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EUI Working Paper **RSCAS** 2014/33

ISSN 1028-3625

Printed in Italy, March 2014
European University Institute
Badia Fiesolana
I – 50014 San Domenico di Fiesole (FI)
Italy
www.eui.eu/RSCAS/Publications/
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Abstract

The institutional setting of open gas networks and markets is revealing considerably diverse and diverging roads taken by the US, the EU and Australia. We will show that this is explained by key choices made in the primary liberalization process. This primary liberalization is based on a definition of network access rights, which leads to different regimes for the transmission services, as well as for the gas commodity trade, as commodity trade depends on the network services to get any market deal actually implemented. Not only do those choices depend on the physical architecture of the network, but also the perceived difficulties and institutional costs of coordinating the actual transmission services through certain market arrangements.

Keywords

Network regulation, gas market, property rights, open access, gas carriage systems

1. Introduction[1]

Natural gas market arrangements are characterized by considerably diverse institutional frames. Initially, one would observe that transmission infrastructures are correspondingly diverse so that it may be concluded that the actual architecture of infrastructures determines the best institutional frame for trade. We will show in this paper that this is only partly true: that necessary condition of a certain network architecture is not sufficient. The choice of an institutional frame for trade does not only depend on the physical architecture of the transmission system but also on the economic mechanisms chosen to frame the transmission services. This primary choice has in turn relevant economic trade-offs so one cannot define a general best design solution.

In developing our reasoning, we will be close to Makholm (2012) and Correljé et al. (2013), who studied the institutional development of market-based gas industries. The former showed how the gas pipeline rules evolved in the United States, and the main economic choices made by policy makers from the XIX century until today. The latter compares how the institutions regulating natural gas in the US and Europe evolved following different paths. These case studies on institutional development are central to understanding regulation in both the US and Europe, and they show a relevant feature: there is no best mechanism that can be applied to every natural gas industry. Any choice brings some costs and some benefits because of the existence of severe transaction costs.

With the aim of generalizing any analysis, our paper builds an analytical framework to understand the economic rationale behind the different regulatory frames observed nowadays. We aim at clarifying the main economic trade-offs of existing models and ultimately to provide policy makers with institutional paths in accordance to their aims. To that end, we show what the key regulatory decisions are and their resulting economic incentives. We then apply this approach to four different regulatory frameworks: the US, Europe (UK), Australia (Victoria) and Brazil. The first three cases are within mature markets and their regulatory approaches show alternative paradigms in the design of gas markets. The fourth (Brazil) is taken as an example of a younger industry where the market design is still evolving.

The economic literature has already discussed the role played by asset specificity in gas industries and the use of long-term contracts. For the US, see for instance Makholm (2012), (Hubbard and Weiner 1991), Mulherin (1986), and (Masten and Crocker 1985). For the EU, see Chevalier (2004) and Correljé et al. (2013). Long term contracts for gas pipelines around the world have been described by Victor, Jaffe & Hayes (2006). All this showed how long-term contracts and their particular clauses have been used to coordinate players and allocate risks among them in the context of highly specific industry assets.

The precise architecture of gas networks, hence the degree of development, of such infrastructures determines the actual industry asset specificity and the potential for market arrangements choices. For instance, a transmission system made up of a single pipeline that links two single points is very highly specific, as all transactions there depend on the coordination among very few players (let say the supplier, the transporter, and the consumer). This is a typical situation at the very first step of development of a gas transmission system, where users are located close to a single supply point (being one production field, one LNG regasification facility or one large pipeline). In this case, vertical (or quasi-vertical) integration is typically efficient to make the system work.

Later on, with many more consumers and diverse suppliers that can be connected to different transmission routes, the gas transactions become less specific. This is typical of more developed

1 This paper is a rewriting of the former WP named "*Gas Network and Market: à la carte?*" issued in September 2013 under the number RSCAS 2013/73. The authors apologize for any confusion that could result from the co-existence of two successive versions under two different names.

transmission systems, where the transmission infrastructure is already a meshed set of pipelines, compressors, storage facilities, etc. In this schematic world one understands why a young gas system such as the Brazilian (using a simple "Y" network) cannot act like the gigantic cobweb of the USA. However, this rationale does not work to explain why the actual European or Australian gas systems do not reproduce the US arrangements. If we want to understand the differences among existing open markets (like with the US, the EU and Australia), the architecture of infrastructure assets does not play the key role. It is the institutional structure of network opening and gas trade which plays that role and we will then concentrate on how gas markets have been opened up to trade and competition.

In section 2 we show that it is the network access regime which is the key piece in a regulatory framework liberalizing the gas industry. Access, however, may have different definitions and content and also be guaranteed with different mechanisms. Section 3 shows that the way in which open access is granted, is the primary decision, and the first key characteristic of any gas market building. Defining and implementing different access regimes result in different economic relationships between the gas commodity trade and the gas transmission services. Section 4 shows the elementary economic trade-offs constraining the different regimes of network open access. In turn different access regimes also lead to different gas markets foundations. Sections 5 and 6 illustrate this frame of analysis in the context of the US, the EU (case of UK), Australia (case of Victoria) and Brazil, from both a short-term and a long-term point of view. The last section concludes.

