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An eCommerce Perspective on Carbon Trading

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An eCommerce Perspective on Carbon Trading

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Abstract

During the last decade, it has become widely accepted that global warming is not simply a natural cycle but that it is being exacerbated by human activity and that the impact of emissions from man-made technologies is substantial and critical. Reduction in the release of greenhouse gasses is therefore very urgent. Rather than direct regulatory action, governments around the world have been convinced to harness the power of markets to the problem. Emission trading schemes (ETS) have been the result, although the process is popularly referred to as 'carbon trading'. This paper considers carbon trading from the perspective of the eCommerce researcher and practitioner. It discusses the nature of the tradable items, and the possible forms of marketplace mechanism in which trading may occur. Both the theory and practice of eCommerce suggest that considerable care will be needed if ETS are to achieve the intended reduction in the global warming effects of industrial technologies.

Keywords: greenhouse gas, emissions trading, permits, credits, offsets

1 Introduction

Climates are changing, as they appear to have done throughout the earth's history. The world is generally regarded as being on a post-Ice Age upswing. There is increasing acceptance, however, that the upswing is being exacerbated by human activity. In particular, there are considerably greater atmospheric concentrations of various gasses than appears to have been the case in the past, and these concentrations appear to result primarily from emissions from human activities since the industrial revolution, and especially during the last 50 years. Governments throughout the world have come to accept that urgent and concerted action is needed firstly to stop the ongoing growth in the harmful emissions, and then to reduce emissions to a level that does not significantly impact temperatures and is long-term sustainable (IPCC 1990, with subsequent major reports in 1992, 1995, 2001 and 2007).

The manner in which this is to be achieved is through the imposition of constraints on emissions that are flexible rather than pre-determined by governments, and involve trading in permits to pollute. A formal descriptor for such initiatives is emission trading schemes (ETS), and the popular term is carbon trading (UN 2008).

Carbon trading has been addressed in some segments of academe, such as economics and experimental computer science. eCommerce journals and conferences proceedings, on the other hand, to date contain very little on the topic. During the lengthy research undertaken during the preparation of this paper, not a single paper was identified in the Information Systems literature that was sufficiently relevant to demand study and citation.

The purpose of this paper is to assist in filling a significant gap in the eCommerce literature, by providing a survey of carbon trading markets from the viewpoint of eCommerce researchers and professionals. In order to provide a firm base for further research in the area, much of the paper is of necessity descriptive. Reference is made to relevant aspects of theory from the eCommerce and cognate literatures. An outline is provided of ETS that are in operation and in the advanced stages of design.

2 Market-Based Controls for Greenhouse Gas Emissions

Climate change has come to be widely regarded as a major policy challenge of the first quarter of the 21st century (UN 1997, EU 2003, Gore 2006). This section takes as a starting-point the desire of governments to reduce greenhouse gas emissions by means of a market-based mechanism. It provides a highly-compressed summary of the rationale underlying ETS. It draws heavily on comprehensive government reports, such as Stern (2007), NETT (2007), PMC (2007) and Garnaut (2008).

Global warming is occurring naturally, as the planet continues to emerge from the most recent Ice Age. The preponderant view among scientists (which remains, of course, subject to challenge) is that the increases in temperatures are being significantly exacerbated by human activities. This is believed to arise primarily from the emission of carbon dioxide (hereafter CO₂), which has the effect of trapping heat inside the earth's atmosphere. The complete set of designated 'greenhouse gasses' (GHGs) also includes methane, nitrous oxide and three groups of fluorinated gases (referred to generically as CFCs). These are much more harmful than CO₂ per tonne of emission, but are currently being released in much smaller volumes. The focus of activity is currently on CO₂, with plans emergent to address other GHGs.

Under the libertarian political philosophy prevalent in the U.S.A., but also influential in some other economically advanced nations, government policy activities are regarded with suspicion, and there is a preference for the adaptation of natural business and social processes rather than outright intervention. At a more practical level, the imposition of change through direct regulation has become increasingly challenging, because the corporations that generate emissions have become very large and they operate supra-nationally. The hitherto conventional approach of imposing obligations and sanctions in the form of a tax was attempted by the European Commission in 1992. Opposition was strong, and the attempt was abandoned in 1997 (Lynne & Kruse 2001, p. 7).

