

## **Towards an Italian natural gas exchange: the implementation of the Clearing House model**

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*In Italy, the natural gas market has undergone a radical transformation began in 2000, through Legislative Decree No 164/00 which has started the process of liberalization. Despite the opening up to competition, many problems still persist, especially at the upstream phase, where the former monopolist Eni holds a dominant position also favoured by the long-term contracts with take or pay clauses. In order to promote competition and protect the end consumer, the Authority for Electricity and Gas has proposed the introduction of a regulated market for gas exchanges. Indeed, the negotiation of natural gas provides higher flexibility and liquidity useful to the evolution of the system in a context of full liberalization. The purpose of this paper is to simulate the behaviour of a natural gas exchange and to assess the impact that the latter has on the price volatility. To this end, we adopt the model of the Clearing House, where buy and sell orders are accumulated over time and the market is cleared periodically at the intersection of demand and supply curves. The results show that, in a natural gas exchange, the volatility of the market price decreases with the increasing number of investors. The price becomes more representative of supply and demand trends, not discriminatory, because equal for all transactions, and oil price independent.*

**Field of Research:** Italian Natural Gas Market, Liberalization Process

### **1. Introduction**

The liberalization process of the gas market in Italy began in 2000 with the Legislative Decree n.164/2000, known as the Letta Decree, which formalizes the will of the Italian Government to transpose the European Directive 98/30/EC, concerning common rules for the internal market in natural gas. The law transposing the EU directive has been subsequently supplemented with numerous implementing measures, such as ministerial decrees and resolutions of the Authority for Electricity and Gas (AEEG), that have led to considerable progress of the legal and regulatory framework, well beyond the minimum dictated by European legislation.

However, progress on the legislative front have not coincided with the gradual improvement of the competitive framework. Indeed, there are many problems that hinder the competitiveness of the Italian gas market. In particular, the

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phase of the industry with the greatest barriers to open competition is that of supply.

The main competitive obstacles are the lack of infrastructural developments for the access to the system and the deficiency of market liquidity and flexibility. The causes of this latter problem are:

- the lack of effective competition among suppliers, which, being outside the EU, are not subject to European legislation;
- the saturation (by the former monopolist ENI) of all gas import pipelines;
- the rigidity of the Take or Pay (ToP) contracts which obliges the buyer to purchase large quantities of gas for a very long time and, therefore, the lack of market liquidity;
- the indexing of the gas price to the crude oil one, and thus its variability and unpredictability.

The lack of competition at the supply phase and the dependence on oil prices is reflected on the retail prices, which differs slightly from those of the years previously the liberalization of the sector.

In order to promote competition and protect the end consumer, the AEEG has proposed the introduction of a regulated market for gas exchanges. Enabling a real natural gas exchange allows to remove the barriers typical of trading over the counter, such as the rigidity of the ToP contracts and the indexing of the gas price to the crude oil one, which causes a high variability and unpredictability. Indeed, the ToP contracts, being indexed to oil prices, mean that the execution price does not reflect the correct trend of supply and demand, but instead it is influenced by the volatility and contingency of oil dynamics.

The introduction of a regulated market for gas exchanges with a sufficient flexibility and liquidity would help to overcome all these obstacles. An embryonic market for gas exchanges is already present in Italy, from October 1st, 2003, and it is the Virtual Trading Point (VTP), where bilateral transactions of natural gas occur on a daily basis. It is a system of electronic trading of gas that is injected into the national pipeline network.

In order to transform the VTP in a real natural gas exchange, in 2004, the Authority, through the Resolution No. 22 (AEEG, 2004) has identified the four phases of development. The last of these phases is the launching of a centralized market for natural gas, managed independently and based on an automatic crossover between supply and demand on the English model of Clearing House that allows the determination of an official price as a reference for the conclusion of transactions. Taking into account the indication of the Authority, in our paper we choose to apply the model of the Clearing House (Mendelson, 1982) to demonstrate the effectiveness of a gas exchange in reducing price volatility.

