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Price and network dynamics in the European carbon market

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ABSTRACT

This paper presents an analysis of the European Emission Trading System as a transaction network. It is shown that, given the lack of well-identified trading institutions, industrial actors had to resort to local connections and financial intermediaries to participate in the market. This gave rise to a hierarchical structure in the transaction network. It is then shown that the asymmetries in the network induced market inefficiencies (e.g., increased bid-ask spread) and informational asymmetries, that have been exploited by central agents at the expense of less central ones. Albeit the efficiency of the market has improved from the beginning of Phase II, the asymmetry persists, imposing unnecessary additional costs on agents and reducing the effectiveness of the market as a mitigation instrument.

1. Introduction

The European Union Emission Trading Scheme (EU-ETS) is the cornerstone of European climate policy. On the one hand, it should allow Europe to reduce its carbon emissions at the least possible cost (see e.g., Stavins, 1995). On the other hand, it should induce economic actors to account for the cost of carbon in their investment decisions (see e.g., Koch et al., 2014; Laing et al., 2013). To fulfil these objectives, the price of carbon has to be a strong and stable signal, the carbon market has to aggregate information efficiently and rapidly. The history of the ten first years of the market shows a less clearcut picture. Prices have been extremely volatile, participation has been restricted, information has been aggregated slowly and inefficiently. A characteristic failure is the fact that the massive overallocation of allowances at the beginning of phase I was diagnosed only after the first reporting period and not endogenously by the market.

We argue that the root cause of this inefficiency can easily be grasped by intuition: a poor market design that hadn't foreseen the need to organize exchange through well-identified trading institutions. Yet, we also argue that there are still lessons to be learned by looking at the mechanics of failure. A unique feature of the European carbon market is the availability of a data set which contains all the transactions performed on the market: the European Union Transaction Log (EUTL). Therefrom, the complete transaction network can be reconstructed. One can then relate the evolution of the structure of the network to the emergence of market inefficiencies.

We hence follow the growing strand of literature that investigates market dynamics with a network-based approach, to gain a detailed understanding of the structure of the EU-ETS market and the relationships between network structure, informational asymmetries and market dynamics. Therefore a set of empirical relationships between the structure of the trade network and the outcome/efficiency of the market is established. More specifically with regard to the latter, we track

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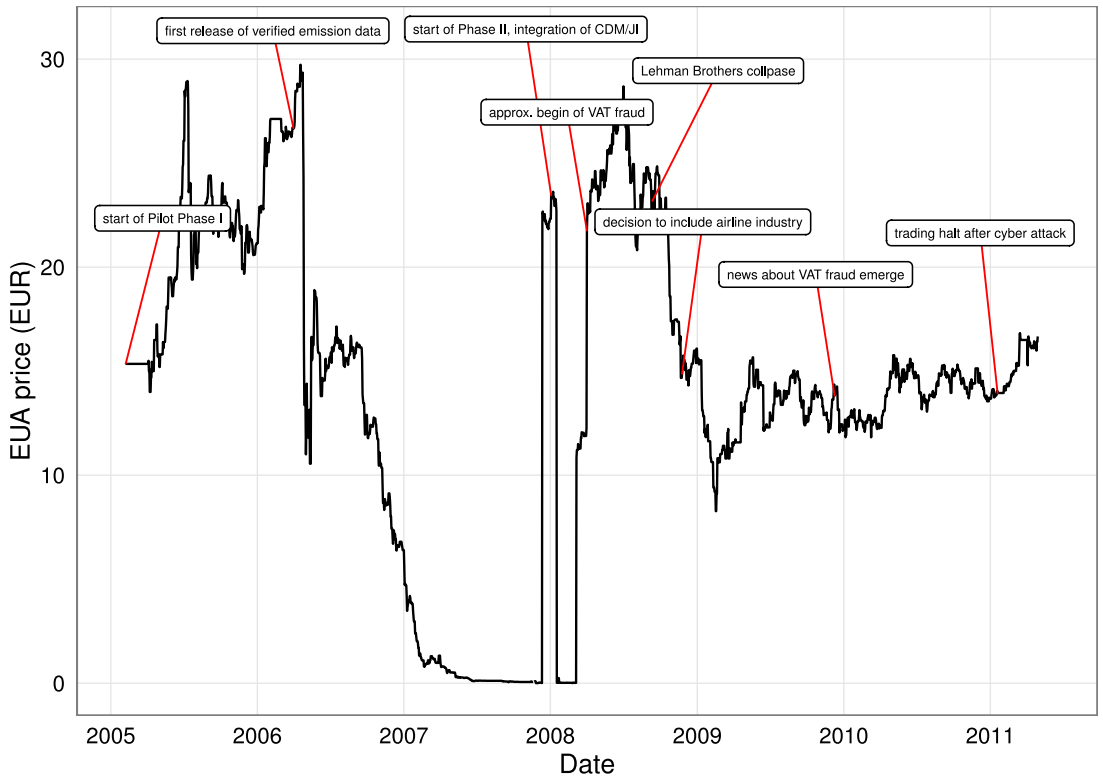

Fig. 1. The price of the EUAs over time, annotated with important market events (see similar figures in Borghesi and Montini, 2016; EEA, 2015).

the evolution of prices and bid-ask spreads. These empirical relationships can be used to track future developments in European carbon trading but also to assess the efficiency of other markets.

Our analysis shows that in the absence of a central market place, agents had to resort to local networks and financial intermediaries to exchange emission certificates. This led to the emergence of hierarchical and assortative networks with fat tailed degree distributions, which turned out to be rather inefficient in terms of the price discovery mechanism and the incorporation of new information. We further show how informed traders can be characterized in terms of centrality measures, and how the evolution of connectivity patterns can serve as an indicator for volatility or liquidity on the market. We find that market efficiency improved during Phase II as the share of spot market trading increases. It is however also shown that the major flaws of the EU ETS in principle persist.

The paper also provides a methodological contribution by introducing a Partial Least Squares Path Modeling (PLS–PM) approach to define endogenously the temporal evolution of the network rather than resorting to an exogenously fixed time-window. Using this approach allows to investigate the structural evolution of the trading network in a dynamic manner.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 provides a description of the organization, the history and the data of the European Emission Trading System. Sections 4 and 5 provide respectively a static and a dynamic analysis of the network. Section 6 concludes.

2. Related literature

The EU-ETS has been the first large-scale carbon market in operation. As such, its performance has been extensively analyzed in the literature. A comprehensive overview of the design, the history and of the early literature on the EU-ETS is given in Ellerman (2010) while Ellerman et al. (2016) documents recent institutional developments. This history can also be summarized by the evolution of the carbon price illustrated in Fig. 1.

The analysis of the determinants of price formation and the management of risks related to carbon markets have been challenging issues for financial econometrics, notably because of the interactions between carbon markets, energy markets and the macro-economy. In this respect, a large body of work by Chevallier and co-authors (see Chevallier, 2011; Zhu and Chevallier, 2017, for an overview) has investigated extensively drivers and structural changes in carbon prices, the informational efficiency of EU ETS, and cross-market linkages between emissions trading and energy markets (see Alberola et al., 2008; Zhu and Chevallier, 2017; Zhu et al., 2015a; 2014; 2015b). Complementarily, a large literature in mathematical finance (see e.g., Borovkov et al., 2011; Carmona and Hinz, 2011; Chevallier and Sévi, 2014; Howison and Schwarz, 2012) has proposed formal models of the dynamics of carbon prices as stochastic processes and derived therefrom pricing methodologies for carbon derivatives.