The impact of who decides the rules for network use: A 'common pool' analysis of the investment dynamics in different gas network regulatory frames

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Abstract
The liberalization of the natural gas industry has been based on the idea that the same infrastructure may be used by different gas owners. Different players using the same resources can give raise to 'commons dilemmas', which is defined by a conflict between individual rationality and group rationality. The individual rationality leads to an outcome that is not rational from the perspective of the group. To avoid 'commons' inefficiencies, it is necessary to establish rules that constrain the players' use of the network. The rules of a 'common pool' may be established through external authority or by the users themselves. In gas industries, the regulators play the role of external authority. The definition of rules by the users themselves is implemented through players' agreements. In the first case the access is completely opened and the same set of rules is applied to every player (common carriage). In the second case, the design of a system of rights is based on players' commercial agreements (contract carriage). Traditionally, the choice is made paying attention to the impact of the rules on the allocation of existent resources (appropriation) and taking into account only an average consumer. We show that, as proposed by the common pool theory, the use of average consumer preferences to define the rules of infrastructure may result in inefficient output.
Moreover, we show that there is also the dynamic impact of the choice of carriage system. One of the main incentives for new investment is the use of the current infrastructure. As the carriage system impacts on the use of the infrastructure, it also has consequences on the long-term dynamics of the gas infrastructure. We compare investment signals in EU industries, based on common carriage systems, and in USA, based on contract carriage systems. The analysis allows us to identify missing economic signals in the EU regulatory framework. Moreover, we show that under common carriers, there is a lack of incentives to innovate in the kind of service that is offered by the network.

1. Introduction

Gas industries assets are characterized by strong site (spatial and temporal) specificity. Moreover, gas and power has also strong physical specificity. This is a source of severe transactions costs. Hence, (O. E. Williamson, 1979), one expects a high level of vertical integration among users and pipeline owners, (J. H. Mulherin, 1986) and (P. L. Joskow, 1987). In order to allow market arrangements to coordinate the industry, it is necessary to create a tradable commodity. So market designs for gas industries begin with the some standardization of the commodity.

One of the key elements to reduce the asset specificity of energy industries, and hence the costs of trading energy in markets, is the transmission infrastructure. Once some standards for physical characteristics are set, transmission infrastructures connect several locations and times of delivery, enlarging the trading space. This reduces the specificity of gas and power, making market arrangements easier. But at the same time, network infrastructures are dedicated assets. So in order to benefit from network infrastructures to reduce gas commodity specificity, one needs to decide how to coordinate the use and investment in the network. This paper tackles the problem of analyzing the available choices to design the regulation intended to guide the transactions associated with network resources allocation and investment.

Under the liberalization frame, complete vertical integration is forbidden: pipeline users and pipeline operators (and owners) must be unbundled, (M. J. Doane and D. F. Spulber, 1994). This rule was established to decrease entry barriers. As gas transmission systems are dedicated assets with high capital cost, they should be accessed by as many shippers as possible. There is an extensive bibliography identifying the asset specificities of the gas transmission system. The new institutional economics has shown the need for long-term contracts to decrease the transaction costs of the coordination between gas commodity and the pipelines (K. J. Crocker and S. E. Masten, 1988), (K. J. Crocker and S. E. Masten, 1985), (J. H. Mulherin, 1986), (R. G. Hubbard and R. Weiner, 1991), (A. Creti and B. Villeneuve, 2004), (C. von Hirschhausen and A. Neumann, 2008), (J. M. Glachant and M. Hallack, 2009). This literature focuses on the characteristics of long-term contracts and their role in guaranteeing the trade among players.

Our paper adds a new level of analysis. We enter into the contract characteristics themselves in order to analyze the kind of service that is actually offered. Unbundling stated as a prerequisite for gas industry liberalization makes network infrastructure a common resource. We show in this paper that the different mechanisms defining the rules of gas network use strongly impact the services offered and the investment incentives. The use of the same resource by a large number of players can be analyzed through common-pool resource theory. This approach allows the analysis of the players' incentives of using common resources and to invest in common resources, (E. Ostrom et al., 1994). This approach complements the transaction costs approach as it discuss the efficiency of the allocation of a resource that is not completely private neither public. In other words, we will analyze the coordination mechanisms taking into account the different partial rights that players may have in a common pool, (E. Ostrom, 2005) and (T. C. Bergstrom, 2010).

To do so, it will make use of the general framework proposed by (E. Ostrom, R. Gardner and J. Walker, 1994) and (E. Ostrom, 2005), with the aim to assess the economic incentives and distortions that gas transport open access rules may imply. The classification proposed in (E. Ostrom, 1994) builds on the description of economic goods based on two fundamental attributes developed by (P. A. Samuelson, 1954) and (R. A. Musgrave, 1959). On the one hand, goods can be classified regarding to the associated difficulty in excluding individuals from benefiting from the service flow; this first property is called excludability, which was introduced by (R. A. Musgrave, 1959). On the other hand, considering that goods behave differently depending on whether the consumption of the good by any individual reduces the possible consumption of the others; this second property is called subtractability[1]. For instance, private goods (the ones better described by mainstream economic theory) are characterized by a situation where it is relatively easy to exclude participants from the particular mechanism (as in the case of any market), and where any consumption of the good reduces significantly the available consumption for the rest of participants. On the other side of the spectrum, public goods are characterized by relatively low levels of both features and their coordination is frequently based on a centralized frame (such as government ownership). One of the main tools used in this paper is the identification of gas networks in the liberalization context to the kind of good called common-pool. This allows us to apply their results on the interaction between rules of infrastructure use and available services, and thus to analyze how the choice of the network regulatory framework may change the available bunch of network services in the short and long term.