2. Defining a trading system

Gas transmission grids are characterized by a number of tight technical constraints, so the transmission services offered to users by a transporter can be said "site-specific" [2] and "dedicated"[3]. Hence, the contracting architecture required to trade gas at different network points and time horizons must necessarily be adapted, as to deal with severe transaction costs. Put it differently, players' identity matters in the gas industry and one has expected a preference for long-term contracts and vertical integration, see (Williamson 1975) or (Williamson 1985). This fits well with the initial structure of gas industries heavily relying on vertically integrated or quasi-integrated utilities all around the world.

From a theoretical standpoint, (Riordan and Williamson 1985) showed, in a general context, that asset specificity is ultimately a design variable, and it is frequently possible to reduce that specificity at the cost of simplifying the characteristics of the final products[4]. An application of this strategy can be found in the proposal of (Joskow and Schmalensee 1983) for building power markets. The reasoning is as follows: as not all segments of activity in the industry share the same transactional characteristics, some industry segments are easier to organize with certain market arrangements than others. Consequently, in the utility restructuring process, policy makers have options to decide that some activities will from now on be organized under market arrangements while the others might stay under command and control.

The same reasoning can be applied to the gas industry as, again, some segments of the industry chain do not really need to be organized under command and control. Dealing with the liberalization of vertically integrated industries can be restated as: what are the industry segments that can be organized under market arrangements? Brousseau and Glachant (2014) identify three key elements in the creation of a trading arrangement (as a market place) which complement both the price mechanism

[2] Gas flows only in a given gas pipe with no alternative as long as it cannot exit it.

[3] When a gas pipe is dimensioned for future gas flows, its size is adjusted to the contracted gas flows. Therefore, the economics of this gas pipe cannot stay independent from significant changes affecting the contracted flows: the pipe capacity is thus dedicated to these flows.

[4] The example used by Riordan and Williamson (1985) is a bumper. It can be designed to be used in any car or to be used in a specific model, probably with negligible differences in production costs. The specificity of both products is the same, looking only at their production characteristics, but are not the same from the demand point of view.

and the settlement process: a) a definition of the valuable characteristics of the product to be traded; b) a measurement of the amount of these characteristics being traded; and c) a registration of the net property right changes implementing the trade among buyers and sellers. Though in the same vein, the creation of a trade system in the gas industry requires complementing the price mechanism and the settlement process with: a) a definition of the valuable characteristics of the commodity traded and of the related transmission services; b) a measurement of the amount of characteristics of the commodity and of transmission services being traded and delivered; and c) a registration of the property right changes implementing this trade among market players. This might be very challenging in the gas industry as long as an extended frame of rights has not been defined: who can do what with whom, when and where? In this industry, we frequently have only few big infrastructures used by numerous buyers and sellers feeding in or withdrawing from a common flow of gas. To open a liberalized gas market, access to the transmission system first has to be open. Thus, although it is easily doable to exclude a vast amount of individuals from using a transmission system, it is a basic choice of liberalization to do the opposite and to widely open access to the network [5]. However, the precise meaning of 'open access' is quite diverse, while all access variants share the characteristic that the infrastructure owner has no right to discriminate amongst legitimate users.

Open access impedes the network from colluding with certain players and excluding other players from accessing the transmission grid and the related market. It is why defining and implementing open access can be identified as the main driver of the institutional diversity found in liberalized gas industries. Liberalization starts with that question: what are the actual key choices made in the implementation of open access? The following sections are devoted to describing the main characteristics of gas industry restructuring alternatives.

3. Opening a market: redefining property rights

An interesting starting point for the reasoning of this section is the physical architecture of a gas grid: for a given grid architecture, what is the best alternative among the various open access schemes? Alas there is no unique better solution…[6] To apprehend the motivation for the variety of existing access regimes, we have to find the rationale behind it. As defined by Ostrom and Hess (2007), property rights delineate the range of actions that individuals can take regarding an asset. In the process of opening access to gas pipelines, several dimensions of property rights are to be dealt with as they may give rights in different ways: injection, withdrawal, flow and pressure management, nomination, exclusion and alienation, etc[7]. In a completely private set of pipelines, all these rights are allocated to the same agent: the owner. As a non-regulated private owner, he has all the rights to access his property, to use it, to manage its components and operation, to exclude or include others in this or that usage and also the ultimate right to sell (and to transfer) any part of this set of rights to others.

On the contrary, within an open access policy certain rights are being given to all potential users, and the full bundle of transmission rights ends allocated among all the players: i.e. all potentially legitimate users plus the regulated owner[8]. For the potentially legitimate users, open access is a right

5 As explained by theoreticians of the commons (Ostrom and Hess 2007), open access is frequently a conscious public policy to avoid exclusion of any from the use of a common resource.

6 It is interesting to note that the electricity industry, also a network industry based on open access, has a more homogenous mechanism for the governance of their transmission system. Where does the difference between both industries come from? One key difference in the governance choices regards the externalities and the capacity to define property rights. As in gas industries it is easier to define property rights, the number of implementable governance mechanisms increases.