The rulemaking process for the realization of the Italian gas exchange continued in 2009 when the Law No. 99, of July 23th (Italian Parliament, 2009), came into force, by which the company for managing the energy

markets (Gestore dei Mercati Energetici or GME) is the only responsible to organize and economically manage the natural gas market under principles of neutrality, transparency, objectivity and competition. Another innovation introduced by Law No. 99 is the introduction, into the gas exchange, of the Single Buyer that is responsible for ensuring the gas supply to final customers with annual consumption of up to 200,000 cubic meters, with a continuing safe and efficient service.

The development of a centralized market for the exchange of natural gas must run concurrently with the creation of conditions for a greater plurality in the supply phase. Therefore, it is evident that the critical points to consider are both the number of the supply operators and the transactions intensity on the spot market.

This paper aims to demonstrate that the creation of a regulated market for gas exchanges, jointly with increased liquidity and flexibility, allows the prices to be more representative of the competitive dynamics and therefore less volatile and less discriminatory, with a benefit to consumers. To verify these hypotheses, we apply the model of the Clearing House, well known in the literature, although not applied to the natural gas exchange.

This research paper is organized as follows: Section 2 provides a review of the main literature; Section 3 shows the methodology of the Clearing House; Section 4 is subdivided in two paragraphs: the first one describes the historical data useful for our simulations and the second one shows the findings deriving from the implementation of the model to the Italian natural gas exchange; Section 5 concludes.

## **2. Literature Review**

The problem of the Italian competitive weaknesses in the upstream supply phase is analyzed by some authors (Cavaliere, 2007; Curcio, 2005), highlighting how it is necessary to adopt certain measures to encourage the entry of new operators on competitive conditions, such as the creation of new gas supply infrastructures and the development of a sufficiently liquid gas market.

This problem is also studied in the European context. A possible solution is identified by Raymond (2007) who underline the importance of the liquefied natural gas pipelines in order to support the arrival of new entrants in the market and to facilitate the implementation of short-term contracts. Percebois (2008) analyses the weight of natural gas in the European Union and the impact of geopolitical considerations in the relationships with the main suppliers, Russia and Algeria, in order to assure the supply security.

In a context of exclusive use of take or pay contracts, for increasing competition, the necessary condition is a sufficient flexibility of supply to fluctuations in demand, that must be ensured by an adequate transport capacity and able to trigger effective competition (AGCM -Autorità Garante della Concorrenza e del Mercato- and AEEG, 2005). Therefore, regulatory

policies are necessary to encourage the implementation of new projects in gas supply and the simultaneous development of a centralized spot market for gas exchanges, able to relax the competitive constraint represented by the supply agreements under take or pay clauses.

The purpose of this paper is to simulate the behaviour of a natural gas exchange, demonstrating its effectiveness in terms of price volatility.

To date, there exists only a small number of studies regarding the characteristics of a mechanism for natural gas exchange. Among the main authors, we can mention Tse and Xiang (2005) who analyse the American natural gas exchange and the improved market quality from competition effects after the introduction of the electronic trading of E-mini futures for natural gas and crude oil futures at the New York Mercantile Exchange (NYMEX).

Serletis and Shahmoradi (2005) investigate the cyclical behaviour of natural gas price movements for the period that natural gas has been traded on an organised exchange in North America. In another paper, the authors investigate the determinants of returns and volatility in the NYMEX Hub natural gas futures contract market (2006).

Woo, Olson and Horowitz (2006) analyse the Californian natural gas price behaviour, assessing the impact on market efficiency and cross-hedging issues.

Boyer and Fillion (2007) assess the financial determinants of Canadian oil and gas company stock returns, positively associated with the Canadian stock market return, with appreciations of crude oil and natural gas prices, with growth in internal cash flows and proven reserves, and negatively with interest rates.

