

Environmental policy, government, and the market

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Abstract Environmental policy is made in a context of both market failure and government failure. On the one hand, leaving environmental protection to the free market, relying on notions of corporate social responsibility and altruistic consumer and shareholder preferences, will not deliver optimal results. On the other hand, nationalizing the delivery of environmental protection is likely to fail because nation states rarely have the depth and quality of information required to instruct all the relevant agents to make appropriate decisions. Thus, as for many areas of policy, appropriate models of environmental intervention will lie between these two extremes. While it is impossible to specify general rules concerning the precise form of intervention, in part because the type of intervention depends upon value judgements, this paper sets out some of the considerations that are particular to environmental policy, and explores several principles for policy design, including information, coordination, and principal–agent problems, with a particular focus on the international context.

Key words: environmental policy, environmental markets, government intervention, cap and trade, climate change, coordination, prices

JEL classification: Q58, Q56, Q50

I. Introduction

Over the course of the twentieth century, the economic borders of the state have sporadically expanded and contracted as a consequence of war and according to the influence of different political philosophies, ideologies, and prevailing value judgements. Prior to the First World War, the state largely played a ‘nightwatchman’ role, providing basic functions such as defence and law and order (Helm, 1986). However, government involvement in the economy has climbed to record highs in recent years, with the state playing a more comprehensive role in providing social security, education, physical and mental health, and in other resource-allocation decisions.

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Most recently, the global financial crisis has led to yet further expansion of the state, with nationalizations of financial institutions, the bail-outs of the automotive sector in the United States, and a coordinated fiscal stimulus from G20 nations amounting to 1.2 per cent of their GDP (Bowen and Stern, 2010). A further relevant development has been the trend towards so-called 'state capitalism'. For instance, the 13 largest oil companies are now controlled by governments (Bremmer, 2009), with the profits often invested by sovereign wealth funds which deliver both financial returns and political influence. The rise of China, with its numerous state-owned enterprises, serves as another powerful example of the increasing trend towards state capitalism.

In Western democracies, the recent state expansion following the financial crises is intended to be temporary, and, indeed, a contraction of the state is imminent, given significantly weaker public balance sheets. All major political parties in the UK are anticipating severe cuts in spending over the next few years, if not for longer. In this context, a re-evaluation of public spending priorities, including on environmental spending, is both inevitable and necessary. In the UK, civil servants are reportedly preparing for budget cuts by examining records from the 1920s when Sir Eric Geddes cut public spending by 25 per cent.¹

This expansion and contraction of the state has significant implications for environmental policy, raising questions about the appropriate scope and role for government in protecting the environment. This issue of the *Oxford Review* considers topics relevant to the realistic design of environmental policy in the context of this shifting relationship between the market and the state. The issue places strong emphasis on accounting for both 'market failure' and 'government failure', and the contributions include considerations of the role of governments and markets in downturns and periods of economic growth (Alex Bowen and Nicholas Stern), the possibility of environmental provision by the free market (Forest Reinhardt and Robert Stavins), the role of government-created environmental markets (Michael Hanemann), the design of policy to spur environmental innovation (Richard Newell), the challenges in determining appropriate environmental prices (Simon Dietz and Samuel Fankhauser), and the critical need to address government failure (Robert Hahn and David Anthoff, and Dieter Helm) when designing environmental policy. While many of the papers in this *Review* focus on climate-change policy, other environmental issues are also pressing.² According to Rockström *et al.* (2009), biodiversity continues to be lost at an estimated rate of over 100 species per million species per year, compared to a background extinction rate of 0.1–1 species per million species of marine life and 0.2–0.5 for mammals.³ Depletion of renewable resources, such as the world's fisheries, and the scale of humanity's impact on the nitrogen and phosphorous cycles are also cause for concern (Rockström *et al.*, 2009).

This paper addresses the design of environmental policy with a focus on delineating the roles of the state and the market. The next section provides a brief general history of the shifting borders of the state and provides a highly stylized taxonomy of state intervention, before considering the specific implications for environmental policy. Section III considers

¹ *Financial Times*, 'Novice Treasury bones up on thrifty ways to make deep cuts', 8 September 2009, p. 3.

² As a thought-experiment, assume that a free, carbon-neutral source of energy is discovered tomorrow, such that climate change is solved at no cost. The marginal productivity of the other (non-energy) factors of production would increase and economic growth would accelerate, leading to even greater pressure on natural capital, such as renewable resources and biodiversity.

³ Biodiversity is important because, in addition to its intrinsic value, option values, and pharmaceutical values, it appears that so-called 'functional biodiversity' may play an important role in regulating ecosystems and shoring up ecosystem resilience (Folke *et al.*, 1996, 2004).

the extent to which firms and consumers might voluntarily internalize environmental externalities, before assessing the effectiveness of government-created markets (such as emissions trading) to address environmental problems. Section IV outlines a realistic set of expectations of government in solving environmental problems, given the inevitable political economy constraints and challenging uncertainties, and seeks to delineate an inevitably imperfect but pragmatic role for government in harnessing firms to deliver more efficient environmental outcomes. Section V considers the respective roles of nation states and the private sector within the international context, including their evolving relationships with international financial institutions. Section VI concludes.

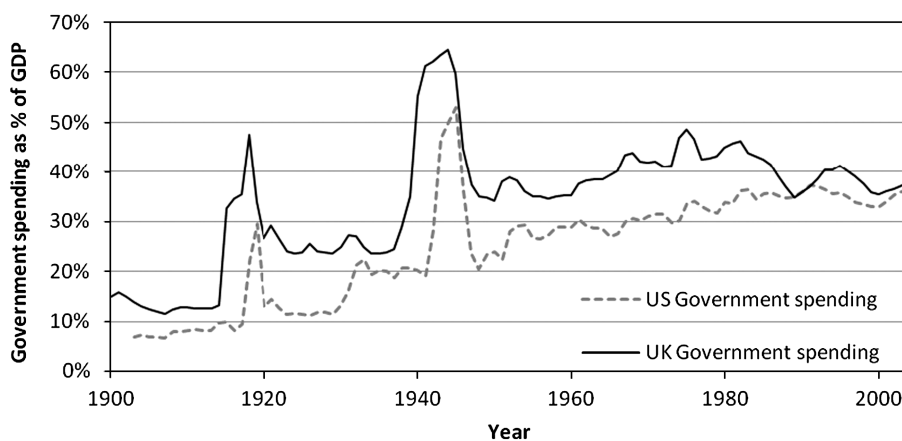
II. Shifting economic borders and environmental policy

Approaches to environmental protection, like other policy areas, reflect the prevailing value judgements about the role and size of the state. We start with a history on the role of the state in general (section II(i)) and then consider a simple taxonomy of government intervention (section II(ii)) before specifically applying this theory to environmental policy (section II (iii)).

(i) The economic borders of the state over time

There has been a striking increase in the state, as measured by government spending,⁴ over the course of the twentieth century, from around 10–20 per cent in 1900 to around 40 per cent at the beginning of the twenty-first century, as shown in Figure 1.⁵ The story is characterized by two strong increases in government spending during the First and Second World

Figure 1: UK and US government spending since 1900



⁴ An alternative measure of the extent of state involvement in the economy might be the quantity of regulation, but crude aggregate measures of the quantity of regulation are likely to be unhelpful (Helm, 2006).

