Centre for Energy and Environmental Markets

The importance of market institution in generating prices

A review from experimental economics and implications for real world experience

DRAFT

Draft CEEM discussion paper for comment
DP_050816

August 2005

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Centre for Energy and Environmental Markets

About CEEM and this paper:

The Centre for Energy & Environmental Markets was founded in 2004 to allow the University of New South Wales to provide interdisciplinary research and advice on the design, implementation and operation of energy and environmental markets. The Centre formally brings together researchers from within the Faculty of Engineering, the Faculty of Commerce & Economics and the Australian Graduate School of Management. The CEEM also has active collaborations occurring across other faculties at the UNSW, and with a number of Universities and other organisations.

This paper provides a review of the lessons from experimental economics in respect of the performance of different types of market institutions. From the fundamentals identified in the laboratory experiments, this paper then questions if current prices observed in the Australian MRET market, the New South Wales NGAC market, and the European Union Emissions Trading Scheme are likely to be genuinely reflective of the underlying supply and demand. A number of reasons drawn from the experimental evidence are outlined as to why observed prices may not be consistent with the underlying supply and demand.

This is an area of ongoing work for CEEM we are actively seeking feedback and comments on the analysis methodology and findings outlined in this paper.

The corresponding author for this paper is:

Karel Nolles
k.nolles@unsw.edu.au

www.ceem.unsw.edu.au

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Why apply experimental economics to the environmental markets?

> "The design and conduct of auctioning institutions has occupied the attention of many people over thousands of years. The Greek historian Herodotus, who described the sale of women to be wives in Babylonia around the fifth century B.C, gave one of the earliest reports of an auction. During the closing years of the Roman Empire the auction of plundered booty was common. In China, the personal belongings of deceased Buddhist monks were sold at auction as early as the seventh century A.D" (Milgrom and Weber 1982)

As the quote above makes clear, markets and auctions have been in use for millennia. It is somewhat surprising then to realise that the theory of market design and behaviour remains a considerable distance behind the practice. In major market reform processes, such as electricity, gas and environmental markets, policy makers have had to make "best guesses" between a bewildering array of possible design decisions, without having clear theory to guide those choices. The considerable differences in structure between different electricity markets around the world is testament to what (Surry 1996) only slightly facetiously referred to as the "great electricity experiment."

This theory lag is discussed with some elegance by (McMillan 1994) in the context of the US Spectrum Auctions[1]. "Theory has limits" he writes, and further "theory sometimes shows that there are effects that work in opposite directions from each other … and implementing a particular theory may require information that is unavailable." In the absence of a developed discipline of "market engineering", capable of predicting market performance "pre-construction" with a similar level of forensic certainty as that expected from civil engineers when constructing bridges, the use of experimental economics techniques to test market performance before going "live" should be an important part of the policy maker's toolkit.

Experimental Economics is the use of laboratory techniques to examine economic systems. This is typically achieved through developing a simplified version of the economic system suitable for implementing in a controlled laboratory environment, and then using remunerated subjects as participants within that laboratory system. This allows the experimenter to define things such as the intrinsic valuations of participants and the underlying supply and demand schedules. Although many seminal experiments have been run by hand, it is often the case today to run the experiments on computer networks, where participants operate a trading screen of some form. In particular, Experimental Economics allows exploration of issues around human decision-making within economic systems.

Since the early 1980's the use of "market based instruments" to facilitate least cost implementation of environmental policy has become relatively popular. Active academic discussion of the application of environmental markets commenced in the early 1970's, with theorists such as (Montgomery 1972) outlining the potential efficiency benefits of such markets.

Although a significant number of environmental markets now exist around the world (see Table 1 for a partial list), few have a significant length of trading history uninterrupted by significant changes in structure. The collective experience that has been gathered suggests that in the environmental markets area, the differences between "perfect market" theory and "practical market" reality is particularly large. Putting together an environmental market – particularly one

[1] The US Spectrum auction were among the world's most theoretically analysed auctions prior to their implementation. However as (McMillan 1994) points out the actual performance was vastly different to the still performed in reality very poorly compared to theoretical predictions.

that drives significant new investment to solve some particularly environmental issue – is a harder task that was initially anticipated.

Despite the problems, the gains from implementing environmental policy via a market instrument can be significant – with some empirical studies suggesting a cost reduction of more than 50% compared to traditional "command and control" type regulation. (Ellerman, Joskow et al. 2003).

Environmental markets have generally been implemented by government agencies different from those agencies traditionally associated with the oversight and management of financial (and other) markets. This has meant that some key lessons about market regulation and surveillance from the design and performance of financial and major commodity markets have not been heeded in the design of many environmental markets.