7 (Schlager and Ostrom 1992) identified these five different property rights.

8 Alternatively, one might consider that gas networks are made up at least of two different products: the resource system (the infrastructure facility) and the flow of resource units, i.e. the services that the system provides, (Ostrom and Hess 2007).

vis-a-vis the transmission facility: a right to be connected to it and to become a user (notably injecting in and/or withdrawing from). But the next key question is then the actual definition and implementation of each of the various transmission rights. We might say that the right of access is an ex ante right to be connected to the network and a promise to be able to use its transmission services later on. Accordingly, the actual right of use acts like an ex post implementation of the ex-ante access right.

That is why the definition of the proper rights to use transmission has to be viewed as the first liberalization choice to be made; the one where policy makers need to first choose between "*common carriage*" and "*contract carriage*". Common and contract carriages are two alternative systems defining the basic frame of infrastructures' usage. Their key elements are firstly the definition of the injection/withdrawal rights and secondly the exclusion rights ("the right to exclude others") for the users and the operator. In the "*common carriage*" system (typically the EU), open injection/withdrawal rights are offered ex ante to all the potential users of each and every pipeline. While the precise ex post implementation (at the stage of network operation) of these open potential rights will depend of the actual way the licensed "transmission system operator" (TSO) will fulfill its license to operate the grid and manage the system flows. The operators of transmission facilities in the EU have no right a priori to exclude people from using their grids and entering the gas system. However, the actual implementation of users' requests for transmission services is a lot fuzzier and is subject to many operational uncertainties that the TSOs will have the right to handle according to their operational license [9]. It ends up firstly that injection/withdrawal rights assigned to a user do not give him any guarantee of excluding the other users for the same usage (individual rights are not exclusive vis-a-vis other potential users); secondly, that the all sets of users' actual rights are in practice fuzzy (as these rights are not exclusive vis-à-vis the TSO). Conversely, that is exactly what the "*contract carriage*" avoids in the US. The set of individual rights to injection/withdrawal is pretty well defined ex ante in the US and restricted to only the people having duly signed a long term usage contract with the owner of the pipeline. This access regime actually excludes all other potential players to compete ex post for the very same usage of this gas network. The US practice ends up with, firstly, that injection/withdrawal rights assigned to an individual user do give her a credible guarantee of excluding all "rival users" for the same usage (the rights of usage are exclusive vis-à-vis all other potential users) and secondly, that the whole set of rights of all the contracted users is in practice fully defined and highly detailed (as being also exclusive vis-à-vis the pipeline operator).

This reveals how much the building of market arrangements in open gas systems logically starts by answering two basic questions: a) How are network users' injection/withdrawal rights defined? And b) How are the corresponding network transmission services designed? Having these two fundamental features established, we would be able to assess the different industry restructuring experiences.

If a gas trade arrangement is implemented in a "contract carriage" regime (typically the US), the network users rights have already been well defined ex ante (before any usage) by the users negotiation of their long term usage contracts with the network owner(s). On the contrary, in a "common carriage" regime (typically the EU), the users rights are defined ex ante only at a central level as a set of regulated rules which asymmetrically produces the common regulation of system operation. In this process the network "system operator" defines the rules of operation of her license in liaison with the gas regulator (bilaterally or multilaterally; within constraints given by the legislation or a court). In a "common carriage" regime they are the system operator and the gas regulator who have the rights to decide whether to define network users property rights as weak or strong, firm or flexible, detailed or not, exclusive or not, rival or not, etc. For instance, regarding the available transmission capacity, all ex ante usage rights are affected ex post by the actual fluctuation of this

[9] The Australian system can be considered a kind of common carriage case where the rules of how to allocate capacity are based on a result of algorithm. Ruff (2012), among others, defines market carriage as the rule of transmission services allocation that depends on the differential of gas prices in different localizations.

capacity. It touches upon other regulated rules ranging from congestion management, balancing tools and activation of line-pack storage. From an incentive point of view, the process of having the network users' rights being centrally defined under common carriage reduces the incentive that these users have to improve the operation efficiency. In contract carriage systems, oppositely, competition among well-defined rights' users promotes such operation efficiency. Moreover, contract carriage's strong property rights also give higher incentives to invest. It is however true that contract carriage does not reduce all transaction costs at the industry level. It is because it excludes all potential users having not signed a contract earlier (when free network capacity was available to new entry into the club of contracted users), and because it restricts the contracted users' rights to the terms and conditions signed earlier at the beginning of the usage contract. However, both the pipe owner and the contracted users benefit with contract carriage form a stronger set of incentives to invest and operate within the range of their stronger usage contract.

In this section we have then identified a central trade-off faced by all gas industry restructuring processes: *(getting a stronger set of incentives to act within the tight path defined ex ante by the carriage contract) versus (getting lower transaction costs to act within the loose path permitted by a common carriage regime for new users entry and ongoing usage adaptation to unforeseen contingencies*). Ultimately, the nature of this trade-off also determines the key features of the gas trade system. An over-estimation of the related transaction costs would lead to inefficient use and development of the transmission infrastructure. However an under-estimation would also bring consistent grid and system inefficiencies. Our next section will go deeper into this by studying some of the international experiences.

