Project Evaluation: Essays & Case Studies

Preface

Motivation

This book contains essays and case studies that are based upon materials that I prepared for "Project Evaluation", which I designed and taught for more than ten years as one of the required subjects in MIT's Department of Civil & Environmental Engineering. The subject was designed to fill a void in the education of civil engineering students, namely an understanding of why major infrastructure projects are undertaken, how they are structured and evaluated, and how they are financed. These topics, which naturally are of central importance to civil and environmental engineering, are related to, but certainly not central to micro-economics, the subject that was previously required for civil engineering undergrads at MIT.

Micro-economics is an interesting and challenging field, but it tends to ignore or brush quickly over some of the central issues in designing and developing infrastructure projects. Where should a project be located? When should it be built? Can it be developed in phases, so that capacity can be added only when and where it is needed? For engineers, planners, and entrepreneurs, these are critical questions. Those who want to be engineers, planners or entrepreneurs must learn how to balance current vs. future costs and benefits, and they must be able to understand and respond to the many factors that influence the pace and location of development. In particular, they must understand the time value of money, the equivalence of cash flows, and the effects of risk and inflation on discount rates and the attractiveness of projects. These are all central topics in engineering economics, but they are largely or entirely absent from the standard introduction to micro-economics. As I tell my students, economics is a bit too close to the Twilight Zone – "a dimension neither of space nor time".

A second concern with micro-economics is that many of the most interesting concepts are extremely difficult to apply without making assumptions that, to an engineer or planner or entrepreneur, seem to be simplistic or heroic or merely untenable. An engineer is likely to treat with suspicion any proposition that begins with "given a cost function" or "given a production function" or "given supply and demand curves". Where do these functions come from? How are these curves calibrated? Some economists have gone to factories and rail yards and studied the inputs and outputs actually required for the various possible means of production. More commonly, economists have relied on statistical techniques to calibrate functions that certainly appear to be very complex to the student (or to the reader of a journal article), but that in fact are a quite simple portrayal of costs or production or demand based upon analysis of what has happened in the past. For many purposes, notably many kinds of policy analysis, econometric modeling and economic theory provide useful insights, but when considering major projects, engineers, planners, and entrepreneurs are more concerned with what can be done in the future than with what was done in the past. New technologies, new designs, changes in relative costs of inputs, and many other factors will influence what will be possible or desirable to do in the future. Someone, presumably the engineers and the planners, will have to figure out what can be done and convince others that it should be done, tasks that require creativity and judgment as well as an understanding of complex systems and methodologies.

While I understand the argument that undergraduates should learn the basics of their field and that they should discipline their mind through thorough rigorous examination and understanding of a complex, intellectually stimulating subject, my personal experience suggests that students require the stimulation of real situations to truly understand the concepts that we try to teach them. Moreover, it is possible to over-emphasize methodologies and theories while doing little to encourage independent thought and initiative. Thus, in designing my class on project evaluation, I included case studies, open-ended problem sets, and a term project in which the students investigated

projects of their own choosing. I had students complete some exercises from an engineering economics textbook, but I was much more interested in how well they could apply the methodologies and ideas in analyses and interpretations of realistic problems.

At this point I should add a short note on my background. As an undergrad I studied math, but lost interest as the theory deepened and the potential applications receded. As a senior and then in graduate school, I shifted to studying what was just beginning to be called "urban systems", but eventually ended up writing a thesis on rail freight system reliability. For the next 35 years, I remained on the research staff at MIT, supervising many research projects that were funded by the rail freight industry – an experience that forced me and my students to pay great attention to detail and to reality. In effect, we spent several decades working with rail researchers and field personnel to understand and improve the cost functions and production functions related to various categories of rail freight. Over this period, the rail industry transformed itself from a nearly bankrupt, over-built and under-maintained system into a thriving, streamlined system with more trains, longer and heavier trains, heavier loads, and more efficient equipment and facilities. The industry had little to spend on research, so it went to great efforts to focus that research on areas where there would be a payoff. Participating in this research proved to be an outstanding way to understand the functioning of an extremely complex, long-lived system as it was updating its infrastructure and equipment to serve new markets.

During my research career, I described much of what I did as being some sort of engineering economics. Several aspects of engineering economics were absolutely critical:

- Net present value and equivalence of cash flows: the ability to compare cash flows over long time horizons for multiple alternatives, often in an attempt to understand the potential for new technologies or operating strategies.
- Engineering-based cost and performance functions: the ability to structure detailed cost and performance functions that captured the relevant aspects of the technologies and operations that were of interest.
- Probabilistic analysis: the ability to include probabilistic features when structuring cost and service functions.
- Identification of key factors: the use of financial analysis, scenarios, and sensitivity analysis to identify the most important factors affecting a project, the use of new technology, or the choice of operating or marketing strategies.
- Approximation: appreciation of the fact that it is seldom necessary to obtain precise results in order to reach solid conclusions.
- Structuring and interpreting results: recognizing that lack of consensus regarding objectives, ambiguity related to costs and constraints, uncertainty about how systems really work, and many other factors make it unwise to accept the totally unwarranted level of precision that can be obtained from modern computational technologies.

My class on project evaluation was, like Caesar's Gaul, divided into main three parts. The first part provided an overview of project evaluation as a multi-dimensional process aimed at creating projects that meet the needs of society. The second part covered discounting, net present value, financial assessment, and other basic methodologies of engineering economics. The third part addressed issues such as risk and uncertainty, technology scanning, public-private partnerships, and the evolution of infrastructure systems over long periods of time.