In part this is because of the understandable reluctance of government departments with an environmental focus to become involved in questions of market regulation, management and surveillance on an ongoing basis.

While understandable, this is **also a dangerous position to take**.

Table 1: An incomplete table of implemented environmental markets

Traded item/category	Countries	Traded item/category	Countries
CO_2	EU	Wetlands	USA
	Canada	Fisheries	Australia
	Considerable number of others.		Canada
			Iceland
NO_x	Canada		Netherlands
	Switzerland		New Zealand
	USA		USA
SO_2	USA	Air quality	Canada
Water qual. trading	Australia		Chile
	USA		Poland
Hunting	Canada		Singapore
	Mexico		USA
Land use	France	Other	Canada (maple grove permits)
	New Zealand		
	USA		USA (permits for lead in gasoline)

Extracted from: (Randall 2003), with additions

The theoretical benefits of using markets to implement environmental or energy policy rest on the assumption that the market is efficient. **That the market performs efficiently is the bedrock upon which public and participant acceptance of market-based environmental schemes rests.**

An efficient market requires (at least) **good design (market institution), good regulation and appropriate surveillance and monitoring.**

In this paper we examine some of the lessons that can be drawn from experimental economics in respect of the Market Institution question, and then draw some conclusions about the probably price performance of the main environmental markets of interest in Australia.

Summary of Market Institutions

Market Institution is a term used to describe the broad manner in which a price and quantity for trade are agreed. The following provides a quick overview of the main institutions, before we consider what experimental economics tells us about them, and the implications for policy in respect of environmental markets.

Posted Prices – The "posted price" institution is the one familiar in the context of retail shopping (eg: Coles supermarket) – one party (typically the seller) "posts" a price, which is fixed for some duration, and the buyer can either accept or reject. A close relative is Posted Price with

Negotiation, where the initial posted price is viewed more as an invitation to seek a discount. (eg: The market for second hand cars)

One-Sided Sequential Auctions – These are auctions where an auctioneer makes known a single price to the market for the good on sale, and then either raises ("English" style ascending price auction) or lowers ("Dutch" style descending price) the quoted price until the supply is equal to the demand.

Double Auctions – In the double auction buyers make bids to buy, sellers make offers to sell, and the available bids & offers in the market (or at least the highest bid and lowest offer) are made known to all market participants. This is the style of market used on the Australian Stock Exchange (ASX) during normal trading.

Decentralised negotiations – The form of market where buyers and sellers establish contact with each other to negotiate prices and quantities on a case-by-case basis. Frequently brokers enter into such markets to reduce the search costs, and this can lead to a decentralised market actually becoming very similar to a more formal auction (as is the case with the NASDAQ), or to a Posted-Offer style market, where sellers advertise prices through brokers and invite potential buyers to then negotiate.

Discriminative Auctions – This is the style of auction used for the sale of Australian Treasury Bonds[2]. Multiple buyers submit bids to a single seller with some quantity of units to sell. At the end of the auction the seller commences at the highest bid, and works down the bid stack until all units have been sold. Each buyer pays the price they bid.

Uniform Price Auctions – The obvious outcome of a discriminative auction is that different parties pay different prices, and parties paying the higher prices tend to become dissatisfied when this fact becomes known. An alternative is to settle all bids at a uniform price that clears the market, since a buyer is unlikely to complain about obtaining a good at a price lower than what was bid. The clearing price is determined by the highest rejected bid. It can also be implemented in a call market, as is used to provide opening prices on both the ASX and the NYSE[3], and is also used by NEMMCO[4] in Australia to provide the half-hourly electricity spot prices.

Evidence from Experimental Economics regarding the relative Market Efficiency of the different Trading Institutions

Market Efficiency is a measure of the extent to which a market allows participants to gain the benefits of trade. That is, efficiency = (Actual gains of trade) / (Potential gains of trade). Market efficiency does not specifically mean that prices are higher or lower – or even consistent between participants. It simply means that the market has performed the core task of ensuring that all goods have been allocated to their optimal uses.

All of the above market institutions and pricing rules have been extensively studied in an experimental context. The experimental evidence is fairly clear that in cases where direct comparisons can be made, the efficiency of the market institutions descends as follows[5]:

- Double Auction
- Discriminatory Call Markets and Sequential Markets
- Clearing house (Uniform price to single seller)
- Posted Offer

[2] http://www.rba.gov.au/FinancialServices/CGSTenderInfo/TBTenders/2005/index.html
[3] New York Stock Exchange. www.nyse.com
[4] National Electricity Market Management Company – The operator of the Australian national electricity market.
[5] Based in part on Table 5.2, Kagel, J. and A. Roth, Eds. (1995). The handbook of experimental economics, Princeton.

