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Benchmarking in water project analysis

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[1] The with/without principle of cost-benefit analysis is examined for the possible bias that it brings to water resource planning. Theory and examples for this question are established. Because benchmarking against the demonstrably low without-project hurdle can detract from economic welfare and can fail to promote efficient policy, improvement opportunities are investigated. In lieu of the traditional, without-project benchmark, a second-best-based "difference-making benchmark" is proposed. The project authorizations and modified review processes instituted by the U.S. Water Resources Development Act of 2007 may provide for renewed interest in these findings.

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1. Benchmarking in Water Project Analysis

[2] An undisputed principle of project analysis is that benefits and costs are to be benchmarked against a "without-project" scenario in which conditions are not static. In this scenario, economic conditions (population, behavior, outputs, prices, etc.) continue to evolve, yet the project does not exist. It is against this benchmark that the "with-project" scenario is compared, and appropriate welfare benefits and costs are computed as differences. The main counsel of the with/without ideal is to avoid the error of invoking an after/before comparison instead of a with/without one [*Howe*, 1971; *Young*, 1996]. Put simply, future periods should not be regarded as repetitions of past periods [*National Research Council*, 1999, p. 50].

[3] A question that is incompletely confronted in the water resource literature is whether the with/without principle erects an weak benchmark in a mature economy characterized by nontrivial water scarcity. Specifically, whereas the "with" aspect of this test seems quite correct, benchmarking against without-project conditions can be contentious because of the multitude of alternative public actions which are available. Yet, with/without has enjoyed an unchallenged primacy among the principles of cost-benefit analysis. With independent review of federally performed cost-benefit analyses being mandated by the U.S. Water Resources Development Act of 2007 [*U.S. Congress*, 2007, section 2034] and revisions to the 1983 *Principles and Guidelines* (hereinafter referred to as PG) [*U.S. Water Resources Council*, 1983] long overdue and required before 2010 [*U.S. Congress*, 2007, section 2031], this is not just an academic matter. In the U.S. alone, billions of dollars in potential project authorizations and consumer welfare are at stake should improvement in this doctrine be warranted. Moreover, this issue may extend to other public project areas such as transportation, and it is also relevant to the other international, national, and state/provincial authorities applying cost-benefit analysis (CBA) to guide decision making.

[4] The hypothesis forwarded for examination here is that the without-project benchmark installs a bias favoring project approval. If it exists, such a bias compounds other biases present in public decision making about water projects, leading to exaggerated reliance on structural approaches to scarcity and underemployment of nonstructural policies. To a great extent, the incidence of this added bias depends on the goals of cost-benefit analysis. Are the goals to illuminate program choices and support a range of attractive policy decisions? Or is the goal to decide whether building a project is better than doing nothing? Perhaps then the final result of this study is to identify a pivotal normative issue for which two opposing stances are defendable. If so, both viewpoints are available to well intentioned economists and planners, and any two people might legitimately disagree on the point without either being wrong. Yet, it will be demonstrated that there is some undeniable discomfort with one of these positions as well as extra analytical effort for the other, and the selection itself is a crucial policy decision.

[5] The following section identifies some institutional background for this issue, in an effort to determine how consistently current water policy is aligned with the with/without principle. An additional objective is to size up the reasonability of a serious CBA policy reform, one that rejects the without-project benchmark. It is argued that the seeds for change were loosely sown in the 1983 PG and its short-lived predecessor, but they have yet to be respected in application. A theoretical framework for this problem is then established after reviewing the CBA literature, some of which tends to be classical in origin. Subsequent sections pose illustrative scenarios in which various benchmarks can be more firmly compared. The water scarcity scenario is especially interesting because of its resemblance to common cases. From the theory and examples an alternative benchmark emerges as a preferred selection. Though the alternative is not ultimately surprising or revolutionary, the choice between the traditional without-project benchmark and the

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suggested alternative is shown to have momentous implications for decision making.

2. Federal Policy Background

[6] The with/without principle has been a feature of U.S. water project analysis since at least 1950. It is explicitly observed in the major federal CBA formulations of 1950, 1958, 1973, and 1983. These institutions evolved to establish economically based standards of analysis which could be agreeably applied by the major water resource development agencies [*Hufschmidt*, 2000]. At various times these (and other) federally authorized CBA procedures have been required or discretionary. Unlike the 1973 rules, the presently applied 1983 PG are not strictly compulsory, yet planning tradition and agency protocols assign a strong authority to the PG's prescriptions.

[7] During the history over which these institutions were developed, important rationales for having CBA requirements included perceived needs (1) to ration federal funds well, (2) to establish a level playing field for the water development agencies, and (3) to develop a sound basis for establishing cost allocations among the beneficiary groups of any given water project. Limiting our attention to the first of these objectives, CBA operates as a system check upon the several forces that collectively pressure fiscal responsibilities. At least three of these forces work to create nonmarket failures [*Wolf*, 1979] in the U.S. system of water project decision making.

[8] 1. The median voter, who tends to be pivotal in democratic decision processes [*Congleton*, 2003], subscribes to the notion that water is a very unique resource deserving of public intervention [*Kelso*, 1967]. Acculturated beliefs include the ideas that economic prosperity is well linked to water availability [*Ingram*, 1990] and that water scarcity problems are water supply problems best remedied by supply development. Voters are apt to support choices aligned with these beliefs whether the choices be referenda, bond issues, or political candidates. These voter perspectives provide traction for political favoritism of water projects over policy solutions that are potentially more efficient.

[9] 2. Politicians want to be associated with perceptible progress and change, so as to enhance their electability and power [*Cortner and Auburg*, 1988]. Water projects are very tangible products and have provided a valuable currency for politicians wishing to cultivate and sustain voter support [*Hundley*, 2001]. Historically, cost-sharing requirements for project beneficiaries have been low [*Waelti*, 1985]. Considerable logrolling and pork barrel politics [*Hird*, 1991] have occurred at the national level as a consequence of these conditions [*Ingram*, 1990], with heavy pressures upon the federal budget throughout the mid-1900s [*Ferejohn*, 1974]. In recent decades this pressure has been diverted to state and local governments as a result of reduced federal interest commencing in the 1970s.

