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Water Transfer between North and South Carolina: An Option for Policy Reform

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ABSTRACT

In recent years, economic development and a severe drought have resulted in conflict between water users in the Carolinas over the flow of the Yadkin-Pee Dee River. Currently, the Federal Energy Regulatory Commission is considering renewal of the licenses of the six North Carolina dams that control water flow into South Carolina. In the present analysis, we provide a simple two-sector model to examine the impact of a water transfer program for the Yadkin-Pee Dee River as one option for policy reform.

INTRODUCTION

Battles over scarce water resources are common in the arid western United States. However, until recently, the eastern states have been relatively free of water supply conflicts. Rapid population and economic growth, combined with severe drought conditions in recent years, have increased the number of disputes over water allocation, especially in the Southeast. Legal wars that began in 1990 between Georgia, Alabama, and Florida over water in the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallaposa river systems continue today.[1] Atlanta's growing population covets water in the Savannah River that is shared by many users in Georgia and South Carolina. In southwestern Georgia, state agencies implemented programs to encourage farmers to reduce water use due to the low flow conditions in the Flint River basin. In the Carolinas, due to the recent drought, officials recorded some of the lowest water levels ever for streams, lakes, and rivers. Although drought conditions eased somewhat in 2003, conflicts over water supplies are likely to resurface in the

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1. *See* JODY W. LIPFORD, AVERTING WATER DISPUTES: A SOUTHEASTERN CASE STUDY 1, 22 (PERC Policy Series Issue No. PS-30, 2004), *available at* http://www.perc.org/pdf/ps30.pdf (last visited June 16, 2005).

Carolinas and the Southeast as ever-increasing demands are placed on this scarce resource.[2]

In this article we examine the conflict between the Carolinas over the water flow in the Yadkin-Pee Dee River (YPDR), located in the piedmont and coastal regions of North and South Carolina. The YPDR flows for 430 miles between Blowing Rock, North Carolina, and Georgetown, South Carolina, where it empties into Winyah Bay. In North Carolina, along a 38 mile stretch of the Yadkin River, Alcoa Power Generating Inc. operates four dams that supply water for power generation and for use in it's aluminum processing plants. Progress Energy operates two dams, also in North Carolina, for hydroelectric power generation. (See Figure 1.) The first dam was completed in 1911 at Blewett Falls, and the final dam was completed in 1962 at Tuckertown. In South Carolina, the Pee Dee River flows freely for 154 miles until it empties into the Atlantic Ocean.

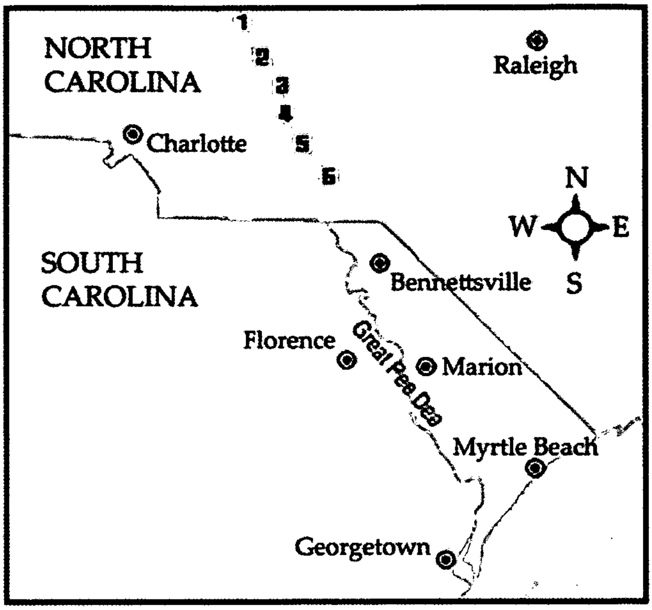
In South Carolina, many river users depend on sufficient water flow and suffer economic costs during low flow periods. In South Carolina, four municipalities use the Pee Dee as a source of drinking water, and Grand Strand cities such as Myrtle Beach and Georgetown depend on an adequate river flow in order to keep saltwater out of the city water supply. Also, five publicly owned wastewater treatment works and five privately owned companies discharge treated waste into the Pee Dee. The South Carolina Department of Health and Environmental Control, which regulates water quality, requires companies that discharge waste into the River to reduce effluent flow when water level is below normal assimilative capabilities. Other industries such as tourism, recreation, and fishing depend on a sufficient flow of water. Farmers and golf course owners use the River for irrigation. Low-water flow levels negatively impact property values near the Pee Dee. An adequate flow of water is also important for economic development of the Pee Dee region in South Carolina, which has some of the highest unemployment and lowest income levels in the state. Also, the U.S. Army Corps of Engineers reports that a flow of less than 1500 cubic feet per second (cfs) will harm wildlife.[3]

