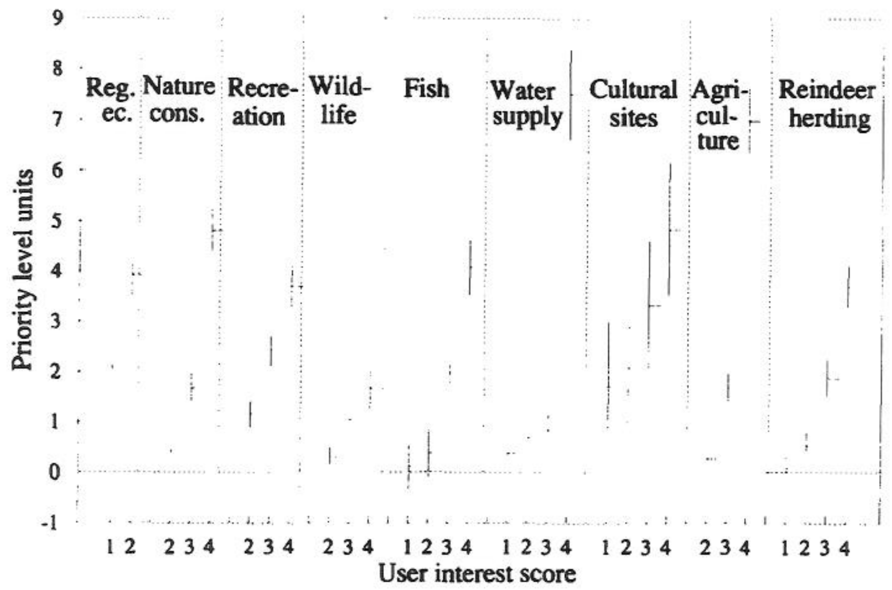

FIG. 1. Ordinal logistic regression estimates of the user interest impact score coefficients. Coefficient estimates are central estimates ± one standard deviation.

the 2% level (χ^2 test) for all variables except the user interest scores of -1 and -2. The estimates of the coefficients are shown in Fig. 1. The uncertainty is indicated with an interval of +/− one standard deviation. Note that the intervals are particularly wide for the cultural sites variable, indicating a less consistent contribution from this criterion.

Most of these results are qualitatively well in accordance both with the main initial intentions of the ranking process and with the intended purpose of the scores.[13] It is also remarkable and reassuring that for all user interests that had noticeable impacts on the ranking, estimated coefficient values are uniformly increasing with the score. This indicates a rather high degree of consistency in the decision-making process behind the MP for a public sector decision-making scheme of such complexity.

The corresponding OLS regression model gives substantially identical results. That model yields an adjusted multiple R^2 of 0.88; i.e., 88% of the variance of the priority group classification of the projects is explained by the variables included, provided that our model is correctly specified.[14]

[13]For one thing, officials participating in the ranking claimed that scores of -1 and -2 were largely neglected in the ranking process; this appears reasonable for -1, while -2 scores appear to have had a slight effect in some cases. Second, there appeared to have been some controversy between the professional experts and the ministry's project officials over how the cultural monuments variable was to be included, and some projects with severe impacts for this variable were moved up in priority in the final valuation by the Parliament. It is thus not surprising that the uncertainty related to the impacts on priority is greater for this variable than for the others.

[14]We also calculated the Spearman rank correlation coefficient for the OLS model, a general (and ordinal) measure of fit, for the logistical model. This was found to be 0.9496, or slightly greater than the R for the OLS model (0.9466).

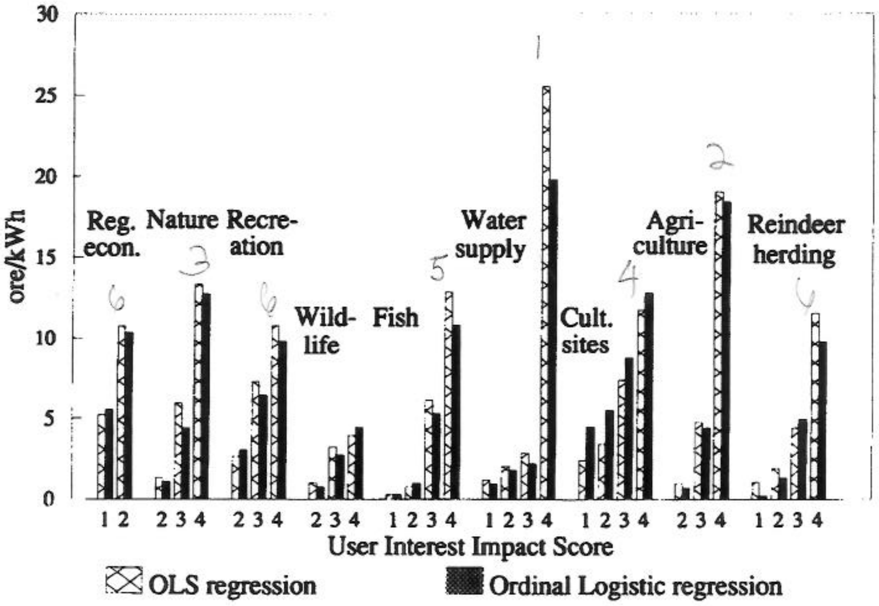

FIG. 2. Evalution of user interest impact scores in economic terms. Ordinary least-squares and ordinal logistic regression give the same substantial results.

