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EFFICIENCY VERSUS MEASUREMENT COST: INSTITUTIONAL DIVERSITY IN NETWORK INDUSTRIES

Eficiência ersus custos de mensuração: diversidade institucional em indústrias de rede

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RESUMO

Este artigo explica a diversidade nos desenhos institucionais que coordenam indústrias de rede, analisando a justificação econômica para a concepção de regras para a utilização das redes. Nós identificamos a rede como um recurso de acesso comum, e apontamos para a definição dos direitos de propriedade como decisão fundamental na concepção de regras. Exige escolher quais as características de rede precisam ser medidas pelos participantes do mercado. Mostramos que a diversidade institucional é explicada pela lógica por trás dessa escolha. Os benefícios da definição de direitos de propriedade vêm em termos de eficiência: a melhoria na coordenação de informação dos participantes sobre o valor das redes. Os custos estão associados à medição das características de rede. Quando os custos são mais elevados do que os benefícios para um determinado serviço de rede, os mercados não são mais uma forma adequada para coordenar a sua atribuição. Além disso, quando os participantes são heterogéneos, os benefícios da medição são elevados.

Palavras-chave: Diversidade Institucional, direitos de propriedade, recursos comuns, custos de mensuração.

JEL: L1; L5, K23.

ABSTRACT

This paper explains the diversity in the institutional designs that coordinate network industries by analyzing the economic rationale of the design of rules to use the networks. We identify the network as a common-pool resource, and point at the definition of property rights as the elementary decision in the design of rules. It requires choosing what network characteristics need to be measured by market participants. We show that the institutional diversity is explained by the rationale behind that choice. The benefits of defining property rights come in terms of efficiency: the improvement in the coordination of participants' information on the value of networks. The costs are associated with measuring network characteristics. When costs are higher than benefits for a certain network service, markets are no longer an adequate way to coordinate its allocation. In addition, when participants are heterogeneous, the benefits of measuring are high.

Keywords: Institutional diversity; Property rights; Common-pool resources; Measurement costs.

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1. Introdução

Segundo o Escritório das Nações Unidas para Drogas e Crime, no ano de 2009 foram registrados quase sessenta mil ocorrências de homicídios no Brasil, superando cinquenta ocorrências por cem mil habitantes. Para os chamados crimes contra o patrimônio, o cenário não é animador, segundo dados do Fórum Brasileiro de Segurança Pública, o número de roubos para o ano de 2009 foi superior a um milhão de ocorrências[3]. Além disso, segundo o Ministério da Justiça, os gastos públicos com segurança somaram um montante superior a trinta bilhões de reais para o ano de 2008.

The institutions used to coordinate network industries around the world are considerably diverse, and this diversity cannot be explained alone by diversity in technological characteristics. In this paper, we aim to understand the logic for institutional design in network industries.

Until de 1980's, the main tools to deal with 'market failures' (externalities, public goods, etc.) were the public provision or the design of command-control regulations, see for instance (Brousseau & Glachant, 2014). Then political and economic factors led to a strong preference for implementing market arrangements in all industries, and network industries were one of the key groups targeted by these reforms. In any case, the implementation of market arrangements was not straightforward, and network industries required the design of sophisticated mechanisms do deal with some of the characteristics previously thought of as barriers to market solutions. This design of new institutions for industries previously dominated by vertically integrated organizations posed a set of new questions, both from theoretical and practical standpoints. After more than 20 years of reforms and a wide range of institutional settings spread around the world, many of those questions remain open. Understanding institutional diversity has become a central issue to address in order to move forward. Many of the remaining open questions can be motivated from the following reasoning: the available technology for most of the network industries is similar; the objective of most of the liberalization reforms is also similar; the rules resulted from the reform, however, are quite heterogeneous.

A first alternative is to explain diversity from the viewpoint of the environment where the liberalization processes take place. It has been shown that elements as country wealth, market concentration and existent infrastructure impact the results of the reform, see (Levy & Spiller, 1993) for telecommunications, (Jamasb, Newbery, & Pollitt, 2005) for electricity, and (Gwilliam, 2003) for urban transport. However, they cannot explain alone the diversity of market designs that one observes. On the one hand, this kind of analysis does not regard the outcome of the reform, but the design of markets resulted from reforms. On the other, countries with similar conditions have often adopted different designs, e.g. in the natural gas industry, (Vazquez, Hallack, & Glachant, 2012), (Ruff, 2012) and (Makholm, 2012).

