The Development of Gas Hubs in Europe

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Abstract

This paper investigates the development of wholesale markets for natural gas at the different stages of market liberalization. We identify three steps in the process: wholesale trade initially develops to cope with balancing needs when the shippers and suppliers segments become more fragmented; once the market becomes more liquid, it turns out to be a second source of gas procurement in alternative to long term contracts; finally, to manage price risk financial instruments are traded. We review in detail the different regulatory measures that must be introduced to create an efficient and functioning wholesale gas market. Finally, we analyze the evolution of gas hubs in the UK, the Netherlands, Germany and Italy in terms of market rules and market liquidity. We argue that each of these country cases can be easily located into the evolutionary path we have highlighted at the beginning, with the UK and the Netherlands leading the process, Germany catching up, and Italy showing an interesting counterfactual.

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1. Introduction

1.1 Background

A gas transmission system has to guarantee the pressure in the pipelines within certain thresholds for security and operational reasons, which in turn requires to maintain the injections into the system and the withdrawals from it balanced at the aggregate level. With the progresses of gas market liberalization, the structure in the upstream (shippers) and downstream (suppliers) segments tends to become more articulated than under the pre-liberalization monopoly. This implies that we move from an environment where the same vertically integrated monopolist was responsible for most of the injections and withdrawals, balancing the ex-post shocks in supply or demand by managing its portfolio of contracts, into a new landscape where different agents each cover a small fraction of the aggregate traded gas volumes. Then, individual shocks may be adjusted within the agents' portfolio to a lesser extent than before, while wholesale trade may offer a way to compensate shocks of opposite sign occurring in the contracts of different agents.

The development of a liquid wholesale gas, however, requires to define and implement a set of rules and mechanisms that are crucial to its success. A well functioning wholesale market, indeed, can maximize the opportunities to clear individual imbalances of the operators, reducing the adjustments at the system level to those that are needed given the overall market imbalance. These latter, in turn, can be cleared only by using flexibility tools that involve varying the net injections of gas into the system by using imports, production swings, storage facilities or interruptible demand. Balancing a gas transmission system, therefore, requires to develop rules for commercial flexibility, that is relevant both to develop a wholesale gas market and for dealing with other sources of physical flexibility. Efficient regulation requires to address quite similar issues, including the definition of a transmission system model, the design of the balancing rules and the set-up of transparency requirements. The specific solutions, however, are in part depending on the different physical flexibility tools that are available in the national gas systems.

In this paper we analyse the different phases in the development of wholesale gas markets, viewed as the consequences of market liberalization. In its initial stage, the wholesale market can provide a useful environment where operators with net imbalances of different sign meet and trade. As market liquidity develops, price signals become more reliable, and trading in the wholesale market becomes a second source of gas provision in alternative to long term contracts. Price variability still remains, due to aggregate shocks, and financial instruments to hedge the price risk are needed. We argue that this process, with balancing, second sourcing and financial instruments as the three steps, tends to develop naturally, as long as market rules are set to help developing wholesale trade.

Gas transactions motivated by balancing needs or second sourcing are related to the final demand for gas, and therefore they tend to develop in gas hubs close to final users and corresponding to the different national gas systems. Moreover, the availability of gas supply not constrained by long term contracts obligations, that constitutes the primary source to fuel the process in the early stages, is larger where domestic gas production plays an important role in the overall supply to the system. Hence, we expect that national gas hubs develop in each country, with a more dynamic process in the gas systems where local production is significant. Conversely, financial instruments may be traded even in market venues that are far away from the location of physical trades. The economies of scale and scope that the financial literature has highlighted to explain the emergence of a small number of dominant security markets applies also to the financial products linked to gas prices. Therefore, we expect that financial transactions will concentrate in a very small number of market venues.

We apply this analytical framework to the evolution of the wholesale natural gas markets in Germany, Italy, Netherlands and the UK[2], analysing their balancing systems and tools for physical and commercial flexibility, and the development of market liquidity. We focus on these countries as, in our view, each of them represents a different evolutionary stage in the development of wholesale gas markets as depicted above.

1.2 Literature review

Although the dynamics of gas markets are receiving increasing attention, a comprehensive analysis of the development of wholesale gas markets in Europe and of the regulatory issues involved is in our view still missing in the literature. NERA and TPA (2005) review and evaluate balancing rules in some EU countries, but the report is by now outdated. Migliavacca (2009) surveys some aspects of the Italian balancing system, highlighting the contacts with the electricity sector, while KEMA (2009) offers an interesting report that deals nonetheless only briefly with balancing and flexibility, being concerned with transmission tariffs. Lapuerta (2010) examines some balancing mechanisms and analyses the balancing system in the UK and Germany and Kayaerts et al. (2011) deal with flexibility issues, with a focus on line-pack. About (physical) flexibility tools, and access to flexibility tools, it is worth recalling Cretì (2009), Cavaliere (2011) and Ejarque (2011) that examine storage under different perspectives. Many studies deal with the impact of European integration on gas market: among others Asche et al. (2002), Roller et al. (2007) and Pollitt (2011). More recently, Neumann and Cullmann (2012) analysed the degree of integration of gas markets based on the prices of eight European hubs, finding a significant level of integration. Asche et al. (2013) analysed the degree of market integration between the British NPB, the Dutch TTF and the Belgian Zeebrugge, also finding a high integration. Petrovich (2013) analyses hubs integration verifying the "reliability" of hub prices as reference price signals. A large literature deals with the implications of the entry-exit model. Among others, it is worth recalling the works by Hunt (2008) that explores the implications of having an entry-exit model on integration and wholesale markets and by Vazquez and Hallack (2013) that identify the central significance that balancing markets assume within the entry-exit framework. A kindred work to ours is Heather (2012), that accurately describes and categorises the main European gas hubs and their liquidity. We move alongside this line of study, but focusing rather on balancing mechanisms and rules, and viewing liquidity as a result of the rules set by each country's regulator.

The paper is organized as follows. Section 2 presents an analytical framework to model the balancing issue and how it has changed with liberalization: a theoretical insight about balancing is offered, taking into account the importance of flexibility instruments and of market design and regulation, and a description of the regulation implemented by the European Commission is included. Section 3 reviews the balancing mechanisms and flexibility tools available for UK, the Netherlands, Germany, Belgium and Italy, following the evolution of their respective hubs as trading platforms and evaluating their performance according to their liquidity. Section 4 compares the indexes computed for each country and concludes.

2. Analytical Framework

2.1 The balancing issue

Natural gas flows in the transmission system from one point to another in the network by virtue of the differential in pressure existing between those two points. Pressure fluctuations stemming from market

[2] A more detailed study that includes also France, Spain and Austria can be found in Dickx et al. (2014).

parties' injections and off-takes to and from the network can threaten the *system integrity*[3], and it is therefore crucial to design a balancing system that ensures that pressure in the system remains within the safe operational limits which guarantee the transport of natural gas through the grid. To understand why and how wholesale trade becomes a useful tool and is needed to efficiently run the system, we start from a description of the main inflows and outflows of a natural gas transmission system (GTS), and compare the case of a vertically integrated incumbent, that resembles the typical pre-liberalization setting, and the environment where the upstream and downstream segments in the gas industry are fragmented with many shippers and suppliers interacting.

2.1.1 Gas Transmission System: inflows, outflows and shocks

The sources of inflows in the system are imports, domestic production and withdrawals from the storage facilities, each characterized by some capacity constraint, that is an upper bound to the feasible flow per unit of time, possibly with some flexibility. Imports can be further distinguished, according to the transportation support, into imports by pipelines and imports by LNG terminals. The second source is domestic production, that feeds the GTS from gas fields located in the same territory, and is bounded above by the production capacity. Finally, gas can enter into the GTS through withdrawals from storage facilities, that may be depleted gas fields, acquifers and salt caverns or, to a minor extent, storage infrastructures attached to the LNG regasification plants. Withdrawals are bounded above by the storage capacity. Moving to outflows, corresponding to withdrawals from the GTS, they can take different forms: final demand by end users directly connected to the GTS or to the distribution networks, exports to foreign GTS's by pipelines or LNG, and injections into storage facilities.

Inflow and outflow decisions are taken by a set of economic agents or institutional bodies within contractual frameworks that usually define ex-ante a certain flow and adjust ex-post to the realized volumes. Outflows, for example, depend on the decisions of final users, who contract their gas provisions according to their predictable needs, and can further withdraw gas adjusting and paying ex-post their off-takes, and are mirrored by a corresponding decision of inflow (e.g. import) by upstream agents as shippers. Hence, the flows in the GTS depend on a large set of demand and supply decisions by different agents, and reflect their underlying choices and unexpected shocks: inflows to meet demand requirements may experience unforeseen stops, and demand by final users typically displays random ex-post adjustments. Supply and demand shocks, therefore, may create imbalances between realized inflows and outflows as compared to the planned and contracted flows based on the ex-ante decisions of the agents involved.

In order to keep the GTS balanced, i.e. with the pressure into the system within given safety boundaries, the difference of inflows and outflows is to remain within certain thresholds. Imbalances, by making the inflows larger than outflows in case of unexpected negative demand shocks or positive supply shocks, or outflows in excess to inflows in the opposite cases, may threaten the equilibrium of the system, moving the pressure out of the security boundaries. Balancing inflows and outflows is therefore a crucial activity in the management of a GTS.

2.1.2 A simple model

To illustrate in a very simple manner the balancing issue, let us consider this oversimplified example, corresponding to a market with four final identical clients. We assume that they are supplied through gas contracts that commit them in the short run to remain with their shipper. The supply side of the market,

[3] From Keyaerts et al. (p.2, 2008) "system integrity" is defined as "*each situation of a transport system where the pressure [and the quality of the natural gas] remain within the lower and upper limits set by the system operator such that the transport of natural Gas is guaranteed*".

instead will be characterized according to the number and size of shippers, that is to the number of gas provision contracts in their portfolio.

More precisely, let us assume that final users' demand is perfectly inelastic and has a predicted component d and a random shock ε_i, according to the expression:

$$D_i = d + \varepsilon_i \tag{1}$$

if $p \leq v$ and 0 otherwise, where $i=1,..,4$. The shocks are iid and may be positive or negative with equal probability, i.e. $\varepsilon_i \in \{-\varepsilon/4, \varepsilon/4\}$. Hence, demand shocks have zero mean and standard error $\sigma_\varepsilon = \varepsilon/4$.

Then, to cover the downstream contract a shipper j signs a corresponding upstream contract for an amount equal to the level of expected demand d, and injects into the system this flow of gas. Hence, the system is ex-ante balanced both commercially (supply and demand for each contract are equal) and physically (injections and ex-ante withdrawals are equal). For simplicity, we assume that all the shippers pay the same upstream wholesale price w to their providers (e.g. producers). This way, the only dimension where the shippers may be heterogeneous, and the upstream market structure can vary, is through the number of shippers and the size of their portfolios.

Although the system is ex-ante balanced, ex-post shocks may create imbalances that require an adjustment. Imbalances have a commercial and a physical dimension. Suppose $\varepsilon_i = -\varepsilon/4$, that is, ex-post customer i's demand is lower than expected, and therefore the gas volumes ordered upstream and injected into the system to serve this contract are larger than the corresponding off-takes. The supplier, then, has an amount $\varepsilon/4$ of gas that is in the system but has not been withdrawn nor paid. On the physical side, this shock contributes to increasing the pressure into the gas system. Commercial rebalancing can be realized by selling the gas to other clients, or by keeping it into the system or into storage facilities, for future sales. A positive demand shock $\varepsilon_i = \varepsilon/4$, in turn, corresponds to short-selling by the supplier and a fall in pressure. The supplier, then, has to cover its position by buying additional gas within the system, trading with other shippers, or from outside, dealing with producers or importers.

It is therefore evident from this brief description that there are several ways in which commercial imbalances can be dealt with, either trading with other agents in the market or relying on outside tools and operators. These alternative solutions have different implication on the physical balancing of the system, in some cases involving further injections or off-takes and in others moving the gas already in the system from one operator to another. Moreover, while physical balancing requires to consider the aggregate state of the system, since pressure depends on total injections and off-takes, commercial balancing, in a liberalized market, is managed by each shipper individually. The relevant issue, then, is to design proper rules such that the balancing actions of individual agents help keeping the system physically balanced at the system level.