[10] 3. Public water resource agencies are predisposed to favor structural solutions to water scarcity [*Ingram et al.*, 1984]. Project construction creates large agency budgets and greater opportunities for staff [*Rucker and Fishback*, 1983; *Cortner and Auburg*, 1988]. Projects forestall the need for more complex, interjurisdictional policy strategies which are difficult for bureaucrats to broker. Agencies are pressured by water-using interest groups that can commonly agree upon structural options when the costs can be exported to a broader population. Additionally, agency staff and leadership have been traditionally dominated by the engineering profession which is attracted to project construction challenges.

[11] These complementary biases act to create inefficient, excessive demand for water projects. Consulting 1950s-era literature it is evident that the rationing objective perceived at that time was not merely concerned with rejecting uneconomic projects, but also with ranking acceptable projects in light of limited funds [*Eckstein*, 1958]. As compared to the net present value metric, the benefit cost ratio has heightened applicability in this decision environment, not only as a tool for ranking projects, but as a tool for vetting individual project components and scheduling multipurpose or multisegment projects.

[12] During the late 1970s President Carter's administration enacted various reforms to address a backlog of yet-to-be-constructed water projects [*Moynihan*, 1983]. Among these reforms was a short-lived revision of the 1973 *Principles and Standards* [*U.S. Water Resources Council*, 1973] then governing project CBA. The Carter-revised 1980 *Principles and Standards* [*U.S. Water Resources Council*, 1980] stated that project alternatives incorporating water conservation were a required element of project CBA. According to the 1980 rules, conservation options include new pricing policies and other methods of reducing demand. The Carter stance on federal water projects became important in the Presidential campaign of 1980, with western republicans most disappointed by the new policy directions [*Cortner and Auburg*, 1988]. So when President Reagan took office in 1981, his administration repealed Carter's rules and commenced formulation of new ones. The resulting 1983 PG no longer highlighted water conservation activities, but they did give attention to the consideration of "alternative plans," an element weakly present in the pre-Carter (1973) rules. Collectively profound PG excerpts include the following three statements: "Alternative plans are to be formulated in a systematic manner to insure that all reasonable alternatives are evaluated" [*U.S. Water Resources Council*, 1983, p. 2]. "An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to alleviate specific problems ..." [*U.S. Water Resources Council*, 1983, p. 6]. "Nonstructural measures include modifications in public policy, management practice, regulatory policy, and pricing policy [*U.S. Water Resources Council*, 1983, p. 7]. Just how all these alternative and project plans were to be sorted was less clear.

[13] Subsequent to these planning changes, the dramatic 1993 Mississippi valley flood highlighted some of the failures of structure-centric water resource planning, thereby drawing attention to the uneven process by which structural (e.g., dams, levees, and pumps) and nonstructural (e.g., zoning restrictions, wetlands preservation, and self-insurance) options for confronting flooding are considered. Benefit measurement under the PG is more generous for flood-controlling structural measures than for nonstructural alternatives [*Interagency Floodplain Management Review Committee*, 1994, pp. 85–86; *National Research Council*, 1999]. Postflood political attention spawned major reports

and calls for reform (R. Feingold, Statement on reforming the Army Corps of Engineers, U.S. Senate, 19 July 2006, available at http://feingold.senate.gov/~feingold/statements/06/07/20060719corpsreform.htm). Structure-centric flood planning was again called into question when Hurricane Katrina (2005) overwhelmed components of the Gulf Coast's flood protection infrastructure established mainly by the U.S. Army Corps of Engineers. 2008 flooding in the Mississippi valley promises to keep this issue alive.

[14] It remains to be seen whether pleas for improved nonstructural flood policy will spill over into more balanced regard for nonstructural water scarcity policy too. Yet, in the case of water scarcity, nonstructural alternatives abound. These alternatives include numerous demandside policies such as the those which impose or motivate water use reductions, as well as expanded water marketing and supply extending options such as leak correction programs and reservoir system reoperations. Across most of these options, specific laws may have to be modified to achieve the nonstructural action, yet it is erroneous to visualize water law as an inflexible obstruction to change [*Ingram et al.*, 1984] and this too is explicitly stated in the PG [*U.S. Water Resources Council*, 1983, p. 6].

3. Previous Literature

[15] There are two literature threads that are especially germane to the benchmarking issue. The first of these pertains to the general goals of cost-benefit analysis, and the second concerns the legitimacy of without-project benchmarking.

3.1. CBA Mission

[16] CBA is not generally regarded as a stand-alone decision-making tool. Two internal limits of the tool restrict the finality of CBA [*Griffin*, 1998]. First is the inevitability of intangible/incommensurable effects which cannot be monetarized (by definition). Consequently, project assessment indices such as net present value (NPV) and benefit-cost ratios are incomplete. Whereas CBA is not strictly the application of "Is NPV > 0"? or such in real-world application, unmonetarized impacts do introduce greater subjectivity into CBA, and this subjectivity blurs the boundaries between economic approval and bureaucratic/political decision making. Decision making then becomes a blend of all of these things even when CBA is required as it once was for U.S.-funded water projects. Second is the distributional baggage accompanying economic welfare metrics. Because discounted and summed welfare measures imbed specific status quo positions pertaining to both interperiod and intraperiod distributions of an economy's rewards, these measures are neither uniquely valued nor unanimously settled [*Griffin*, 1995]. So, whereas CBA has always been a normative tool, its subjective dimensions are exacerbated by these two limits.

[17] Given these facts, CBA must adopt an advisory role wherein there are subjective tradeoffs to be resolved among the various appraised and unappraised and distributional impacts of a water project. Consequently, CBA is best portrayed as part of a discovery process in which a water project is weighed. A central issue here is the breadth of the CBA mission. Is it solely concerned with the merits of a given water project with regard to no action or is it attempting to indicate good public programs generally? Without-project benchmarking turns out to be aligned with the smaller mission. E. J. Mishan provides some of the strongest advice in the CBA field, and his following statement visualizes the CBA mission as a little bigger, guiding selection among multiple structural options instead of just one: "The general question that a cost-benefit analysis sets out to answer is whether a number of investment projects, A, B, C, etc., should be undertaken and, if investible funds are limited, which one, two, or more, among these specific projects that would otherwise qualify for admission, should be selected" [*Mishan*, 1976, p. x].