Over time, the basic framework remained unchanged, but I was able to develop ever more detailed notes, additional assignments, more open-ended case studies, and more complete presentations for my undergraduate class on project evaluation. I also gave lectures on project evaluation in graduate courses at MIT in the Department Civil & Environmental Engineering, the Center for Transportation & Logistics, and the Engineering Systems Division. After retiring from my full-time appointment at MIT, I began to transform my lecture notes and other course materials into a series of essays and case studies suitable for a textbook. At the request of Jenny Welter, an editor at John Wiley & Sons, I expanded my notes by adding a great many simple examples, hundreds of problems, and new material on project management and engineering economics. In 2011, Wiley published *Toward More Sustainable Infrastructure: Project Evaluation for Planners and Engineers*, a 500-page textbook that covers the basic methods of project evaluation, provides examples attuned to infrastructure systems, and includes case studies that illustrate the breadth

and excitement of project evaluation as related to infrastructure systems. Solutions to the problems, an instructor's manual, and power point presentations for each chapter are all available from Wiley. These materials can provide students and instructors with tools and concepts that they can use in understanding or teaching the need for projects, the options that are available, and the methods for evaluating and refining the options that are available.

However, a 500-page textbook is not the ideal format for presenting the concepts of project evaluation to a broader audience that includes grad students interested in infrastructure systems, mid-career engineers making the transition to management, public officials involved with infrastructure systems or anyone else with an interest in planning for, management of, or investment in infrastructure systems. I therefore decided to return to my class notes and professional papers in order to create a shorter, more focused book that would be readily available to anyone interested in infrastructure systems. Instead of a textbook with long chapters and hundreds of examples and problems, this book focuses on concepts and case studies directly related to project evaluation. It assumes the reader is familiar with supply & demand and other basic economic concepts; it does not cover project management; and it avoids going into esoteric elements of engineering economics such as equivalence relationships involving gradients or geometric sequences. Nevertheless, most of material in this book is very similar to what is in the textbook, because both books draw upon the same notes, case studies, technical papers, and presentations that I developed while teaching my class on project evaluation between 1997 and 2009.

The material includes two categories of documents, namely essays and case studies. Those who wish to gain a broad conceptual framework for understanding project evaluation in the context of infrastructure systems can read the essays; those who wish more detail on methodologies in the context of specific projects can concentrate on the case studies. Each essay and each case study is a stand-alone document that be read without being distracted by references to definitions or methods developed in prior or subsequent chapters. *Project Evaluation: Essays and Case Studies* should therefore be useful to practitioners and anyone with a general interest in project evaluation or infrastructure, even though it may be less appealing to a professor hoping to find a multitude of simple examples and a great many problems for his students to solve.

Although this book does not include sample problems and problem sets, such materials can be found under "1.011 Project Evaluation" as part of MIT's Open Courseware website at www.MIT.edu or directly from:

http://dspace.mit.edu/bitstream/handle/1721.1/75001/1-011-spring-2005/contents/index.htm?sequence=5

This web site provides the syllabus, reading lists, assignments, quizzes and other class materials for several different versions of the class. It also includes student presentations for a half dozen major projects, each of which would be interesting to a general reader of this book. The URL shown above is for the 2005 version of "Project Evaluation", which is the most complete version on Open Courseware for the years when I alone was responsible for this subject.

Structure of *Project Evaluation Essays and Case Studies*

Project Evaluation: Essays and Case Studies is published in two stand-along volumes. The first volume provides an overview of project evaluation as a multi-dimensional process aimed at creating projects that meet the needs of society. The essays and case studies in this volume provide a framework for understanding and evaluating projects, taking into account not only the financial and economic issues, but also social and environmental factors. The essays in this volume emphasize that analysis will not necessarily determine what projects are considered, what projects are proposed, what projects are approved or what projects are ultimately successful. Projects may be motivated by a vision of a greater society, by an idea for addressing a specific local problem, by the prospects of making a profit while providing a needed service, or by simple greed. Some apparently excellent projects cannot be financed, while it may be easy to fund some very questionable projects. Case studies in Volume I are mostly based upon actual infrastructure projects.

Volume II examines the equivalence relationships that can be used to compare cash flows or economic costs and benefits over the life of a project. It covers the concepts and methodologies that can be used by investors, bankers,

and entrepreneurs in deciding whether or not to finance projects, and it shows how public policy can use taxes and other regulations to encourage projects that have public benefits. Most of the case studies in Volume II present hypothetical situations that illustrate how various methodologies can be used in project evaluation.

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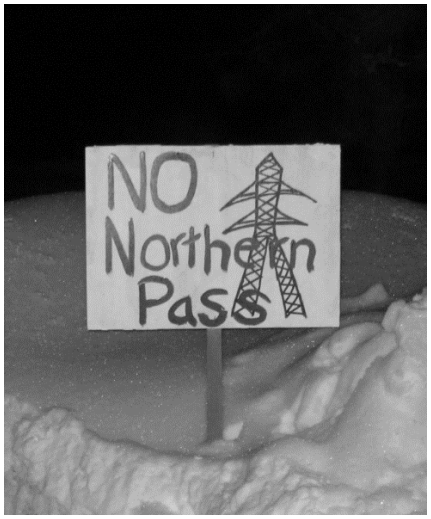
October 2016

High Voltage DC Transmission Lines in Quebec



Protesting Extension of HVDC Lines Across New Hampshire

The Province of Quebec has invested heavily in hydropower that Hydro Quebec, a crown corporation, transmits electricity to New England and New York via steel lattice towers that are typically 90 feet tall or taller. Northern Pass, a proposal to construct nearly 200 miles of such lines across New Hampshire, is strongly resisted by conservation groups and the public, who would prefer the line to be buried in order to avoid destroying the natural beauty that is beloved by residents, attracts tourists, and lures retirees and second home owners to the North Country.

Resource: Project Evaluation: Essays and Case Studies

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