

Water Resource Economics: The Analysis of Scarcity, Policies, and Projects

by *Ronald C. Griffin*

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Mark Twain is often credited with saying that whiskey is for drinking and water is for fighting over. Like a lot of things, there may be good reasons to fight over water, but there are also bad reasons. One of the latter is misunderstanding. Unfortunately, there have been lots of misunderstandings related to water and many of these have been specifically related to not understanding the economic characteristics of water. For example, too often it has been believed that the absence of a price for water or a service provided by water means that it has no value to society. Similarly, it has been believed that the observation that spending on irrigation projects leads to job creation is a sufficient condition for supporting such spending.

Ronald C. Griffin has written a book that is at once both a textbook for non-economists who wish to be introduced to the economic perspective on water allocation issues and an effort to confront and refute a number of the misunderstandings regarding economics that permeate the water resources field. On both fronts, Griffin does an excellent job and if enough non-economists were to read *Water Resource Economics: The Analysis of Scarcity, Policies, and Projects*, there would be fewer misunderstandings and, as a result, perhaps fewer disputes. (It's probably also true that if hydrologists or engineers would write comparable books for economists to read, that

would reduce economists' share of the misunderstandings related to water.)

This book is aimed primarily at non-economists working or studying in the field of water resources (engineering, geography, etc.). As Griffin states, one of the book's objectives is to "assemble and apply the minimal set of economic theory needed to understand and operationalize water resource economics" (p. xiv). There also appears to be a second, less obvious, objective. This is to use economics to confront and refute a number of misconceptions commonly encountered in the water resources field. I don't know whether the author intended this to be a goal of the book but as the following discussion demonstrates, it happens frequently enough to be a recurring theme.

The book is comprehensive in scope and addresses the following topics: the supply, demand, and pricing of water; markets and other institutions employed to allocate water; valuing water; and assessing policies related to reallocating water. These topics are applied to both surface and groundwater supplies and the text indicates where differences in the physical features of these two water sources dictates differences in economic analysis. The principle limits on the scope of the book stem from its concentration on matters relating to the quantity of water rather than its quality and from its almost exclusive reliance on American cases and empirical evidence. The text employs a well-balanced mix of written, graphical, and mathematical presentations and assumes readers have some basic math

background (differential and integral calculus as well as linear algebra), although not necessarily much by way of economics training.

Water Resource Economics has twelve chapters including introductory and concluding chapters. All chapters have a summary section as well as exercises that provide useful questions and problems for students to test their knowledge. A number of the chapters have appendices that deal with mathematically more advanced material. Although citations are quite complete, a valuable addition to the book would have been a list of suggested further readings placed at the end of each chapter. This would be especially useful as this is likely to be the first time readers encounter such a sustained and substantial discussion of the economics of water resources. These lists, for example, could have provided more advanced treatments of some topics and real world case studies.

Chapter 1 introduces a number of issues and themes that are covered in the book including a brief description of the “economic approach” to understanding the issues confronting water resources management. By “economic approach” Griffin means an approach grounded in modern neo-classical economics with an emphasis on microeconomics. This approach is complemented later in the text with the use of an institutional perspective on the evolution of water laws (Chapter 4) and a discussion of some of the econometric issues surrounding the estimation of water demands (Chapters 9 and 10). Griffin divides most of the issues concerning water managers today into those related to either the demand or the supply of water. Because most of the forces driving changes in the demand for water are in the direction of increasing demand and most of the forces driving changes in supply are in the direction of decreasing supply, Griffin argues rightly that the economic approach to water resources management is an increasingly valuable perspective to understand. Griffin concludes the chapter by acknowledging that the economic perspective on environmental issues in general and

water resources in particular is anthropocentric in nature. While this may be a limitation, Griffin points out that it does not mean that environmental services provided by water resources cannot be valued—only that that valuation must be centred in humans’ assessment of its significance. This is a potential limitation of economic analysis that is often cited by non-economists (Sagoff 2004) and it would have been valuable to investigate the debate further in the chapter.