A second alternative is to look at the heterogeneity of market designs through the lens of positive theory. (Finon, Pinto Jr, & de la Vega Navarro, 2004), (Perez, 2005), (Glachant & Perez, 2008) and (Littlechild, 2014), among others, have studied the institutional constraints for the reforms. This literature highlights how the evolution of the liberalization reforms, and consequently the market designs, is constrained by the political and institutional characteristics of each country.

[3] Consiste no número total de roubos registrados pelo Ministério da Justiça, Secretaria Nacional de Segurança Pública – Senasp, Secretarias Estaduais de Segurança Pública e Defesa Social, Instituto Brasileiro de Geografia e Estatística – IBGE. Nesses estão incluídos roubos a instituições financeiras, de carga, veículo, dentro outros.

This paper approaches the problem from a third point of view, namely the lens of normative theory. The logic for it is to propose a normative framework for the market design in network industries, i.e. to identify the economic rationale for the design of each institutional setting. In that view, we point at the key variables that policy makers choose while deciding the implementation of markets. Such choices can be conscious decisions or not, but they are always present. Therefore, we explain an additional dimension of institutional diversity as different choices of these key variables in each market design.

In order to build the framework for the analysis, we build on the idea that, in a liberalized context, the infrastructure becomes the site for the exchange of goods. This fact changes the economic characteristics of the infrastructure. We show that it becomes a common-pool resource as defined by Elinor Ostrom, see (Ostrom, 2009). In this context, the definition of the rules regarding the infrastructure use becomes a fundamental piece of the industry organization, as it defines the trading sites and many features of the good itself, including measurement and property rights features. This paper shows that there is a fundamental trade-off in choosing the network rules: measurement cost versus efficiency incentives. On the one hand, to obtain an efficient market allocation of services, one needs to define rules for network use that allow revealing both the users' preferences and the cost of network services. On the other hand, as highlighted by (Barzel, 1982), the ability to reflect costs and benefits depends on the ability to measure the service, and such measurement has costs. Therefore, each choice of market design depends on the definition of network rules. In turn, network rules depend on the perception about how to balance the previous trade-off. Ultimately, each market design needs to assess costs and benefits of allocating network services using market arrangements. This is a fundamental source of institutional diversity: market designs differ in the assessment of the trade-off efficiency versus measurement cost.

The program of this paper is the following. After this introduction, we continue by analyzing the transformation, associated with liberalization processes, of network infrastructures into common-pool resources. Section 3 we describe the main elements related to the implementation of that transformation, which is related to a transformation of property rights structure. Section 4 describes the essential trade-off of market design –efficiency versus measurement, and section 5 applies the framework to energy industries. Section 6 concludes.

2. Networks as common-pool resources

The concept of network has been used in many different contexts, which makes difficult to develop a general definition. Industries ranging from social interaction to power systems are often termed network industries. In this paper, we restrict our attention to the case where such activities involve many individuals using the same infrastructure in order to be interconnected. Even in this case, there is little agreement in the definition of network. Loosely, the intuition behind the concept of "network industry" can be thought of as industries with activities that involve the interaction of many individuals, see for instance (Shy, 2001). The devil is in the details, however. A significant example is the case of gas networks. The European approach, see (Newbery, 2002), considers the set of infrastructures used to transport gas from one point to another as a "block". However, an alternative view, started by (Kahn, 1988) and best represented by (Makholm, 2012), considers each pipeline of the system an independent facility, and thus competition among pipelines is a relevant force in the coordination of the industry. That is, in the US, the gas network is considered a set of interconnected pipelines instead of a single block of infrastructures. Consequently, a large part of the efficient institutional set-

ting in the industry is already decided on when defining the network as a set of interconnected infrastructures or as a single block of infrastructures. In that view, one finds European gas networks organized as natural monopolies, whereas in the US the network presents some level of competition.