4. The actual diversity of gas markets: the network access in practice

In this new section we will start by looking at existing network access schemes. Accessing networks actually has different meanings depending on the rules of usage. We may organize the different usage rules under two broad headings: firstly, the mechanism allocating rights of usage among all the potential users, and second, the definition of the actual transmission service characteristics corresponding to the implementation of these usage rights (for instance where and when a nominated amount of gas commodity might be injected into or withdrawn from a given pipe or set of pipes).

4.1 Capacity allocation: implicit vs explicit mechanisms

First we will start with the implicit capacity allocation mechanism. In such a regime the market outcome for transmission capacity allocation and the market outcome for the commodity trade are voluntarily coordinated ex ante. The basic rule in an implicit design is that the transmission capacity is always allocated according to the merit order established in the wholesale commodity market. It is why one says that the transmission capacity is "implicitly" allocated within the commodity market. The idea of an implicit design originally comes from a pioneering power market theory, found in Schweppe, et al. (1988). In a power market implicit design, the dispatch of electricity generation depends on both the power producers' bids and the continuous recalculation of the corresponding network constraints (notably losses and congestion). It is why this method of transmission allocation brings an enhanced operational efficiency: all the commodity market players can access quasi real time the transmission network exactly as the network is at every moment. Hence an implicit allocation deeply reduces the transaction costs uncured by the commodity market players as these players only need worry about their commodity market game. They do not have to coordinate the positions taken within the commodity market and other positions to be taken in the independent world of "blind" transmission capacity allocation at their own risk. In the gas industry, one also finds this purely rationale implicit process in the Victoria gas market design, which allocates the near to real time recalculated network capacity through the commodity merit order[10]. In other words: the commodity market continuously receives a feed-back on the coming transmission constraints or externalities fed by the commodity trade decisions. With more operational efficiency and less transaction costs, the implicit design is not without substantial merits.

Secondly, an alternative to the implicit design also exists, which is the “explicit” allocation. Here one finds an independent and separated transmission market where transmission capacity is priced and traded for itself disregarding what the actual commodity market equilibrium might be. It is up to each commodity trader to determine how to coordinate the two positions taken in the independent markets for commodity and for transmission. The US provides the typical explicit universe. Here the rights to use the pipelines capacity are defined ex ante by the usage contracts and do not take into account how trade will work later on in the gas commodity market. That is, gas wholesale pricing does not define who is entitled to use the infrastructure and no one calculates the social or the industry value of network constraints and externalities corresponding to the actual usage of the infrastructure. The US is thus just the opposite to the Victoria market model, where it was the commodity market clearing algorithm that decided who will ship gas within the network (through an optimization of the use of the entire network infrastructure among all gas commodity market players).

To better understand what is at stake there, consider two players, A and B, who want to carry gas to player C by using a pipeline with capacity able to carry only one of the two players’ volumes. In the Victoria implicit access model, the gas commodity carried will be the cheapest offered according to the actual network constraints. In the US model, it will depend on who has bought the right to carry its gas ex ante. If this right is owned by the player with the most expensive commodity offer, both the expensive and the cheap commodity players may voluntarily and bilaterally negotiate for the commodity sourcing (before injecting it in the pipeline) or for a reallocation of the right to use the pipeline. If this secondary trade of capacity and commodity is made in a significant hub, this ex-post bargaining of rights might become multilateral. However, nobody optimizes the entire gas market trade according to the actual grid capabilities (and vice-versa: the grid usage and operation are not conceived at the industry level to saturate all the commodity trade potential gains).

However, Europe is neither in the US nor in Australia... the EU still has different national regulations. But as showed by Glachant et al. (2013), there are also key EU common features, most of which are copied from the UK regulatory frame. [11] At very first glance it seems to be an explicit allocation of transmission capacity. In order to ship gas, players need to use the system, which is made up of two rights: the right to enter and the right to exit (hence: an “entry / exit system”). However, with a deeper view of these rights, one finds very significant differences to the US model. A key is the network operator’s role in case of congestion. In the UK, when defining the network users rights ex ante, the network operator strongly simplifies the actual physical characteristics of the gas network. Hence, the usage rights being allocated only align with a assumption of expected flows. As a result, actual flows do not necessarily correspond to the expected flows and operational reactions from the system operator are needed to keep control of the gas system. In this frame, one of the easiest tools for the system operator to manage the actual gas flows is simply to… buy or sell gas in the commodity market. When doing so, the system operator simply re-inserts the actual use of the network by gas shippers… into the commodity market… through a new round of gas trade. It is why while the transmission rights have been allocated “explicitly” (independently from the gas trade merit order),

[10] (Ruff 2012) describes the clearing mechanism as a model that could optimize up to 24 hours period each day. It takes into account the ability to transport and to store inside the line-pack in order to determine amounts of shadow prices of gas withdrawal at multiple locations. Even if it may have potentially strict constraints of time and localization, the gas market in Victoria is currently unconstrained.

