The Economic Value of Irrigation in the Texas Panhandle

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Abstract

The Texas Panhandle relies largely on the Ogallala Aquifer for access to water for irrigated agricultural production. With current pumping rates and slow recharge rates, the aquifer will at some point in the future no longer be an economically viable source of water for agriculture. The objective of this study is to estimate the value of irrigated agriculture to the region. A hypothetical policy restriction is imposed which assumes a one hundred percent conversion to dryland agriculture. The study estimates the economic impact of such a change on producer income and the resulting socioeconomic impacts on communities in the region.

Key Words: economic impacts, IMPLAN, irrigated production, Ogallala Aquifer, water policy

JEL Classifications: Q18, Q32, Q38

Introduction

The Texas Panhandle relies almost exclusively on the Ogallala Aquifer for access to water for irrigated agricultural production. With current pumping rates and slow recharge rates, the aquifer will at some point in the future no longer be an economically viable source of water for agriculture. Instead, water will most likely be reserved for municipal and industrial uses where pumping costs are less important. While municipalities in the region have largely secured their supplies of water through purchases of water rights, agriculture's access to irrigation is nonetheless a policy issue of importance to cities. Agriculture serves as a major underpinning to the region's economic activity although it is not the only industry operating in the region. The decline in the aquifer will affect agricultural profitability which, in turn, will result in negative economic impacts to other sectors in the local economy. Policy makers need information about these impacts in order to make plans for future economic changes.

In addition to immediate concerns about water availability, it is clear that agriculture in most, if not all, of the region will eventually have to switch to dryland production methods at some point in the future because of declining water tables and increased pumping costs. That is, the water will simply become too expensive to acquire to be used in the production of bulk commodities.[1] This switch will have implications as to how land is used; for instance, what crops are viable to produce. Although a total conversion to dryland agriculture is not expected to occur in the immediate future, this analysis will provide reasonable bounds on the effects of water use/availability changes on the region's economy. This will set the stage for future analyses with more specific policy/water use proposals.

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[1] This, of course, assumes that the price of basic commodities remains relatively stable. If there are dramatic increases in commodity prices over the long-run, it might justify additional pumping from the aquifer in the future, further putting pressure on eventual water availability. However, there is no evidence to support that line of thinking.

The purpose of this study is to estimate the value of irrigation to the Texas Panhandle in order to begin exploring the implications of different water policies and provide policy makers with perspective for making decisions to address the eventual changes in the regional economy with declines in irrigated agriculture. Specifically, the value of irrigation is examined by comparing the *status quo* to an economy based on one hundred percent dryland agriculture across the region. This study does not attempt to model the time path of declines in the aquifer or to identify specific portions of the region that have more or less water. This study estimates the economic impact of an absence in irrigation in total on producer income and the resulting socioeconomic impacts on communities in the region.

Literature Review

For one hundred years, the rights to groundwater in Texas have been regulated by the modified rule of capture (Potter 2004). The rule of capture simply states that the groundwater underneath a landowner's property is theirs to use as they see fit. In Texas, this rule has been modified to prevent waste, subsidence, and harmful use (Potter 2004). While this common property right is still in effect, the Texas Legislature does recognize the right to manage groundwater through legislation such as Article 16, section 59 of the Texas Constitution, or the conservation amendment (Caroom and Maxwell 2004).

Management of groundwater in Texas is handled locally through groundwater conservation districts (GCDs) which are part of sixteen groundwater management areas (GMAs). In 2005, House Bill 1763 required GMAs to develop desired future conditions (DFCs), or the quantified condition of water resources at some point in the future, through which to conserve groundwater resources (Mace et al. 2006). Conservation districts are required to create plans through which these DFCs can be reached. The GMA that is responsible for the High Plains, has

proposed a 50/50 DFC, which means that in fifty years the Ogallala Aquifer will have fifty

percent of its current volume still remaining (Conkwright 2009). Other areas of the Texas

Panhandle are using, or proposing to use, 50/50 rules while a few counties are proposing

variations of the rule.