From the viewpoint of institutional analysis, the gas example points out that, to a certain extent, the characteristics of network industries are not only associated with their physical characteristics, but decisions in the design of the institutional setting play a central role, (Hallack & Vazquez, 2014). The strategy we pursued in this paper is to use the concept of common-pool resources[4] to characterize the networks infrastructures in a liberalized context. Common-pool resources are defined by (Ostrom, 2009) as goods that are subtractable and where exclusion is costly. So the first step is to analyze whether network resources, after restructuring the industry[5], fit in such definition. In that view, as discussed by (Ostrom, 1990), it is important to differentiate the resource system, which in our analysis is the network infrastructure, and the flow of resource units, which in our analyses are services provided by the network.

Subtractability refers to a situation where the use of a resource unit (withdrawal from the network) decreases the available amount of resource units (units of network services) in a certain period[6]. In presence of overcapacity, some authors (Newbery, 2002) does not take into account the impact of one user of the infrastructure in the others, however, this analysis is not sustainable in the long run. As soon as appear congestion events it becomes clear that the use of a player impact the use of the other players of the same infrastructure. In this context, the subtractability can be clear observed in the network industries, except in the case of large amount of over capacity. Excludability refers to the cost to exclude a user of withdrawing a unit of resource (a unit of network services) in a certain period. The liberalization being based on facilitating access to the infrastructure meant to increase the costs to exclude.

Many network infrastructures are usually "naturally" excludable goods, in the sense that it is not particularly difficult to exclude individuals to use big network infrastructures. It is the case of gas transmission networks, where the physical connection of a player to the network is observable. However, restructuring network industries typically implied opening the access to network infrastructures. As explained by (Ostrom & Hess, 2007), open access can be a consequence of conscious public policy to guarantee the access of all players to the use of a resource. That is the case of most network industries, where the physical connection is guaranteed by law. Although the precise meaning of that "open-access" is quite diverse, all share the characteristic that the infrastructure owner has no right to discriminate users, and should allow a large number of players to access the infrastructures. Therefore, despite some differences in the implementation of open access, all the cases are characterized by the choice of creating difficulties to the exclusion of players of access to the network. Next section will analyze in more detail this characteristic of network industries restructuring.

[4] See for instance (Ostrom, 1990).

[5] Industry restructuring here can be understood as the institutional change aiming to include market arrangements in industries historically organized through vertical monopolies. It can be observed in most of the capitalist countries after the 80's and especially in the 90's.

[6] In this regard, the key point is the congestion of the infrastructure. In fact, the flow of services that the infrastructure may offer is limited. For instance, natural gas networks are a combination of pipelines and compressors. The gas flows from the higher-pressure point to the lower-pressure point, limited by the technical characteristics of the pipeline system. The maximum volume that can be transported through the pipeline is largely limited by the pipeline characteristics and the compressor potential. In that view, the use of the flow of services by a certain player decreases the amount of available services in the same period.

In a context aiming to include competition in the supply side, access of many players to network infrastructure was a key element and some mechanism for facilitating this access can be found in any market design. The easier access means on the other hand greater difficulty (or higher cost) to exclude players to access the infrastructure. In this context we can admit that the exclusion became more difficult. The services provided by network infrastructures in a liberalized context are subtractable and have low excludability. Therefore, network infrastructure has the characteristics of a common-pool resource.

3. Open access: Changes in the structure of property rights

The decrease of the excludability of the network infrastructures meant a change in the characteristics of the property rights. Before the liberalization, network industries were organized through vertical integration and the infrastructure owner had full property rights on the assets. Consequently, the owner decided how to use the asset. It was often used by a small amount of players, frequently one single firm. In order to develop the market, the infrastructure was opened to be used by several players[7]. To that end, a separation of rights was implemented: the infrastructure owners usually kept their right to receive the revenues from the use of the infrastructure (among other rights), but they lost their rights regarding the decision on the infrastructure use.

Although it is widely recognized that, in order to implement market arrangements in network industries, networks need to be accessed by several players, many players using the same resource leads to a new set of problems. For instance, individual incentives for the use of the same resource may raise commons' dilemmas. In that situation, the rules of use are necessary to coordinate collective action. Nonetheless, the way to establish those rules is far from unique and it may deliver a wide range of outcomes. In this framework, we show in this paper that a fundamental element to explain market design diversity in network industries is a consequence of the rules for network use, and the rights to decide them.

