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Water Research Center

Annual Report

E-030

Principal Investigator: Kent W. Olson

Department: Economics

Title: Regulating the Intertemporal Allocation of Water in the Ogallala

Summary:

The principal objective of this study is to determine if there is a sound economic case for government regulation of the intertemporal pattern of withdrawals from the Ogallala Aquifer. The basic premise of the study is that such a case must be based on evidence that exploitation of this aquifer is characterized by market failure; i.e., the failure of current institutions to allocate this resource so that its contribution to economic welfare is maximized.

The analysis is based on a relatively simple model which illustrates the three most likely sources of market failure for the Ogallala: intergenerational inequity, common pool externality, and inequality between the social rate of time preference and the guiding rate of interest for private water users. The evidence and arguments for the existence and policy relevance of each of these failures is examined critically, and several implications for policy are discovered. First, the argument that we ought to allocate Ogallala water by reference to criteria of intergenerational equity lacks substance. Second, the evidence appears strong for the view that the Ogallala does <u>not</u>

exhibit common property externality like so many exhaustible resource deposits. Finally, there is a good case for an inequality between the social rate of time preference and the private guiding rate of interest; however, the quantitative dimension of this inequality, and its exact implications for policy design, are not yet known.

Statement of the Problem:

The agricultural economy of Northwest Oklahoma is based heavily on withdrawals of water from the Ogallala Aquifer. There is considerable concern, therefore, about whether this aquifer is being mined too rapidly. The objective of this project is to establish a standard for evaluating rates of withdrawal, and to assess instances in which the private sector is purported to be in violation of these standards. Such an assessment should be of interest to policy makers charged with designing and comparing alternative means of optimizing the development of the Ogallala.

Results:

The results are outlined in the above summary and in the attached paper based on the results of this study.

Principal Beneficiaries:

The primary consumers of these results will be economists interested in the Ogallala, and policy makers concerned with finding ways to cope with eventual economic depletion of this resource. Presumably, the major beneficiaries will be those who profit most from policy based on an accurate assessment of the current state of exploitation of the Ogallala.

Contributions to Present State of Knowledge:

This study casts considerable doubt on the correctness of the common view that the Ogallala is a classic common property resource which is exploited too rapidly because of common pool externality. The results of the study also weaken the case for special treatment of the Ogallala according to the criteria of intergenerational equity. Finally, the study uncovers a case that is analyzed inadequately in the literature; that of the quasi-common pool resource, a class to which the Ogallala seems to belong.

Publications Resulting:

I am currently revising the attached paper for submission to a professional, refereed journal in economics.

Presentations Made:

The attached paper was presented at a session of the Southwestern Economics Association, held in Fort Forth, Texas, in March, 1984.

Attachment:

SHOULD GOVERNMENT REGULATE INTERTEMPORAL RATES OF WITHDRAWAL FROM THE OGALLALA AQUIFER?

Based on the Project:

Regulating the Intertemporal Allocation of Water in the Ogallala

Sponsored by:

Water Research Center, Oklahoma State University

by

Kent W. Olson

August, 1984

As is true for many of our natural resources, there is growing concern that groundwater supplies are being depleted by rapidly increasing demands. On the Great Plains the focus of this concern is the Ogallala Aquifer, a vast underground water formation from which annual withdrawals exceed annual natural recharge. This aquifer is, for all practical purposes, an exhaustible resource, and prospective depletion has produced suggestions for a variety of means by which demands could be dampened or the Ogallala inventory augmented.

One solution proposed frequently is government regulation of the intertemporal pattern of withdrawals, the objective of which would be to push back the date of exhaustion. The purpose of this study is to determine whether there is a very good economic case for this type of government activity.

The basic premise of this inquiry is that such a case would have to be built, first, on the demonstration that exploitation of the Ogallala is marked by one or more market failures, and, second, that a governmental "correction" could be implemented at a cost lower than the loss occasioned by such failures. The analysis begins with a simple model which illustrates the three most likely sources of market failure for the Ogallala. This is followed by an evaluation of arguments and evidence for and against each, and a discussion of the implications of this evaluation for the design of government policy.

