The Effect of a Cap-and-Trade model for Groundwater use: A case study in the Texas Southern High Plains

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Selected Poster Prepared For Presentation At Agricultural & Applied Economics Association's
2013 AAEA & CAES Joint Annual Meeting, Washington, DC , August 4-6, 2013

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Abstract

This study evaluated the possibility of implementing a proposed cap and trade policy on water use in the Texas Southern High Plains. The results suggested that the decision of producers to enroll in a cap and trade policy introduced under a restricted 50/50 management plan, will be impacted by water levels in the aquifer and subsequently the viability of pumping irrigation water in the future. It is to be realized that while polices like these will have a definitive impact on the crop-mix and farm income of the region, they could still serve as useful tools to promote long term conservation of groundwater resources in the region.

Relevance

Producers in the Texas Southern High Plains face the depletion of the Ogallala aquifer as withdrawals for irrigation have far exceeded the recharge. Recent policy regulations have been established in the area to reduce groundwater consumption for irrigated agriculture. This project proposes to explore the policy implications of implementing a cap and trade model in this region.

Introduction

Groundwater levels in the Ogallala Aquifer have witnessed a declining trend over the last fifty years. Policy makers and stakeholders have been studying and analyzing various options in order to maintain adequate groundwater stock in the aquifer for future use. Several water conservation policies have been evaluated for the region as a result of a survey of stakeholders (Amosson et al. 2009). Among those water use restriction is one. Water use restriction policy is a mandatory annual or multi-year limit that reduces the amount of water pumped from the Ogallala Aquifer for irrigation purposes with an objective to sustain water for future use. Policy regulations that have been passed in the area affect water use for agricultural irrigation to increase sustainability of the Ogallala aquifer. The High Plains Underground Water Conservation District No. 1 adopted a 50/50 Management Goal to have 50% of the current saturated thickness of the Ogallala aquifer available in 50 years. To achieve this management goal the District implemented rules that restrict annual pumping to 1.75 acre feet per contiguous acre for 2012 and 2013; 1.5 acre feet for 2014 and 2015; and 1.25 acre feet starting in 2016 (Postel, 2012).

Objective

The objective of this project is to estimate the permit price and penalty for violation while implementing a proposed cap and trade policy on water use in the Texas Southern High Plains. This will be accomplished through two tasks:

•Using a non-linear optimization model driven by yield response functions to predict water use and net revenue from farming over 50 years.

•Estimating the compensated variation, permit price, and penalty for violation while implementing the cap and trade policy over a 50 year planning horizon.

Methods

A non- linear dynamic optimization model was developed using GAMS (General Algebraic Modeling Systems) under two specific scenarios to evaluate the impact of a cap and trade policy for irrigation water in the Texas Southern High Plains region. Hale county was chosen as a representative county with cotton, corn, sorghum, and wheat as crops with substantial acreage to impact the overall irrigation water use in the county. A status-quo scenario (unrestricted) was compared with a 50/50 management plan (restricted) to estimate the changes in saturated thickness, water applied per cropland acre, and per acre net revenue from farming over a 50 year planning horizon. The most recent crop prices, input costs, and the price of natural gas ($/mcf) were used as input to the model, and district budgets from Texas AgriLife Extension Service (Texas AgriLife Extension Service, 2011) were used to calculate costs of production for each crop and output prices averaged over 5 years. Crop production functions used in the model were derived from crop models by establishing a quadratic relationship between crop yields and amount of water applied for each crop. The difference in the net revenue between the two scenarios over a stipulated planning horizon provided a measure of the compensated variation (CV) in $/acre which reflects the willingness to pay on behalf of the producers for water units available for trade, when a 50/50 plan is implemented. The change in marginal pumping cost for irrigation water was also calculated to derive the price of permit and penalty for violation, when implementing the cap and trade policy. The formulae used for estimation are:

1. Price of permit = CV – MPC

2. Penalty for violation = CV+MPC

where: CV is Compensated Variation, and MPC is Marginal Pump Cost, both in $/acre

Results

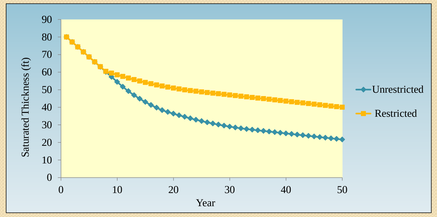

Figure 1. Saturated thickness changes for the unrestricted and restricted (50/50 plan) scenarios

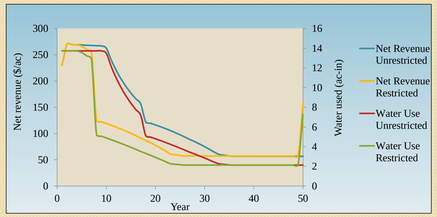

Figure 2. Changes in water use and net revenue for the unrestricted and restricted (50/50 plan) scenarios

1. Saturated thickness levels declined under both scenarios, with the unrestricted scenario showing a higher decline from 80 ft to 22 ft, as compared to the 50/50 scenario where the saturated thickness declined from 80 ft to 40 ft (Figure 1).
2. Due to the restriction on water availability under the 50/50 management goal, the net revenue per acre showed a higher decline when compared to the unrestricted scenario on account of reduction in irrigated production over the planning horizon. The Net present values per acre under the restricted and unrestricted scenarios were $3,282 and $4,295 respectively (Figure 2).
3. The water use per acre was also impacted in a similar manner with a higher decline in water applied per cropland acre under the restricted scenario, as compared to the unrestricted scenario.
4. An interesting observation for the 8th year of the planning horizon under the restricted scenario was the sharp decline in net revenue per acre and water availability. A possible explanation could be that at this point water became a limiting factor because of declining levels of saturated thickness, and that is when the differences under the two scenarios became more evident (Figure 2).
5. Figure 3 depicts the changes in CV, price of permit, and penalty of violation in the event of a 50/50 management plan being implemented, and a cap and trade policy introduced. Until year 8, the producers have no incentive to enroll in a cap and trade policy because water availability is not a constraint. Soon after, as water becomes limiting the market for a cap and trade policy opens up and continues to function as long as it is viable to pump water for irrigation.
6. Around year 32, the declines in saturated thickness are large enough for the producers to switch from irrigated to dryland production to remain economically viable, and at this point the cap and trade market begins to shut down.

Results (continued)

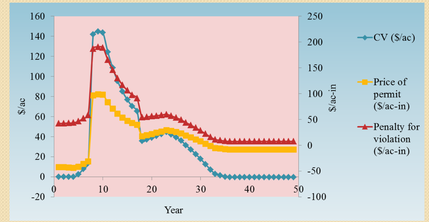

Figure 3. CV, price for permit, penalty for violation for a cap and trade policy over 50 years.

Conclusions

1. This study evaluated the possibility of implementing a proposed cap and trade policy on water use in the Texas Southern High Plains. The results suggested that the decision of producers to enroll in a cap and trade policy introduced under a restricted 50/50 management plan, will be impacted by water levels in the aquifer and subsequently the viability of pumping irrigation water as we move further into the planning horizon.
2. The cap and trade market of water does not operate before the 8th year and after the 32nd year, due to adequate supply until the 8th year, and physical limitation faced for pumping water after the 32nd year respectively. Also, the CV stays zero during these time periods. The highest price of permit, as well as penalty of violation is encountered in the periods where water becomes limiting, and the overall supply in the area declines.
3. While polices like these will have a definitive impact on the crop-mix, farm income, and the regional economy, they could still serve as useful tools to promote long term conservation of groundwater resources in the region.

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