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Were the hydro dams financed by the World Bank from 1976 to 2005 worthwhile?

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HIGHLIGHTS

- An ex-post evaluation is made of hydroelectric dams financed by the World Bank.
- Cost overruns, time overruns, and the cost of time overruns are measured.
- The PV of benefits produced by this portfolio was 1.8 times the PV of the costs.
- Real cost overruns were 27% and cost of time overruns 3.5% of ex-ante costs.
- Risks of cost overruns must be evaluated in relation to projected benefits of dams.

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ABSTRACT

Because hydro dams are complex to design and usually involve long-term planning, they are particularly susceptible to cost and time overruns. The controversy surrounding their development remains an unresolved issue in the energy policy debate. This study re-examines the cost issues associated with a portfolio of 58 dams that were financed by the World Bank from 1976 to 2005. Further, an estimate is made of the value of the benefits produced by these investments to determine the magnitude of economic rates of return for the individual projects and the overall portfolio of dams. Even though this portfolio of dams suffered substantially from cost overruns, the net contribution of these dams has been positive and substantial. The ex-post real economic rate of return for the entire portfolio is estimated to be greater than 17 percent. The important policy implication of this study is that each investment in a hydro dam needs to be appraised taking into consideration the distribution and probabilities of costs that might be incurred, as well as the potential benefits. Adequate margins must exist of ex-ante benefits over costs to account for the risks of cost overruns.

1. Introduction

This paper analyzes the net economic benefits of a portfolio of 58 hydro dam projects that were financed between 1976 and 2005 by the World Bank and for which project completion reports are available. The study both investigates the issues associated with the cost and time overruns that are common with the implementation of the dams and measures the actual economic benefits created by these dams. Benefits are measured from each project's completion until 2014 and projected from 2014 until the end of the dam's planned useful life.

The World Bank is the largest and perhaps most influential financier of this type of large infrastructure project (Bosshard, 2013). Its lending policies for dams can have a major effect on the choice of power technologies available for developing countries. Hence, while the data collected for this study are for dams financed by the World Bank, the outcome of the study is not confined to World Bank projects, but applies generally to dams proposed for developing countries, where capital resource are scarce and the decision to build should be guided by the need to achieve a least-cost electricity expansion strategy.

With international efforts to meet the challenges of a stable energy future and combat climate change problems, there is a need to determine whether hydro dams can potentially serve as one instrument for meeting the clean energy policy targets.

Previous studies using data from before 1986 revealed the severity and chronology of cost overrun problems for hydropower dams financed by the World Bank (Merrow and Shangraw, 1990;

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Bacon and Besant-Jones 1998; Head, 2000). In addition, the historical pattern of cost escalation of large construction projects has been extensively documented (Pickrell, 1990; Flyvberg, 2007; Flyvberg et al., 2002, 2009; Sovacool et al., 2011). In what is perhaps the most comprehensive effort to date to investigate the problems of building dams, Ansar et al. (2014), using a reference class of projects for analyzing the performance of large dams, found that nine out of ten large dams constructed had cost overruns. Sovacool et al. (2014) presented a major study of the construction problems of the power industry, describing the frequency and magnitude of construction cost overruns in the electricity sector. Overall, about 75 percent of hydroelectricity projects had cost overruns.

These studies suggest that there is substantial bias toward the underestimation of the capital costs of hydropower projects at the planning stage compared with their actual costs upon completion. Construction delay is also identified as a major problem (Wachs, 1989; Merrow and Shangraw, 1990; Morris, 1990; Bacon et al., 1996; Flyvberg et al., 2002, 2009; Ansar et al., 2014; Sovacool et al., 2014).

Despite the efforts to understand the problem of cost overrun and the rationale behind building dams, fewer analyses have taken into consideration the benefits side of hydropower dams (World Bank, 1996; Asmal, 2000). Thus, the justification for the current study is two-fold. One is to re-examine the nature of the cost escalation of World-Bank-financed hydropower projects involving dam reservoirs where the component related to time overruns is estimated separately from the cost overrun. Bacon et al. (1996) estimated average cost overruns for World-Bank-financed hydropower projects at 27 percent with a standard deviation of 38 percent. Our selection of 58 hydro dam projects allows us to undertake a study that, while overlapping with the dataset used by Bacon et al. (1996) on half of the projects, adds 29 more recently constructed dams. By classifying the dataset in this way we can determine whether the avoidance of cost and time overruns by projects financed by the World Bank has improved over time.