Sources of Public Concern

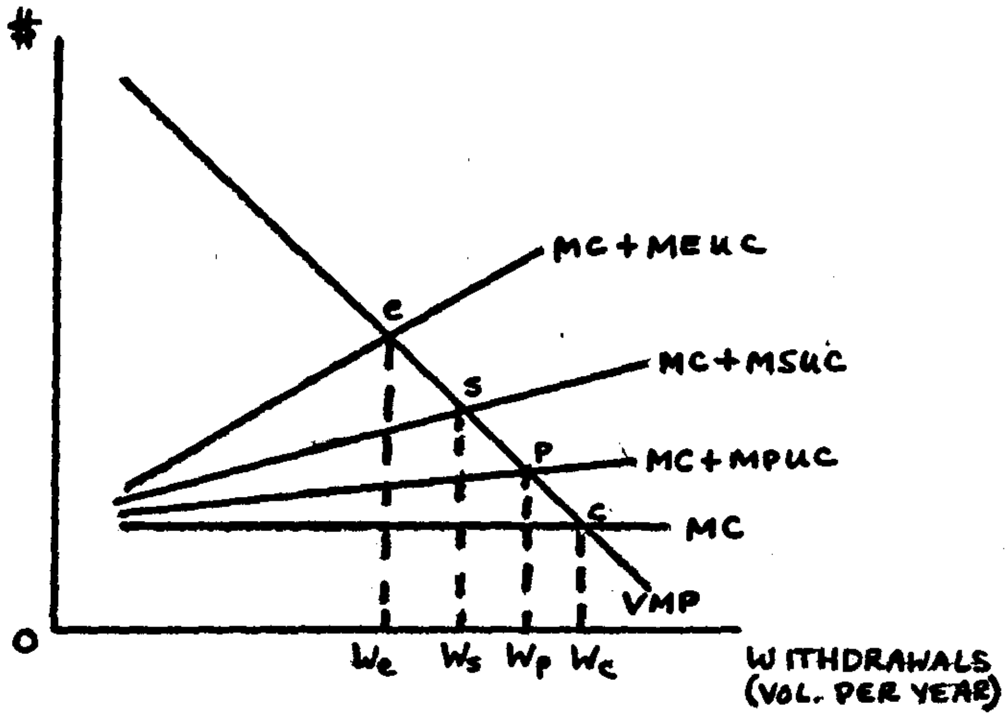
It is commonly known that the Ogallala Aquifer is being mined--annual withdrawals, principally for irrigated agriculture, greatly exceed natural recharge for most of the aquifer. The economic exhaustion of the Ogallala and major shifts from irrigated to dryland agriculture have been projected in several studies,[1] giving rise to much concern by High Plains farmers, agricultural suppliers and processors, the financial community, and politicians.

For the most part, the rate at which the Ogallala is mined depends on the decisions of thousands of farmer-irrigators, who pursue their own self-interest. Economists normally presume a coincidence between private and social interests in the absence of market failures. Thus, the economic exhaustion of the Ogallala need not constitute a social problem. However, the extraction stage for other exhaustible resources is often marked by market failure. It seems natural, then, that economists have raised the market failure question for this particular resource.

There are three types of market failure that are potentially the most applicable to the case of the Ogallala. The first is the intergenerational inequity produced by the laissez-faire allocation of an exhaustible resource. The second is the common pool externality that characterizes deposits of liquid exhaustible resources. The third is the difference between the social rate of time preference and the rate of interest used as a guide to intertemporal choices by private exploiters of natural resources.

The potential effects of these failures can be explained and compared with the aid of Figure 1. This figure depicts withdrawals from the Ogallala by a typical farmer-irrigator during a typical year under different circumstances. The value of marginal product (VMP) curve, the farmer's demand curve for groundwater, is downward-sloping as a consequence of the diminishing returns from applying ever larger quantities of water to a fixed surface acreage. The lowest of the four cost curves, the one labeled MC, depicts (assumed) constant marginal costs of pumping and application.

Each of the remaining cost curves contains a term which measures the future value of water pumped during the current period. MPUC, marginal



$
MC+MEUC
MC+MSUC
MC+MPUC
MC
VMP
e
s
p
c
0
W_e W_s W_p W_c
WITHDRAWALS (VOL. PER YEAR)

FIGURE 1

private user cost, is the highest marginal net revenue (expressed as a present value) that could be earned by shifting each unit of groundwater pumped currently to some future period. The discount rate assumed here is the farmer's guiding rate.

