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THE ROYAL SOCIETY

An overview of a free-market approach to climate change and conservation

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This paper describes the convergence of environmental and financial markets, reviews the evolution of market-based environmental programmes as an example of the seven-stage evolutionary process witnessed in a variety of markets and summarizes the emergence of greenhouse-gas-mitigation markets and their potential role in advancing land stewardship, biodiversity and other environmental services.

Emissions trading has been developed to meet the demand to reduce pollution while avoiding economic disruption. Consistent with the seven-stage pattern of market evolution, the US programme to reduce the damage from acid rain established a standardized environmental commodity, developed 'evidence of ownership' necessary for financial instruments and provided the infrastructure to efficiently transfer title. The success of the system in reducing pollution at low cost has provided a model for other market-based environmental protection initiatives.

The demand for cost-effective action to reduce the threat of climate change has initiated the same evolutionary process for markets to reduce greenhouse-gas emissions. Many of the land- and forest-management practices that can capture and store atmospheric CO_2 can also provide other environmental benefits, such as biodiversity preservation and enhanced water quality. The presence of a carbon-trading market will introduce a clear financial value for capture and mitigation of CO_2 emissions, thus introducing a new source of funding for land stewardship and forest rehabilitation. The market is now emerging through a variety of 'bottom-up' developments being undertaken through governmental, multilateral, private-sector and non-governmental-organization initiatives.

The extension of markets to other emerging environmental issues is now underway, and the linkages between environmental sustainability and capital markets are being more deeply understood. The early evidence indicates that environmental sustainability can be compatible with maximization of shareholder value.

Keywords: free market; climate change; conservation; greenhouse-gas-mitigation markets

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1. Introduction

The last decade of the 20th century witnessed the convergence of environmental protection initiatives and financial markets. Market-based mechanisms such as emissions trading have become widely accepted as a cost-effective method for achieving environmental improvements.

Historical precedent seems to indicate that the evolutionary nature of markets follows a concise seven-stage process. The evolution of environmental markets is undergoing a process similar to that experienced by other established or 'mature' markets. Examples can be drawn from the equity, commodity and fixed-income markets. More recently, the seven-stage process can be observed in the emergence of sulphur dioxide trading under the Acid Rain Programme in the US.

As societies move towards a carbon-constrained world, greenhouse-gas-emissions (GHG-emissions) trading is gaining acceptance by the private sector and governments as a cost-effective way to reduce the risk that human-induced climate change is causing. Therefore, we are witnessing the same evolutionary process in the case of CO_2 emissions.

The benefits of using market mechanisms such as emissions trading can also be seen in the field of conservation. Carbon sinks such as forests can play a major role in the protection and enhancement of habitats, thus contributing to overall environmental gains in the form of improved water quality and biodiversity preservation (Walsh 1999).

In the near term we can expect that the convergence of environment and finance will take the form of a greater interrelationship between a corporation's financial performance and its environmental management, as well as increased use of market-based mechanisms to address such issues as water quality and fisheries.

2. The emergence of emissions trading

The past decade has seen the convergence of environmental and financial markets in the form of the 'commoditization' of natural resources such as air and water. These resources have traditionally been treated as having a 'zero' price, which encouraged over consumption and contributed to the problem sometimes referred to by economists as 'the tragedy of the commons.'

The principle behind the market-based approach is to treat the environment as a truly scarce resource by establishing limits on its use. The use of a property-like instrument—such as emissions allowances and offsets—provides a mechanism that can ensure efficient use of the resource and yields a price in a market that was previously not available. The price of tradeable emission rights signals the value society places on use of the environment and denotes the financial reward paid to reduce those emissions. Importantly, these rewards are received by those who own the property rights in the resource and therefore are most likely to manage it efficiently. Certainty as to ownership, and legal title, is fundamental both to the success of the market and to ensuring that the value of the resource is realized by those entitled to it. This not only avoids the 'tragedy of the commons', but also liberates new capital that can be dedicated to environmental improvement (see De Soto 2000).