An alternative approach has been developed, which endeavours to harness market processes to achieve the policy objective. Economists successfully argued for the creation of "a tradable instrument ... that can be exchanged between sellers and buyers in a ... market. This enables the movement of [tradable instruments] about the economy to their highest value (or most economically efficient) use" (Garnaut 2008, p. 322). Markets in such tradable instruments are intended to enable polluters to either reduce their pollution (if they can do so cheaply enough), or buy tradable instruments from other sources (if other polluters can reduce their own pollution more cheaply).

The emphasis has accordingly shifted since the mid-1990s away from the imposition of obligations and sanctions that are of the nature of taxes (i.e. payments to government). Instead, polluters are assigned emissions levels (generally lower than their current emissions), which they are able to meet through a combination of emissions reductions and the acquisition of 'permits' that they can variously be granted and buy. The generic term for such markets is 'emissions trading'. The term 'carbon trading' is widely used in relation to the trading of emissions of not only CO₂ but also the other greenhouse gasses (most of which are carbon-based).

Emissions trading has developed within two rather different contexts. One is voluntary schemes. The dominant framework, however, is the Kyoto Protocol. This is an international agreement that establishes legally binding commitments by industrialised nations to reduce greenhouse gas emissions. It is intended that developing countries, which have no short-term obligations in relation to GHG emissions, be progressively drawn into the scheme. The Protocol was negotiated in 1992, commenced operation in 1997, and was formally adopted in 2005 (UN 1997). Kyoto has been adopted by all developed countries except the USA, and the Obama Administration may move towards adoption from 2009 onwards.

The Kyoto Protocol creates a framework within which 'Emissions Trading Schemes' (ETS) can be established. The primary such scheme is operating within the European Union (EU). Other such ETS are in preparation, including in Australia and New Zealand.

Under a Kyoto-compliant ETS, polluting companies that are subject to the scheme are required to meet an emission target during an accounting period, which is typically a calendar year. They can do this in several ways:

- by adapting their technologies and practices to keep their emissions during that period below their target;
- by being granted 'allowances' (Assigned Allocation Units or AAUs), i.e. receiving gratis permits. If they have excess permits, they can sell them;
- by buying permits from:
 - the government; or
 - organisations that have permits to spare;
- by buying 'credits'. These are discussed in the following section.

Many analyses have been conducted by and for Governments, primarily by economists. Recent analyses are in NETT (2007), PMC (2007) and Garnaut (2008). The purpose of

the research project – from which this paper is the initial publication – is to consider aspects of the design of ETS from the perspectives provided by eCommerce theory.

For an emissions trading scheme to work, a number of elements need to be in place. The following sections consider two key aspects of the design of ETS:

- the nature of the tradable items; and
- the market mechanisms whereby they are bought and traded.

3 Tradable Items

A crucial aspect of the design of an ETS is to ensure that there are items that parties actively want to trade. This section briefly outlines key elements of theory, and applies it to each of the tradable items arising under Kyoto and voluntary schemes.

3.1 Theory

The viability of markets is dependent on a number of characteristics of the tradable item. Fundamentally, the item needs to be desirable, in the sense of having perceived intrinsic value. That value needs to be credible, and durable, with any time-limitations being transparent. A tradable item whose period of currency is long or upwardly flexible is referred to as being 'bankable', in the sense that a lender is more likely to accept it as security against a loan. The units or lot-sizes in which it is available need to be small enough to facilitate trading transactions to occur. There needs to be a sufficient volume of the tradable item available to enable a market to emerge and to sustain itself.

Four categories of tradable items are usefully distinguished (Clarke 1993, Torlina et al. 1999, Kaplan & Sawhney 2000, Clarke 2001, Pavlou & El Sawy 2002). Custom-built goods and services are 'once-off' items or activities, such as buildings and industrial plants, and designs for them. Standard goods and services are items or activities that exist as recognisable 'products'. Customised goods and services are standard products that incorporate some flexibility and can be adapted somewhat to match the buyer's preferences. Finally, commodities are items that are standardised to such an extent that they are substitutable. To be regarded as a commodity, a tradable item has to exist in considerable quantity, in essentially identical form. Tradable items whose natural characteristics vary somewhat may be 'commoditised' by classifying them into appropriate categories.

Commodities can be traded more simply than the other categories, because negotiation is primarily about price (although perhaps also quantity, and in some cases delivery or performance attributes). The designers of synthetic tradable items therefore generally endeavour to commoditise them.