MSUC, marginal social user cost, is the same as MPUC, except that the discount rate used to calculate present value is the social rate of time preference. Thus, MSUC > MPUC to conform to the commonly-made assumption that the social rate of time preference (SRTP) is less than private discount rates.

The MEUC label attached to the highest cost curve stands for marginal equitable user cost. It depicts an extreme view of intergenerational equity which requires that economic choices which affect both present and future generations must be discounted with a rate equal to zero. This is not the only possible, or necessarily the best, intergenerational choice criterion. It is frequently mentioned in the literature, but it is used here mainly as a heuristic device.

The intersections between each of the cost curves and VMP can be interpreted as follows. Point c (corresponding to current withdrawals of Wc) corresponds to equilibrium for the profit-maximizing farmer-irrigator who places a value of zero on the option of withdrawing each of the units from 0 to Wc during some future period(s). This is purportedly the response of an exploiter of a common property resource, operating according to the "rule of capture." He withdraws as much as he profitably can today out of fear that it won't be available tomorrow.

Point p depicts the current year equilibrium for the irrigator with secure, well-defined property rights to groundwater. This individual will consider future net returns on units pumped during the current period. Point p is to the left of c as long as future discounted net returns at the margin are positive. The difference between p and c will be smaller, the higher the private discount rate.

Point p is to the right of s as long as the discount rate used by the irrigator just described is greater than the social rate of time preference. Ws, the quantity at which VMP = MC + MSUC, is the quantity consistent with intertemporal efficiency in the allocation of groundwater. Both Wp and Wc depict market failure in terms of this efficiency test.

As noted above, point e (and We) reflect an intertemporally equitable, rather than an efficient, allocation of groundwater. It is well known that equity among generations does not necessarily require application of a zero discount rate to extraction decisions.[2] Thus, it is not always true that We would be less than Ws. This will be a crucial point for this study, however, only if it turns out that intertemporal allocation of the Ogallala should be governed by an intertemporal equity criterion. This is the first issue addressed below.

Intertemporal Equity

Exhaustible resources cannot both be used and distributed equally across generations. Our good fortune at being alive now, in an era of relative abundance, is a sheer historical accident. Since we cannot claim credit for our existence, there is no basis for treating the gifts of nature as our exclusive property, to do with as we please.

How, then, do we determine a just distribution of exhaustible resources among generations? We can begin by recognizing that our interest, and that of prospective future generations, is not in resources, per se; rather, it is in what they contribute to our (and their) lives. Thus, justice does not command an equal distribution of welfare or utility (and certainly not of resources).

Indeed, we cannot be held responsible for making other people happy, even if it were possible to determine (which it is not) whether we were doing so by measuring individual utility. Rather, justice applies to opportunities, and the distribution of nonrenewable resources across generations should be guided by means that distribute opportunities equally across time.

The problem is not that the more we use, the less future generations will have, but that they may end up with fewer options in the absence of effective action by the current generation. Depletion is not avoidable, but depletion without compensation is avoidable. The exact form of required compensation is not always clear; however, the intent of compensation is clear--to make investments that will preserve the range of options for future generations.

This view of justice as intergenerational opportunity implies that there is no need to preserve a particular resource, much less a particular deposit of a particular resource. However, if we don't practice preservation or conservation, we must develop either substitute means of providing either the same goods or services as those provided by the depletable resources, or acceptable substitutes for the goods and services, themselves. Either compensatory alternative is "just" as long as consumption is the appropriate end of economic activity.

This implication is the key to determining if withdrawals from the Ogallala should be guided by an intergenerational equity criterion. Only if we are unable to arrange compensation in the above sense would conservation of this particular resource be required.

