about 2.0 billion. The contract has been made public in both countries and its design shares some of the features common to long-term minimum bill contracts.

However, the contract is weak on the dimensions stressed in this paper and, in particular, the management of contingencies related to a generalized shortage of gas in Bolivia sometime in the future. Given the level of certified or proven reserves, optimism about deliverability is similar to the one stated at the moment of writing contracts between Argentina and Chile. The commitment of the Bolivian side is only contemplated in the take-or-pay provision, but a clause in the contract implies that, in face of interruptions, priority of supply will be granted to the domestic market, then followed by previous export contracts to Brazil. Even though the domestic market is small compared to export volumes, it has a large potential of development if policies promoting domestic industrialization are adopted. Thus the contract is subject to the same problems that were present in the Argentina-Chile integration surveyed in this paper. The fact that the contract was signed by both governments does not add much security of

supply given that it is a commercial contract between two public firms and there is no agreement or commitment at a government level and above the contract (beyond an agreement of intentions to cooperate in the project). Finally, the contract has also a feature that do not belong to good practices of regional infrastructure integration and its reading casts doubts on the willingness of Argentina to normalize export permits to Chile.<sup>18</sup>

At the regional cooperation level the message of this paper is that there are reasons to enlarge the focus on regulation-cum-competition design for infrastructure projects (see for example Beato and Benavidez, 2004). More attention to conditions to sustain exchanges on the infrastructure are required. Some of these conditions go back to good policy design to mitigate regulatory risks of sovereign decisions by governments, particularly if the view is that policy-induced mistakes are responsible for impeded exchanges. The question of commitment mechanisms by participant governments (to domestic pricing policies for example) is a difficult one but it may deserve a coordinated effort.

But some other conditions go beyond good regulatory design for infrastructure and to the realm of energy planning, particularly if the view is that mistakes in long term energy policy, for example in the form of absence of monitoring of conditions of aggregate consistency of private decisions, are responsible for broken exchanges. A weak form of coordination between governments is to create a permanent exchange of information and monitoring. In the case studied in this paper, the governments of Argentina and Chile agreed on that mechanism in 2002 (see Table 2), when the evidence suggests that the crisis was already well into the radar. Since this weak form of coordination may be seen as too little for the required corrections, it should be set well in advance to avoid being too late. The contract between ENARSA of Argentina and YPFB of Bolivia contemplates a monitoring mechanism of this sort.

Hard forms of coordination of energy policies are more difficult to suggest and implement given the traditional reluctance of governments to commit what are viewed as strategic policy decisions including national security of supply. Nevertheless this case shows that critical assessment and risk evaluations of energy planning may render high benefits for energy infrastructure integration. Coordination here would imply simply a request that energy plans in an agreed format are made available and subject to stress tests. In the case described in this paper, Argentina abandoned energy planning (not to mention stress testing) in the belief that privatization with a good regulatory framework and efficient private participants would suffice for sustainable energy development. It did not, and the message written inside the World Bank mission report in 1990 was superseded by unfounded unlimited optimism.

## 7. Concluding Remarks

This paper draws on applied contract theory and uses evidence on policies, markets and private transactions to discuss the experience of natural gas infrastructure integration in the

---

<sup>18</sup> Clause 3.3 of the contract states that the quantities delivered will be allocated to serve domestic markets in Argentina and “cannot be allocated to increase exports authorizations to third countries (being public and/or private companies) without the agreement of both parties”. The claim of Bolivia to Chile of a way out to overcome its insularity is a longstanding one. Beyond this fact, the policy of exports authorizations of Argentina will continue to be tied to required gas to be redirected to domestic markets or on the above mentioned mechanism of making alternative fuels disposable.

Southern Cone of Latin America. The argument is that contracts on international exchanges supported by infrastructure may become incomplete due to contingencies not anticipated at the moment of writing. Sources of contingencies may lie in supply and demand shocks or be related to policy-induced price distortions. Some or all of these sources may create imbalances in domestic markets of exporting countries, leading to aggregate inconsistencies.