[18] Other writers envision something still grander. Haveman, who has also been well engaged in this literature area, says [*Haveman*, 1976, pp. 159–160]

> Benefit-cost analysis is a tool of the decision maker; its function is to generate information on the economic effects of alternative public expenditure decisions and to assist the decision maker in his search for the set of alternatives that generate the greatest net benefit. In focusing discussion on the economic benefits and costs of alternatives, this kind of analysis improves the political decision process. It uncovers gains and losses which might otherwise be neglected in the bargaining mechanism and encourages decision makers to undertake a comprehensive search of alternative means of attaining objectives.

[19] Contemporary thought seems to adopt this latter perspective. The 1983 PG discussed above do too, as indicated by the prior excerpts compelling investigation of nonstructural alternatives.

3.2. On the With/Without Principle

[20] Literature addressing the foundations of the with/without principle appears to be rare, testifying to a possibly unquestioned adoption of a seemingly obvious idea. Although Eckstein attributes earlier treatment to *Regan and Weitzell* [1947], his 1958 text gets closer to a firm evaluation of the principle. Eckstein's initial guidance is only slightly more revealing than guarding against an after/before assessment: "The 'with and without' principle is no more than ... that any action be evaluated in terms of the difference it makes" [*Eckstein*, 1958, p. 52]. But he also illuminates the idea more deeply in a discussion of "alternative costs" as a measure of benefits. The alternative costs procedure turns out to be related to the benchmarking issue.

[21] Alternative costs is a sometimes misused procedure, because alternative costs are an apt measure of benefits only when there are clear assurances that the alternative would actually be undertaken in lieu of the project. Eckstein reminds us that the benefit of a project is the lower value of either willingness to pay or the cost of an alternative capable of providing the same results [*Eckstein*, 1958, pp. 52–53]. Later in his text Eckstein offers discussion of the alternative costs of alternative "local" or federal developments to a federal water project [*Eckstein*, 1958, pp. 69–70]. An uneasy distinction is drawn between the relevance of alternative costs depending on whether the alternative is local or federal. Eckstein felt that local alternative costs establish an upper bound to benefits, but the costs of federal alternatives do not affect benefit measurement. The distinction appears to hinge on Eckstein's presumption of a binding constraint on the availability of federal funds for projects. Given 1950s competition for water project funds, this presumption may be reasonable. Because of the constraint, too few projects are constructed and the opportunity

cost of federal funds is greater than their face value. So, according to Eckstein, limiting a project's benefits to be no greater than the costs of an alternative federal project capable of providing the same service would understate benefits. On the basis of this argument, Eckstein leaves us with this "rule": "alternative costs limits benefit if the alternative cost is met out of funds that lie outside the [federal funds] constraint" [*Eckstein*, 1958, p. 70]. This rule statement is introduced with an interpretative message: "Clearly, economic efficiency requires that the least cost method of federal development be selected; but the second best federal plan bears no relation to benefits" [*Eckstein*, 1958, p. 70]. Placing these arguments in a benchmarking context, the Eckstein position is that the second best federal plan is an inappropriate benchmark. Yet Eckstein's argument may not be fully consistent with his earlier "in terms of the difference it makes" statement. If, in the absence of the water project being studied, an equally beneficial, second federal project is built, the "difference" would appear to be the extra cost of the second project. All federal funds would still be expended on better-than-threshold projects (NPV $\gg$ 0).

[22] Federal funds may be as limited as ever, so the Eckstein rule is arguably as correct as it was 50 years ago. It is left for us to reject or extend Eckstein's advice for contemporary settings where large water projects are now practical endeavors for state or local governments, not just the federal government, and where state and local policies are key options because of the difficulty of identifying any unemployed natural water available for capture by new projects. In contemporary settings however, alternative state or local programs have greater relevance to benefit measurement of federal projects. Federal instruments in the water scarcity arena have been mainly structural. The chief worry is that if higher-level (federal or state) decision making does not explicitly consider lower-level (state or local) options, then it is tacitly leading all levels of government down an inefficient path, because nonfederal options are likely to be second (and commonly first) best. Not only might a "third-best" project then be constructed in lieu of more efficient measures, but important state and local policy reforms are hindered as lower governments will await uncertain higher-level appropriations once a federal project has been approved but the money for it has not been dedicated.

4. Theory of Second-Best Benchmarking

[23] Suppose that a political or administrative process has forwarded a specific water project as the prime candidate for addressing a given set of water scarcity issues. Suppose additionally that the project will result in economic state A, where A = $\{A_1,A_2,..,A_T\}$ represents the sequence of economic substates that will occur over a planning horizon extending to T. Both the project and its resulting economic state are referred to as A. It is presumed that the present public task is to perform a CBA (and possibly a cost allocation analysis) for this center stage project.

[24] Similar, vector-valued economic states are available if A is not built. Ø (null) is a "do nothing" program in which no public policies may be altered, yet private action will continue to evolve. That is, Ø = $\{Ø_1,Ø_2,..,Ø_T\}$ is construed as the benchmark without project as the term "without" is customarily recommended in economic analysis. B, C, etc. are alternative public actions involving other projects or policies. Some of these options might be resolved at different governmental levels than the one at which A is being decided. To maintain a water emphasis, these other economic states are the consequences of the distinctive water projects or water policies that they entail. The range of options is known to be quite diverse. Possible strategies include water use regulations of multiple types, water fixture regulations, growth controls and moratoriums, intersectoral transfers, interbasin transfers, and opportunity cost-inclusive pricing of either water or new connections to water service. The many options can be timed, combined, or sequenced in various ways too, leading to other feasible economic states, so one would soon exhaust the alphabet in a complete listing of interesting economic states. Let Z be the last (26th) available state other than doing nothing. As a matter of notational convenience, let X denote any one of the alternative actions except for Ø or A (i.e., $X \in \{B, C, \ldots, Z\}$). The full public choice set is $\Omega = \{Ø, A, B, \ldots, Z\}$. Arbitrary elements of Ω are given by ω.

