Chapter 5

A Strategic Evaluation of Technology Transfer in the Logging Industry: Transfer Participants’ Communication Differences Affecting the Adoption of Portable Timber Bridge Technology
This research identified preferred channels of information flow for transferring portable timber bridge technology to the logging industry and discerned communication differences and problems associated with transfer participants. This study found that companies, industry foresters, and trade associations should be the preferred channels for transferring new technology information to the logging industry and an information flow diagram was developed.

However, there were significant differences between participants in transferring technology, and factors in the choice to use, promote, or design portable timber bridge technology. Most differences occurred at the intermediary level, especially between loggers and intermediaries. There were no significant differences between loggers and technology developers.

There were significant differences between intermediaries and technology developers for effective methods in the dissemination of new information to loggers. Technology developers rated the Internet much higher than intermediaries as an effective method for transferring new technology information. When personal computers become more popular, the Internet could impact the information transfer process in the logging industry. However, this study found that intermediaries did not recognize the developing trend. To meet market demand plays an important role in when technology developers
design their products. However, this factor was not preferred by transfer intermediaries in their decision to disseminate portable timber bridge technology.

The results of this study indicate that differences at the intermediary level (e.g., between intermediaries and loggers, intermediaries and technology developers) may be the major transfer obstacles in the information flow diagram. The differences found in this study may be one reason that the adoption process of portable timber bridge technology has been slow. In order to successfully transfer technology to the logging industry, technology promoters should notice the differences between transfer participants in the information flow diagram.
Introduction

Market expansion is considered an important strategy for long-term success by the forest industry. New technological innovations are often viewed as one method of market expansion. Today’s technology is changing at a rapid pace, increasing in complexity, and often too costly to develop within a firm (Reilly 1988). Forces that lead to technological innovation are not always from inside the industry. Often the industry receives technology push from outside sources.

Federal government funded research and development (R & D) has been considered 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). However, the transfer process may not always be 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). For example, the adoption-diffusion models developed in the 1950’s (Rogers 1983). However, 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). In order to have success in technology transfer, it is
necessary to overcome communication difficulties among groups (Irwin and Moore 1991).

In an attempt to better understand the technology transfer process in the logging industry, especially transfer of portable timber bridge technology, this study identified preferred channels (information flow diagram) for transfer and identified communication differences and problems associated with transfer participants within the information flow diagram.

**Backgrounds of the Study**

Technology transfer from outside sources 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 administrated by the USDA Forest Service (beginning in Fiscal Year 1989) to help rebuild local infrastructures and increase the use of underutilized or low-value timber species for bridge construction. Since its beginning, over $20 million has been authorized for research, construction, and transfer of information regarding the use of timber for modern bridges (USDA 1995).

During the summer of 1998 a study was undertaken by the Center for Forest Products Marketing and Management at Virginia Tech in cooperation with the Wood In Transportation Program, USDA Forest Service, to investigate the market for portable timber bridges, the barriers to technology transfer, and effective promotional channels.
The first part of the study utilized questionnaires using the “mall intercept” method to interview over 150 loggers. This research discerned sources which were identified as important sources by loggers for receiving new technology information, important materials in the selection of a portable bridge, and the intermediaries which loggers preferred as effective channels in receiving new technology information. This research also evaluated important factors affecting loggers’ decisions in the process of adopting portable timber bridge technology.

This study indicated that loggers have become aware of the benefits of utilizing portable timber bridges. When consumers make decisions in purchasing a certain product they must recognize a need for the product, search for information, evaluate alternatives, and then make decisions (Assael 1992). Two elements in new product introduction are needed, awareness of the product and product trial. Therefore, the steps in the adoption of new innovation can be described as the following: awareness of the product → knowledge of the product → evaluation of the product → trial of the product → adoption of the product → post-adoption assessment (Rogers 1983, Assael 1992), (Figure 5.1). This study revealed that most loggers are in the steps between evaluation and trial of the product.

The second part of the study utilized a mail survey to over 600 technology transfer intermediaries (pre-identified by loggers) in the logging industry. These intermediaries included state agencies (foresters), industry foresters, marketing professionals in private companies, officers in trade associations, and extension specialists. This part of research identified sources that are important for intermediaries
in learning about new technology information, evaluated effective methods for the dissemination of new technology information, and identified which factors were important in influencing their decision(s) in the dissemination of portable timber bridge technology information to end-users.