Doran and Ronn (2008) study the price volatility in the energy markets, computing the seasonality patterns for natural gas, heating oil and crude oil. Park et al. (2008) examine the dynamic integration among major natural gas spot markets in North America and investigate each individual market role in price discovery.

Murry and Zhu (2008) analyze the price behaviours at selected, representative natural gas trading hubs in the U.S.A., showing empirically that the spot price responses at some trading hubs were asymmetric, thus demonstrating a market advantage by either buyers or sellers.

Our paper differs from other studies because we analyze the volatility of natural gas prices based on the model of the Clearing House, which is the mechanism of price formation suggested by the Italian Regulator (AEEG, 2004). This model has been widely analyzed in the literature, although not applied to the natural gas market. Indeed, some authors (Raberto, 2001; Cincotti, 2003) have presented an artificial financial market where the price formation process was performed by means of a Clearing House. Other authors (Liu, 2008) have investigated the roles of both the market microstructure and agent behaviour through a stochastic model with a

Clearing House microstructure and a population of zero intelligence agents. Within the energy markets, Guerci et al. (2005) have implemented a Clearing House mechanism in order to study an electricity market.

### 3. The Clearing House Model

The aim of this paper is to simulate the behaviour of a natural gas exchange and to assess the impact that the latter has on the price volatility. To this end, we adopt the model of the Clearing House introduced by Mendelson (1982), applying it to the Italian natural gas exchange. Using this model, each trader submits his couple of quantity and price to the Clearing House, which matches the orders and provides the market clearing-price.

We choose this model because it is one of the most fundamental market mechanisms, where orders are accumulated over time and the market is cleared periodically. The Clearing House mechanism represents the functioning of many securities exchanges around the world and therefore can be suitable to describe the behaviour of the natural gas exchanges.

In our paper, we use the Clearing House model in order to evaluate the effectiveness of a natural gas exchange in terms of price volatility.

The procedure of the Clearing House is developed in the following way:

- the market is cleared every  $T$  units of time;
- orders are accumulated during this time interval and await clearing time;
- an order is either a buy order, qualified by an upper limit price, or a sell order, qualified by a lower limit;
- all orders remain sealed until clearing time;
- then, the market clearing operation amounts to constructing the cumulative demand and supply schedules and intersecting them at a market-clearing price.

In this model, the demand and supply schedules are depicted by step functions with unit jumps: their intersection identifies the market clearing price, but the latter may not be unique, but enclosed within a range of prices, which we call the clearing-price range. This range is delimited by a lower limit price ( $L$ ) and an upper limit price ( $U$ ). We denote the length of this interval by  $\Delta=U-L$ . The quantity traded,  $Q$ , is uniquely determined; it is possible to have  $Q=0$ , i.e., market clearing with no resulting trades.

Let the bid and ask limit prices be independent samples from a uniform distribution over a finite interval  $[0, m]$ , where  $m$  is the maximum price, which could represent a price ceiling imposed by the regulatory authorities.

The other hypotheses of the Clearing House model are the following:

- the arrivals of buy and sell orders over time are governed by independent, identical Poisson processes;
- the demand and supply are independent Poisson processes with rates  $\lambda=\alpha T$ ,

We call the Poisson rate  $\lambda$ , which represents the expected number of buy (sell) orders per unit price, the order intensity. The latter is a positive real number, equal to the expected number of occurrences ( $\alpha$ ) that arise during the given interval (T).

The independence between the processes of demand and supply is consistent with the nature of liquidity-motivated transactions. Within the transactions of securities markets, one can identify two types of traders: the liquidity-motivated ones, who have a lack of information and want to convert securities into cash or vice-versa; and insiders ones which are transactors with special information. In the liquidity-motivated transactions, sell orders are generated by traders who are willing to convert the traded asset into cash, while buy orders originate from a different population of traders who are willing to convert cash into the traded asset. This is in contrast to the case of insider trading, where both types of orders may originate from the same source. In our paper, like most of the studies on market-making mechanisms, we are focused on the liquidity-motivated type.