Implementation of water conservation policies could have a noticeable impact on

agriculture and the regional economy in the Texas Panhandle. Agriculture is a large industry in

the region and is a crucial part of the region's economic well being. According to a study

performed examining the years 2001-2004, agricultural cash receipts totaled about 2.9 billion

dollars annually (Amosson et al. 2005). The same study indicated that agriculture in the region

annually generated about $6 billion throughout the regional economy and 46,404 jobs over the

same period. Another indication of the importance of agriculture to the Texas Panhandle is the

amount of state agricultural activity that the region accounts for. On average, the region

accounts for about half of the revenue received in the state from corn and wheat production, ten

percent of revenues in the state from cotton, and eighteen percent of sorghum revenues

(Amosson et al. 2005).

Many studies that have quantified the economic impacts of irrigated agricultural

production on a region have utilized IMPLAN (Impact Analysis for PLANning) which is an

input-output model building system. This computer-based system was originally developed by

the United States Department of Agriculture's Forest Service to assist in land and resource

management planning. The most current version of IMPLAN was developed by the Minnesota

IMPLAN Group (1999) and provides access to comprehensive and detailed data coverage of the

entire U.S. by county. IMPLAN datasets are compiled from a wide variety of sources including

the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and the U.S. Census Bureau.

One advantage of the IMPLAN model is that it allows the incorporation of user-supplied data throughout the model building process. This aspect makes the model more flexible and enhances the accuracy of impact results (Minnesota IMPLAN Group 2004). The IMPLAN model is the primary tool used in this study to measure regional economic impacts of irrigation on the Texas Panhandle Region.

Thorvaldson and Pritchett (2006), used the IMPLAN model to estimate the regional economic impacts of future reduction of irrigated acres in four river basins in Colorado. The study assumed all irrigated acreage lost was fallowed while the remaining acres maintained their current crop mix. Impacts were measured using an instant, one-year permanent loss of irrigated acreage. The estimated impacts included severe damage to the agricultural sector of the economy as well as a loss of jobs and industry output in other sectors of the economy. In addition, the tax revenue loss estimates were substantial. It was noted that the impacts varied according to region and thus, water policies should be tailored accordingly.

The issue of water is not a new topic for the region and the problem has been examined by other researchers. Many studies attempt to find ways to conserve and extend the usefulness of the Ogallala Aquifer for agriculture rather than identify the consequences of an eventual loss of the irrigation resource.

One study performed in the Southern High Plains Region identifies the effect of integrated systems of agriculture on water use (Allen et al. 2005). The study compared a cotton monoculture system to an integrated cotton- livestock system. The results of this study indicate two things. First, there was no increase in productivity in terms of the cotton crop from rotating cotton with livestock. The second result was that the cotton-livestock system used about twenty-three percent less water than the cotton only system. While this study does imply that converting

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to an integrated system would use less water, there are some caveats. The first is that there is no information involved about the costs involved with using such a system. Without such information it is difficult for decision makers to use these results as a basis for implementing policies that would encourage such practices, or to be prepared for the consequences of such policies on the region (Allen et al. 2005). In an extension of the study, the authors add information about the difference in profitability between systems which can be useful to policy makers in encouraging a switch to an integrated system (Allen et al. 2008). A second issue is acknowledged by the authors themselves. An integrated system may use less water, but it may not conserve water. The result of switching to this system may be an increase in irrigated acreage by producers and no decrease in total water use (Allen et al. 2005).

A second study about water conservation is of greater use in terms of policy analysis. The study looks at the implementation of five different policies to lessen water use from the Ogallala Aquifer and estimates their impact on the economy over a sixty-year period (Amosson et al. 2009). The policies included in the study were the use of biotechnology in which crops required less water, the adoption of better irrigation technology, a water restriction that reduces water use by one percent each year, a temporary conversion to dryland agriculture that reduces the amount of irrigated acres by ten percent for fifteen years, and a permanent conversion of ten percent of irrigated acres to dryland production. For each of the five scenarios, economic optimization models were used to estimate changes in net farm income and in the aquifer. These results were then aggregated and input into IMPLAN to determine changes in the regional economy as a result of the policies. These results were compared to a baseline that assumed no change in aquifer use.

