Chapter 4

Developers' Perceptions in the Transfer of Portable Timber Bridge Technology

(ABSTRACT)

Portable timber bridge technology developers from universities, federal and local governments, and trade associations were surveyed by a mail questionnaire. This study found no significant differences (by different professional groups) in terms of preferred channels for disseminating new technology information, effective methods for disseminating new technology information, and for important factors influencing their decision to provide new technology to the logging industry.

In general, technology developers rated personal contact as the preferred source and method for disseminating new technologies and innovations to loggers. Respondents indicated that reducing environmental damage to the forest was the number one factor influencing their decision(s) to provide new technology to the logging industry, followed by increased adoption of BMP, and to meet market demands.

The most frequently used material in portable timber bridge design was softwood lumber. However, respondents also indicated that engineered wood and steel are becoming increasingly important in the selection of materials for portable bridges. This indicates that steel portable bridges could be a major competitor for portable timber bridges and their impact in the market could affect the adoption of portable timber bridges.

The main reasons developers designed portable timber bridges were: to provide environmentally sound alternatives for stream crossings in forest operations, ease of construction, and ease of transportation. Needed areas for improving portable timber

bridge utilization, in the US, were light-weight construction (while still maintaining load capacities), low-cost design, and better marketing techniques. These viewpoints are close to loggers' opinions and should be included in the strategic marketing plan to increase the adoption of portable timber bridges.

Introduction

Technology innovations have been considered a key factor to most industrial competitiveness and economic growth (Devin et al. 1987). New technological innovations are often viewed as one reason for market expansion and market expansion is essential to the long-term success of many forest products firms. Today's technology is changing at a rapid pace and it is increasing in complexity, therefore it is often too costly to develop within a firm (Reilly 1988). Often a company receives technology (technology push) from outside sources. Development of these new technologies is often came in universities, private research laboratories, or government-sponsored research agencies.

Federal government funded research and development (R & D) has been considered as a major source of advanced technologies, which, if transferred to end-users successfully, could be a key competitive advantage for corporate America in the global market place (Spann et al. 1995). Chapman et al. (1989) indicated that transfer efforts from 257 federally-sponsored research projects to private sectors produced $22 billion in benefits to the US economy. However, the transfer process has not always been smooth. Many technology transfer efforts between public and private sectors have been disappointing (Piper and Naghshpour 1996, Spann et al. 1995). In the past, technology transfer was viewed as a unilateral flow process (i.e., good technologies sell themselves). An example is the adoption-diffusion model developed in the 1950's by Rogers (1983). These models did not provide much guidance for improving or speeding up technology transfer efforts and processes (Baldwin and Haymond 1994). More recently, the subject has been heavily emphasized for marketing considerations. Yet, technology transfer processes and efforts are far more complex than most research recognizes (Baldwin and Haymond 1994). It has been suggested that, in order for success in technology transfer, it will be necessary to overcome communication difficulties between groups (Irwin and Moore 1991).

Dearing (1993) indicated that the fundamental problem of transferring technology is one of difference; differences between cultures, organizations, and individuals. Strategies to overcome these differences are based on difference reduction and aim to shorten the perceptual gaps between communication or transfer groups (Dearing 1993). Although technology developers (at federal agencies) and technology end-users may have different views and concerns about innovation, strategies to bridge the differences between these groups are essential to smooth or speed up the transfer efforts. In an attempt to better understand the technology transfer process in the forest industry, especially transfer of portable timber bridge technology, this study investigated the communication behavior of technology developers within the industry and provides information to improve the transfer of portable timber bridge technology.

Background of the Study

Technology transfer between federally supported research and private sectors has been demonstrated recently in the timber bridge market. The US Congress funded the Wood in Transportation Program (WIT) (formally known as the National Timber Bridge Initiative), which is administered by the USDA Forest Service. It began in Fiscal Year 1989 to help rebuild local infrastructures and increase the use of underutilized or low-value timber species for bridge construction. Since that time, over $20 million has been authorized for research, construction, and technology transfer of information regarding the use of timber for modern bridges (USDA 1995).