2. Joey Holleman, *S.C. Declares Statewide Drought*, STATE NEWSPAPER, June 9, 2004, at B1.

3. Although navigation on the Pee Dee was active early in the nineteenth century, following the growth of railroads, navigation on the Pee Dee declined and is not an important activity today. SUZANNE LINDER, A RIVER IN TIME: THE YADKIN-PEEDEE RIVER SYSTEM 137 (2000).

Figure 1

Dams on the Yadkin – Pee Dee River



Alcoa Power Generating Inc. Dams

1. High Rock Lake (12,200 acres)
2. Tuckertown Reservoir (2,550 acres)
3. Narrows Reservoir/Badin Lake (5,350 acres)
4. Falls Reservoir (203 acres)

Progress Energy Dams

5. Lake Tillery (5,260 acres)
6. Blewett Falls Lake (2,570 acres)

Similarly, water users in North Carolina could suffer economic costs if Alcoa and Progress Energy, the dam owners, are required to release more water than optimal for generating electricity. Because the generated electricity cannot be stored, firms control the water flow to generate electricity when needed. Furthermore, there is a significant amount of residential development along many area lakes. Studies document that property owners on lakes, such as those created by dams, suffer lower property values and recreational values when lakes are drawn down.[4]

A combination of increased water demand and below normal rainfall between 1997 and 2002 created a struggle between YPDR users in the summer of 2002.[5] The decrease in water flow is illustrated in Table 1. The Federal Energy Regulatory Commission (FERC) sets the minimum flow that owners of the six dams in North Carolina must release downstream.[6] Under the current license agreements, which were issued in 1958, FERC requires dam owners to release a minimum daily average flow of 1200 cfs. In 2000, the average flow of the Pee Dee River was 4990 cfs, but in August of 2002 the average flow fell to 930 cfs. An emergency agreement between FERC and affected parties was reached in August 2002 to maintain a water flow of 900 cfs daily.

Table 1. Annual Mean Streamflow, Pee Dee River, 1991-2002

Year	Annual Mean Streamflow (cubic feet per second)
1991	10,750
1992	7,984
1993	9,737
1994	9,416
1995	11,550
1996	9,480
1997	8,749
1998	11,420
1999	5,008
2000	4,990
2001	2,145
2002	2,772

The low water flows during the summer of 2002 resulted in significant costs to downstream users of the river. Although the water flow can be highly variable, falling to as low as 200 cfs on some days,

4. *See, e.g.*, Notie H. Landford, Jr. & Lonnie L. Jones, *Recreational and Aesthetic Value of Water Using Hedonic Price Analysis*, 20 J. AGRIC. & RESOURCE ECON. 341, 347–49 (1995).

5. In South Carolina, the cities of Bennetsville, Cheraw, Florence, and Georgetown withdraw water from the Pee Dee River. The City of Florence began to draw water from the Pee Dee in the fall of 2002. *Water Quality for Today and Tomorrow: City Prepares for Start-up of New Regional Water System*, FLORENCE FOUNTAIN, Fall 2002, at 1, *available at* http://www.cityofflorence.com/fountain/index.html.

6. *Pee Dee Leaders Want Assurance Water Flow Will Meet Region's Needs*, FLORENCE MORNING NEWS, Nov. 20, 2003, at A7.

recreational users of the Pee Dee have complained for years about "weekend droughts" created by the dam owners holding back water on weekends when less electricity is generated. South Carolina industrial firms incurred approximately $136,000 per month in additional costs for the rental of auxiliary pumps and additional waste treatment due to the low flows. Also, the firms incurred at least another $2.5 million for numerous procedures such as pursuing in-house conservation measures, expanding wastewater holding capabilities, constructing cooling towers to decrease withdrawals from the river, and drilling a system of wells to decrease surface water use.[7]

Although much has been written on water disputes both internationally[8] and in the western United States, very little analysis has been completed on water conflicts in the eastern United States. In the present analysis, we show that the lack of clearly defined property rights is a contributing factor in the current conflict over the water flow along the Yadkin-Pee Dee River. We provide a simple two-sector model to examine the impact of a water transfer program, in the spirit of Ronald Coase, for the Yadkin–Pee Dee River.