The five different scenarios that the study examines result in marginal differences in economic impact and aquifer use. Utilizing biotechnology and issuing water restrictions resulted in the largest benefits in terms of water conservation. The permanent switch to dryland agriculture scenario is similar to the objective of this study in which the effect of a complete conversion to dryland production will be examined. In this scenario, the saturated thickness of the aquifer increased by 4.2% from the baseline over sixty years and the economic effect was minimal, a one percent decrease from the baseline (Amosson et al. 2009). These results indicate that the economic impact of switching to dryland may be small, however, only ten percent of irrigated acres in eight targeted counties were gradually converted to dryland over a time period of fifteen years.

Conceptual Framework

This study estimates the value that irrigation adds to agricultural production. From a production standpoint, water use is constrained to zero so that the "shadow price" of irrigation can then be estimated. In this case, the "shadow price" is the difference in regional economic activity between the current state and a hypothetical state where no irrigation occurred in the region. Input-output analysis using regional economic data will be employed to estimate the economic impacts between the two scenarios. This type of analysis portrays the economy in terms of a circular flow of income between producers and consumers. Identifying these economic flows and interdependence will allow assessment of the effects of irrigation on the overall regional economy. Ultimately, input-output analysis is used in this study to determine the socioeconomic value of irrigated agricultural production.

Three main parts of input-output analysis include the transactions table, technical coefficients, and multipliers. The transactions table is the beginning building block underlying

input-output analysis. This table captures the production flows between the industries, or sectors, in a region's economy. The figure in the ith row and j^{th} column represents the amount that sector i delivered to sector j in a particular time period. The values that appear in the relative column for a processing sector are essentially the inputs or factors of production that an industry requires to produce output.

Technical coefficients are derived from the transactions table. These coefficients represent the amount of inputs required from each industry for the production of one unit or one dollar's worth of output for a certain industry. The demand for a portion of one industries' output (X_i) by industry j is a function of the level of production in X_j. This relationship can be shown as follows:

(2) $$X_{ij} = a_{ij} X_j$$

The technical coefficients (a_{ij}) are solved for by dividing the column entry of a processing sector by the adjusted gross output. The resulting equation for technical coefficients is the formula:

(3) $$a_{ij} = \frac{X_{ij}}{X_j}$$

The technical coefficients can be used to determine the amount of output that is necessary from an industry to fulfill the direct demand from purchasing industries. The table of coefficients represents only the direct effects of a change in output in one industry on the other industries in the economy that supply its inputs (Miernyk 1965).

The purpose of input-output analysis is to determine how a change in final demand affects gross output. Technical coefficients provide a means for linking final demand to gross output. However, the Leontief inverse, or multiplier matrix, is necessary to calculate the total addition to output from a change in final demand. Multiplier effects are captured by solving a

system of equations in matrix form. The set of equations for all industries in the economy can be represented as follows:

(4) $$X - AX = Y$$

where X is a n x 1 vector of gross output, Y is a n x 1 vector of final demand, and A is an n x n matrix of input coefficients (a_{ij}) where there are n sectors in the economy. With the use of the identity matrix, equation 4 can be simplified to the following:

(5) $$(I - A)X = Y$$

The inverse of $(I - A)$ can be used to express gross output as a function of final demand:

(6) $$X = (I - A)^{-1}Y$$

The matrix $(I - A)^{-1}$ is known as the Leontief inverse, or the multiplier matrix. An exogenous shock to final demand in an economy is then multiplied by the Leontief inverse to obtain the new level of gross output (Richardson 1972).

The socioeconomic model IMPLAN uses multipliers to estimate the response of a region's economy to a "shock" of some type. The estimated multiplier effects are broken down into three components including direct, indirect, and induced effects. Direct effects represent the difference in gross receipts between the current state and the non-irrigated state. These values are specified as direct final demand changes. Indirect effects represent the impacts caused by industries buying from industries to supply additional (or fewer) inputs for irrigated production. Induced effects represent the response of all local industries caused by the change in household income/spending generated by the direct and indirect effects of final demand changes (Minnesota IMPLAN Group 2004). For example, say a producer switches from irrigated corn to dryland sorghum due to restricted water use. They will probably not purchase as much fertilizer (direct effect). The fertilizer dealer will not purchase as much fertilizer for the store room (indirect

effect). Now, both the producer and the fertilizer dealer do not have as much profit, so they cannot spend as much at the local grocery store (induced effect).