As defined by (Ostrom & Hess, 2007), property rights are institutions that define the range of actions that individuals can take regarding a certain item. These actions include different dimensions as to access, withdraw, manage, exclude and alienate[8].

Set of 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*
Exclusion	*The right to determine who will have the access right, and how the right may be transferred*

[7] The change on the rights structure of the networks is a common point of most of market design. As the networks infrastructure have cost structures of natural monopolies (most of the time) it is inefficient to duplicate the infrastructure, on the other hand, the access of infrastructure is essential to interconnect users and suppliers. The presence of many suppliers is possible just if many players access the same infrastructure (excluding the possibility of many networks).

[8] (Schlager & Ostrom, 1992) identified these five different property rights, which are relevant to coordinate the use of common-pool resources.

Alienation[9]	*The right to sell or lease management and exclusion rights*

Source: Author elaboration, based on (Ostrom, 2009)

When dealing with private goods, these rights can be allocated to the same agent. A private owner has the right to access its property, to use it, to manage it, to exclude others to use it and the right to sell (transfer) the set of rights. With open access, the characteristics of the good changes, and these sets of rights are separated. Open access rights mean the right to access the facility (to be physically interconnected and potentially become a user), but they do not necessarily mean the right to acquire any service. The right to use a service is the withdrawal right, the withdrawal of units (services) from the set of resource units. Using the example of the gas industry, the resource system is the infrastructure (pipelines and compressors) and the flow of resources units is the service itself (i.e. the transport of gas by pipelines).

This separation can be applied to different network industries, the train is another easy example, the resource system is the set of lines and the trains themselves, and the flow of service units is the transport of people. In this case, it is important to separate property rights regarding the pipeline itself the property rights related to the use of the infrastructure. Pipelines may keep their ownership of the assets and sell to shippers the rights to use the pipeline, or in other words, a unit of the resource flow. The separation of the pipeline from the services allowing its use is a separation of property rights. The implementation of market arrangements in network industries depends on the separation of property rights: the separation of the infrastructure (which is the key entry barrier in a network industry) from the service of using the infrastructure is central to allow entry in network industries.

This separation of rights can be found in every restructured network industry: market players must have the right to use services, even if they do not own the infrastructure facility. On the other hand, the definition of rights to use the system can be well defined or not. Higher precision of the service implies that the rights attached to the property are better defined. Services may be weakly defined, and in this case at least part of the property rights are allocated to a third party who must fulfill the gap[10].

The definition of the property rights of the users has been quite heterogeneous. The services units may be more or less flexible, i.e., with precise definition of how to use the infrastructure or with a loose definition. In the first case, the flow of services needs to be strictly measured and it is easier to allocate the associated costs to the user. In the second case, the importance of measurement decreases. In that view, property rights are better defined in the first case than in the second (following the description of (Barzel, 1982). Goods with weakly defined rights have higher transaction costs decreasing the efficiency of markets in allocating available resources. And consequently, some other kind of mechanism to allocate part of the available resource is often used (as we will see below in the examples from energy industries).

[9] The common usage of property right expression have 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, 2009), page 24.

[10] It can be done through an extra set of services that users' area obliged to pay. In the electricity sector is current, in any market design, the presence of complementary services to maintain the stability of the network. In the transport, the airport also have a bunch of services that are paid by all users which is complementary to the services of using the infrastructures, for instance management of routes.

Therefore, the definition of open access is a central element in the implementation of market arrangements in network industries. Next, we analyze the process of defining such rights to access the network.

4. Design of rules: Incentives versus measurement

As we described in the previous section, the definition of rights to use network services explains the implementation of market arrangements in network industries. Nonetheless, assuming that the physical network characteristics are essentially the same in different systems (for the same industry, say electricity), one would expect correspondingly similar implementations of rights of use. This is not the case, however. Actually, policy makers (or market designers) face trade-offs when deciding the rights associated with services. It is necessary to consider the benefits and costs of the design. The benefits depend on how valuable are services attributes for users, whereas the costs depend on the effort to measuring resource characteristics. The aim of the following is to analyze the fundamental criteria behind those different definitions, in order to understand why the diversity in the institutional settings.