- Negotiated Prices
- Posted Offer with subsequent negotiation

This is of course not to say that in the real world the double-auction is always a superior form of market institution to the posted-offer market. There are clearly practical difficulties for example in operating a busy grocery store on the basis of a Double Auction.

What it does say is that in those cases where both a Double Auction or a Posted Offer institution would be viable choices, the experimental evidence is strongly in favour of the Double Auction, and a choice to the contrary would need to demonstrate clearly what special feature meant that an alternative mechanism provides a better societal outcome.

Comparing the Posted Offer and the Double Auction

The overall effect of the posted-offer institution is to raise prices and reduce market efficiency as compared to the Double-Auction.

This is particularly the case when limitations on seller's capacities create market power. That is, in a posted-offer style market where participants have market power, the exercise of that market power is easier than in other market institutions.

The price-increasing effects of this institution are illustrated by data from Ketcham, Smith & Williams (1984) – see Figure 1.

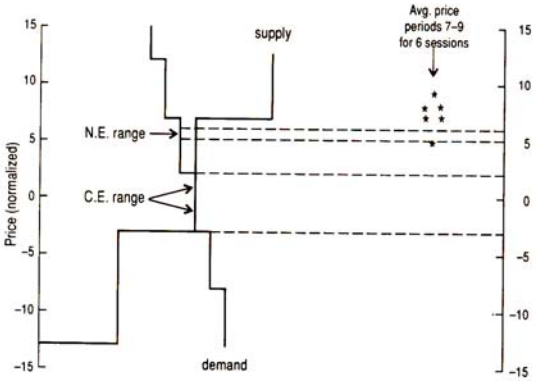


Figure 1: Price performance of the Posted-Offer institution. From Ketcham, Smith, Williams (1984).

Notice in this experiment that a defined competitive equilibrium (C.E) exists (at "0" on the y-axis), and that the supply curve has one large supplier who by withdrawing a single unit from sale could influence the price to the Nash Equilibrium (N.E).

The key point is that average prices obtained through the market were at or above the Nash Equilibrium range.

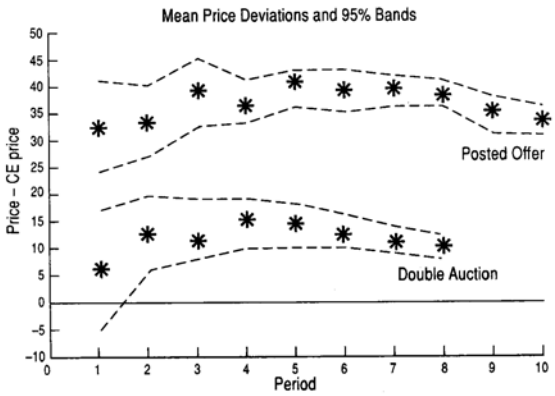


Figure 2: Posted Offer compared to Double Auction. From (Kagel and Roth 1995) using data from (Davis and Holt 1993)

Importantly, the experimenters deliberately conducted a set of 6 parallel Double Auction sessions, with the same environmental variables and underlying supply/demand curves. In all but one of those sessions prices were statistically indistinguishable from the competitive equilibrium price.

Davis, Harrison & Williams (1993) also compared the various institutions under conditions of cycling supply and demand, and noted that "the Posted Offer efficiency is only 66% on average, and, as a result, the PO prices do not track the changes in equilibrium prices very well."

Call Markets

A near alternative to the Double Auction is the Call Market with a uniform price. Call markets have also been considerably studied. Consistent with many of these studies (Smith, Williams et al. 1982) concluded that call markets have strong competitive tendencies, and among the most efficient form of uniform pricing institution. They tend to slightly under-perform in terms of market efficiency and speed of price convergence to the equilibrium price as against a Double Auction for the same goods.

Market Structure and Market Power

What is "Market Power" ?

(Holt 1989) suggests two definitions of market power, although for current purposes the second is the more useful, which is based on the USA Department of Justice horizontal merger guidelines. A participant has market power if a unilateral deviation from competitive behaviour is profitable, assuming other participants continue to use the strategies that otherwise delivered the competitive equilibrium.