There are basically three measures of economic activity that can be estimated through IMPLAN including industry output, value added, and employment. Industry output is the value of total production of an economy or the total economic activity that occurs in a region. Value added is the income or "wealth" portion of industry output that includes employee compensation, proprietary income, other property income, and indirect business taxes. Finally, employment is simply the number of jobs in an economy (Minnesota IMPLAN Group 2004). These are the measures reported in this study.

Data and Methods

The study area is the Texas Panhandle Region which consists of the top 26 counties in Texas highlighted in Figure 1. Two scenarios are evaluated in order to estimate the economic impacts of a total conversion to dryland policy. A baseline is estimated for every county in which producers operate in an unregulated profit maximizing manner (current situation). Then, an alternative scenario assumes all irrigated agricultural production is converted to dryland.[2] This scenario is evaluated with respect to impacts on the regional economy to determine the effects of irrigation.

It is necessary to first estimate the differences in gross receipts per acre between irrigated crops and their dryland alternatives. There are four main crops analyzed in this study including corn, sorghum, wheat, and cotton. The dryland alternatives are assumed to be the relative dryland crops with the exception of corn which is assumed to convert to sorghum. Texas AgriLife Extension budgets are used to estimate the difference in gross receipts between

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[2] This should not be construed as an advocated policy or even a proposed policy. Rather, this extreme is necessary to establish the impact of irrigation on the regional economy.

irrigated and dryland crops using a three year average (Amosson et al. 2006, Amosson et al. 2007, Amosson et al. 2008). The differences in gross receipts by crop are then applied to the 2008 irrigated acreages within each county (National Agricultural Statistics Service 2008). Then, a socioeconomic input-output IMPLAN model is used to estimate the changes in the region's economy due to changes in gross crop receipts. Analysis-by-parts is used in which specific crop production functions are entered into the IMPLAN model. This method allows more specific results for irrigated and dryland crops. The IMPLAN model creates multipliers to estimate economic impacts in terms of direct, indirect, and induced effects for economic indicators including industry output, value added, and employment.

Results

Dryland production has lower net returns for producers than irrigated production, and therefore, a smaller economic impact on the region relative to the current situation. This directly decreases the value of the agricultural industry within the region. The direct impact to producers, in turn, results in indirect and induced socioeconomic impacts to communities within the region. For example, as producers buy fewer inputs for production, the industries supplying those inputs will be indirectly affected and will likely cut the amount of product supplied and their level of employees. Lost jobs in both the agricultural and input supplying industries lead to an induced effect. That is, those employees will no longer spend their income at local businesses such as retail and grocery stores, affecting an even larger portion of the economy. The result is a decrease in total industry output, value added (or wealth), and jobs in the region.

Results indicate that irrigated agriculture adds approximately $1.6 billion in industry output to the Texas Panhandle economy. A portion of this impact, $400 million, would be made up by the conversion of the irrigated acreages to their dryland alternatives. Thus, relative to the

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current situation, a completely dryland production system in the region would have an approximately $1.2 billion smaller contribution to total regional output (Table 1). Value added is the portion of total industry output that contributes to the wealth or income of an economy. For this study, a dryland scenario results in a decrease in value added of $631 million relative to the current irrigated production, which is offset by an increase of $157 million from dryland production for a net loss of approximately $474 million (Table 2). Employment in the Texas Panhandle region would also be different under a completely dryland production system. Approximately 16,650 jobs are tied to irrigated production. An additional 4,536 jobs would be retained from the increase in dryland production resulting in a net impact of 12,113 fewer jobs for a completely dryland production system relative to the current situation.

Discussion and Conclusion

It is apparent that irrigated agricultural production adds economic value to the Texas Panhandle region. Total regional output is above $36 billion annually. Irrigated agriculture accounts for $1.6 billion or 4.5% of this total. Furthermore, the value added to the economy from irrigated agriculture constitutes about 4.7% of the total economic value added in the economy. In addition to the output and value added generated by irrigated agriculture, the 16,650 jobs associated with irrigation amounts to jobs for about 7.4% of all employment in the region. For an industry that contributes so much to the region, losing this value would have serious negative consequences to the region.