[25] Denote the net present value of any given program j as $W_i(j)$ where i is the benchmark economic state from which j is assessed. As is well known, net present value is an aggregate welfare measure that employs a weighted sum of single-period welfare measures, and the single-period welfare measures are themselves aggregates over an appropriate accounting stance for the geopolitical boundaries of the decision-making agency. Therefore, with a discounting factor given by δ_t and with W^t denoting aggregate net benefits in period t,

$$W_i(j) = \sum_{t=1}^{T} \delta_t W^t_{i_t}(j_t). \qquad (1)$$

If all project effects can be monetarized, then CBA finds project A to be a dynamic improvement relative to benchmark i if and only if $W_i(A) > 0$. The additive nature of (1) with positive weights allows further examination to concentrate on single-period benchmarking. That is, should the single-period W^ts on the right side of (1) be consistently biased, the error cannot cancel itself once summed. Setting aside then the nonessential time indices, the main investigative question becomes whether single-period net benefit welfare measures, $W_i(j)$, are socially meaningful when i = Ø, j = A, and corresponding elements of $\{Ø_1,Ø_2,..,Ø_T\}$ and $\{A_1,A_2,..,A_T\}$ are selected for Ø and A. When analyzing the social desirability of project A, the with/without principle dictates that CBA utilize a $W_Ø(A)$ welfare measure for each period. By concentrating the modeling framework upon that of a single, arbitrary period, we can focus on whether $W_Ø(A)$ is a useful test for project acceptability. If it is, the temporal aggregation of T of these measures according to (1) is acceptable, at least on benchmarking grounds. Other problematic properties of the multiperiod *W* aggregation are not examined here. This means that the intertemporal and potentially intergenerational weighting system addressed by discounting will not be a concern [*Ferejohn and Page*, 1978; *Weitzman*, 2001].

[26] Asking whether $W_Ø(A)$ is positive or negative amounts to a potential Pareto improvement test. It is well known that (1) exact (Hicksian) welfare measures are

ideally employed in the calculation of $W_{\emptyset}(A)$, (2) an infinite multitude of such exact measures are possible depending on the underlying utility bases, and (3) the two most celebrated exact measures, compensating and equivalent variations/surpluses, bracket the more readily computed Marshallian measure [*Griffin*, 1995]. To emphasize the benchmarking issue apart from these "exact" ideals and other technicalities associated with welfare calculations in the presence of income effects, we will assume that $W_{\emptyset}(A)$ is uniquely computable. The specific assumption is that each consumer's marginal utility of income is constant across the range of program changes, so as to secure path independence of the welfare measure [*Just et al.*, 2004, chapter 5 appendix]. This is a strong assumption, yet it also establishes a charitable environment for focusing on the benchmarking issue apart from other complicating considerations.

[27] The examination here stems from the potentially underappreciated fact that "$W_{\emptyset}(A) > 0$?" is a simple improvement test. It states only that project A offers net gains summed across the populace as contrasted to no public actions at any government level. The main potential failures are that there may be other programs X for which $W_{\emptyset}(X) > W_{\emptyset}(A) > 0$ and because all the programs of {A,B,...,Z} are targeting the same water scarcity problems, they are overlapping and their net contributions are interwoven. Should A pass a with/without cost-benefit test and be consequently enacted, scarcity conditions are altered in the region, thereby modifying the economic merits of remaining programs. The interdependence is especially pertinent because project A's construction is irreversible. It permanently influences $W_{\emptyset}(X)$ levels for all programs, and it is likely to influence the relative rankings of these programs in terms of the $W_{\emptyset}(X)$ metric. Because all scarcity-addressing programs are implicitly competing with each other for implementation, the construction of A will displace programs which may otherwise have higher $W_{\emptyset}(X)$ if A were not enacted. Thus, construction of A alters subsequent public choices, with potentially widespread economic consequences for public welfare. It is also quite feasible for A to modify human settlement and economic development patterns, as compared to other programs, with the potential for fostering long-term problems as infrastructural depreciation and sedimentation come to reduce the water supply increment enabled by A. Conversely, the prospective implementation of program X can be expected to modify the welfare consequences of A. X adoption will generally lower the NPV of A.

[28] Considering the range of available social choice prior to the adoption of A, the efficient selection is most naturally stated as

$$\max_{\Omega}\left[W_{\emptyset}(\emptyset), W_{\emptyset}(A), W_{\emptyset}(B), \ldots, W_{\emptyset}(Z)\right], \tag{2}$$

where the arguments of the objective functional apply the identical, standard benchmark. Assuming reflexivity [*Sen*, 1979, pp. 2–3], we presume that $W_{\emptyset}(\emptyset) = 0$, yet the Ø benchmark is conceivably the best available state and should be explicitly recognized in the choice set as it is in (2). There are other ways and other benchmarks that can equivalently express the efficiency ideal of (2), but (2) is the most evident extension of the with/without project analysis principle into an explicitly multioption domain. As it is customarily performed, with/without CBA does not employ (2) because it omits options B–Z, leaving only Ø and A in Ω.

[29] Considered from another perspective, the center stage project A proposes a best state only if it yields nonnegative welfare relative to all feasible economic states. That is, A is efficient if

$$W_{\omega}(A) \geq 0 \ \forall \ \omega \in \Omega. \tag{3}$$

We shall refer to (3) as universal benchmarking, because it applies the universe of feasible benchmarks. With the assumptive base adopted here, (2) and (3) are equivalent formulations. The proof of this equivalence stems from path independence which implies that $W_{\emptyset}(A)$ can be computed in steps without altering results. Choosing an arbitrary state, ω, as a step: $W_{\emptyset}(A) = W_{\emptyset}(\omega) + W_{\omega}(A)$. Thus, $W_{\omega}(A) = W_{\emptyset}(A) - W_{\emptyset}(\omega)$. If A solves (2), then $W_{\emptyset}(A) - W_{\emptyset}(\omega) \geq 0$ for all ω, thus demonstrating (3). These steps are reversible, inferring that (3) implies (2).

