



## Analysis

# Price discovery and intermediation in linked emissions trading markets: A laboratory study<sup>☆</sup>

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## ABSTRACT

Many new and proposed emissions trading systems involve multiple countries and regions. The introduction of interregional trading raises questions about how flexible state- or national-level authorities should be in allowing individual firms to trade with firms or authorities in other states or countries. This paper uses laboratory methods to evaluate the efficiency and pricing performance of linking trading across regions at the firm-to-firm level. In one treatment, individual firms trade directly with firms or authorities in other regions. We compare performance in this treatment to an intergovernmental trading treatment, where emissions trading is restricted to occur only between intermediaries. A baseline treatment of autarky, where firms only trade with other firms in their country or region, provides a benchmark to assess the efficiency benefits of allowing linking. Although efficiency and price discovery are both improved by allowing intermediation in linked permit markets, we find that further gains can be realized through direct firm to firm trading. Buyers in high cost regions and sellers in low cost regions benefit the greatest from linking.

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## 1. Introduction

Emissions trading programs have been successfully used in the last 20 years to regulate environmental problems at the local, national and regional levels. The acid rain market to reduce SO<sub>2</sub> emissions in the United States (Carlson et al., 2000; Joskow et al., 1998) and the recent European emissions trading market are prominent examples of such programs (Boemare and Quirion, 2002; Convery, 2009; Kruger et al., 2007). Many new and proposed emissions trading systems, particularly those that propose to mitigate climate change, involve multiple

countries or regional jurisdictions within countries. Some regulators have explicitly expressed a desire to link their emissions trading programs with other markets, for example the EU (European Community, 2008) and a regional Governors' association designing a program for the Midwestern US and Canada (Haïtes and Mehling, 2009) are examining ways to link their markets. This trade integration raises questions about how flexible state- or national-level authorities should be in allowing individual sources such as firms to trade with sources or authorities in other regions or countries. In newly emerging carbon markets at the regional level, such as the Regional Greenhouse Gas Initiative (RGGI), Western Climate Initiative (WGI) and Midwestern Greenhouse Gas Accord in the US, decisions will need to be made as to whether firms would be allowed to trade with firms in other states or whether trades only occur through intermediaries (Haïtes and Mehling, 2009).<sup>1</sup>

<sup>1</sup> Another example of intermediation in environmental markets is water trading in California, where water trading across districts occurs through state or irrigation district intermediaries. Farmers can trade directly with other farmers within districts but not across districts. The California Department of Water Resources recommended that any water transfer market would need a combination of governmental requirements and voluntary limitations (CDWR, 1993). Intermediation in this application is particularly important due to local externalities, such as stream flow impacts, which are not present in applications such as greenhouse gas emissions.

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In this paper we evaluate the efficiency tradeoffs of linking emissions markets by allowing individual sources and firms to trade emissions permits with sources and firms in other markets. Regulators may authorize such cross-border and across-region trading, and if this trading has effective enforcement then the flexibility and increased liquidity provided by this trading may significantly improve efficiency and price discovery. If instead trading is conducted by government representatives this could lead to significant cross-border transaction costs and a reduction in efficiency.<sup>2</sup> Linking markets only through national or regional government representatives could also affect competitive price discovery because it has the potential to increase market power (Böhringer and Löashel, 2003).

Trading through government agents may however also provide some benefits. Intermediaries could help locate spatially dispersed potential trading partners, screen firms according to different criteria and provide centralized transaction price information. Monitoring and enforcement of regulations need not be identical across linked markets (Tuerk et al., 2009), and trading through government agents could also potentially reduce enforcement costs since legislation relating to enforcement and compliance would be based at the national or state level. Even though intermediation or government approval of certain projects could raise transaction costs, these benefits are among the reasons that intermediation was mentioned in the Kyoto Protocol and its Clean Development Mechanism (Gagelmann and Hansjürgens, 2002; Lecocq and Ambrosi, 2007). Governmental involvement may also be needed to hold some reserve of permits, especially if enforcement is imperfect and regulators hold permits to cover emissions by noncompliant firms (Konishi, 2005).

Our specific goal in this paper is to investigate price discovery, market efficiency and the welfare impacts of alternative forms of inter-regional linking. Accurate prices of emission permits are important to help firms decide when to adopt new abatement technology or when to incur research and development expenditures for new technologies. Studying the allocative efficiency and welfare consequences of linking permit markets is useful to understand possible sources of political support for integration. Laboratory experiments allow for careful control and can be particularly useful to examine behavior and performance of emissions markets because it is difficult and costly to examine alternative regulatory scenarios in the field (e.g., for a recent survey see Cason, 2010). While there are several experimental papers that study different features of emission markets (e.g., Bohm and Carlén, 1999; Klaassen et al., 2005), ours is the first to explore intermediation and linking.

