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Implications of Incorporating Risk into the Analysis of an Irrigation District's Capital Renovation Project

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Title: Implications of Incorporating Risk into the Analysis of an Irrigation District’s Capital Renovation Project

Authors: Michael Popp, M. Edward Rister, Ronald D. Lacewell, Allen W. Sturdivant, James W. Richardson, and John R.C. Robinson

Water shortages in the Texas Lower Rio Grande Valley have prompted investigation and analyses of various means to increase the efficient use of the area’s existing water supply and to develop new sources of water. Methods for increasing efficiency in and across the region’s 29 independent irrigation districts include various capital renovation projects (e.g., canal lining, flow metering, pipeline) of different magnitudes and of different economic lives, as well as other water management-type projects, including wastewater treatment, desalination, etc. Due to funding limitations and the need to estimate and compare the economic performance associated with different projects, a means of evaluating and prioritizing these projects was sought. A spreadsheet model, Rio Grande Irrigation District Economics (RGIDECON©), was developed by Texas A&M economists (Rister et al. 2002) to provide the basis of a consistent means of project appraisal and to facilitate priority ranking of projects based on expected, deterministic, economic performance represented by the costs of anticipated water and energy savings. The structure of RGIDECON© has been formally approved by the Bureau of Reclamation (Walkoviak) and endorsed by the Border Environmental Cooperation Commission, North American Development Bank, and the Texas Water Development Board.

Like most capital investment analyses, RGIDECON© relies on precise mathematical calculations to assess the net present value (NPV) and annuity equivalent (AE) calculations of an investment project. The potentially imprecise point estimates used as input data in the analyses may flaw these calculations, however, leaving the analysis incomplete. The probability of reality and the calculated performance values actually equaling one another is close to zero due to the uncertainty surrounding the estimates of key input data concerning several years into the future. It is difficult to assess the impact of such variations in the data on a project’s performance, the overall risk associated with a project, and the probabilities of different outcomes occurring for a project when using strictly deterministic or point estimate analysis without regard for risk.

The method of simulation, or stochastic modeling, as an evaluation approach for project appraisal under uncertainty seeks to solve this problem. Simulation was first described in the early works of Hertz and further incorporated by Reutlinger and Poulquen in the analysis of capital investment projects undertaken by the World Bank in place of cost/benefit analysis in the early 1960’s. Simulation involves assigning appropriate probability distributions to input variables containing uncertainty, accounting for correlation coefficients amongst these variables, and randomly and repeatedly selecting values from within the selected probability distributions to create a probability distribution for an entire project’s performance considering the realistic
Griffin notes that because of the potential federal funding component of the projects, it could be appropriate to ignore the risk component of the standard discount rate, as that is the usual approach for federal projects.
savings is estimated at $19.36 per ac-ft with a 90% probability that the cost will be between $10.91 per ac-ft and $26.69 per ac-ft (Figure 1). Consideration of correlation in analyses (b) and (c) introduces lessened variation in the projected cost estimates as illustrated in Figure 2. Statistical evaluations of the differences in the variation among the three different analyses results are significant at the 0.01 level. These results are summarized in Table 1. Similar types of results for the energy analyses are not presented here due to space limitations.

These results add another dimension to the appraisal and assessment of various capital renovation projects by incorporating risk associated with uncertainty into the analysis and by providing the probabilities of achieving different costs of water and energy savings. Instead of basing priority ranking of projects solely on the expected, deterministic, economic performance of the costs of water and energy saved, this analysis allows for a more in-depth priority ranking of projects while considering the uncertainty of data estimates for the various input parameters. With the potential risk of each project identified, various methods for ranking risky decisions (e.g., stochastic dominance) can be utilized to best prioritize projects based upon the risk aversion coefficients of the decision-makers involved (Richardson).

References:

Griffin, Ronald C. Professor of Natural Resource Economics, Department of Agricultural Economics, Texas A&M University. College Station, Texas. Personal communications, Spring – Summer 2002.


Table 1. Comparison of Risk RGIDECON© Results Considering Varying Degrees of Correlation Among Input Variables, Hidalgo County Irrigation District No. 1, 72” Pipeline Capital Renovation Project, 2004.

<table>
<thead>
<tr>
<th>Analysis Description</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Std. Dev.</th>
<th>90% CI Lower</th>
<th>90% CI Upper</th>
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<tbody>
<tr>
<td>Deterministic</td>
<td>$24.68</td>
<td>$24.68</td>
<td>$24.68</td>
<td>-</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>(a) Stochastic - No Correlation</td>
<td>$19.36</td>
<td>$5.41</td>
<td>$32.82</td>
<td>$4.83</td>
<td>$10.91</td>
<td>$26.69</td>
</tr>
<tr>
<td>(b) Stochastic - Intra-temporal Correlation</td>
<td>$19.34</td>
<td>$7.37</td>
<td>$30.66</td>
<td>$4.19</td>
<td>$11.86</td>
<td>$25.52</td>
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<td>(c) Stochastic - Intra- and Inter-temporal Correlation</td>
<td>$19.38</td>
<td>$7.12</td>
<td>$31.32</td>
<td>$4.21</td>
<td>$11.92</td>
<td>$25.71</td>
</tr>
</tbody>
</table>

CDF - Annuity Equivalent Dollar Cost of Water Saved per Ac-Ft

Figure 1. Comparison of Stochastic Independent Analysis Results to Deterministic Analysis Results.

Figure 2. Comparison of CDFs for All Correlation Analyses.