Chapter 69

SHARE TRADING AND COUPON BANKING INTERACT TO IMPROVE PERFORMANCE IN EMISSION TRADING MARKETS

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Emissions trading refers to the exchange of permits conveying the legal right to discharge specified quantities of waste. Unlike naturally occurring markets for many commodities and services, emissions trading markets are the product of deliberate choices by regulatory authorities. Frequently these choices must be made without practical experience or clear guidance from theory. Laboratory experiments are well suited to investigating such choices without the high economic and political cost of field trials.

Under a typical emissions trading plan the regulatory authority sets a quota on the total allowable discharge of a specified waste during each control period. This quota is distributed among eligible firms in the form of permits which we shall call coupons. Some rule is required to determine the allocation of coupons among firms. Normally firms' initial shares of coupons will be proportional to their shares of pre-regulatory emissions, perhaps adjusted to reflect some standard of best practice. Firms are then free to trade coupons among themselves.

The demand for coupons is derived from firms' discharge of wastes, which is determined in turn by their technological choices and volume of production. Firms may or may not be able to control their production processes and volumes precisely. If not, at the beginning of the control period they will be uncertain about the exact quantity of coupons they will require by the end. This uncertainty may lead to unstable coupon prices, since firms may arrive at the end of a control period having discharged more or less waste than expected. They must attempt to clear their surplus or deficit of coupons in what may be termed a "reconciliation" market. Both the supply of, and demand for, coupons will be highly price inelastic and small variations in excess demand for reconciliation coupons may cause great variation in coupon prices. This may be avoided if firms are permitted to carry forward ("bank") unused permits from one period to the next because firms can then meet unexpected demand from their coupon inventories.

Emissions trading plans can vary in many potentially important details. One of these is banking, which is important in facilitating intertemporal reallocation of coupons as well as mitigating the effects of production uncertainty on coupon prices. A second is the manner in which trading in future coupons is to be organized. For example, one proposal advanced in the early 1990s provided for simultaneous trading in coupons (dated and potentially bankable permits to discharge a specific quantity of waste) and in shares (time streams of coupons defined as a fraction of each year's total allowable discharge). In this chapter we focus on the interaction of banking and share trading under varying conditions of uncertainty in the production of emissions.

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Several studies have addressed aspects of this issue. Franciosi, Isaac, and Reynolds (1999) and Cronshaw and Kruse (1999) investigated banking in the context of proposed trading rules for the US EPA sulfur dioxide allowances market. Both found relatively low efficiencies. Subjects in the Franciosi et al. experiment underbanked while Cronshaw's and Kruse's overbanked coupons relative to the efficient time path. Muller and Mestelman (1994), reported in more detail in Mestelman, Moir, and Muller (1999), showed that open outcry markets with shares and coupons outperformed the environments tested both by Franciosi et al. and by Cronshaw and Kruse. Carlson et al. (1993) report two experimental sessions which show that a limited form of intertemporal substitution of coupons eliminates price spikes in the reconciliation market under uncertainty. The only systematic investigation of the interactions of banking, share trading and uncertainty, however, is that reported by Godby et al. (1997).

Godby et al. created a laboratory environment in which coupons were distributed to subjects through shares bearing two coupons in each of the first four periods and one coupon in each of the remaining eight periods. Trade was conducted through a computer-mediated double-auction. In the most complex treatment (with banking, share trading and uncertainty in the control of discharges) subjects first traded shares and then received coupon dividends. Next, they traded coupons and then chose how much waste they planned to discharge in the current period and the corresponding use of coupons. Actual discharges were then computed by adding a random element which was previously determined but unknown to the participants. Finally, subjects were informed of their actual coupon requirements and allowed to participate in a reconciliation market. Subjects were provided with computerized assistance in valuing coupons and shares: a *planner* allowed experimentation with the probable consequences of holding varying numbers of coupons and shares and a *wizard* advised on the increment or decrement in expected profit which would be caused by a unit change in holdings of coupons or shares, assuming these were efficiently allocated. The individual effects of coupon banking, share trading and uncertain control of discharges were investigated through a complete $2 \times 2 \times 2$ factorial design replicated three times.

Figure 1 compares a baseline session in which there is neither banking of coupons, nor trading of shares with a session in which coupon banking and share trading were both permitted. There was uncertainly in the control of emissions in both sessions. In the baseline session, prices generally follow the competitive market prediction, being low in periods 1 to 4 when the coupon dividend is high and high in periods 5 to 12 when the coupon dividend is low. The adjustment to the higher price is relatively slow for a double auction experiment. Reconciliation trades are highly variable and lie distinctly off the path of regular coupon prices. These confirm the price spikes found by Carlson et al. (1993).