Tradable items to support emission control objectives would preferably comprise one, or more likely a small set of, commoditised assets. Trading would then be straightforward. Greater market depth would be achieved by consolidating what might otherwise be multiple small markets into just a few. Moreover, short-term and day traders would be more likely to be attracted, because they rely on sufficient turnover and price movement to provide opportunities to take a turn in the going rate of tradable items in which they have no intrinsic interest.

The following sub-sections apply this basic theory to the various instruments that are created within the Kyoto framework and related voluntary schemes.

3.2 Permits

Under Kyoto-compliant ETS, the fundamental tradable items are permits. These are certificates that can be used to satisfy an organisation's obligations to achieve an emissions target in a given accounting period. Permits are undifferentiated, and hence they satisfy the requirements of a commodity. To satisfy the policy objective, the targets set must of course be lower than the emissions that the organisation would otherwise have generated.

Permits will only have intrinsic value if the scheme imposes known obligations on polluters, and the permits satisfy a reliable quantum of those obligations. There also has to be good reason to believe that the obligations will be enforced, which depends on three elements being in place: meaningful sanctions for non-compliance, enforcement of those sanctions, and survival of the obligations even if sanctions are imposed.

Permits have to be brought into existence by some credible organisation. They must be in themselves credible. In particular, they must retain their intrinsic value irrespective of changes in circumstances. Purchasers must be confident that they get what they paid for, irrespective of any subsequent events, including for example the closure or dissolution of the organisation that originated the unit, or from whom they bought it.

Governments have generally provided permits, gratis, to at least some polluting organisations, in many cases equivalent to a large proportion of the polluters' targets. The intellectual rationale underlying this arrangement is that it creates an incentive for those organisations that are capable of reducing their emissions relatively cheaply to do so, and then sell their excess permits in order to recoup some of the costs involved in emissions reduction. A more pragmatic reason for gratis permits has been the need to avoid powerful polluters preventing the scheme coming into operation.

The supply of permits is, however, something of a self-denying prophecy. There are two sources: a government authority that issues them (variously by gift and by sale); and organisations that have more of them than they need. Polluters only have saleable permits where they emit less than their target; and since targets are intended to be set in a challenging manner, most polluters are likely to find it difficult to generate an excess. Government authorities must make finely-judged decisions, in order to issue a sufficient volume of permits that emitters can fulfil their obligations, but not so great a volume that they become so inexpensive as to discourage investments in emissions reductions.

Determining targets and allocations is critical to the process. They may be computed by more or less scientific means, but will inevitably be moderated not only by practicalities and costs but also by political factors. For example, targets and allocations could be based on past and and/or current measurements of the specific industrial plant, or of samples of comparable plants, or on estimates of economy-wide pollution allocated across sources of pollution; and they may be adjusted for such factors as enterprise size and exposure to international competition. Considerable complexity, guesswork, politics and gaming is involved.

The currency of permits has conventionally been for a calendar year nominated by the authority at the time of issue. There are advantages in endowing the permits with greater durability by making them open-dated. They can then be used in any year, or

any of a range of years – providing greater flexibility in the forms of bankability, and arbitrage across related tradable items.

The denomination in which permits have been issued has conventionally been 'one tonne of CO₂' and increasingly 'one tonne of CO₂ equivalent', in order to encompass other GHGs. This requires, however, that a set of equivalence ratios be determined. Because this is at least to some extent arbitrary, such ratios will inevitably be a further area of political activity.

The release of permits can be undertaken once each year, or they can be released progressively, e.g. quarterly. If the permits are year-specific, a proportion of future-year permits could also be sold in advance of the commencement of that year (e.g. 20% in each of the fifth, fourth, third, second and final quarters preceding the end of the year to which the permits are applicable). This creates the likelihood of multiple surges of interest each year and hence greater scope for an active market and hence for price-information to be visible to affected organisations on an ongoing basis.

3.3 Credits

The second category of Kyoto-compliant tradable instrument is credits. These need to have currencies and denominations designed to be compatible with the obligations and permits. The credits can then be purchased by organisations as a means of satisfying part of their obligations. They have been conceived so as to be equivalent, such that credits represent commodities from the viewpoint of market designers.