⁵ Helm (1986) and the papers collected in vol. 2 no. 2 of the *Oxford Review of Economic Policy* provide excellent analyses of issues relating to the economic borders of the state.

Wars, when the rapid mobilization of capital and labour was necessarily coordinated by strong and purposeful governments. In both cases, while state involvement in the economy declined rapidly following the end of the wars, on neither occasion did it return to former levels.

During the 1950s and 1960s there was broad confidence in the ability of governments to deliver directly on public programmes, with a shared focus on reconstruction and nation-building. In the UK, guided by memories of weak government during the Great Depression, major industries were nationalized and the welfare state was established following the Beveridge Report (Beveridge, 1942). China and India began their 5-year plans, the Bretton Woods institutions were established, and ‘planning’, rather than ‘prices’, was the dominant paradigm for coordinating economic activity. As in other areas, environmental policy tended towards ‘command-and-control’ interventions, rather than setting prices and allowing individuals and firms to respond.⁶

While the state continued to grow over the 1970s, the revival of monetarist theory began to provide growing intellectual opposition to increasing enlargement. More importantly, while economic growth had financed the increasing public sector in the 1950s and 1960s, growth faltered in the 1970s with the two oil shocks and the collapse of the Bretton Woods system. These conditions ushered Margaret Thatcher into power in the UK in 1969, and Ronald Reagan in the US in 1970, with a corresponding change in political philosophy. In due course, this would also bring changes to environmental policy with the creation of environmental markets,⁷ such as the United States’ acid rain markets in sulphur dioxide (SO₂) and nitrogen oxides (NO_x) following the 1990 Amendments to the Clean Air Act.⁸

Over the last decade, the left-leaning government in the UK has enlarged the state, and has further extended its reach following the global financial crisis which served as a reminder that asset markets are subject to booms and busts and are not self-regulating.⁹ The crisis has also created doubts about market-based approaches to environmental problems. At the international level, climate-change policy appears to be moving from being predominantly market-based, relying on systems such as the Clean Development Mechanism (Hepburn, 2007), to a mixed system which includes a role for national planning, represented by the focus on ‘nationally appropriate mitigation actions’ (NAMAs) for developing countries, and the actions in the Copenhagen Accord (UN FCCC, 2009). At the European level, carbon markets and market-based renewables obligations coexist with more direct interventions on energy efficiency and renewable feed-in tariffs (Helm, 2010), and the EU has taken a relatively directed approach to the award of subsidies for carbon capture and storage plants.

⁶ Key examples of environmental legislation in the US from that period include the Air Pollution Control Act in 1955, the Wilderness Act in 1964, the National Environmental Policy Act in 1969, which created the US Environmental Protection Agency, and the Clean Air Act in 1970.

⁷ Pigou (1920) proposed pricing emissions directly through pollution taxes, and, following Coase (1960), it was realized that the allocation and trading of property rights, such as marketable emission permits, would have similar efficiency properties (Crocker, 1966; Dales, 1968; Montgomery, 1972).

⁸ See Joskow *et al.* (1998) and Montero (1999); Colby (2000) discusses markets in water and fishery rights.

⁹ Pigou (1929) argued that these fluctuations stem from little more than ‘variations in the tone of mind of persons whose action controls industry, emerging in errors of undue optimism or undue pessimism’. Arguably less mystical and more mundane explanations of the presence of large-scale socially unproductive incentives were more relevant to the 2008 financial crisis.

(ii) A general taxonomy of state intervention

The theoretical case for the ‘free market’ is typically based either on the notion that markets *instrumentally* produce better outcomes than state intervention, or that free markets are valuable *in themselves* because they relate closely to, and support, intrinsically valuable political freedoms. We will address the instrumental arguments and refer the reader elsewhere for a discussion of the ideological arguments for free markets.¹⁰

Proponents of the view that markets generate better outcomes have relied upon either the neo-classical notion of perfect competition and the theorems of welfare economics (Arrow, 1951; Debreu, 1951) or the Austrian tradition (Hayek, 1948; von Mises, 1936; Schumpeter, 1934, 1942) which stresses the evolutionary and dynamic nature of markets and the critical role of prices in communicating information and allowing individual agents and firms to self-organize within a complex adaptive economic system.

To put this into context, the degree of state involvement in delivering social outcomes (such as environmental protection) might be considered to be on a spectrum running from ‘free market’ at one end, to ‘nationalized delivery’ at the other end:

- *free market*: no government involvement; individuals and firms voluntarily acquire information on externalities and voluntarily and altruistically internalize those externalities;
- *information provision*: government assumes the role of aggregating and disseminating information about externalities and their shadow prices, but does nothing more;
- *moral suasion*: government provides information and may even seek to persuade people and firms to change their preferences and objectives.¹¹ In its best form, this might constitute a form of ‘government by discussion’. Another recently popular, but some would argue more sinister, notion is that government might influence people’s decisions by ‘soft paternalism’ or nudging people’s decisions by careful design of the ‘choice architecture’ (Thaler and Sunstein, 2003);
- *economy-wide relative prices*: government determines the appropriate price or quantity of the social good or externality (e.g. carbon dioxide (CO₂) emissions, SO₂ emissions, water effluent, biodiversity) and implements policy to correct relative prices (e.g. economy-wide taxes, trading schemes, etc.);
- *output-based intervention*: government specifies output standards for specific sectors or firms (e.g. CO₂/MW standards), but does not require the use of any particular method to deliver those standards;
- *input- or technology-based intervention*: government specifies or encourages or requires firms to employ particular technologies or inputs (e.g. SO₂ scrubbers), either through explicit regulation or through taxes or subsidies;
- *project-level intervention*: government specifies or encourages particular projects to occur, through subsidy or other financial (e.g. balance sheet) support (e.g. EU carbon capture and storage (CCS) programme);

¹⁰ Helm (1986) provides an excellent critical assessment of both strands of thought. See also Stern (1989) and Stiglitz (1989).

¹¹ Asheim (2010) provides a careful formal account of the various reasons to be cautious in the concealment or manipulation of information in an attempt to shift preferences and behaviour.

- *state capitalism*: state-owned enterprises follow guidance given by their (government) shareholder; some flexibility for implementation may be retained if targets are expressed and political incentives put in place, but often executives are given direct instructions;
- *nationalized delivery*: government finances and delivers on environmental protection directly through central government departments.

For the environment, unlike other areas of economic activity, relying on the ‘free market’ or on ‘information provision’ is highly unlikely to deliver satisfactory outcomes because firms have inadequate incentives to internalize externalities without government intervention (see section III). At the other extreme, there are some sectors of the economy in which direct government delivery may be appropriate—the military is generally run directly by government departments (even if some duties are outsourced to military contractors), and a great deal of infrastructure is provided directly by governments, reflecting the need for planning and coordination in infrastructure at the regional, national, or international levels. Indeed, state provision may be preferable if decentralization to the market would create risks of incoherent and uncoordinated outcomes. However, state provision may also entail greater politicization of operational decisions (and hence lower economic efficiency), and may require a great deal of information that is often unavailable. Furthermore, nationalizing industries and removing competition undermines the evolutionary dynamic in the economy that generates diversity and wealth (Hayek, 1948; Helm, 1986).¹²

For many policy problems, the impossibility of a ‘free market’ approach and the inefficiency of ‘nationalized delivery’ implies a role for government in the middle of the spectrum. While it is manifestly impossible to specify any general rule as to the appropriate point in the spectrum, several more concrete general insights on the role of the state are available.