Now it is true that water is an essential resource, but the water in the Ogallala is valuable essentially because it provides the means to produce food and fiber for the nation, and income and some elements of culture and community for residents of the High Plains. Should the Ogallala become depleted, there is abundant water available elsewhere for growing the same, or readily substitutable crops, or the same, or substitutable, animal protein.[3] In the absence of technological change, of course, these crops and animals could be provided only at higher real cost. However, it is not hard to conceive of technological change being rapid enough to keep costs elsewhere falling as fast as the aquifer is being depleted economically. Contrary to popular belief, the rates of depletion are quite slow, ranging from .35 percent per year in Nebraska to 1.6 percent per year in Texas.[4]

As the Ogallala is depleted some residents will be forced to relocate if new opportunities are not created within the region, if they have not been able to save enough to replace lost income, or if they do not receive social compensation sufficient to avoid moving. The economy will create opportunities elsewhere for those who do move, and the slow rate of depletion will facilitate this process. Nonetheless, it should be possible to arrange for actual compensation via an intergenerational cash transfer, thus complying with the spirit of intergenerational justice.

Perhaps the hardest opportunity to preserve is that provided by the sense of community and culture of the region. Insofar as the key to this is the size of the total population, recent projections indicate that this may be a minor problem. According to the <u>High Plains Study</u>, the population decrease during the next 40 years will be very small, and confined largely to the southern portion of the Ogallala.[5]

It is hard to avoid the conclusion that the Ogallala is not in the same class at all as a future environment threatened by CO_2 buildup, by nuclear waste disposal, and by acid rain, or as a depletable and widely used fossil fuel. These are the types of resource allocations that really require the development of intergenerational equity criteria.

But, if not an intertemporal equity criterion for the Ogallala, can we feel comfortable using a present view criterion, given that its application requires discounting, a procedure that incorporates this generation's judgment that future values are less important than current values?

The standard argument for discounting says that it is permissible to harm the future, as long as it would be possible to benefit the future on balance by compensating investments, whether or not they are undertaken. This is like saying that it is all right for me to harm you if I have the option of aiding you, even if I don't exercise it. If the harms are minor and I am aiding you on balance through other activities, then the non sequitur may be overlooked. But when grave harms are done the argument has little appeal.

What is being asserted here is that the harms imposed by depletion of the Ogallala are either relatively minor, or easily correctible by a wide variety of direct and indirect compensatory investments of the type that will normally occur in a dynamic economy. One caveat is in order, however. The mere acceptability of the discounting procedure does not justify any level of discount rate. In fact, the requirement that compensation be spread out over intergenerational time would seem to rule out any discount rates much above, if any, the long-run growth rate of the economy. Alternatives earning real returns above this level would not appear to be sustainable across this time span.

The Common Pool Problem

Mention is made of the phenomenon in the literature often enough that apparently it is not unusual for marginal private costs to be less than marginal social costs for aquifers with declining water tables. Presumably, this view is based on the belief that aquifers are essentially like bathtubs, so that if a user of the tub's water pumps from one point the entire level of water in the tub falls if inflows are less than withdrawals. If farmers have this view they will rush to capture as much as they can individually before others do. Under the worst of circumstances, they will value the option to withdraw in the future at zero, and will pump to the point where today's VMP just equals MC.

The problem with this hypothesis in the present context is that the hydrogeologic properties of the Ogallala do not appear to be similar to those implied by the standard theorem. In the common pool bathtub aquifer water would move quickly laterally to fill in cones of depression created by pumping. According to Beattie,[6] cones of depression in the Ogallala are very steep, suggesting slow lateral movement--an inference supported by hydrogeologists at Oklahoma State University with whom I have consulted on this matter.

This suggests that groundwater stocks to which the Ogallala farmer has property rights are not seriously subject to depletion by actions of neighboring pumpers, or that individual cones of depression fill in largely through lateral migration of water located under one's own property. Thus, the Ogallala may not have the hydrogeologic properties of the classic common property case discussed in the literature for water and oil.

This is clearly a subject about which economists need to become better informed. However, the truly critical question is what irrigators believe is happening beneath their land as a result of their neighbors' actions, and how they behave as a consequence of this belief. Conversation I have had with a few High Plains farmers suggest that they do believe that the Ogallala is a common property resource. However, there are indications that farmers center their concern around the local agricultural community and view the resource as community property. Accordingly, they expect reasonable use of the resource by members of the community. Thus, one plausible, but untested, hypothesis is that there are community-centered sanctions against excessively rapid withdrawals. Moreover, given that the typical High Plains farmer is a long-term community resident, and that those imposing the sanctions are expert irrigators, themselves, these sanctions may be quite effective. In effect, the rule of customary behavior may outweigh the rule of capture.