[11] Note that the UK has been considered a successful case of a gas market in Europe, and its main principles have been followed by national regulations and by the European Union guidelines and directives. For instance, two of the elements of the regulatory model now implemented in the EU are the entry/exit system and the daily balancing.

these rights only correspond to a simplified usage contract that the system operator keeps under its own central control according to the actual network flows.[12]

In Brazil, where the rights of use were designed closer to the US carriage model, shippers must contract for transmission capacity ex ante in a separated contract with a separated pricing[13]. The absence of numerous competitive players and alternative transmission routes made this model appropriate because of its simplicity. However, with the potential increase of players and the potential development of new network capacity, a set of regulatory changes are currently being discussed. Some proposals are based on a mechanism of allocation derived from a simplified network modeling -hence a model closer to UK.

4.2 What transmission allocates: the flexibility issue

Transmission of gas through a network has two inherent dimensions that strongly impact trade in the commodity market. They are the spatial and the temporal dimensions of the gas delivery between the seller and the buyer. It is the feasible transmission path which counts as a secondary necessary condition to the location and time frame of any agreed gas trade. In practice indeed they are the transmission services which say where and when distinct gas trades can be considered by the market as the very same product hence as actual substitutes. The larger the area of injection/withdrawal and its time frame of operation, the higher the commodity market liquidity (by increasing the number of players and of deals lodged in the very "same" market equilibrium). However, the more the gas being uniformly traded in the commodity market differs from the real physical flows in the network, the more the gas system operator has to activate strong "ancillary transmission services" to reconcile the "notional" commodity trade and the actual network flows. (Vazquez, Hallack, and Glachant 2012).

What one may call the "temporal" characteristics of gas transmission services corresponds to the time lag allowed between the gas injection and the gas withdrawal corresponding to a nominated grid usage. In real life, market players may be allowed -as grid users- to inject into and withdraw from the system at different time horizons without changing the standard market characteristics and value of their trade. In such a flexible market & network arrangement, the temporal specificity of the real gas flow in the network is institutionally decreased to ease the commodity trade.

What one may term the "spatial" characteristics of transmission services draws the set of grid points where users may inject and withdraw after having bought a standard transmission service. That is, the set of points where the market players may trade without any risk or extra costs of delivery. It literally draws the limits of the commodity market. In such market/network arrangements, the spatial specificities of real gas flows in the network may be institutionally decreased by giving the players extended rights to homogeneously trade in larger zones. This decreases the transaction costs associated with trading the gas commodity at different locations. Correspondingly, transmission services may be defined as institutionally the same for a set of different feasible physical paths, so the transaction costs associated with tailoring transport services according to particular commodity trade opportunities are decreased… from the traders' point of view.

This is typically what the UK provides to its gas commodity trade: a gigantic 'virtual hub'. It builds a virtual place of trade where any connection to the physical network is treated as staying inside the same commodity market. In addition, a "daily balancing" principle allows players to keep their actual injections and withdrawals unbalanced until the end of the gas day, i.e. it allows players to buy and

[12] For more about the simplification of the network on the entry-exit model with virtual hub, see Hallack and Vazquez (2013) and Vazquez, Hallack, and Glachant (2012).

[13] It is important to notice, however, a key difference between the Brazilian and US systems in the implementation of open access. Contrary to the US system, in Brazil there has so far been no full separation of property rights between pipeline users and pipeline owners. The incentives in these cases can preclude competition, as explained by Makholm (2012) when analyzing the evolution of the US case.

sell intraday gas at any time within the day to cover their imbalances. Notice that this does not mean that the gas commodity price is the same throughout the day, but it does mean that the gas having been nominated one day ahead for transmission can be acquired in the different hours of the day with no other cost than its rolling market price.

If we come back to Victoria, a gas price for all locations and for the entire coming day also exists. However, if unexpected congestion occurs, the system operator re-schedules the actual flows and makes ancillary payments (based on market bids) to the commodity players being hit. In Brazil, until now, there has been only a low level of transmission simplification to favor the gas commodity trade. This low favor for commodity trade also corresponds to the rude architecture of the network (a mere Y). Until now, the spatial characteristics of transmission services being offered in Brazil are strictly defined in the ex ante carriage contract and any change in the actual flow entry/exit calls for an explicit renegotiation of this contract clause with the transmission owner. However, contract renegotiation is facilitated in Brazil because there is just one main shipper (Petrobras), so the renegotiation and adaptation of carriage among the shippers is never a contentious issue. For temporal simplifications of gas flows, Petrobras uses the inner flexibility of its long-term supply contract unless the entire gas system is already at full[14]. To end with the US, both the spatial and temporal characteristics of transmission services are strictly defined ex ante by the carriage contract's terms and conditions. This contractual frame is defined only pipeline by pipeline, and independently by each transmission owner. There is no "system operation" of the whole set of pipes. Hence, the spatial flexibility of transmission and trade can only be low to very low (except at large crossing of pipes, the physical hubs). The US carriage contracts are location specific as being frequently defined "point- to-point"; while some more flexible contracts also exist usually within a given region (from a defined set of entry points to a defined set of exit points). Notice that in the US, such transmission services with higher flexibility (those taking into account a set of points) frequently have higher costs than "point-to-point" contracts. These standard contracts also define the temporal characteristics of injection and withdrawal. The federal regulator FERC imposes only one restriction on the rigidity of the basic carriage contract: pipelines which do not allow basic time flexibility to the users must offer them a complementary menu where to buy some flexible transmission services [15] (FERC 2008).