First, the greater the information advantage (disadvantage) of the decentralized market over the centralized state, the more (less) policy should simply focus on ‘getting the prices right’ and the more (less) the appropriate intervention will lie towards the top of the list above. Frequently, prices can serve as powerful coordinating device, because they transmit information so efficiently. However, this also causes problems if prices are transmitting the wrong information because markets are distorted in some way.

Second, the greater the need for a coordinated vision and planning to provide the relevant public goods, as for instance with complex national transport or energy investment, the more the type of intervention is likely to be towards the bottom of the list. For instance, the Chinese communist state has arguably been able to deliver transport and energy infrastructure more reliably over the last decade than Western economies, where multi-party democracies lead to problems in providing a long-term credible vision, and where a greater protection of individual rights generates delays or problems with planning permissions.

Third, the greater the likelihood and severity of principal–agent problems (Stiglitz, 1987) in government, the more likely the appropriate intervention is to be towards the top of the list, and vice versa. For instance, where government department chiefs seek to maximize something other than net social welfare (for instance, the size of their bureaucracy), government interventions are likely to be inefficient. Similarly, where civil servants or government teams are particularly susceptible to capture by private interests, policy is unlikely to provide

¹² The view that market economic systems function in a manner analogous to ecological systems, subject to the forces of natural selection, is noted by Keynes (1926) and developed by Helm (1984).

a level playing field and efficient results. Principal–agent problems also arise in the private sector. Where the connection between manager rewards and long-term shareholder value is loose or severed, it is unlikely that the market will generate socially-beneficial outcomes, even in the absence of other market failures.

Fourth, organizational structure and competence also matter. A government intervention conducted by a high-calibre, well-functioning team able to acquire the requisite information, perform suitable analysis, and carefully and explicitly balance the competing considerations in the public interest, rather than pretending that there are no trade-offs, will be more likely to succeed. In contrast, interventions by a department without the appropriate skills or organizational structure are likely to fail. If government failure is likely, it must be asked whether the consequences will be better or worse than simply living with the market failure, without the government intervention.

In sum, markets and governments always fail to some degree, so the suitable approach for a given policy problem will, in addition to reflecting specific value judgements not addressed in this paper, strike a balance between the problems of market failure on the one hand (see section III) and government failure on the other hand (see section IV).

(iii) Environmental policy and the economic borders of the state

What do these broader insights about the role of the state generally imply for specific environmental interventions? Even though there are no general rules about state intervention, are there ‘special’ features of specific environmental policies that warrant particular attention?

In the context of evaluating UK policy on estimating the social cost of carbon, Pearce (2003) argues that climate change is not ‘special’, in the sense that it should not be analysed inconsistently with other policy areas. Indeed, in its simplest form, environmental policy merely requires internalizing (often negative) externalities and providing public goods, as do many other areas of state involvement. However, while the environment should not be given favourable (or unfavourable) treatment, there are seven potential specific considerations apposite to the state’s role in environmental protection.

First, many environmental problems involve a degree of *irreversibility*, as a result of thresholds and non-linearities found in natural systems (Perrings and Pearce, 1994). For instance, extinct species cannot (yet) be brought into living existence, and the second law of thermodynamics implies that some transitions are extremely costly or impossible to run backwards. While other forms of capital decisions also involve a degree of irreversibility, natural capital stocks may have particularly acute irreversibilities. The implications are that consequences of policy failure are likely to be more severe, so a precautionary approach is appropriate, which may require higher environmental prices or more direct intervention from the state.

Second, and related to the challenge of irreversibility, is the relevance of *inter-generational considerations and sustainability*. Sustainability issues arise in several other policy areas, but given that economic growth over the last century has led to extensive substitution away from natural capital towards manufactured capital (Pearce *et al.*, 1994), it is no surprise that the analytical apparatus to address sustainability issues has been developed by environmental economists (Pearce *et al.*, 1989). In addition to addressing the sustainability challenge (by collating appropriate data and setting suitable long-term objectives), a further non-trivial challenge for the state is to anticipate the preferences of humans in the distant future, which are highly uncertain from today’s vantage point.

Third, we are often interested in the *system-wide properties* of the natural environment, recognizing that different species within an ecosystem, including humans, interact and depend upon other species. Some environmental protection may have an analogy to the provision of macroeconomic stability, so that environmental policy must extend well beyond the simple microeconomics of internalizing externalities, to maintaining desirable system properties (such as low inflation, or a stable bee population to support human agriculture).

Fourth, relevant ecosystems often do not respect national borders, so policy must sometimes involve *international* coordination. The provision of international public goods raises conceptual problems for the role of the state, because providing such goods involves multi-lateral coordination, and some weighting (explicit or implicit) on consequences abroad, relative to consequences at home, is necessary. Furthermore, developing trust-based relationships with other nations is needed to overcome the inherent Prisoner's Dilemma problems. Some of the international dimensions of climate change are discussed further in section V.

Fifth, environmental policy sometimes involves more scope for *rent-seeking* than in other policy areas. For instance, in climate-change policy in Europe, property rights worth roughly €25 billion have been allocated for free to firms in a manner that is not entirely transparent or efficient, so the pay-offs to lobbying have had the potential to be extremely high. Furthermore, the need for government to work in partnership with the private sector to deliver environmental quality also increases interaction and the scope for rent-seeking. Finally, it might be argued that the coincidence of shared 'green values' between government civil servants and leading environmental firms enhances the likelihood of a green 'pork barrel'. That said, many other policy areas—agriculture is one example—have enormous pork barrels, so environmental issues are clearly not alone in this respect.

Sixth, issues such as biodiversity preservation and climate change often rely upon more *complex and uncertain science* to underpin policy than in other areas, implying that policy-making by the state is more difficult to get right.¹³ The potential for unintended consequences of government policy is high. However, as Helm (1986) notes, there is no evidence for the presumption that such unintended consequences will be perverse, rather than benign or indeed beneficial. The implication here is simply that better analysis, and certainly greater humility, is required to deal with environmental challenges.

Seventh, some environmental problems are large enough to be *non-marginal*, so that the conventional shortcuts employed in cost-benefit analysis are inappropriate (Dietz and Hepburn, 2010). However, this is true of many other areas, where large-scale investment in employment, health, transport, and defence, for instance, can have significant knock-on effects for the wider economy. Nevertheless, this means a system-wide, integrated approach rather than a marginal, microeconomic approach, is likely to be appropriate.