Timber bridge technology research is led by the USDA Forest Products Laboratory in Madison, Wisconsin. The major activities include improving design standards and construction procedures and maximizing the availability of technology information to end-users (Moody 1994). With the USDA's lead, research universities throughout the US have participated in developing new designs and standards for timber bridges (Smith and Cesa 1998).

It is essential that the WIT Program be accessible to the public, which includes highway officials, bridge engineers, and community decision-makers. In order for the WIT Program to be successful, information about the use of wood in transportation must be transferred and disseminated to others. Technology transfer has been conducted primarily under the direction of the Timber Bridge Information Resource Center (TBIRC) located at Morgantown, West Virginia. Transfer activities include a quarterly newsletter (Crossings), research reports, production of the Timber Bridge Manual, the sponsorship of several timber bridge workshops and training sessions, and a information library and staff ready to assist those who contact the Center. The TBIRC also identifies emerging technologies, stores, retrieves, and disseminates information to meet the needs of managers, planners, designers, builders, engineers, and others (USDA 1997).

As previously mentioned, the fundamental problem of transferring technology is one of difference, differences between cultures, organizations, and individuals. It has been suggested that a better way to overcome the problem is to reduce the degree of differences between communicative parties (Dearing 1993). It is important to pay close attention to communication and information flow through different cultures involved in the technology transfer process.

Therefore, the technology transfer process between federally-supported research agencies and the end-users can be viewed as a communication network system that includes three major subgroups: 1) technology developers who develop new timber bridge technology, 2) end-users who may potentially use the technology, and 3) transfer intermediaries (channels) who bridge these groups and provide necessary efforts to smooth the links between technologies and applications. This relationship has been presented in many technology transfer studies (e.g., Rogers 1983, Irwin and Moore 1991, Baldwin and Haymond 1994). This framework described how information flow and information is exchanged between diverse groups.

Problem Statements

To date, most of the WIT's research emphasis has been placed on permanent bridge structures. There appears to be a large potential market existing for portable timber bridges. Portable timber bridges can be used as temporary stream crossing structures during forest management and timber harvesting operations. Little research by the USDA Forest Service has been conducted on how to facilitate technology transfer through an effective communication system to the target end-users.

Most of the problems associated with the communication of technology transfer are based on the fact that they are comprised by different organizations or people from different cultures. For example, the agricultural and logging community are a relatively close-knit group with shared values and emotional attachment to the land which facilitates communication among its members. But scientists and engineers are a highly diversified group, not wedded by shared emotions (McFall and McKelvey 1989). In fact, the cultural differences between technology developers and end-users (loggers) makes any technology transfer mechanism a difficult task. Recognizing the complexity of technology transfer, the goals of this study were to identify, from the technology developers' point of view, what are the important channels to disseminate their technology, what are the factors influencing their decisions to provide new technology to the logging industry, what are effective methods to disseminate portable timber bridge technology, what are the main factors that encouraged them to design portable timber bridge(s), and what could be done to increase the utilization of portable timber bridges.

Objectives

Specifically, the objectives of this research were:

1) identify important sources in the dissemination of new technology information;

2) identify the factors influencing technology developers' decisions to provide new technology for the logging industry; and

3) identify which intermediaries are the most effective communication channel(s) in transferring developers' new technology.

Research Methods

Sample Frame

The sample frame for this research was technology developers who have been involved in the design of portable timber bridge(s) for the WIT Program. A list was provided by the WIT Program which contained 20 developers, including university professors, state or local highway engineers, federal research engineers, and consulting engineers. This research also added another 5 developers whose names were obtained from recently published reference journals and trade journals.

Questionnaire Development and Data Collection

Data were collected using a mail survey. The first part of the questionnaire used categorical questions to identify profession type, current topics to be disseminated to the logging industry, types of portable timber bridges they designed, price ranges for the portable timber bridges they designed, what materials and dimensions they utilized in their designs, design specifications, and educational level. The second part of the questionnaire utilized rating scales to measure important sources for disseminating new technology or innovation to the logging industry, effective methods for disseminating new technology information to loggers, factors influencing their decisions to provide new technology for the logging industry, and important factors in the design of portable timber bridges. The third part of the questionnaire (open-ended questions) specifically asked respondents what the main factors were that encouraged them to design portable timber bridges, what are the perceived benefits of the portable timber bridges (which they have designed), what areas of research needed to be addressed for improving portable timber bridge utilization, and what is required to increase the use of portable timber bridges for logging and forest management.