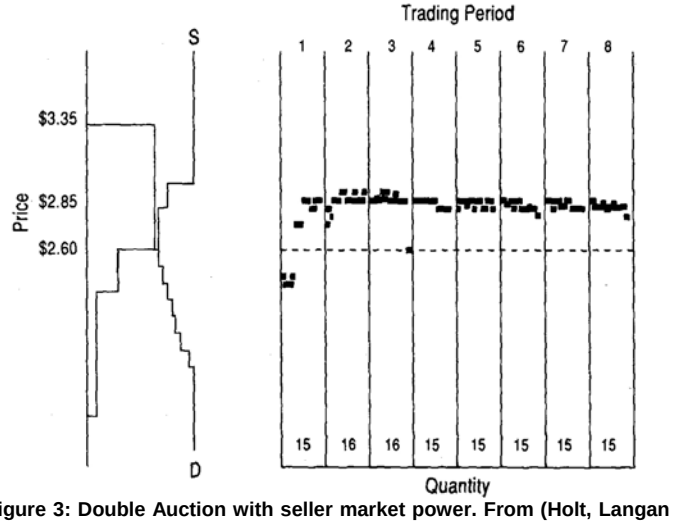


Figure 3: Double Auction with seller market power. From (Holt, Langan et al. 1986)

A large number of experiments have been conducted examining different aspects of market power. It is a consistent theme that where market power exists, participants quickly learn how to maximise profits through the use of it.

Figure 3 shows an example from a paper by (Holt, Langan et al. 1986). By strategic withdrawal from sale of a small number of units the marginal supplier can raise the price to $2.85. The additional profit on the smaller number of units sold makes this a profit maximising strategy. Note that by the end of the second trading period (out of eight), the participants have been consistently moved to the higher price.

With the underlying supply/demand curves in the case above, which represent a severe from of market power on the part of a single participant, no trade institution will be able to prevent the application of market power. However a more common situation is where some form of cooperation (or collusion) is required between a number of participants in order for market power to be exercised. An enormous body of experimental work has been conducted examining collusion and cooperative behaviours.

Factors that have been shown experimentally to facilitate collusion

The following factors in the ability to collude to move market prices can be drawn from the experiments that have been conducted.

- Multi-period repetition with the same group of participants.
- Communication between parties
- The ability of parties to punish "deviation" from the collusive course.
- The existence of vertically related markets .
- Significant market concentration.
- Significant search or transaction costs.
- Where a posted price institution is used. Particularly if the market is small.

Other factors that challenge the assumption of a competitive market in respect of Environmental Markets

To the above list, for which considerable experimental evidence exists, there are three factors that are also worth considering, but for which no or limited experimental evidence is currently available.

Reputational Risk and the Perceived "Cost of Carry"

In the environmental markets the primary driver of value is the regulatory requirement that a company purchase some quantity of a given environmental instrument. From the company's point of view it is frequently the case that the potential for reputational loss outweighs any financial incentive to trade "optimally" in the market. For this reason we suggest that the environmental markets will tend to have more "buy and hold" behaviour than might be expected in other markets. If the market institution allows, such participants will "over-buy" and then hold their surplus "units" until required for regulatory acquittal, and consider the financial "carry costs" and any associated foregone profit from the market as being a "cost of doing business and meeting the regulatory requirement."

Anecdotally it is an often-heard comment from brokers in the Australian MRET and NGAC markets that participants do not appear to rationally consider the cost-of-carry when making purchase decisions.

In an environment where the cost of carry or unit creation is either insignificant or not appreciated, a considerable difference may exist between trading behaviours. There is some experimental evidence – including from experiments conducted by CEEM, that when participants are given an allocation for free they tend to "hold" to it, and not behave in a manner that is as "commercial" as compared to the case where they had purchased or created the unit for resale with a positive cost.

In the case of the recent CEEM experiments, two institutions were trialled. In the first, "suppliers" of units were given an allocation (at no cost) at the start of each period, and the task was to sell these units to "retailers". There was no penalty for not selling all the units provided, only the foregone profit from failing to sell at a profit.

In the second institution, "suppliers" had to pay a cost to obtain the units, which could then be resold to retailers for a profit.

In both institutions that actual payoffs and values were the same.

Participants in the first institution were much more willing to withhold units from sale in an attempt to increase the market price, judging that the financial risk of not selling all the units could be disregarded.

This would tend to support the conclusion that grandfathering of a significant number of "units" or allowing units to be created for very low costs from current activities can lead to the overall market price being raised, since the market risk of failing to cover costs on unsold units is lessened, thus relaxing the commercial incentives. This is a preliminary finding, and CEEM is now conducting further experiments.

This finding is however anecdotally supported by the recent experience of the State of Virginia in the auctioning of NOx permits. Up to this point all permits had been grandfathered, however to allow for new entrants it was required for all participants to return 5% of their allotment each year, which would be auctioned to the highest bidder – including new entrants. Following the first auction a dramatic rise in the volume of trading was observed, possibly due to companies having observed the (surprisingly high) auction results achieved and concluding that the permits in fact had a real value to them, and should thus be profitably used or sold, and not held as insurance.