In the following section, we discuss water rights and allocation polices. Next, we construct a simple two-sector model that permits a determination of the economic effects of water flow on Pee Dee River users. In the fourth section, we examine the efficiency of current water allocation and consider policy options that may create more efficient solutions. Practical issues regarding the implementation of a water market for the region are addressed in the fifth section.

WATER RIGHTS AND ALLOCATION POLICIES

In general, states in the western United States apply the prior appropriation doctrine to determine water rights among various water users. The prior appropriation system evolved to serve the needs of water users in arid and semi-arid environments by giving a right to the earliest water users even if that user was far from the water source.[9] By contrast, the eastern United States relied on the common law riparian doctrine to determine rights to surface water such as the Yadkin–Pee Dee

7. Telephone Interview with Sally Knowles, Director, Division of Water Quality, S.C. Department of Health and Environmental Control (Aug. 20, 2002).

8. For an extensive review of the literature on conflicts and agreements on shared international boundary waters, see, for example, Shlomi Dinar & Ariel Dinar, *Recent Developments in the Literature of Conflict Negotiations and Cooperation over Shared International Fresh Waters*, 43 NAT. RESOURCES J. 1217 (2003).

9. BONNIE COLBY SALIBA & DAVID B. BUSH, WATER MARKETS IN THEORY AND PRACTICE 36-37 (1987).

River. Under the riparian doctrine, a landowner has the right to "reasonable use" of water running through or abutting his or her land. Therefore, the riparian right is a limited property right and is not easily marketable. In addition, when a user dams a waterway to produce hydropower, the regulatory authority of the FERC supersedes private rights.

The Federal Power Act authorizes the FERC to license non-federal dams that produce hydropower. The licenses typically extend for 30 to 50 years and include operating conditions such as the amount of water that dam owners must release. When licensing a hydropower dam, the FERC must "address both the economics and engineering issues and the potential environmental and socioeconomic effects of project development and operation."[10] The Commission is required to "ensure that the project to be licensed is best adapted to a comprehensive plan for developing the waterway for beneficial public purposes."[11] Mitigation measures to protect environmental or other nonpower benefits are sometimes included in FERC licenses. However, FERC methodology generally quantifies only the net benefits from power generation and any costs of environmental protection measures.[12]

FERC guidelines do not provide for the economic interests of downstream users of the Yadkin-Pee Dee River. Also, no incentive mechanism accounts for the changing economic value of water flows during periods of drought. Currently, neither the upstream nor the downstream users have clearly defined property rights over the flow of the Yadkin-Pee Dee River. However, since the FERC's property rights supersede all private rights, a Coasian solution may still be possible. When property rights are well defined and transaction costs are low, a market allocation of water will be efficient, as described by Coase.[13] In the current context, the FERC has the ability to determine who has the right to restrict the water flow along the river. Presently, the riparian right is allocated to the dam owners but does not include the right of exchange. If the FERC were to expand the upstream user's water rights to include exchange or to give the rights to the downstream users altogether, then a market of buyers and sellers could be possible. Alternatively, if the transaction costs are substantial, the FERC could act as an arbitrator between the competing economic interests.

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10. FED. ENERGY REGULATORY COMM'N, HYDROELECTRIC PROJECT LICENSING HANDBOOK, 1-2 (Apr. 2001).

11. *Id.* at 1-3.

12. ROBERT BLACK ET AL., ECONOMIC ANALYSIS FOR HYDROPOWER PROJECT RELICENSING: GUIDANCE AND ALTERNATIVE METHODS 1-4 to 1-5 (1998).

13. Ronald Coase, *The Problem of Social Cost*, 1960 J.L. & ECON. 1, 15-16.

Increasingly, policy makers are turning to market mechanisms to include a wider array of economic interests in water allocation issues. Although the efficiency of water transfers has been recognized for decades, water transfers are not widely utilized.[14] At least 14 western states have introduced water transfers to their water markets.[15] In California and Arizona, agencies have transferred 100,000 acre feet of water.[16] In California, the 1992 Central Valley Project (CVP) Improvement Act introduced wide policy reforms including the creation of a water market that transferred water between any CVP contractor (principally farmers) and any user (principally urban water users). The CVP is overseen by the U.S. Bureau of Reclamation and includes a system of surcharges to finance a fish and wildlife restoration fund. The CVP also allocates water to protect and enhance fish and wildlife habitat.[17]

Other incentive policies can improve water allocation. When water prices are too low, as may be the case for some irrigation projects, higher prices can improve efficiency.[18] Alternatively, government agencies can purchase water rights, as is the case with the Georgia Environmental Protection Division. In Georgia, a program was implemented that pays farmers for reducing their use of the Flint River. In a March 2001 auction, farmers agreed to remove 33,006 acres from irrigation for an average payment of $135.70 per acre.[19] The increased water flow protects ecosystems and endangered species.