Credits can be awarded to new projects that adopt a low-emissions design as an alternative to a conventional one (e.g. a solar, wind or geo-thermal installation rather than a coal-fired power station). They can also be awarded for enhancements to existing installations and processes that result in emissions reductions. Other recipients of credits can be organisations that contribute to the sequestration of emitted carbon by creating new carbon sinks, or increasing the sequestration rate of existing carbon sinks. Projects of these kinds include investments in afforestation and other forms of carbon-absorbing land-use, and desisting from clearing forests.

The industrial processes that give rise to large volumes of emissions are generally of very large scale, and operate on long planning periods. To be available for purchase now, credits must therefore be granted in advance. As a result, there is vast scope for 'gaming the system'. Authorities must carefully determine a set of rules for evaluating applications for credits, and carefully apply them. Once a credit has been granted, however, it would risk the credibility of the entire undertaking if they were to be retrospectively withdrawn; and hence it is likely that credits will need to stand even where there is subsequent discovery of error or fraud.

Under the Kyoto scheme, two separate categories of credits have been established. In industrialised countries, Emission Reduction Units (ERUs) can be granted for projects that qualify under the Joint Implementation (JI) arrangements (UN 2009b). In developing countries, Certified Emission Reductions (CERs) can be applied for under the Clean Development Mechanism (CDM – UN 2009a).

3.4 Offsets

The term 'offset' is used here to refer to credits that arise outside the Kyoto framework, through so-called 'voluntary schemes'. Considerable effort was invested in the U.S.A.

during the Bush Administration in an endeavour to create a scheme based on private sector initiatives rather than government fiat. The result has been a range of competing standards, or 'certification regimes', for evaluating projects and awarding offset credits (Hansen 2008, p. 8).

Kyoto-framework ETS can simply ignore the offset credits generated under such schemes. There are several reasons why this may be inadvisable, however. The voluntary schemes are aligned with the policy intent, and the scale of the 'carbon trading' market can more readily reach the critical mass it needs if offset credits are included. Moreover, it is crucial for the U.S.A. to be drawn into the international emissions control movement, and it is likely to be much easier for the Obama Administration to achieve this if existing initiatives are recognised.

The challenge in doing so, however, is to align the currencies and the denominations, and most importantly to determine equivalence among the standards, i.e. to satisfy the requirements of commoditisation, without detracting from the formal credit schemes (i.e. JI and CDM).

3.5 Derivatives

Companies operating in financial markets have developed a range of tradable items that build on or 'derive from' tradable items. These are capable of being applied to carbon permits or credits. In the context of derivatives and financial markets more generally, permits are 'the underlying commodity'. The markets in which permits are traded are sometimes referred to as 'spot markets' (because the trade must be settled immediately, or 'on the spot'), in order to distinguish them from 'derivatives markets'.

One simple form of a derivative is a 'future'. This is an undertaking by a party to provide some quantity of an underlying tradable item, at an agreed price, at an agreed time in the future. Another form of derivative is an 'option'. This is an undertaking by a party to buy or sell some quantity of an underlying tradable item, at an agreed price (the 'strike price'), at any time in the future up to an agreed date. Both of these kinds of obligations constitute tradable items in their own right, derivative from the underlying instrument.

Futures and options can be valuable for parties that have a direct interest in the intrinsic value of the underlying commodity, because they represent a form of insurance against risk. For example, a company that will need to buy a quantity of iron ore in a month's time may be concerned that the price may go up. It can buy an option to purchase that quantity or some part of it at an agreed price. The cost of the option is comparable with the cost of an insurance policy.

Futures and options also provide investors with additional places to put their funds. The focus of such 'traders' is on favourable changes in the price of the instrument. Derivatives of these kinds are attractive to speculators because they represent a form of 'leveraging', in that they provide the investor with means of gaining an interest in a quantity of underlying tradable item even though they lack the funds to actually acquire them. In these ways, more players and funds are drawn into the market than would otherwise be the case, and hence the volume, the market depth and the fungibility of the commodity are enhanced. Because futures and options attract large numbers of traders rather than the relatively small number of parties directly interested in the tradable item's intrinsic value, derivatives appear likely to account for a substantial proportion of carbon-related trading.

A range of other derivatives exist, and more can be dreamt up, which can be referred to as 'complex derivatives' or 'structured derivatives'. At least among some categories of investors, there may be resistance to complex derivatives for some years following the 2008 global financial melt-down, because complex derivatives that built on (and obscured) highly insecure 'sub-prime' mortgages were a large factor in the collapse.

