



FINDING TECHNOLOGY PAYBACK POTENTIAL

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EXECUTIVE SUMMARY

In August 1993 the Construction Industry Institute formed the Technology Strategy Task Force "to develop a strategy to advance the industry through technology". The task force identified the need to better understand how and why managers in construction firms make decisions to adopt or reject a new technology, what factors affect such decisions, and how existing industry conditions inhibit innovation. This report gives results from the research project sponsored by the task force to fill this need. The study focuses on construction means and methods technologies, which include information technologies for project control, product and process information and electronic communications, and physical technologies for fabricating and installing components.

To support developing effective strategies, this research focused on two key issues. First, how do Contractors make decision to adopt or reject a new technology? This identified the forces that drive contractors to adopt or reject a new technology and the criteria they use to decide. Second, the study identified the current industry conditions that inhibit the adoption of new technologies.

Findings regarding decision process

The study identified four major forces that drive decision processes regarding new technology. External requirements, such as pressures from owners, designers, competitors and regulators, drive the adoption of new technology. Priority problems drive new technology when existing methods cannot meet project requirements. Potential competitive advantage and technological opportunity to improve efficiency are the other two forces that drive adoption of new technology.

Factors related to the market, organizations, and projects influence the decision to adopt a new technology. Owners' and designers' pressures create the market forces. The organizational factors are top management's attitude and the structures and policies in the contractors' organizations that support innovation. Project factors include risk allocation, extent of cooperation between the parties, and freedom from costs and time pressures.

Findings regarding industry conditions

The second set of findings concern existing industry conditions that inhibit the rate of technological innovation. The findings also identify the reasons that cause these conditions. The most important conditions are: low pressures from owners, low pressures from designers, and reluctance of contractors to adopt new technologies.

The low pressures from owners are indicated by the following findings: owners do not specify means and methods technologies, owners do not use technological capabilities as criterion for contractor's selection, and owners do not share technology risks and costs with the contractors. The primary reasons for this owners' attitude are considering contractors responsible for means and methods, lacking information regarding technologies and benefits, and focusing on short-term project performance.

The low pressures from designers are supported by findings that designers do not specify means and methods technologies and designers do not consider construction methods in design. The primary reasons for this attitude are liability concerns, economic disincentives, and lack of awareness.

The research identified the following issues as the primary reasons for reluctance to adopt new technologies:

- risk aversion
- project cost and time pressures
- uncertain competitive advantage from using new technologies
- lack of corporate structure to support technology
- lack of information regarding contractors' technologies and benefits.

Recommendations to increase innovation

The findings from the research and other task force activities identify the following changes as essential for increased technological innovation: increase owners' demand, reduce designers' disincentives, and increase contractor's motivation.

Owners' demand can create the necessary market forces for contractors to utilize value-adding technology. To foster such market forces owners should first increase knowledge of the benefits of new technologies and the opportunity costs of not using them. This will encourage changing the procurement paradigm, by using technological capabilities as criterion for contractors' selection. Owners can also create a project environment that support innovation, through risk sharing and teamwork.

The first action needed for designers to promote and support construction innovation is for owners to select designers based on knowledge of construction means and methods in addition to expertise regarding product technologies. Owners can reduce the designers liability by sharing the risk involved in the implementation of a new technology. Owners can also remove designers' economic disincentives by compensating for additional cost and time involved in innovation.

Decreasing contractors' reluctance to pursue new technology begins with increase awareness of benefits and incentives to move beyond single project mentality. A technology clearinghouse could provide reliable information regarding the performance of new technologies, the actual costs, potential risks, as well as the best implementation methods. Contractors can also establish organizational mechanisms that support innovation. For this, management must allow time and resources for employees to test new technologies outside projects pressures, consider technological opportunities as part of business or project planning, and establish mechanisms to collect and disseminate information about innovative technical solutions and diffuse them to the organization.

1. INTRODUCTION

1.1 Importance of the construction industry

With business receipts for new construction averaging eight to nine percent of the GNP during the past three decades, the U.S. construction industry is one of the crucial sectors of the economy (MacAuley 1981, U.S DOC International Trade Administration 1988, Program of the Subcommittee on Construction and Building 1994). In 1993 the construction industry produced \$470 billion in new construction, or eight percent of the GNP and employed six million persons (Subcommittee on Building and Construction, National Institute of Standards and Technology, 1994).