A SIMPLE TWO-SECTOR MODEL

We construct a two-sector model of the North and South Carolina economy in which water flow restriction of the YPDR by the

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14. *See, e.g.*, B. Delworth Gardner & Herbert H. Fullerton, *Transfer Restrictions and Misallocation of Irrigation Water*, 50 AM. J. AGRIC. ECON. 556, 569-70 (1968); H. Vaux, *Managing Water Scarcity: An Evaluation of Interregional Transfers*, 20 WATER RESOURCES RES. 785-92 (1984); SALIBA & BUSH, *supra* note 9, at 4-5.

15. MARIELLA CZETWERTYNKSI, THE SALE AND LEASING OF WATER RIGHTS IN WESTERN STATES: AN OVERVIEW FOR THE PERIOD 1990-2001, at 2 (Andrew Young Sch. of Policy Studies, Ga. State Univ., Water Policy Working Paper No. 2002-002, 2002), *available at* http://epp.gsu.edu/waterpdf/w2002002.pdf (last visited June 16, 2005).

16. *Id.*

17. M. Weinberg, *Assessing a Policy Grab Bag: Federal Water Policy Reform*, 84 AM. J. AGRIC. ECON. 541, 542 (2002).

18. Ariel Dinar & J. Letey, *Agricultural Water Marketing, Allocative Efficiency, and Drainage Reduction*, 20 J. ENVTL. ECON. & MGMT. 210 (1991).

19. RONALD CUMMINGS ET AL., USING LABORATORY EXPERIMENTS FOR POLICY MAKING: AN EXAMPLE FROM THE GEORGIA IRRIGATION REDUCTION AUCTION 27 (Andrew Young Sch. of Policy Studies, Ga. State Univ., Water Policy Working Paper No. 2002-003, 2002), *available at* http://epp.gsu.edu/waterpdf/w2002003.pdf (last visited June 16, 2005).

industries controlling the dams may adversely affect downstream users. On the YDPR there are two significant withdrawal uses—city water supply and industrial processing. There are five in-stream uses: hydropower, waste disposal, property value enhancement, recreational/wildlife, and city water suppliers who need in-stream flow to stop saltwater intrusion. In this model, the Carolinas' economy is divided into two sectors: Sector 1, the industrial sector upstream in control of the dams, and Sector 2, the downstream users, defined as industrial firms and city utilities. We do not include non-market benefits such as wildlife and habitat protection, aesthetic value, and recreational benefits, but only consider benefits to users that either withdraw water or discharge effluent into the water.

We employ the specific factors model as originally described by Jones, Mayer, and Neary.[20] A key feature of the model is the introduction of a water flow variable, z, that functions as a cooperative input to industry upstream (Sector 1) and at the same time a negative externality to downstream users (Sector 2). The variable z represents the ability and willingness of upstream dam owners to restrict water flow further, particularly during times of already low water flows, such as under drought conditions. The ability to restrict water flow contributes positively, along with a fixed amount of capital and a variable amount of labor, to produce the upstream user's output. The variable z is an externality to Sector 2 since downstream industries do not have control over how or when upstream users decide to restrict the YPDR water flow. Also, the upstream use of z adversely affects the output of downstream users who incur additional costs at lower water flow. For example, if a firm is required to reduce effluent flow during periods of low water flow, it might incur costs from increased waste treatment.

We describe the determination of all endogenous variables in the economy when water rights are not well defined and therefore not transferable. This is the current situation in which the FERC sets the minimum water flow. We produce comparative static results from the model.