Let us consider all the possible states of the world, corresponding to the different combinations of realized shocks in the demand of the four final customers. We can describe the following configurations:

i) <u>All four customers demand less than expected</u>, that is $(-\varepsilon/4, -\varepsilon/4, -\varepsilon/4, -\varepsilon/4)$ is the vector of demand shocks. In this case, the system has an aggregate imbalance equal to $-\varepsilon$, and a corresponding increase in the volumes of gas unexpectedly left into the system and in the pressure.

ii) <u>Three of the four customers are hit by a negative demand shock while the remaining one demands more than expected</u>. There are four combinations of shocks corresponding to this case, $(-\varepsilon/4, -\varepsilon/4, -\varepsilon/4, \varepsilon/4)$, $(-\varepsilon/4, -\varepsilon/4, \varepsilon/4, -\varepsilon/4)$, $(-\varepsilon/4, \varepsilon/4, -\varepsilon/4, -\varepsilon/4)$ *and* $(\varepsilon/4, -\varepsilon/4, -\varepsilon/4, -\varepsilon/4)$, with an aggregate imbalance of $-\varepsilon/2$.

iii) Two negative and two positive shocks, corresponding to six different configurations, $(-\varepsilon/4, -\varepsilon/4, \varepsilon/4, \varepsilon/4)$, $(-\varepsilon/4, \varepsilon/4, -\varepsilon/4, \varepsilon/4)$, $(-\varepsilon/4, \varepsilon/4, \varepsilon/4, -\varepsilon/4)$, $(\varepsilon/4, \varepsilon/4, -\varepsilon/4, -\varepsilon/4)$, $(\varepsilon/4, -\varepsilon/4, \varepsilon/4, -\varepsilon/4)$, $(\varepsilon/4, -\varepsilon/4, -\varepsilon/4, \varepsilon/4)$ while the system is balanced at the aggregate level.

iv) One negative and three positive shocks, the reverse of case ii), with an aggregate positive imbalance of $\varepsilon/2$, with more off-takes and injections and a fall in pressure.

v) All four customers hit by a positive demand shock, with an aggregate imbalance ε and a significant fall in pressure.

These different configurations of the system require therefore aggregate balancing actions to restore a equilibrium between ex-post injections and withdrawals. These actions may involve, for instance, varying the net position in the storage facilities to compensate the physical imbalances in the network of pipelines. We will discuss more in detail the different tools in the next sessions.

The way individual and aggregate shocks can be managed, however, depends on the private actions of the shippers, and therefore on how the supply side is shaped. We consider the following market configurations according to the number of shippers and the size of their portfolios of contracts, where the capital letters identify a shipper and the numbers correspond to the contracted customers.

a) **A(1,2,3,4)**: only one shipper is active and manages all the provisions contracts. This configuration can be thought as corresponding to the pre-liberalization market structure
b) **A(1,2), B(3,4)**: two symmetric large shippers
c) **A(1,2,3), B(4)**: two asymmetric large shippers
d) **A(1,2), B(3), C(4)**: one large and two small shippers
e) **A(1), B(2), C(3), D(4)**: a symmetric fragmented market structure with four small shippers.

What changes according to the different cases is the ability of a shipper to adjust the individual shocks within its overall portfolio of contracts, and therefore the net imbalance that remains once these adjustments are realized. In case a), where a single shipper manages all the contracts, its net imbalance corresponds to the aggregate imbalance of the system. Hence, for instance, if the system is in state iii), and the realized shocks are $(-\varepsilon/4, -\varepsilon/4, \varepsilon/4, \varepsilon/4)$, the monopolist shipper, as well as the system, are balanced. However, if the shippers' market structure is a symmetric duopoly (case b), the two agents are unbalanced, with A having a net surplus of gas of $\varepsilon/2$ corresponding to B's net shortage of gas. In this case, A and B could trade, balancing their respective commercial imbalances, without resorting to trading with external agents as producers or importers, and leaving unchanged, and balanced, the physical injections and off-takes.

Equivalently, if the market structure is case e), with each shipper managing one provision contract, no one has any possibility to adjust demand shocks within its portfolio, while trading offers the largest scope for clearing commercial imbalances. For instance, if the system is in state ii), with three customers demanding less than expected and one demanding more, two shippers can trade clearing their commercial positions of opposite sign, while the residual shippers remain unbalanced, with an aggregate gap $-\varepsilon/2$ equal to the aggregate imbalance at the system level.

This discussion shows that when individual customers are hit by shocks, with different aggregate effects described in the i)-v) states of the world, some of these shocks of opposite sign can be adjusted either within each portfolio, or relying on trade between shippers with opposite net positions. This way, shocks can be netted out up to the aggregate imbalance at the system level, that requires to deal with other tools and agents.

The adjustments allowed by wholesale trade, indeed, may play a crucial role. If agents would not be able to exploit these additional opportunities to clear their commercial imbalances, they should use alternative channels, as additional imports, or net variations in their storage positions, that would exacerbate the physical imbalances of the system. Consider again the example above, where state ii) materializes and three negative demand shocks occur, while market structure corresponds to case e) of a fragmented symmetric oligopoly. If no trade among shippers can be realized, the three of them with a demand lower than expected accumulate gas in the system, while the last operator, facing a customer with more demand than expected, would clear its position in a way that further injects $\varepsilon/4$ in the system, for instance by importing additional gas. As a result, aggregate imbalances would move up from $\varepsilon/2$ to ε, requiring a larger adjustment to balance the system.

In the following table, we show the amount of expected internal compensations within the portfolios and the volume of expected wholesale trading between shippers that is realized in the different market structures, as well as the expected amount of external adjustment that must be realized to cope with the net aggregate imbalance at the system level in the different states of the world. The values are obtained starting from the sixteen different shock configurations, identifying in each of them the internal adjustment and wholesale trade in the different market structures and then computing the overall expected volume of internal adjustment and wholesale trade.

Table 1 – Wholesale trade, Portfolio adjustment and External adjustment, different market structures

Market structure	Wholesale trade	Portfolio adjustment	External adjustment
a) monopoly	0	5ε/16	6ε/16
b) symmetric duopoly	ε/16	4ε/16	6ε/16
c) asymmetric duopoly	2ε/16	3ε/16	6ε/16
d) asymmetric oligopoly	3ε/16	2ε/16	6ε/16
f) symmetric oligopoly	5ε/16	0	6ε/16

The table shows that the aggregate shock that hits the system, equal to ε, can be split in three parts. A first component, corresponding to the aggregate state of the system (6ε/16) requires to compensate the aggregate imbalance by changing the level of injections or withdrawals at the system level, for instance by using a variation in the net storage positions. The residual part of the shocks (10ε/16), however, can be adjusted, since they hit with opposite imbalances individual contracts (implying therefore an expected net transfer of volumes across contracts equal to 5ε/16). The way they are cleared, through internal adjustment within each portfolio or by trading with other shippers, depends on the perimeter of the shippers' portfolios, that is on the market structure. The larger the size of the portfolios, the higher the percentage of shocks that are adjusted within, and the lower the scope for clearing positions through trading between shippers.

Table 1 shows also how wholesale trade between shippers develops as we move across different market structures. Two features positively affect the volumes traded: the number of shippers, and the number of agents with the smaller portfolio size. These two elements, indeed, negatively affect the ability to internally compensate shocks within each portfolio, and therefore the residual scope for wholesale trading. Hence, we can argue that as long as liberalization drives the market toward more fragmented and symmetric supply configurations, the volumes of gas traded for commercial balancing increase.

This example can be easily generalized. Suppose there are N clients of equal size, each one with a demand corresponding to (1) and iid shocks $\varepsilon_i \in \{-\varepsilon / N, \varepsilon / N\}$ with equal probability. Then, there are 2^N different sequences of N shocks. If K and $N-K$ are, respectively, the number of negative and positive shocks, each sequence composed by these shocks, that we define as $(K,N-K)$, occurs $N!/(K!(N-K)!$ times. In any such sequence, if there is a single operator, $min\{K,N-K\}$ shocks can be internally adjusted within the portfolio with the same number of shocks of opposite sign, while $N-(2\varepsilon/N)min\{K,N-K\}$ remain unbalanced and require to change the net injections/withdrawals in the system. If there are $M>1$

operators, each one managing a portfolio of $n=N/M$ clients, then, the sequence $(K,N-K)$ of shocks can be relabelled, according to the portfolios of the M operators, as

$$((k_1,n-k_1), (k_2,n-k_2),\ldots., (k_{M-1},n-k_{M-1}), (K- \Sigma_{j\neq M} k_j,n- K+\Sigma_{j\neq M} kj)) \quad (2)$$

with $k_j \leq min\{n,K\}$ and $\Sigma\, kj=K$.

Each individual vector of shocks $(k_j,n-k_j)$ for operator $j=1,..,M$ occurs $n!/(k_j!(n- k_j)!$ times. Each operator $j=1,\ldots,M$, then, will be able to adjust $min(k_j,n-k_j)$ shocks within its portfolio of n contracts, with a net unbalance of $n-(2\varepsilon/N)\ min(k_j,n-k_j)$ to be cleared through transactions with other operators, if feasible. Then, when the size of the individual portfolios, n, becomes smaller, the number of internal adjustments falls as well, and each operator has to rely more on market transactions to adjust its overall net imbalances.

The following proposition summarizes the results so far.

Proposition 1: *When gas customers' demand is hit by random shocks while supply contracts are set according to the expected demand, individual shippers may face ex-post individual imbalances, while the system as a whole may be unbalanced as well. These latter imbalances can be cleared only dealing with agents, and using tools, outside the network of pipelines (e.g. imports, storage). Shocks hitting individual customers' demand can be cleared through compensations within each operator's portfolio of contracts and through wholesale trade between shippers with opposite net positions. This latter tool involves larger volumes of trade the larger the number of shippers and the larger the number of shippers with small portfolios.*

We move now from volumes to prices, in order to see whether the different market structures affect the way prices are formed in the wholesale market, and if price manipulation is more likely in certain environments than in others. The issue is relevant because the total volumes of gas traded in the market are much larger than the gas traded on the wholesale market for balancing purposes. Then, we want to understand if the price that is set on the wholesale market reflects the actual conditions of the overall gas market, or if it delivers biased signals instead. In the first case, the wholesale market produces a public price signal that helps operators taking their decision on the basis of the evolution of market fundamentals. Since gas trading inherited from the pre-liberalization world is based on long term contracts, where prices are private information and are often set according to formulas that do not reflect the actual scarcity of the resource[4], a reliable price signal in the wholesale market can introduce an important innovation in the market.

Because in our model the customers are homogeneous with a willingness to pay v, and the shippers have a reservation price w while differing only in terms of the size of their portfolio of contracts, the analysis of market equilibria is very simple. As long as demand and supply of gas are equal, the equilibrium price is[5] $p = (v + w)/2$. When, instead, aggregate supply is larger than aggregate demand, because there are more shippers with a long than a short net position, the market price is $p = w$. Finally, in the opposite case when short positions prevail, the equilibrium price is $p = v$.

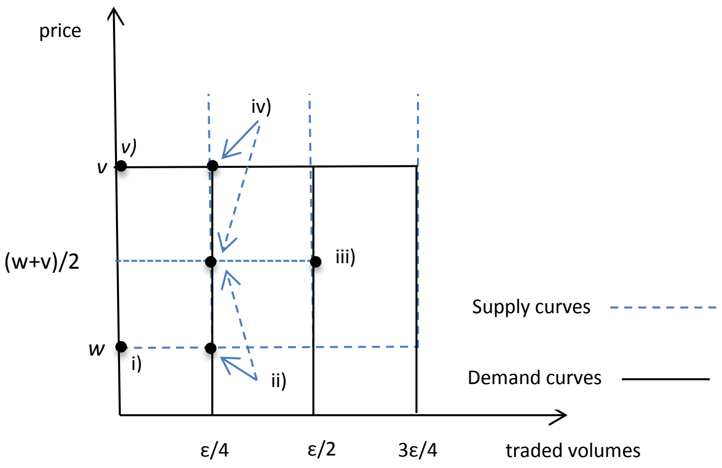
The key issue, then, is whether the prices set on the wholesale market reflect the corresponding imbalances of total demand and supply in the gas system, and are therefore reliable signals of market fundamentals. The figure below shows the equilibrium prices in the five states of the world i)-v) previously described. Price equilibria are obtained in the five states of the world by considering the

[4] See Stern J. (ed.) (2012), *The Pricing of Internationally Traded Gas*, Oxford U.P.

[5] Although any price between w and v clears the market, we focus on this solution, that can be thought as the outcome of a balanced bargaining process.

supply and demand of gas stemming from individual net imbalances of the operators, once considered the internal adjustments within their portfolios of contracts.

Figure 1 - Equilibria for all states of the world.



Then, apparently, the price that is formed on the wholesale market to trade the net positions of the shippers reflects the overall state of the gas system: a high price occurs in states *v)* and *iv)*, in which total demand for gas is larger than total supply, since in these two states some of the shippers are short and they deliver an excess demand for gas on the wholesale market to clear their imbalances. The opposite occurs when the system is in excess supply - states *i)* and *ii)* – and some shippers are long and offer excess gas on the wholesale market. Finally, a balanced gas system as well as a balanced wholesale market occurs in state *iii)*.

