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12 The Economics of Carbon Offsets

James B. Bushnell

12.1 The Motivation for Offset Markets

The evolution and growth of offset markets is recounted in Lecoq and Ambrosi (2007) and Grubb et al. (2010). The most significant current global offset program, the Clean Development Mechanism, emerged from the Kyoto Treaty. It combined the desires for flexible market-based mechanisms with the goal of financing a low-carbon development trajectory in emerging economies. Offset mechanisms comprise a prominent part of the proposed US CO_2 market articulated in H.R. 2454 (the Waxman-Markey Bill). There are also important roles for offsets in regional US carbon markets such as in California and the northeast United States as well as for voluntary carbon offset markets.

The primary distinction between offset programs and other forms of regulation are that offsets pay firms to *reduce* their emissions rather than raise the costs of continuing to emit. The entire concept of offset programs is, therefore, closely related to the question of the "reach" of traditional regulations. If all sources of emissions would fall under traditional regulations, there would be no need to extend those regulations through offsets. There are many reasons why traditional regulatory measures may be constrained. In the case of greenhouse gas (GHG) emissions, the most obvious is that emissions from any given jurisdiction hold consequences for the entire world. The fact that environmental damages span boundaries far greater than the reach

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of even international organizations makes the consistent application of traditional regulation almost impossible. A second reason is practicality. The effective implementation of cap-and-trade mechanisms requires reasonable monitoring and transactions costs for the sources falling under the cap. Some nonpoint sources of GHG emissions, such as those associated with land use, would be difficult to integrate into a cap-and-trade program under any circumstances. A third reason is political; some sectors may simply be more successful at convincing governments that they should be exempted from mandatory emissions limits.

If we accept the fact that some countries and economic sectors are unlikely to fall under a mandatory limit on their GHG emissions, the question then becomes how best to motivate those sectors to reduce emissions. Ideally, those actions would be coordinated in some fashion with the sectors that are directly regulated. This is where offset markets come into play.

Although the fundamental need for offsets is rooted in the limits of regulatory jurisdiction, today's programs are, in fact, motivated by a host of goals. A primary goal for many regulated industries is cost control. The prospect of a deep pool of offset projects providing a potentially low-cost supply of reductions creates an effective cap on allowance prices in a cap-and-trade system.[1] Among developing nations and many nongovernmental organizations (NGOs), offset mechanisms have been seen as an important new source of capital to aid in development and the alleviation of poverty. For firms and individuals outside of sectors that might fall directly under a cap, such as the US agricultural sector, an offset mechanism offers a potentially lucrative new source of revenue.[2]

From the perspective of economic efficiency, the great promise of an offset market is the potential for reducing GHG emissions at a much lower cost. To the extent that low-cost options for reducing emissions exist in sectors that are not directly regulated under a cap, an offset market allows for these "low-hanging fruit" to be harvested in place of more expensive reductions from the capped sector. For example, if the marginal source of abatement under the European emission trading system (ETS) costs twenty euro per ton, and the opportunity cost of preventing a similar ton of CO_2e through deforestation in Africa is two euro per ton, the same level of CO_2e emissions could be achieved at a cost of eighteen less euros if a European firm were allowed to offset its ETS emissions by financing the African project.

This relates closely to the notion of extending the jurisdiction of a cap. If there were no jurisdictional or measurement issues, these same efficiencies could be reaped by simply placing all relevant sectors under the same cap-and-trade regime. As I discuss in the following, this maximum-cap approach

1. The economic analysis of proposed GHG regulations by agencies such as the US Environmental Protection Agency and the California Air Resources Board highlight the sensitivity of future allowance prices to the cost and availability of offsets.

2. See United States Department of Agriculture (2009).

would also avoid many of the information and incentive problems that are of such concern in offset markets. However, the reality given both domestic and international political and legal constraints is that important sectors and countries will be outside of a binding cap-and-trade regime. The question is, therefore, whether the informational and incentive problems with offset markets can be sufficiently overcome to capture these potential savings.

12.2 Criticisms of Offset Markets

Despite the alluring potential of offset mechanisms for reducing mitigation costs and overcoming jurisdictional boundaries, the programs remain quite controversial. At the heart of most criticisms of offset programs is the concern that the programs are not, in fact, yielding the emissions reductions implied by their transacted quantities. In this section, I discuss the various types of enforcement concerns in the context of the more general economic and regulatory issues to which they are related. In the following section, I explore the various methodologies that have been applied to mitigating these problems.