Chapter 2 covers a significant amount of material that forms the foundation of all that follows in the text. The chapter begins with the supply-demand model. While developing the model, Griffin introduces a number of important concepts including opportunity cost, the relationship between elasticity and substitution possibilities and the difference between the demand for a commodity and the requirement or need for a commodity. The last concept is especially important in the field of water resources management because there is a long and ignominious history of assuming that water use is not dependent on economic conditions and that most applications of water in commercial settings were best modeled as fixed coefficient technologies with no opportunities for conservation or substitution. The idea of returns to scale is also introduced, however, the presentation perhaps may allow a common misconception to slip through. Griffin posits a production function where output depends only on the quantity of the water input. He then asserts that water’s positive marginal product is signaled by a positive first derivative and the technology’s having returns to scale is signaled by a positive second derivative. This is all fine in a world of one input and no distinction between fixed and variable inputs. However, it is possible to misinterpret Griffin’s presentation as showing the relationship between changes in output and changes in a single input, holding fixed all other outputs; in other words to confuse returns to scale with increasing marginal product. Unfortunately, it’s not uncommon to see returns to scale

misinterpreted as the increasing marginal product of a single input in the short-run in the water resources literature. As a result, it would have been useful if Griffin had more carefully distinguished between the two concepts.

The chapter also introduces the reader to the basic ideas surrounding welfare analysis. This is an important topic as it forms the basis of the text's later treatment of project analysis and cost-benefit analysis. Griffin distinguishes between two related concepts: neutral economic efficiency and aggregate economic efficiency. The former is better known as Pareto optimality: when no reallocation can raise any agent's welfare without lowering another's. The latter arises from the allocation of resources that maximizes the sum of agents' net benefits (and, has as a necessary condition, the equality of marginal net benefits). Griffin correctly points out that the first concept is not particularly useful as a tool in applied policy analysis while the second is crucially important in assessing proposed water reallocations. I would diverge slightly from Griffin only because I think the difference between the two concepts lies more in whether agents' levels of welfare are assumed to be comparable (in a cardinal sense), rather than the weighting of individual agents' level of welfare as Griffin argues. Luckily, this difference in interpretation is unlikely to matter to the average student reading the chapter. What is more likely is that they will understand the fundamental point: that welfare economics provides a comprehensive and rigorous method for ranking policy options based on their impacts on aggregate social welfare (as indicated by households' preferences), rather than some other less attractive method of ranking. As an example of this and of the Griffin's use of economics to confront commonly held positions in water management, the chapter concludes by applying the concepts of welfare economics to assess whether water conservation per se is a legitimate goal beyond efficiency in water use. Griffin argues that water conservation may be a legitimate social goal, when

it promotes a set of goals that include efficient water use (others may include ecological goals).

Chapter 3 extends the analysis of the previous chapter by considering efficiency in dynamic settings. It begins with a valuable discussion of the relationship between rates of time preference and market interest rates. This is followed by an equally valuable discussion of the social costs of capital. With the preliminary topics covered, the chapter then discusses the concept of dynamic efficiency and considers the relative merits of alternative ways of judging projects (NPV, IRR, BC ratio, etc.). Griffin uses graphical analysis to illustrate the efficient solution to a two-period problem of allocating a finite resource (such as a deep aquifer) and then generalizes the solution to a multi-period problem. The solution has the features of a Hotelling-like dynamic extraction profile. Griffin then highlights the features of the general model by providing an illuminating numerical example of drawing from a reservoir. One particular feature of the model that might have merited further attention is the behavior of the stock's shadow price along the efficient extraction profile. Griffin concludes the chapter by comparing and contrasting several dynamic allocation rules including dynamic efficiency, safe yield, and sustainability.