This study identified that intermediaries from different professional groups do have different preferred sources for learning about new technology information, effective methods for disseminating new technology information, factors influencing their decisions to disseminate new technology information, and factors in the promotion of portable timber bridges. It is very difficult to develop a unified channel strategy to fit all intermediaries. However, understanding the differences among those intermediaries is essential in order to promote portable timber bridge technology.

The third part of the study included over 20 portable timber bridge technology developers (who were surveyed by a mail questionnaire). Important sources utilized by technology developers for disseminating technology information were identified. Also, this research, from a developers’ point of view, evaluated effective methods for disseminating new technology information, identified factors influencing their decisions to provide new technology to the logging industry, and identified preferred intermediaries (channels) for transferring their new technology to the industry.

The technology developers’ 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(s) to the forest was the number one factor influencing their decision to provide new technology to the logging industry.

**Problem Statement and Objectives**

As previously mentioned, most end-users (loggers) of portable timber bridge technology are in the steps between evaluation and trial of the product. How to successfully “push” them to fully adopt this technology requires an understanding of the information flow within the industry and overcoming the communication differences between loggers and other transfer participants.

A fundamental problem in transferring technology is one of differences, differences between cultures, organizations, and individuals. It has been suggested that better methods (strategies) to overcome this problem are to reduce the degree of differences and to shorten the perceptual gaps between communication or transfer groups (Dearing 1993). Although technology developers, transfer intermediaries, and technology end-users may have different views and concerns about innovation, strategies to bridge the differences between these groups are essential to the success of any technology transfer effort. Therefore, this research identified preferred channels of information flow for transfer of portable timber bridge technology in the logging industry and then identified differences between technology transfer participants.
Specifically, the objectives of this research were to:

1) to develop a preferred channel (information flow) diagram for portable timber bridge technology transfer, and

2) identify the communication differences between transfer participants based on results from each discrete survey.

Research Methods

Results reported in the following sections were based on the data from the following surveys:

Logger Study: The sample frame for this segment of research was loggers located within the Eastern half of the United States. To determine if differences existed between demographic areas, four distinct demographic regions were identified. They were: East, South, Mid-Atlantic, and Midwest. These four regions accounted for a major portion of timber bridge studies which were funded by the WIT Program (Cesa 1997). Data were collected utilizing the “mall intercept” interview method. Several trade shows were attended: 1) “Expo Richmond ’98, The 26th East Coast Sawmill & Logging Equipment Exposition” (May 8-9, 1998) in Richmond, Virginia., 2) “West Virginia Timber and Wood Products Show” (June 13-14, 1998) at the Barbour County Fairground, West Virginia, 3) “Logging Congress” (September 11-12, 1998) in Green Bay, Wisconsin, and 4) the “Kentucky Wood Expo” (September 19-20, 1998) at the Laurel County Fairground, Kentucky. Also, during the same time period, questionnaires were sent to the Alabama Forestry Association and selected Cooperative Extension personnel in the
New England states (New York, New Hampshire, and Maine). These organizations agreed to distribute the questionnaires to loggers and asked loggers to fill out the questionnaires at logger training or education classes. Then the organizations returned the questionnaires to Virginia Tech.

One hundred and fifty eight useable questionnaires were returned and included the classroom survey. Furthermore, respondents were segmented by different demographic regions and data collection locations. Eighty nine respondents were from the Mid-Atlantic region, Mid-West region (30), South region (23), and 15 from the East region of the United States. Trade shows resulted in 131 useable questionnaires, and 27 useable questionnaires were returned from different logger education or training classes. To test for non-response bias, data obtained from non-respondents (via phone calls) were compared to data obtained from the original survey using student t-tests. No significant differences ($\alpha=0.05$ level) were found between the two data sets, which indicated that non-response bias did not appear to be a problem in this case.

**Intermediaries Study:** A mail survey was utilized for primary data collection. The mailing list was compiled from the following sources: 1) 1997-98 North American Factbook (1997), 2) Cooperative Extension Service Personnel in Forest Management and Wood Products (1995), 3) Membership Directory of the Society of American Foresters (1998), 4) Directory of the National Association of State Foresters (1997), and 5) Registration List of Expo Richmond ’98 Participants (1998). A sample frame of 628 individuals was developed from the above listed sources. Individuals included state, regional or district foresters, local foresters, industry foresters, trade association officers,
extension specialists, and private company marketing managers. The important technology transfer intermediaries (channels) were pre-identified by technology end-users (loggers) during the first part of the study.