Studies conducted by Agricultural Economists at Texas A and M indicate that Ogallala farmers in Texas actually do apply groundwater to a point short of where its marginal value in crop production falls to the marginal cost of pumping and application.[7] This suggests that farmer-irrigators do meter out water with an eye to the future. Alternatively, it may reflect the fact that surface acreage becomes a constraint before VMP has fallen to the level of MC.

Finally, in an important study by Gisser and Sanchez,[8] it is shown that if the storage capacity of a bathtub aquifer is large relative to annual withdrawals, and only the land overlying the aquifer can be irrigated (both conditions are satisfied for the Ogallala), the intertemporal allocation of groundwater under competitive, laissez-faire conditions is virtually identical to that achievable under optimal control designed to maximize the present value of the future income stream.

What the preceding arguments and evidence strongly suggest is that the probability is quite small that we either should or do have a classic common pool problem in the case of the Ogallala. Whether this implies no role at all for government is a matter considered below in the policy section of this paper.

The Discount Rate Problem

If the recognition and discounting of future values of today's withdrawals is appropriate, which discount rate should be used? This is a question that has spawned a large literature, much of it directed toward the choice of a rate for evaluating public investments, but, more recently, it has surfaced in the debate over whether markets efficiently allocate energy and environmental resources over time. It is a little surprising, therefore, that the question has not been featured in the groundwater literature. The Gisser-Sanchez optimal control solution is socially optimal, for example, only if the discount rate contained in the objective function is the appropriate social discount rate.

Strictly speaking, the SRTP is the rate at which individuals collectively trade off present and future consumption, or it is the slope of the community indifference curve between present and future consumption. If we are to honor the Paretian value judgment that consumers' preferences should direct the allocation of resources over time, then the SRTP is the most appropriate rate for discounting future values.

Private investors, however, are guided by rates of return they can earn by sacrificing a unit of present consumption. In an ideal world, the SRTP is equal to the rate of return that could be achieved by a marginal sacrifice of a unit of present consumption, or the SRTP is equal to the social opportunity cost of capital (SOC). However, in the real world, SRTP and SOC are quite likely to diverge, and private choices guided by SOC are likely to be non-optimal.

It is normally claimed that SOC > SRTP.[9] However, there is not, nor could there be, a consensus value in the literature for the size of the difference between the two rates. There could not be a consensus because, first, there are several ways to estimate SRTP, none of which conforms perfectly with the theoretical construct. Second, there is no agreement on what constitutes the SOC. Values have appeared for SRTP generally ranging from 3 to 5 percent, while reported estimates of SOC have ranged from 7 to 13 percent.[10]

It is tempting to draw estimates from these sources and apply them to the Ogallala case. However, there is a problem which precludes use of this method: there may be a significant difference between estimates of SOC and the private opportunity cost (POC) rate that actually guides High Plains farmer-irrigators, and it is the latter that is relevant for determining the degree of deviation from the optimal level of withdrawals.

Now I am relatively confident that SRTP will be significantly below SOC, where the latter is measured by something like the rate of return on investment in the corporate sector, and the former is estimated by any of the conventional methods.[11] However, I am less confident that this will be true when the comparison is between SRTP and the POC of High Plains farmer-irrigators. What counts for the latter is what this group expects to earn on the best alternative in which they would (not "could") invest--not necessarily on what they are currently earning, or have earned historically, on investment in irrigated agriculture. I am not aware of any empirical estimates of the POC for this, or a similar group.

Policy Implications

It cannot be claimed that the preceding analysis provides a clear answer as to whether the government ought to regulate withdrawals from the Ogallala, and, if so, by how much and by what method. What I hope to have accomplished by this point, however, is the identification of the important aspects of this issue that need further clarification before a definitive answer can be given.

First, I think that the argument that we ought to allocate Ogallala groundwater by reference to criteria of intergenerational equity, rather than by reference to criteria of allocative efficiency, is on shaky ground. The Ogallala simply does not provide the kinds of opportunities for consumption among future generations that cannot be provided for otherwise by ordinary kinds of investments, or even by general compensation, say, in the form of intergenerational cash transfers. Thus, policy makers can safely ignore this rationale for regulating withdrawals.

Second, the evidence is becoming quite persuasive for the view that the Ogallala is not a classic common property resource, and that farmer-irrigators do not act according to the rule of capture. This verdict is not certain, and there are still some aspects of this issue which need additional research.