The gas transport network in a liberalized market is a private infrastructure used by a set of economic players (the shippers). Individuals, thus, consume the flow of services produced by network facilities, rather than directly consuming the facilities themselves, (E. Ostrom et al., 1993). The economic rationale that stems from the identification of gas networks as a common-pool resource is that the most effective regulatory design would be something between of traditional pigovian regulatory approach, (A. C. Pigou, 1932), and full property-right approach, (R. Coase, 1960) .

In order to coordinate these transactions without vertical integration, two different (and even opposite) systems were established in Europe and USA, (J. D. Makholm, 2006). In Europe natural gas pipelines have been regulated as national (or regional) networks through a set of codes applied to any user. In USA, each pipeline defines its services separately and based on the negotiation with the users, (M. Vazquez et al., 2012). Most of the following analysis will be devoted to discussing the pros and cons of network use coordination in European countries and USA.

After this introduction, section 2 discusses the common pool nature of the natural gas transmission systems. An infrastructure been used by different players, which the use of one impact the available capacity for the others players. Moreover, the services offered subtract different amounts of available capacity. The use of different services impacts differently on the total use of the network.

Section 3 builds a series of illustrations based on simple games. The network can be used to provide flexible and/or flat services. So we suppose possible rules for service allocation. We show that the expected output changes according of the rules established. Moreover, we analyze games representing the impact of defining ex-ante rules (by a third party), and of defining rules according to players preferences (negotiation between shippers and pipelines).

Section 4 discusses in depth the different implementation of network rules. Such implementations are called carriage systems. We show that the definition of property rights implied by the carriage systems results in whether the system defines ex-ante rules or rules based on players' negotiation. We show that

[1] Subtractible goods are rivals in consumption, as proposed by Samuelson (1954).

carriage systems adopted by EU and USA are different in this regard, and consequently the rules of network use are different.

Section 5 makes a step further with the study of how these different mechanisms to define rules actually impact on investment decisions. The mechanism of defining rules (the carriage system) impacts on the rules of infrastructure use. But infrastructure use impacts on investment. As a result, we show that the mechanism that defines the rules of use of a common infrastructure actually impacts on the dynamics of investment. Moreover, the mechanism chosen also affects the incentives for service innovation.

The last section is dedicated to conclusions and the underlining about open questions. We especially discuss about the impact of the common resources theory may have to the traditional approach of network industries regulation by adding a new level of analysis: the rules of common pools' use.

2. Gas transmission systems as common pool resources

The two main characteristics that motivate our analysis are the common-pool nature of networks in a market environment and the heterogeneity of services that they may offer. In this section, we first describe the services that the network may offer, and then we characterize the common-pool nature of the infrastructure.

2.1 Services heterogeneity

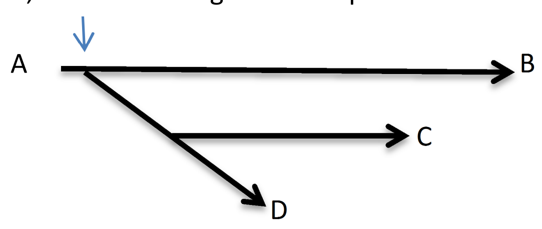
Natural gas pipelines are able to offer at least three kinds of services, which are: a) transport of gas between two points in a determined point in time; b) transport between two regions (being each region a set of points) in determined point in time; c) transport and storage of gas (different timing between the moment of injection and withdrawal of gas), (M. Hallack, 2011).

a) Point-to-point transport

The simplest way to think of gas transmission is considering the injection of gas in point A and the withdrawal of gas in point B. The gas is transported by the pressure differential between point A and point B. Thus, by increasing pressure in point A, the gas flows to point B where it is delivered. It is a point-to-point transmission service.

b) Region-to-region transport

When a set of pipelines is considered, it is possible to offer a service giving the right to transport from A to B, and also the right to transport from A to C, and from A to D.



c) Line-pack storage

The combination of pipeline and compressor may allow gas storage. The pressure differential between two points makes the gas flow. But on the other hand, the increase of pressure in the total system (by decreasing pressure differentials) actually stores gas[2].

The transmission services between regions (b) and the use of the line-pack storage (c) are actually the offer of flexibility services, both time and spatial flexibility, (M. Vazquez and M. Hallack, 2012). We will call such services flexible transmission services. The point-to-point services (a) will be called flat transmission services.

2.2 Services subtractability

Common-pool resources are characterized on the one hand by the relatively high difficulty in excluding potential beneficiaries of networks services, and on the other by the relatively high subtractability of use. The use of a pipeline by any player subtracts the resources available for the others players. Thus, the pipeline services are subtractible services.

Common-pool resources may be subject of prisoner's dilemmas. To avoid the inefficiencies associated with prisoner's dilemmas, it is necessary to establish some rules for the use of the resource. For instance, one the basic rules to be implemented is to respect the security limits of the pipeline. The transmission system needs to respect pressures limits and thus there are a limited number of players that can use the resource in the same time. Moreover, as resources are limited, it is necessary to define who has the right to use it.

But the physical system may deliver different service and the different services impact differently in the total available resources. The use of flexible services decreases the availability of flat services[3]. In that view, flexible services subtract network capacity in a different manner than flat services. The exact value depends on the amount of flexibility: temporal flexibility (hourly, daily, weekly...) and spatial flexibility (the size of the region where the gas can be injected and withdrawn). Moreover, the relation between the cost of flexible and flat transmission services depends on physical characteristics of the network components: compressor stations (mechanical characteristics, position and power...) and pipelines (size, diameter, material, thickness...), (J. M. Glachant and M. Hallack, 2010).

Therefore, in addition to the rules related to the common resource, it is necessary to define the rules aimed at coordinating the amount of flexible and flat services that will be offered by the network. As the subtractability of different network services is not homogeneous, there is a need for additional rules to

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[2] This is a simplification of the gas flow equations, which also include other variables as temperature, different phases of natural gas and etc. For details on this, **Mokhatab, S.; W. A. Poe and J. G. Speight.** 2006. *Handbook of Natural Gas Transmission and Processing*. Gulf Professional Publishing..