Our second focus is to estimate the benefits side of this sample of dams and to determine their net economic contribution to the societies in which they are located. We go beyond just looking at the unfavorable cost escalation of specific dams, which has been the theme of many recent studies of hydro dams. The results from this analysis provide further information to guide appraisals of hydropower dam investments in an industry that has long been characterized by information asymmetries between project promoters and financiers.

Because each hydropower site is unique in terms of both costs and benefits, the value of potential benefits that can be produced needs to be ascertained before it is suggested that hydro dams are a poor choice of electricity investment based on their past record of cost overruns. For example, the Chukha Dam in Bhutan had a real cost overrun of 156 percent, yet an ex-post evaluation showed that on a total investment of US$ 403 million, an economic net present value (NPV) in excess of US$ 4.7 billion was created (Dhakal and Jenkins, 2013). If it was not for India's appreciation of the potential benefits of the Chukha Dam, and hence its willingness to bear the risk of cost overruns, it is highly unlikely that financially fragile Bhutan could have seriously considered the dam's construction.

2. Methods

For the analysis of cost overruns, four concepts are used: estimated nominal cost, estimated real cost (base year price), actual nominal cost, and actual real cost. The estimated nominal cost used is the sum of base cost (using constant prices), plus an amount to reflect the provisions for physical and price contingencies. According to the World Bank appraisal methodology that has been used since 1976, cost estimates for projects should include a price contingency to account for expected changes in the price level of both imported and locally purchased inputs. In addition, an amount is set aside for physical contingencies. This contingency accounts for expected errors in forecasting of base cost estimates that affect the quantities of inputs required to complete the project (Bacon et al., 1996). Therefore, the estimated real cost at appraisal is derived by simply deducting the price contingency from the estimated nominal project cost, but including physical contingencies. Projects completed before 1976 are excluded to maintain a consistent methodology for evaluating the cost performance of the selected projects.

The change in the real cost schedule of a large project can be the result of two factors. First, real cost changes can occur because of changes in input quantities and real price adjustment; second, change orders will alter the real cost as a project is redesigned. The change in real cost reported here is the difference in cost between the real estimate of cost (which includes physical contingencies) at the time of appraisal – the point of decision making – and the actual real completion cost. Real cost overrun as measured in this study excludes cost changes owing to change orders.

The actual nominal cost (in current prices) is the completion cost of the project as reported in the World Bank's Implementation and Completion Reports (ICRs), while the actual real cost is the deflated values of the actual nominal costs. The impact of general inflation on the cost of a project will usually be transferred eventually to consumers of the project's output through adjustment of electricity tariffs to reflect movements in the general level of prices. Hence, a budget overrun caused by general inflation should not be counted as a real cost overrun.

For a balanced view of the true value of dams, we propose an analytical framework that incorporates the uncertainties underlying both the costs and benefits of hydropower dams. The uncertainty underlying the benefit side is the volatile price of fuel that is avoided by undertaking the hydropower investment. The downside uncertainty in the cost of hydro is the risk of capital cost and time overruns. To find the effect of these risks and uncertainties on the outcome of our analysis, we collect data for completed dams and parameters for evaluating the alternative plant based on actual statistics from historical records, such as the ICRs, post evaluation reports, and other sources. Data on the actual capital costs of open-cycle and combined-cycle plants financed by the World Bank and completed during the period covered by this study are used to estimate the fixed capital cost of the alternative plants avoided by constructing the hydropower dam.

2.1. Data and measurements

Information was collected from the World Bank ICR and SAR for each of the 58 projects. These projects together account for over 34 gigawatts (GW) of installed power-generation capacity.

Table 1 shows the composition of data used for this analysis. The cost per megawatt (MW) of an installed power station is also presented in 2010 constant US dollar (US$) prices. As shown in Table 1, the 58 hydroelectric projects are concentrated in Africa (13), Latin America (15), and Asia (22). Of the remaining plants, five are in Europe and three in Oceania. The average size (in MW) of the projects is much smaller in Africa and Oceania than in Latin America and Asia. The average cost per MW of capacity of projects when fully implemented is significantly lower in Asia (US$ 1.39 million/MW) than in Africa (US$ 2.38 million/MW), Latin America (US$ 2.05 million/MW), Europe (US$ 2.02 million/MW), and Oceania (US$ 4.35 million/MW) (Table 1, column 6).