Chapter 4 considers from an economic perspective the social and legal institutions governing the allocation of surface and groundwater. It starts by making the important point that the development of social institutions, such as those governing natural resource uses, is endogenously determined by social forces and trends and by the relative scarcity of natural resources. This point is important to understanding the debate surrounding the application of water markets in low-income countries where the introduction of complex legal institutions may clash with preexisting, less formal, rules for allocating resources that grew out of local traditions and cultures. The chapter next considers the relative efficiency properties of alternative alloca-

tive institutions: open access, common property (possibly governed by informal but enforceable mores and rules), state property, and private property. Griffin points out that the last of these is the strongest basis for control of use and for trading amongst uses. Griffin's presentation regarding the efficiency properties of alternative property rights regimes is nicely balanced. The argument in section 4.1 concludes by pointing to the importance of well defined property rights for efficient allocations. However, the presence of these rights is a necessary, but certainly not a sufficient, condition for efficiency. To demonstrate this, Griffin then introduces the first welfare theorem and catalogues instances such as externalities, public goods, and natural monopoly when the assumptions underlying the first theorem are not met. (If water quality had been considered in the text, it would have been natural for Griffin to also assess the efficiency consequences of imperfect or asymmetric information situations.)

As part of the discussion of the causes of market failure, Griffin also discusses possible solutions: efficient production of public goods through the vertical summation of their demands, internalization of third-party effects for externalities, and regulation for monopolies. Having established the importance of property rights, Griffin then briefly discusses exactly how they are important by presenting the Coase theorem and the potentially significant role of transactions costs in the theorem.

Griffin now turns his attention to an economic assessment of the legal institutions and laws governing water use. The text first covers laws pertaining to surface water allocation (mainly in the United States) and then those related to groundwater. The treatment here is excellent. The text covers riparian rights, permit systems (such as those found in the eastern U.S. states and all of the Canadian provinces), prior appropriations doctrine, and correlative shares. Throughout the text, the concern is to assess the extent to which any institution or law serves as a sound

basis for the efficient allocation of surface water. Griffin points out that, despite a "maturing" of surface water laws, complexities and ambiguities continue to keep transactions costs high and, thus, inhibit welfare-improve transactions. The state of groundwater laws is less satisfactory. Griffin reviews legal concepts of absolute ownership doctrine, reasonable use doctrine, correlative rights to groundwater, and the application of the prior appropriations doctrine to groundwater. All of these are seen to be inadequate bases for allocation given the possibilities of externalities across users and/or across time periods when exploiting groundwater. Thus, Griffin turns to Smith's elegant two-part system of rights in groundwater and points to its attractive incentive properties. The chapter concludes by briefly looking at conjunctive management of surface and groundwater resources and at a sampling of the treaties and compacts surrounding interjurisdictional water allocations.

Chapters 5 and 6 employ a number of the concepts developed earlier in the text to demonstrate how they can be used to assess water-related policies. Chapter 5 considers a number of specific policies such as efforts to increase the supply of water. In addition, chapter 5 briefly considers policy analysis in a multi-period setting and addresses the often contentious issue of secondary effects. Fortunately on this last point, Griffin clearly delineates the limited instances when secondary impacts can legitimately be considered as part of the welfare effects of a project. Chapter 6 presents a more general treatment of several issues related to the application of cost-benefit analysis to water resources planning. Griffin argues that CBA should be considered as more than simply the calculation of the present value of a project's net benefits. Instead, it should be seen as a comprehensive decision-support framework in which all impacts of project—including those that can be monetized and those that cannot—can be accounted and assessed.

Despite the text's assertion regarding the generality of CBA, the discussion in Chap-

ters 5 and 6 is somewhat narrow in scope. On the one hand, Griffin's presentation is clear and helpful to the reader. On the other hand, Griffin retains the economist's fairly narrow view on policy analysis and eschews any discussion of evaluating the process by which policies are developed (e.g. assessing the transparency and accountability of decision makes), incorporating distributional concerns into policy analysis or the evaluation of methods other than cost-benefit analysis (such as multi-criteria, multi-objective policy assessment (compare this with the discussion in van den Bergh 1996).