Assuming the above assumptions, the expected trading volume is given by:

$$E[Q] = \frac{\lambda m}{2} - \frac{1 - e^{-2\lambda m}}{4} \quad (1)$$

The expected values of L and U are given by:

$$E[L] = \frac{m}{2} - \frac{1 - e^{-2\lambda m}}{4\lambda} \quad (2)$$

$$E[U] = \frac{m}{2} + \frac{1 - e^{-2\lambda m}}{4\lambda} \quad (3)$$

Therefore, the expected clearing-price range is given by:

$$E[\Delta] = \frac{1 - e^{-2\lambda m}}{2\lambda} \quad (4)$$

The expected clearing-price range is a decreasing convex function of the order intensity  $\lambda$ .

As the order intensity  $\lambda$  tends to infinity, both  $E[L]$  and  $E[U]$  tend to the "deterministic" price at the intersection of the expected demand and supply curves,  $m/2$ , and their variances tend to zero.

So far, we have not specified which of the prices in  $[L, U]$  would be selected as an execution price ( $P_E$ ). We assume here that the execution price  $P_E$  is either L or U, where L is selected with probability  $1/2$  and U is selected with probability  $1/2$ . Let  $\delta$  be a random variable indicating whether L or U has been selected, i.e.,

$$P_E = \begin{cases} U, & \delta = +1 \quad \text{with probability } 1/2 \\ L, & \delta = -1 \quad \text{with probability } 1/2 \end{cases}$$

Clearly,

$$E[P_E] = \frac{1}{2} E[L] + \frac{1}{2} E[U] = \frac{m}{2} \quad (5)$$

Under these assumptions, the execution price is an unbiased estimate of the "true" underlying price.

Finally, the execution-price variance is given by:

$$Var[P_E] = \frac{m}{4\lambda} \left[ 1 - \frac{1 - e^{-2\lambda m}}{2\lambda m} \right] \quad (6)$$

The execution price variance is a measure of market illiquidity and it is a decreasing function of the order intensity  $\lambda$ : as the expected number of orders per clearing increases, the execution price becomes less variable; as  $\lambda$  tends to infinite, the variance of the execution price approaches zero.

In the next section, we use the Clearing House model to describe the behaviour of the Italian natural gas exchange.

#### **4. Implementation of the Clearing House model to the natural gas exchange**

In this section the behaviour of the of natural gas exchange is simulated to test its effectiveness. To this end, historical data relating to the VTP, explained below, are utilized.

##### **4.1 Data Section**

Through the use of the Clearing House model, we assess the effects of a possible opening of a gas exchange in the Italian market.

To that end, we carry out three types of simulation. In the first one, we analyse the current situation of the VTP, where 63 traders carry out sales and acquisitions of gas.

In the second simulation, we consider all wholesalers of the Italian market that realistically could be the users of the gas exchange. Furthermore, we take into consideration the trading company Single Buyer as a supplier of natural gas to final consumers. Therefore, for this simulation, we assume a total of 79 traders (all the Italian wholesalers and the Single Buyer).

In the third simulation, we consider all sellers of the Italian retail market, for a total of 209 traders.

The application to the Italian context of the Clearing House mechanism is consistent with the main assumptions: investors act with intent of liquidity and bids are launched from different subjects and independently.

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For subsequent simulations we take into account the statistical data related to the VTP, explained in the following.

In the 2008-2009 thermal year about 6060 transactions were made, with an average of 96.19 transactions per year per operator. Considering the clearing period of one day, the average is amounted to 16.6 total daily transactions. In the first half of the 2008-2009 thermal year 63 subjects performed transfers and acquisitions of gas from VTP, of which 53 were also users of the transport system. Ten subjects are also traders at VTP.

Figures 1 and 2 show the transactions of gas occurred at the entry points of the national gas system and at VTP until March 2009, in terms of volumes and number of transactions.