These various features mean that intervention for certain environmental problems will require a more cautious, long-term, nuanced, and sophisticated approach than in some other policy areas. Policy often cannot simply internalize environmental externalities and provide environmental public goods, assuming that policy in other relevant areas is already 'first best'. Broader macroeconomic issues and sustainability concerns created by conventional economic growth also need to be factored into environmental policy. However, this does not necessarily imply direct or heavy-handed government intervention. Rather, it suggests

¹³ This applies just as strongly to the technological developments that may reduce environmental problems. For instance, recent breakthroughs in the exploitation of unconventional shale gas, which appear to increase reserves in the United States from around 10 to 90 years (Ruester, 2010), may also significantly reduce the marginal cost of greenhouse gas abatement in the medium term (Hoyas and Crooks, 2010).

that good environmental policy requires the combination of a clear government vision about the top-level objectives and specific interventions that harness the coordinating role of the price system where prices are, or can be adjusted to be, reasonably close to social costs.

III. Market failure and environmental protection

(i) The provision of environmental protection by the free market

Given the analysis above, it may seem extremely challenging to defend the simplistic view that the free market can regulate itself to provide environmental protection superior to that provided with the assistance of government regulation. However, recall that prior to the financial crises of 2008–9, the view was expressed that financial regulation was similarly unnecessary, because ‘risks in financial markets are regulated by private parties’ (Greenspan, 1994). As such, while it may seem obvious that government policy will be required,¹⁴ in this section we consider just how far one might expect markets to provide environmental protection without government intervention.

There are two arguments for the view that firms will take at least some action to protect the environment without government regulation. First, if consumers are well-informed about environmental problems and are altruistically willing to internalize environmental costs, then firms can address environmental problems by simply serving their customers and satisfying these preferences. Moreover, firms will make profits in so doing. For instance, much to the surprise of many, a flourishing voluntary market in carbon offsets—where individuals voluntarily pay firms to reduce emissions and retire credits on their behalf—has developed and grown exponentially in recent years, and was worth at least US\$400m in 2008 (Ecosystem Marketplace, 2009).¹⁵ Consumer-led environmental protection of this sort does not require ‘corporate social responsibility’ (CSR), defined as the sacrifice of profits for the social interest (Reinhardt and Stavins, 2010), as firms are simply supplying the goods and services demanded by consumers.

Although there are pockets of altruistic consumers who are willing to internalize their own externalities, most consumers are not so generous. Voluntary markets for environmental protection are likely to remain marginal compared to government initiatives without a major cultural shift, which seems unlikely to occur. Indeed, voluntary carbon markets have been quickly dwarfed by government-created emissions trading schemes with which firms are legally obliged to comply. While the voluntary market was worth US\$400m, compliance carbon markets were estimated to be worth almost 1,000 times more, at around US\$120 billion in 2008 (Capoor and Ambrosi, 2009).

If consumers are largely unwilling to pay voluntarily, might shareholders be willing to accept lower profits? Reinhardt and Stavins (2010) consider the limits of CSR. They note that the legal basis for the view that firms must exclusively maximize profits is surprisingly

¹⁴ The critical role of government in internalizing externalities has long been obvious to environmental economists (Pigou, 1920; Baumol and Oates, 1971, 1988; Helm and Pearce, 1990).

¹⁵ This figure excludes an additional US\$300m in volumes on the Chicago Climate Exchange (CCX), which while strictly ‘voluntary’ may be partially motivated by firms seeking early credit for ‘pre-compliance’. Alternatively, firms may trade on the CCX to learn about carbon markets and to refine their strategies before the imposition of a mandatory regime.

weak. If firms may legally sacrifice profits in the public interest, and if other market imperfections provide them with rents that enable them to make such sacrifices on a sustainable basis, then managers can devote some portion of shareholder returns to voluntary protection of the environment. However, despite a large literature on CSR, there is still no strong evidence that firms devote substantial profits to the public interest, and Reinhardt and Stavins conclude that such efforts will always remain complements to, rather than substitutes for, government action.

In other words, as economists would expect, the evidence suggests that consumers are unwilling to pay (much), and shareholders unwilling to sacrifice profits (much), in order to protect the environment. In short, environmental problems will not be solved by ‘free market’ or ‘market-led’ solutions. In contrast, however, agents who are unwilling to act individually may nevertheless be willing to act collectively (Sen, 1967).¹⁶ For this to occur, government can provide coordination, backed by real enforcement mechanisms. The more difficult questions, addressed in section IV, are when, where, and how government intervention should occur.

(ii) The potential of government-created markets

Although the unaided free market cannot be relied upon to address environmental problems, a more persuasive view is that government can assist by creating and regulating environmental markets, which would otherwise be missing. The classic example is, perhaps, emissions trading schemes, which provide firms with flexibility on how (and when) environmental objectives are met. Government sets the overall objectives, and leaves it to the market to deliver. By establishing a cap-and-trade scheme (or setting an environmental tax) and leaving the rest up to the private sector, the government can effectively delegate the task of environmental protection to firms, without ‘picking winners’ and without detailed and planned intervention in specific environmental projects. Prices, rather than detailed planning, perform the coordinating function.

Over the past two decades, interest in environmental markets has increased, particularly with respect to acid rain and climate change, but also in relation to biodiversity offsets and other ecosystem trading (Nemes *et al.* 2008). Climate change appears reasonably well-suited to a market approach, as greenhouse gases mix globally (so the spatial location of emissions is irrelevant), and other approaches, such as carbon taxes, have historically encountered political difficulties (Hepburn, 2006). The canonical example of a greenhouse gas emissions market is the multi-billion euro market created by the European Emissions Trading Scheme (EU ETS).

However, Hanemann (2010) casts doubt on the view that this relatively light touch will be sufficient to address a problem such as climate change. He argues that the acid rain trading was only successful because of the presence of several preconditions—most critically the availability of ready technological solutions and low-sulphur coal—that enabled the achievement of short-run emission reductions through operational innovation and cost minimization. While a carbon price, delivered by a carbon market, may well be a necessary component of successful climate-change policy, complementary government interventions are also likely to be required.

¹⁶ The view that ‘citizen preferences’ may be different to ‘consumer preferences’ is also relevant in this context (Sagoff, 1988).

A related conclusion is drawn by Newell (2010). As is well known, there are (at least) two externalities in many environmental problems—the absence of a price on emissions and the presence of positive spillovers from research and development (R&D). Getting environmental prices right is a necessary, but not a sufficient, condition to deliver optimal environmental R&D. Complementary policies, such as R&D support, are required. Newell argues that government should help to compensate for underinvestment by private firms by focusing on areas firms otherwise ignore, such as fundamental research.

Furthermore, where environmental challenges require substantial capital expenditure and longer-term investment decisions, policy credibility is as important as getting the prices right (Helm *et al.*, 2003). Establishing a short-term market with appropriate prices is of little use if these price signals are not credible over the long-term investment horizon. A credible market with prices that are moderately too low or too high may be superior to a market with ‘perfect’ short-term prices that firms do not believe will continue in the long term. For instance, the EU ETS faced particularly an acute credibility problem in its first phase, 2005–7, which has been partially addressed in the second phase, 2008–12. Credibility problems in UK and EU climate policy are also noted by Helm (2010).