Another concern relates to the treatment of the welfare effects of specific policies in Chapter 5. For example in section 5.6, Griffin considers the somewhat unusual case of a policy to increase water demands (perhaps as a result of a local government luring a new business to relocate to its city with tax incentives). The water agency's technology is characterized in Figure 5.4 as decreasing returns to scale. This, combined with the agency's practice of average cost pricing, implies a preexisting amount of welfare loss associated with some customers consuming despite the marginal cost of supply exceeding their marginal benefit of consumption. With the policy-driven increase in demand, this situation is aggravated and the deadweight loss arising from excess consumption necessarily increases. In the second-best environment in which the water agency employs inefficient pricing, an increase in demand may or may not lead to an increase in aggregate welfare. Griffin's analysis of the policy, however, considers only the impacts on consumers (average cost pricing ensures the agency's profits remain zero) and thus does not provide a full social accounting of the welfare effects of the policy.

The focus of the presentation shifts to water markets in Chapter 7. Griffin provides the reader with an excellent description of the interplay amongst history, institutions, and economics in order to assess the workings of these markets. The chapter begins with a straightforward de-

scription of the economic basis for welfare-improving trades and outlines the methods for quantifying the gains from such trades. One problematic point that is not emphasized is the difficulty these models have in predicting the price at which trades will actually occur. The attention in the chapter then focuses on the workings (and failings) of water markets. The balance in Griffin's treatment of this often controversial subject matter is shown by his coverage of both the beneficial impacts of market-driven reallocations, as well as the externalities that can arise from trades. Griffin then addresses the relative merits of the political, institutional, and market-based ways of surmounting these externalities. Regarding groundwater marketing, Griffin convincingly makes the perhaps counter-intuitive argument that, despite the plethora of potential causes for market failures, well-designed markets hold more promise than prevailing institutions.

Griffin also tackles the contentious "Area of Origin" stance that presents a potential impediment to many market-based water reallocations in the United States. Advocates of Area of Origin positions argue that water sales may lead to income reductions in the seller's region due to secondary or "spin-off" effects and, as a result, sales should be blocked or compensation schemes be created. Griffin demonstrates to the reader that such a position, like other efforts to inhibit free trade, confuses the creation of income with its redistribution. Griffin concludes that "the recommendation of economic efficiency is to forget about third-party protection relating to area-of-origin impacts. Any protection will reduce the net benefits the state receives from its water endowment." (p. 231).

Chapter 8 continues the discussion of issues related to allocating water by examining pricing by municipal water suppliers (pricing of irrigation water and of raw water supplies is not covered). The chapter begins with a good description of water agencies' common procedures for the cost accounting and pricing of potable water and contrasts these with economic prescriptions. Griffin's presentation highlights the numerous ways

in which local water agencies' practices encourage inefficient water use through incomplete cost accounting and mispricing. Griffin then turns to the economic perspective on pricing and derives several variants of marginal cost prices. While perhaps a blinding flash of the obvious to resource economists, Griffin's emphasis on including the shadow price of raw water input in cost accounting and pricing is particularly welcome. On the other hand, the cost function upon which Griffin bases the derivation of pricing rules is somewhat idiosyncratic. It posits costs of supply to be a function of the quantity of water delivered, the number of connections, and the number of new connections). This may be "a better choice" for the specification as Griffin argues (p. 258), but it is different from the standard neo-classical presentation of supply costs and should be identified as such. In addition, while the treatment of water pricing rules in this chapter is straightforward, it is perhaps somewhat limited. Griffin touches briefly on multi-part and seasonal pricing, however, this section seems to be presented with less attention to detail when compared to the treatment of water markets found in the previous chapter. For example, a number of topics such as optimal nonlinear pricing (Brown and Sibley 1986), cost allocation and pricing with lumpy investments (Russell and Shin 1996), and the pricing of fire-fighting services are not dealt with.