Before administering the survey, the questionnaire was evaluated by portable timber bridge developers and knowledgeable faculty members in forestry and forest products marketing at Virginia Tech. A pretest was conducted with timber bridge developers and personnel from the WIT Program. Responses to the pretest were used to clarify question wording and to ascertain factors in the technology transfer process. The questionnaire, along with a hand signed cover letter, was mailed in January of 1999 to 25 individuals (Appendix C). This was followed two weeks later with a letter requesting non-respondents to answer the questionnaire. Four weeks from the original mailing a second questionnaire and letter were mailed. In order to maximize the return rate of this study, follow up phone calls were made to encourage respondents to return the survey after the second mailing.

Data Analysis

Data analysis began with one-way and cross tabulations to examine, categorize, and tabulate data. This research recognized that the sample size is relatively small and may not appear to meet the assumptions for parametric tests (normal distribution). Nonparametic statistical tests were utilized to analyze data under these circumstances. Nonparametric tests are known as distribution-free tests because they make no assumptions about the underlying distribution of data and these tests are also utilized to analyze unbalanced data sets (SPSS 1998). The Kruskal-Wallis test was used to test for significant differences between different professional groups (technology developers). The Kruskal-Wallis test is a nonparametric analogue to one-way analysis of variance (ANOVA). The Mann-Whitney “U” test was utilized to test for non-response bias. When the student t-test is inappropriate to use as a test statistic, the nonparametric procedure most often used is the Mann-Whitney test (SPSS 1998). Both test statistics were performed by using the SPSS™ (1997) software package.

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) model’s pairwise comparison technique was employed in this study to identify which channel(s) respondents preferred to disseminating their new technology information. The AHP model, developed by Saaty (1980), is a multi-criteria decision analysis techique. Typically, the AHP model has three levels of hierarchy, which include the overall goal (top level), the elements that affect the goal (second level), and the comprises the options (lowest level). At each level, elements are compared pairwise with respect to their importance in the decision making process (Figure 4.1).

This research utilized two levels of hierarchy, level one, with the goal of identifying the importance of individuals regarding the transfer of information in the logging industry, and level two, seven pre-identified elements (intermediaries) that affect the goal. The respondent could express his/her preference between each set of two elements. For example, verbal transfer can be expressed as, equally important, moderately important, strongly important, very strongly important, or extremely strongly important. The descriptive preference is then transformed into absolute numbers 1, 3, 5, 7, and 9, respectively, with 2, 4, 6, 8 as intermediate values for comparison between two successive qualitative judgements. After forming the comparison matrix, relative or priority weights for the elements are derived (Saaty 1980). Priority weights are the components of the eigenvector of the matrix. The significance of these numbers is that they represent the conversion of the pairwise comparisons of the criteria into a ratio scale. This new scale is called a derived scale (Saaty 1988). Priority weights are important for this scale and the sum of these numbers (within the matrix) are always one.

It is important to determine priority weights in pairwise comparison. Several methods have been utilized in research to calculate priority weights, including normalized eigenvalues, logarithmic least squares, and least squares methods (Yang and Lee 1997). However, the three methods mentioned above have been proven to receive the identical results in terms of consistency, and the normalized eigenvalues are suggested when the data are not entirely consistent (Saaty and Vargas 1984). Approximation of the eigenvector can also be used, such as using a geometic mean (Saaty 1988).

Compared to conventional rating scale measurements, the AHP model provides more actual and statistical indicators for researchers. In this research, paired comparisons were made between seven pre-identified information transfer intermediaries. They were extension specialists, state agencies (foresters), WIT Program personnel, trade shows, trade associations, procurement foresters, and companies producing and promoting portable bridges. There were 21 pairs for respondents to express their preference [n/2 (n-1), n=7] (Saaty 1988). Individual results were geometrically averaged to form a composite matrix. Expert Choice™

(1994), a computer program based on the Analytic Hierarchy Process, helped to form the questions, data entry, and analyzed the results for the researcher.