[3] For more details see **Lapuerta, C.** 2003. "Brattle's Assessment of the Operation of the Nts," *The gas trading arrangement: Reform of the Gas balancing Regimes.* UK: OFGEM, , **Lapuerta, C. and B. Moselle.** 2002. "Convergence of Non-Discriminatory Tariff and Congestion Management Systems in the European Gas Sector," The Brattle Group. Report to European Comission, , **Keyaerts, N.; M. Hallack; J. M. Glachant and W. D'haeseleer.** 2011. "Gas Market Effects of Imbalanced Gas Balancing Rules: Inefficient Regulation of Pipeline Flexibility." *Energy Policy*, 39(2), 865-76..

coordinate such decisions. We will show in the next section, by means of simple games, that defining such set of rules is not straightforward.

3. Different uses of the gas transmission resource: analyzing games outputs

In this section we show how rules of network use impact on the final output, and how contracts may be used to minimize the impact of such rules on users' choices. Following the methodology of analyzing simple games we will show how the rules of transmission system allocation can generate incentives for diverse outputs, (E. Ostrom, R. Gardner and J. Walker, 1994).

To do so, we will consider a simple representation of the technical decisions associated with the operation of pipelines. Specifically, we will consider only two kinds of services: flexible and flat use. In that view, we focus on how to decide if available resources are devoted to provide flexible or flat services.

3.1 Potential prisoner's dilemmas when networks offer different products

The first step of our reasoning is to put forward a simple example of commons dilemma. Consider a simplified model of a gas network that two players can use. Both players obtain a value for the flat use of network $v_{flat} = 6$ and a value for the flexible use of the network $v_{flex} = 10$. Players decide on two possible options: using 2MW of flat network capacity, or using 1MW of flat capacity plus 1MW of flexible capacity.

Game 1

Let us assume first that network capacity is 4MW regardless the combination of flat and flexible use of the network. For the same transmission system, the amount of available flex capacity is equivalent of the amount of flat capacity.

Table 1: First Game Illustration

Demand of network	Network capacity	Strategic form of the game		
4 Flat	4		**2 Flat**	**1 Flat – 1 Flex**
3 Flat - 1 Flex	4	**2 Flat**	(12,12)	(12,16)
2 Flat – 2 Flex	4	**1 Flat – 1 Flex**	(16,12)	(16,16)

The grey box of Table 1 represents the equilibrium of the game. In this case, there is no commons' dilemma regarding the rules of resource allocation. But the result is based on considering that the services offered by the transmission network are equivalent for the system (the use of flexible capacity subtracts the same amount of the available capacity than flat capacity). It means that, actually, whether the use is flexible or flat is irrelevant, as they affect the others players the same way.

Game 2

Nevertheless, in practice, flexible capacity subtracts more from the available amount than flat capacity. Hence, the impact of flexible demand for network capacity is different of the impact of flat demand. Flexible services demand more capacity from the total capacity of the system than flat services. To illustrate this, consider the following modification of the initial game: the capacity of the network, if both players choose to use it flat, is 4MW. If one player chooses flexible use, the flat capacity is 2MW and the flexible capacity is 1MW. If both players use the network flexibly, the flat capacity is zero and the flexible capacity is 2MW. It means that the use of flex capacity (1MW) leaves less available flat capacity for further allocation than the use of flat capacity (1MW)[4].

Capacity allocation 1

If the demand for network is higher than its capacity, the rules for allocating network capacity are the following: a) the capacity is allocated equally among users and b) the flex capacity is allocated first (there is priority for flex capacity before the allocation of any flat capacity).

Table 2: Second Game Illustration

Demand of network	Network capacity	Strategic form of the game		
4 Flat	4 Flat		**2 Flat**	**1 Flat – 1 Flex**
3 Flat - 1 Flex	2 Flat – 1 Flex	**2 Flat**	(12,12)	(6,16)
2 Flat – 2 Flex	2 Flex	**1 Flat – 1 Flex**	(16,6)	(10,10)

In this second game, the equilibrium is represented by the grey box in Table 2. We observe a prisoner's dilemma because players have to choose between more capacity or more valued capacity. If the other player chooses valuable capacity, the amount of your own capacity is restricted. The use of the rules allocating capacity to both shippers equivalently and giving priority to flexible capacity results in prisoners' dilemmas outputs.

But it is possible to consider a different allocation rule.

Capacity allocation 2

If the demand for network is higher than its capacity, the rules for allocating network capacity are the following: a) the capacity is allocated equally among users and b) the flat capacity allocated first (there is priority for flat capacity allocation before the allocation of any flex capacity).

Table 3: Third Game Illustration

Demand of network	Network capacity	Strategic form of the game		
4 Flat	4 Flat		**2 Flat**	**1 Flat – 1 Flex**
3 Flat - 1 Flex	3 Flat – 0.5 Flex	**2 Flat**	(12,12)	(12,11)
2 Flat – 2 Flex	2 Flat - 1 Flex	**1 Flat – 1 Flex**	(11,12)	(11,11)

In this game, the equilibrium is represented by the grey box of **Table 3**. We observe that the previous dilemma is now solved by giving priority to the allocation of flat capacity.

Lessons that may be drawn from the examples

Looking back on these three examples we observe that the game output depends a) on the characteristics of the services offered and b) on the allocation rule.

The output of the games changes depending whether the impact of services in the system is equivalent or not. In the former case, in case of excess of demand, the capacity is used equivalently by the two kinds of services.

[4] In other words the opportunity cost to use one unit of flexible capacity is higher than the opportunity cost to use one unit of flat capacity.

However, if the use of a unit of flexible service impact differently on the system, it raises the question of how to allocate capacity in case of restrictions. We show that if flex services (more valuable and more costly) or flat services (less valuable and less costly) have priority in the use of the system, we generate different outputs.

