Evaluating the Shadow Price of Water for Irrigation – A Case of the High Plains

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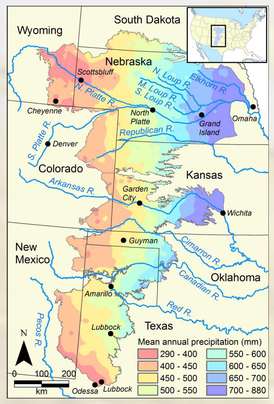
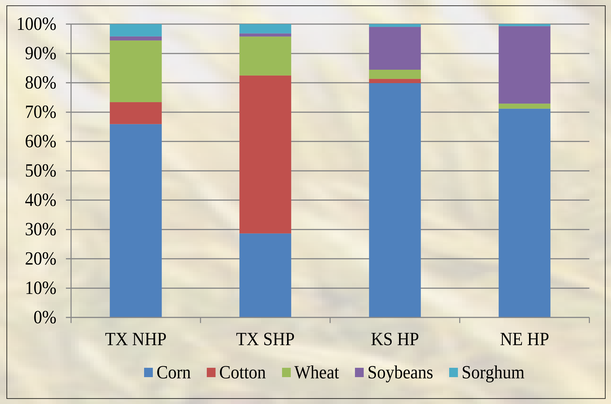
1 Background and problem setting

- About 27% of US irrigated land depends on the Ogallala Aquifer – High Plains (HP) is a key region for livestock, corn, wheat & soy
- The Ogallala's volume is predicted to fall by 52% between 2010 and 2060
- Irrigation makes 61% of total water use in TX, 85% in Kansas and 94% in Nebraska
- Actual water rates for irrigation do not reflect the real value of water (water is underpriced)
- Appropriate water pricing crucial for economic efficiency & natural resource conservation
- Recent research on shadow prices limited (Mesa-Jurado et al., 2012; US EPA, 2012; Hellegers and Davidson, 2010) & comparative regional analyses missing

Case study area



Percentage of water used in High Plains by crops in 2010



2 Research objective

The objective is to evaluate economic value of water for irrigation in High Plains (Texas, Kansas, Nebraska) in 2010 and 2011. The main focus is on:

a) Shadow price of water on regional level ($/af)

Shadow price of water for irrigation = ratio of total production net returns to the total amount of water used for irrigation

b) Shadow price of water in actual (drought) conditions compared to expected production conditions – example from TX HP

3 Methods and data

- Farm-budget residual valuation - inputs and outputs in the crop production process (Comparative-statics analysis)
- A profit-maximizing firm will use water up to the level where the net revenue gained from one additional unit of water is equal to the marginal cost of obtaining this water (Lange, 2006)
- Crops included in the analysis: corn, cotton, wheat, soybeans, sorghum
- Data from: National Agricultural Statistics Service (NASS), Texas Water Development Board (TWDB), Texas AgriLife Extension Agricultural Economics Station, Kansas Department of Agriculture, Kansas AgManager.Info, University of Nebraska-Lincoln
- Subsidies averaged for all crops in KS ($30/ac). Subsidies not available in TX and NE
- Irrigation in Nebraska estimated based on the actual water demand due to missing data

$$Y = f(X_K, X_H, X_L, X_W)$$

$$Y_i * P_i = Q_{Ki} * P_{Ki} + Q_{Hi} * P_{Hi} + Q_{Li} * P_{Li} + Q_{Wi} * P_{Wi}$$

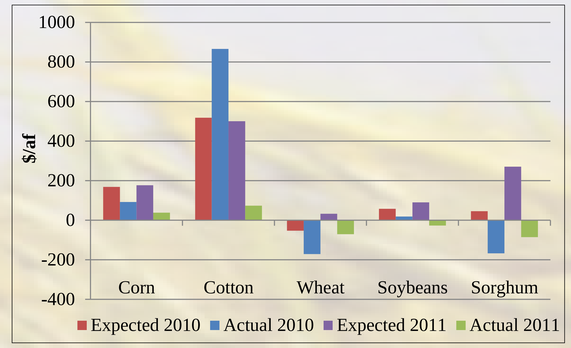
Y – output of agricultural production
X_K – capital input
X_H – labor input
X_L – land input
X_W – water input (irrigation water)

P_{Ki} – price of capital input; P_{Hi} – price of human labor; P_{Li} – price of land used;
P_{Wi} – price of water
Q_{Ki} – quantity of capital input; Q_{Hi} – quantity of human labor input;
Q_{Li} – area of land applied to produce the crop
Q_{Wi} – amount of water applied for the crop production

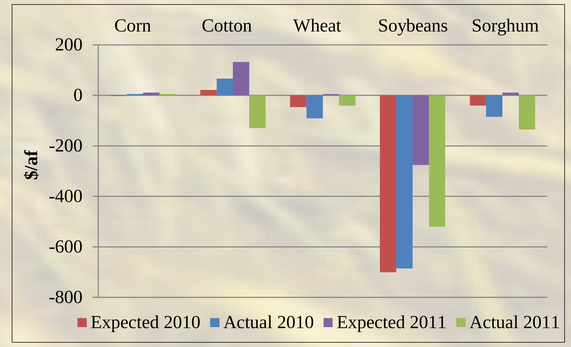
4 Shadow price of water for irrigation

2010	Crop	Net returns (million $)	Irrigation water (af)	Shadow price of water ($/af)
Texas Northern HP				
	Corn	89.4	971,853	**92.02**
	Cotton	95.8	110,663	**865.99**
	Wheat	-52.8	309,361	**-170.71**
	Soybeans	0.38	20,486	**18.61**
	Sorghum	-10.3	61,906	**-166.85**
Texas Southern HP				
	Corn	3.4	656,335	**5.13**
	Cottonc	81.5	1,233,028	**66.10**
	Wheat	-27.6	304,248	**-90.73**
	Soybeans	-17.5	25,566	**-685.17**
	Sorghum	-6.1	72,277	**-84.94**
Kansas HP				
	Corn	103.9	1,339,319	**77.64**
	Cotton	1.4	24,674	**56.43**
	Wheat	-24.0	52,416	**-458.35**
	Soybeans	-5.0	244,034	**-20.74**
	Sorghum	-12.5	16,372	**-765.10**
Nebraska HP				
	Corn	249.9	10,023,162	**24.94**
	Wheat	-2.2	239,988	**-9.04**
	Soybeans	434.7	3,718,404	**116.91**
	Sorghum (total)	-8.3	100,308	**-82.85**

Shadow price of water based on expected and actual net revenues in TX Northern HP



Shadow price of water based on expected and actual net revenues in TX Southern HP



5 Conclusions

- Unprofitable production in 2010: wheat and sorghum in TX NHP & NE HP + wheat, soybeans and sorghum in TX SHP & KS HP
- Lowest positive net production returns: soybeans in TX NHP ($ 0.38 mil), cotton in KS ($1.4 mil) and corn in TX SHP ($3.4 mil)
- Lowest positive shadow price of water: corn in TX SHP ($5.13/af) and soybeans in TX NHP ($18.61/af). The highest shadow prices of water: cotton in TX NHP ($865.99/af) and soybeans in NE ($116.91/af)
- Variations in net returns and shadow price of water for irrigation regardless of the wet and dry production year (2010 and 2011) in TX
- Challenge: higher water prices for irrigation beneficial for conserving water resources; but severe economic impacts on farms' productivity possible & higher governmental subsidies necessary
- Increase in water rates possible, but due to water scarcity (i.e. persistent drought) rather than to a politically or environmentally driven approach

6 References

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