Non-Response Bias

A common concern in survey research is non-response bias. To test for non-response bias, data obtained from early respondents (returned after first mailing) were compared to data obtained from late respondents (returned after second mailing) using the Mann-Whitney "U" test. Respondents were compared in several key areas, which include: important channels for disseminating new technology, important factors in the design of portable timber bridges, and effective methods for dissemination of portable timber bridge technology. No significant differences (at the 0.05 level) were found between the two sets of data, which indicated that non-response bias does not appear to be a problem in this case.

Results and Discussion

Two respondents indicated that they were not involved in designing portable timber bridges and four organizations indicated that the person (whom we contacted) was either no longer with the organization or there was no such person in the organization (confirmed via phone calls). This resulted in 15 useable questionnaires returned (out of 19 portable timber bridge developers). Furthermore, respondents were sorted by different professional groups. Four respondents were employees of state or local government, 7 were university professors, 2 were officers of trade associations, and 2 respondents were employees of federal government (Table 4.1).

Section one of the questionnaire asked respondents to indicate the current technologies or topics to be disseminated to the logging industry, types of portable timber bridges they designed, price ranges for portable timber bridges they designed, what materials and dimensions they utilized in their designs, what were their design specifications, and what were their age and educational levels.

The most frequent topic or technology planned to be disseminated to the logging industry was new timber bridge systems or standards, followed by impacts of forest roads on water quality. The most frequent type of portable timber bridges designed were engineered portable timber bridges, followed by skidder bridges (Table 4.2). When asked what the price ranges were for the portable timber bridges they designed, 55 percent of the respondents reported over $7,500 and 33 percent of the respondents reported between $5,001 to $7,500 (Table 4.2). The most frequent material utilized in their design of portable bridges was softwood lumber, followed by hardwood lumber, engineered wood, and steel (Table 4.3). When asked what dimensions they used in their designs, 2 x 12' were the most used dimensions, followed by 2 x 10', and 2 x 6' (Table 4.3). The most frequent design specification (in compliance with highway standards) used in their design of portable bridges was HS 20-44, followed by HS 25-44, and HS 15-44 (Table 4.3). Approximately 80 percent of respondents were over age of 40. All respondents held graduate degrees.

Section two of the questionnaire utilized rating scales [on the scale of one (below average importance) to seven (above average importance)] to measure important sources of new technology or innovation for disseminating to the logging industry, effective methods for disseminating new technology information to loggers, factors influencing their decisions to provide new technology for the logging industry, and important factors in the design of portable timber bridges. For the important sources of disseminating new technology or innovation to the logging industry, respondents rated personal calls to loggers as the number one source in disseminating new technology or innovation, followed by personal calls to industry foresters, loggers education programs, trade magazine articles, and companies producing new technology (Table 4.4). The least important sources for disseminating new technology or innovation to the logging industry were direct mail advertising and state agencies (foresters).

To determine if differences existed between professional groups in terms of important sources in disseminating new technology or innovation to the logging industry, a Kruskal-Wallis test was used. A significance level of 0.05 was used throughout the study. The null hypothesis tested in here was "*There are no differences between professional groups in terms of important sources for disseminating new technology information to logging industry*". No differences were found between profession groups [no variable's asymptotic value (p-value) was less than 0.05] (Table 4.4). This indicates that, in terms of important sources for disseminating new technology information to the logging industry, different professional groups did not have different sources in this case.

To determine if differences existed between variables in this question, Figure 4.2 illustrates the mean and mean range (lower limit to upper limit) at 95 percent confidence interval (C.I.) for each variable. Except the variables of personal contact with loggers and direct mail advertising, all other variables did not show any differences from each other. One reason for this may be the sample size is relatively small (15 responses).

Respondents were asked what were the most effective methods for disseminating new technology information to loggers. Respondents reported that personal visits were the most effective method, followed by trade shows, videos, and conferences. The least effective methods for disseminating new technology information to loggers were peer-reviewed journals and manuals (Table 4.5). To determine if differences existed between professional groups in terms of effective methods for disseminating new technology information to loggers, a Kruskal-Wallis test was utilized. The null hypothesis tested was "*There are no differences between professional groups in terms of effective methods for disseminating new technology information to loggers*". No differences were found between professional groups (Table 4.5). Reasons for this may be that respondents preferred personal visits, trade shows, and videos as the most effective methods for transferring technology information, but did not prefer to use peer-reviewed journal or manuals to transfer technology information to loggers.