[30] At issue is whether allegedly improving social choices, as assessed by CBA when it is constrained by the with/without principle, can be expected to produce improved social welfare. Whereas with/without-constrained CBA inquires only about the sign of $W_{\emptyset}(A)$, thereby comparing A to arguably the least relevant economic alternative if society is sincere about addressing water scarcity, a universal test of A's efficiency would compare A to all options. Ø is unique among the available states. Because it merely constitutes a status quo scenario, it is the only economic state that does not purposefully confront water scarcity problems with a targeted program. Hence, it is quite possibly a weak basis for comparison.

[31] Let S be the "second-best" economic state contained in Ω. By second best, it is meant that S is the solution to (2) when $A \notin \Omega$. (Thus, S is actually first best unless it is bested by A.) If A is to be benchmarked against any single economic state, then an aggregate public or representative agent would prefer that the second-best state be used. If CBA is to be constrained to a single-benchmark test, only $W_S(A) \geq 0$ instills full confidence about the goodness of project A when many program alternatives are available. That is, benchmarking against S using $W_S(A)$ is equivalent to universal benchmarking. $W_S(A)$ is of course an idealistic test in that we ordinarily lack clear means for identifying S in the absence of universal benchmarking. Yet, the informational demands of universal benchmarking need not prevent analysts from making important progress. Progress over and above a Ø test is easily achieved in many cases. For example, reasonable candidates can always be found by asking "If A is rejected, what public programs might be reasonably enlisted"? Oversights are certainly possible here, yet the bias intrinsic to a least stringent test (the Ø benchmark) appears to be even less attractive.

5. Linearized Illustration

[32] To spotlight the effects of these arguments, consider a setting in which discrete public objectives and optional programs are independent and uniformly distributed. Suppose that there are nine public objectives (e.g., water supply, highway maintenance, education, and health care) labeled 1–9 where an objective's number also represents the social value of achieving the objective. Achieving all objectives

Table 1. Benchmark Comparison for a Limited Budget of 0.6

Assessed Program	With Programs	With/Without Value	Substitute Program(s)	"Difference It Makes" Value
9.1	9.1,8.1,7.1,6.1,5.1,4.1	+8.9	+9.2,−4.1	+4.0
8.1	"	+7.9	+8.2,−4.1	+4.0
7.1	"	+6.9	+7.2,−4.1	+4.0
6.1	"	+5.9	+3.1	+3.0
5.1	"	+4.9	+3.1	+2.0
4.1	"	+3.9	+3.1	+1.0
3.1	9.1,8.1,7.1,6.1,5.1,3.1	+2.9	+4.1	−1.0
2.1	9.1,8.1,7.1,6.1,5.1,2.1	+1.9	+4.1	−2.0
1.1	9.1,8.1,7.1,6.1,5.1,1.1	+0.9	+4.1	−3.0
9.2	9.2,8.1,7.1,6.1,5.1,4.1	+8.8	+9.1,+4.1	−4.0
8.2	9.1,8.2,7.1,6.1,5.1	+7.9	+8.1,+4.1	−4.0
7.2	9.1,8.1,7.2,6.1,5.1	+6.9	+7.1,+4.1	−4.0
6.2	9.1,8.1,7.1,6.2,5.1	+5.9	+6.1,+4.1	−4.0
5.2	9.1,8.1,7.1,6.1,5.2	+4.9	+5.1,+4.1	−4.0
4.2	9.1,8.1,7.1,6.1,4.2	+3.9	+5.1,+4.1	−5.0
3.2	9.1,8.1,7.1,6.1,3.2	+2.9	+5.1,+4.1	−5.0
2.2	9.1,8.1,7.1,6.1,2.2	+1.9	+5.1,+4.1	−5.0
1.2	9.1,8.1,7.1,6.1,1.2	+0.9	+5.1,+4.1	−5.0
9.3	9.3,8.1,7.1,6.1	+8.8	+9.1,+5.1,+4.1	−9.0
8.3	9.1,8.3,7.1,6.1	+7.9	+8.1,+5.1,+4.1	−9.0
7.3	9.1,8.1,7.3,6.1	+6.9	+7.1,+5.1,+4.1	−9.0
6.3	9.1,8.1,7.1,6.3	+5.9	+6.1,+5.1,+4.1	−9.0
5.3	9.1,8.1,7.1,5.3	+4.9	+6.1,+5.1+4.1	−10.0
4.3	9.1,8.1,7.1,4.3	+3.9	+6.1,+5.1,+4.1	−11.0
3.3	9.1,8.1,7.1,3.3	+2.9	+6.1,+5.1,+4.1	−11.0
2.3	9.1,8.1,7.1,2.3	+1.9	+6.1,+5.1,+4.1	−11.0
1.3	9.1,8.1,7.1,1.3	+0.9	+6.1,+5.1,+4.1	−11.0

therefore yields 45 units of benefit. For each objective suppose there are nine conceivable public actions labeled 0.1−.9 where the label also designates the action's costs. Using this system, program a.b has these properties: it addresses only objective a, benefits = a, costs = 0.b, and benefit-cost ratio = 10a/b. Each program is assumed to be fully successful in achieving its objective, meaning that there are nine perfectly substitutable programs for each objective. There are 81 possible programs, all of which yield net benefits when considered individually via the with/without principle. Benefit-cost ratios range from 10/9 to 90. All 45 units of benefit are achievable at a minimum total cost of 0.9 units.

[33] To investigate a range of conditions that include those studied by prior literature, consider two conceivable situations: an unlimited public budget and a limited budget. For each of these situations, we wish to contrast benefit assessment via two benchmarks. The first benchmark utilizes the with/without principle, and the second inquires about "the difference it makes" by applying the second-best benchmark. While an interesting approach may be to simulate incomplete knowledge regarding the second-best program by randomly selecting it, perfect information is assumed here. Of course, for both benchmarks, a with assumption will presume that the program being assessed will be implemented even if it is not first best.