A copy of a news article regarding these auctions is provided at the end of this paper.

Shared desires for non-market outcomes

There may exist non-market reasons why some market participants may share a desire for a particular market outcome – which strengthens the incentives for tacit collusion.

As an example, if there is a belief that the outcomes from this market will be used to set future baselines or benchmarks, or to drive future policy. Under this circumstance some participants will have an interest in seeing price being artificially high or low, and they may be able to cooperate to achieve this, particularly where the market is relatively small.

Bubbles and False Equilibria

> "Or, to change the metaphor slightly, professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the price being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds the prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not the case of choosing those which, to the best of one's judgement, are really the prettiest, nor even those which the average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practice the fourth, fifth and higher degrees" – Keynes – 1936

In the context of environmental markets (as in the share market) it is generally the case that the true "fundamental worth" of the asset is uncertain. The problem arises when each participant in the market does not genuinely believe their own opinion to be the best estimate of the opinion of others. Under that circumstance a participant may be prepared to purchase something that they believe to be over-valued, in the hope that somewhere else in the market another participant exists who is even more foolish (or less informed), thus leading to a speculative bubble.

Given that regulatory markets are – by definition – driven by government regulatory action, and that this is a reason for ongoing rumour about changes in policy and direction, it is possible that the relatively small environmental markets will in fact be more susceptible to asset bubbles than the larger financial asset markets.

This is also consistent with the findings of the CEEM experiments on the MRET market. In the MRET market a considerable source of uncertainty exists due to baselines and the delay between the generation of MWh and the creation of the associated REC (at which point the REC becomes visible and known in the registry.) Although our testing series is incomplete, a typical price path is for prices to be well over equilibrium in early periods, and then crash in later periods as more information about over-production becomes known in the market.

Experimental Evidence about the role of Forward Markets

Theoretical analysis of the interactions between spot markets and forward markets is relatively limited – in large part because the underlying market models for the spot market already present considerably theoretical difficulty in predictive terms.

The Cournot model of a market is frequently used in theoretical contexts, being relatively mathematically tractable. In this model sellers make simultaneous decisions about output quantities, and the aggregated production determines the market price in that period.

One particularly notable theoretical piece on the nature of such interactions was developed by (Allaz and Vila 1993), who used a Cournot model to explore the mechanism by which a spot market arrives at a Nash equilibrium characterised by over-production (due to the Stackleberg Leader problem[6]), leading the market to stablise at a point of over-production and low prices. (Allaz and Vila 1993) go on to demonstrate that a forward market could assist, by allowing participants to lock in future sales and to signal future intentions. Their theoretical analysis demonstrated that in the limit of a continuously tradeable forward contract, such a market allows the underlying Cournot spot market to achieve the competitive equilibrium prices.

That is, the existence of a well functioning forward market allows a dysfunctional spot market to converge to the equilibrium price.

The Allaz and Villa model has been experimentally tested by (Brandts, Pezanis-Christou et al. 2003), who found a good alignment between the theoretical performance and the experimental results.

At CEEM we are currently seeking to conduct a similar experiment, looking at the impact on the MRET market of introducing forward trading.

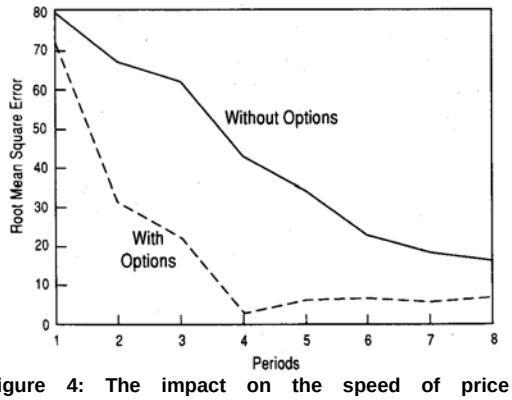


Figure 4: The impact on the speed of price convergence to equilibrium of having a forward option market. Extracted from (Kagel and Roth 1995), who used unpublished data provided by (Kluger and Wyatt 1990).

[6] Under some conditions each participant fears that if they don't commit to a large quantity, their competitor will, and thus it is better to "strike first". Unfortunately if all participants think this way, they all "strike first", and the results is over-production.

The impact of forward contracts has also been examined in the area of asset markets. In particular (Porter and Smith 1989) found that the introduction of a futures market reduced the amplitude of the bubbles considerably.