4 Market Mechanisms

Given that tradable items exist, means are needed to conduct transactions that achieve exchange of those tradable items against cash, or against other goods or services. This section briefly outlines some relevant theory, and then applies it to the various categories of tradable carbon identified in the preceding section. It is necessary to distinguish the initial sale of tradable items from subsequent trading in them.

4.1 Theory

A market is a context within which goods and services are transferred from entities that have them to entities that want them. Key functions that the context must support are mutual discovery by buyers and sellers of one another and their offerings and needs, and the facilitation of transactions.

The term 'market' was originally close to synonymous with 'marketplace', and associated with physical locations. The term 'marketspace' is convenient as a means of distinguishing the virtual contexts that have been enabled by advances in information technology, that have greatly extended market reach and thereby enhanced market depth, and that are the subject-matter of eCommerce (Rayport & Sviokla 1994, Clarke et al. 2000, Weill & Vitale 2001, Clarke 2001).

Marketspace transactions commonly comprise exchange of value between two parties, facilitated by infrastructure, perhaps mediated by a marketspace operator, perhaps also mediated by agents or brokers, and perhaps supported by service providers. Exchange is usually reciprocal (but may involve indirect recompense, or even no recompense at all) and immediate (but may be deferred). The tradable items that are exchanged may be goods, services, or cash of some kind (Clarke et al. 2000). A two-sided goods and services exchange is called 'barter'. A two-sided cash exchange is called 'currency conversion'. A transaction with goods or services on one side and cash on the other is called a sale or a purchase, depending on which party's perspective on the transaction is adopted.

A primary characteristic of an effective market is sufficient scale to attract at least parties that perceive intrinsic value in the tradable items, and preferably also traders. Scale involves not only sufficient parties but also sufficient transactions. From the point of view of traders, a degree of price-volatility is essential (because their interest is not in the intrinsic value of the tradable items but in the prospect of profit from price variations).

Another important feature is comprehensibility. The scheme as a whole must be sufficiently coherent that buyers, sellers and other actors believe that they understand it sufficiently well to make reasoned business judgements.

A wide range of alternative market-mechanisms exist whereby trading can occur. Some schemes are inherently to the advantage of the seller (e.g. catalogues with fixed prices,

and auctions of various kinds such as English and Dutch, whose purpose is to stimulate competition among would-be purchasers and hence a high sale-price). Other mechanisms are inherently to the advantage of the buyer, and include Request For Proposal (RFP), for Tender (RFT), and for Quotation (RFQ).

Some market designs, on the other hand, are balanced, and encourage buyers and sellers, and especially traders (who are successively buyers and sellers, often repetitively so), by avoiding inherent bias in favour of either party. Common forms of balanced market are negotiation processes and clearinghouse auctions, also known as exchanges.

Different forms of trading are appropriate to different categories of tradable items (Clarke 2001). For tradable items that are commodities, or that have been commoditised, there may be no further attributes that need to be negotiated beyond quantity and price, and hence the trading mechanism is essentially a price-setting mechanism. In those circumstances, the efficient and equitable processes of an exchange are likely to be attractive to all parties.

4.2 Trading of Permits, Credits, Offsets and Derivatives

Many of the government reports on ETS design have been dominated by economists and appear to have had little input from eCommerce practitioners. This sub-section applies the eCommerce theory and practice outlined above to carbon trading.

The clearinghouse auction or exchange process is appropriate for the trading of commodities. In a clearinghouse auction, both buyers and sellers submit bids to a market-space operator. Where an offer to buy corresponds to an offer to sell, the market-space operator 'matches' them. Buyers and sellers do not generally know, nor need to know, the identity of the other party to the transaction.

A range of variables exist, which need to be resolved in ways acceptable to all parties. For example, bids may match on price but not on size; and multiple offers to buy may be matchable with multiple offers to sell, and hence rationing has to be applied. The sequence in which matching is performed needs to be practical, but also transparent and perceived to be equitable. Mature exchanges include facilities whereby buyers and sellers are at least partly protected against default by counter-parties, by the market-space operator and by agents.