But in addition, some solutions result in prisoners' dilemmas. In the first case, where flexibility has priority, the game structure is the one corresponding to the prisoners' dilemma. In the second one, however, changing the rule and given priority for flat capacity, the dilemma disappears. The essential requirement for doing so is to know that flat capacity, even with lower value, is the efficient assignment, because choosing flexible capacity implies a too costly reduction in the transmission capacity.

Therefore, the rules of network use (given access priority to one or another kind of capacity) play a central role to define the efficient output. Anyway, it may be possible for the pipeline operator of the previous examples, to anticipate that flat capacity is more efficient, and thus the coordination could be done by the process of capacity calculation. We show below that this is not the case in presence of players' heterogeneity.

3.2 Including players' heterogeneity in the game

The simple examples developed above show that the definition of the rules allocating network services may be central to avoid dilemmas in the choice of network use, when the services offered have different costs for the system. We may assume that some fixed mechanism (priority for flat capacity, in the example above) is able to allocate common resources among players, taking into account their preferences and the system costs. However, in the presence of players' heterogeneity, this might not be straightforward.

Consider a simplified model of a gas network that two players can use. However, the two players have different preferences (thus give different value) for flexible and flat capacity. The first player obtain a value for the flat use of network $v_{flat} = 6$ and for the flexible capacity $v_{flex} = 10$. The second player obtain a value for flat capacity $v_{flat} = 6$ and for flex capacity $v_{flex} = 30$.

Let us consider the two options for capacity allocation of the previous section.

Capacity allocation 1

If the demand for network is higher than its capacity, the rules for allocating network capacity are the following: a) the capacity is allocated equally among users and b) the flex capacity is allocated first (there is priority for flex capacity before the allocation of any flat capacity).

Table 4: Heterogeneous players: Game 1

Demand of network	Network capacity	Strategic form of the game		
4 Flat	4 Flat		**2 Flat**	**1 Flat – 1 Flex**
3 Flat - 1 Flex	2 Flat – 1 Flex	**2 Flat**	(12,12)	(6,36)
2 Flat – 2 Flex	2 Flex	**1 Flat – 1 Flex**	(16,6)	(10,30)

Capacity allocation 2

If the demand for network is higher than its capacity, the rules for allocating network capacity are the following: a) the capacity is allocated equally among users and b) the flat *capacity allocated first (there is priority for flat capacity allocation before the allocation of any flex capacity).*

Table 5: Heterogeneous players: Game 2

Demand of network	**Network capacity**	**Strategic form of the game**		
4 Flat	4 Flat		**2 Flat**	**1 Flat – 1 Flex**
3 Flat - 1 Flex	3 Flat – 0.5 Flex	**2 Flat**	(12,12)	(12,21)
2 Flat – 2 Flex	2 Flat - 1 Flex	**1 Flat – 1 Flex**	(11,12)	(11,21)

First of all, the use of the network depends on the rules of network use. But in this case, contrary to the first examples, we are not facing only a prisoner's dilemma. Both equilibria are maximizing the welfare of the corresponding game. What these examples show is that the pipeline operator, in the process of calculating the capacity, is inducing different games. Moreover, the distribution of the social welfare is not the same in both allocation schemes.

The conclusion that can be drawn for the games with heterogeneous users is that there is one solution for capacity that makes the flat player to end up better off than in the other solution. Therefore, the initial mechanism considered to allocate capacity, characterized by a pipeline operator using the capacity calculation to coordinate the use of the pipeline, cannot be done efficiently in the case of heterogeneity. The capacity calculation process defines the game that network users will be playing, and thus the rules for network use affect the use of the network.

3.3 Adding negotiation to reveal preferences

Consider a case where the final capacity calculation (of flat and flexible services) takes into account the players preferences. For this we may allow players to sign contracts without any 'a priori' restriction on services. The pipeline operator is not informed about the future use of the pipeline, so the solution is to create the mechanisms for players to reveal their preferences. Hence, players should negotiate (and commit) before the capacity calculation takes place. It is necessary to have mechanisms allowing communication in the contracting process.

Consider that a pipeline operator is trying to allocate pipeline capacity efficiently. To do so, some bidding mechanism may be established in order to allow players to reveal the kind of service they need and how much they are willing to pay for them. This negotiation may be done through bilateral contracts or through auction-like processes.

In this game we introduce the negotiation process by bilateral contracts. To do so, there are two possible contracting options. Both contracts involve implicit commitment of the pipeline operator.

- The first contract says that player 1 commits to choose 2Flat and the capacity will be that of the first equilibrium. As she knows that player 2 will try to induce the second equilibrium, she commits to an additional payment. Such payment is so that player 1 still prefers the first equilibrium, so if both players sign this contract player 1 pays one euro to player 2.
- The second contract says that player 2 commits to choose 1Flat-1Flex and the capacity will be that of the second equilibrium. As she knows that player 1 prefers the first equilibrium, she specifies an additional payment of 3 in the case that both players sign the contract.

Finally, if players do not agree in a contract, the pipeline operator chooses the most valued of the previous equilibria. In this instance, the pipeline operator chooses the second equilibria.

Table 6: The role of negotiation

Strategic form of the game		
	Contract 1	**Contract 2**
Contract 1	(11,22)	(6,36)
Contract 2	(16,6)	(13,27)

This last example shows that if players are able to negotiate their capacity, they would be able to find a better solution which allows them to maximize the welfare through the redistribution gains. This last table might be related to the Coases' concept that assuming that players are able to negotiate rights between them they will get a better welfare independent how the rights is initially allocated, (R. Coase, 1960). In this case, as the pipeline operator has the rights to use the pipeline before the negotiation takes place, it may be interpreted as in the Coasian context.