This tentative answer, however, has to consider the possibility of market manipulation, that might distort the wholesale price away from the level consistent with market fundamentals. Consider, in particular, case c) of asymmetric duopolies, in which one shipper has three contracts and the other just one. In this case, when the shocks are as in the state of the world ii), that is $(-\varepsilon/4, -\varepsilon/4, -\varepsilon/4, \varepsilon/4)$, shipper A has a net supply of $3\varepsilon/4$ on the wholesale market while shipper B has a net demand of $\varepsilon/4$ to clear its imbalance. As shown in figure 1, then, the equilibrium price would be $p = w$. However, in this case, shipper A, that monopolizes the supply of gas in this realization of the shocks, can withdraw part of its supply, selling only $\varepsilon/4$ on the wholesale market, with a price $p = (w + v)/2 > w$. This is convenient since the level of trade remains the same, depending on the demand for gas from the shipper in a short position, but the price obtained by shipper A is higher.

A similar argument applies to the state of the world *iv)* where $(\varepsilon/4,-\varepsilon/4,-\varepsilon/4, -\varepsilon/4)$. Shipper A, in this case, has an excess demand of $3\varepsilon/4$ facing a net supply of gas of $\varepsilon/4$ on the wholesale market by shipper B, leading to a price $p = v$. However, by withdrawing part of its demand, shipper A can apparently balance the wholesale market and pay a price $p = (w + v)/2 < v$.

Notice that this distortion does not occur when the market structure is less asymmetric. Consider the two configurations of shocks just discussed when the supply side is an asymmetric oligopoly (case d) with shipper A managing two contracts and two other shippers, B and C, each endowed with one contract. In this case, since the number of negative shocks (3) is larger than the dominant shipper portfolio size

(2), and therefore, when A is unbalanced and is willing to trade, it faces always a competitor on its side of the market, and has no incentive to restrict output leaving room to another shipper.[6]

We summarize our findings on wholesale pricing in the following proposition.

Proposition 2: *When the market structure of the shippers is not excessively asymmetric, the price that is set on the wholesale market is an unbiased signal of the state of the aggregate market for gas. When one shipper dominates the market, managing a large portfolio of contracts, it can manipulate the market price pushing it up when in a long position and down when being in a short position. In these cases, the wholesale price does not reflect the market fundamentals.*

To sum up, demand and supply shocks require to adjust ex-post imbalances to keep the system in equilibrium. These adjustments may be in part obtained by compensating individual imbalances of opposite sign and equal size, while aggregate imbalances require dealing with agents outside the system as producers or final users. Exploiting all the possibilities of clearing the individual imbalances, either within each portfolio of contracts or by trading between shippers, reduces the size of the residual aggregate imbalances to be cleared. Hence, balancing can we viewed as a double task: first exploiting all possibilities of matching opposite positions in the contracts, and then dealing with the residual aggregate imbalance.

The way the first task is implemented depends on the perimeter of individual portfolios of contracts, that determines how many shocks can be cleared within the portfolio by internal adjustments, and which ones, instead, require to deal with other agents. The more the market is liberalized, the wider the role of wholesale trading as a balancing tool. Notice that these adjustment, by compensating shocks within the system, do not involve a change in the aggregate imbalance of the system, but require commercial and organizational flexibility to re-direct contracted gas towards new customers.

Dealing with the residual net imbalance at the system level, instead, involves using different tools that affect the net injections and withdrawals. This task, in turn, requires to deal with other agents, as producers, importers, storage facilities or even final customers. In all these cases, the set of physical and commercial tools available for balancing greatly improves these adjustments. We therefore briefly review the main ingredients of physical and commercial flexibility.

2.1.3 Physical Flexibility Tools.

Consider first aggregate imbalances that cannot be cleared adjusting individual portfolios or trading among operators within the wholesale market. In this case the task is to keep the physical volumes of inflows and outflows balanced (physical balancing). The subject in charge for this task can use several tools to affect the amount of gas injected and withdrawn from the system. Starting from injections, any imbalance between inflows and outflows can be adjusted through an increase or a decrease in the gas transported through the pipelines from outside the system, as long as there is remaining capacity

[6] Even in the less asymmetric case d, where shipper A endowed with two contracts and competes with two single-contract shippers, B and C, we may have price manipulations. Consider the state of the world *iii)* when the system is balanced. A possible configuration of shocks, in this case, entails A having two customers consuming less than expected, with a supply of gas equal to $\varepsilon/2$ and facing B and C that instead have short-sold and have to buy additional gas for the same overall amount. The equilibrium price, in this case, would be $p = (w + v)/2$ with profits $\Pi = (v - w)\varepsilon/4$. Shipper A, then, might reduce its supply and sell only $\varepsilon/4$, shifting the market to excess demand and raising the price to $p = v$. The profits, however, would remain the same. If, however, the price when the market is in equilibrium is $p = \alpha w + (1 - \alpha)v$, it is easy to see that such price manipulation is convenient when $\alpha > ½$. Hence, price manipulation by the larger shipper is feasible and convenient even in case d, where the asymmetry among operators is less strong, as long as the pricing rule is biased towards the buyers ($\alpha > ½$).

available, and with line pack, realized by varying the amount of gas in the GST and, correspondingly, the pressure within the admitted boundaries. Although only small volumes of gas can be supplied through line-pack, it allows for a quick response to (hourly) flexibility requirements as a consequence of variations in gas flows. A variation in supply can also be realized through the LNG terminals or the production sites (production swings), with different time lags in the adjustment. As outlined by the IEA (2002), favourable economic conditions, such as the low required investments and proximity to the markets and geological characteristics (e.g. high pressure and high permeability) allow to easily vary the production rate without incurring in excessive additional costs making gas fields efficient sources of flexibility.

Finally, rebalancing the system can be managed through storage, beyond the programmed injections or withdrawals. From a physical point of view, depleted gas fields have a large storage capacity and a relatively low cushion gas requirement but have slower injection and withdrawal rate and are therefore best suited to respond to seasonal variations in demand for gas as opposed to salt caverns and LNG reservoirs. As a consequence, depleted fields, as aquifers[7], are best used for seasonal flexibility than for short-term gas requirements. As opposed to the previous facilities, salt caverns have the ability to respond quickly to variations in gas demand and therefore are best suited for daily and weekly flexibility requirements. In LNG storage sites, gas is stored as liquefied natural gas (LNG) and as such occupies 600 times less space than natural gas under gaseous form. LNG storage facilities are highly suited to respond to peak-day requirements as they have very high deliverability rates (though lower injection rates) and do not require any cushion gas. Nevertheless these facilities have usually small total capacities and the costs associated are very high.

Flexibility can also come from the demand side thanks to the so called "interruptible contracts" (otherwise contracts with interruption clauses) usually subscribed by large industrial consumer and power generation plants. Customers that signed an interruptible contract take on the obligation to interrupt gas consumption in a given timeframe, under given conditions, usually linked to weather temperatures (IEA, 2002). Interruptible demand is best suited to serve short-term flexibility needs and less appropriate for protracted periods (Frontier Economics, 2008).

2.1.4 Commercial flexibility.

So far we have briefly considered aggregate imbalances and the main ways to rebalance the system when the difference of total inflows and outflows exceeds certain boundaries, seriously affecting the pressure in the network. These sources of gas variation used to rebalance the system correspond to physical tools that allow reducing the gap between total inflows and outflows, achieving the physical balancing of the system. From our description of the different sources of inflow and outflow, it is evident that these gas exchanges involve different operators, and therefore they need a commercial counterpart to be executed. If, for instance, additional gas must be injected to cope with an unexpected increase in demand, and import by pipeline is the candidate source, the agent in charge for rebalancing needs to deal with producers or importers, according to the existing set of contracts and their rules, in order to provide the extra gas needed to balance the system, or to rely on storage. It might happen that, although physical flexibility is available, because there is still free transmission capacity in the international pipelines, the contracts in place do not allow to increase the supply of gas at will, preventing the usage of this source to rebalance the system. Hence, if physical flexibility is a precondition, commercial flexibility is the second component needed to balance the system when aggregate imbalances arise due to unexpected shocks.

[7] Aquifers are similar to depleted gas fields in terms of storage capacity and withdrawal and injections rates, however the overall costs associated with aquifer storage facilities are slightly higher and a higher share of cushion gas is needed.

Commercial flexibility, that is the existence of commercial tools that allow to trade gas between agents, is also a key requirement for those internal adjustments that take place between agents with opposite imbalances, even when no aggregate imbalance occurs, to compensate their relative positions without modifying the total injections in the system. As argued above, the fragmentation introduced with the liberalization processes in Europe has moved these compensations from organizational adjustments within the same portfolio to commercial transactions between different agents, enhancing the importance of commercial flexibility to guarantee this trades be cleared

In this perspective, a wholesale market may become a very useful tool when individual excess supplies and excess demands of different operators can be cleared through transactions with no need of intervention by the system operator. The development of a wholesale market, in turn, requires to set up a complex and articulated set of rules that we consider in the next section.

2.2 The design and regulation of a wholesale gas market as a balancing tool

We move now to the analysis of the market design and regulatory measures that must be built in order to create an economic and commercial environment where the wholesale trades can be dealt with and where the economic agents have the proper incentives to contract among them.

2.2.1 Transmission system models.

The first issue to address entails the definition of some basic rules that affect how the gas can be exchanged within the system. A certain amount of gas, when entering the system, is indeed characterized by a specific entry point, while serving a final user requires to deliver the gas at a certain point of withdrawal where the user is located. Hence, when a shipper is willing to contract with an agent located at a certain point on the system, it has to ensure that the gas is transported to the point of withdrawal by entering a contract with the TSO in charge for the management of the system. In other words, each specific inflow and outflow of gas is associated with certain physical points within the National Transmission System (NTS) and with associated routes on the system.

In an efficient and liquid wholesale market we would expect a certain amount of gas entered into the system to be sold at different exit points, whose destination might change over time due to new contracts that replace the previous ones, for instance due to the compensations between agents with opposite imbalances created by shocks. The routes that implicitly must be used to execute these trades, or, more precisely, the balancing of the system when managing these different trades, change therefore over time, modifying the agreements with the TSO on the usage of the system. It is therefore important that all these changes may be managed within a unified commercial framework to perform them as easily as possible, adjusting the transmission charges when a new route is used without requiring to sign a new contract with the TSO. For instance, the possibility of changing the original nominations of the flows is crucial to redirect the gas provisions to the new origin or destination.

In order to facilitate the development of wholesale trade, different transmission system models have been proposed, namely: *postal* (or postage stamp), *point-to-point* and *entry-exit* capacity model[8]. In practice these three models incorporate each a different set of rights and obligations between the TSO and a shipper on the network access thereby defining three alternative types of transportation contracts. Following the definition provided by Lapuerta and Moselle (2002), in a postal model a shipper enters into

[8] Models on capacity (or network access) shall not be confused with tariffs models (distance-based, entry-exit and postal) since it is possible that these models coincide or not. Given the scope of this paper we are going to discuss only the different capacity models and not the tariff ones. For a discussion on the latter see Lapuerta and Moselle (2002).

a contract with the TSO that gives the former the right to inject and withdraw natural gas from any entry and exit point respectively on the grid. In addition the shipper is authorized to change entry and/or exit point without the need to sign a new contract with the TSO. In an entry-exit model the shipper is contractually bound by an entry capacity contract to inject natural gas at a given predefined entry point but has access to all exit capacity at any exit point on the grid. In case the shipper would want to inject natural gas from another entry point, a new transportation contract needs to be signed. Finally in a point-to-point model, network users have the ability to inject and withdraw natural gas from a specific pair of entry and exit point on the grid, *de facto* tying the contract to a specific route.

Hence, it is evident that the flexibility in managing a certain amount of gas, required to clear compensations between agents with different imbalances, is strongly affected by the transmission system model adopted. The entry-exit model has important properties that make it fit to develop wholesale trade. First, it delivers most flexibility to network users by giving them the freedom to book independently entry and exit capacities and therefore fostering the entry of new participants in the market without suffering the competitive disadvantage of having a small portfolio of costumers as opposed to large existing network users[9].

Secondly, the entry-exit model favours the emergence of a virtual balancing point by automatically creating a single entry-exit zone on which the “entry paid” natural gas can be either directly transported to an exit point or traded on equal terms by all network users. As a result, the virtual balancing point can both serve the purpose of balancing network users’ and the TSO’s portfolio and of trading natural gas in a given entry-exit market zone thereby becoming a proper virtual trading point.

An entry-exit point model, therefore, allows to actually perform all those trades among upstream and downstream operators that are needed to clear the imbalances produced by individual shocks in a fragmented wholesale segment. At the same time, it is evident that the commercial framework permitted in this transmission system model is fit to facilitate any wholesale trade, motivated by short term balancing needs as well by the desire to exchange gas for other purposes, as it may happen in a more mature phase where the hub serves also as an additional source of gas for downstream users.. The adoption of an entry-exit model facilitates trading on the secondary market for capacity “*by creating a small number of homogenous commodities (one for each entry or exit point), rather than the hundreds or thousands that exist under point-to-point (one for each combination of entry and exit points)*” as stated by Lapuerta and Moselle (2002).