For simplicity, the production technology in both sectors is one of constant returns to scale. Both sectors employ labor that is mobile across sectors and in fixed supply $\overline{L}$, in the quantities L_1 and L_2, respectively. Besides labor, Sector 1 employs two other factors of

20. R.W. Jones, *A Three Factor Model in Theory, Trade, and History*, *in* TRADE, BALANCE OF PAYMENTS AND GROWTH 3, 3–4 (Jagdish N. Bhagwati et al. eds., 1971); Wolfgang Mayer, *Short-Run and Long-Run Equilibrium for a Small Open Economy*, 82 J. POL. ECON. 955, 956–57 (1974); J.P. Neary, *Short-Run Capital Specificity and the Pure Theory of International Trade*, 88 ECON. J. 488, 488–89 (1978).

production: capital in the amount $\overline{K}$ and restrictions to the flow of river water, in the amount z, to produce x_1 quantity of industrial output. Sector 2, on the other hand, employs only two factors of production: labor in the amount L_2 and sector specific capital, which we will refer to as utility and industrial plants in the amount $\overline{\Lambda}$ to produce the output x_2. Firms in Sector 1 determine the optimal employment of L_1 and z by minimizing per unit cost of production. Sector 2 firms determine the optimal employment of L_2 by minimizing average cost. The production functions for the two sectors are:

1) $x_1 = F(L_1, \overline{K}, z); \quad +,+,+$

2) $x_2 = G(L_2, \overline{\Lambda}; z); \quad +,+,-.$

In (1), the plus signs indicate that all three factors are normal inputs, with positive marginal products. Similarly in (2), both labor and downstream waste and water treatment plants are normal inputs, with positive marginal products. Recall that, the negative sign of z indicates that the increased usage of the resource z by Sector 1 increases costs for Sector 2, and effectively constitutes a negative externality. Further, note that in (2), Sector 2 firms have no control over Sector 1's use of z under the current FERC regulation.

All marginal products are diminishing, and the marginal product of any given factor rises if the employment of another factor rises in that sector. Except for the decrease in the marginal products of labor and treatment plants for Sector 2 when z rises, all factors are cooperative. Further, we treat the Carolinas as a small open economy, in that it faces parametric commodity prices $\overline{p}_1$ and $\overline{p}_2$.

The wage rate is flexible and ensures full employment of labor so that,

3) $L_1 + L_2 = \overline{L}$.

The intersectoral mobility of labor ensures that the value of marginal product of labor is equal in the two sectors, which in turn equals the single economy-wide wage rate, w. This is determined by

4) $\overline{p}_1 MP_L^1(L_1, \overline{K}, z) = \overline{p}_2 MP_L^2(L_2, \overline{\Lambda}; z) = w$

Given the stock of capital $\overline{K}$, the rental of capital, r is endogenously determined by

5) $\overline{p}_1 MP_K^1(L_1, \overline{K}, z) = r$.

Similarly, given the fixed supply of downstream plants, $\overline{\Lambda}$, the return on plants is

6) $\overline{p}_2 MP_\Lambda^2(L_2, \overline{\Lambda}; z) = \lambda$.

Sector 1 employs the water, z, up to the point where the value of marginal product of this resource equals its factor price. Because z is unpriced, upstream industrial firms employ this resource up to the point $\hat{z}$ where the value of marginal product of z equals zero. Therefore

$$7)\quad \overline{p}_1 MP_z^1(L_1, \overline{K}, z) = 0.$$

This completes the model in which seven relationships determine the seven endogenous variables, x_1, x_2, L_1, L_2, w, r, and λ. The variables exogenous to this model are the product prices $\overline{p}_1$, $\overline{p}_2$, and factor supplies $\overline{L}$, $\overline{K}$ and $\overline{\Lambda}$.

To determine the equilibrium values for this model economy, recall from (7) that the unpriced input, z, will be employed by the upstream sector until the value of its marginal product equals 0. We will call this value $\hat{z}$, where the hat represents an equilibrium value of the input. With the determination of z equal to $\hat{z}$ in equilibrium, from equations (3) and (4) we obtain both the employment levels of labor in the two sectors, $\hat{L}_1$ and $\hat{L}_2$ and the wage rate $\hat{w}$. Consider that on the left hand side of (4) with a given level of capital and usage of z up to $\hat{z}$, the value of the marginal product of labor in the upstream industry is determined for each level of labor, L_1 up to $\overline{L}$. Similarly, on the right hand side of (4), the value of the marginal product of labor in Sector 2 is determined for each level of L_2 up to $\overline{L}$ given $\hat{z}$ determined by upstream users and the fixed supply of downstream facilities, $\overline{\Lambda}$. Further, the mobility of labor between these two sectors equalizes the values of their marginal products at the economy wide wage rate, $\hat{w}$, and thereby along with the fixed total supply of labor, $\overline{L}$, in (3) determines the equilibrium levels of labor in the two sectors, $\hat{L}_1$ and $\hat{L}_2$. Finally, given the levels of the factor supplies determined above, from (5) and (6) we obtain the equilibrium values of $\hat{r}$ and $\hat{\lambda}$.