One can attribute most potential verification and enforcement problems to three key institutional factors that dominate offset programs. An important observation to which I will return, however, is that two of these three factors would apply to *any* regulations directed at mitigating GHG emissions although the interaction of these factors does make the problem worse in the context of offsets. The first factor is jurisdictional. Offset programs test the limits of international regulatory cooperation in that differing regulatory agencies in different countries need to at least agree on consistent measurement and reporting metrics, and officials in the "host" countries of projects need to provide or allow access to data for verification purposes. Another complication from jurisdictional limits are the many types of indirect impacts that climate policies can have on land use, energy consumption, and industrial activity in other jurisdictions. These effects include the leakage of emissions to other jurisdictions as well as the types of indirect land-use questions that have come to play a large role in biofuels and forestry policy. All these indirect impacts have the consequence of reducing the actual net reductions of GHG emissions from the level one might measure by focusing only on "local" reductions.

The second institutional issue relates to the strength of regulatory and governance institutions within many of the countries that might seem to be prime candidates for selling offsets. This is perhaps most pronounced in the context of land-use related offsets.[3] Unfortunately, the development of

3. Murray, Lubowski, and Shongen (2009) highlight the fact that about half the potential GHG savings from the forestry sector comes from Africa and that governance and infrastructure improvements are likely necessary before much of that potential can be reliably tapped.

strict environmental measurement, let alone enforcement, practices is likely beyond the resources of the regulatory institutions in many of these countries. This problem is greatly complicated by the fact that the incentives of officials in differing jurisdictions are often not aligned. Developing countries would like to get access to the capital provided by offset programs and may be less directly concerned about the true mitigation associated with any given project. At least in the context of an offset regime, the enforcement powers in effect reside outside of local jurisdictions. Final accreditation decisions are made by an international governing body in the case of the clean development mechanism (CDM), and by the US Environmental Protection Agency (EPA) in the case of H.R. 2454.

The third issue, to which I will devote the bulk of our attention in this chapter, relates to the fundamental aspect of offset programs. This is the fact that offset programs require a determination of an *emissions baseline* from which the attributable reductions can be measured. Assuming the institutional issues described in the preceding could be overcome, regulators should be able to reliably verify the actual emissions of a facility, or at least a sector. However, baselines (e.g., the emissions in the absence of an offset) by definition cannot be *observed* because they are the product of a "what-if" exercise. The regulator can hope to accurately measure the emissions of a facility after it registers for an offset but can only estimate what those emissions would have been if the facility had not sold any offsets. By contrast, under a cap-and-trade program, the baseline is essentially zero, and firms must provide emissions allowances to offset any emissions observed above zero.

By structuring a program around the concept of paying firms to *reduce* emissions, offset regimes become vulnerable to two classic regulatory problems; moral hazard and adverse selection. The latter involves paying too much to firms with already low emissions, while the former involves firms actively taking steps to inflate their baselines. I discuss each of these issues in the following subsections.

12.2.1 Moral Hazard

The moral hazard, or perverse incentive, problem stems from the fact that emissions baselines are not only the private information of firms, but can also in some cases be readily influenced by those firms. In the offset context, this can take two forms. Firms (or countries) could actively pursue investments in high-carbon sources, with the intent of earning offset payments to drop those investments. Alternatively, firms or countries could delay investments that would lower emissions from existing sources with the same intention.

One of the most controversial offset initiatives has been the funding of hydrofluorocarbon-23 (HFC-23) mitigation under the CDM. This is an extremely potent GHG that is a by-product of industrial coolant manufacturing. Because of its potency, investments to capture HFC-23 emissions qualified for large CDM credits whose value arguably far exceeded the value of the product for which this pollutant was a by-product. In the face of these obviously perverse incentives, it has been argued that firms expanded or maintained operations solely to qualify for CDM payments to capture their by-product.[4] New projects for the capture of HFC-23 may no longer qualify for CDM credits, and activities to capture industrial gases claim an increasingly modest share of newly qualified projects.

12.2.2 Adverse Selection

The primary concern in offset markets is the phenomenon that offset sales will be particularly attractive to firms whose true baselines are lower than the regulators' estimates. These firms can essentially be paid for "reductions" that would have happened anyway. In the jargon of offset policy, this problem is known as *additionality.* In H.R. 2454, additional is defined as:

> The term additional, when used with respect to reductions or avoidance, or to sequestration of greenhouse gases, means reductions, avoidance, or sequestration that result in a lower level of net greenhouse gas emissions or atmospheric concentration than would occur in the absence of an offset project.