The lesson is that while governments can intervene to make markets work better, and to create otherwise missing environmental markets, the appropriate intervention varies with the nature of the environmental problem. For extremely simple environmental problems, it might be enough just to get the prices right (or at least less wrong). For climate change, even getting carbon prices right would not be enough—there are too many other market failures, the investment requirements are too long term, the investments are non-marginal, and international political economy considerations are critical. The carbon prices that have so far emerged from two decades of policy attention are still not credible, and even if the spot prices were ‘right’ (which they are not), additional intervention would be required (Hannemann, 2010). These additional interventions might include support to reward innovation, for instance, or innovative financial mechanisms to increase the risk-adjusted return on investment to make large-scale, long-term shifts in the economy towards cleaner modes of production. But policies put in place to achieve these ends need to be mindful of the likelihood of government failure.

IV. Government failure and environmental protection

(i) What government will not provide

Helm (1986) notes that ‘[j]ust as markets are rarely, if ever, perfect resource allocators, so too governments are rarely, if ever perfect planners’. There are two main reasons why governments are likely to be less than perfect.

First, governments never have complete information. There is now a vast literature on the economics of ‘imperfect economies’, outlined by Stern (2009), beginning with Meade (1955) and proceeding by exploring optimal policy as imperfections are introduced into an otherwise perfect economy. Incomplete information is one such imperfection, and it is pervasive and critical. In many areas of environmental policy, the information requirements of optimal policy are substantial. Determining the ‘optimum’ often requires aggregating complex scientific information on damages, determining consumer preferences such that those damages can be valued in monetary terms, and then obtaining detailed information on aggregated

private-sector abatement costs so that a balance between costs and benefits can be struck. This much is required even under a ‘price’-based approach. Dietz and Fankhauser (2010) discuss the significant levels of uncertainty involved in pricing climate-change damages, and explore pragmatic, but ultimately second-best ways to circumvent these uncertainties. For a ‘planning’-based intervention, optimality further requires that the government know each and every firm’s *individual* abatement cost function. Even in a communist country, this information is enormously costly, if not simply impossible, to obtain. In most democratic societies, even if it were possible to acquire reliable data on the abatement costs of millions of individuals and firms, they do not have to disclose this information to government, and, indeed, may not wish to do so.

Second, governments are comprised of individual humans, and humans are subject to lobbying, manipulation, and subtler forms of persuasion by others who have an incentive to shape policy for their own benefit.¹⁷ As Anthoff and Hahn (2010) and Helm (2010) demonstrate, political economy considerations, including ‘regulatory capture’, often prevent government interventions from generating anything resembling ‘optimal policy’. In Europe, the policy process that resulted in the EU ETS involved a series of concessions to industry that reduced both the efficiency and effectiveness of the scheme.

Unfortunately, awareness of rent-seeking problems does not appear to help governments to overcome them. Policy-makers in the US have had the benefit of observing the emissions trading scheme being negotiated in Europe, and yet experience with the various US legislative drafts on energy and climate change of 2009 and 2010 suggests that the outcome, if, indeed, there is one, will be just as inefficient, with large pay-offs being made to powerful incumbents.

Government failure is not only limited to the design of emissions trading schemes. It is unlikely other policy instruments, such as environmental taxes, would fare much better. The point is that when ‘government failure’ is likely, the political economist should avoid comparing ‘optimal’ trading schemes with ‘optimal’ taxes, and instead examine ‘realistic’ trading schemes (given the relevant set of interest groups and their incentives) and ‘realistic’ taxes. For instance, one might compare short-term trading schemes where most of the permits are handed out for free, with taxes that are too low, with many exemptions, and which are tinkered with over time.

(ii) What are realistic expectations of government?

Despite this somewhat pessimistic account of the potential for government to intervene without failing, there are several things that *only* the state can do, and which it is reasonable to expect that it *should* do. First, it is reasonable to expect that government be able and willing to set out a clear, overarching vision and top-level objectives. Market participants are not in a position to set overall objectives for the economy, because they are compromised by their own interests and because they lack the coercive power to design interventions that incentivize economic behaviour towards those objectives.

The expectation that government will define top-level objectives implies that government needs to compile national accounts that describe, at least roughly, the real income and wealth of the economy. For the large part, however, governments fail to meet this expectation be-

¹⁷ The public-choice school, exemplified by the work of Buchanan and Tullock (1962) and Buchanan and Wagner (1977), explored these themes and emphasized the role of rent-seeking in policy formation.

cause of the continued inaccurate accounting treatment of natural capital and other non-market goods and services (Stiglitz *et al.*, 2009). While some efforts are being made to measure appropriate indicators, such as the growth rate of *per capita* genuine wealth (Arrow *et al.*, 2004), it will be difficult to define and implement top-level objectives until appropriate national indicators are available. Sustainable economic growth is an important policy objective for many nation-states, yet current economic growth pathways appear to be converting natural capital into manufactured capital at a rate that is unsustainable. Identifying critical natural capital stocks (Pearce *et al.*, 1996) and their relevant thresholds is arguably an important role for government.

Second, it is reasonable to expect that government will, in an iterative and sometimes erroneous fashion, gradually move towards the adoption of policies that move the economy towards, if not achieve, the overall set of top-level objectives (howsoever defined). Getting the prices 'right' seems often to be too much to expect; getting them 'less wrong' should be achievable.

Third, the state can reasonably be expected to ensure that the 'rules of the game' specified by its policies are implemented in an impartial and fair manner. While any major shift in the rules themselves (such as the introduction of carbon pricing) will inevitably create winners and losers, the implementation of the rules should be clear and predictable so that firms can trust the price signals emanating from government.

Fourth, ideally the rules would be relatively stable, and not changed retroactively. Unfortunately, evidence suggests that this is often too much to ask. Conditions are continuously changing, and the temptation to reverse previous decisions, and to do so in a retroactive manner, is often irresistible.

Fifth, policy should be designed with an explicit assessment of whether it allocates risks to the parties in a best position to bear them. Sensible risk allocation will reduce the overall social costs of the intervention.

What does this imply for environmental policy? If government can deliver on these reasonable expectations, then there is likely to be a large domain in which government intervention for environmental protection is likely to be preferable to market failure.

With these considerations in mind, if government is embarking on a large-scale stimulus to escape recession, funds might be deployed for spending on long-term infrastructure investment (rather than consumption) to support natural capital stocks and reduce their depletion rates (Bowen and Stern, 2010). Unfortunately, the recent opportunity for such investment was largely missed, with only roughly 15 per cent of fiscal stimuli estimated to have been directed at 'green measures' (Edenhofer and Stern, 2009; Robins *et al.*, 2009).¹⁸

Now, with budget cuts looming, government policy on the environment might instead focus on reforming the tax system away from taxing goods and towards taxing bads, including environmental pollution. This would deliver shifts in relative prices (in a potentially revenue-neutral fashion); or might raise revenue from environmental taxes and/or the auctioning of environmental allowances and/or the reduction of fossil subsidies.