To determine if differences existed between variables in this question, Figure 4.3 illustrates that the variable of personal visits is different from the variable of reviewed journals. Since the sample size is relatively small, other variables did not show differences from each other.

Respondents were asked what factors influenced their decision(s) to provide new technology for the logging industry. Respondents indicated that the reduction of environmental damage to the forest was the number one factor influencing their decision(s) to provide new technology to the logging industry, followed by increased adoption of Best Management Practices (BMP) and to meet market demand(s). The factor least influencing decision(s) to provide new technology to the logging industry was to increase safety of forest operations (Table 4.6). This indicates that reduction of environmental damage to the forest and increased adoption of BMP were the main factors for technology developers to provide new technology to the industry (especially for the design of portable timber bridges). Since respondents were mainly timber bridge designers, safety issues of forest operations may be less important for them in the providing new technology to the logging industry.

A Kruskal-Wallis test was utilized to determine if differences existed between professional groups in terms of important factors influencing their decisions to provide new technology for the logging industry. The null hypothesis tested was "*There are no differences between professional groups in terms of important factors influencing their decisions to provide new technology to logging industry*". No differences were found between professional groups (Table 4.6). This could indicate that respondents did not have different factors that influenced their decision(s) to provide new technology to the logging industry. Since the sample size is relatively small, Figure 4.4 does not show any differences between variables.

Respondents were asked what were important factors in the design of portable timber bridges. Respondents indicated that ease of handling, and ease of installation were the most important factors, followed by low cost. The least important factor was promoting the use of low-grade timber (Table 4.7). This indicates that ease of handling, ease of installation, and low cost were the important factors when respondents designed portable timber bridges. On the other hand, the factor of promotion of low-grade timber may not be considered in the design of portable timber bridges.

To determine if differences existed between professional groups in terms of important factors influencing their decisions to provide new technology for the logging industry, Kruskal-Wallis test was used. The null hypothesis tested was "*There are no differences between professional groups in terms of important factors in the design of portable timber bridges*". This analysis resulted in significant differences between professional groups (Table 4.7). One variable which appears to result in group differences was increased harvest efficiency. Rating means for increased harvest efficiency by group were: university professors (6.2), officers in trade associations (6.0), employees of federal government (3.5), and employees of state or local governments (4.5). This indicates that university professors and officers in trade associations preferred increased harvest efficiency as an important factor when designing portable timber bridges, but employees of federal government did not prefer this factor as important.

To determine if differences existed between variables in this question, Figure 4.5 illustrates the mean and mean range (lower limit to upper limit) at 95 percent confidence interval (C.I.) for each variable. The variables of ease of installation, ease of handling, and low cost did not show differences from each other (means for these variables fell in each other's mean ranges). However, these variables are different from other variables. This indicates that respondents viewed these variables (ease of installation, ease of handling, and low cost) the same as an important factor in design of portable timber bridges.

The last part of the questionnaire (open-ended questions) specifically asked respondents what were the main factors that encouraged them to design portable timber bridges, what were the perceived benefits of the portable timber bridges (which they have designed), what areas of research needed to be addressed for improving portable timber bridge utilization, and what will be required to increase the use of portable timber bridges. For main factors encouraging the design of portable timber bridges, respondents stated that providing an environmentally sound alternative for stream crossings in forest operations, ease of construction, and ease of transportation were the main factors in the design of portable timber bridges. This may indicate that the motivation for designing portable timber bridges was to provide environmentally sound products and products that are easy to operate.

When respondents were asked what were the perceived benefits of portable timber bridges they have designed, respondents indicated that cost effectiveness, ease of building, and reduced impact on water quality were the major benefits of their portable timber bridge. This indicates that the utilization of portable timber bridges may not only be environment-friendly, but also a cost effective way to improve forest operations.

Respondents were asked what areas of research needed to be addressed for improving portable timber bridge utilization. Respondents stated that light-weight construction (but still maintaining load capacities), low cost design, and better marketing techniques were needed for improving portable timber bridge utilization. This may indicate that low cost, better construction designs, and better marketing strategies can help to improve portable timber bridge utilization in the US. Finally, respondents were asked what would be required to increase the use of portable timber bridges for logging and forest management. Most respondents reported that decreased cost and weight of portable timber bridges, increased the awareness of the benefits of utilizing portable timber bridges, enforced regulations, and increased marketing efforts could help to increase the adoption of portable timber bridges.