The additionality problem has come to dominate the debates over offset markets, and there is a large amount of enforcement language and effort put into trying to mitigate it. There is also a rich literature on environmental regulation under imperfect information that has also focused on this problem. In this literature, the main culprit is adverse selection. Particularly relevant for this discussion is the work of Montero (1999, 2000), which examines the consequences of voluntary "opt-in" to a cap-and-trade program. These opt-in provisions, such in the US SO_2 program, bear many similarities to offset mechanisms. In Montero's derivation, allowing opt-in produces a trade-off between the efficiency gains of lower-cost abatement and the "excess emissions" resulting from adverse selection.

However, some of this focus on additionality and the mechanisms deployed to combat it may be misguided as not all additionality problems may stem from adverse selection. A key issue is the extent to which an overestimate of baselines is a firm-specific or aggregate phenomenon. The regulators information about aggregate emissions is also a factor. If the additivity problem stems from the fact that the regulator overestimated the baselines from the entire sector, then the implications of an offset program can be very different. The result is still less "abatement" than expected, but this does not necessarily translate into more emissions than expected.

Consider the case of the Chinese power sector. As Wara (2008) documents, an impressive percentage of new Chinese power plants received

4. See Wara (2008) Grubb et al. (2010) argue that, despite the incentive problems, the program did result in meaningful early reductions in a very potent GHG.

CDM credits by virtue of their *not* being coal plants. Almost certainly, as Wara argues, some of these plants would have utilized noncoal technology in the absence of an offset payment.[5] However, consider the possibility that future projections of Chinese business as usual (BAU) emissions and, consequently, emissions caps in the developed world assumed that new power plants *would* utilize coal. If this were true, then the BAU projection for the entire Chinese power sector and, therefore, of future global emissions was overstated. Viewed in this light, the CDM provided new information about aggregate emissions and could, in theory, allow for reductions from the capped sector to adjust to this new information.

In the sale of offsets, the key information asymmetry lies in the estimates of BAU emissions, in particular for the uncapped sector. It is common in the mechanism design literature to assume that the regulator knows the distribution of information (here expected emissions, or "baselines") but does not know where any specific firm falls in that distribution. This is the asymmetry framework utilized by Montero (2000). In related work (Bushnell 2010), I represent this as a special case, but it is also important to consider the very real prospect that the regulator may not have perfect information about even the aggregate distribution of baselines. In particular, the regulator may be wrong about the expected mean baseline.

Independently Distributed Baselines

First consider the case where the regulator does know the distribution of baselines but not the baseline of an individual firm. For any given firm, the actual marginal costs of providing offsets might be lower or higher than that of the average firm in the uncapped population. This is because their true baseline emissions from which they must abate may be higher or lower than the regulator's estimate. This "true" cost of offsets reflects the *actual* costs of reducing emissions from a baseline level that differs from the regulator's estimate. Thus, the firms with the lowest actual baselines have the lowest "costs," and, in a competitive market, these will be firms selling offsets. Conversely, it is the high baseline firms for whom offset sales are most expensive who stay out of the offset market.

Because the low-baseline firms participate and the high baseline firms do not, the actual reductions from the uncapped sector will be less than the offsets traded, and total emissions from the uncapped sector will be greater than the official estimate of reductions. Although the regulator's estimate of total baseline emissions from the uncapped sector are correct, the self-selection of low-baseline firms into the offset program leaves only high-baseline firms without abatement. The result, after offsets are transacted, is

5. Haya (2009) provides many examples of energy projects in India that funded under the CDM were not considered additional even by their developers. Lewis (2010), by contrast, emphasizes what she considers a critical role offsets have played in providing financing for Chinese power projects.

more emissions than anticipated from the uncapped sector and, therefore, more emissions overall.