This is consistent with data prepared by (Kluger and Wyatt 1990), and presented in a graphical form by (Kagel and Roth 1995), from where Figure 4 has been reproduced. This experiment examined the number of repeated trading periods required for prices to converge to the competitive equilibrium. In the "With Options" treatment participants were also able to conduct a single round of forward option trading at the start of each period. The extra information provided through the option market substantially improved the dynamic performance of the otherwise relatively inefficient institution.

The effect of the instrument design

In implementing an environmental market a large number of instrument design decisions must be made. These include questions such as:

- The longevity of the instrument – does the permit/credit survive indefinitely, or expire after some period of time.
- The timing of acquittal to the regulator – should it be annual or on some shorter or longer period. Should all participants have to acquit at the same time?
- The ability to bank/borrow from future periods
- The amount of information to be released to the market about instrument creation, and associated issues such as baselines.

Again, many of these questions have been examined experimentally, including in experiments at CEEM.

Annual Periods and Market Performance

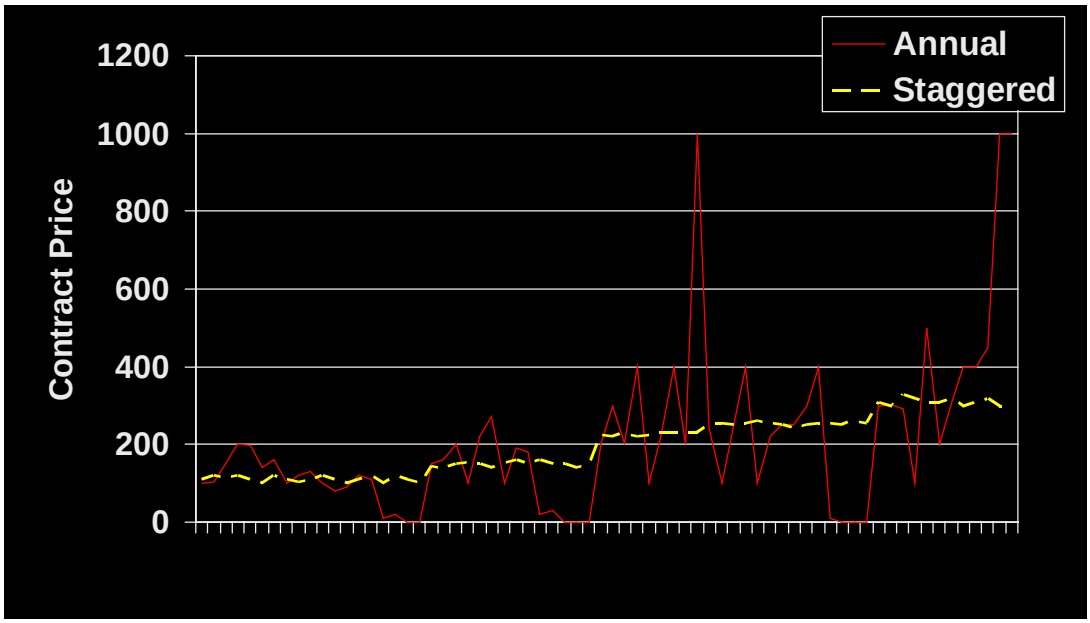
The experimental evidence suggests that more frequent acquittal of smaller parcels, or some mechanism for staggering acquittal dates between liable parties, is likely to encourage better price discovery and reduced volatility.

Consider by way of analogy the Commonwealth Government Securities (CGS) market. Government bonds are issued by the RBA on a regular basis, with periods out to 10 years. These bonds are then actively traded in a secondary market. Through both these mechanisms, the market has constant price-volume points about the government's issuing intentions and the prevailing market prices. The annual volume on issue in the CGS market is around $50 billion.

Clearly issuing $50 billion of bonds on one day, rather than in a series of auctions through the year would be extremely disruptive to the market. Clearly any mismatch of funds between investors and the available bond issuance on that day would appear as large swings in price as the market sought equilibrium on the large volume suddenly entering the market. It would not be considered sensible financial policy to issue bonds in this manner.

This issue has also been considered experimentally in respect of the Californian RECLAIM market. The following graph is extracted from (Ishikida, Ledyard et al. 2000), who ran a series of experiments based on the proposed RECLAIM market rules, and in particular the impact of having a single Annual Issue date versus having credit issues staggered through the year. The results from the market experiments are dramatic.

Clearly, more frequent issuances moderated market volatility and volatility increased as the volumes grew over time under the annual issue model.



This was a somewhat stylised experiment, and ignored the impacts of forward trading and banking, both of which are very much features of real world markets such as the MRET, NGAC and EU ETS markets.