The first assumption of our analysis is that different players may use the transmission system. However, they need to follow some rules. These rules can be defined ex-ante (through a sharing rule about what kind of service has priority). But we showed in this section that the rules may be implemented by a system of contracts. This implies a definition of the rules for network use, so the pipeline operator is not involved in the definition of the game.

3.4 Summary

This section started from a very simple model (table 1) of common-pool resources providing two services with equivalent impact on the system. The model included two players' with equivalent preferences. In this case, we showed that the rules of use do not have any substantial impact on the output.

After that, we included some important features of the real operation of pipelines: the two services offered have different impacts on the system (table 2)[5]. We showed that the result of the game depended on the rules about how to allocate resources among services. We showed that the output will depend on the rules of use. Nevertheless, it was possible to find an (ex-ante) rule that delivered the highest output.

In the third game (table 3), we included another element of the current gas industry: the players have heterogeneous preferences for network services.[6] In this case, not only did we observe the importance of the rules, but also the problems to find an ex-ante rigid rule that allowed players to obtain the equilibrium with the maximum welfare.

[5] In the current gas industry, it is quite relevant the difference of the impact between a flat and a flexible use of the transmission system as we explained in the section 2.

[6] The preferences of flexibility in the natural gas industry are also quite different for class of consumers. For instance, there are at least three consumer's profiles: household (seasonal and daily cycles), industrial consumers (flat or daily or weekly cycles) and gas fired power plants (volatile demand by hour, may present also some seasonal and daily tendencies), see **Glachant, J. M.; M. Hallack and M. Vazquez.** 2012 *Building Gas Markets in the European Union*. Edward Elgar (Forthcoming).

Next, we included another mechanism allowing the allocation of common resources according to players' preferences. We called it negotiation: the rules may be implemented by a system of contracts with players' preferences revelation.

The story told through simple games show us the role of the rules of the transmission system in the total output. Moreover, it shows that the definition of an ex-ante rule in presence of heterogeneous preferences between players tends to lead to an 'inefficient' output. And the inclusion of a mechanism that defines the rules of use taking into account the preference of users increases the expected output.

4. Mechanisms defining the rules for the use of gas transmission infrastructure: the carriage systems

We have shown using simple games that the decision-making process to offer network services defines the game that network users are playing. Consequently, the definition of the network services offered plays a key role in the allocation of network resources.

In this section, we will analyze the mechanisms that are defining the rules for network use in practice. Such mechanisms depend on the kind of carriage system used. Carriage systems define the constraints on the property rights of a certain infrastructure used to carry something. The infrastructure of transport may be gas pipelines, electricity transmission lines, telecommunication lines, etc.

From this paper's point of view, we will be analyzing how the rules delimitating the services offered is defined. With this analysis in mind, we will compare the current situation in the EU systems to the US systems. The logic for this is that they may be considered extreme cases of carriage systems in a liberalized industry. Specifically, we will show that the EU scheme corresponds to the game explained in table 4 and 5 (the rules for capacity allocation are defined 'ex ante' by a third part), whereas the US scheme corresponds to the game in table 6 (the rules defined by negotiation among players).

4.1 Mechanisms, property rights and decision-makers

In the liberalized gas industry, all carriage systems are hybrid models that can be placed between centralized and private control. Table 7 summarizes such carriage systems.

- The *private carriage* is characterized by the full rights of the owner over the infrastructure: it has the right to use, to sell and to forbid third party uses. This is the typical scheme for vertically integrated firms under private ownership

- The *contract carriage* is defined by long term contracts whose service characteristics are defined in bilateral agreements. Such agreements specify a set of criterions of rights to use infrastructures and the tariffs

- The *market carrier* is based on defining the rules of resource allocation from commodity prices. The rules of resource allocation allow implicit negotiation among shippers. The negotiation is not done directly by shippers, as in the case of contract carriage. It is done by a centralized player using an optimization algorithm, which takes into account the commodity prices the infrastructures characteristics, so that the allocation maximizes the social surplus[7]

- The *common carrier* establishes the rights of using the network by a set of common rules, which are homogenous rules applied to every shipper. In that view, they are rules defined based on the needs of the average shipper

Table 7: Pipeline Carriage System

Pipeline carriage legal frame	Centralized Intervention in the use of infrastructure	Examples
Private carriers	0	Interstate USA pipelines – before 1985, EU pre-liberalization contracts
Contract carriers	+	Interstate USA pipelines - after 1992, Brazil after 2009
Market carriers	++	Australia (new projects after 1994)
Common carriers	+++	UK, France, and main principals of EU regulation after liberalization

Source: Author elaboration data from (A. Moran, 2002),(NERA, 2002),(M. Colomer, 2010), (L. E. Ruff, 2011)

To understand the consequences of different carriage systems in the use of network resources, it is useful to analyze them from the standpoint of property rights. In fact, in common pool resources, the separation between the different property rights allows understanding how the liberalization process changed the rights of pipelines (they unbundled the infrastructure rights, (A. Kotlowski, 2007) . Furthermore, it allows understanding how different combination of rights may give different economic incentives, (E. Ostrom and C. Hess, 2007).

"*Property rights define actions that individuals can take in relation to other individuals regarding some 'thing' if one individual has a right, someone else has a commensurate duty to observe that right. Schlager and Ostrom (1992) identify five property rights that are most relevant for the use of the common-pool resources, including access, withdrawal, management, exclusion and alienation" (Ostrom, 2002, page 16).*

Table 8: Set of Goods Property Rights

Access	The right to enter a defined physical area and enjoy nonsubtractive benefits
Withdrawal	The right to obtain resources units or products of a resource system
Management	The right to regulate internal use patterns and transform the resources by making improvements

[7] This carriage system is often applied to electricity system. Actually it is an implicit allocation of the network through the signals given by the commodity prices.

Exclusion	The right to determine who will have the access right, and how the right may be transferred
Alienation[8]	The right to sell or lease management and exclusion rights

Source: Author elaboration, based (E. Ostrom, 2005).