In recent years, VTP has greatly increased its importance, both in terms of traded volumes and number of trading. This occurred because in November 2006, in accordance with the Authority, traders can transact with the national hubs, without being at the same time users of the transport system.

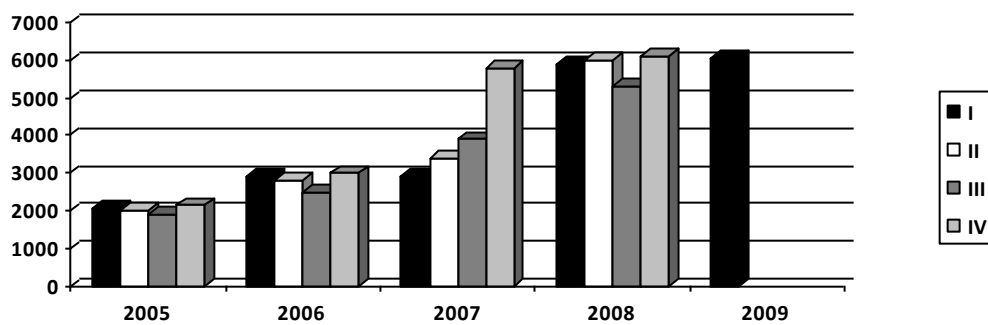


Figure 1: Volumes of transactions at VTP

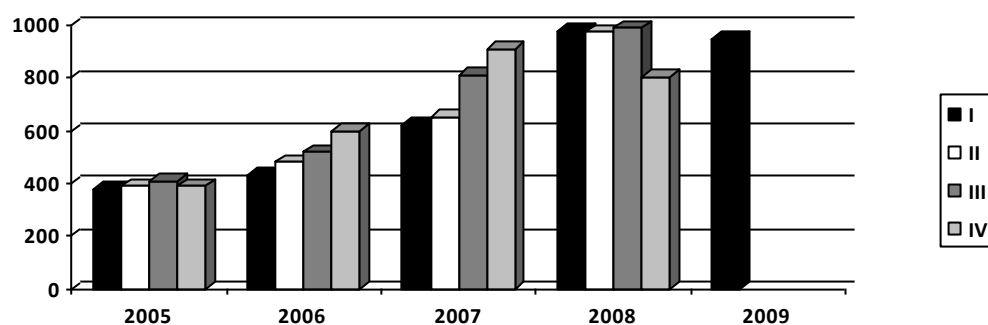


Figure 2: Numbers of transactions at VTP

### 4.2 Analysis of the results

The assumptions of our simulations are listed below. We hypothesize that there is a clearing day ( $T = 1$ ) and that the order intensity depends on the number of traders. This latter is evaluated considering the current average of



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96.19 transactions per year per operator. It is also assumed as the upper limit  $m = 70$  € cents.

Tables 1 and 2 summarize the results of simulations. The orders intensity increases with the number of operators. Indeed, with 79 operators, the average of daily total transactions increases to 20.54, while with 209 operators reaches 54.34, with an orders intensity equal to 0.29 and 0.78 respectively.

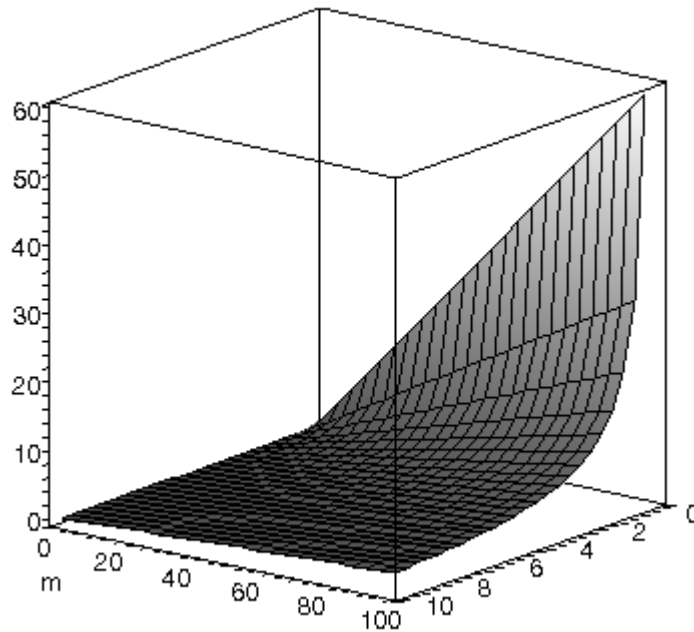
The expected clearing-price range is reduced with the number of operators, from 2.08 (with the current 63 operators) to 0.64 (with 209 operators).