However the fundamental point is that in a general sense the effect on market dynamics of having a single regulatory “drop dead” date for all participants will be to engender price volatility in the lead up to that date.

Real World Markets

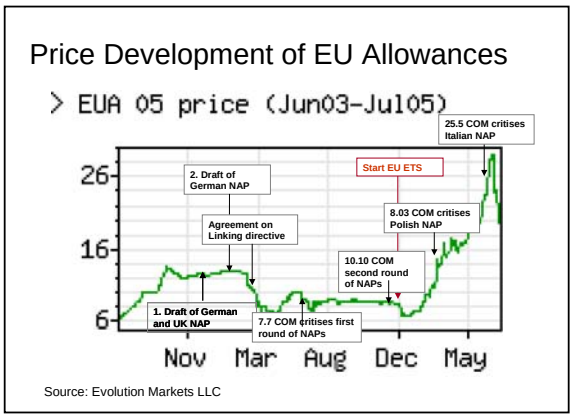
The use of markets as instruments of public policy – be it in energy, telecommunications, or environmental policy – is predicated on the assumption that the price prevailing in the market reflects the genuine underlying supply and demand.

However we have already observed in the previous survey of experiments that there are many cases where in controlled laboratory situations the prices generated in a particular market institution do NOT reflect the underlying supply and demand.

There are a number of occasions in known environmental markets where prices do not seem fully consistent.

A good example is in the EU ETS, where CER units that can be used both for international emissions trading (under the Kyoto Protocol) and acquitted under the EU ETS trade at a very considerable discount to the more narrowly defined EU Emission Allowances.

Previous work conducted by CEEM[7] suggests that prices in the NGAC market are considerably higher than fundamental of analysis of supply would suggest is rational.



The MRET market has recently encountered considerable price movement with no obvious change in fundamentals.

The experiments previously discussed suggest that some combination of the following effects may be at work.

Market Institution Effects:

The NGAC and MRET markets are primarily using a bilaterally negotiated OTC form of market institution, with a certain amount of intermediation by brokers. Broker's prices are more indicative as an "offer to treat" – that is – to enter for further negotiations – than being firm prices ready to be accepted. In is in effect approximating a Posted Offer market with Negotiation.

This form of institution is known to be particularly inefficient, slow to converge to the competitive equilibrium, and susceptible to the exercise of market power in-so-far as it does not apply strong competitive pressure to the participants.

[7] Of particular relevance is Passey, R., I. F. MacGill, et al. (2005). "The NSW Greenhouse Gas Abatement Scheme: An analysis of the NGAC Registry for the 2003 Compliance Period." Centre for Energy & Environmental Markets Working Paper. University of New South Wales(DP_050405).

Instrument Structure:

Both the MRET and NGAC markets are driven by a single annual acquittal date. As demonstrated by (Ishikida, Ledyard et al. 2000), such a instrument design would tend to increase volalitity, and to concentrate trading towards the acquittal dates.

Some evidence of this effect may be obtained from market participants who have (anecdotally[8]) suggested to AFMA that having the supply side of MRET dominated by a small number of existing generators, who must reach their baselines before they can produce RECs, combined with a single annual acquittal date means that (spot) market liquidity appears to vary considerably over the year. In particular, spot market liquidity appears to improve toward the end of the compliance period, as the existing generators reach their baselines and commence producing RECs. This pattern of RECs entering the market in a short period is also reminiscent of the "annual issuance" model examined in the RECLAIM case.

Market Concentration:

In the MRET and NGAC markets there are a relatively small number of significant market participants. As outlined in (Passey, MacGill et al. 2005) the NGAC market shows evidence of significant market concentration:

1. There is a high level of market concentration. A single participant, Integral Energy, created almost half (46%) the 2003 NGACs, and together with EDL (17%) and AGL (8.5%), created over 70%.
2. The Herfindahl-Hirschman Index (a metric used to quantify market concentration) for the supply side of the NGAS in 2003 is around 2,540. Indicatively, a market where the HHI exceeds approximately 1,800 may be considered highly concentrated, with the implication that the assumptions of a competitive market may be violated.

This combined with a OTC bilateral negotiation institution (which is particularly susceptible to the exercise of market power) would suggest that prices could be consistently above the equilibrium – ie: the marginal abatement cost.

Impact of Grandfathering and Baselining

Both the NGAC and the MRET markets have participants who because of historical production are in effect obtaining a considerable volume of certificates for little additional cost. (over 95% of 2003 NGACs were generated by plant that was commissioned before the start of the scheme.)

As previously discussed, there is growing experimental evidence that having participants holding units for free makes them much more prepared to attempt to withhold supply to maintain high prices, since the down-size risk of doing so is minimal. This is particularly the case given the perpetual nature of the traded instrument, since withholding supply in early years not only increased prices now, but also leaves considerable additional units for later sale.