Comparing the gas network property rights under common and contract carriage, exclusion and alienation rights are weak in both carriage systems. In a liberalized market, the network itself is considerably regulated, even if the rights to use the infrastructures (offering services or managing flows) are held to some extent by pipelines and shippers.

Regarding access rights, the definition of open access has become quite confuse in the economic literature (E. Ostrom and C. Hess, 2007). To clarify it, one might consider that common pool resources are made up of the resource system (the facility) and the flow of resources units or benefits from the system (the service allocation). Open access rights mean the right to access the facility, but they do not mean the right to acquire any service. The right to use a service is the withdrawal right, the withdrawal of units from the set of units. Thus, the right of withdrawal (the right to use network services), is in fact the right sold by pipelines to shippers. These are pipeline rights sold in order to pay for the infrastructure investment and operation.

And in that view, withdrawal rights are quite different under the two carriage systems. In fact, withdrawal rights under contract carriage are stronger than under common carriage. This is the key difference between the two carriage systems. In the common carriage system, the withdrawal right is assigned but it is not guaranteed. Hence, withdrawal rights assigned to a user do not mean the exclusion of another shipper's right of use. The European principle of 'use-it-or-lose-it' is one of the main pieces to bring together the different EU network regulations. This may be put in terms of who defines the services, or who defines the operational meaning of withdrawal right. Common carriages are based on defining services by often homogeneous rules (central authority). In contract carriages, the definition of the service is in the hand of pipelines and shippers.

The differences in management rights may be viewed as a consequence of the previous differences in withdrawal rights. As the operation depends on the characteristics of the services sold, the decision regarding the infrastructure management is a pipeline right in both systems. Pipeline decisions, however, are constrained by the withdrawal rights required by shippers. In common carriages, management rights are limited by the common rules regarding the capacity. This includes rules ranging from congestion management to the amount of line-pack use[9]. On the other hand, in contract carriage system, the pipeline management rights are restricted by the characteristics of shippers' withdrawal contracts. From the

[8] The common usage of property right expression has been quite close of right of alienation. "In much of the economic literature, private property is defined as equivalent to alienation. Property rights systems that do not contain the right of alienation are considered to be ill-defined. Further, they are presumed to lead to inefficiency since property-rights holders cannot trade their interests on a improved resources system for other resources, nor can someone (**Ostrom, E.** 2005. *Understanding Institutional Diversity*. Princeton, New Jersey: Princeton University Press., page 24).

[9] One example of this kind of rules constraining the amount of line-pack that can be used by the pipeline operator can be seen in the UK.

incentive point of view, restricted management rights under common carriage decrease the incentive to improve the operation efficiency[10]. In contract carriage systems, the main incentive to improve infrastructure management is the possibility to offer more (or more valuated) withdrawal services. Hence the incentive of management rights is limited to the profitable efficiency improvement.

In liberalized markets, the network does not have full rights because of its asset specificity does not allow easy transactions of network services. But such services may be more or less flexible, and the way to offer them may be more or less competitive. Actually, the rights to use and offer services significantly change depending on the carriage system used. Goods with poorly defined rights increase transaction costs decreasing the efficiency of markets in allocating available resources[11]. Thus, it is important to underline the differences between the transactions of the assets and the transactions of the rights to use the network infrastructures.

4.2 Comparing USA and EU carriage systems

We will show in this section the practical implications of the choice of carriage system. The two paradigmatic cases are the EU (common carriage) and US (contract carriage).

Common carriage must be distinguished from Third Party Access (TPA), according to Newbery (2002). The European Commission defined TPA in 1992 "as regime providing for an obligation, *to the extent that there is capacity available*, on companies operating transmission and distribution networks for....", (EC, 1992), emphasis added. Under these terms, TPA is only a non-discriminatory rule, which can considered here as open access rules (i.e. all the shippers have the right to be served according to the contracted service). In other words, the original TPA rules could only impose the obligation to the pipeline owner to offer capacity if there is available capacity, or if it has not been allocated before. These non-discriminatory rules in the use of pipelines are a policy trend observed in all countries which went through a liberalization process[12].

These initial open access rules can be observed as compatible with the legal framework of both contract and common carriers. The differences between the two concern the definition of available capacity.

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[10] In the UK some regulatory incentives to increase operational efficiency have been utilized, and they try to recover the economic incentives to improve operational efficiency.

[11] The works of **Demsetz, H.** 1968. "Toward a Theory of Property Rights." *The American Economic Review*, 57(2)., **Barzel, Y.** 1982. "Measurement Costs and the Organization of Markets." *Journal of Law and Economics*, 25(1), 27-48, **Cheung, S. N. S.** 1970. "The Structure of a Contract and the Theory of a Non Exclusive Ressources." *Journal of Law Economics*, 13(1), 49-70., Barzel (1982), **Williamson, O. E.** 1991b. "Economic Institutions: Spontaneous and Intentional Governance.".*Journal of Law, Economics, and Organization*, 159-87. and **Libecap, G. D.** 1986. " Property Rights in Economic History: Implications for Research." *Explorations in Economic History*, 23(3), 227-52. and **Libecap, G. D.** 2008. "Ransaction Costs, Property Rights and the Tools of the New Institutional Economics: Water Rights and Water Market," E. Brousseau and J. M. Glachant, *New Institutional Economics : A Guidebook.* Cambridge University Press, provide the foundations to understand the relationship between transaction cost and property rights theory.

[12] As noted by **Kotlowski, A.** 2007. "Third-Party Access Rights in the Energy Sector: A Competition Law Perspective." *Utilities Law Review*, 16(3)., the definition of Third Party Access does not provide a clear definition of a TPA right. However, the underlying concept in the text of the Directives could be that TPA corresponds with an obligation to contract and a duty to perform. However, no definition contracts and duties was clearly established.