Thus far, much of the text's discussion has been based on the presumption that the analyst has available reliable estimates of the relevant water demand and supply curves. The next three chapters concentrate on a variety of issues related to estimating and employing these relationships. Chapter 9 begins with a review of the methods available for estimating water demand relationships. The review starts with a discussion of the point expansion method and perhaps gives it too much credence. Griffin's treatment of this topic raises the more general issue of the appropriate balance to be struck between the need to present topics and methods in a way that is accessible to a reader relatively unfamiliar with econom-

ics and the need to maintain technical rigour. The issue of where to find the balance between these two opposing forces is discussed more fully below.

The review then moves onto residual imputation as a basis for estimating demands. In contrast to the treatment by Young (2005), Griffin argues this method is reliable and is capable of providing credible estimates of the marginal benefit of water. The next method is mathematical programming. Griffin points out that this approach is most appropriate for industrial and agricultural applications where water can be applied to several possible activities. An interesting application that Griffin does not address is the issue of internal water recycling. In this application, there may exist significant discontinuities in a firm's response to changes to water prices: for wide range of price, changes elicit no response and then at some price of water where adoption of internal recirculation becomes profitable, the firm installs recirculation capital and water intake can drop by up to 90% (Stone and Whittington 1984). Griffin then briefly considers production functions as basis for nonresidential water demands. The final approach considered is econometric estimation of water demand functions. The discussion here would have benefited from a brief treatment regarding what has arguably been the most important topic in this literature—namely the challenges surrounding the definition and construction of the price variable when households face nonlinear price schedules. Another issue that merited discussion is the forecasting of water demands. In line with the text's effort to confront misconceptions within the water management field, it would have been useful to draw on the research literature that has demonstrated that the 'requirements' or fixed coefficient method of modeling water demands has led in the past to significantly inflated estimates of forecasted water demand growth (Renzetti 2002). The discussion surrounding the estimation of water demand equations concludes with a review of estimates of price elasticities and a valuable discussion

of the factors influencing their values. Chapter 9 then concludes with an introduction to nonmarket valuation methods (specifically CVM, hedonic, and travel-cost methods). Griffin provides a short and balanced discussion of each method, although the emphasis on valuing changes in water quantity (and not water quality) does limit the discussion somewhat.

Chapter 10 parallels the previous chapter by examining a number of issues related to the estimation of the marginal cost of supplying water. It begins with a review of alternative empirical procedures: point expansion, employing accounting data, using engineering data, and finally, econometric procedures. The discussion is somewhat terse but this is understandable given the fact that the empirical literature on this topic is significantly less well-developed than the literature on water demand estimation. A second concern relates to the conceptual cost model that Griffin employs here. As was discussed in the case of the water pricing chapter, the cost model is somewhat unconventional. Nonetheless, this does not detract from the presentation, and indeed, provides some useful insights into costing and pricing.

The remainder of chapter is devoted to the thorny issue of privatizing local water supply facilities. If any topic related to water resources ever demonstrated the veracity of Twain's assertion about water, it is the participation of private firms in the supply of potable water. Fortunately, Griffin handles this issue as he has several in preceding chapters: with balance and with a focus upon the economic issues involved. This is done by first reviewing the arguments in favor of and against privatization. In addition, Griffin correctly points out that a significant impediment to achieving any potential efficiency gains that might arise from privatization, is that privatization of a public water monopoly is unlikely to be followed by deregulation and increased competition. Griffin concludes that the empirical evidence fails to reject the null hypothesis of equal efficiency (or, perhaps more appropriately, inefficiency) across

different ownership types. Given the experience of privatization in England, France, and particularly low-income countries (Renzetti and Dupont 2004), the discussion would have benefited from drawing on evidence from these regions.

Chapter 11 reviews applied models that integrate supply and demand-side information in order to study water allocation and pricing rules. These models tend to be quite complex in their effort to extend the physical and economic features of single-market models. The complexity of these models, however, typically comes at a cost of needed abstraction from some real-world features of water allocation. As a result, Griffin cautions the reader that, since these models typically neglect transactions costs and other sources of market distortions, their predicted outcomes are idealized efficient benchmarks rather than predictions of the results of real-world allocations. After presenting an example of these multi-market models, Griffin discusses the various forms of the models. He points out that they are all multi-sector and some incorporate dynamic and/or uncertainty features. The chapter concludes with the presentation of an interesting dynamic model of competing demands for ground-water extraction that demonstrates the costs of inefficient regulations governing withdrawals. Some applications of these models not considered by Griffin include their ability to assess the linkages between water allocation policies and trade liberalization policies (Tsur et al. 2004, ch. 5) and/or water allocation policies in low-income countries where market- and policy-induced distortions can be significant.