It is also consistent with the previous arguments that the potential for wholesale trades is larger the wider the area that is included into the system model. Indeed, the area delimited by the entry-exit model defines implicitly the set of trades that belong to the same virtual balancing point, and that can be easily adjusted to close the imbalances due to shocks. The larger this set of trades, the wider the opportunities to close individual imbalances through in-market trades rather than out of the system adjustments. If, therefore, the physical characteristics (i.e. no relevant regional bottleneck within the system) of the transmission system allow it, it is desirable to create a single national wide entry-exit capacity system in conjunction with a single balancing zone thereby allowing trade to take place at a single virtual trading point rather than at multiple points on the grid (KEMA, 2009).

While the adoption of an entry-exit model creates a commercial framework that facilitates the trade of imbalances among the operators, it is further necessary to create the effective incentives such that the

[9] As Lapuerta and Moselle (2002) explain, flexibility in terms of injection and withdrawal locations of natural gas on the grid is crucial for the development of competition since greater flexibility reduces the competitive importance of the shipper’s size. In fact, a point-to-point capacity model is the most inflexible model and shippers with a large customer base enjoy a competitive advantage from the fact that they can perform internal swaps and maximize the utilization rate of the defined routes for which they have contracts. On the contrary, the postal and entry-exit models deliver greater flexibility and are valuable to all shippers regardless of their size.

operators do adjust their trading positions through the wholesale market, rather than leaving them at the responsibility of the TSO. For these reasons, the proper design of balancing rules, i.e. of a balancing regime, is a second building block in the creation of a wholesale market.

2.2.2 Balancing regimes.

The design of balancing rules aims at reaching two goals. First, creating the proper incentives for the operators to clear their individual imbalances by reciprocal trading in the wholesale market, in order to reduce the residual gap to the aggregate imbalance at the system level. Secondly, to efficiently deal with this aggregate imbalance using all the physical flexibility tools available. A role for the TSO is crucial under this respect, and many different solutions can be envisaged. The TSO may play as a coordinator, leaving the balancing actions to private operators, or it can take a more active role into the trades. We'll review the different balancing regimes later in the country case studies.

Since any individual imbalance that is not cleared by the operators requires the TSO to intervene, purchasing or selling gas from other agents, either on the wholesale market or relying on external subjects and sources as the storage facilities, production swings or line-pack deals, these interventions are costly to the system. The incentives provided to the operators to induce them to clear their individual imbalances, therefore, must be based on these avoided costs, i.e. they have to be market based. Moreover, the responsibility for balancing the transmission system has to be shared between shippers and the TSO, with the network users taking primary responsibility for balancing their inputs against their off-takes from the relevant *balancing zone* and within a given *balancing period* through the use of the *short-term wholesale gas market.* The rules of the balancing regimes are stated usually in the Network Code.

In a daily balancing setting, for instance, at the end of each day (so called *Gas Day*), for any residual deviation between gas injections and withdrawals, shippers incur *imbalance charges* for the imbalanced volumes accumulated throughout the day in a given balancing zone, and not timely compensated. These imbalance charges are designed to incentivize shippers to keep their positions balanced (to minimize their residual deviations) and have to be cost-reflective (i.e. reflect the actual costs incurred by the TSO to balance the system). The TSO, on the contrary, has only a residual role in balancing, i.e. assures that from a physical point of view the system is kept within safe operational limits by engaging in trading on the wholesale market (what are called usually *balancing actions*), or recurring to contracts with third parties to supply natural gas (the so called *balancing services*) through one of the balancing tools we have described above

Balancing services as well, requiring the TSO to elicit flexibility tools, may be dealt with through bilateral contracts, or creating a more organized form of exchange. For instance, the TSO may act as a dealer by buying storage services from the shippers and realize this way a rebalancing of the unbalanced gas moving it from the pipelines to the storage facilities or vice-versa.

To conclude, from our discussion, it emerges that for the implementation of a market-based balancing regime it is necessary that in every balancing zone there is an easily accessible and sufficiently liquid traded market, based upon a virtual trading point in an entry-exit system, which allows both shippers to trade and to fulfil their balancing obligations, and the TSO to carry out its balancing actions.

2.2.3 Fundamental data transparency.

The majority of stakeholders in the natural gas market agree with the view that increased fundamental data transparency represents a crucial step for the development of liquid trading hubs[10]. *Fundamental data transparency* refers to the availability on an equal basis to all market participants of information

[10] Among others IEA (2009), Ofgem (2009), Heather (2012) and EU institutions in several documents.

regarding physical gas flows in the grid, storage and LNG facilities, and other relevant physical information mainly before trading[11]. Reminding the different ways in which balancing, and more in general, wholesale trade can be realized, using different flexibility tools and contracting with several sets of agents, the information that is potentially useful to the market participants to efficiently organize their activities is quite large. It involves both information on programmed and realized flows through the different facilities and on available capacities, that are essential if ex-post balancing actions must be taken. These information should be released by the different agents and institutions active in the wholesale market and managing the flexibility tools that can be used to balance the system, including the TSO, the shippers and suppliers and those that manage the storage and LNG facilities.

2.3 EU Regulation: From Physical Flexibility to market Flexibility

In the previous section we have discussed the main building blocks that must be set in order to promote a wholesale gas market as the primary instrument to manage the balancing of the system. And we have observed that once set up, this market environment is fit to trading gas also for purposes other than strict balancing needs. The European Commission has moved in the last few years to promote these processes along coherent lines, setting a framework of rules and procedures that may guide the different member states in developing gas hubs within their gas systems.

Concerning the transmission system model, under Regulation 715/2009 (EU, 2009) the European Commission has favoured and required by September 2011 the adoption of the entry-exit capacity model as a way to promote competition and the creation of an internal market for natural gas through the development of liquid wholesale gas markets[12].

The European gas market is currently fragmented in terms of balancing arrangements across Member States and with a multitude of balancing zones within and across countries. For this reason, the European Commission has included in the Gas Regulation specific provisions for the harmonization of balancing systems across Member States with the over-arching goal of creating a balancing regime that facilitates and promotes gas trading within and across European countries towards greater integration (ACER, 2011).[13]

The Network Code submitted by ENTSOG to the European Commission in October 2012 (ENTSOG 2012) outlines the "Balancing Target Model", which can be summarized as follows. First, the Network Code requires Member States to implement a *market-based* daily balancing regime with shared responsibilities of the shippers and the TSO. The TSO, burdened with residual obligations, adopts balancing actions by buying or selling *short-term standardized products* on the wholesale gas market, giving priority to *Title Market Products*, i.e. non-physical products traded at a virtual trading point, or

[11] Sometimes it is referred also to as "*pre-trade transparency*" since it is often delivered prior trading occurs. Nonetheless, fundamental data transparency within this paper refers to all "physical data" related to the natural gas market and which can be distinguished from pure financial data and information.

[12] "*To enhance competition through liquid wholesale markets for gas, it is vital that gas can be traded independently of its location in the system. The only way to do this is to give network users the freedom to book entry and exit capacity independently, thereby creating gas transport through zones instead of along contractual paths. The preference for entry-exit systems to facilitate the development of competition was already expressed by most stakeholders at the 6th Madrid Forum on 30 and 31 October 2002*" European Union (2009), Recital 19.

[13] Specifically, the Gas Regulation requires the European Network of Transmission System Operators for Gas (ENTSOG) to submit to the European Commission the Network Code on balancing based on the Agency for the Cooperation of Energy Regulators' (ACER) Framework Guidelines on Gas Balancing in Transmission Systems, published in October 2011.

recurring to other types of standardized short-term products defined in the Network Code[14] (ENTSOG, 2012). When these interventions on the wholesale gas market cannot guarantee the system integrity (for example due to the lack of liquidity on the wholesale market or when the response time of balancing services is faster as compared to the lead time of short-term products), the TSO may recur to *balancing services* trading with third parties.[15]

Regulators at the European level have also included a set of provisions in the Gas Regulation concerning fundamental transparency requirements and related record keeping obligations. First, under Article 18 of the Gas Regulation (European Union, 2009), transmission system operators are required to make public detailed information regarding the services they offer according to the network code and all appropriate information on capacities at all relevant entry and exit points on the grid and on supply and demand of natural gas based on the nominations received by market participants both ex-ante and ex-post along with actual and estimated future flows of natural gas in and out of the system. Second, within the same Regulation, Article 19 imposes similar transparency requirements on storage and LNG facilities operators and the obligation to publish information regarding the volumes of gas in each single or group of storage facilities, the volumes within LNG facilities, the available storage and LNG capacities and the relative inflows and outflows of natural gas (European Union, 2009). Although binding transparency requirements are laid out in the Third Energy Package for all system operators, it has been highlighted by ERGEG (2010) that currently such requirements are far more detailed and comprehensive for TSOs than for storage and LNG facilities operators[16].

The importance of fundamental transparency has also been attested by the several voluntary initiatives undertaken by players in the market, complementing the European provisions. These pro-transparency voluntary initiatives share the willingness to increase transparency in the natural gas markets by implementing information disclosure requirements, by increasing accessibility through more frequent, time-effective and detailed information, by creating European-wise comprehensive data, by harmonizing formats and units and/or by using more user-friendly platforms which allow stakeholders to easily access and use the relevant data. These initiatives have been undertaken by several organizations (or associations of organizations) and system operators at the national or regional level. Among them, the *Transparency Platform* launched in 2009 by ERGEG represents an important step towards greater transparency in the EU natural gas market by providing an integrated information platform for data published by the individual TSOs across European countries.

2.4 From balancing to second sourcing and price risk management

In the previous sections we have analysed the potential role of gas hubs as a balancing tool in a liberalized market, and the regulatory and market design issues to be implemented in order to create an economic environment where balancing takes place. As long as liberalization proceeds, the gas hub becomes the central place where balancing trades are performed and liquidity increases (Proposition 1), and a more fragmented market structure make the prices a more and more reliable signal of the demand and supply variations in the system (Proposition 2). As such, the wholesale market may gain a further important role by providing a reference to the decisions of individual traders. Thereby, a liquid wholesale

[14] The short-term standardized products include: Title Market Products, Locational Market Products, Temporal Market Products and Temporal Locational Market Products (ENTSOG, 2012).

[15] See Article 16 (1) of the Network Code (ENTSOG, 2012) for further details on the circumstances under which Balancing Services shall be used by the TSO.

[16] Therefore, ERGEG defined a set of non-binding transparency requirements under the Guidelines of Good Practice (GGP) both for storage and LNG operators to complement the Gas Regulation and Directive. Available at: http://www.energy-regulators.eu/portal/page/portal/EER_HOME

market may offer additional opportunities of trade to the upstream and downstream operators, as long as the prices that prevail in the hub correctly reflect the evolution of gas demand and supply.

At this stage, therefore, the wholesale market can represent a second source of gas for suppliers, as opposed to long or medium term contracts with the shippers for the bulk of their needs (the *d* component in our toy model above), and can, as well, be an alternative place where shippers can realize a share of the sales that their long term contracts with the producers require to conclude according to take or pay obligations. Moreover, a liquid wholesale gas market can give local producers additional opportunities to sell, exploiting differences in prices with respect to those of long term contracts. In this sense, the proximity of gas fields within a national gas system may allow gas producers to exploit opportunities in the wholesale market, by increasing production when prices are favourable, that instead are less easily managed when the main source of injection is through pipelines and long term contracts with far away producers. From this perspective, therefore, we expect that a significant source of domestic gas may favour the increase in market liquidity.

In conclusion, the second phase in the evolution of the wholesale markets can be associated with the development of larger volumes of gas traded and with the use of the wholesale markets as a parallel source of gas, together with the long and medium term contracts with the upstream operators.[17]

Even in a liquid wholesale market, still, some price variability remains, reflecting the underlying aggregate shocks of the system (see figure 1). Hence, relying on the gas hub to procure gas, for balancing or final usage purposes, leaves the operator exposed to some price risk, in particular when long term transactions coexist with short term trades. The creation of a portfolio of products and contracts, with different maturity and structures, then, can offer new tools for price risk management, satisfying an underlying demand for hedging.

The third phase in the development of wholesale gas markets, therefore, can be associated with the supply of a full range of products that are fit to price risk management, as futures and forward contracts. It is important to notice that while the first two phases, related to balancing and second sourcing, are strictly connected to the physical provision of gas, and therefore are naturally committed to take place within the gas system they serve, the development of financial instruments to manage the price risk is mostly unrelated to the physical delivery of gas, and therefore can take place in market venues different from those where the related physical deliveries occur.

This argument suggests that while it is likely that gas hubs driven by balancing and second sourcing needs will develop in all the European countries, with obstacles and incentives related to the structural features of the system, the availability of physical flexibility tools and the kind of regulation adopted, the emergence of market venues where the financial products will be traded may not necessarily follow the same pattern. The financial literature on security markets has highlighted the economies of scale and scope emerging from a concentration of trade in few large venues (Clayton et al., 1999, Foucault et al 2013) and it seems reasonable to extend these predictions to the trade of financial instruments related to the gas markets. Hence, the evolution of the gas wholesale markets in Europe may be characterized by the consolidation of national hubs focused on balancing and second sourcing and the prevalence of few focal market venues where the instruments for covering the price risk of gas contracts will be traded.