Introducing banking and share trading leads to dramatic changes. Banking is predicted to smooth coupon prices over time; indeed the competitive equilibrium price band is constant, despite the reduction of coupon dividend from two to one per share in period five. Figure 1 shows that coupon prices stay very close to this band. Moreover the frequency and amplitude of price spikes in the reconciliation market is greatly

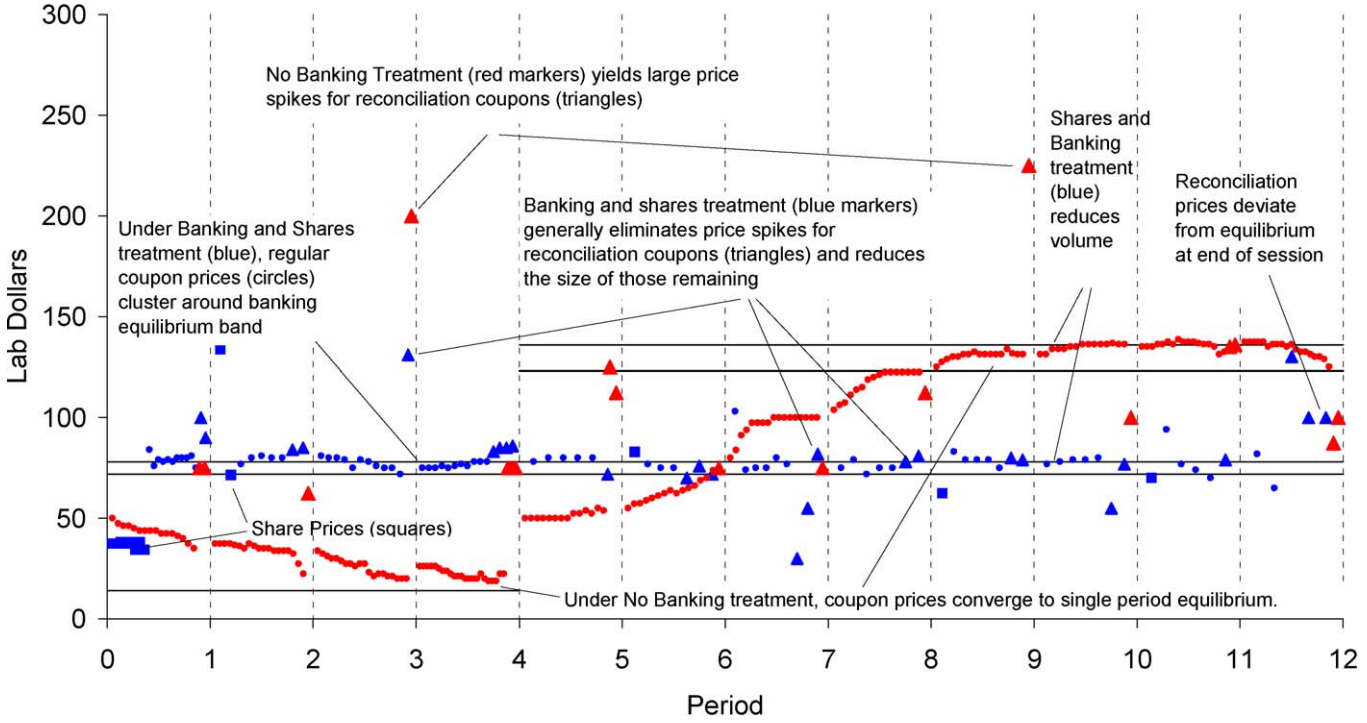

Figure 1. Share trading and banking markedly improve price performance. Without shares or banking (red markers), trading volume is high and reconciliation prices (triangles) exhibit large spikes. With banking and share trading, trading volume is reduced. Regular coupon prices (circles) and most reconciliation prices lie close to the equilibrium band. After period 1, share prices (squares; expressed as coupon equivalents) are also close to the equilibrium band. Data are from a typical session for each treatment.

reduced and many reconciliation trades lie close to or in the competitive equilibrium band. The introduction of share trading substantially reduces coupon trading volume. Early share prices lie outside the equilibrium band but quickly converge to it and stay near it until the end of the session. Other sessions (not illustrated) show that share trading accelerates the adjustment to the change of dividend in period 5 in treatments with no banking.

Coupon banking and share trading affect the efficiency as well as the price behavior of emissions markets. Efficiency can be measured by the percentage of available reduction in system abatement cost, i.e., gains from trade, that are realized under a trading institution. Godby et al. (1997) considered a wide variety of efficiency measures differentiated chiefly by the definition of potential gain from trade.