[34] In the unlimited budget case, the preferred public strategy is to select the least expensive program addressing each social objective, and implement them all. Obviously, for each a.1 program the second-best program is a.2. Casual examination suffices to show that every a.1 program yields with/without net benefits of +a−.b = +a−.1, whereas it only makes a difference of +0.1 as compared to the second-best program which would otherwise be adopted. Thus, whereas the "benchmarking effect" is quantitatively large (benefit measures of +a−.1 versus +0.1), both benchmarks are supportive of adopting all nine a.1 programs. On the other hand, for programs a.b with b > 1, with/without net benefits are again +a−.b whereas program a.b makes a difference of +.1−.b < 0. In these situations, the two benchmarks give opposing advice regarding program acceptability. Observe that the "errant" advice of the with/without principle is corrected as long as it is never applied without also insisting that only least cost programs be selected. Second-best benchmarking embeds universal benchmarking as noted previously, so no added requirements are needed.

[35] Further investigation demonstrates that normal, limited budget cases tend to exacerbate the separation between with/without and second-best benchmarking for uniformly distributed options. These situations are more complex, so Table 1 lists some of the less costly programs and their assessments. A budget limit of 0.6 is assumed to be in place. For each program being assessed, that program and a first-best complement of other programs form the with-program group identified in second column. With/without appraisal of the program under study looks at the program in isolation from budget consequences, inferring that there no differences between this assessment and that of an unlimited budget. Each program a.b again yields with/without net benefits of +a−.b, as observed in the third column.

[36] Second-best benchmarking, through its application of universal benchmarking, provides a more complete recommendation for limited budgets. Changes in forming the benchmarking program group are partially listed in the fourth column. (When we are appraising program a.b, it is obvious that program a.b must be deleted from the set of second-best programs.) For example, in lieu of program 9.1, it is optimal to adopt program 9.2 and drop program 4.1,

thus maintaining compliance with the available budget and maximizing social rewards. The resulting appraisal using second-best benchmarking is labeled as the ''difference it makes'' in the final column. Comparing the with/without value to the difference it makes indicates the impact of benchmark selection under these plain yet illuminating circumstances.

[37] Therefore, depending on how deeply program consequences are investigated and whether the overall budget is limited, different recommendations are generated. With unlimited funds, considering each program relative to doing nothing produces a positive endorsement for all 81 programs. Considering each relative to the second best program produces a positive endorsement for nine or fewer programs, depending on whether a limited budget is applicable. Full attention to limited budget conditions has the power to accentuate the magnitude of ''the difference it makes'' and can even reverse recommendations obtained for unlimited budget conditions. All such reversals are justifiable because of the influence of the budget constraint.

6. Model of Water Scarcity Programs

[38] To move beyond arbitrary program benefits and costs situations, an informative model can be heuristically specified to display these issues in common water scenarios. The parameters used here are empirically informed by western U.S. conditions in a relaxed sense, yet they do not represent a specific study area. These demand conditions and water availability assumptions are replaceable with other reasonable scalars, but the results would not be improved for our purposes here. The assumed parameters establish transparency for the scarcity setting while the emphasized results remain qualitative. Our goal is to examine the relative rankings of a project's benefits according to various benchmarks.

[39] Suppose a single-period, single-basin setting in which there are but two sectors. This period may be the current period or some future period within the planning horizon of a proposed water project. 100 units of surface water are available with existing water development. Customarily, 80 units of this water are applied to land by the agricultural sector (Ag). The remaining 20 units are used by the municipal and industrial sector (MI). The following ''without project'' details describe a water supply shortfall. This shortfall can be alleviated by project A which will harness another 5 units of the basin's free flowing water supply. The project is under consideration by federal or state authorities where the federal level is most germane to a Water Resources Development Act situation involving CBA and independent review by an expert panel. The costs of this project are immaterial at this point as the main interest lies with the proper estimation of project benefits. Therefore, project costs are set aside. Ignored costs include the reduction in instream water. Without-project conditions are as follows.

6.1. Agricultural Conditions

[40] Irrigators are paying \$30 per unit of water to one or more irrigation districts for farm-delivered surface water. This district-established rate is conveniently assumed to be both the average and marginal costs of water delivery, and precisely 80 units of water are demanded at this price. The institutional rules require that the 80 units of water be beneficially used to irrigate crops or pasture. Districts allow farmers to lease their normal water allotments among one other, but out-of-district transfers are prohibited by state government. Conveyance losses are zero within districts. At the current demand level, the price elasticity of demand is given by $\varepsilon_{ag} = -0.75$.

[41] These basic conditions suggest there may be no allocative inefficiencies within the agricultural sector and no motivation for initiating a water supply project. Moreover, the marginal value of undelivered water (residing in the natural watercourse) is zero to irrigation ($MVW_{ag} = 0$). Taken together, these conditions indicate the constant elasticity demand function $w_{ag} = 1025.5p^{-0.75}$ represents irrigators collectively when the (80 units, \$30) demand point and −0.75 elasticity are substituted in the constant elasticity functional form to identify the 1025.5 parameter.

6.2. MI Conditions

[42] The clients of a single urban utility are paying \$1300 per unit for delivered and treated water. This price is regarded as the average cost of retail water, but it exceeds marginal processing and delivery costs because of returns to scale in treating and transporting water. Marginal costs are \$1000 per unit. Water conveyance and processing losses are zero within the utility's service area. At the current water price, the quantity of wholesale water demanded is 25 units of water, so there is a perceived shortage of 20%. The null (without-project) policy may allocate available water using a host of methods, possibly including educational programs, moral suasion, regulations, and even declines in water pressure or lapses in service. Demand elasticity is given by $\varepsilon_{mi} = -0.5$. These assumptions suggest the constant elasticity demand function $w_{mi} = 901.4p^{-0.5}$.