The results of this research may help to establish whether there is a good case for or against government action to correct a common property externality. It would not, per se, determine the best type of action to take. Even if there is such an externality, it would probably be better to correct it via establishment of clearly defined property rights for resource stocks, coupled with transferability of consumptive rights to these stocks, than to establishment of quantitative restrictions on annual withdrawals.

Third, additional research is also needed to establish the relative sizes of SRTP and POC. Here the results would seem essential for determining the need for government policy to achieve intertemporal efficiency in resource allocation. The results would also be quite useful in designing at least one type of government action. If we knew how much SRTP and POC were likely to diverge, it should be possible to calculate two optimal control solutions, one for each rate, and to determine a tax formula that could be imposed to achieve the SRTP solution (as in Brown and Deacon[12]).

These prescriptions are somewhat different from those encountered in the current literature. The dominant view seems to be that the principal market failure is a reflection of the common property nature of the Ogallala, and that this should be corrected via clear definition, assignment, and free exchange of property rights to resource stocks. I concur with this solution for this problem, but I question the importance of the problem in the case of the Ogallala. The view expressed here, instead, is that the principal problem may be that of a divergence between SRTP and POC. This problem would not be correctible by changes in the way property rights are defined, assigned, and exchanged. Rather, it may require use of taxes as a regulatory device.

Notes

1. The most recent, and most thorough of these is the Six-State High Plains Ogallala Aquifer Regional Resources Study, a report for the U.S. Department of Commerce and the High Plains Study Council, by High Plains Associates (Camp Dresser and McKee, Inc., Black and Veatch, and Authur D. Little, Inc.), July, 1982. Actually, this report indicates that this scenario is more descriptive of the Southern Ogallala States (Texas, Oklahoma, New Mexico) than of the Northern Ogallala States (Kansas, Colorado, Nebraska).
2. For elaboration of this theme see: Talbot Page, "Intergenerational Justice as Opportunity," and Allen V. Kneese, Shaul Ben-David, and William D. Schulze, "The Ethical Foundations of Benefit-Cost Analysis," both in Douglas MacLean and Peter G. Brown, Editors, Energy and the Future, Rowman and Littlefield: Totowa, New Jersey, 1983.
3. The most comprehensive work on this issue with which I am familiar was done by Earl Heady and his associates at Iowa State University ("U.S. Supply Situation for Food and Fiber and the Role of Irrigated Agriculture," in the TAMU Centennial Year Water for Texas Conference. Texas Water Resources Institute, Texas A and M University, College Station, Texas, 1976). Results of their modeling efforts suggest that the capacity of U.S. agriculture to meet future demand would not be constrained by the availability of irrigation water supplies.
4. High Plains Associates, Table V-1.1.
5. High Plains Associates, 5-50.
6. Bruce R. Beattie, "Irrigated Agriculture and the Great Plains: Problems and Policy Alternatives," Western Journal of Agricultural Economics, December, 1981, 289-299.

7. I first encountered this claim in Water Current, Vol. 2, No. 2, Summer, 1983, (a brief quarterly review of water research conducted by the Texas Water Resource Institute). It was later confirmed in correspondence with Ronald Lacewell of Texas A and M, one of the principal investigators cited in this issue.
8. Micha Gisser and David A. Sanchez, "Competition Versus Optimal Control in Groundwater Pumping," Water Resources Research, Vol. 16, No. 4, August, 1980, 638-642.
9. Due, for example, to the existence of taxes, and differences in the treatment of risk by investors with respect to the way they view different investments. See William J. Baumol, "On the Social Rate of Discount," American Economic Review, December, 1968.
10. Two good surveys of various studies are: D. W. Pearce and C. A. Nash, The Social Appraisal of Projects, New York: John Wiley and Sons, 1981, Chapter 9; Edward D. Gramlich, Benefit-Cost Analysis of Government Programs, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1981, Chapter 6.
11. On this comparison, see Martin S. Feldstein, "Does the United States Save Too Little?" American Economic Review, Vol. 67, February, 1977, 116-121.
12. M. G. Brown and R. Deacon, "Economic Optimization of a Single-Celled Aquifer," Water Resources Research, Vol. 8, 1972, 557-564.