A WATER TRANSFER PROGRAM

In the framework of this two-sector model, we investigate the consequences of a FERC decision that creates a water market as an alternative to the traditional command and control policy that the FERC uses to control water flow. We consider a FERC policy that sets a minimum flow requirement but allows the dam owners to sell water flow above the required amount to users either upstream or downstream. However, for ease of exposition, we will continue to refer to Sector 1 as upstream users and Sector 2 as downstream users. We assume, initially, that transaction costs are low.

In this framework, the benefits of the water transfer program are described below. In Sector 2, we represent the value to the downstream firms of a unit reduction in river water (an increase in z) on the YPDR by $MC_z^2 = -\bar{p}_2 MP_z^2(L_2, \bar{\Lambda}; z)$, where MC refers to the marginal cost of a reduced flow to the downstream industrial firms and city utilities sector. Recall that before Sector 1 was given the right to sell its use of the unpriced environmental resource, z, Sector 1 would continue to use z up to $\hat{z}$ where the value of its marginal product was zero, irrespective of the cost imposed on Sector 2. However, since Sector 1 has been granted the ability to sell this right, there now exists an incentive to choose a level of z such that the value of the marginal product of z to Sector 1 is equal to the marginal cost of z to Sector 2. That is,

8) $$\bar{p}_1 MP_z^1(L_1, \bar{K}, z) = -\bar{p}_2 MP_z^2(L_2, \bar{\Lambda}; z) = \tilde{p}_z,$$

where $\tilde{p}_z$ is the equilibrium price of the resource z as traded between the two sectors.

The increase in water flow (a decrease in z) reduces the cost in value added to downstream firms to a greater degree than the fall in value added to upstream industry, leading to an unambiguous increase in the real Gross State Product of the Carolinas. At the resource employment level of $\hat{z}$, the marginal cost to downstream users from an increase in z is greater than the gain to industry (equal to zero) due to the same increase. If transaction costs are small, Sector 1 has an incentive to sell the use of z to Sector 2 and Sector 2 is better off than by buying those rights. The equilibrium quantity of water flow for Sector 1 declines from $\hat{z}$ to $\tilde{z}$.

In this model, the marginal product of labor and the marginal productivity are endogenous variables. The marginal product of labor declines in Sector 1 because labor, capital, and water flow are cooperative inputs. The reduced marginal productivity of Sector 1 labor causes the industrial wage to fall. Workers, therefore, migrate from Sector 1 to Sector 2, thereby causing the wage rate in Sector 2 to also fall. However, the increase in water flow raises the productivity of Sector 2 workers, thereby causing the value of the marginal product of labor for downstream users to increase. The relative magnitude of the labor market leaves the direction of the equilibrium wage rate in the economy unclear and may result in $\tilde{w} > \hat{w}$ or $\tilde{w} < \hat{w}$.

As Sector 1 uses less water and fewer workers are employed, the productivity of capital falls and causes the return to capital to also fall to $\tilde{r}$, which is less than $\hat{r}$. The productivity of Sector 2 rises because of reduced disruptions to water flow and increased employment of labor in that sector. As a consequence, the return on waste and water treatment plants rises to $\tilde{\lambda}$. Further, Sector 1 output declines because z and L_1 fall. Sector 2 output rises, however, because z increases and L_2 rises. Sector 1 capital owners are worse off because $\tilde{r}\overline{K}$ is less than $\hat{r}\overline{K}$, although Sector 2 plant owners benefit because for a given number of downstream facilities the per unit returns rise to $\tilde{\lambda}$.

PRACTICAL ISSUES OF WATER MARKETS

The degree to which water transfers occur depends on the opportunity costs to the users. For example, firms emitting waste into streams can reduce their environmental impact by using holding ponds to decrease the amount of effluent discharged into the river. If holding ponds are more cost-effective than purchasing water from dam owners, firms will prefer the former approach. Moreover, some water uses are more higly valued than others. Frederick et al. observe that the highest average water use values generally are for industrial processing ($282 per acre foot) and domestic use ($194 per acre foot), while hydropower ($25 per acre foot) is generally the lowest.[21] However, timing is very important for hydropower. Indeed, Progress Energy uses their two dams primarily for peaking and load-following generation. On the YPDR, water demand for irrigation is likely to be low, while demand for domestic use is likely to be high.

