Accepted Manuscript

Title: Optimal Groundwater Management under Climate Change and Technical Progress

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PII:	S0928-7655(17)30034-9
DOI:	https://doi.org/doi:10.1016/j.reseneeco.2017.10.005
Reference:	RESEN 1044
To appear in:	*Resource and Energy Economics*
Received date:	28-1-2017
Revised date:	6-8-2017
Accepted date:	20-10-2017

Optimal Groundwater Management under Climate Change and Technical Progress.

Abstract

We develop a dynamic model of groundwater extraction for irrigation where climate change and technical change are included as exogenous state variables in addition to the usual state variable of the stock of groundwater. Our key contributions are (i) an intuitive description of the conditions under which groundwater extraction can be non-monotonic, (ii) a numerical demonstration that extraction is non-monotonic in an important region overlying the Ogallala Aquifer, and (iii) the predicted gains from management are substantially larger after accounting for climate and technical change. Intuitively, optimal extraction is increasing in early periods when the marginal benefits of extraction are increasing sufficiently fast due to climate and technical change compared to the increase in the marginal cost of extraction. In contrast, most previous studies include the stock of groundwater as the only state variable and recommend a monotonically decreasing extraction path. We conduct numerical simulations for a region in Kansas overlying the Ogallala Aquifer and find that optimal groundwater extraction peaks 23 years in the future and the gains from management are large (29.5%). Consistent with previous literature, the predicted gains from management are relatively small (6.1%) when ignoring climate and technical change. The realized gains from management are not substantially impacted by incorrect assumptions of climate and technical change when formulating the optimal plan.

1 Introduction

The economic dependency on irrigation of large agricultural regions such as the Great Plains in the United States makes aquifer depletion a much-discussed policy and research issue. Premature aquifer depletion can be costly. Temporally misallocating the resource causes suboptimal levels of social welfare derived from mining the resource over time. Furthermore, premature depletion results in a diminished ability to cope with the added stress of higher evapotransporative needs associated with climate change.