4.1.Design of incentives

A first dimension of the choice is the implementation of incentives to help in the allocation of network services among market participants. In that view, one needs to design the rules of the game that yields efficient network allocation when players use equilibrium strategies[11]. This is the objective of the theories of mechanism design and implementation (see for instance (Wilson, 1993) for a very general problem formulation). The setting considered involves an economic environment that is characterized by private information —information observed only by a subset of players, and the objective is to design rules that obtain efficient results.

But in presence of private information, it is necessary to analyze the process to obtain such results. The design problem becomes the design of rules that make players choose decisions that result in the most efficient outcome. This includes, for example, the design of incentives to obtain truthful revelation (incentive compatibility). But when one needs to design rules to guide players' behavior, efficiency should not be measured in terms of outcomes but of mechanisms. (Holmström & Myerson, 1983) dealt with this problem, and defined (among other two) ex ante efficiency to describe a design that maximized players' expected welfares over the set possible realizations of their private information, subject to incentive compatibility. That is, even if monopoly rents may be unavoidable with few participants, as well as informational rents may be unavoidable in presence of private information, the optimal mechanism is that minimizes those effects.

Applying these concepts to our problem of defining rights to use network services, the objective would be to design a set of rules that maximize players' welfare subject to incentive compatibility. Following the reasoning above, that would be obtained by assigning one price to each service to be allocated. Assuming that price fulfills incentive compatibility, the mechanism would be efficient according to the criteria we considered. It that view, every product characteristic is potentially valuable, and hence it should be available to players in order to let them choose. These ideas are close to the conclusions of (Laffont & Jean Tirole, 1993) in the context of procurement contracts. The work showed

[11] The word equilibrium here should be understood as the equilibrium of the game.

that offering contractors a menu of possible contracts would allow screening contractor's preferences, and hence improve efficiency. Similarly, having one price for each network service would allow screening network users' preferences and thus obtaining efficient outcomes. But the previous results are based on assuming that the screening is costless. However, measuring attributes has a cost, as we discuss next. Thus, it will be necessary to compare the value that players give to a specific attribute and the cost to measure it.

4.2.The measurement problem

The reasoning of mechanism design stems from the assumption that players already have (private) information. That is, the process of producing information is not taken into account. But producing information is costly. (Barzel, 1982) proposed an alternative reasoning that was based on the concept of measurement cost. Loosely, the intuition of the ideas developed in that work is that it is not possible to define an economic meaning for property rights without measurement. The central message could be stated as: in order to exchange, players need to measure the attributes of what is going to be exchanged. Furthermore, measurement implies errors, and institutional design can be explained from the minimization of measurement costs.

In our case, network services need to be measured. Considering that alone, there is no difference with respect to general treatments of the problem: individuals will choose the preferred level of measurement and the preferred contractual relationships to trade, in order to minimize wasteful measurement. However, as shown above, the use of the networks in a liberalized industry was regulated to some extent. This regulation can include the definition of services (including the choice of how much service characteristics should be measured), or it let the definition of service characteristics be negotiated between users and network operators.

Some of the network services are extremely difficult to measure and networks are characterized by significant externalities. Externalities mean that one player affects the benefit of other players. Consequently, high externalities mean high valuable attributes. The difficulty to measure means higher costs, but the impact of one player on others means higher benefits of measuring network services. Combined, these two elements (measurement costs and externalities) mean that measurement costs above some level will result either in mis-coordination of network activities or in command and control arrangements. Hence, in order to implement market arrangements, the designer needs to implement, as we saw in the previous section, regulated access rights.

The key element of the previous analysis was "measurement costs above certain level". This paper is intended to underline that the decision is a designer problem. In the situation we are considering, at the point measurement costs need to be assessed, no organization is still implemented. Consequently, that "certain level" is an estimation of the designer. Different designers can have, thus, different estimations (especially in highly uncertain situations). Different estimations will lead to different institutional designs.

4.3.The trade-off efficiency versus measurement

The key concept in the analysis developed in this paper is that accurate reporting may be more costly than the profits associated with the reports, because information is costly. In that case, there is no incentive-efficient mechanism and the designer must choose a compromise. Such compromise is defined by the designer deciding on some of the network services without taking into account users'

preferences. That is, as the designer needs to give up receiving reports from network users, the designer will need to estimate ex ante network users' preferences. This will be done by assuming a certain set of types for market participants, regardless their true valuations. This is equivalent to socialization, as the designer will be, at least partly, mistaken.