[43] Thus, a rate increase to \$2031.25 would support allocative efficiency within this sector if no additional water is available. Points on the aggregate MI demand schedule then include (25, \$1300) and (20, \$2031). Also, $MVW_{mi} = 1031$ expresses the marginal value of natural water to this sector. Delivered water is arguably underpriced by \$731 per unit, but present pricing policy is responsive only to accounting costs, not opportunity costs, as typifies worldwide situations.

6.3. Program Options

[44] Five alternative scarcity programs are listed in Figure 1. They are (Ø) the null conditions just described, (A) project A which would provide a five-unit supply increase to the urban area, (B) regional water marketing between Ag and MI sectors, (C) improved local water pricing for MI customers, and (BC) a combined policy of the regional and local measures. It may be important to recognize that the null policy ultimately rations available water using noneconomic instruments in addition to the \$1300 rate. All five programs actually ration water in some way(s), though with differing consequences. An advantage of this particular set of options is that it exemplifies alternatives available in actual water scarcity settings.

[45] Two noteworthy considerations differentiate the null policy from the other programs. First, under the null policy some portion of utility's total revenue may be used to fund the nonprice, coercive-regulatory measures of Ø. Although the null program does not directly confront scarcity, it is not

Program	Features	
	Ag details	M&I details
Ø	p_{ag} = \$30; water must be used for irrigation	p_{mi} = \$1300; rationing costs: k_R% of total costs and k_O% overage of marginal consumer losses
A	Project A: Construct a water supply project yielding 5 units of water for the M&I sector with no impacts on the agricultural sector.	
B	Regional Water Marketing: Allow intersectorial water trade; 50% of transferred water is lost in conveyance; no other transaction costs.	
C	Local Pricing Reform: Price M&I water efficiently. [Ag is priced efficiently at \$30 given the intersectoral trade constraint.]	
BC	Enact programs B and C simultaneously. Revised M&I pricing and the trade value of Ag water can synchronize to reallocate water beyond the initially visualized shortfall level.	

Figure 1. Available actions.

immune to it. If nothing else is done, thereby leaving the shortfall to be handled by pressure reductions, the shortage will still invite deliberations among leaders and other public expressions of consternation interpretable as costs. While these costs may ordinarily be a small portion of utility costs, they are not among the costs of the other four programs once enacted. Let k_R denote the rationing costs of the null policy, where k_R is expressed as a percentage of total costs. Second, the nonprice rationing of the null program will be unable to isolate and eliminate the truly marginal uses of water [*Fakhraei et al.*, 1984]. That is, nonprice policies will result in water service to some inefficient water uses which have inadequate value (less than \$2031/unit) while errantly eliminating some higher-valued water uses. This failure may be economically significant. The extent of this problem depends on various factors, including the heterogeneity of clients and freedom of choice, the range of behavioral choices left to clients by null policy measures. Let k_O denote the percentage "overage" by which the null policy forfeits consumer welfare over that of the local pricing policy (program C).

6.4. Results

[46] Figure 2 is a diagram of the welfare implications of these programs. Only demand curve segments for the action-relevant ranges are shown. For the MI sector, programs Ø and C provide for consumption at w_{mi} = 20. Programs A and B both provide w_{mi} = 25. For the agricultural sector, w_{ag} = 80 is attained by Ø, A, and C, and w_{ag} = 70 is attained by B. Program BC, combining both programs B and C, will result in a unique allocation of the region's existing water supply.

[47] If (1) the null, without-project program is the benchmark from which the other programs are assessed, and (2) the potential Pareto improvement criterion is satisfactory (as it is for cost-benefit analysis), then the

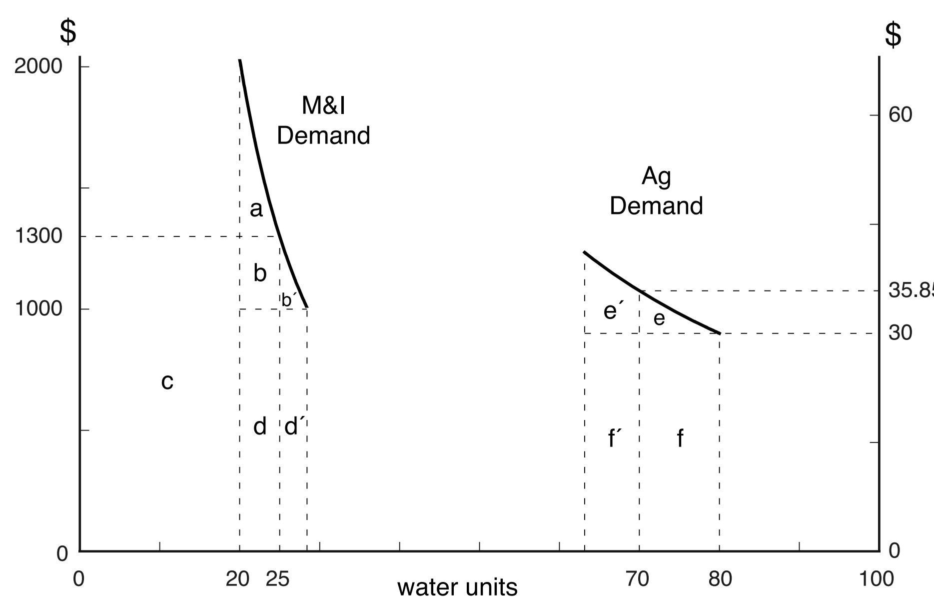

Figure 2. Welfare implications.

following welfare changes relative to the without-project scenario are computable:

$$W_{\emptyset}(A) = +k_R c + (1 + k_O)(a + b)$$
$$W_{\emptyset}(B) = +k_R c + (1 + k_O)(a + b) - e$$
$$W_{\emptyset}(C) = +k_R c + k_O(a + b).$$

Results for program BC are postponed. The first of these expressions is a standard benefit measurement for project A, consistent with the popularized with/without ideal. Ordinary project analysis will implicitly assume $k_R = 0 = k_O$, and it is worth repeating that project A's construction costs and other-sector impacts (e.g., environmental) are omitted from $W_{\emptyset}(A)$ because of our focus upon benefits measurement.

