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METHODS

The dynamics of carbon sequestration and alternative carbon accounting, with an application to the upper Mississippi River Basin

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Abstract

Carbon sequestration is a temporal process in which carbon is continuously being stored/released over a period of time. Different methods of carbon accounting can be used to account for this temporal nature including annual average carbon, annualized carbon, and ton-year carbon. In this paper, starting by exposing the underlying connections among these methods, we examine how the comparisons of sequestration projects are affected by these methods and the major factors affecting them. We explore the empirical implications on carbon sequestration policies by applying these accounting methods to the Upper Mississippi River Basin, a large and important agriculture area in the US. We found that the differences are significant in terms of the location of land that might be chosen and the distribution of carbon sequestration over the area, although the total amount of carbon sequestered does not differ considerably across programs that use different accounting methods or different values of the major factors.
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JEL classification: Q20; Q25

1. Introduction

Carbon sequestration through land use changes and forestry has been the focus of considerable attention in the climate change literature because of its potential as a cost-effective mitigation strategy. With the Kyoto Protocol becoming a binding treaty, countries may have further incentives to incorporate it into their greenhouse gas management plans. Carbon sequestration is a temporal process that removes carbon from the atmosphere either evenly or unevenly over time: the amount of carbon removal is larger in some periods than in others. Negative sequestration, that is,

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carbon release into the atmosphere, is also possible over some time intervals even though a project has overall positive sequestration. In order to properly assess different sequestration projects, it is critical that this temporal attribute be properly accounted for. In this paper, we examine some of the important issues related to carbon accounting and its policy implications when sequestration becomes part of the climate change mitigation portfolio.

In reporting the amount of carbon that has been sequestered in a project, several accounting methods and their variations have been used or proposed in the literature including the annual average carbon, the annualized carbon, and ton-year carbon. Simply speaking, the annual average carbon, the most widely used accounting method, is the sum of total carbon sequestered over a fixed period of time divided by the length of the period. To reflect our preference for benefits that have occurred earlier, the annualized carbon accounting method discounts carbon sequestered later. Although new relative to annual average carbon, annualized carbon (or its variation the present discounted value of carbon) has been employed by many studies including Adams et al. (1999), Plantinga et al. (1999), and Stavins (1999). A third accounting method, the ton-year carbon, takes into account the duration of carbon kept outside of the atmosphere. Several studies (e.g., Watson et al., 2000; Moura-Costa and Wilson, 2000) have analyzed this method with an emphasis on how it facilitates the comparison between projects that sequester (or release) carbon for different lengths of time.

Different projects may show up as the favorable choices when different accounting methods are used. Even under the same accounting method, the ranking of projects may differ as the value of some factors varies. The first factor is the project duration. There might be some natural choices for the value of this factor, for example, the saturation point which is the length of time needed for a carbon pool to reach equilibrium. Given that there may be different carbon pools in a single project (let alone in multiple projects), the use of saturation point may result in: (a) different durations in different projects and (b) a somewhat subjective decision on which, if any, carbon pool's saturation point to use. In fact, different durations of projects have been employed in the literature to suit the underlying nature of the analyses. For example, Stavins (1999) used a period of 90 years to allow at least one rotation of each project species; Parks and Hardie (1995) limited their study to the life of a temperate forest; and Adams et al. (1999) chose a 50-year period to investigate the costs of sequestration through both afforestation and improvement in forest management.

The effect of the choice of project durations is largely determined by the path of a sequestration project (i.e., distribution of carbon sequestration over time), which is the second factor we are going to explore. Obviously, an accounting method that gives more weight to early sequestration will favor a project that sequesters carbon in relatively early periods. Although seldom discussed in the literature on the cost of sequestration, the effects of different mitigation paths have been extensively debated in the more general climatic change literature (see Wigley et al., 1996; Ramakrishna, 1997). Some have argued that delaying abatement may be costly because there is socioeconomic inertia in the energy system and the process of climate change is difficult to reverse. If earlier carbon sequestration is valued more, then we may prefer one sequestration project over another even if both projects can sequester the same amount of carbon (undiscounted sum) at the same amount of cost over the same period of time. To take into account the timing of carbon uptake, discounting can be used.

The discount rate is the third factor that we are going to discuss. Instead of sensitivity-type analysis, we examine how the discount rate interacts with sequestration paths and project durations to affect the results of sequestration policies. The advantage of discounting is that it can reflect preferences for early carbon reduction and allow us to focus on some summary measures (e.g., annualized carbon) without being too concerned about the paths of sequestration. However, discounting also brings its own complications because, as we illustrate, a different discount rate may favor a different sequestration activity and, even at the same discount rate, different projects may become the favorable choice as project durations vary.

Some studies have started investigating the issue of accounting for time in climate mitigation through carbon sequestration. The differences of alternative accounting methods and the factors affecting them are discussed in the special report on Land Use, Land-Use Change and Forestry by the Intergovernmental Panel on Climate Change (Watson et al., 2000, Chapters 2

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