This is essentially the framework examined by Montero (2000). If I assume that the cap is set with optimal desired emissions levels in mind, this excess of pollution becomes a potentially serious problem. There are also savings as the capped sector spends less to abate. Montero demonstrates these trade-offs.[6]

Correlated Baselines among Uncapped Firms

An alternative implication emerges as the baseline levels become more highly correlated. Consider the possibility that regulators overestimate the BAU emissions from the entire uncapped sector. The offset costs of most firms are now lower than the actual costs of abatement because most have to do less abatement than expected. Prices for offsets and allowances are, therefore, lower, and participation in the offset market increases. Although there are more offsets being sold, there is now much less abatement going on, and the share of emissions from the capped sector increases quite a bit relative to the case with no offsets. However, total *emissions* are actually below the aggregate expected level. This is because of the large negative shock to emissions in the uncapped sector. I define excess emissions as additional emissions *above the cap* that are created by introducing offsets. In the case of highly correlated baselines, total emissions from the uncapped sector (vertical striped area) can be much lower than expected, even though there is a considerable amount of emissions reductions that are not "additional." This is because the low baselines of firms who are selling offsets also imply low baselines even from firms who are *not* selling offsets.

Note that introducing offsets does increase emissions relative to the no-offset case. In the absence of offsets, aggregate emissions are well below the cap because the low-emissions shock fell outside the cap.[7] The low realization of baseline emissions make compliance with the cap easier, and allowance prices adjust accordingly.[8]

In this example, the baselines of most uncapped firms are overestimated.

6. If unlimited transfers are allowed, optimal emissions levels can still be obtained by anticipating the adverse selection and reducing the cap in the capped sector by the amount of excess emissions produced by the offsets.

7. This discussion assumes that the cap is set in terms of emissions, rather than an outcome-based measure such as atmospheric concentration of GHG.

8. This result is similar but not necessarily identical to what would happen if both sectors were capped. If both were capped, then the lower baselines could lower the aggregate abatement necessary without requiring active abatement from the uncapped sector. This can be more efficient as active abatement (the portion of offset sales require action) could still cost more than the equilibrium permit price. If the abatement quantity required from the capped sector yields a marginal abatement cost, after accounting for the lower baselines, that is less than the cost of abatement from the uncapped sector, it would be more efficient for all active abatement to come from the capped sector—even though less-active abatement would be required due to the lower baselines. In this case, the maximal cap would be more efficient.

The excess emissions of offset markets are not symmetric to the baseline realization, however. If the baseline emissions are underestimated, this simply reduces the amount of offsets sold. In the extreme, if the baselines of all firms are underestimated, then there is no adverse selection problem, in the sense that no firm is being paid to do what it would have done anyway absent a payment. In fact, uncapped firms would have to do more abatement than they would receive credit for. While underestimating the BAU emissions of uncapped firms can lead to problems stemming from overall regulations that are, ex post, too lax, these problems are not exacerbated by the existence of an offset market.

In summary, the implications of the adverse selection problem is tied strongly to the assumptions about the distribution of "errors" in the forecast of business as usual emissions. If this error is independently distributed across firms, offsets can produce underabatement. If the errors are highly correlated, however, the offset market can reveal information about the aggregate baseline and allow the abatement decisions of firms in the capped sector to adjust accordingly.

12.2.3 Discussion

As the previous section demonstrates, the question of additionality can be viewed in two lights; the adverse selection view, in which offsets pay the "wrong" firms to reduce, while other firms more than make up the difference, and one in which uncapped firms benefit from a coincidental, surprisingly clean development path. In some circumstances, there can be an important distinction between the two types of additionality. If the offset market were dominated by the latter "pleasant surprise" phenomenon, offsets can play a useful role despite the additionality problem.

Of course, the degree to which this distinction matters is closely linked to the level of the cap in the capped sector. In the context of Kyoto Treaty, the reductions required of the signatories are extremely modest. Any prospect of a pleasant surprise among nonsignatories would not come close to constituting the overall reductions called for by the Intergovernmental Panel on Climate Change (IPCC) and other groups. In short, most view the Kyoto Treaty as so lax that the world needs every ton of reductions it can produce. This is reflected in the fact that there has been relatively little market for excess reduction credits from Annex 1 Kyoto nations, such as Russia and the United Kingdom, because those excess credits are viewed as coincidental. These credits, known as "hot air," have largely been shunned, although this picture could change as Kyoto deadlines approach.[9] The distinction also has less meaning in the context of voluntary offset markets, where there is no mandatory cap to be adjusted.