Let us consider the extreme case where the designer chooses not to intervene in market decisions. Looking at the incentive force only, this situation could be interpreted as one where the market would provide one price for each network service associated with the infrastructure. But one needs to consider in addition the measurement cost. Hence, the situation would be similar to the ones described in (Barzel, 1982): market participants will choose the most beneficial combination of incentives benefits and measurement cost for each attribute. But, because of network industries characteristics, these choices are not "naturally defined[12]" but designed. The designer's choices may result in a significantly inefficient mechanism. As part of the decision is taken ex ante by the designer there is no guarantee that most valuable attributes are considered and the trade-off between cost and benefits of measuring is taken into account.

The heterogeneity of individuals' preferences play a key role in determining the trade-off. The designer need to estimate network users' preferences in order to decide on the allocation of services that are left outside the market, and that estimation is subject to errors. These errors tend to increase when players give different values for the products´ attributes. Consequently, the costs of leaving services outside markets depend on the relative difficulty of service allocation by the designer. And that difficulty increases when players are highly heterogeneous.

5. Examples from energy industries

The use of network infrastructures to carry energy is frequently observed: oil pipelines, gas pipelines, electricity lines, railways carrying coal, etc... The physical properties of electricity and gas make networks the most economical way to transport energy in most of situations. We use in this section both industries, which have been transformed with the liberation process, to show that the way in which open access is defined has been key determinant in the design of the market.

5.1. An example with power networks

Consider the case of power markets design with regard to the somewhat surprising diversity of spatial characteristics in US and EU markets. In particular, the market for Pennsylvania, Maryland and New Jersey (PJM) has more than one thousand day-ahead prices. The Spanish market has one. These differences are explained using the framework developed above.

The idea is that the two implementations of market arrangements have different perceptions of the optimal trade-off between incentives and measurement. To illustrate it, consider that in order to sell electricity produced at one node of the network to a buyer located at a different node, electricity needs to be transported through power lines. Such transportation is technically complex, involving many requirements for injections and withdrawals. Among them, consider the requirement that the power generator producing electricity needs to be rotating at a very precise velocity, synchronized with the rest of plants in the system (this is called frequency regulation). Measuring electricity flows

[12] Naturally defined meaning here defined without any third party intervention or as consequence of the habits and routines of players.

each second is rather costly, and probably producers would choose not to measure the flows that often. The problem here is that a power network is characterized by strong externalities, i.e. not measuring may result in the lack of synchronization and hence in the collapse of the entire power network (balckout). In that view, the designer cannot leave the decision to market participants.

On the other hand, defining different prices for electricity at different nodes of the network improves the efficiency of the allocation. To solve the trade-off, market arrangements in power systems rely on a combination of markets and command and control allocations. Some spatial signals are given through prices, whereas frequency regulation is done outside markets by means of a "system operator"[13].

The question is how to decide the meaning of "some spatial signals"[14]. Using the analysis of this paper, the designer will implement prices only for the nodes of the network where the benefits of incentives are greater than the costs of measurement. For instance, if the values for electricity in two nodes are relatively similar, but measuring electricity at the two nodes is relatively costly for market players, the designer will decide to manage the flows outside the market, defining a single price for the two nodes. The allocation of the remaining services would be done under the responsibility of the system operator, and they are called in the power markets literature “ancillary services”.

A key element of this analysis is that the designer needs to estimate players’ measurement costs ex ante. Not only does it imply an information problem, but also uncertainty about the real measurement costs. Consequently, it is sensible to expect different estimations depending on the designer. From that reasoning, US power market designers estimate low measurement costs for spatial characteristics whereas Spanish designers estimate large measurement costs.

In both cases, however, designers estimated some network services as prohibitively costly (as frequency regulation), and left them to regulated agents called system operators. In other words, in all cases the network was regarded as a monopoly. We will see that this is not the case in gas systems.

5.2. An example with gas networks

Consider now a system of gas pipelines. The flow of gas through them is, as in the case of power networks, technically complex. Consequently, applying the same framework, one would conclude that some network services are managed by a system operator. But it is important to note that this is a result of the designer’s estimation of the ratio efficiency/measurement. And in this case we observe different opinions from the designers in the US and Europe.