Emissions trading has its intellectual roots in a seminal article by Nobel Laureate Ronald Coase, entitled 'The problem of social cost' (Coase 1960). Coase argued that assigning property rights to public goods will yield a socially efficient use of resources, even when externalities are present. Once rights are assigned, parties can negotiate—given perfect information and low transaction costs—through the market to achieve an optimal usage of common property resources. The assignment of rights and the means by which they can transferred are the function of property laws and market regulations. Once these are present, together with agreed terms of trade, the market can operate freely, allowing buyers and sellers to adjust their needs as best suits their individual requirements.

These market-based mechanisms represent a movement away from highly prescriptive environmental policies that are thought to impose higher compliance costs compared with more flexible regulations. It is widely believed that traditional 'command and control' regulations fail to exploit the least-cost opportunities to cut pollution, and do little to reward innovative pollution avoidance and reduction efforts. The goal of market-based regulation is to reduce the cost of achieving a given pollution-reduction target or, equivalently, to realize larger pollution reductions at the same cost. The cap-and-trade emissions-trading approach exploits differences in pollution-mitigation costs faced by different emission sources. Trading uses a price signal and profit motive to encourage the sources that can cut pollution most cost effectively to take advantage of their comparative advantage and make more of the overall pollution cut. The goal is to help society find and move along the least-cost pollution-reduction supply curve. From a political economy perspective, by lowering the unit price of cutting pollution, emissions trading is thought to increase the quantity of pollution reduction the public is willing and able to purchase. In addition to the transparency and accountability features of trading systems, improved affordability of environmental protection is one of the central reasons emissions trading is gaining greater acceptance.

3. Historical evolution of markets

In order to better understand the current state of environmental markets, it is useful to examine the historical development of other 'mature' markets. The history of markets indicates that their evolutionary path follows a concise seven-stage process. Examples can be drawn from the equity, commodity and fixed-income markets (Sandor 1992). More recently, the seven-stage process can be witnessed in the emergence of sulphur dioxide trading under the Acid Rain Programme in the US.

To understand how markets can evolve, we present a seven-stage process that helps describe the many forces that accrue over time and sometimes develop into more sophisticated and efficient markets. The steps can be characterized as follows.

(1) The occurrence of a major structural change that creates a demand for capital.

(2) The creation of uniform standards for a commodity or security.

(3) The development of a legal instrument that provides evidence of ownership.

(4) The development of informal spot markets (for immediate delivery) and forward markets (non-standardized agreements for future delivery) in commodities and securities where 'receipts' of ownership are traded.

(5) The emergence of securities and commodities exchanges.

(6) The creation of organized futures markets (standardized contracts for future delivery on organized exchanges) and options markets (rights but not guarantees for future delivery) in commodities and securities.

(7) The proliferation of over-the-counter markets and deconstruction of traded instruments.

Within this framework, we present some historical examples of the market-evolution pattern for equities, commodities and fixed-income securities, and we consider its application to environmental markets.

4. Examples of the seven-stage process

In 1492, the 'discovery' of America (from the European perspective) created a tremendous structural change. The Age of Discovery demanded a great amount of financial capital, as business activity expanded in both the New World and between Europe and Asia. An important byproduct of this era was the formation of the Dutch East India Company. This was a critical innovation, which led to the acceptance of the limited liability corporation. Before that, there were 'partnerships' that raised capital, but it was the limited liability corporation and the development of transferable equity shares that provided a standard instrument and the evidence of ownership. Its use ultimately led to trading on a number of regional exchanges in and around Amsterdam, followed in the 16th century by the development of futures and options trading on these shares.

In the case of agricultural commodities, the removal of restrictions on grain imports into England and the Crimean War acted as the structural changes, stimulating grain production in the US, which became a large exporter of agricultural goods. Growth in demand for grain continued as the US population reached 35 million by the end of the Civil War. Capital was needed to finance the storage and shipment of grain from the Midwest to the major population centres in the East Coast. At that time, there was unorganized trading in physical sacks of grain, which had to be inspected on an individual basis. The creation of the Chicago Board of Trade in 1848 ushered in grain standards and grading procedures, an innovation that preceded the creation of government standards by 50 years. Ultimately, a tradeable legal instrument called the 'warehouse receipt' emerged, which provided evidence of ownership and facilitated both capital raising and ownership transfer. The birth of futures trading in 1865 was followed by options trading at a later stage.