But changing relative prices in a revenue-neutral fashion will not always be sufficient, for three reasons. First, in addition to the relevant environmental externality, the R&D externality is often difficult to internalize without some form of public subsidy (Newell, 2010). Second, attempts to price the relevant externalities rarely deliver first-best results, because optimal prices are either impossible to determine (Dietz and Fankhauser, 2010) or politically impos-

¹⁸ Two notable exceptions are China and South Korea, which devoted around 30 and 80 per cent, respectively, to 'green' measures (Edenhofer and Stern, 2009).

sible to implement. As such, complementary measures are often required (Hanemann, 2010). Third, the scale of the climate-change challenge is such that extraordinary levels of investment are required to shift the economy on to an environmentally sustainable pathway. For instance, while the numbers are inevitably highly uncertain, the International Energy Agency (2009) estimates that the world might require additional cumulative investment of US \$10 trillion in the period 2010–30 in order to follow a 450ppm pathway consistent with increasing energy demand. Further sums are required to protect the remainder of the world's tropical forests, and the carbon stocks and biodiversity therein. The Copenhagen Accord on climate change of December 2009 anticipates transfers from rich to poor of US\$100 billion annually by 2020 (UN FCCC, 2009). In the UK alone, Helm (2009) roughly estimates that around £50 billion per annum is needed for general infrastructure investment over the next decade to 2020, of which over 20 billion is directly or indirectly related to the transition to a low-carbon economy.

In practice, encouraging investment on this scale is likely to require more than just the adjustment of relative prices; additional funds will be necessary. If public funds are not available, private capital might be incentivized to fill the gap. Here, the principles outlined above are particularly important: (i) national accounts should be reasonably accurate so that objectives can be appropriately determined at the outset; (ii) environmental prices should be roughly correct; (iii) rules should be established and implemented in a fair and impartial manner; (iv) rules should be stable and not changed retroactively; and (v) risk should be efficiently allocated. With these principles in place, it is possible to provide an appropriate risk-adjusted return to induce unsentimental private capital to flow to the necessary environmental investments.

V. The international dimension of environmental policy

(i) Context

Environmental problems often do not neatly map on to national boundaries. Many significant problems are transboundary (e.g. water pollution in major rivers, acid rain) or international (e.g. climate change, over-fishing, biodiversity loss). For international problems, the relationship between government and the market is complicated by the fact that there are *many* governments and *many* markets. Determining appropriate roles for 'planning' and 'prices' in a complex political and international context is challenging. Yet this is what is required, because the interactions between states and firms ultimately determine whether environmental problems are solved, and at what cost.

In the case of climate change, financial support for developing countries to reduce greenhouse-gas emissions was one of the key issues in discussions leading up to the UN FCCC conference in Copenhagen in December 2009. As noted above, the International Energy Agency (2009) estimates that additional energy-related investment of US\$10 trillion will be required to 2030, of which US\$200 billion per annum would be within non-OECD countries by 2020. Yet developing country governments have other pressing demands for their capital, and they see climate change as historically caused by rich western countries who are also in the best position (financially and technologically) to mitigate the consequences. Yet western governments are also apparently unwilling to allocate the necessary upfront capital.

It follows that the low-carbon investment requirements will not be met without the engagement of private capital. Institutional investors, such as pension funds, could provide much of the capital if an appropriate risk-reward balance were available. It is estimated that pension funds alone control assets worth more than \$12 trillion and that sovereign wealth funds have a further \$3.75 trillion under management (Vivid Economics, 2009). However, to redirect those funds from high- to low-carbon activities, the expected returns on climate-change mitigation need to be commensurate with the perceived level of risk. Investment risks in developing countries include political risks (of war or expropriation), currency risks, project management risks, as well as uncertain international and national government climate-change policies.

Institutional investors have consistently called for the implementation of credible long-term climate-change policies, so that they can justify redirecting capital towards solving the problem. This is also likely to be in the interests of the taxpayer, because credible long-term policy reduces the cost of capital and hence the overall cost of delivering low-carbon infrastructure investment in the energy and transport sectors. While rich countries have significant credibility problems (Helm *et al.*, 2003), the climate policy credibility problems in poorer countries are arguably even more acute.

For these reasons, the treasuries of rich countries have been asked to consider the potential for supporting low-carbon investment in developing economies using alternative finance mechanisms such as risk guarantees, concessional loans, and softer forms of political and policy insurance (Neuhoff *et al.*, 2009; London School of Economics, 2009; Vivid Economics, 2009). These mechanisms, which leverage public balance sheets without involving the direct provision of capital, are referred to in this context as ‘public finance mechanisms’ (PFMs).

(ii) Public finance mechanisms

The first-best approach to stimulate the investment of the requisite amounts of institutional capital is clearly to enact domestic regulations that provide credible long-term carbon price signals to investors. In the international context, so-called ‘advance market commitments’ proposed by Barder *et al.* (2006) appear to warrant further investigation.

As a complement to (partially inadequate) domestic climate policy, carefully designed PFMs may be able to leverage considerable amounts of private investment, potentially up to \$3–15 for every \$1 of public funds (Vivid Economics, 2009), by reducing risk such that the risk-adjusted return of the project clears the relevant hurdle rate. PFMs have tended to be implemented on a project-by-project or programmatic basis, and represent state intervention closer to the ‘planning’ rather than the ‘prices’ end of the spectrum, described in section II (ii) above. As with many such government interventions, there have been both positive and negative previous experiences to date.

One instructive positive experience is the coordination of the complex Baku–Tbilisi–Ceyhan (BTC) pipeline to export oil from Azerbaijan, which opened in 2005. Complex infrastructure projects of this nature are likely to be necessary to reduce emissions from the energy sector globally. The BTC project involved 11 oil companies (led by BP, the project sponsors), 15 commercial banks, two public international financial institutions (IFC and EBRD), eight export credit agencies (ECAs), and various government authorities. The total investment was \$3.8 billion. Without the involvement of the two public international financial institutions, it is considered less likely that the project would have proceeded (Vivid

Economics, 2009), because they provided cover for political and environmental risks, enhancing the enforceability of host government agreements and helping to ensure a transit deal for Georgia, reducing the risk of future disputes and interruptions. It is estimated that \$10 of private debt was raised for every \$1 of public debt provided from the IFC and the EBRD.

There are at least four useful lessons from past experience with PFMs if they are going to incentivize institutional investors to allocate their capital to low-carbon infrastructure in developing economies (Neuhoff *et al.*, 2009; Vivid Economics, 2009). First, there are multiple market failures, layered on top of the greenhouse gas externality, that complicate the international dimension of the response to climate change. These include financial market failures, such as the absence of a market for long-term currency risk exposure, or for political risk coverage in several countries. As such, multiple government interventions are likely to be required.

Second, the institutional architecture for delivering these instruments matters. The more political the institutions, the greater the risk that the credibility problem has not been eliminated, but has rather simply been shifted from one institution to another. Experience suggests that the multilateral banks may be better channels of public finance than national governments in this context.

Third, the value of coordination appears to be very high. Bringing the relevant state and private parties together to build understanding and trust, to clarify incentives and to negotiate contractual structures that are consistent with self-interest may make the difference between success and failure. In any such collaborative forum, even though the public bodies are not regulators, the risk of regulatory capture rises considerably. Militating against that is the requirement placed on international financial institutions to make market or near-market returns on their investments.

Fourth, institutional investors seek investments at a very large scale, commensurate with the quantities of capital on their balance sheets. It follows that if PFMs are to shift the direction of institutional investors towards protecting natural capital, they must influence investment opportunities at scale, which implies tipping the profitability of major projects for large corporations, or shifting profitability of a large number of smaller projects which can be aggregated into a fund by a manager and pitched to institutional investors to attract their capital.