The Argentina-Chile integration experience fits well into this mold. At an aggregate level the evidence presented in this paper shows how policy decisions framed the integration of markets and later on reversed the integration path when shortages of a generalized nature began to emerge. We argued that an inquiry into the sources of the shortages is relevant for separating anticipated from unexpected shocks, supply from demand impulses, and policy-induced from market-participants-induced distortions. This separation is also essential to discern the degree of responsibility of Sellers and Buyers in private transactions, like the one referred to using the Gas Andes pipeline. The evidence falls short of being conclusive on the dominant or ultimate factor behind the broken exchanges, even though the quantitative evidence on market disequilibrium post 2002 seems more robust than casual evidence on lack of investments or supply fatigue. But this may reflect the state of available data and of used methods and is open to further inquiry. What seems clear and conclusive is that the event being studied is of an aggregate nature rather than an isolated break of an individual exchange relationship. Rather, the crucial distinction is whether this was due to policy-induced or agents-induced mistakes. In this respect, individual decisions by natural gas producers to move to massive contractual export arrangements and the possibility of tacit coordination given its effects on domestic market equilibrium is another avenue of research that deserves attention.

Finally, this paper has clear lessons for both private agents and policy-makers alike. While regulatory risk mitigation solutions in both contracting and policy making have been stressed before, this paper adds specific points on back-up contract provisions designed to cope with aggregate imbalances, on ex-ante weak forms of supranational coordination related to information about market conditions and on energy planning dialogues that test consistency and stress situations in markets where exports originate. Methods and institutional mechanisms to perform this coordination seem to be another useful area of applied policy research.

## References

- Beato P. and J. Benavides (2004) (eds.), Gas market Integration in the Southern Cone, IADB, Washington.
- Cafiero C., E. Dellepiane and L. Gorzelany (2004), “Emergency and International Exchanges”, (In Spanish), mimeo, CEARE, Buenos Aires, November.
- Cont W. and F. Navajas (2004), “The Simple Anatomy of the Argentine Energy Crisis” (In Spanish), DT N°82, FIEL.
- Crocker, K. and S. Masten (1988) Mitigating Contractual Hazards: Unilateral Options and Contract Length, RAND Journal of Economics, 19(3), 327-343.
- Heymann D. (2006), “Macroeconomics of Broken Promises”, mimeo, ECLAC, Buenos Aires Office.
- Masten, S. (1988) “Minimum Bill Contracts: Theory and Policy”, The Journal of Industrial Economics, 37(1), 85-97.
- Masten, S., and J. Crocker (1985) “Efficient Adaptation in Long-Term Contracts: Take-or-Pay Provisions for Natural Gas”, American Economic Review, 75(5), 1093-1093.
- Navajas, F. (2003), “Some Remarks on Sectoral Reform in Argentina”, Conference on Sectoral Reform, Stanford Center for International Development, Stanford University, November.
- Navajas F. (2006), “The Argentine Energy Crunch 2002-20XX” (In Spanish), DT N°89, FIEL.
- Neuhoff, K. and C. von Hirschhausen (2005) “Long-term Contracts for Gas Imports – A Theoretical Perspective”, Cambridge, CMI Working Paper.
- Neumann A. and C. von Hirschhausen (2006), “Long Term Contracts and Asset Specificity Revisited – An Empirical Analysis of Producer-Importer Relations in the Natural Gas Industry”, 06-010 WP, CEEPR, MIT.
- Rufin C. (2004), “Regional Public Goods and Infrastructure”, in Estevadeordal A., B. Frantz and T.R. Nguyen (eds.), Regional Public Goods. From Theory to Practice, IABD and ADB, Washington.
- Salanie B. (1997), The Economics of Contracts. A Primer, Cambridge, Mass.: MIT Press.
- Scheimberg S. (2006), “Argentina Oil and Natural Gas: Upstream & Downstream”, (In Spanish), mimeo, September.
- Secretary of Energy (2006), National Energy Balances. Series 1970-2004, Buenos Aires.

Tirole J. (1994), "Incomplete Contracts: Where Do We Stand", Econometrica, Vol.67, N°4, pp. 741-781

World Bank (1990), Argentina: Energy Sector Study, Volume I, Report N° 7993-AR, February 26, 1990.