Even the expected trading volume increases with the number of operators. Regarding the execution price, it remains constant because of the assumptions of the model (see Eq. 5), while the variance and standard deviation ( $\sigma$ ) depend on the type of simulation. In particular, in the third simulation, the execution-price variance fell by 68.6% compared to the current case in which only 63 wholesalers are operating in the system. This decrease in volatility would make the price more representative of the effective trend of demand and supply and less discriminatory for the wholesalers and retailers with less bargaining power, which could then provide a lower price to final customers.

More generally, as may be seen from figure 3, the variance decreases with the increase of orders intensity, while raises with the increase of the limit price  $m$ .

If we assume a further increase in the expected trading volume, caused by a greater number of orders from each wholesaler or by an increase in participants in the negotiations, *ceteris paribus*, it will get even more positive results, with a higher variance reduction, making the price equal to its mean value.

Actually, in the Italian context, the number of traders is limited, because distributors and retailers do not have the bargaining power necessary for negotiations and the Italian gas market is characterized by a lack of liquidity. For these reasons, in the initial phase of the gas exchange opening, the involvement of a Single Buyer is necessary, as guarantor of the supply of natural gas to households and small companies at competitive prices and with a continuing safe and efficient service.



**Figure 3: Trend of execution-price variance in relation to the order intensity and the limit price**

**Table 1: The values of order intensity and the expected values of L and U for the three types of simulation**

No Traders	$\lambda$	E(L)	E(U)	E( $\Delta$ )
63	0.24	33.96	36.04	2.08
79	0.29	34.14	35.86	1.72
209	0.78	34.68	35.32	0.64

**Table 2: The expected values of  $P_E$  and of Q and the execution-price variance and standard deviation ( $\sigma$ ) for the three types of simulation**

No Traders	E( $P_E$ )	E(Q)	Var( $P_E$ )	$\sigma(P_E)$
63	35.00	8.15	70.74	8.41
79	35.00	9.90	58.86	7.67
209	35.00	27.05	22.23	4.71

## 5. Summary and Conclusion

This paper analyses the effects of a possible opening of a gas exchange in the Italian market. To this end we adopt the Clearing House model, a mechanism of price formation widely analyzed in the literature on financial markets. The strength of this paper is the originality in applying this model in a different field, such as the natural gas market. Indeed, in the previous literature there are no studies regarding the mechanism of price formation in the gas exchange. Therefore, the aim of our research paper is to assess the effectiveness of the Italian gas exchange in terms of price volatility.

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To verify our hypotheses, three different simulations are performed. In the first one, we consider the 63 traders currently on the VTP; in the second simulation we assume 79 operators considering all the Italian wholesalers and the Single Buyer; in the last simulation we take into consideration all the 209 Italian retail market traders.

The simulations results show that orders intensity increases with the number of operators; while the expected clearing-price range is reduced. Other important outcomes are that the expected trading volume increases with the number of operators, while the variance decreases. This reduction allows the prices to be more representative of the competitive dynamics and therefore less volatile and less discriminatory, with a benefit to consumers.

Therefore, the introduction of a regulated market for gas exchanges with a sufficient flexibility and liquidity would help to overcome the obstacles that characterize the Italian natural gas market, such as the lack of competition at the supply phase, the rigidity of the ToP contracts and the dependence on oil prices.

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