As noted in Section 3, the ratios $-b_{kj}/b_C$ express the willingness to pay in terms of higher economic costs per kWh related to a project, in order to avoid the consequences associated with each score of $-j$ for user interest k. These estimated ratios are described in Fig. 2. We see that most scores of -4 are associated with implicit costs in the range of 0.10–0.20 NOK/kWh, and scores of -3 generally with costs about half this level, all in 1982 NOK.[15] The costs in Fig. 2 represent environmental costs in a very particular way, namely as the environmental costs systematically associated with the user interest scores, that are consistent with the MOE ranking of projects under the MP.

Expected total implicit costs per kWh for each project can now be found by adding the economic costs to the implicit user interest (or environmental) costs. The latter are computed from the numbers indicated in Fig. 2, by multiplying these numbers by the (negative) score associated with each user interest variable for each project. Such calculations have been made for each of the 542 projects entering into the MP and are presented in Fig. 3.[16] Here projects are ordered in a sequence of gradually higher-priority groups.[17] Column widths represent project capacity, and column heights total implicit costs per kWh; the area under the columns is thus total implicit costs for each project. The bottom part of each column comprises economic costs, and the top part implicit environmental costs. It

[15]One USD is approximately 7 NOK, and thus 0.10–0.20 NOK/kWh is equivalent to about 2–3.5 cents per kWh.

[16]The detailed calculations for each project are not reproduced here, but can be obtained from the authors on request.

[17]Note however, that *within each priority group* the sequencing of projects is according to project number and thus arbitrary with respect to total calculated cost.

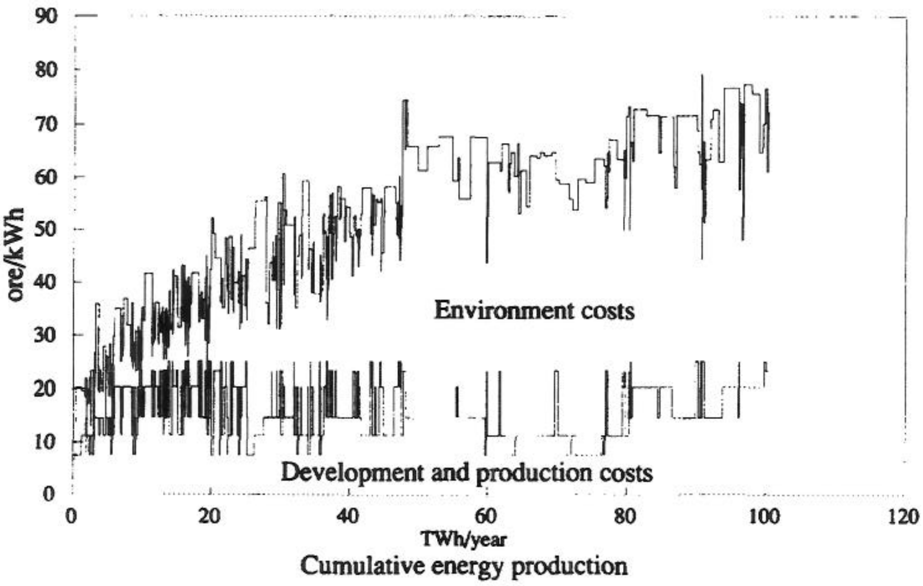

FIG. 3. The implicit long-run marginal cost curve of a hydroelectric development plan. Each rectangle corresponds to a hydropower project. The widths indicate production capacity. The upper curve represents total costs. The projects are ordered according to their rank in the MP, but the order within each of the 16 rank groups is arbitrary.

is clear from the figure that projects with low calculated implicit costs on the whole have been placed in low-numbered priority groups; i.e., the curve described by the total cost for each project (the "long-run marginal cost curve") is largely rising, but is far from smooth. Thus several projects with low implicit costs have been given lower priority than other projects for which total costs are higher. Note that economic costs alone generally are not rising with higher priority groups, while implicit environmental costs are. These comprise about 70% of economic costs on the average for the projects in priority groups 1–5 and about 160% for all groups. Implicit environmental costs are thus a substantial fraction of total costs.