[48] Observe now that the shortcomings (k_R,$k_O > 0$) of the inefficient null policy decline in explicit relevance as other benchmarks come into play. Applying the assumed path-independent character of welfare measurement as a computational shortcut, the following expressions identify project A's evaluation using different benchmarks.

$$W_B(A) = W_{\emptyset}(A) - W_{\emptyset}(B) = +e$$
$$W_C(A) = W_{\emptyset}(A) - W_{\emptyset}(C) = +a + b.$$

Thus, there are multiple valuation possibilities for project A. These valuations can be ordered:

$$W_{\emptyset}(A) \geq W_C(A) > W_B(A)$$
$$\text{where } W_{\emptyset}(A) = W_C(A) \text{ only if } k_R = 0 = k_O.$$

Next, consider the implications of enacting programs B and C together. By itself, the water marketing policy (B) results in only 5 additional units of MI water, because the MI rate does not reflect true marginal costs. When rates also can be revised to incorporate both marginal processing costs and the prevailing marginal value of water, additional marketing becomes viable. Such marketing occurs up to the amount at which the marginal value of unprocessed water is twice as high in MI use as it is in irrigation because of the 50% conveyance loss identified in Figure 1. Hence, new MI pricing synchronizes with trading opportunities so as to support the efficient urban behavior depicted in Figure 2, with the utility acquiring more than 5 units of water from irrigators under the relaxed state marketing rules. Resulting MI consumption is 28.425 units of water at a price of 1005.56. Revised pricing is not useful in irrigation districts as the market incentives modify irrigator behavior to regionally efficient consumption levels (w_{ag} = 63.15). Additional results for a BC program and a BC benchmark are found to be

$$W_{\emptyset}(BC) = +k_R c + (1 + k_O)(a + b) - e + b' - e' \text{ and}$$
$$W_{BC}(A) = W_{\emptyset}(A) - W_{\emptyset}(BC) = +e - b' + e'.$$

Because $b' > e'$ (not visually apparent because of the differing vertical scales), the following ordering of all four benchmarks evaluation of project A is obtained:

$$W_{\emptyset}(A) \geq W_C(A) > W_B(A) > W_{BC}(A)$$
$$\text{where } W_{\emptyset}(A) = W_C(A) \text{ only if } k_R = 0 = k_O.$$

Under the highly likely presumption that either $k_R > 0$ or $k_O > 0$, an important result is obtained:

$$W_{\emptyset}(A) > W_C(A) > W_B(A) > W_{BC}(A). \quad (4)$$

The results of (4) demonstrate a few of the basic propositions that bear upon the general question of benchmark selection and the specific appropriateness of applying a without-project benchmark. Equation (4) shows that the without benchmark is the most generous available standard. This result occurs because the without benchmark applies the least incentive-laden policies in addressing water scarcity. While the null policy is not truly an idle policy in coping with scarcity, it tends to rely on politically established instruments as noted previously. Such policies are less attentive to relative benefits and costs than economically oriented policies. Another point highlighted by (4) is the uneven welfare measures that emerge from alternative benchmarks. Overall, the benefits assignable to project A are very sensitive to the selected benchmark. In an economy possessing unique, complementary, and incentive-based alternatives to A, as in this example, it is to be suspected that a combination program would offer the best alternative to A. This intuition is verified here, since the benefits of project A are least when measured from a BC benchmark.

7. Conclusions

[49] Social choice results for the common water scarcity problem just examined correspond with what the provided theory and generic linearized example also show. As a principle of cost benefit analysis, the with/without doctrine is not what it can be, and what it is may well undershoot the needs of modern-day analysis. It is demonstrated that the standard without-project benchmark is prone to produce a favorable assessment of otherwise dubious water projects. This finding emerges from single-period analyses, so the bias will ordinarily be amplified by present value calculations over many periods. The resulting bias complements other biases favoring water projects as scarcity solutions. Because the policy options emphasized here are addressing an identical water scarcity matter, the underlying issue is more fundamental than the problem of obtaining correct Hicksian welfare measures in a multipolicy environment [*Hoehn and Randall*, 1989].

[50] Perhaps then the with/without principle should be rejected in favor of a more deliberate, "difference-making" standard that explicitly acknowledges the range of available programs. Such a modification would ultimately elevate decision making, so that modestly helpful programs or projects do not end up supplanting better programs. U.S. policy has made weak yet identifiable strides in these directions, but the with/without principle has yet to be firmly dismissed at the federal level. The Water Resources Development Act of 2007 [*U.S. Congress*, 2007] may invite closer attention to this issue.

[51] Regardless of the government level at which a water project decision is being made, it is efficient for all governmental levels to be mutually supportive. If federal, state, and local governments can each analyze water programs under expectations that the others will operate efficiently, better decision making can be fostered to the

betterment of overall public welfare. Crucial alternatives to large-scale federal and state water projects exist at the state and local levels. So it is important to formalize attention to state and local policies when projects are analyzed. Theoretically, second-best "difference-making" benchmarking is equivalent to universal benchmarking, leading us to inquire about the second-best program, regardless of its governmental level. This is a more insistent standard for analysis. It invites a fuller discovery process in the conduct of CBA, which is largely about discovery. Moreover, second-best benchmarking demands more advanced analysis in the economic modeling of CBA, since an array of policies should be inspected and formally contrasted for their welfare effects.

[52] One could argue that these findings lack merit if society is either (1) satisfied with a basic improvement test (relative to doing nothing) or (2) content with the classical prescription that a project is only justifiable if it passes a with/without CBA and is least cost among all available strategies. The first position involves a less stringent normative stance, so it is difficult to challenge completely. However, it is shown here that projects passing the weaker test often do not make a positive difference for public welfare, and they commonly supplant better policy strategies. Regarding the second position, competing water programs do not achieve equivalent levels of service, so a least cost rule may not be operational. More importantly, the second part of the classical prescription is almost always ignored when CBA is performed, at least at the federal level in the United States. One must wonder whether this oversight is actually enabled by the with/without principle, given its emphasis of but two economic states.

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