Before moving to the analysis of the national gas systems and the emergence of wholesale gas hubs in 5 European countries, we briefly summarize some predictions stemming from our analysis.

[17] For an analysis of the competitive effects of take or pay contracts v. wholesale market provision see Polo and Scarpa (2013)

Prediction 1: The first phase in the development of a wholesale gas market entails balancing as the primary objective of traders, while a more mature phase entails gas provision as a second sourcing in the wholesale market. These phases tend to develop in each national gas system.

Prediction 2: An entry-exit model, a market based balancing regimes and rules for fundamental transparency are the more favorable market design for the development of a wholesale market for balancing needs.

Prediction 3: The wider the virtual trading area within a national gas system, the more rapid and effective the development of wholesale gas markets

Prediction 4: Market liquidity increases more rapidly in countries endowed with significant domestic gas production.

Prediction 5: Transactions of financial instruments to hedge gas price risk concentrate in a small number of market venues.

3. Case studies

In order to analyze the determinants of the different development stages of gas hubs, we use case studies of four European countries' gas hubs[18], the British NBP, the Dutch TTF, the two German hubs NetConnect and Gaspool and the Italian PSV, each representing a different stage of development of wholesale gas market. This way, we aim at testing the set of predictions from our analysis and verifying whether the sequence of phases from balancing to second sourcing to financial instruments tends to replicate the pattern of evolution of national gas markets.

3.1 Methodology

For each country, we build a set of indexes that are able to capture some key dimensions of gas markets and analyze the balancing regime in place. As explained in the predictions, in our view, the key elements that make a gas market work are a combination of resource availability, good rules for balancing and trading, transparency and market integration. Resource availability and market integration are somehow a matter of pure chance: a country either has or does not have gas, and the degree of market integration depends, at least to some extent, to its geographical position, although it is also crucial to build adequate infrastructures. To evaluate such elements we built a set of indicators, displayed in table 2 below.

Table 1 – Indexes for the case studies.

Characteristics	Indicators	Formulation
Production	Self-sufficiency index	
Balancing rules	Years since market-based balancing. Integrated market area within countries. No barriers to entry for operators (e.g. quality conversion) Transparency rules	Qualitative assessment.

[18] More details can be found in Dickx et al. (2014), where also the gas hubs in Belgium, Spain, Austria and France are reviewed.

Market integration	Price convergence.	Difference between price of country *i* and price at reference hub.
Liquidity	Volumes of gas traded, Churn ratios, bid-ask spread, number of traders	Gross Churn Ratio = traded gas / internal consumption Net Churn Ratio= traded gas / physical deliveries

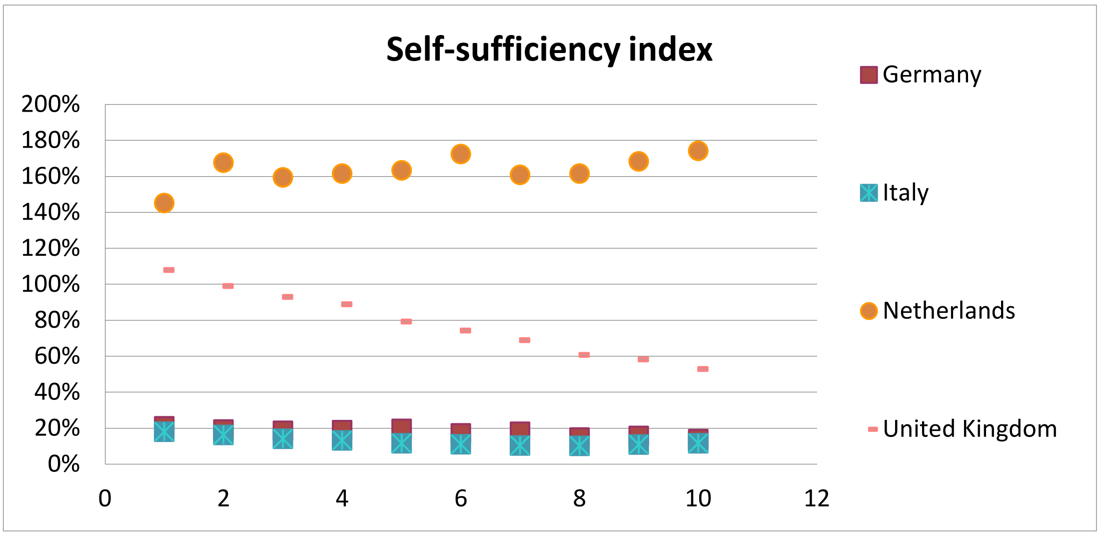
The SSI index interpretation is straightforward: it is a measure of the ability of a country to produce e enough gas for internal consumption and for export. From Prediction 4, we expect that countries with a higher SSI will yield higher traded volumes in the wholesale market. Since liquidity is a multidimensional feature, we measure it through several indicators. We compute the volume of gas traded, the net and gross churn ratio and the bid-ask spread of the wholesale price. This set of variables can also give a hint on the relative importance of trade in the gas hub compared with total gas consumption in the national system.

3.2 Domestic demand and gas production

The importance of domestic production in the national gas systems clearly distinguishes the UK and Dutch cases from Germany and Italy, these latter been provided mostly from imports. The UK began the extractive activity of natural gas in the mid-1960s, in the region of waters surrounding the United Kingdom called UK Continental Shelf (UKCS). Domestic production peaked in the year 2000 and the UK became a net importer of gas at the end of 2004. UK's virtual hub, NBP, has been the first European gas hub. The Netherlands is a main producer and exporter of natural gas in Europe. Production coming from the Groningen field, although decreasing, is sufficient to cover internal gas demand and to be exported to neighboring countries. Germany is one of the world's largest players in the natural gas sector, being a major consumer, providing a fair amount of gas storage and serving as a transit country for gas (mainly to France, Italy and the UK). Furthermore, its gas demand is expected to rise, due to the decision of dismantling the existing nuclear plants in favour of a more secure and environmentally sensitive energy policy (WEO, 2011). Yet, currently, the effects of this decision are partially offset by the reduced demand for power, due to several causes: among others, an increased energy efficiency and a growing share of renewables in the technology mix to generate power. Moreover, the very low ETS price in 2013 has made coal fired power plants very competitive, further displacing gas plants in the German wholesale electricity market. The Italian natural gas market is one of the most dynamic in Europe. Italy is the fourth importer of gas worldwide, and it can rely on a well-developed transmission network to receive gas from abroad. Domestic production of natural gas has been constantly declining since the 90s[19]; as a consequence imports have steadily acquired importance and amount nowadays to approximately 90% of gas consumption.

[19] AEEG (2013) reports a slight increase in domestic production in the years 2011 and 2012, but it has not been sufficiently high to alter the country's external dependence.

Figure 2 - Self-sufficiency index. Data sources: IEA, Eurostat.



3.3 Balancing rules

Although the EC has sponsored a precise set of rules in terms of transmission system model, balancing rules and rules for fundamental transparency, the four countries that we review have adopted different regimes, due to different structural features of the national gas systems as well as for specific regulatory choices. Since balancing rules are rather complex mechanisms, we review them country by country to better illustrate the specific features.

3.3.1 UK

Following the wave of liberalizations in the 80s and 90s, and the subsequent entry of many firms in a once monopolistic market, controlling and balancing gas flows into the British gas pipelines became challenging. The solution identified by the energy regulators and policymakers was to introduce a mechanism coherent with market liberalization, in which every economic agent would be responsible for its own balancing. Shippers were entitled to participate in an auction, offering on a daily basis all of the gas not previously allocated, in order for it to be used for balancing purposes. This system, called *Flexibility mechanism* heavily relied on the physical balancing tools available.

In the space of only few years, the NBP worked so well that shippers began to exchange gas for trading purposes and not only for balancing. In 1999, the flexibility mechanism has been replaced by the so called *New Gas Trading Arrangements* (NGTA), characterized by more reliance on market-based tools for balancing, in order to improve prices as signals of demand/supply conditions and to reduce the cost of balancing. Operators have incentives to clear their positions, with the TSO (National Grid) balancing only residually the system at a price related to the System Average Price (SAP). Rules on balancing are established via a Uniform Network Code which is published and managed by the Joint Office of Gas Transporters (Joint Office of Gas Transporters, 2012). The price set on the OCM is used as a reference for the SAP[20]; subsequently, the System Marginal Buy Price (SMBP) and the System Marginal Sell Price

[20] The System Average Price for a day is the price in pence/kWh calculated as the sum of all balancing transaction charges divided by the sum of the market transaction quantities and non-trading system transaction quantities for all balancing transactions respectively effected in that day (Joint Office of Gas Transporters, 2012).

(SMSP) are computed. The SMBP is the price paid for gas in case of a negative imbalance, and the SMSP is the price paid in case of a positive imbalance. The main market instrument to acquire the resources for balancing is the On-the-day Commodity Market (OCM). OCM is a platform of continuous and anonymous exchange managed 24/7 by ICE-Endex. Exchanges can either refer to the virtual point (NBP), or be physical exchanges related to precise locations in the network (Ofgem, 2009).

Initially introduced as a simple balancing platform, NBP has soon become a reference for wholesale gas trading. Nowadays, around half of the gas consumed in the UK is traded via NBP, and the remaining half through bilateral contracts, typically long-term (Heather, 2010; DG Energy, 2012). Players in NBP are primarily gas shippers, but there are also producers, power generators and financial institutions. Necessary condition to trade at the NBP is to obtain a shippers' license from Ofgem. The most common form of trading is over-the-counter; almost all of the trades entail gas delivery within the NTS, only few are still transacted at the Entry Points, and some others are of financial nature. Over the years, the NBP is increasingly suffering the competition with the Dutch TTF, which is rapidly taking the lead in gas market transactions. As a result, traded volumes at NBP are reducing (figure 3).

3.3.2 Netherlands

The Dutch national transmission network is operated by Gas Transport Services B.V. (GTS), a 100% affiliate of Gasunie, which owns and operates the 11,800 kilometers of high pressure pipelines in the country. N.V. Nederlandse Gasunie (Gasunie in short form) is a Dutch natural gas infrastructure and transportation company operating in the Netherlands and Germany (where it owns approximately 3,000 km of network). Gasunie is 100% state owned; the Dutch Ministry of Finance represents the Government's shareholder interest. In 2004 GTS introduced an entry-exit capacity system and the virtual trading point TTF. In 2005 the ownership unbundling of Gasunie into GasTerra, as trading company, and Gasunie as transportation company, has been implemented. In 2011 a "new market model" (in Dutch, Nieuw marktmodel) has been introduced in order to facilitate and strengthen the functioning of the gas market and increase security of supply. With the new market model since April 1st, 2011 the Title Transfer Facility (TTF), the Dutch virtual trading point, has become the central trading point for all natural gas in the Dutch transmission system. In addition the amendments to the Gas Act also introduced a new balancing regime in the Netherlands in line with the guidelines outlined by ACER. With the new balancing regime every market party is responsible for keeping its own portfolio balanced through buying and selling gas on the TTF, implying that the TTF has become the central balancing platform for all natural gas in the Dutch transmission system. GTS acts only as a residual responsible for balancing the system. For details on the balancing system used in the Dutch system, refer to Dickx et al. (2014).

Since the unbundling of Gasunie into GasTerra, as trading company, and Gasunie as transportation company in 2005, TTF has notably improved in terms of traded volumes and number of market participants, thanks to the efforts of the Dutch government. Indeed, in its first phase, TTF development was sluggish due to structural factors, such as lack of import infrastructure and storage facilities, and organizational factors, such as a poor utilization of the transport infrastructure, problems with quality conversion, poor transparency and an outdated balancing regime (NMa, 2007). The government strategy focused on improving competition, market integration and trading by increasing gas transport capacity, interconnections with neighboring countries and promote market coupling initiatives; by increasing import capacity and storage facilities in light of the decreasing indigenous production; and by adopting a new market model for wholesale natural gas including a new balancing regime.

The elimination of the two types of gas quality traded at the TTF (H-gas and L-gas) in 2009 represented another positive change. Before 2009, shippers had to reserve quality conversion capacity with GTS to convert H-gas to L-gas for supplying end-consumers, and this created a barrier to entry to other shippers and was detrimental to the development of the TTF. Following the amendment to the Gas Act, quality conversion is now part of GTS's system services with cost being socialized over all entry and exit points on the grid. Nowadays, after NBP, TTF is the most developed hub in Europe, and it serves as a reference market for continental Europe. As can be noted from the figures 3 and 9, the churn ratio and traded volumes show an increasing tendency. Moreover, a comparison of traded volumes and churn ratios at TTF and the British NBP shows that the gap between the two hubs is constantly reducing (figures 3 and 9).