A more modern example of the market evolution pattern is the fixed-income market for mortgage-backed securities. The post-World War II economic boom in the US created a great demand for housing in California, which had to be financed by institutions in the eastern part of the country. Although standardized mortgages guaranteed by the Federal Housing Authority (FHA) and the Veterans Administration (VA) assured capital flows into the sector, it was a highly inefficient market. Mortgages were sold on an individual basis or in small packages and the buyer had to have individual documentation for each loan. The 'credit crunch' of 1966 and 1969 and the uncertainty surrounding the timely payment of the principal and interest during foreclosures gave rise to the formation of the Government National Mortgage Association (GNMA). This enabled the 'bundling' of small loans into securities to be collateralized by the FHA/VA and backed by the US government. It provided an efficient and homogeneous evidence of ownership and conveyance vehicle, which ultimately evolved into spot and forward markets, primarily among Wall Street dealers and mortgage bankers. This informal arrangement served the function of an exchange until the world's first interest-rate futures contract—based on the GNMA mortgage-backed instrument—was launched at the Chicago Board of Trade in 1975. From that date, financial futures secured acceptance and ultimately, in the 1980s, so did collateralized mortgages.

Therefore, looking at equities, physical commodities and fixed-income instruments, and examining their development from the 16th to the 20th century, indicates that they all follow the pattern of market evolution we have outlined. We are now on the verge of a whole new field of tradeable products in the form of environmental contracts and derivatives (Sandor 1999).

The example from the SO_2 market in the US is particularly informative. A latent demand for this market in abating sulphur gases resulted from a significant increase in the burning of high-sulphur coal by electric utilities in order to satisfy the demand for electricity. Increased pollution in the form of sulphuric emissions accompanied the increased output of electricity. Generated in more densely populated sections of the US, this pollution resulted in large increases in respiratory problems for affected populations. In addition, acidification damaged rivers, streams and forests. Latent demand became effective demand as public concern over human health and environmental problems motivated legislators to pass the Clean Air Act Amendments (CAAA) of 1990.

As the examples below show, the CAAA simultaneously performed three functions.

(1) It standardized an environmental commodity (a legally authorized allowance to emit one tonne of sulphur dioxide).

(2) It produced the 'evidence of ownership' necessary for financial instruments.

(3) It established the infrastructure to efficiently transfer title.

The system has been highly successful and has achieved more reductions than the law requires at costs that are an order of magnitude lower than the highest forecasts. There has not been an incident of non-compliance in almost seven years of the programme's existence. Studies by the General Accounting Office and non-governmental organizations put the annual costs of the programme at \$1–2 billion, while the health benefits have been estimated to range from \$12 billion per year to \$40 billion per year, according to a US Environmental Protection Agency (USEPA) report. Compliance flexibility and trading have lowered compliance costs more than 75% compared with initial forecasts.

Figure 1 shows the average forecast compared with actual allowances prices at the annual USEPA auction over the course of the acid-rain programme. Prior to enactment of the CAAA, industry studies forecast compliance costs as high as \$1800 per tonne of SO_2 reduction, with most forecasts in the \$300–1000 per tonne range. In reality, allowances, or emission permits, currently sell for less than \$200 per tonne and have averaged *ca.* \$130 at the annual EPA auctions held at the Chicago Board of Trade over the programme's life. Motivated by the ability of a company to 'bank' excess allowances, reductions in excess of what is required by law have been achieved.