Figure 2 plots net efficiency by treatment. In this measure, the potential gains from trade are defined to take into account the slight reduction in aggregate coupon availability caused by the realization of the random error term uncertainty treatments. Figure 2 reveals three particularly interesting results. First, banking substantially increases efficiency in both the shares and no shares conditions. This is chiefly due to the fact that banking allows the market to reallocate coupons over time. The initial distribution of coupons (two per share in periods one to four and one per share in periods five through twelve) is not efficient given the abatement cost schedules built into subjects' payoff functions. Provided the pollution damage function is linear in period by period emissions, reallocating coupons from early to late periods via banking is both privately and socially efficient. Second, share trading always increases efficiency, as shown by the positive slope of the lines in Figure 2. The effect is noticeably greater in the case of banking. Third, banking *as a market institution* can actually reduce efficiency. The topmost line in Figure 2 reports the net efficiency of the no banking treatments expressed as a percentage of the maximum achievable gains from trade given that coupons simply could not be reallocated over time. This *adjusted net efficiency* measure coincides with the standard measure in the banking treatments. The adjusted net efficiency of no-banking sessions lies above the adjusted net efficiency of the banking sessions, indicating that subjects achieved a larger fraction of the potential gains from trade in the no-banking condition. This effect, however, is very much reduced when share trading is permitted.

The results are significant for both environmental policy and the study of markets. Proposals for explicit trading in shares, prominent in Canadian policy discussions five years ago, are now less frequently heard. The laboratory results suggest this is unfortunate. At a broader level, the results raise two questions about auction markets generally.

First, what explanation is to be offered for the apparent reduction in market efficiency induced by banking? One conjecture is that banking provides agents a degree of flexibility in production planning without a corresponding market to guide it. If so, a complete series of future markets might provide the market signals required for improved intertemporal efficiency.

Second, what explanation is to be offered for the role of shares in improving price performance and reducing the efficiency losses due to banking? On the one hand, shares

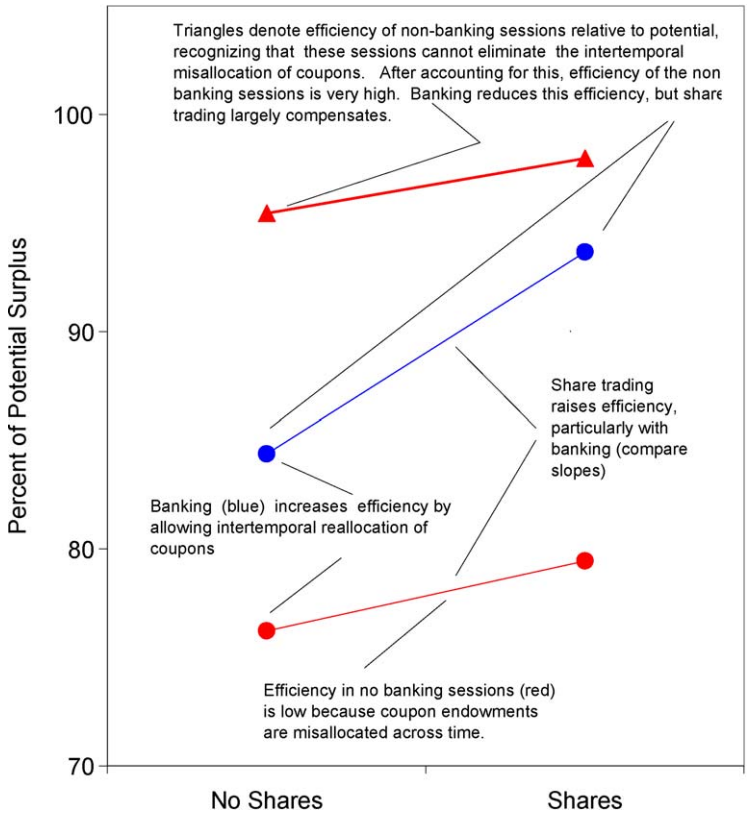

Figure 2. Share trading consistently promotes efficiency, especially in the presence of banking. Banking raises gross efficiency by allowing intertemporal redistribution of initially misallocated coupons. Abstracting from this, banking without shares reduces the efficiency of the market institution. Share trading largely compensates for this effect. Data points are means for uncertainty treatments.

seem to be a substitute for organized trading in future coupons. If this is the case, performance should be enhanced even more by instituting such futures markets. On the other hand, trading in shares may represent a way of reducing the complexity of futures markets, in which case a market restricted to trading current coupons and shares might actually outperform a more complete set of futures markets.

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