Looking forward to a post-Kyoto world, however, the implications change

9. See Grubb et al. (2010).

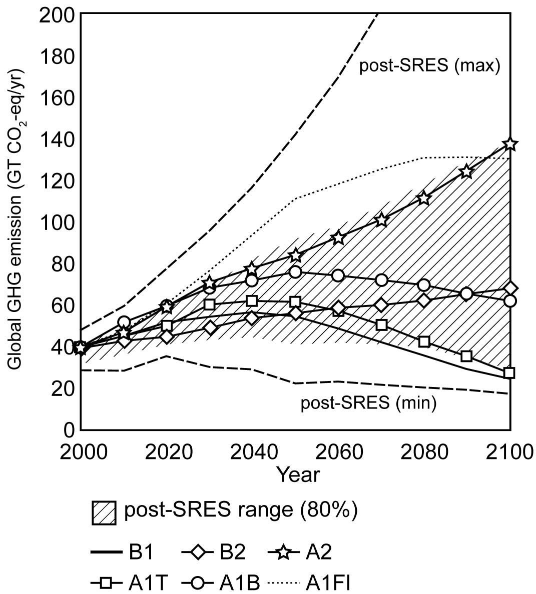

Fig. 12.1 Emissions trajectories of Intergovernmental Panel on Climate Change (IPCC) scenarios
Source: IPCC (2000).

somewhat. If a significant share of developed nations commit to proposed targets of 50 percent to 80 percent reductions, a pleasant surprise scenario could influence thinking about the needed stringency of those caps.[10] The potential stringency of future caps is largely dependent upon a political process, and the potential role of offsets plays a part in those negotiations. Those close to this process acknowledge that a tighter cap in the United States would be much more likely to gain acceptance if offsets are a part of the picture. If caps in the developed world are set ambitiously enough, this may not be the kind of Faustian bargain that critics of offset markets make it out to be.

On the other hand, if the worst-case IPCC scenarios materialize, even 80 percent reductions from developed nations would be insufficient to achieve a stabilization of GHG at levels deemed acceptable by the IPCC. Active abatement would have to be pursued in developing countries. Even under these circumstances, offsets can play an important role for some sectors of developing countries.

An examination of the IPCC scenarios (figure 12.1) for future BAU GHG emissions reveals just how much scope there is for an impact of a coinci-

10. The Annex I nations under the Kyoto Protocol account for roughly half of global GHG emissions today, but under the IPCC A2 scenario, this share would decline to under one-third.

dentally clean development path. There is a great deal of uncertainty about future emissions, with much of that uncertainty falling in the developing world. While fossil-fuel intensive, high population scenarios imply roughly a tripling of emissions by 2100, other scenarios imply a peak around 2050 followed by a steady decline.

Another key question is, therefore, whether additionality is likely to reflect adverse selection or common low baselines. In the case studied by Montero (2000), power plants that opted into the SO_2 program had low baselines because their output was reduced to be replaced by other plants. The case studies of the CDM appear to be different matters. There is evidence that many projects earned emissions reduction credits while not meeting the broad definition of additionality. The power plant projects identified in India and China may very well have not been additional, but their construction did not imply higher output from some other power facilities.

12.3 Implications for Offset Market Design

The preceding discussion attempts to highlight three implications. First, not all forms of additionality should be viewed as equally onerous to the effectiveness and efficiency of emissions caps. Second, the perverse incentives to manipulate baselines are an equally serious concern with no redeeming qualities. Third, offset markets can produce several other types of unintended consequences such as leakage, but those risks apply to almost any measures directed at reducing GHG emissions at less than a global scale. The current regulatory focus on additionality tends to paint all these problems with a broad brush without consideration of the context or their implications.

With these observations in mind, it is useful to consider the various policy tools that have been adopted or considered in order to address the perceived difficulties with offset mechanisms. Importantly, two frequently mentioned solutions, capping the number of offsets and discounting their effectiveness, do not address these problems very well. A cap on the number of offsets allowed into a market can limit the overall severity of the adverse selection problem, but by less than commonly thought. If adverse selection is a serious problem, the projects that are allowed would be the ones with the lowest baseline draws. If the baselines in the uncapped sector are instead highly correlated and much lower than expected, then limits on offsets restrict the ability of the mechanism to adjust to the "pleasant surprise" and allow for fewer reductions in the capped sector.

A devaluation of offsets treats all projects as equally nonadditional. As I have argued in the preceding, if this truly were the case and caps were strict enough in the capped sector, this is precisely when additionality does not reduce efficiency. In fact, it produces the exact same outcome as if the uncapped sector were under a mandatory cap and had been allocated allowances equal to its expected baseline. In either case, emissions are reduced and the uncapped sector reaps a windfall. However, both sectors benefit from the added participation of the uncapped sector relative to a case where that participation is limited. If instead baselines are uncorrelated and additionality is a serious problem, only the most extreme nonadditional projects are likely to be financially viable at the reduced returns provided by a genetic devaluation.