The performance of the construction industry has a direct effect on the performance and competitiveness of the manufacturing sector. As product life cycles are reduced and time to market becomes the critical competitive factor for several industries, the speed, quality and effectiveness of construction of new industrial facilities plays a key role in manufacturing competitiveness. In the public sector, the effectiveness of construction directly affects the quality of civil infrastructure which is a key factor in a nation's wealth and quality of life.

1.2 Challenges

This important sector of the economy faces significant problems. Construction costs increased over the 1965-80 period at a faster rate than inflation (MacAuley 1981). Since 1968 productivity in the construction industry has declined by 2.8 percent annually (Stokes 1982). This decline has been among the most serious in the U.S. economy.

The construction industry faces intense and diverse challenges for change. Among the many driving forces, the following necessitate an increased rate of technological innovation (Tatum 1989):

- Owners in the manufacturing industries, struggling to regain competitive advantage, are demanding "more construction for the money" (BRT 1983) and are pointing out that advanced technology is one this may be achieved.
- Constructed facilities are becoming much more complex, and therefore greater technological sophistication is required to build them. "High-tech" projects are the growth market for construction. (high-tech 1985).

- New technology is developing to allow significant performance improvement in construction. Computer databases, robotics, automated process control and positioning are examples of fast-developing technologies that offer promise (Howard et al 1989, Moavenzadeh 1985, Paulson 1985).

1.3 The problem

Advances in technology are widely regarded as major sources of improvement in the competitive positions of firms and industries (Porter 1985) as well as of increases in national economic growth and standards of living (Schumpeter 1935, Rosenberg 1982). However, the benefits from such advances obviously depend on the extent to which they are utilized.

In recent years several researchers and practitioners have identified the need for accelerating the adoption of new technologies in order to increase the productivity and competitiveness of the construction industry. In 1982, The Business Roundtable found that the U.S. construction industry is far less progressive than many other major industries in developing and adopting new technology. It concluded that this situation was one of the reasons for the rapid increases in U.S. construction costs. The National Research Council (1986) also concluded that the slow adoption of new technology and inadequate R&D have undoubtedly been major factors, though possibly not the only factors, in the productivity problems of the construction industry. The CII whitepaper "Innovation in the US Construction Industry: An Essential Component for America's Economic Prosperity and Well-Being" identifies the need to transform the construction sector into a high-technology, high skilled sector (CII 1994). Finally, the President's Technology Policy Goals identify the importance of technological innovation for a construction industry that can provide affordable housing, support manufacturing competitiveness and renew the infrastructure (Technology for America's Economic Growth, A New Direction To Build Economic Strength, 1993).

1.4 Objectives

In August 1993 the Construction Industry Institute formed the Technology Strategy Task Force "to develop a strategy to advance the industry through technology." The task force formulated the problem statement: "The construction industry is inadequate in development and adoption of improved technologies, with resulting loss of cost effectiveness."

Because in free market economies technological diffusion is determined by managerial decisions at the level of the individual firms, the task force identified the need to answer two research questions related to technology adoption: First, how and why do managers in construction firms make decisions to adopt or reject a new technology, and what factors affect such decisions? Second, what industry conditions facilitate or inhibit technological innovation?

Thus, the objectives structuring this research are:

- increase understanding of how managers make technology adoption decisions
- increase understanding of the market forces affecting technological innovation
- increase understanding of the project conditions influencing innovation
- increase understanding of organizational factors facilitating innovation.

1.5 Scope

The study focuses on construction *means and methods* technologies. The findings of the research are therefore applicable to such technologies and may or may not be relevant to other technologies (e.g., new product technologies). Construction means and methods technologies include:

- information technologies for project control (document management and cost control systems)
- technologies for product and process information (e.g., CAD systems for detailing and coordination)
- information technologies for communications (electronic data interchange)
- physical technologies for fabricating and installing components.

Control technologies include systems that manage information regarding project cost, schedule, procurement, changes, etc. Control systems also exist at the company level because the home office needs information across projects. New control technologies studied include the Electronic Document Imaging System (EDIS) for managing all project related paperwork (at both the company and the project level) and barcoding application to manage inventory and support timekeeping. Benefits include

improved control of project status, greater access to all relevant information, and increased ability to retrieve information.

Product and process information technologies include the methods used by contractors to develop and present product and process information. New technologies in this category include 2D and 3D CAD systems for detailing, coordination drawings, isometrics, etc. These technologies improve product and process information to customers and field personnel (presentation) can reduce errors/rework (better coordination and interference checking) and accelerate the process.

