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GAS STORAGE AND SECURITY OF SUPPLY IN THE MEDIUM RUN

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As security of gas supply raises serious concerns, strategies against disruption are becoming of crucial importance in Europe. By diversifying the risk of disruption and financing pipeline construction, long-term contracts with producers are the primary supply instruments. Security of supply targets can also be met by increasing system flexibility (fuel switching, interruptible contracts, cross-border pipeline capacity and liquid spot markets). However, these mechanisms have a limited capacity to absorb shocks that would endanger all the European countries at the same time (accident, civil war or terrorist attack). To ensure uninterrupted services in the short-medium term, precautionary gas storage is indispensable.
The conditions to be fulfilled in relation to security of supply and availability of storage for existing suppliers and entrants have been specified by national laws in application of the Directive 98/30/EC on the liberalization of the gas market.1 These rules are now potentially subject to change, as European discipline has continued to stress the matter of security of supply both in the new Directive 2003/55/EC, fostering competition in gas markets, and in Directive 2004/67/EC. The latter has obliged European countries to define the roles and responsibilities of all market players in ensuring gas availability and set minimum targets for gas storage, at national or industry level. The storage policy has to be transparent, and member states have to publish regular reports on emergency mechanisms and the levels of gas in storage that the Commission will monitor–a procedure which to date is in place in the US only.
The issue is a very complex one, so simplification is essential if any progress is to be made. We assume in most of the paper that the size of disruption is single-valued and known, its probability is also known and stationary, and disruption marks a permanent transition to a state of lower excess supply. Given these assumptions, we derive the dynamics of accumulation and drawdown in a continuous time context.

After a discussion of the literature in Section 1, Section 2 presents the model. Private stockholding decisions balance the valorization of gas in the event of a crisis, with the carrying costs (capital immobilization and technical costs). We make no distinction between domestic and foreign production in this analysis. Moreover, we focus on the medium term in which both the seasonality of demand (short term) and the exhaustibility of gas (long term) can be practically neglected.2 In Section 3, we characterize the competitive equilibrium. Stockpiling before the disruption increases gas prices, so accumulation is all the faster in so far as potential profits loom large. The limiting factor to accumulation is that the value of the stored cubic meter in case of crisis decreases as stocks pile up. As the growth of precautionary storage progressively slows down, there is a target stock that will never be exceeded. The comparative statics gives scenarios for possible substitutions between precautionary stocks and transport infrastructures.

The irreversibility hypothesis essentially allows to solve the model by backward induction and is less restrictive than it would appear to be. The dynamics described is exact for any situation in which the utilization of precautionary stocks is shorter than the time required to find alternative supplies. Reasonable parameters (interest rate, storage costs, crisis probability, extent of the crisis) support this approach. Moreover, partially relaxing the irreversibility hypothesis, we study the implications of forewarning of a crisis for storage behavior (Section 4). In a companion paper, Creti and Villeneuve (2006) develop an algorithm for solving a Markovian version of the model in which crises are of variable durations. Though this latter approach may be deemed more realistic, its drawback is that most results are based on simulations. On the contrary, the computational ease due to the irreversibility hypothesis enables us to derive explicit solutions for equilibrium prices, stocks and drainage time. Most importantly, we provide a complete theoretical treatment of the effects of public interventions (Section 5), which is, ultimately, the main focus of this paper.

The understanding of potential market failures or imperfections is of crucial importance in the perspective of the European Directive aimed at improving the security of gas supply. For example, stockholders may fear antispeculation measures taken once the crisis has occurred. We show that this lack of protection of property rights is likely to discourage storage completely, and that responsible policy consists in a series of measures (subsidies, public agency) taken ex ante. We provide in Section 6 a method to evaluate storage policies in a dynamic setting and apply it to simulate the relative cost of imperfect policies in a detailed example.

In the last part of the paper, we suggest two important extensions of the basic model that deal with specific characteristics of the gas industry: non negligible injection and release costs, and limited storage capacity (Section 7).

To conclude, we underline some results that might prove useful in the context of the gas industry:

Whether precautionary stocks should be accumulated is calculated, knowing the potential minimum and maximum prices, the carrying costs and the probability of crisis.

The optimal target stock and the corresponding drainage time increase with the probability of a shock and decrease with the unit cost of storage and the interest rate.

Additional gas pipelines are likely to decrease the optimal depletion period and thus the need for precautionary stockpiling.

The model appropriately describes stock dynamics and equilibrium also when the crisis, more realistically, has finite length.

Announcement of the crisis matters. Differentiating between the alert and the crisis as such, we illustrate the effect of the delay between these two events on the structure of the equilibrium path.

The cost structure and the availability of limited storage capacity do not alter the main properties of the model.

Precautionary storage regulation should be flexible enough to accommodate changes in expectations and in the economic environment, and should supplement other means, such as long-term contracts, interruptible demand, spot and forward markets, to safeguard security of natural gas supply as recommended by the recent European directives.

Our policy analysis is based on a complete understanding of the optimum as well as of constraints that may hinder its implementation. Indeed, the optimal rules (accumulation and drainage) we characterized may present practical or political difficulties, like expropriation threats that discourage efficient storage. Imperfect security obligations may be better or worse than no storage.

Alternative scenarios (obligation to hold gas stocks equivalent to x% of the annual supply, to meet 1 in x years peak day demand and 1 in y years winter duration, etc.) and different assumptions of regulation of final and transportation prices can be rationalized–or eliminated–by calibrating the parameters of the model.

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1 In Italy, entrants importing non-EU gas are required to hold stocks equivalent to 10% of the annual supply. In Spain, overall gas supply dependence upon any single external supply source must not exceed 60% and gas companies are obliged to keep gas reserves of
at least 35 days of supply. In Denmark, the integrated gas firm has designed its back-up and storage capacity to be able to continue supplies to the non-interruptible market in case of a disruption of one of the two offshore pipelines supplying gas to the country. In France, strategic stocks can withstand disruption of the largest source of supply up to one year.

2 See Chaton, Creti and Villeneuve (2005) for a complementary approach.