In trying to assess these figures one might perhaps argue that hydropower is likely to have fewer adverse environmental consequences than most other ways of generating electricity.[18] This may be so, but it is an issue about which little is known. Our results may be confronted with one special valuation study, of one river included in the MP (Rauma in western Norway), reported in [6]. The total willingness to pay among *local residents* to preserve this river was estimated at about 10 øre per kWh, using contingent valuation. The corresponding implicit environmental cost for this project was calculated at 29 øre per kWh. Considering possible *national valuation* tied to Rauma, to be added to the 10 øre figure cited above, the results from the two approaches are not totally out of line with each other.

[18]For a comparison see [10], which indicates that environmental costs for electricity generated from coal (a "dirty" fuel) may be from 50 to about 500% of economic costs, with current and efficient technologies.

All estimates of implicit evaluations referred to so far are based on the MOE ranking. Subsequently, the plan was subject to revisions through political hearings where sector and regional interest had their say. This brought about some reshuffling of the ranking scheme before it finally was approved by the Parliament. An OLS regression analysis of the Parliament ranking produced substantially the same results as before.[19] One difference is that the total implicit costs attached to user interest variables now are somewhat higher, namely 173% of economic costs for all priority groups, compared to 159% in the MOE ranking. Also, interestingly, the adjusted R^2 drops from 88% in the MOE ranking to 83% in the Parliament ranking. It could here be that the additional political factors behind the Parliament ranking are more "erratic" than those behind the MOE ranking, thus introducing "noise" into the process.

5. CONCLUSIONS AND FINAL COMMENTS

In the present paper we have studied the decision-making process behind the Norwegian Master Plan for Water Resources and derived implicit valuations of each of a number of environmental attributes (or user interests) affected by such developments, so as to make them consistent with the ranking of the 542 hydropower projects entering into the MP. On this basis we calculate total (direct economic and implicit environmental) costs for each project and derive a long-run total implicit marginal cost curve for Norwegian hydropower development. This curve is largely rising, but not uniformly so, due to possible model specification errors or inconsistencies in the rankings. Implicit environmental costs comprise about 70% of direct economic (construction and operating) costs for projects in priority groups 1–5 (considered most suitable for hydropower development) and about 160% for all projects. Eight out of 13 specified user interest variables were found to have systematic effects on the rankings. For all these, the ranking process was highly consistent, in the sense that successively greater negative scores, indicating a greater negative impact on the respective environmental attribute, implied a greater willingness to pay to avoid the impact. The results across user interests are perhaps more surprising. The largest valuations are tied to a score of −4 (the worst possible consequence) for agriculture and water supply and not for more traditional environmental variables such as nature conservation, outdoor recreation, fish, and wildlife.

Our study underlines the basic principle that a ranking of projects with both direct economic costs and adverse environmental consequences always implies an economic valuation of the environmental variables involved. The MP process was designed at least in part to avoid such a valuation procedure. An obvious

[19]The difference in coefficients from OLS estimations on the MOE data and those for the final ranking in the Parliament are small and generally unsystematic. The parameter values from the latter estimation are not reproduced here but may be obtained from the authors on request. One difference to note is that the coefficients related to water supply are lower when based on the Parliament ranking. The coefficient attached to a −4 score is here 15 øre/kWh, compared to 26 and 20 øre in the OLS and logit estimations of the MOE ranking, and the score attached to −3 is slightly smaller than that to −2 for the Parliament ranking (although both are very small and insignificant). The latter is a type of inconsistency we did not find anywhere for the MOE estimations.

alternative approach here would have been to build the rankings on a more direct assessment of such values.

If our derived valuations are correct, they should have consequences for Norwegian energy policy. First, the price of electric power in Norway would have to rise considerably given price equal to total long-run marginal cost, a basic efficiency criterion. Second, this could have negative implications for the chosen rate of hydropower development, through lower electricity demand.

An open question is still whether our derived implicit valuations represent "true" valuations. By this we could mean either the actual valuation among the Norwegian population or policymakers' intended valuations. One single available study tentatively indicates that the public's valuation is somewhat overestimated here, but more valuation studies are necessary to settle this issue. In future similar works one should also let policymakers face the implicit valuation consequences of their policy choices and permit subsequent adjustments whenever derived valuations deviate from those intended. We admit that this may be difficult in practice for decision-making processes of the size and importance of the present one, because of the political nature of such processes. Bureaucrats and politicians may neither have sufficient faith in our method for deriving implicit preferences, nor agree with our interpretations of the results. We still hope that our study will have some impact on future Norwegian energy policy and on the view of decisions on government projects involving substantial environmental impacts, in Norway and elsewhere.

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