[8] To the best of our knowledge there has been no formal measure of liquidity publicly tracked prior to the commencement of AFMA's Environmental Products Revaluation Curve in November 2002. AFMA EP Curve records bid-offer spreads for Spot market transactions.

Potential for tacit-collusion and vertical market optimisation

The MRET and NGAC market are multiple period repeated "games" – in that each year is a semi-independent period, in which a small number of known participants engage under a near form of the posted offer with negotiation market institution.

The same (or nearly so) participants also engage in a related vertical market, namely the electricity market. There is considerable scope for a participant with a considerable holding of grandfathered or cheap NGACs to attempt to obtain a competitive advantage in (say) the retail market for electricity by withholding supply from the NGAC market, and thus forcing competing retailers to have to pay more for NGACs.

Since the participants deal repeatedly in connected markets it is also an environment where "tacit-colluders" have the potential to "punish" any deviation from the withholding behaviour.

Asymetric Information

In MRET and NGAC markets all participants know the value induced on the buy side (being the penalty or tax avoided - $57 in the case of MRET for example), however the underlying costs on the supply side are private. There is thus an information asymmetry between the participants.

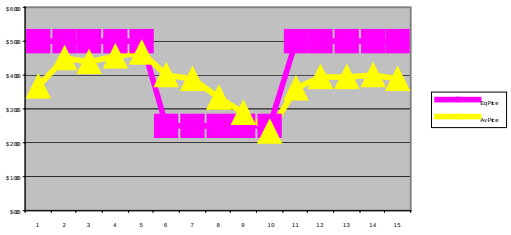


Figure 5: Prices in a CEEM experiment where the induced value is PRIVATE.

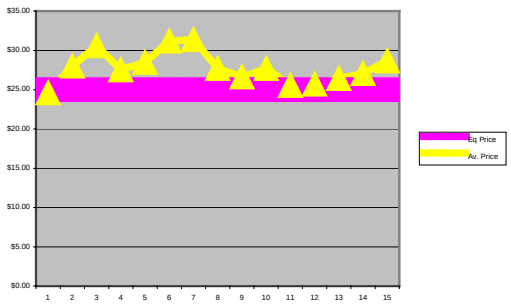


Figure 6: Prices in a CEEM experiment where the induced value is PUBLIC.

A recent CEEM experiment examines this. Two treatements were conducted – both with the same underlying supply/demand schedules. In one treatment, the "penalty rate" applied to the "retailers" was private – the value of it being known only to each individual retailer. They were unaware of the penalty rate applied to other retailers. The second treatment allowed all participants to know that a uniform penalty rate applied across the market.

The results are shown in figures 5 & 6. The theoretical equilibrium price is shown in purple, and the actual average prices in each period in yellow.

The clear result was that in the first case prices were consistently lower than the equilibrium, and converged towards the equilibrium from below. In the second treatment, prices were consistently higher than equilibrium, and converged from above.

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Pollution auction tops forecast
State pockets $10.5 million in the sale of allowances to emit nitrogen oxides
BY GREG EDWARDS
TIMES-DISPATCH STAFF WRITER
Friday, June 25, 2004

A state auction of nitrogen-oxide pollution credits for industry has raised much more money for the state budget than expected.

The auction, held yesterday, raised roughly $10.5 million after expenses of $200,000, said William M. Shobe of the Virginia Department of Planning and Budget. The state had projected that the auction would raise about $8.8 million.

"It was great," Shobe said. The credits sold for well above their market price on Wednesday, he said.

Nitrogen oxides are a key pollutant that creates smog. The Environmental Protection Agency created a system of allowances - the right to pollute at certain levels - as part of a plan to cut nitrogen oxide emissions by two-thirds in a 22-state region that includes Virginia.

The General Assembly set aside 5 percent of the state's allowances for use by new power plants and factories. The state Department of Environmental Quality approved the auction of those allowances for 2004 and 2005.

Power-plant developers objected to the auction and thought they should get the allowances for free, but were unsuccessful in opposing the plan before the DEQ. They then turned their attention to the General Assembly.

Developers argued that auctioning the allowances would discourage power-plant development. Lawmakers this year passed a bill, sponsored by Sen. Thomas K. Norment Jr., R-James City, that forbids the auction of any allowances beyond those auctioned yesterday.

The auction results, however, might cause lawmakers to rethink the policy of handing out the allowances at no charge.

Any ideas? Staff writer Greg Edwards can be reached at (804) 649-6390 or gedwards@timesdispatch.com

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