3.3.3 Germany

Germany started wholesale gas trading in 2002, with the creation of the Bunde-Oude hub on the Dutch/German border. This first attempt was indeed not particularly successful: difficulties in obtaining third-party access to pipelines and the complex network ownership situation, together with competition with the neighbour Title Transfer Facility (TTF) market in the Netherlands caused trading activity at Bunde to have indeed little impact and lacking liquidity. In October 2006 three new German hubs were launched - the BEB hub, the E.ON Ruhrgas hub and the Gaz de France Deutschland (GDFDT) hub. In July 2005 the new German Energy Law, Energiewirtschaftsgesetz (EWG), came into force following the EU Directive 2003/55/EC7. To comply with EU legislation, market rules in Germany had to be changed towards a non-discriminatory network access based on an entry-exit system. The Federal Regulatory Authority (Bundesnetzagentur, BNA) discussed issues concerning network access with the stakeholders, but the rules for network access were defined by representatives of network operators, and in July 2006 a Cooperation Agreement was released, which sought to standardise the grid access scheme in Germany.

Germany was divided into 19 entry-exit zones, called “Marktgebiete”, i.e. “market areas”; at the end of 2008 the areas were reduced to 12 and now they are only three, two for H-gas, NetConnect Germany (NCG) and Gaspool, and one for L-gas. This process has been strongly encouraged by BNA, that starting from September 2010, through the Gas Network Access Ordinance (GasNZV) explicitly required TSOs to reduce the market areas for L-gas to one and for H-gas to two by April 1, 2011 (BNA, 2011). NetConnect became operational in October 2008. While NCG since then covers the South and West of Germany, Gaspool as the second major market zone is located in the northern part of Germany. In contrast with the rest of the EU countries, Germany has 17 Transmission System Operators, divided in two large groups, according to their belonging to the NCG or GASPOOL area. They all chose the form of the ITO, and most of them are subsidiaries of gas suppliers or large energy groups.

The basic system currently in place in Germany for balancing the system is based on the “GABi Gas“ model (Grundmodell der Ausgleichsleistungs- und Bilanzierungsregeln im Gassektor) that was implemented in May 2008. However, this system is experiencing a series of profound changes, e.g. EEX reference prices as a new basis for calculating compensation energy, instead of the method originally entailed in GABi (Germany Energy Blog, 2011). Furthermore, as stated above, BNA has explicitly declared that the whole system is going to be reformed. GASPOOL and NCG are the responsible for balancing within their market area (see Dickx et al, 2014). The recent evolution of the German market can be appreciated in the performance of volume-based indicators, particularly the traded volumes of NCG (figure 4).

3.3.4 Italy

In Italy gas is imported mainly via pipelines, and sales are dealt with through long term contracts, or via the wholesale market by means of the virtual hub PSV (*Punto di Scambio Virtuale*). Natural gas is traded on the PSV principally over-the-counter, while the gas exchange is not yet fully developed, in spite of being in function since October 2010. PSV is managed by the system operator Snam Rete Gas, while the energy exchange operator GME (*Gestore Mercati Energetici*) organizes and manages the natural gas markets in all their aspects.

Starting from the 1st of December 2011 Italy implemented the new balancing system (SBMS) with the aim of creating a competitive, transparent and efficient gas market and of boosting liquidity and flexibility. The SBMS has entailed the creation of a balancing platform (PB-GAS), organized and operated by the GME on behalf of Snam Rete Gas, which is the sole counterpart of the transactions of the PB-GAS and is ultimately responsible for the overall physical balancing of the Italian gas system, guaranteeing the system integrity and security of supply. The PB-Gas is organized as a daily auction, in which authorized players have to submit daily demand bids and supply offers for the storage resources that they have available. Likewise, Snam Rete Gas may - as balancing operator - submit demand bids and supply offers for a volume of gas corresponding to the overall imbalance of the system, with a view to procuring the resources offered by participants and needed to keep the gas system balanced. It is therefore notable that Italy developed a mechanism to auctioning storage resources, the main instrument of physical flexibility in the Italian system needed to cope with aggregate imbalances, while still wholesale trade of gas to clear individual imbalances is not well developed.

Currently, storage represents the major flexibility tool available to Snam Rete Gas to physically balance the system along with the availability of line-pack in the national pipeline grid. Stogit, of the Eni group, owns 96.5% of storage capacity. Italian storage facilities consist only of depleted gas fields and as a result have a lower ability to respond quickly to variations in demand with respect to other types of gas reservoirs. Italy also imports LNG through two LNG terminals. Along the obligations related to the PB-GAS, shippers have the possibility to buy or sell gas at the PSV, the Italian virtual trading point, engaging in OCM bilateral agreements or to trade on the gas exchange operated by GME. The implementation of PB-Gas has been extremely beneficial both for liquidity and for price alignment with other European exchanges (see figures 5, 10 and 13).

3.4 Liquidity

All the four countries reviewed have experienced a stable increase in liquidity, although their development started in different periods, and their relative position allows to identify a clear ranking. We measure liquidity, a multidimensional concept in itself, by using different indexes. The first one refers to the volumes of gas traded, and gives a first measure of how large is the activity of the hub. A second set of indicators refers to the churn ratios, both gross and net, that illustrate how intense is the trading activity compared to a benchmark of the volumes of gas. Finally the bid-ask spread has been used extensively in the financial literature to account for market liquidity.

Traded volumes. The British NBP and the Dutch TTF are by far the two gas hubs with the larger volumes of gas traded, with TTF performing very well in the last few years and almost catching up NBP, as shown in the figure below.

Figure 3 - Comparison between OTC traded volumes at NBP and TTF (in bcm). Source LEBA, GTS, National Grid.

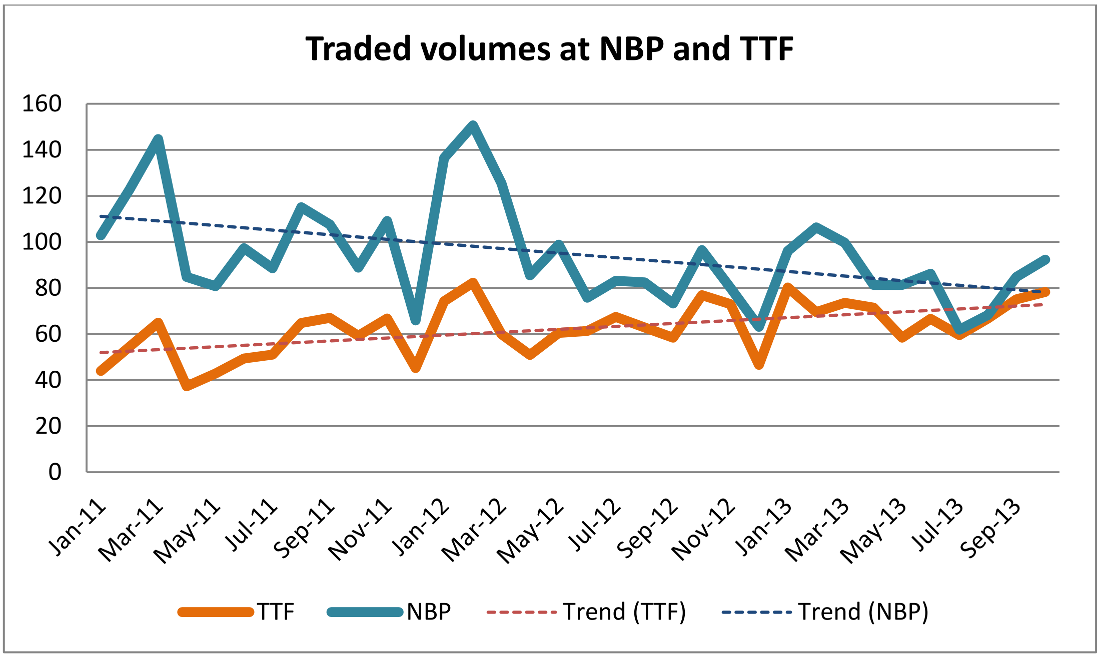
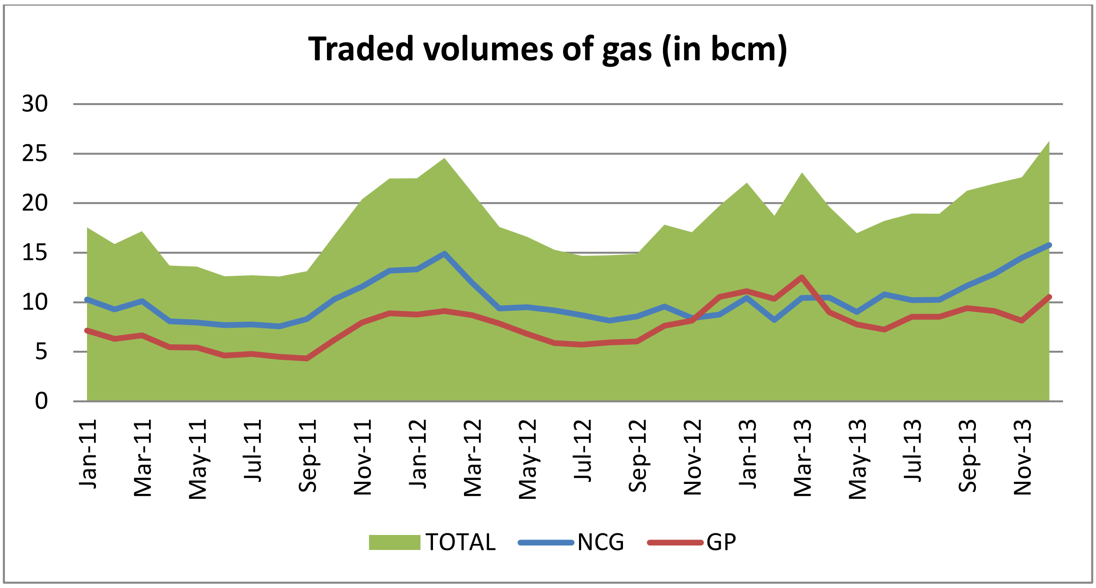


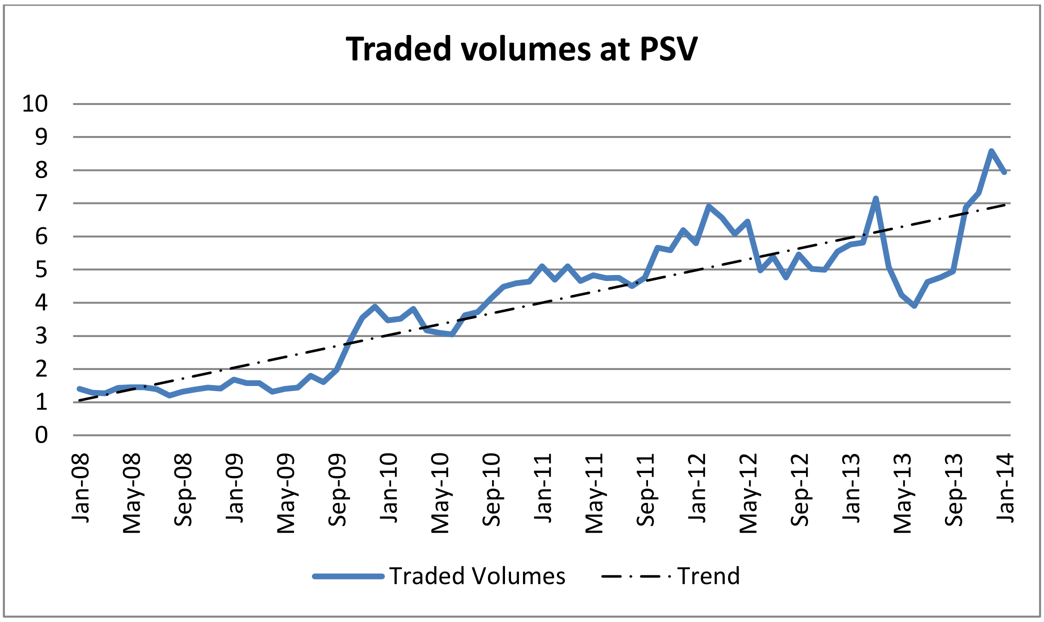
Figure 4 - OTC traded volumes in Germany. Data source: Gaspool, NetConnect.



Germany, in particular after the number of balancing zones has been progressively reduced, has observed an increase in liquidity, although the total volumes traded are far below those recorded in the British and Dutch hubs.

Finally, the Italian PSV, although established at the end of the last decade, has been lagging behind for several years, with two main turning points: the creation of a proper balancing platform (PB-Gas) at the end of 2011 and the auctioning of international capacity towards the north-west European markets (TAG pipeline) in 2012. The volumes of gas traded place the Italian hub at the bottom in our ranking, a result that is even more striking if we consider the absolute dimension of the Italian gas market.

Figure 5 - OTC traded volumes at PSV. Source: Snam Rete Gas.