Where substantial turnover is achieved, further challenges arise. Price changes occur naturally, e.g. as a result of seasonality in supply and demand. This attracts traders into the market, seeking a turn on the rate. Where a commodity is bought and sold on multiple exchanges, prices may vary between exchanges and hence opportunities for arbitrage exist. This attracts day-traders, seeking short-term returns. Particularly in thin markets, the scope exists for a player to 'corner the market', put buyers on drip-feed, and hence achieve very high prices. The combination of inherent and extraneous factors is liable to produce price volatility, by which is meant substantial swings in price that do not appear rational to an observer, and particularly not to parties that are interested in the intrinsic value of the tradable item.

Subject to these many provisos, eCommerce theory is broadly supportive of the assumptions of ETS designers to the effect that exchanges will be readily able to facilitate trading in suitably-designed carbon-related tradable items.

4.3 Initial Sale of Permits, Credits and Offsets

For trading to be possible, the initial owner of a tradable item has to make it available for purchase by others. This section considers the initial sale of each of the categories of tradable item involved in carbon trading.

Permits are created by a government authority, and the conventional approach is to release them on a progressive basis. During the start-up phase and as a result of political manoeuvring, they may be gifted to emitting organisations; but in principle they should be sold. The manner in which they are sold needs to stimulate sufficient subsequent turnover to ensure that a current 'carbon price' is known at all times, and is sufficiently high to stimulate investment aimed at achieving emission reductions.

It would be feasible for the issuing authority to simply publish on an exchange an offer to sell. If an established market already exists, then this may be appropriate; but that by definition cannot be so in the case of initial offerings, and may still not be so with, say, the second and third of five quarterly tranches. It would therefore be necessary for the authority to determine the offer-price unilaterally. Setting the offer-price considerably lower than buyers' expectations risks a 'give-away' and windfall profits for those lucky enough to have their offers to buy matched with the under-priced offer to sell. Setting the price considerably higher than buyers' expectations risks little or no sales occurring and hence the absence of a market. This could be addressed by starting high and gradually lowering the price of the offer to sell until sufficient matches were achieved. On the other hand, it may be better to acknowledge that a clearing-house auction is not the appropriate market mechanism to suit the particular purpose, and adopt another instead.

Various seller-driven mechanisms offer advantages over the balanced mechanism of an exchange. English auctions are feasible, but it is likely (and desirable) that there will be many bidders seeking only part of the available quantity; and hence a complex set of rules may be needed to ensure clearance of the available permits in an equitable manner.

Alternatively, sealed-bid auctions may be preferable. In this case, the bids from offerors are simultaneous rather than serial, and non-visible rather than open. It is feasible to design the bidding rules such that bidders can make multiple alternative bids, indicating different volumes that they are prepared to purchase at different prices. Alternatively, multiple rounds of simultaneous sealed bids could be permitted, with publication of the aggregate of the offers received after each round. This would enable later-round bids to take into account the earlier offers. Where multiple, related tradable items are being issued (such as the last 20% of the current year's permits and the first 20% of the following year's permits), bidders may wish to make multiple alternative offers in each round.

Such arrangements require that bidders have a considerable level of sophistication, and are only likely to attract sufficient players if the rewards are perceived to be substantial. There are two main ways in which that might be the case: a contrivance whereby the permits are sold at a discount from the apparent market price (e.g. payment 10% below the final bid price – which is likely to be factored into bids anyway), or the prospect of sufficient price-appreciation or price-volatility.

In the case of credits and offsets, it is tenable for offers to sell to be published on an exchange. On the other hand, alternative approaches appear likely to yield better results

for the originators of credits and offsets. Either an English Auction or a sealed-bid auction (RFT) could be applied. In practice, many projects that give rise to credits and offsets are likely to involve large scale and long time-periods. It therefore appears likely that credits and offsets may be the subject of long-term contracts between the originators and the purchasers, with purchasers and their consultants involved in the initiation and conduct of the project.

5 Operational ETS

This section provides a brief overview of ETS that have been implemented, or planned at a sufficient level of detail that they appear reasonably likely to be implemented. In each case, brief observations are provided from the perspective of eCommerce theory, in order to indicate potential areas of future research.

Following the Kyoto Agreement, the European Commission created the EU ETS (EU 2003). It ran in an intentionally preliminary form from 2005 until 2007 (Phase I). It moved into a transitional form on 1 January 2008, which will run until 2012 (Phase II). "It currently covers over 10,000 installations in the energy and industrial sectors which are collectively responsible for close to half of the EU's emissions of CO₂ and 40% of its total greenhouse gas emissions" (EU 2008b). The EU envisages that a mature scheme will be operational from 2013 (Phase III). Official overviews are provided by UN (2007) and up-to-date information is at EU (2008a).