The last chapter of the book concludes by drawing together a number of the themes presented in the text. This is done by briefly describing "economically inspired principles" that should guide water resources management. In Griffin's view, these are the most important contributions made by economics to understanding and promoting socially beneficial water allocations. For example, Griffin highlights the importance of considering the opportunity costs of

water allocations, the difference between water demands and water requirements, and the need of marginal cost pricing. Following these principles may not be *sufficient* to ensure efficient pricing rules or the institutions governing water trades are designed and implemented but they certainly are *necessary* to avoid many of the policy errors and disputes that have be-deviled past water projects.

Water Resource Economics achieves its objectives very well. First, it is an excellent textbook. It provides clear, balanced, and comprehensive coverage of the most important topics related to the application of economics to water resource allocation problems. Griffin has also accomplished the difficult task of finding the appropriate level of technical analysis for students and professionals who are engaged in water resources management, but who do not necessarily have extensive training in economics. This is a particularly impressive feat when one sees that some of the topics covered include the efficient allocation of public goods, the optimal depletion of a nonrenewable resource over time, and the incentive effects of alternative property rights regimes. This coverage is complemented nicely by case studies, end of chapter exercises, and a number of technical appendices.

When writing a textbook such as *Water Resource Economics*, the author must undoubtedly make a number of choices regarding the topics to cover and the level of technical difficulty to employ. Regarding the choice of topics, the coverage of topics is quite comprehensive and no major issue is neglected. Nonetheless, it's always possible to find topics that one thinks deserving of more attention and my list would include a treatment of the efficiency properties of nonlinear price schedules, more use of non-American examples, and a discussion of irrigation water pricing. Griffin has chosen an appropriate level of technical difficulty. Most of the important results are explained intuitively and are demonstrated with a relatively modest use of calculus and algebra. Perhaps the only topic that could have used

a more in-depth treatment is the issue of specifying the price variable in econometric models of residential and industrial water demands. Griffin also does an excellent job of showing how standard economic models need to be adjusted to account for the peculiarities of water. These include accounting for return flows in models of efficient allocation, noting the importance of stock effects in intertemporal aquifer depletion models, and recognizing the possibility of rivalrous and nonrivalrous demands co-existing for a given body of water when assessing allocation rules and property rights. The final choice that merits attention is the issue of when and to what extent is it appropriate to present methodological "shortcuts" as constituting standard practices in applied economic analysis. Examples of this include the point expansion method of approximating an unknown demand or supply curve and perhaps benefit transfer techniques. In the real world, these short cuts may be used because of budget, informational or time constraints. It is always difficult to predict the loss of accuracy from adopting these methods but a textbook aimed at instructing relative newcomers to economics should perhaps identify them for what they are: shortcuts that are sometimes dictated by the constraints imposed on a project rather than preferred methods of analysis.

Water Resources Economics also achieves its second (perhaps implicit) objective of confronting and refuting misconceptions regarding the economic features of water resources and water management admirably. Examples of Griffin's efforts in this regard include restricting instances when the inclusion of secondary affects is appropriate in cost-benefit analysis, rejecting the use of area of origin arguments to block or restrict water marketing, promoting water conservation as a goal separate from efficient water use, dictating that the price of delivered water should include the shadow price on scarce raw water supplies and, finally, challenging the idea that the absence of a price implies the absence of value. The readers, then, are doubly well

served by *Water Resources Economics*; they will learn not only how to carry out the economic analysis of a wide variety of issues related to water resources management, but they will also be taught how to avoid some of the misconceptions that have plagued water resources management in the past.

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