There has also been steady growth in the trading of allowances, from 700 000 tonnes in 1995 to *ca.* 12 million tonnes in 2001. The market has now reached a value

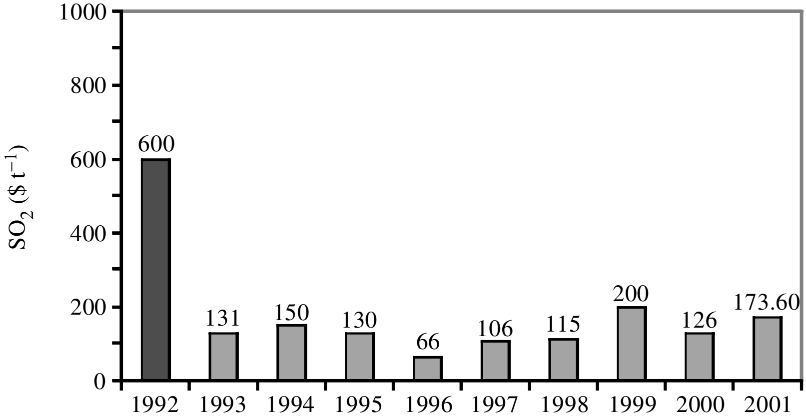

Figure 1. SO_2 price forecast and auction results. (The figure of $600 for 1992 is the median forecast from Hahn & May (1994). Auction prices from the Chicago Board of Trade and USEPA (1999).)

of *ca.* $2 billion each year for registered trades. Environmental Financial Products estimates that, in addition, there may be $2 billion a year in derivatives such as options, forwards and other unregistered trades.

The programme works because acid rain is a regional problem and multiple sources contribute to the problem. It relies on a fixed environmental goal—an emissions limit, or cap. Direct monitoring of emissions is used both to verify that the cap is achieved and to insure the value of the tradeable allowances. The relevant variable to be measured is the total loading of SO_2 emissions in the atmosphere, not emissions from an individual source. Violations of SO_2 air-quality standards will prevent a company from buying allowances. The emission-monitoring protocols are clearly established by law. Differences in mitigation costs across sources contribute to costs savings.

Cap-and-trade emissions-trading systems are successful from both an environmental and economic viewpoint because they provide industry with the flexibility in method, location and timing of emission reductions. The entrepreneurial skills of industry are harnessed for pollution reduction. The system provides direct financial incentives for least-cost solutions and technological innovation to reduce emissions. All of these characteristics of a successful emissions-trading programme may be applied to GHGs.

5. The emergence of an international emissions-trading market for GHGs

The evolution of environmental markets undergoes a process similar to that experienced by other established or 'mature' markets. We believe there is a case for extending what we have learned in the SO_2 cap-and-trade programme to other areas, mainly global warming.

It might be useful to frame this discussion in light of what the eminent economist Joseph Schumpeter called the three phases of the inventive process: invention, innovation and imitation (Schumpeter 1942). The first is the creation of the idea. The second is innovation, which is the commercialization of the idea. The third is the diffusion or replication and the widespread use of the idea. Economists and business leaders have long been concerned with the process of invention and innovation. Although the primary areas of attention have been in the industrial arts, students of technological change would probably agree that non-patentable creative activity in the economic and financial markets has spawned significant social benefits. Simple examples of financial innovations that have had immeasurable impact include the development of double-entry bookkeeping and the limited liability corporation. These may indeed rank with industrial inventions such as the steam engine, or even the semiconductor.†

With the success of the sulphur-trading programme and other environmental markets, such as the market mechanisms established under the Montreal Protocol to deal with ozone-depleting substances, trading in GHGs represents the replication or imitation phase. Emissions trading is a market-based option that has been proven in solving other pollution problems. It should be applied to limiting emissions of CO_2, methane and other heat-trapping GHGs. Emissions trading has become a more widely accepted approach to the climate-change issue and it also might help provide incentives to support efforts to enhance biodiversity conservation.

The scientific community still debates whether the potential warming of the planet is natural or human induced. Nonetheless, there is a general consensus that the rapid increase in the atmospheric concentrations of GHGs introduces the risk of fundamental and costly changes in the Earth's climate system. While the exact nature, timing and magnitude of the expected climatic changes cannot be predicted with certainty, the nature of the risks includes more severe drought/precipitation cycles, longer and more extreme heat waves, spread of tropical diseases, damage to vegetation and agricultural systems due to comparatively rapid climate shifts, and threats to coastlines and coastal properties due to higher sea levels and storm surges.