These lessons indicate that finding appropriate models of public–private cooperation for large-scale, low-carbon infrastructure projects will be difficult, but not impossible. Risks of inefficiencies and capture are present, and structuring the incentives is challenging, but as public treasuries are unwilling and probably unable to nationalize the delivery of low-carbon infrastructure, and as ‘prices’ alone are insufficient, relatively complex arrangements between firms and governments may be necessary.

VI. Conclusion

The design of environmental policy, as with other policy areas, requires an understanding of the appropriate border between the state and the market, and a humble appreciation of the fact that both governments and free markets fail a great deal of the time. Understanding these limitations and designing interventions accordingly is likely to be an important determinant of whether critical environmental challenges are successfully addressed in the coming decades.

The analysis in this paper suggests that approaches to environmental protection at either extreme of the spectrum—‘free market’ and ‘nationalized delivery’ of environmental protection—are unlikely to deliver optimal results. The appropriate model of environmental intervention will most often lie in the middle. While general rules to specify the precise form of intervention are not available, several important principles for policy design were set out in this paper and the others in this issue of the *Oxford Review of Economic Policy*.

First, information matters. If the decentralized market has an advantage over the centralized state, policy should simply focus on ‘getting the prices right’ (or at least less wrong). Second, setting top-level objectives also matters. Some policy issues cannot be left to market participants because they are self-interested and are unable to determine a social optimum, or because the degree of coordination and planning required is too great. Third, principal–agent problems matter. Bureaucrats do not necessarily maximize social welfare and may be captured by private interests; nor do chief executives necessarily maximize long-term shareholder value. Understanding these problems is important for environmental policy design. Fourth, organizational structure and competence matter. Talent and incompetence are to be found in both public and private sectors; an incompetent private sector may be worse than a competent public sector, and vice versa.

While environmental problems share the features of other public-goods problems, they also often have characteristics that merit more careful consideration, such as irreversibility, intergenerational and sustainability issues, systemic effects, international dimensions, significant scope for rent-seeking, high levels of uncertainty, and non-marginality. These features imply that environmental policy may often be more challenging than other policy areas, requiring government to provide clarity about the top-level objectives, coupled with credible policy interventions that explicitly or implicitly internalize social costs and harness the price system to provide investors in natural capital with an appropriate risk-adjusted return. That said, we have also seen that for environmental problems such as climate change, prices interventions may be necessary but not sufficient. Complementary measures are likely to be required to address other market failures and to overcome patterns of environmentally detrimental behaviour (Hanemann, 2010). Finally, given the forecasts of enormous investments required to address climate change, one important role of the state is to provide a clear policy framework with credible, stable rules to produce an appropriate risk-adjusted return that induces private capital to invest in relevant natural capital and environmental technologies to protect it.

References

- Anthoff, D., and Hahn, R. (2010), ‘Government Failure and Market Failure: On the Inefficiency of Environmental and Energy Policy’, *Oxford Review of Economic Policy*, **26**(2), 197–224.
- Arrow, K. J. (1951), ‘An Extension of the Basic Theorems of Classical Welfare Economics’, in J. Neyman, (ed.), *Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability*, Berkeley, CA, University of California Press, 507–32.
- Dasgupta, P., Goulder, L., Daily, G., Ehrlich, P., Heal, G., Levin, S., Mäler, K.-G., Schneider, S., Starrett, D., and Walker, B. (2004), ‘Are We Consuming Too Much’, *Journal of Economic Perspectives*, **18**(3), 147–72.
- Asheim, G. (2010), ‘Strategic Use of Environmental Information’, *Environmental and Resource Economics*, published online 10 April.

- Barder, O., Kremer, M., and Williams, H. (2006), 'Advance Market Commitments: A Policy to Stimulate Investment in Vaccines for Neglected Diseases', *The Economist's Voice*, 3.
- Baumol, W. J., and Oates, W. E. (1971), 'The Use of Standards and Prices for Environmental Protection', *Swedish Journal of Economics*, 73, 42–54.
- (1988), *The Theory of Environmental Policy*. 2nd edn, Cambridge, Cambridge University Press.
- Beveridge, W. H. (1942), *Social Insurance and Allied Services*, London, HMSO.
- Bowen, A., and Stern, N. (2010), 'Environmental Policy and the Economic Downturn', *Oxford Review of Economic Policy*, 26(2), 137–63.
- Bremmer, I. (2009), 'State Capitalism and the Crisis', *McKinsey Quarterly*, July.
- Buchanan, J. M., and Tullock, G. (1962), *The Calculus of Consent: Logical Foundations of Constitutional Democracy*, Ann Arbor, MI, University of Michigan Press.
- Wagner, R. E. (1977), *Democracy in Deficit: The Political Legacy of Lord Keynes*, Elsevier.
- Capoor, K., and Ambrosi, P. (2009), 'State and Trends of the Carbon Market 2009', Washington, DC, World Bank, May.
- Coase, R. H. (1960), 'The Problem of Social Cost', *Journal of Law and Economics*, 3, 1–44.
- Colby, B. G. (2000), 'Cap-and-trade Policy Challenges: A Tale of Three Markets', *Land Economics*, 76(4), 638–58.
- Crocker, T. D. (1966), 'The Structuring of Atmospheric Pollution Control Systems', in H. Wolozin, (ed.), *The Economics of Air Pollution*, New York, W.W. Norton & Co., 61–86.
- Dales, J. H. (1968), *Pollution, Property and Prices*, Toronto, University of Toronto Press.
- Debreu, G. (1951), 'The Coefficient of Resource Utilization', *Econometrica*, 19, 273–92.
- Dietz, S., and Hepburn, C. (2010), 'On Non-marginal Cost–Benefit Analysis', Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, Working Paper No. 18.
- Fankhauser, S. (2010), 'Environmental Prices, Uncertainty, and Learning', *Oxford Review of Economic Policy*, 26(2), 270–84.
- Ecosystem Marketplace (2009), 'Fortifying the Foundation: State of the Voluntary Carbon Markets', Washington, DC, Ecosystem Marketplace, available at http://www.forest-trends.org/documents/files/doc_2343.pdf
- Edenhofer, O., and Stern, N. (2009), 'Towards a Global Green Recovery: Recommendations for Immediate G20 Action', report submitted to the G20 London Summit, 2 April.
- Folke, C., Holling, C. S., and Perrings, C. (1996), 'Biological Diversity, Ecosystems, and the Human Scale', *Ecological Applications*, 6(4), 1018–1024.
- Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., and Holling, C.S. (2004), 'Regime Shifts, Resilience, and Biodiversity in Ecosystem Management', *Annual Review of Ecology, Evolution, and Systematics*, 35, 557–81.
- Greenspan, A. (1994), 'Statement by Alan Greenspan, Chairman, Board of Governors of the Federal Reserve System, before the Subcommittee on Telecommunications and Finance of the Committee on Energy and Commerce, US House of Representatives, 25 May, accessed at http://fraser.stlouisfed.org/historicaldocs/805/download/27981/Greenspan_19940525.pdf
- Hanemann, M. (2010), 'Cap-and-trade: A Sufficient or Necessary Condition for Emission Reduction?', *Oxford Review of Economic Policy*, 26(2), 225–52.
- Hayek, F. von (1948), *Individualism and Economic Order*, Chicago, IL, University of Chicago Press.
- Helm, D. R. (1984), 'Enforced Maximisation: Competition Evolution and Selection', D.Phil. thesis, University of Oxford.
- (1986), 'The Assessment: The Economic Borders of the State', *Oxford Review of Economic Policy*, 2(2), 1–24.
- (2006), 'Regulatory Reform, Capture, and the Regulatory Burden', *Oxford Review of Economic Policy*, 22(2), 169–185.
- (2009), 'Infrastructure, Investment and the Economic Crisis', in D. R. Helm, J. Wardlaw and B. Caldecott (eds), *Delivering a 21st Century Infrastructure for Britain*, London, Policy Exchange.
- (2010), 'Government Failure, Rent-seeking, and Capture: The Design of Climate Change Policy', *Oxford Review of Economic Policy*, 26(2), 182–96.