Table 1 - Network access: comparison of cases studies

	Allocation of transmission capacity	Spatial characteristic of transmission services	Temporal characteristic of transmission services
United States	Explicit	Fragmented - low level of simplification	Limited - various simplification levels
United Kingdom	Explicit (but with implicit secondary features)	Enlarged - high level of simplification	Enlarged - high level of simplification
Victoria (Australia)	Implicit	Enlarged - high level of simplification	Enlarged - high level of simplification
Brazil	Explicit	Enlarged - low level of simplification	Enlarged - high level of simplification

Source: Authors elaboration

14 It became an anti-trust case in Brazil in 1998 when Petrobras was using part of the pipeline to store gas (by line-pack) and another company (British Gas) asked for available capacity. For details see CADE (1998).

15 We do not have data regarding what the rate of pipelines is offering higher and lower temporal flexibility (higher timing difference between injection and withdrawal). What we observe is the increased offer of services of flexibility in US, for some examples of services and related data, see Hallack (2011), chapter 6.

These examples show how much network access may rely on different rules of use. These access features are now clearly established as key elements for defining different gas market regimes: what is traded as much as where and when. In practice, defining the transmission services allocation process and its temporal and spatial characteristics means defining a substantial part of the commodity market foundations.

5. The actual diversity of gas markets: alternative network investment paths

We have just seen that the actual use of transmission capacity is central to trade because it gives boundary conditions to the feasibility of market trade. Therefore, the development of the network infrastructure also moves these market foundations. The network investment path may be defined in different ways. A part of this definition depends on how the network is already being used (it gives the weight of the past offer and demand of transmission services over investment decisions) or how the network might be used in the future; this influences expectations about the possible usage of a new infrastructure. Besides that, the investment path also corresponds to a certain allocation of decision rights (how much capacity, where, when, what technology, at what cost and price, etc.). The last key element is of course the allocation of investment risk.

There are at least two extreme paths to decide on new network investment. In a very decentralized world, it is the users of the network who credibly reveal their demand for new network capacity and routes by contracting with the investors around a network action plan. Oppositely, in a very centralized world, a central planer makes system forecasts according to preferred scenarios, a selected data base and self-defined algorithms. Then the planer derives from his universe of assumptions, preferences and computing the likely investments optimizing the forecasted future system and the related business plan.

Let us start by comparing the US and the Victoria models. The US is a typical example of a decentralized process of network investment based on shippers firm contracts negotiated with the transmission investors ex ante. Oppositely, Victoria shows a network investment central plan. In the US, transmission contracts lodge the investment process in the investor - shippers bargaining where usages and tariffs are defined according to a given "cost of service" (calculated with the pipeline costs and characteristics of the services contracted; and checked by the federal regulator). The construction of any new pipeline requires a certificate of "Public Convenience and Necessity" to be obtained from this federal regulator. This allows the regulator to oversee if competition is not raising some economic inefficiencies or too highly-fixed-cost businesses[16]. Nevertheless the key proof of the economic convenience and necessity of a new pipeline is the ex ante commitment of enough shippers' demand. Since the 2000's, FERC has started accepting that pipeline investors could also bear a part of the network utilization risk (in order to get more capacity built – think shale gas boom for instance). But FERC is sticking to the firmness of ex ante contracting and requires the pipeline owners to guarantee that the costs will not be socialized ex post across the successive generations of contracted users[17]. The

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[16] Kahn (1988) has a nice example of a gain in economic efficiency by merging two different pipeline projects in the US.

[17] "In the Policy Statement, the Commission explained that as the natural gas marketplace has changed, the Commission's traditional factors for establishing the need for a project, such as contracts and precedent agreements, may no longer be a sufficient indicator that a project is in the public convenience and necessity. The Commission, therefore, changed its policy regarding the pricing of construction projects so that market decisions by pipelines and shippers, as opposed to regulatory tests, would better reveal whether there is sufficient support for the project and whether the project is financially viable. The Commission established a threshold requirement that the pipeline must be prepared to financially support the project without subsidy from its existing shippers. This will usually mean that the pipeline would have to price the project using incremental rates in which the full costs of the project are recovered solely from the shippers subscribing to the new capacity. Under this policy, the pipeline and its expansion customers could share the risks of the project, but they could not shift any of those risks onto existing customers." (FERC, 2000, p. 3) http://www.ferc.gov/legal/maj-ord-reg/PL99-3-001.pdf

procedure for approval of new pipelines is hence highly formalized. Network investment developers must declare an "open season" where users are invited to assess their capacity needs (before getting the regulated final price)[18]. Investors have to get enough firm commitment of the future users ex ante. These players negotiating the coming investments are also the ones who must bear the risk. FERC avoids cross-subsidies among generations of users, especially between users of an existent capacity and users contracting to add capacity to the same pipe. Thus, each investment is to be fully paid by the buyers of the new transmission services contracted by the new infrastructure. Of course, the present use of existing pipelines impacts the investment decision through shippers' willingness to buy new transmission services. If shippers are looking for more transmission services and are not able to find any or enough in the secondary market[19], they will also be inclined to look for new investments. In a nutshell the process of network investment in the US is encapsulated in a well-defined set of property rights for each unit of past or new transmission services: the straight "single pipeline contract" (Makholm 2012)[20].