In the United Nations Framework Convention on Climate Change (UNFCCC), ratified by most of the nations of the world, industrialized countries agreed 'to aim to reduce' GHG emissions to 1990 levels by the year 2000. At the Third Conference of the Parties to the UNFCCC (COP-3), the Parties agreed to the Kyoto Protocol. Broad acceptance of trading was reflected in its text. The central goal of the Kyoto Protocol is to slow the human contribution to increased atmospheric concentrations of CO_2. The Protocol specifies quantified emission limits for developed countries, as well as the further articulation of the economic mechanisms of emissions trading, Joint Implementation and the Clean Development Mechanism (CDM), and the role of carbon sequestration or 'sinks'.‡

6. Benefits for conservation

The Kyoto Protocol's goal of slowing the pace of rapid climate change would, on its own, provide an enormous service towards the preservation of biological diversity. More directly, Kyoto acknowledged that carbon sinks, such as forests and soils, act to capture and store atmospheric CO_2. An immediate opportunity to provide financial support for conversation can arise from a GHG-emissions-trading system.

† Economics Nobel prize winner Kenneth Arrow made this observation in the 1970s in Chicago.

‡ During the Sixth Conference of the Parties (COP-6) second meetings in Bonn in July 2001, the Parties to the Convention (excluding the US) agreed to allow reforestation projects under the CDM, to develop some simplified CDM procedures and to allow some credits for sequestration resulting from reforestation as well as from forest and soil management in developed countries.

This emerging market can be harnessed to help finance reforestation and encourage improvement in agricultural soil quality and agricultural watersheds. To the extent that the Kyoto Protocol can be implemented in ways that provide financial support for these efforts, protection and expansion of habitats that support biological diversity will be enhanced.

The presence of an emissions-trading market will introduce a clear financial value for GHG emissions released or captured. A new and visible price will be associated with the carbon-mitigation environmental service produced by expanded forest stocks and increased soil sinks. New and expanded forests and soils sinks can earn a direct cash award in the carbon-mitigation market. This opportunity to profit in the emissions-trading market (by selling emission credits to those entities who find it less costly to outsource part of their emission-mitigation commitment) provides a new source of funding for activities that will also protect biological species. This is an indirect market in support of biodiversity, but a potentially powerful one nevertheless (Walsh 1999).

Traditional approaches to habitat protection, national parks and other limited-use areas are often resented, particularly in areas with substantial population growth and limited alternative sources of income. By excluding local people and limiting or preventing their use of the resources, these methods encourage illegal activities, including poaching and logging, stimulate costly and often destructive internal migration and encourage the misuse of resources. These negative externalities are avoided and positive externalities achieved when the value of the environmental services of the area are fully realized and that value is received by local people. Where, for example, the value of growing forests exceeds their value as sources of timber or fuel, they are protected with the concomitant effects of preserving watersheds, wildlife habitat, biodiversity and amenity. This not only provides additional income, but it also encourages sustainable use of the resource and employment. New opportunities for sustainable harvest of natural products, ecotourism and horticulture arise or are enhanced. Local people thereby become stakeholders in their environment rather than trespassers on it (see Schumpeter 1942; Saunders *et al.* 2002).

The potential for emissions-trading solutions can be extended to agriculture and forestry. Taking US agriculture as an example, farmers can offer a highly effective system for capturing or 'sequestering' carbon from the atmosphere. A major means of sequestering more carbon in cropland is through best-management practices. The most effective and readily available methods for increasing the amount of carbon stored in soils is a set of activities referred to as 'conservation systems'. Most important among these are the various forms of conservation tillage. Crop roots and stalks are left in place, thus reducing soil venting (and carbon release) effects of conventional tilling practices. Low- and no-till practices lead to a substantial increase in the amount of carbon built up and stored in soils (Sandor & Skees 1999).

Conservation-tillage practices also provide a wide range of terrestrial and aquatic habitat benefits, ranging from less erosion and less herbicide and water run-off compared with fields where conventional plowing is done. In addition to improving local water habitat, the prospect of basin-wide improvements in water quality can help reduce large-scale regional problems. In the case of developing countries, by increasing the carbon content of soil and providing increased crop yields, conservation-tillage practices may help to avoid pressure to convert forests to croplands.