Although earlier we assumed that transaction costs from transfers will be low, this may not be the case. If transaction costs, which include conveyance, information, and enforcement costs, are high, fewer water transfers will occur. As a practical matter, transaction costs can be reduced by auction as in southern Georgia with the Georgia Environmental Protection Division.[22] For the YPDR water market that we propose, conveyance costs are nominal, because the water flow changes by increasing or decreasing the flow from the dam. Information costs could involve searching for trading partners, negotiating prices, and identifying legal requirements.[23] Water markets may not develop because of the high costs of monitoring and measuring the resource.[24] For example, when an agency must monitor each individual farmer to

21. KENNETH. D. FREDERICK ET AL., ECONOMIC VALUES OF FRESHWATER IN THE U.S., 9 tbl. 3.1 (Resources for the Future, Discussion Paper No. 97-03, 1997).
22. CUMMINGS ET AL., supra note 19, at 24.
23. SALI BA & BUSH, *supra* note 9, at 239.
24. *Id.* at 27.

see if irrigation restrictions are being met, enforcement costs are much higher. However, monitoring water flow from the dams should not be costly, because the U.S. Geological Survey maintains a number of gauging stations throughout the YPDR basin.

The costs of a water transfer should include the full opportunity cost to the user, including the effects on public interest values and third parties. Although the transfer program may benefit upstream and downstream users, it may be inefficient from a societal perspective if nonmarket benefits such as recreation value and wildlife habitat are not included in the transfer negotiations. Groups concerned with uses that depend on in-stream flow may not be well represented in negotiations because they may be poorly organized or subject to the free-rider problem. Although contract restrictions impose transaction costs on participants, the costs may be necessary to protect third-party and public interests. To maintain in-stream flow for recreational use and habitat protection, a mechanism could be developed within the water transfer program. For example, a fee could be levied on all transfers, as is the case in the CVP.[25] A state agency could monitor stream conditions and use the fees to purchase increased stream-flow for habitat protection. It is possible that private conservation groups such as The Nature Conservancy would purchase water rights to improve wildlife habitat. As demand for nonmarket benefits such as wildlife habitat increases, the value of increased flow for such uses is likely to be higher.

A potential concern from creating a water market is that redistributing water rights may affect water quality. Weber shows that the water seller's location can affect water quality.[26] For example, if upstream water buyers purchase water flow and thereby reduce downstream flow, water quality downstream could deteriorate as less pollutants are assimilated. The YPDR is water quality limited for dissolved oxygen for a segment downstream from the city of Florence. To control such problems, the water contract could be conditioned on restricting trades that cause water quality deterioration. State agencies such as the S.C. Department of Health and Environmental Control would restrict actions that led to water quality deterioration. Also, courts have enforced the Public Trust Doctrine to protect water quality.[27] Alternatively, a program of effluent trading could be implemented to

25. John B. Loomis, *Water Transfer and Major Environmental Provisions of the Central Valley Project Improvement Act: A Preliminary Economic Evaluation*, 30 WATER RESOURCES RES. 1865, 1868 (1994).

26. Marian L. Weber, *Markets for Water Rights Under Environmental Constraints*, 42 J. ENVTL. ECON. & MGMT. 53, 54 (2001).

27. SALIBA & BUSH, *supra* note 9, at 249.

decrease transaction costs. A case study of effluent trading on the YPDR found efficiency gains from such a program.[28] A comprehensively defined water rights market should incorporate water quality conditions, although this may increase transaction costs for buyers and sellers.

Chile's experiment in water markets provides important practical insights for understanding the advantages and disadvantages of water markets.[29] Chile's 1981 Water Code strengthened private property rights, implemented market incentives, and reduced state regulations in order to improve water allocation. The Water Code has encouraged some agricultural areas to invest in more efficient irrigation and made it easier to change the allocation and use of water. However, water rights sales and transactions have been uncommon due to transaction costs and private investment in more efficient water use has been less than expected. This is due in part to the limitations of geography, infrastructure, legal and administrative complexities, cultural and psychological attitudes, and ambiguous economic signals.[30]

Some available models can provide guidance on the design of a water market institution, which can be critical to the success of transfers. The "smart" market concept "combine[s] the information and incentive advantages of decentralized ownership rights...with" central coordination programs.[31] Murphy contends that the "smart" uniform-price double auction yielded highly efficient outcomes even with a limited number of trading opportunities for each participant.[32] The double auction, in which initial allocations for participants are grandfathered in, may be an appropriate method to conduct trades. Electronic trading systems can provide useful information that may reduce transaction costs and facilitate trade. Another laboratory experiment considered what pricing and closing rules should be used, as well as how provisional results should be reported.[33] The Georgia Environmental Protection Division implemented their recommendation of an iterative discrimination auction in March 2001.