Totally opposite to this is the Victoria model [21]. Here transmission services are allocated among users only after the opening of the new infrastructure and only at the short-term operational stage: through a ranking based on the commodity market price differential. In this model, one cannot ask users to commit to a preferred capacity to be used in the future as these users do not hold any individually exclusive rights to use the future network capacity. Thus, the investment plan is inevitably conceived by a central planner. In practice, this planner is not the transmission operator (like in the EU), but the market operator, the publicly owned Australian Energy Market Operator (AEMO).[22] It determines the volumes the pipelines might carry and the amount of gas to be stored inside these pipelines. Remember that the network -by changing its internal pressure- can store more or less gas; it is called the "line-pack"[23]. AEMO is not an advisor in this process, but is actually responsible for determining whether the capacity should be expanded (Moran 2002). However, all the risks are not borne by AEMO or the transmission companies but the collectivity of the users. All related costs are to be put into the network tariffs.

In the UK (as a leading EU example), the investment decision may come both in a centralized and decentralized manner. The centralized process is the traditional and the bigger one.[24] The network owner and operator (National Grid) proposes a development plan to the regulator. If accepted, the assets are introduced into the regulated asset base when operating and the allowed revenue is

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18 There is an initial tariff proposed by the pipeline which is reviewed after the investment (plus a test period). The pipelines must publish rates for firm carriage and rates for interruptible service. Tariff rates must be approved by FERC and are normally strictly in line with costs, which are full costs in the case of firm access and operating costs for interruptible service. The US approach effectively transfers the equity in the pipeline to the firm capacity holders.

19 Note that US shippers (owning the right to transport gas) have the right to trade their capacity on the secondary market, where the price is not regulated.

20 The USA carriage system is frequently called contract carriage, in the sense that the shippers´ rights and duties depend on the contract.

21 In Australia the National Gas Law and Rules set out the regulatory framework for the gas pipeline sector. The AER (Australian Energy Regulator) regulates pipelines in jurisdictions others than Western Australia. The pipelines can be regulated or not and are applied among the regulated different models (and level of regulation). The Victorian Transmission System has been regulated since 1997.

22 The Australian Energy Market Operator (AEMO) was created by the Council of Australian Governments (COAG) and developed under the guidance of the Ministerial Council on Energy (MCE). AEMO is responsible for guaranteeing the electricity and gas market functions, NEM (National Electricity Market) system operations, management of Victoria's gas transmission network and national transmission planning.

23 The carriage system observed in Victoria (Australia) is called market carriage, as the rights and duties depend on the gas market. On the investment decision side, the decision has a big hand in the gas market operator forecast.

24 The carriage system in UK is frequently called regulated carriage system, where the rights and duties of shippers depend on a set of rules (network code).

recovered from the community of the users through the transmission tariffs. However, for a more efficient network development, the UK also opened a users' commitment process through "open seasons". It works with auctions of entry capacity. However, it does not mimic the US case. On the one hand, this "entry auctioning" does not end with strong property rights over the use of the new capacity[25]. On the other hand, the capacity actually built is not restricted to the amount chosen by the users. Furthermorethese committed users bear a significant risk as the price will be determined parallelly to network tariffs set in the future.

Table 2 - Network investment: comparison

	Who drives the process?	Who bears the risks?	How network uses impact investment decisions?
United States	Both Investors and users	Users contracting for the new capacity	Through the users willingness to contract
United Kingdom	Investors and regulator (+ mechanism to grasp users preferences)	All network users[26]	Through the assumptions of network development plan
Victoria	Regulated Market Operator	All network users[27]	Through the assumptions of the network development plan
Brazil	Government agency (+ mechanism to grasp users preferences)	Users contracting for the new capacity	Through the assumptions of network development plan and existing set of contracts

Source: Authors elaboration

In Brazil, the network development until the 2009 Gas Law was mainly based on ex ante contracting, as in the US. Forecasts, risks and duties were then placed on the users' and pipeline owners' shoulders. With the new law, the government took over (through a dedicated public agency EPE[28]) the planning of network development. The objective is said to be to accelerate network investment, but it is still unclear five years later how this will effectively work, who will actually bear the risk and how the recorded actual network use will affect network development.

As we have seen, there the investment paths used for developing the gas networks are –again- quite different across these countries. The roles of network users, pipelines owners and central planners in deciding the investment and allocating its risks are also quite contrasted. It goes from a central investment path supposed to calculate everything ex ante at the entire system level but puts all the ex post risks on the community of future users. This investment path is nevertheless coherent with a

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25 Entry capacity is separated from the exit capacity as explained above, so the actual path that the shipper may use can change. There is a model forecasting the demand/offer and flows, but it brings us back to the centralized model.