There are a couple critical issues related to these findings that should be mentioned. First, all available scientific evidence indicates that for all practical purposes the Ogallala Aquifer is a stock resource. So, water policy in the aquifer is one of managing depletion. Because of this, the second critical issue is that the overall value of irrigated agriculture will

decline through time. The results presented here focus on the value of irrigation today. As the aquifer declines and fewer acres are irrigated, the overall value of irrigation will decline as well.

In this study, it is assumed that producers simply moved from the irrigated form of a crop to the dryland version. In reality, very little is known about how producers would respond. In many cases, the assumption made in this study is probably reasonable. However, additional research about producer responses to reduced water is needed to better predict eventual changes in production practices and the requisite impacts on the overall economy.

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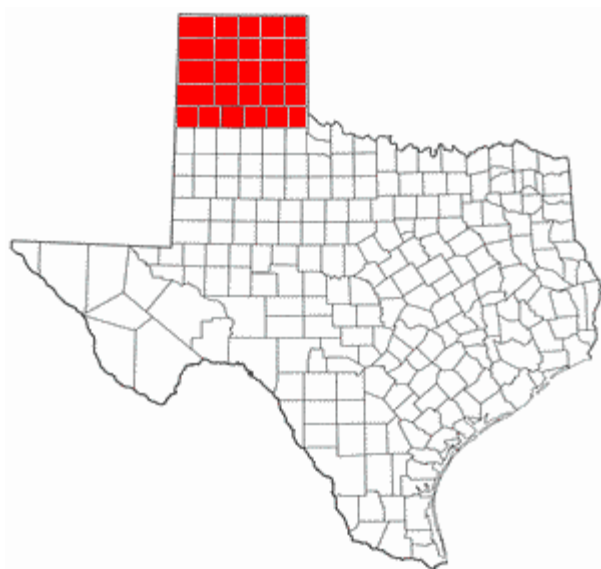
Figure 1. Texas Panhandle Study Region.

Table 1. Industry Output.

Crop	Impacts			
	Direct	Indirect	Induced	Total
Irrigated Corn	-591,303,636	-325,966,773	-173,689,530	-1,090,959,939
Irrigated Cotton	-82,776,730	-55,526,796	-26,866,015	-165,169,542
Irrigated Sorghum	-18,217,650	-13,719,457	-4,017,557	-35,954,664
Irrigated Wheat	-177,382,041	-126,258,408	-39,349,900	-342,990,349
Dry Cotton	30,066,233	22,063,384	8,804,445	60,934,063
Dry Sorghum	104,414,310	71,043,288	34,013,797	209,471,394
Dry Wheat	63,414,855	40,331,975	20,390,095	124,136,925
Total	**-671,784,659**	**-388,032,788**	**-180,714,664**	**-1,240,532,111**

Table 2. Value Added.

Crop	Impacts			
	Direct	Indirect	Induced	Total
Irrigated Corn	-177,097,115	-166,705,051	-100,228,923	-444,031,089
Irrigated Cotton	-20,435,802	-29,713,949	-15,504,082	-65,653,833
Irrigated Sorghum	-1,830,037	-6,985,959	-2,318,779	-11,134,775
Irrigated Wheat	-24,028,423	-63,417,805	-22,710,755	-110,156,982
Dry Cotton	3,935,145	12,451,480	5,081,434	21,468,058
Dry Sorghum	24,336,385	40,216,842	19,629,890	84,183,117
Dry Wheat	16,608,907	22,806,201	11,767,260	51,182,369
Total	**-178,510,941**	**-191,348,241**	**-104,283,953**	**-474,143,135**

Table 3. Employment.

Crop	Impacts			
	Direct	Indirect	Induced	Total
Irrigated Corn	-6,597	-3,075	-1,597	-11,268
Irrigated Cotton	-464	-762	-248	-1,474
Irrigated Sorghum	-203	-144	-38	-385
Irrigated Wheat	-1,979	-1,171	-373	-3,522
Dry Cotton	169	355	81	605
Dry Sorghum	1,165	1,023	313	2,501
Dry Wheat	707	533	190	1,430
Total	**-7,202**	**-3,240**	**-1,671**	**-12,113**