Table 1. *Government and multilateral GHG-emissions trading initiatives*

(UNCTAD denotes United Nations Conference on Trade and Development; OECD, Organization for Economic Co-operation and Development; UNEP, United Nations Environment Programme; UNDP, United Nations Development Programme; UNIDO, United Nations Industrial Development Organization; CDM, Clean Development Mechanism; AIJ, Activities Implemented Jointly.)

international agency initiatives	emerging plurilateral trading groups	national GHG-emission trading and CDM/JI programmes or proposals
World Bank Carbon Fund	*Umbrella Group*	UK
UNCTAD Global Policy Forum	Japan	Denmark
OECD Workshops & Research	US	EU
International Energy Agency	Canada	Germany
UNEP	Australia	Norway
UNDP	New Zealand	Netherlands
UNIDO	Iceland	US
European Commission	Norway	Canada
Nordic Council	Russia	New Zealand
	Ukraine	Russia
	EU	Ireland
	North America	Slovakia
	US	32 host countries with CDM/AIJ offices or projects, including Costa Rica, Brazil and Central America
	Mexico	
	Canada	
	Baltic countries	

If managed properly, participation in the international carbon market could soften farm-income cycles by taking land out of crop production and putting it into conservation when relative prices favour carbon sequestration over food production. Leading scientists expect that climate change brought about by increased GHGs may bring more extreme draughts and floods. Thus farmers and foresters cannot only sell a new ‘crop’ in the international environmental service market, they can also help solve a problem that threatens their own livelihood.

7. The emerging market for GHG-emission reductions

Markets for GHG-emissions trading are emerging around the world despite uncertainties regarding the Kyoto Protocol and the likelihood of an international regime created by the United Nations. However, these emerging markets, and an international market linking them, are still in their infancy. The standards or protocols for monitoring, verification, legal contracts, trade documentation and eligibility of offsets are not yet in place. There are no organized exchanges or clear market prices. Each transaction is different, leading to high transactions costs. In short, the commodity, and the trading of it, are now moving through the seven-stage process (Sandor & LeBlanc 2002).

Nonetheless, the amount of activity related to GHG-emissions trading is significant. Table 1 indicates some of the initiatives undertaken by international agencies, such as the World Bank Carbon Fund and the research and support activities of the United Nations and European umbrella organizations, as well as programmes and proposals of national governments and emerging groups of national trading partners.

Natural trading partnerships are developing. The evolutionary process of market development also mirrors the history of international political cooperation. International agreements tend to grow from small beginnings—the European Coal and Steel Community has evolved to the Common Market and, now, the European Monetary Union. In the case of carbon trading, a group of countries is beginning to coalesce into what we call a 'plurilateral' trading regime, involving a system of conventions and regulations evolving first among a small group of countries. In the context of the Kyoto Protocol negotiations, these include the Umbrella Group, consisting of the US and countries that sided with it in supporting unrestricted use of trading mechanisms and sinks and the countries of the EU, which took an opposite stance on trading issues. However, the EU released a proposal at the end of October 2001 to establish an emissions-trading programme to start in 2005.

At the national-governmental level, the UK launched an emissions-trading system for GHGs in early 2002, developed by the government and a consortium of businesses known as the Emissions Trading Group. The British government has also indicated that it will attempt to merge this initiative into the pilot EU programme with as little friction as possible.

Efforts are also under way in the Netherlands, where the government plans to launch a CO_2-trading system by 2004–2005, and in Germany, where a public–private task force is preparing a proposal for a trading system design. In Japan, a working group comprised of members of the public and private sector has been meeting to discuss setting up an emissions-trading market. Denmark launched the first national domestic GHG-emissions-trading market, but it was limited to the power sector.

Bipartisan support to take domestic action is gaining momentum in the US Congress. Senators McCain (Republican, Arizona) and Lieberman (Democrat, Connecticut) recently announced support for an economy-wide cap-and-trade system for GHGs. Legislators have advanced proposals for registries for carbon sequestered in biomass and soil. Discussions at recent hearings before the Senate Commerce and Environment and Public Works Committees indicate the interest of numerous Senators in implementing measures to reduce US GHG emissions, including implementing a cap-and-trade system for the utility sector. The Senate Foreign Relations Committee passed a unanimous resolution in the middle of 2001 calling on President Bush to return to the bargaining table to either revise the Kyoto Protocol or negotiate a new binding international agreement. Governments of New Jersey and New Hampshire and others have made specific commitments to reduce GHG emissions.