Number of traders: A complementary measure of the development of a hub, alongside the volumes traded, is the evolution of the number of market operators and of the number of transactions at the hub. As illustrated in the model of section 2, more operators translate in increasing market fragmentation, and thus more need for clear and functioning balancing rules. However, more operators trading at the hub generally increase also the number of transactions and the traded volumes, contributing to a higher degree of market liquidity. As can be seen in the figures below, all hubs experienced a significant increase in the number of traders.

Figure 6 – Number of traders at TTF. Source: GTS.

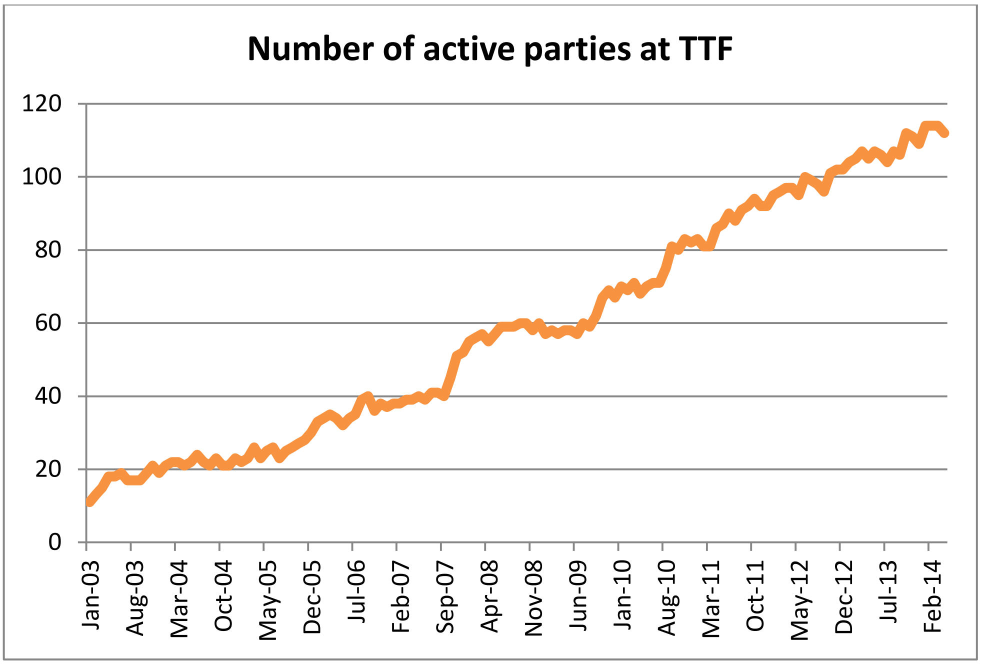


Figure 7 – Number of traders at NetConnect. Source: NetConnect Germany.

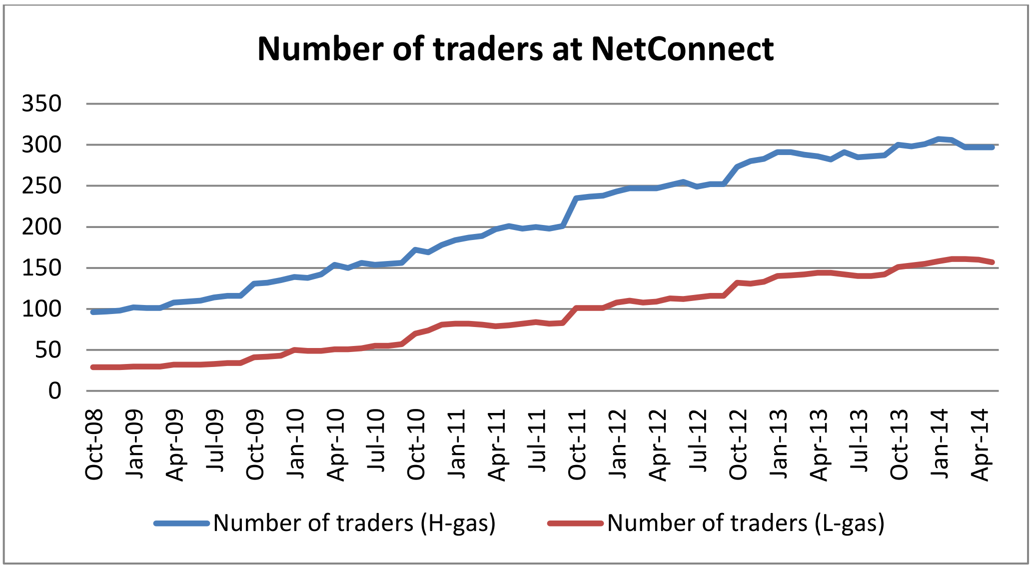
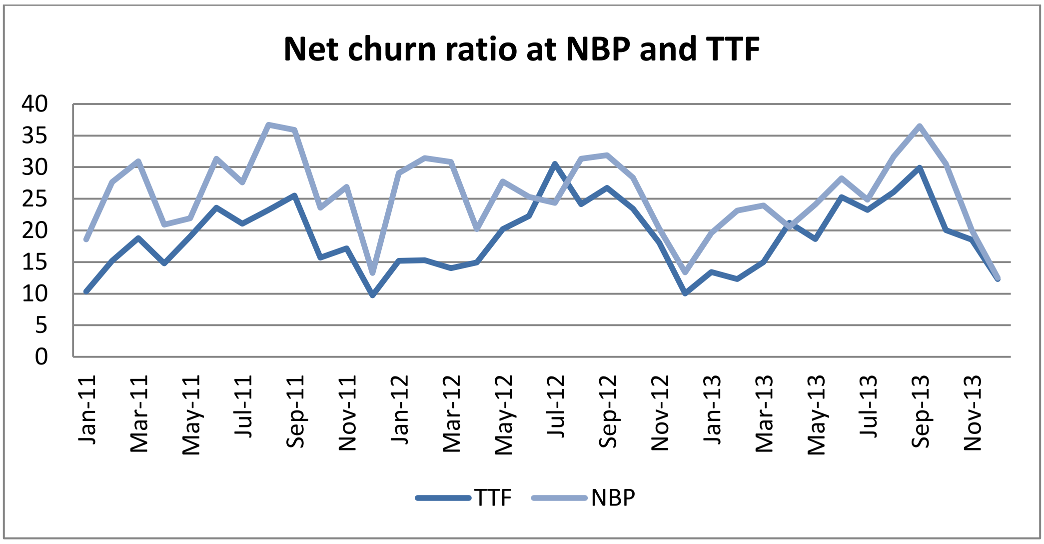


Figure 8 – Number of traders at PSV. Source: AEEG.

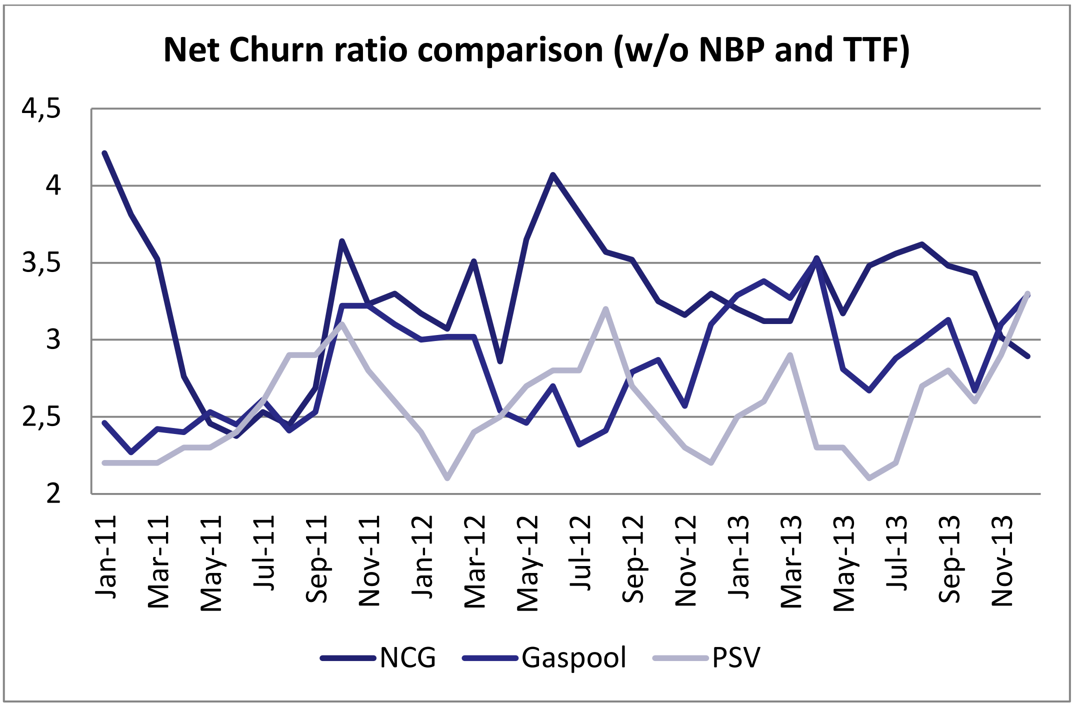
Churn ratios: a similar ranking as for the volumes traded, with the British and Dutch hubs leading, and the German and Italian hubs lagging behind, emerges also from the comparison of the churn ratios as a measure of liquidity. We show in the next two figures the net churn ratio (traded volumes over physical deliveries) separately for the two largest hubs and for the German and Italian one.

Figure 9 - Churn ratios at NBP and TTF.



The comparison of the values clearly illustrate the lack of liquidity that still characterizes the German and Italian cases.

Figure 10 - Churn ratios at the two German hubs and PSV.



Bid-ask spread: finally, we compare the bid-ask spread in the four gas hubs considered. This measure, widely used in the financial literature as a measure of market liquidity, does not seem to convey a clear picture that reproduces the previous ranking. Indeed, the Italian PVS, that was underperforming according to the other liquidity indicators, a judgment shared by many commentators and market expert, has a lower bid-ask spread than the other hubs, while these do not display a clear ranking in the interval considered.

Figure 11 - Relative bid-ask quotes for OTC trades at NBP, NetConnect and TTF. Source: Bloomberg.

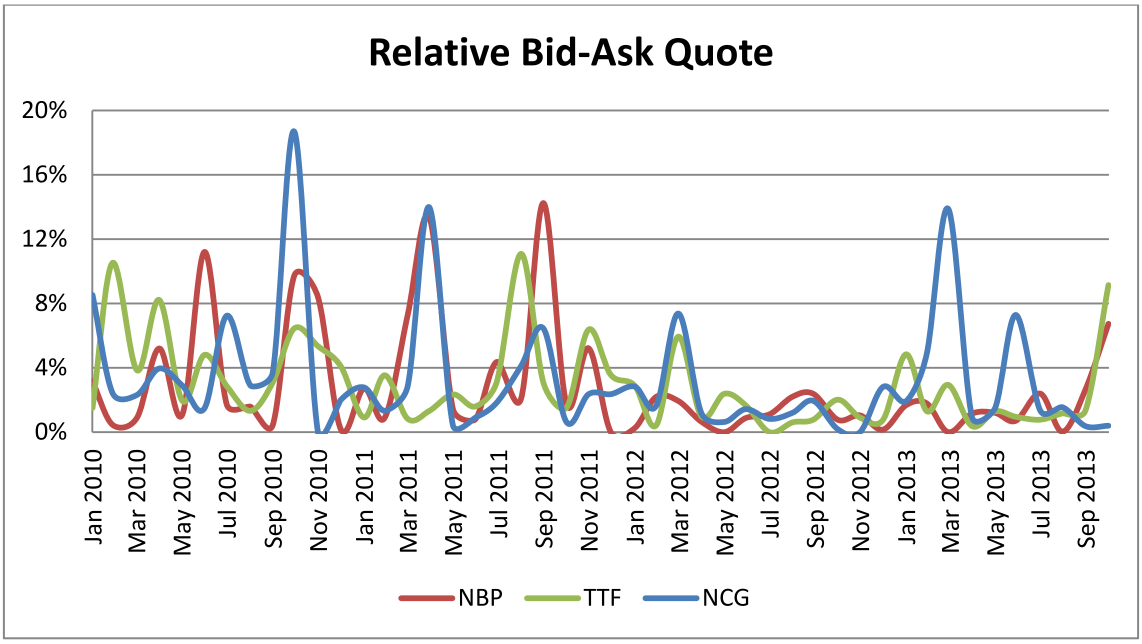
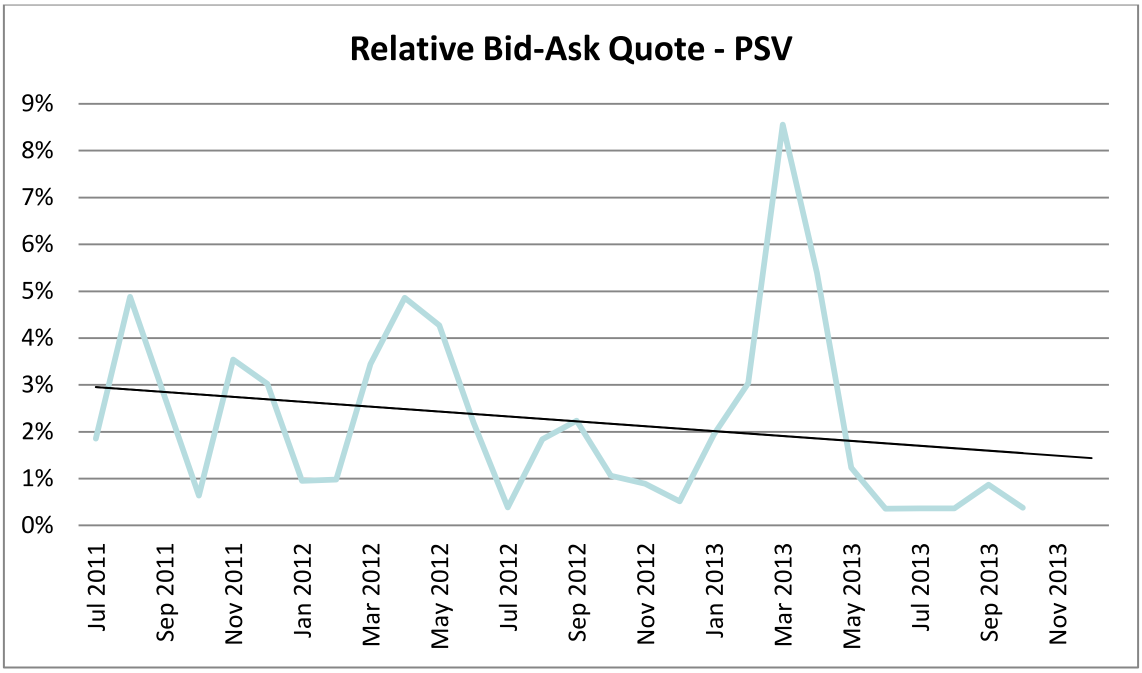