This dimension of the choice of carriage system was explained in section 3 by means of simple games. This section has discussed so far the implementation of the carriage systems in terms of property rights. The definition of property rights, and especially of withdrawal rights, implies the definition of who is deciding on the possible use of network resources. This in turn was the source of different incentive systems in the games described in section 3.

From this standpoint, the legal frameworks for contract and carriage systems define the implementation of TPA. Put it differently, even with TPA, it is of critical importance the definition of available capacity, and the definition of available capacity depends on the definition of property rights. So whether the carriage system is identified with the situation of the game in section 3.2 or the one in section 3.3 ultimately depends on the definition of property rights. In other words, the set of incentives implemented by contract and common carriages depends on who is deciding on the services offered, and that is defined by the definition of property rights. In contract carriages, the available capacity depends on the occupation of pipelines according to contract clause characteristics. In common carriages, the available capacity depends on the possible flow regarding regulated criteria.

The definition of a set of rules of network use has gradually become the model adopted by the EU countries, and recommended by EU institutions such as ERGEG and ACER[13]. The regulation under 'common carriage' has led to the homogenization of the services offered. The common carriage system actually offers similar services to all shippers and allocates capacity with ex ante priority rules (as defined in our examples in section 3.2). Hence, as we pointed out in section 3.2, if users' profiles are similar, it is feasible to find a common set of rules that, applied to the group of users, allow an efficient management of resources.

Under the US contract carriage, we observe a relatively large amount of contract types. This in turn allows different flexibility degrees and flexibility types. Network services consider line-pack utilization, nomination scheduling, geographical localization. Furthermore, we observe unbundled flexibility services, such as loan and parking services. Moreover, flexibility services had not been offered just by network operators, but also third parties, as traders managing infrastructure portfolios, storage or LNG regasification owners.[14] Thus, contract carriages imply situations that were described by the game with negotiation in section 3.3 (this game may also represent market carriages).

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[13] A current example is the discussion looking for homogenous EU congestion management and capacity allocation rules, **ACER.** 2011b. "Framework Guidelines on Gas Balancing in Transmission Systems," Agency for the Cooperation of Energy Regulators, Draft for Consultation, DFGC-2011-G-002, and **____.** 2011a. "Framework Guidelines on Capacity Allocation Mechanisms for the European Transmission Network," Agency for the Cooperation of Energy Regulators, Draft for Consultation, DFGC-2011-G-001, .

[14] Concerning the pipeline contracts in the USA and Canada, the settlement of arrangements between pipelines and users instead of formal regulatory process has been underlined. "In general, the settlements have better reflected the actual preferences of the customers and the companies, unconstrained by the formal regulatory process. The settlements have also been characterised by flexibility, variety, a wide scope, innovation and learning, as some legal scholars have noted", (**Littlechild, S.** 2009. " Regulation, over-Regulation and Some Alternative Approaches." *European Review of Energy Markets*, 9, 153-59. page, 17).

5. Rules for the use of infrastructures: a key piece in the investment dynamics

The previous section has shown that the allocation of property rights (especially withdrawal rights) defines who decides on the network rules. In this regard, we showed in section 3 that the definition of the network rules characterizes the game that network users will be playing (and therefore the gas market output). The conclusion of the analysis is network resource allocation is in general more efficient when network rules are set through systems of contracts.

In that view, the system of property rights affects the outcome of the gas market. We will show in this section that property rights definition is also at the core of the network investment decision. Therefore, property rights affect, besides present market outcomes, future possibilities for network use and thus future market outcomes.

5.1 Network rules and investment decisions

Regardless the way in which the network is planned, infrastructure investment decisions depend on the expected demand of transmission services, minus the transmission services already available (the services that the installed infrastructure may offer). The analysis of the available services (or the services that may be offered by the installed infrastructure) is thus an important step to define the investment that will be necessary to face the forecasted demand. But the available services, as we described in the first sections of this paper, are the result of the existent infrastructures plus the rules of use. And the definition of network rules depends in turn on the carriage system. As the carriage system defines the property rights associated with the infrastructure, the carriage system defines the decision set of players regarding existent infrastructure (figure 1).

Figure 1: Multilevel Rules Incentives

Carriage System	How the infrastructure allocation are defined		
Current Capacity	↓ Network Usage Rules **+**	Existent Infrastructure	
Future Capacity Investment	*Available capacity*	***+***	Demand Expectation

Source: Author elaboration, based on (E. Ostrom, 2005) and (T. M. Koontz, 2003).

Investment in gas infrastructure involves decisions on the type of investment, in addition to the amount of investment. Gas network are made up of many pieces, and the choice on those pieces depends on the use the players will make of the network. In this context, investment decisions are largely affected by the expectation of future needs for network services. Therefore, if players are constrained in the use of the network, network investments will be constrained as well. This creates a lock-in equilibrium, hiding relevant characteristics of the network use.

An example of the previous lock-in equilibrium is the investment in storage facilities in the Spanish and Italian systems. Both systems are characterized by common carriers, and thus by network uses constrained by ex-ante rules. The former system specifies LNG regasification to be the provider of flexibility. The Spanish investment shows an unparalleled preference for LNG terminals. On the other hand, the Italian network rules specify underground storage as the main provider of flexibility. Likewise, the Italian investment shows an unparalleled preference for underground storage, (M. Hallack, 2011).

Open access under contract carriage actually has the capacity to inform players of the shippers' preferences. In the US case, we have observed network development very different from what the theory of regulated monopoly forecasted. According to this theory, competition is unsuitable for natural gas networks: it would lead to wasteful duplication, would not efficiently coordinate the use of the pipeline network, and would produce erratic price behavior. Experience with contract carriages indicates that competition led to gas price convergence in the network, eliminating pockets of non-responsive and possibly monopolistic prices, and integrating markets. Flexible transport services create the functional paths and they are assembled in response to prices and arbitrage opportunities, (W. D. Walls, 2008).