Table 2 indicates a sampling of regional and private activities and efforts to foster GHG-emissions trading.

While some state and regional governments around the world have initiated their own emissions-trading efforts in response to climate change, the activity in the private sector is perhaps more impressive.

It is estimated that tens of millions of dollars have changed hands in private GHG-emissions transactions. The private sector's response is most likely based on

Table 2. *Examples of local and private GHG-trading initiatives*

provincial, state and local-government efforts	private corporations and exchanges	examples of private transactions
US	internal trading: BP, Shell, Pemex	Nuon–GSF
Oregon	corporate emissions targets: Alcan, Pechiney, DuPont, OntarioPower Generation, TransAlta, Suncor Energy, Alcoa	SFM–Salish and Kootenai Tribes
New Jersey	Chicago Climate Exchange	OPG–PetroSource
California	Dutch Electricity Board/ FACE Foundation	Environmental Financial–Costa Rica
New Hampshire	Edison Electric Institute/ Utilitree	Ontario Power–ZAPCO
Wyoming	Hancock Natural Resources Group	BP–The Nature Conservancy (TNC)
Midwestern states	registries: Cantor Fitzgerald (www.CO2e.com), Natsource/Arthur Andersen, Environmental Resources Trust	Arizona Public Service–Niagara Mohawk
NE states and Canada	Pew Center on Global Climate Change	Suncor–Niagara Mohawk
Australia	World Resources Institute	Sumitomo–United Energy Systems (Russia)
New South Wales (NSW)	International Climate Change Partnership	Pacific Power Australia–NSW
Western Australia	International Petroleum Exchange	Tesco–Uganda forest
Brazil	Winnipeg Commodity Exchange	Waste Management Inc.–Enron
Amapá	Chicago Board of Trade	American Electric Power–TNC
Amazonas	Paris Bourse	Central & Southwest–TNC
Paraná	Dexia	Illinova–Environmental Synergy
Canada	International Emissions Trading Association	Consorcio Noruego–Costa Rica
PERT (Ontario)	WBCSD	Toyota–NSW
GERT (British Columbia)		
British Columbia		
Alberta		
International		
International Council of Local Environmental Initiatives		

the perception that GHG-emission limitations of some sort will emerge and will drive fundamental changes in energy systems, although uncertainties in terms of timing and precise rules remain.

Individual companies, such as BP and Royal Dutch Shell, have instituted internal trading programmes. Other companies, such as Suncor, DuPont, Ontario Power, Alcan, TransAlta, Pechiney and Alcoa have voluntarily adopted a limit on their emissions and are meeting the goal with a combination of internal reductions and external trading or offset purchases. Several other US, Canadian, European and Japanese

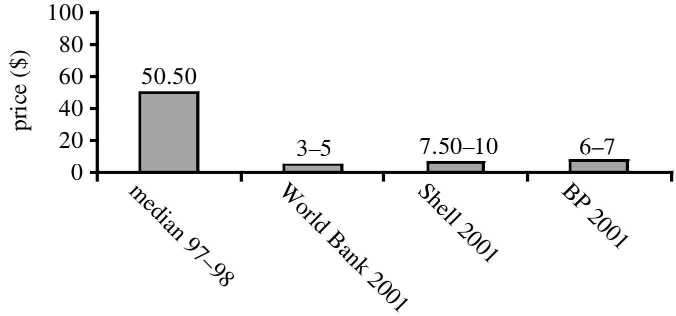

Figure 2. CO_2: 1997/1998 median price forecasts and 2001 actual trading prices ($ per tonne of CO_2). (Median forecasts from Charles River Associates, Wharton Econometrics, Professor Robert Stavins, Professor Richard Cooper.)

companies have conducted pilot trades or made investments in sequestration or other offset projects. Groups of companies have sponsored offset investments—such as Edison Electric Institute in the US and the FACE Foundation in the Netherlands. The Chicago Climate Exchange, a voluntary pilot programme for trading GHGs starting in the US, includes 52 companies and organizations that have agreed to participate in the design phase of a formal emissions-trading market. Voluntary private registries or trading platforms are also being established, which will help provide the necessary market infrastructure.