Communication technology refers to the systems used to exchange control and project information between project participants (e.g. submittal process, change order process, etc.) as well as project and home office. Electronic Data Interchange (EDI) technologies increase the speed of information flow, enable wider dissemination, and facilitate faster response to unexpected situations.

Physical technologies include methods for fabricating and installing construction components. The methods contractors use are determined by design requirements and other project conditions (work and site characteristics, schedule pressures, local conditions, etc.). New technologies considered include: a new coil line for HVAC duct fabrication and a laser screed for concrete finishing.

1.6 Report outline

The report consists of seven parts. Part one introduces the problem of technological innovation in the construction industry and identifies the objectives and scope of the research. Part two describes the methodology. Part three gives an overview of the relevant literature. Part four presents the case studies and interviews conducted and describes the data analysis. Part five presents the research findings regarding decision-making process and current industry conditions that inhibit technological innovation. Part six develops conclusions regarding technology diffusion, processes of innovation, and decision making regarding adoption of new technology. Finally, part seven develops recommendations for increased adoption of new technology and for future research.

2. METHODOLOGY

To develop effective technology strategies, the task force identified the need to increase understanding of two key issues. First, how do Contractors make decisions to adopt or reject a new technology? This would identify what forces drive contractors to adopt or reject a new technology, what criteria they use and what factors have strong influence on the decision. Second, the task force identified the need to better understand the current system and how the existing industry conditions (market forces, etc.) inhibit the adoption of new technologies. This requires understanding of the role of the key project participants, owners, designers and contractors. The method used to answer these questions included five major tasks, as shown in Figure 1.

2.1 Review literature

The first task was a thorough review of the literature on technological innovation, construction innovation and decision-making. The literature review presents existing models of innovation and identifies important factors that affect technology adoption.

2.2 Collect data

Data collection included three subtasks: develop interview guides, select cases, and interview participants.

2.2.1 Develop interview guide

Based on the literature review the task force and the researchers developed interview guides for contractors, designers and owners to collect data regarding the following issues (see Appendix A):

Decision-making process

This part collects data regarding the steps of the decision-making process, the decision outcome (adoption or rejection) and the factors that influenced the decision.

Current industry conditions

Data regarding industry conditions describe the project, organizational and market factors that create incentives or disincentives for contractors to adopt new technologies. The data are described in more detail in Section 4.2 and Appendix D.

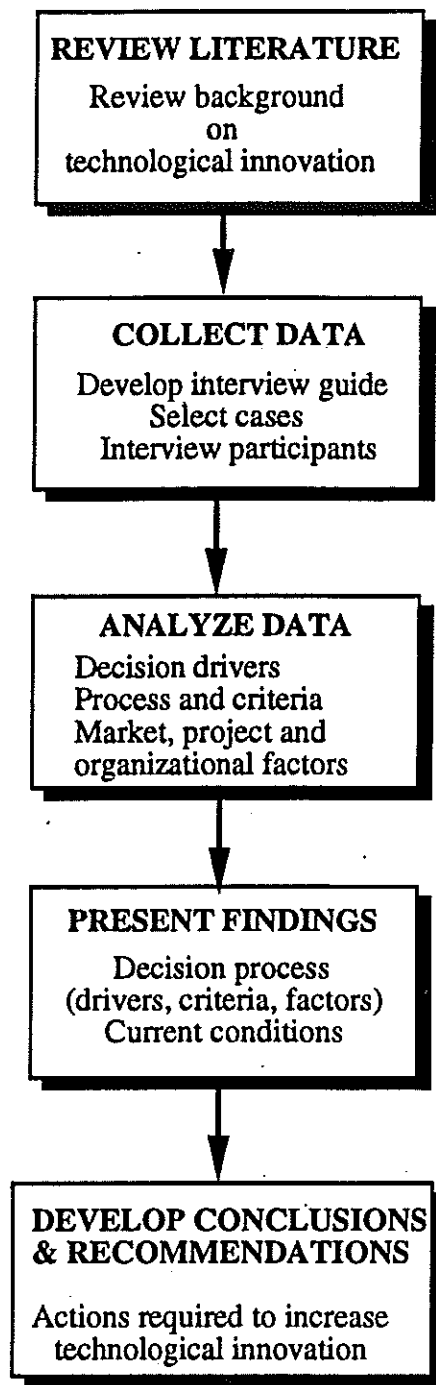


Figure 1. Research methodology