AHP Analysis

The question asked respondents when disseminating new information on products or technology, which intermediaries are most important to them. It then asked respondents to indicate their level of preference for the most important factor by selecting a value (1 to 9) from that factor's scale. The question compared the relative importance of one intermediary to another. Paired comparisons were made among seven pre-identified information transfer intermediaries [extension specialists, state agencies (foresters), WIT technology developers, trade shows, trade associations, procurement foresters, and companies producing and promoting portable bridges]. Each respondent made 21 paired comparisons to express their preferences. Individual results were geometrically averaged and one composite matrix was developed (Table 4.8). Saaty (1980) indicates that if an inconsistency ratio is around 0.1 or less, the judgments should be considered consistent. However, some inconsistency is carryover from previous experiences in most comparison processes and may not necessarily be eliminated (Saaty 1990). The inconsistency ratio for aggregate responses of all respondents was equal to 0.02 (much less than 0.1). It indicates that the results are considered consistent. Priority (relative) weights indicated that respondents preferred companies that can produce new technology as the most important channel to disseminate new technology information (0.241), followed by industry foresters (0.197), extension personnel (0.130), trade associations (0.127), trade shows (0.123), the WIT Program personnel (0.121), and state agencies (0.061), respectively (Figure 4.6).

Sensitivity analysis was employed to determine if increasing efforts in one or more intermediaries or channels would affect the respondent's preferences. This (sensitivity) analysis indicated that when the WIT Program increased its efforts (doubling the priority weight), changes could affect respondents' preferences and the priority weights of other intermediaries were decreased. However, priority rank weight did not change (Figure 4.7).

Conclusions

The results of this study indicated that technology developers in different professional groups do not have different preferred channels for disseminating new technology information to the logging industry. Respondents rated personal calls to loggers as the number one source for disseminating new technology or innovation, followed by personal calls to industry foresters, trade magazine articles, and trade shows. There were no differences between professional groups for effective methods in the dissemination of new technology information to loggers. Respondents reported that personal visits were the most effective method, followed by trade shows, videos, and conferences. Also there were no significant differences between professional groups in terms of important factors that influenced their decision(s) to provide new technology for the logging industry. Respondents indicated that reducing environmental damages to the forest was the number one factor influencing their decision(s) in providing new technology to the logging industry, followed by the increased adoption of BMP, and to meet market demands.

The most frequent topic or technology planned to be disseminated to the logging industry was new timber bridge systems or standards. The most frequent type of portable timber bridge designed was engineered portable timber bridges, followed by skidder bridges. Most respondents (55 percent) reported that the portable timber bridges they designed were over $7,500. The most frequently used material in portable timber bridge designs was softwood lumber. However, respondents also indicated that engineered wood and steel are increasingly important in the selection of materials for portable bridges.

There are significant differences between professional groups in terms of important factors in the design of portable timber bridges. Respondents indicated that ease of handling and ease of installation were the most important factors in the design of portable timber bridges, followed by low cost. The promotion of low-grade timber rated least as a factor in the design of portable timber bridges. This indicates that when developers design portable timber bridges, the use of low-grade timber may not be a consideration.

The main reasons encouraging respondents to design portable timber bridges were to provide environmentally sound alternatives for stream crossings in forest operations, ease of construction, and ease of transportation. Needed areas for improving portable timber bridge utilization in the US were light-weight construction (while still maintaining load capacities), low cost design, and better marketing techniques. This may indicate that these areas could also be major adoption barriers for portable timber bridges.

Finally, the results of this study identified that respondents preferred companies that can produce new technology as the most important channel to disseminate new technology information, followed by industry foresters, extension personnel, trade associations, trade shows, the WIT Program personnel, and state agencies, respectively (through AHP analysis). In general, more marketing efforts are needed to promote portable timber bridges to the logging industry and the design of portable timber bridges must also focus on reducing total construction cost, reducing the weight of portable timber bridges, and increasing load capacities of portable timber bridges.

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