- Helm, D. R., and Pearce, D. (1990), 'The Assessment: Economic Policy towards the Environment', *Oxford Review of Economic Policy*, **6**(1), 1–16.
- Hepburn, C., and Mash, R. (2003), 'Credible Carbon Policy', *Oxford Review of Economic Policy*, **19**(3), 438–50.
- Hepburn, C. (2006), 'Regulating by Prices, Quantities or Both: An Update and an Overview', *Oxford Review of Economic Policy*, **22**(2), 226–47.
- (2007), 'Carbon Trading: A Review of the Kyoto Mechanisms', *Annual Review of Environment and Resources*, **32**, 375–93.
- Hoyas, C., and Crooks, E. (2010), 'Energy: A Foot on the Gas', *Financial Times*, 11 March, accessed at <http://www.ft.com/cms/s/0/39c9ebf6-2d48-11df-9c5b-00144feabdc0.html>
- International Energy Agency (2009), 'How the Energy Sector Can Deliver on a Climate Agreement in Copenhagen', special early excerpt from the *World Energy Outlook 2009* for the Bangkok UN FCCC meeting, Paris, OECD/IEA, October.
- Joskow, P. L., Schmalensee, R., and Bailey, E. M. (1998), 'The Market for Sulfur Dioxide Emissions', *American Economic Review*, **88**(4), 669–85.
- Keynes, J. M. (1926), 'The End of Laissez Faire', reprinted in *Essays in Persuasion*, c.w. xi, London, Macmillan.
- London School of Economics (2009), *Meeting the Climate Challenge: Using Public Money to Leverage Private Investment in Developing Countries*, September.
- Meade, J. E. (1955), *Trade and Welfare, The Theory of International Economic Policy, Vol. II*, Oxford, Oxford University Press.
- Montero, J.-P. (1999), 'Voluntary Compliance with Market-based Environmental Policy: Evidence from the US Acid Rain Program', *Journal of Political Economy*, **107**(5), 998–1033.
- Montgomery, W. D. (1972), 'Markets in Licences and Efficient Pollution Control Programs', *Journal of Economic Theory*, **5**, 395–418.
- Nemes, V., Plott, C. R., and Stoneham, G. (2008), 'Electronic BushBroker Exchange: Designing a Combinatorial Double Auction for Native Vegetation Offsets', July, available at SSRN, <http://ssrn.com/abstract=1212202>.
- Neuhoff, K., Fankhauser, S., Guerin, E., Hourcade, J. C., Jackson, H., Rajan, R., and Ward, J. (2009), 'Structuring International Financial Support to Support Domestic Climate Change Mitigation in Developing Countries, Climate Strategies', September, accessed at http://www.iddri.org/Publications/Publications-scientifiques-et-autres/isda_financial-support_september-2009-report.pdf
- Newell, R. (2010), 'The Role of Markets and Policies in Delivering Innovation for Climate Change Mitigation', *Oxford Review of Economic Policy*, **26**(2), 253–69.
- Pearce, D. W. (2003), 'The Social Cost of Carbon and its Policy Implications', *Oxford Review of Economic Policy*, **19**(3), 362–84.
- Atkinson, G., and Dubourg, W. R. (1994), 'The Economics of Sustainable Development', *Annual Review of Energy and the Environment*, **19**, 457–74.
- Hamilton, K., and Atkinson, G. (1996), 'Measuring Sustainable Development: Progress on Indicators', *Environment and Development Economics*, **1**, 85–101.
- Markandya, A., and Barbier, E. (1989), *Blueprint for a Green Economy*, London, Earthscan.
- Perrings, C., and Pearce, D. W. (1994), 'Threshold Effects and Incentives for the Conservation of Biodiversity', *Environmental and Resource Economics*, **4**, 13–28.
- Pigou, A. C. (1920), *The Economics of Welfare*, London, Macmillan.
- (1929), *Industrial Fluctuations*, London, Macmillan.
- Reinhardt, F., and Stavins, R. (2010), 'Corporate Social Responsibility, Business Strategy, and the Environment', *Oxford Review of Economic Policy*, **26**(2), 164–81.
- Robins, N., Clover, R., and Singh, C. (2009), 'Building a Green Recovery', HSBC Global Research, May, accessed at http://www.hsbc.com/1/PA_1_1_S5/content/assets/sustainability/090522_green_recovery.pdf
- Rockström, J. *et al.* (2009), 'A Safe Operating Space for Humanity', *Nature*, **461**(472), doi:10.1038/461472a.
- Ruester, S. (2010), 'Recent Dynamics in the Global Liquefied Natural Gas Industry', Resource Markets Working Paper No. RM-19, January.
- Sagoff, M. (1988), 'The Economy of the Earth', Cambridge, Cambridge University Press.

- Schumpeter, J. (1934), *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*, Cambridge, MA, Harvard University Press.
- (1942), *Capitalism Socialism and Democracy*, New York, Harper.
- Sen, A. K. (1967), 'Isolation, Assurance, and the Social Rate of Discount', *Quarterly Journal of Economics*, **81**, 112–24.
- Stern, N. (1989), 'The Economics of Development: A Survey', *The Economic Journal*, **99**(397), 597–685.
- (2009), 'Imperfections in the Economics of Public Policy, Imperfections in Markets, and Climate Change', FEEM Working Paper No. 106, December.
- Stiglitz, J. E. (1987), 'Principal and Agent', *The New Palgrave: A Dictionary of Economics*, **3**, 966–71.
- (1989), 'On the Economic Role of the State', in A. Heertje (ed.), *The Economic Role of the State*, Oxford, Blackwell.
- Sen, A., and Fitoussi, J.-P. (2009), 'Report by the Commission on the Measurement of Economic Performance and Social Progress', 14 September, available at http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf
- Thaler, R. H., and Sunstein, C. R. (2003), 'Libertarian Paternalism', *American Economic Review*, **93**(2), 175–79.
- UN FCCC (2009), 'Copenhagen Accord', Draft decision -/CP.15, FCCC/CP/2009/L.7, 18 December, accessed at <http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf>
- Vivid Economics (2009), *Catalysing Low-carbon Growth in Developing Countries: Public Finance Mechanisms to Scale Up Private Sector Investment in Climate Solutions*, Report for United Nations Environment Programme (UNEP) and Partners, October.
- von Mises, L. (1936), *Socialism: An Economic and Sociological Analysis*, London, Jonathan Cape.