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28. Sean Blacklocke, *Effluent Trading in South Carolina*, *in* THE MARKET MEETS THE ENVIRONMENT 205, 222 (Bruce Yandle ed., 1999).

29. CARL J. BAUER, AGAINST THE CURRENT: PRIVATIZATION, WATER MARKETS AND THE STATE IN CHILE (1998).

30. *Id.* at 33-36.

31. Kevin A. McCabe, *Smart Computer-Assisted Markets*, 254 SCIENCE 534, 534 (1991).

32. James J. Murphy et al., *The Design of "Smart" Water Market Institutions Using Laboratory Experiments*, 17 ENVTL. & RESOURCE ECON. 375, 393 (2000).

33. CUMMINGS ET AL., *supra* note 19, at 11, 25.

CONCLUSION

In light of recent federal policy reforms like the Central Valley Project Improvement Act and increasing demands for scarce water, a water transfer program for YPDR users may be practical as well as desirable. When the FERC issued the licenses for the six dams almost 50 years ago, downstream users placed little demand on water flow. Today, as relicensing of the dams is being undertaken, downstream users demand greater amounts of water. Although the critical shortage of water flow on the Pee Dee River in 2002 was partially the result of a five-year drought in the Carolinas, growing demand for water will likely create the need to make difficult allocation choices in coming years. One reason that a YPDR water market has not developed is that, when river water is not very scarce, the costs of creating a market are greater than the benefits. Increasing demand for Pee Dee water will create a stronger incentive to better define, monitor, and enforce property rights. Better defined property rights would require an institutional change that would be similar to changes that some western states have already implemented.

To make water markets work, the economic benefits to the buyers must outweigh the costs of obtaining the water. Until the conflicts over YPDR water supply arose in 2002, there was little reason to question the efficacy of the command and control approach as an allocation mechanism. With growing demand for water, our simple model shows that creating a market to allocate YPDR water-flow increases societal welfare.

A Coasean solution to the problem of inefficient resource use relies on well-defined property rights to create market exchanges to improve resource allocation. In the framework of a simple two-sector model, we investigated the consequences of a FERC decision that awards transferable water rights to Sector 1 (industries upstream that control the dams). The creation of a water market will increase the real gross state product in both North and South Carolina. We expect that the decision will increase Sector 2's value added more than it decreases Sector 1's value added, because the benefits of increased water flow are greater than the costs. A policy change that defines property rights to include exchange rates would create a market for the resource z. With a market, because the rights to water can be transferred, water will be allocated to it's highest valued in-stream or withdrawal use.

In addition to improving resource allocation, water markets have several advantages over the current policy of the FERC setting the minimum amount of water flow. A water transfer program can adjust for demand changes that result from changes in weather patterns.[34] When drought years occur, water prices will rise and, if water is plentiful, prices will fall. Markets also encourage users to consider the opportunity cost of their decisions. For example, if a dam operator could increase operational efficiency with a technological change, the firm would do so if other water users were willing to pay for increased water flow.

Across the United States, 139 dam licenses expire between 2003 and 2010, and many others that have already expired are going through the relicensing process. Negotiations on the YPDR dam licenses, which expire April 30, 2008, began in the fall of 2004. A recent study that examined 72 projects relicensed between 1980 and 1996 found that the FERC does not explicitly weigh the social benefits and costs of relicensing decisions.[35] Clearly there is room for improved analysis and policy. Given the growing demand for water in many places, it is likely that the FERC will scrutinize various policy issues. A better understanding of the economic impact of water flow decisions will improve policy choices that will shape the Carolinas' future.

34. Because the dams would be able to have water reserves during drought periods (as was the case in 2002), the dams can improve societal welfare.

35. Michael R. Moore et al., *Testing Theories of Agency Behavior: Evidence from Hydropower Project Relicensing Decisions of the Federal Energy Regulatory Commission*, 77 LAND ECON. 423, 440 (2001).