The gas system in the US is characterized by the absence of a system operator. That is, all measurement decisions are taken by market players. In that view, the decision is to leave the trade-off measurement/efficiency to the market, and hence choosing a situation described by the traditional theory of measurement costs. Note that in this case we cannot identify a market design in the US gas market, in the sense discussed in this paper. In this view, although there are a set of institutions in place that allows well-functioning market arrangements, there is not a designed mechanism put in place to shape incentives, in the sense of (Myerson, 1983). Note that the rules to shape the market may appear through active design (a set of individuals that design a mechanism to coordinate players in a

[13] A regulated agent in charge of the power network operation.
[14] The same analysis can be done with time characteristics.

certain fashion) or it can be a "natural"[15] consequence of the institutions in place –for instance, bilateral negotiations or tacit agreements between players[16].

On the contrary, European gas systems are based on the existence of a system operator. This means that having the same situation, European designers decided that the level of measurement/efficiency should be a regulated. The European approach chose to create markets based on the design of mechanisms to decrease the impact of network specificities in the trade. Consequently, virtual hubs for gas trade were created. In this context, network services are sold as a ticket that gives you a set of homogenous rights. A gas seller who intends to sell the gas to any player (independently of its localization) should buy an entry ticket, and that allows them to inject the gas in the system, without specifying what network services are going to be used. Analogously, a gas buyer should buy a ticket to withdraw gas from the system (exit capacity), which gives the right to buy gas of any supplier independently of where it is in the system and what is the network services required to deliver the gas.

In this case, the rule transformed the network infrastructures (which are quite specific assets, with high measurement costs) into a site to trade (which is independent of the physical specificities). However, this choice comes at a cost. The job of actually manage the flows and match entry/exit tickets with the physical requirement demands a group of services provided by the system operator[17].

This approach has two main justifications. First, as the network was defined as regional monopolies, and some of them had commercial interest in the final market, the regulators did not believe that players would be able to fairly negotiate the rules of use (service definition); Second, in order to increase the liquidity of energy commodities, the definition of network services was loosely defined so that it does not represent a barrier to trade. In practice, it means that important part of the network allocation resources is made outside the market.

The implementation of the previous combination of measurement/efficiency was done by different systems of property rights. The US pipeline regulation builds on strong property rights: they are better defined in the contract, they are less subject to regular intervention and, typically, a lower amount of services is allocated outside the market.

In Europe, the definition of flexible network services, which is loosely related with the actual service used by players, makes the definition of users' rights weaker. The rights associated with the use of network services is weaker because, first, the actual cost of using the network is socialized among many users (using the network in different way has different costs, but if they are under the same umbrella of homogenous services they cannot be differentiated); second, as part of the allocation of infrastructure resources depends on a third party that coordinates the actual flow, there is a range of decisions out of the trade sphere that impact the amount of available units of services.

6. Concluding remarks
7.

[15] Note that the word natural here is meant as the opposite of designed. Anyway, from a broader perspective, markets have always been consequence of the historical development of social institutions.

[16] In the US example, the property rights on pipelines were transformed and a set of new institutions was established to allow well-functioning markets. However, as explained by (Makholm, 2012), the institutional setting comes from the historical development of property rights on pipelines and they are not based on a specific designed mechanism for the sector.

[17] For more details of pros and cons of virtual hubs design, see (Hallack & Vazquez, 2013).

The diversity of market arrangements in network industries can be categorized in terms of the definition and allocation of access rights to the infrastructure. We have showed that the diversity of institutions found in different restructuring experiences is a consequence of different design choices. Those choices are determined by two opposite forces. On the one hand, establishing a complete set of incentives for network service allocation requires, in the limit, using market arrangements for all existing services. On the other, producing the information required to trade all services is costly, and may be prohibitively so for some of them. It is necessary to compare the value given to the products attributes and the cost to measure them.

Therefore, the problem faced by designers is to decide whether the benefits obtained from allocating some service through markets are greater than the costs associated with them. Those costs are related to individual decisions on whether to incur in measurement costs. However, such decisions have an impact on other players because of network externalities. To avoid such inefficiencies, the designer needs to estimate ex ante the tradeoff. That estimation, essentially subject to uncertainty, explains why different systems have chosen different institutional settings.

8. References

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