Multiple exchanges support trading within the EU in permits, credits and derivatives. An early analysis is Hasselknippe (2003), and a catalogue of exchanges, and data on turnover volumes, are maintained by the Norwegian company Point Carbon.

Several aspects of the experience in the EU have been negative (e.g. NETT 2007, pp. 245-250). In particular, throughout Phase I and still during Phase II, almost all of the available permits have been issued gratis to polluters. Considerable uncertainty arose concerning aspects of the scheme's design and operation. A great deal of price volatility was experienced, which analysts attributed primarily to the over-allocation of permits combined with the lack of 'intertemporal flexibility' (in theoretical terms, the durability) of the instruments (DCC 2008a, p. 146). Then, towards the end of Phase I, the price of permits collapsed, as it became apparent that some governments were not committed to enforcing requirements on polluters.

On the other hand, some credibility has been salvaged, and a considerable volume of trading has occurred, about 80% of it in derivatives, during both Phase I and the early stages of Phase II. Germany commenced selling permits into the open market in January 2008, and the U.K. conducted its first auction of permits in November 2008. However, even in those countries, only a small fraction of the permits are being sold at this stage – 9% and 7% respectively (EU 2009).

Elsewhere, the New Zealand Parliament passed legislation in 2002, 2006 and 2008, whose intention was to enable progressive development of an ETS (FL 2009). There was a change of Government following the election in November 2008, however, and at the date of writing the whole matter was before a Parliamentary Committee (NZPSC 2008).

In Australia, a series of studies was undertaken (NETT 2007, PMC 2007, Garnaut 2008). In July 2008, the Rudd Government committed to the commencement of trading

in 2010 (DCC 2008a). Details of the Government's policy were published in a White Paper in December 2008 (DCC 2008b). The scheme's design is broadly consistent with the EU ETS, but it differs in specific ways. Several of the differences are intended to achieve greater temporal flexibility, in an endeavour to avoid excessive price volatility. A proportion of permits will be gifted but the remainder sold, released progressively by means of monthly auctions of current and near-future vintages of permits. The government intends to itself conduct the sale of permits, using much the same auction mechanism as is used for government bonds.

In addition to Kyoto-compliant ETS, voluntary schemes to achieve emission reductions have operated since about 2000 in a number of countries, including The Netherlands (Boots 2003) and N.S.W. (NETT 2007, p. 188-195, NSW 2008). A UK ETS operated on a voluntary basis 2002-06 (DECC 2006). The UK Government claimed it to have been the world's first economy-wide greenhouse gas emissions trading scheme.

A predecessor to carbon trading exists in the USA in the form of the Acid Rain trading program, which was instigated in 1990 in relation to sulphur dioxide emissions (EPA 2008). During the Bush Administration 2001-2008, similar voluntary schemes emerged addressing GHGs (Lynne & Krause 2001, Ellerman et al. 2003, Hansen 2008). Trading commenced in 2003.

The instruments and mechanisms used in the US and other voluntary schemes are quite different from those in other ETS. As a result, voluntary schemes are at risk of remaining islands that cannot be integrated with Kyoto-compliant ETS. This threatens the achievement of sufficient scale, and raises the spectre of international tensions or rivalry undermining fulfilment of the policy purpose.

6 Conclusions

Viewed from the perspective of eCommerce theory and practice, it is unsurprising that the early implementations of ETS have had limited success. On the basis of the preliminary survey reported on in this paper, crucial factors include care in the design of the tradable items, open-ended currency of permits to provide a deeper and more flexible market, assurance that the items' intrinsic value is not undermined by weaknesses in the enforcement regime, limited issue of gratis permits, care in the choice of market-type for the initial sale of permits, regulatory power and action to avoid behaviour detrimental to the policy objectives, and avoidance of complex derivatives whose impact on volatility and credibility are likely to be negative.

If human activity is indeed significantly exacerbating climate change, carbon trading by means of ETS is a vitally important initiative, and eCommerce researchers should be paying attention to it. They have not done so to date. This paper provides a platform whereby research can be undertaken into specific topics within the broad field, by the author and the author's associates, and by others.

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