The solution identified by Montero (2000) is very different. A first-best reduction can be achieved if the cap were further tightened in anticipation of the excess emissions yielded from adverse selection in the uncapped sector. This allows full participation by the uncapped sector but still reaches the same overall emissions aggregated over both sectors. Unfortunately, this approach is both politically difficult and depends upon accurately predicting, on a sectoral level, the severity of the adverse selection problem.

To date, the primary bulwark against additionality concerns has been a review process that has been simultaneously criticized as too onerous to allow for substantial investment and also inadequate in weeding out nonadditional projects.[11] While some are concerned this may fatally delay investments, others feel that the incentive problems can only be adequately managed within a small program.

Those concerned with streamlining the review process are attracted to a shift away from project-specific review to a more programmatic approach. This offers several potential benefits. First, a programmatic approach can greatly lower the transactions costs of review and certification relative to the value of the offsets produced. Second, such an approach can help access a broader array of activities including energy efficiency and prevention of deforestation that have been largely absent from markets such as the CDM. Last, a program-level review can focus on risks, at an industry level, of the "bad" form of adverse selection while being less concerned with correlated, coincidental reductions. For example, investments in building efficiency may very well prove to be economic in the absence of offset programs and, therefore, not truly additional. But even if that is the case, increased efficiency in one building is unlikely to imply *worse* efficiency in others. A programmatic approach can also mitigate the moral hazard problem at the facility level by reducing the importance of the actions at a specific facility. However, there are still concerns about government level incentives.

Last, one tool that has not been applied to offset markets is the application of randomized trials. For example, a population of applications could be chosen to supply offsets, while another set is retained as a control group against which to judge the actions of the accepted population. This may be usefully combined with a shift in focus to evaluation at the program or sector level. Such approaches have been usefully applied to address similar adverse

11. See Grubb et al. (2010) and Wara and Victor (2008).

selection and moral hazard problems in programs that pay for reductions in energy use.[12] Atypical increases in emissions from countries or firms that become eligible for offsets relative to those that are not would indicate an inflation of baselines. Measuring the reductions from offset eligible projects *relative* to others can detect adverse selection relative to a common baseline, but it would also discount gains from commonly shared (e.g., coincidental) reductions. Because, returning to the earlier discussion, there are circumstances in which it is beneficial to allow credits for those coincidental reductions, the treatment of these shared effects would depend upon the stringency of overall caps.

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12. See Wolak (2010).

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Comment Kala Krishna

The goal in this very interesting chapter by Bushnell is to analyze some issues related to the implementation of carbon offsets in an overall plan to reduce emissions through the use of tradeable emissions permits.

There has been considerable discussion in the literature on such offsets. The main problem with offsets is in their implementation. While emissions levels are possible for a government to keep track of and penalize, changes in emissions levels require more effort to keep track of and are subject to potentially more manipulation by agents. Not only do past emissions need to be verified, but strategic manipulation by agents also needs to be policed. For example, agents will find it worthwhile to raise or misreport their emissions at the baseline to gain more from "reductions" in the future. Ted Gayner, in an article in the *American,* June 23, 2009, entitled "Offsets Chipping away at the Cap" illustrates this difficulty using the following example:

> In 2007, the House of Representatives launched its "Green the Capitol" initiative, which took on the goal of making House offices carbon neutral. After purchasing compact fluorescent light bulbs and shifting its electricity production from coal towards natural gas, the House still found itself far short of reaching its goal. To make up the difference, it bought 24,000 metric tons of carbon offsets [and] spent $14,500 to pay farmers for carbon-reducing "no-till" farming, even though the practice was started prior to the purchase of the offsets.

This example is related to the issues raised in Bushnell's chapter, which points out that offsets are more likely to be taken up by fake emissions reducers, as in the preceding, than by real emissions reducers because fake ones find it less costly to take up offsets than real ones. Why might this be so? This comes out most clearly if we model the technology behind emissions and work out a simple example, which is what I do in the following. I will first explain intuitively where the demand for emissions comes from and then try and embed what Bushnell does in a very simple example that might help the reader come to grips with what lies behind the slightly more abstract setting that is dealt with in the chapter.

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