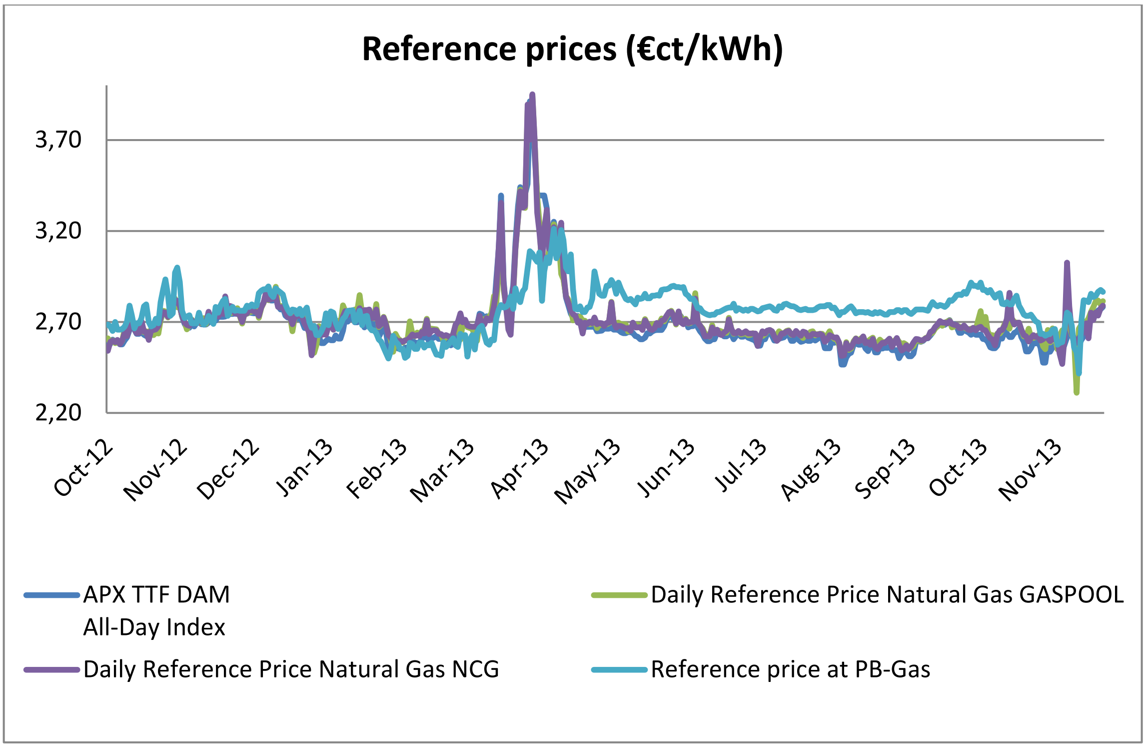
Figure 12 - Relative bid-ask quotes for OTC trades at PSV. Source: Bloomberg.



3.5 Price convergence and market integration

A measure of market integration comes from the comparison of the wholesale prices in the different hubs. In a world without frictions, indeed, if the markets are perfectly interconnected the price differences should reflect the corresponding transport costs from one to the other market area. Taking TTF as a reference price hub, it can be seen from the next figure that continental hubs (especially ZTP and TTF) show a remarkable degree of price alignment. Given the proximity of the markets, this result is hardly surprising. With the exception of Italy, where prices tend still to be slightly higher and sometimes significantly different, altogether the five markets studied show a good degree of price similarity.

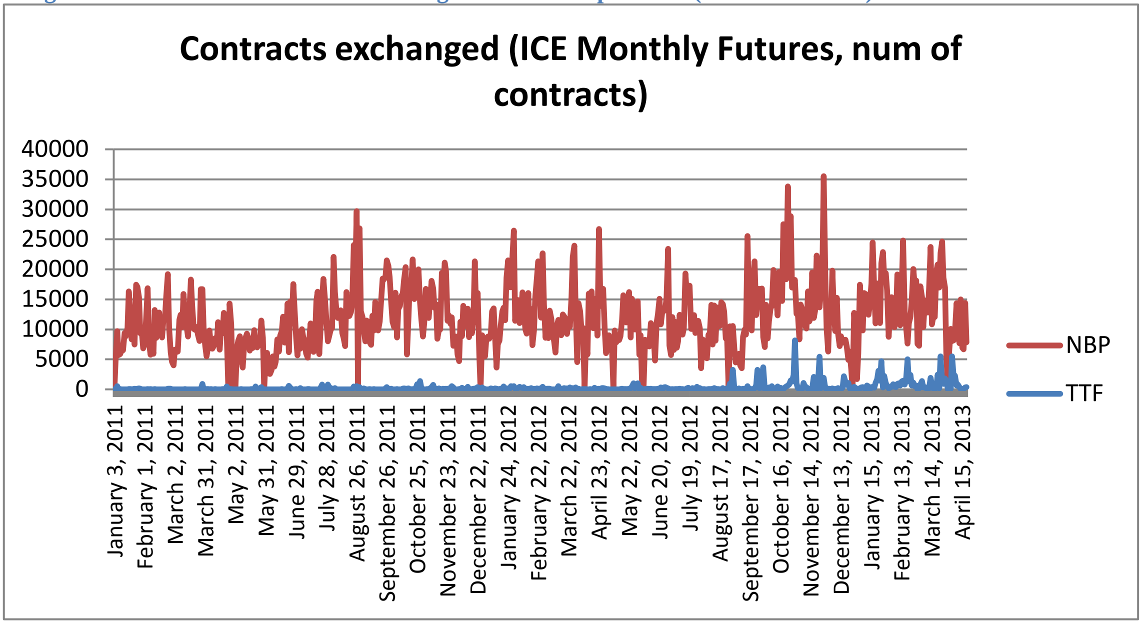
Figure 13 - Reference prices at the hubs. Sources: ICE Endex, GME, GTS.



3.6 Financial transactions

Finally, we show in the next figure the number of contracts in financial instruments related to gas traded at the NBP and at the TTF, the two market venues where most of the trade occurs. It is evident from the figure that, although the traded volumes related to gas contracts are more and more similar, with the Dutch hug catching up the NBP, nothing similar is occurring for the transactions for financial instruments to hedge price risk in the gas market. Indeed, NBP concentrates most of the trade.

Figure 14 - Number of contracts exchanged on the ICE platform (1 month futures). Source: ICE.



4. Results and discussion

Wholesale gas trading has been a consequence of market liberalization. Not by chance, the first country introducing a wholesale market has been the UK, which is also the first European country that liberalized its energy markets. The emergence of many fragmented market operators which needed to balance their positions has given impulse to the creation of the National Balancing Point and the creation of the Flexibility Mechanism. In a few years, NBP has been transformed from a simple balancing platform to a gas trading point, where shippers can purchase and sell gas for sourcing purposes, and not only for balancing. A liquid wholesale market should yield a price that reflects supply and demand conditions, as opposed to the price ruling long term contracts, that is adjusted less frequently and indexed to oil. Nonetheless price volatility that has been experienced also in the UK (Alterman, 2012), calls for the introduction of financial instruments for managing and hedging the price risk. Indeed the UK has developed a wide range of instruments available for hedging, traded on different platforms but mainly on the ICE (International Commodity Exchange). The UK gas system and the NBP offer along their evolution clear evidence of these three steps in the evolution and maturity of a wholesale gas market.

Following EU requirements, all the countries object of study introduced an entry-exit system for natural gas transmission, providing transparent and accessible data to market operators. What slightly differs from country to country are the rules for balancing and the design of the market. Although the differences appear to be small, they may have a big impact on market development.

TTF has begun only recently its race to become the reference hub for Continental Europe, but thanks to natural advantages like gas availability in the Netherlands, an appropriate market regulation and a strong push from the Government, it is nowadays closing the gap with NBP, at least in terms of traded volumes. In particular, as discussed above and in line with prediction 3, what has favoured TTF development has been the provision of a balancing system that works and encourages trade, thanks also to the elimination of barriers to entry. Nonetheless TTF does not yet compete with NBP in terms of financial trading. Instruments available for hedging at TTF are as wide as for NBP, and TTF title are listed on all the main European energy exchanges, but the volumes of financial instruments exchanged, although increasing, are still far below those of NBP. This evidence seems consistent with our prediction, that concentration in financial instruments in a few, or a single, security exchanges may replicate an analogous tendency to concentration that we observe in security markets.

Germany is managing the passage from balancing to sourcing, updating its regulation and trying to improve its balancing mechanism. Starting from the reduction of market areas to the new rules for market-based balancing, it appears that Germany's effort is bringing good results. At first the NCG hub seemed the most promising one, but trading volumes and other liquidity indicators of the two German hubs are now converging. In general, the market division in two areas reduces the total liquidity and may create barriers for market entry. Furthermore, the German system is still under revision, and it might be difficult to predict if new rules will be implemented to complete the passage to a sourcing platform. Germany's exchange trading mainly is run on the EEX (European Energy Exchange), where some futures contracts are available for operators.

Italy offers an interesting counterfactual of the model we depicted; it has only recently implemented a balancing platform, and peculiarly has done so only after the creation of an OTC market at PSV and an exchange, to encourage trading, reverting through regulation what we suggest should be the natural path of a gas hub from balancing to second sourcing. The increase in volumes and market liquidity seems to have received a decisive boost once the rules for balancing through the PB-gas have been set, restoring the rational sequence of steps that we are suggesting. Interestingly, the volumes traded at the old exchange have fallen to zero, suggesting that operators prefer to trade on the balancing platform, in order to exploit the opportunities associated with a large number of operators while adjusting their portfolio of transactions. The country has limited instruments for hedging; only a physical forward market has been implemented on the GME platform.

Our review of the development of gas hubs gives a precise ranking, with the NBP leading the process and presenting the three main functions, balancing, second sourcing and risk management, well developed and very liquid. TTF, exploiting both the natural resources endowment of the country and a strong policy commitment to set up an efficient wholesale market, has almost reached NBP in volumes traded and churn ratio, qualifying itself as the reference hob for continental Europe. The British and Dutch wholesale markets, moreover, are playing an increasing role in the overall transactions of gas, expanding their importance with respect to bilateral trading through long term contracts.

Germany and Italy, instead, are still lagging behind, although the gas traded is constantly increasing on their hubs. Regulations have been less effective, for different reasons, in adopting efficient rules. Germany has experienced a long and complex process moving from a large number of small balancing zones to the present set-up, based on Gaspool and NetConnect. Germany, as Italy, is a large gas market mostly based on imports through long term contracts with take-or-pay obligation. In our view, this is another reason why the increase in liquidity is not being as large as in the British and Dutch cases. The Italian wholesale market, PSV, offers additional evidence of the importance of properly designing market rules, to help the development of trading from balancing to gas provision. Liquidity is today increasing at a significant pace once a balancing platform has been set up, while the initial attempts to create a wholesale market for the provision of gas was unsuccessful.

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