The innovative market-based tool of GHG-emissions trading is now undergoing the same evolution path observed with the history of SO_2 trading. Nonetheless, some researchers predict that GHG-emissions trading will not work. They are forecasting prices of GHG reductions to meet the Kyoto Protocol targets of the order of $200 per tonne of carbon reduced, or a total of $120 billion annual cost to the US economy. If the flexibility and incentives of emissions trading are allowed, this is likely to be an order of magnitude too high, similar to the forecasts of the cost of SO_2 reductions made prior to the enactment of the CAAA. Others estimate the cost of compliance with the Kyoto Protocol reduction schedules, assuming the full use of emissions trading, closer to $20 per tonne of carbon reduced. This translates to a total annual cost in the US of $12 billion, an amount the $9 trillion US economy could easily absorb. Figure 2 shows the median forecast for CO_2 compared with actual trading prices during 2001.

8. Other emerging environmental markets

We can also see the Schumpeterian replication stage in other emerging environmental markets. Water trading and the linkages between sustainability issues and equity performance are gaining momentum.

Water scarcity caused by pollution will provide the structural change to encourage the development of market-based mechanisms for water quality improvement. A wide range of existing pollution reduction and mitigation options suggests that market instruments can be used to aid clean-up efforts to minimize some of the environmental, economic and health problems associated with water pollution.

The relationship between a corporation's financial performance and its environmental management policies is also gaining strength. The last few years have seen the development of several funds and indices, such as the Dow Jones Sustainability Index. These sustainable-investment instruments track companies based on a set of criteria that measure their pro-activity in issues ranging from environmental performance, pollution mitigation and workforce diversity.

As the performance of many of these indices has showed, sustainability and maximization of shareholder value are compatible objectives. Many corporations understand the need to manage environmental and social risk exposure. Environmental stewardship and participation in emissions-trading programmes have opened new opportunities for the creation of profit centres and increased stakeholder gains.

9. Conclusions

Market-based mechanisms such as emissions trading have become widely accepted as a cost-effective method for achieving environmental improvements. There is growing appreciation that market-based solutions offer a low-cost method for managing environmental risks. The convergence of environmental and capital markets may offer sizable benefits for conservation practices in agriculture and forestry worldwide. Further evidence of this convergence can be found in recent developments, such as water trading and sustainable investing, which are also inherently linked to emissions trading.

History shows that market evolution follows a seven-stage process that can be observed in equities, fixed-income securities, physical commodities and the SO_2-allowance trading programme. The SO_2 cap-and-trade emission-reductions programme has been enormously successful. However, there was great scepticism at the start, much like the scepticism now being expressed about carbon trading. The sulphur-trading model can be successfully extended to GHGs. Although its international dimensions add complications, we have successful environmental precedents such as the effort to slow high-level ozone depletion via the Montreal Protocol. This issue is not daunting. Transactions in carbon offsets have already occurred and additional trading is under way. The carbon-trading history will not be unlike that of other environmental markets, where government regulation gives value to the commodity while the design and implementation are left to market forces, letting governments ratify the process.

A 'bottom-up' characterization of the development of a global market is demonstrated by the numerous initiatives and activities worldwide that promote emissions trading and GHG reductions, even in the absence of compelling rules or regulations. As more national governments institute laws and regulations for GHG emissions, multiple standardized trading systems are expected to develop. The final form of the market will likely be global, but it appears that it will emerge through the evolution and ultimate linking of individual efforts.

An effective and efficient market-based solution will become even more important as we move quickly towards a carbon-constrained world. Active use of market mechanisms could prove an inexpensive insurance policy against the unknown but potentially catastrophic problems that may emerge because of the rapid increase in global carbon emissions and other environmental degradation.

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