The previous analysis may be interpreted from the viewpoint of the games of section 3.2. We showed that the use of the network depended on the definition of the network rules. Moreover, we showed that for some network rules, the equilibrium obtained was not welfare-efficient. In such situation, if the network planner has to forecast the future use of the network, she will not have signals of the most efficient use of the network, and thus she will not be able to undertake the investments corresponding to the efficient use of the network. On the contrary, the game with negotiation in section 3.3 gave allowed obtaining the equilibrium with the efficient use of the network. Hence, the efficient investment was possible.

We have also shown that such simple games are representation of different carriage systems. These carriage systems are characterized by different definitions of withdrawal rights. Thus, we can observe that the choice of the carriage system have dynamic implications. One on the hand, the carriage system impacts on the use of infrastructure and thus on amount of available services; on the other, it impacts on the investment decision and thus the available capacity in the next periods.

5.2 Delimiting the room for innovation

Infrastructures regulated by common carriages were adapted for the new economic environment. That is, they were adapted to the change of demand profile. However, the adaptation provided by the common-carriage solution may be discussed. First, it is not clear that the tools chosen are the efficient ones, because decision-makers under common carriages are less informed about demand profiles than shippers. Second, common carriages are characterized by the lack of incentives for service innovations. Hence, not only is it a matter of lack of existent information, but of lack of innovation in service arrangements (created by the misallocation of resources in the flexibility provisions).

Comparing the result of flexibility services' development in gas industries through the optic of make-or-buy decisions[15], we can observe an example where the adaptability of make decisions may also generate

[15] **Williamson, O. E.** 1991a. "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives." *Administrative Science Quarterly*, 36(2), 269-96. has discussed the coordination mechanisms features of market

negatives outcomes. In this case, the regulatory internalization of flexibility services (or the adaptability to the new demand conditions) has actually blocked the promotion of service innovation. In other words, the theory has emphasized the higher adaptability of hierarchic forms of coordination (e.g. s regulation[16]) in order to deal with changes in the environment. And, actually, in our cases studies, we observed how regulatory coordination has driven network operators to adapt to the new gas demand providing flexibility services. However, the regulatory adaptability has a cost, because there is no guarantee that the new situation accommodation is actually the best solution.

Rate-of-return regulation is a clear example of that. One may consider that it has high potential to accommodate to the new situation, as the regulated enterprise (as workers of an enterprise) will follow any command to 'do this or do that', (O. E. Williamson, 1991a). Nonetheless, compared to a vertical relation in an enterprise, the enterprise in a market environment tends to have feed-back regarding their managerial decisions. In the vertical relation of regulators, the evaluation of decisions over regulated enterprises is much less clear, and it is often affected by political interactions.

We showed that the use of infrastructures under common carriages drives investment decisions and thus changes the network design. The 'ex post' evaluation of network decisions is quite difficult. The adaptation process implies that, after any decision is taken, all further decisions will take into account the last one. Regulatory adaptability removes possible coordination failures between players in the process of adaptation to new situations; in this context the regulatory command actually substitutes the need of industry to adapt relying on bilateral agreements. However, as a consequence of the regulatory action, there are also constraints on service innovation. In a context of market changes, when innovations are more likely to be developed, the possibility of negative outputs associated with regulatory interference needs to be carefully taken into account.

Compared to the USA contract carriage, the EU common carriage is an open access system, but it has showed little adaptation to changing circumstances. It has not delivered products with the diversity that is required to serve diverse customers, as observed in the USA. The EU flexibility market has not innovated.

6. Conclusion

We have shown in this paper that the question "who decides the rules from network use" may be viewed as the starting point for the definition of market outcomes. Once the mechanism deciding rules is set, the rules define the set of possible incentives. We have shown the role of negotiation "ex-ante": when players negotiate to define the rules for network use, it allows taking into account players' preferences.

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procurement (buy) and internal procurement (make). He has emphasized that these coordination mechanisms actually have different features regarding adaptability, incentives and control instruments.

[16] "Rate-of-return regulation and internal organization are analogous institutions in that both employ low-powered incentives and relatively flexible administrative decision processes rather than courts to dissolve disputes", **Crocker, K. J. and S. E. Masten.** 1996. "Regulation and Administered Contracts Revisited: Lessons from Transaction-Cost Economics for Public Utility Regulation." *Journal of Regulatory Economics*, 9(1), 5-39., page 24, note 20).

In order to determine who is deciding on the rules, the definition of property rights is central. Put it differently, the definition of property rights defines who is defining the rules. And such definition of property rights is done in the choice of carriage system. The preferred carriage system in the EU, the common carrier, establishes a set of property rights that end up in the definition of “ex-ante” network rules. The carriage system implemented in the US, the contract carrier, implies a set of property rights that allows the revelation of players’ preferences in the process of defining rules.

We have also shown that the definition of the game that network users play is determines not only the present market outcome, but also the future development of the network. Therefore, the definition of property rights, which in turn defines the game, is a central element in the dynamics of the industry. When the property rights correspond to a common carrier, the set of rules do not take into account players’ preferences. Therefore, the set of “ex-ante” rules defines a lock-in.

Moreover, the role of innovation is significantly reduced when players’ preferences are not adequately represented in the investment decisions. The carriage systems defining the players who define the set of services possibilities provided by network delimit the role of players to innovate. The hierarchical coordination tends to induce less innovation, especially in the absence of competitive threat. With the contract carriers, where interested players are the main responsible to settle the network use rules, the flexibility requirements drove service innovation. With common carriers, where the rules was mainly defined according to an ‘exogenous’ third party, the network rules did not respond to the new conditions.

Given a complex system and a dynamic world, centralized investment decisions on gas transport networks do not seem the best coordination mechanism to face a liberalized gas market with heterogeneous and mobile preferences.

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