If markets were perfectly competitive and always in equilibrium, inter-firm trading would strictly dominate trading using intermediaries if intermediaries introduce any transaction costs. In practice, however, the impact of intermediaries could depend on how the markets are organized. Earlier experimental research on intermediation demonstrated that traders or speculators can significantly reduce price fluctuations in cyclical markets. This is observed in both double auction and posted offer markets, though the convergence to the inter-temporal competitive price is slower when trades are conducted using posted offer rules (Hoffman and Plott, 1981; Williams and Smith, 1984). Plott and Uhl (1981) examined the behavior of agents or middlemen in markets where buyers and sellers were not allowed to interact directly and find that the prices converged to competitive equilibrium predictions and market efficiency levels were high. Intermediaries were engaged in inter-

temporal transactions in all of these studies, for example buying in one market and then selling in another market in a later period.

In contrast, in our experiment the intermediaries trade across markets and act as both buyers and sellers in the same period. The firms are restricted from trading across markets, with intermediaries needed for all inter-market trades. Although intermediaries like these have often a significant impact on economic activity, they have rarely been studied in experiments. The only directly comparable trading environment is one considered by Kimbrough, Smith and Wilson (2008), who explore how trades between intermediaries (whom they call merchants) compares to trade between individual firms (called villagers). Merchant intermediaries in their experiment perform a similar role as our intermediaries by taking the product from the local market and selling it in an inter-market meeting place. Their focus, however, is on the process through which intermediation emerges naturally, rather than when it might be required due to explicit regulation.

We report results from three treatment conditions. In the first treatment firms are allowed to trade with firms in other regions, whereas in the second treatment intermediaries have the sole authority of conducting across-border trades. In the first treatment, there is no required intermediation. A third treatment of autarky, where firms only trade with other firms in their own region, helps evaluate the efficiency benefits of allowing inter-market trades.

Our results show that emissions trading across regions leads to higher efficiency and faster convergence to equilibrium prices as compared to the autarky treatment. Buyers in high cost regions and sellers in low cost regions benefit the greatest from linking. The treatment with required intermediation however leads to higher transaction costs because additional trades are required to move permits through the intermediaries, and it also realizes fewer efficiency gains compared to the treatment with direct inter-firm trading. Our results could help explain the role played by intermediaries in various economic exchanges in addition to the emission trading context discussed here. Intermediaries such as private brokers and state trading enterprises, for example, have a significant influence in international agricultural markets. The link between farmers and private brokers can be crucial to facilitate interregional grain flows, particularly in regions that are prone to food insecurity and famines. In some regions, state trading enterprises could control the production and distribution of products that have implications for public health (such as tobacco and alcohol). Although these brokers and public marketing enterprises are perceived to be beneficial for such purposes, they are often observed to engage in anti-competitive trading activities which can have important efficiency and distributional effects (Fafchamps and Hill, 2008; FAO, 2002; Osborne, 2005).

## 2. Experimental methodology

### 2.1. Design

The experiment followed standard procedures of laboratory markets (Davis and Holt, 1993), allocating 208 distinct subjects (69% male) to separate market sessions conducted on different days. Subjects' trading decisions earned them trading profits, which were paid in cash immediately at the conclusion of their session. Trading occurred simultaneously in four markets, all conducted anonymously on a network of computers that were visually isolated in a dedicated experimental economics laboratory. The different markets could be interpreted as different national or regional emissions permit markets. Participants in these markets are similar to firms who would face different costs of reducing pollution. In some treatments they could trade across different markets (perhaps only through intermediaries) and in another they traded only within the same market. As in standard textbook theory of emissions markets, participants' incentives to trade arose from differences in abatement costs and permit allocations. Those with high marginal abatement costs and low initial

<sup>2</sup> In emission markets, transaction costs can arise at various stages of trading. Firms in several of the early national and local emission trading programs reported high levels of search, information, bargaining, decision and reporting costs, all of which can be considered part of transaction costs. Researchers have commented on the importance of transaction costs in tradable emission markets and have raised the concern that these costs can reduce the cost-effectiveness of emission markets (Cason and Gangadharan, 2003; Gangadharan, 2000; Hahn, 1989; Stavins, 1995).

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