26 The regulator determines how to share the cost among all the users through tariffs definition. Different participation in the costs can be allocated among a set of shippers according to the tariffs structures. For instance, one possible choice could be set to zero participation in the cost allocation for some subset of users.

27 The regulator determines how to share the cost among all the users through tariffs definition. Different participation in the costs can be allocated among set of shippers according to the tariffs structures. For instance, one possible choice could be set to zero participation in the cost allocation for some subset of users.

28 Empresa de Planejamento Energético.

"common carriage" access regime where the users' ex ante individual property rights on transmission services are weak. Oppositely, we also find a quasi-private investment path where all key ex ante decisions are bilaterally framed by investors and users and all risks borne by these ex ante decision-makers. Of course these decision makers ignore the system level effects of their private choice. But this is coherent with a "contract carriage" access regime where the users' ex ante individual property rights on individual units of transmission services are strong. One sees that the loop between each contrasted access regime and its particular investment path is mainly rationale.

6. Final remarks

Yes, gas transmission systems are not necessarily natural monopolies. But one cannot derive too much from this right assumption. Observing several cases of liberalization in the gas industry, one also observes significantly different choices in the design and the implementation of trading arrangements. It comes from another assumption to be made: gas liberalization trajectories depend both on the architecture of the gas network and on the access regime implemented.

In this paper, we have characterized the gas industry restructuring as the design of a system of rights to access the infrastructure. Although the notion of "open access" has been often used in economic literature, it still lacked definition as an arrangement of rights to use a common infrastructure. We have showed that the mechanisms defining and implementing open access rights are actually the roots of the diversity of gas liberalization designs, thus the "*à la carte*" policy.

From a theoretical viewpoint, the higher the difficulty to exclude potential rival users from an actual access to the network (as imposed by the common carriage regulatory frame), the higher the "commons" problems that need to be coped with when defining users ex ante rights and implementing actual network operation rules. Getting these access property rights better defined would have required lowering the costs of usage exclusion, and avoiding the socialization of associated network operation costs.

In the US, each pipeline typically sells point to point transportation through individual long term contracts. It is up to the pipeline users to organize their individual portfolios of point-to-point contracts into something more flexible at the industry level (think of a secondary trade among themselves). It is up to the market players to find or to create these secondary markets, being organized or not; or with brokers. Network users have firm transmission rights and they have to bear the transaction costs of any needed rearrangement. On the other hand, as the rules of network usage are encapsulated into ex ante negotiated contracts, these rules are often more responsive to the anticipated users' needs. Moreover, such strong rights push the users to reveal their true preferences and help competition with pipeline investors' new entry. This is why the carriage contracts have been a key coordination mechanism for the long run evolution of the US industry.

In the EU, on the other hand, the network of gas transmission is generally considered zone by zone as a basket assembling all the transmission assets found into each zone. This causes these assets to maintain monopolistic characteristics because of the exclusive rights of operation given in each zone to a single "system operator". This goes with an access regime based on unilaterally and centrally defined regulated rules of open access. These regulated central rules allow the creation of "virtual" commodity trade areas corresponding to the transmission operation zones. That is, within these zones any gas arriving at an entry point may be carried to any exit point into the same zone, so there is no individual transaction cost for this pair of buyers and sellers. The trade system is completed by a large amount of gas system operations (managed by the system operator) in order to bridge the gap between the actual network flows resulting from the network users' actions and the virtual flows having been taken into account in the commodity trade. While increasing the appetite to trade within a zone, this dual process (virtual trade/actual network flows) comes at the cost of a weaker set of efficiency incentives.

The Brazilian model used to have features close to those of the US system. However, in the last years, policy-makers have been increasingly worried about the lack of entry in the commodity market and of liquidity in the secondary trading of transmission services. Thus, they are considering changing the system and traveling the path set by European design. A centralized mechanism for pipelines investment has been launched recently (January 2014), and future measures towards more centralized regulation will be seen soon.

In Australia, the Victoria model is closer to a typical "nodal power market" design than to any other gas market either the US or the EU. This model prioritizes the short-term efficiency by allocating a centrally calculated short term system capacity according to commodity price differences (efficiency is defined as allocating capacity to whoever values the commodity the most according to actual transmission constraints). Here the right to use the transmission service directly depends on the commodity market and their relation is defined by a computing algorithm. We may consider this as the opposite of the US model, as a transmission right in Victoria is not a well-defined, tradable and individual right. However, in principle, if the gas commodity market is efficient, so will be that short-term capacity allocation. Of course, the efficiency of that allocation also depends on the computing capability of the algorithm. And there is unfortunately no simple and transparent way to do that computing. To close, as the individual property rights are so weak for each individual user, the incentives for each user to individually contribute to new capacity investment ex ante are as weak.
Besides all the other specificities of existing gas markets, a key foundation of each is found in its regime of transmission access rights. By understanding how these access regimes work, we can better understand the economic rationale of the existing gas network and market diversity.

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