Three hundred and eighty six questionnaires were returned. There were 11 bad addresses and six respondents indicated that they did not interact with loggers. This resulted in 369 useable questionnaires. Respondents were segmented by different profession groups. One hundred and ninety two respondents were state agencies (foresters), 66 industry foresters, 20 trade association officers, 28 extension specialists, 42 marketing or management professionals, and 21 were other type of professionals (e.g., log buyers or land managers). The adjusted response rate was 58 percent. To test for non-response bias in this study, data obtained from non-respondents (via phone calls) were compared to data obtained from the original survey using student t-tests. No significant differences (at the $\alpha=0.05$ level) were found between the two sets of data, which indicated that non-response bias was not a problem in this part of the study.

Technology Developer Study: 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. This research also added another 5 developers whose names were obtained from recently published reference and trade journals. Data were collected using a mail survey.

Two respondents indicated that they were not involved in designing portable timber bridges and four organizations indicated that the person (who 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 segmented by different profession groups. Four respondents were employees of state or local government, 7 university professors, 2 officers of trade associations, and 2 respondents were employees of federal government. 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. No significant differences (at the 0.05 level) were found between the two sets of data, which indicated that non-response bias did not appear to be a problem in this case.

Analytic Hierarchy Process (AHP) questions (which surveyed loggers and technology developers) were used to identify preferred channels (information flow diagram) for transferring portable timber bridge technology. Variables (channels or intermediaries) in this question were important transfer middlemen in the logging industry, which included state agencies (foresters), extension personnel, industry foresters, companies producing new technology, trade associations, and the WIT Program personnel.

In order to discern for differences and problems associated with technology transfer participants in the information flow diagram, several questions contained in each of these questionnaires were analyzed. These questions were: 1) important sources in receiving (loggers), learning about (intermediaries), and disseminating (technology developers) new technology information, 2) important factors in the decision to use (loggers), promote (intermediaries), and design (technology developers) portable timber
bridge technology, 3) important materials in the selection of a portable bridge (loggers and intermediaries), 4) effective methods for disseminating new technology information (intermediaries and technology developers), 5) important factors influencing the decision(s) to provide (technology developers) or disseminate (intermediaries) new technology information. Also, several open-ended questions (in each survey) were used to identify the needed methods to increase the adoption of portable timber bridge technology.

Data Analysis

Analytic Hierarchy Process questions were used to identify preferred channels and construct an information flow diagram for transferring portable timber bridge technology. The AHP model, developed by Saaty (1980), is a multi-criteria decision analysis technique. Typically, the AHP model has three levels of hierarchy, which includes the overall goal (top level), the elements that affect the goal (second level), and the lowest level (which comprises the options). At each level, elements are compared pairwise with respect to their importance in the decision making process (Figure 5.2).

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, oral 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, and 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 produce 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 geometric mean (Saaty 1988).

In this research, paired comparisons were made between seven pre-identified information transfer intermediaries. They were extension specialists, state agencies (foresters), WIT technology developers, trade shows, trade associations, procurement foresters, and companies producing and promoting portable bridges. There were 21 pairs for respondents to express their preference \[\frac{n}{2} (n-1), n=7\] (Saaty 1988). Individual results were geometrically averaged to form a composite matrix. Expert Choice™
(1994), a computer program based on the Analytic Hierarchy Process, was used to analyze the results.

Analysis of differences and problems associated with technology transfer participants utilized both multivariate analysis of variance (MANOVA) and nonparametric (Kruskal-Wallis) tests to test for significant differences between technology transfer groups. Since the sample size of technology developers was relatively small, analysis that involved technology developers utilized nonparametric statistical assumptions. A MANOVA test produces a test statistic (in this case the multivariate version of a t-test, Hotelling’s $T^2$-test ) that compares two groups with a critical value (p-value) to obtain a significance level (Grimm and Yarnold 1995). Nonparametric tests are known as distribution-free tests because they make no assumptions about the underlying distribution of the data. The Kruskal-Wallis test was used to further analyze data under nonparametric statistic assumptions. The Kruskal-Wallis test is a nonparametric analogue to one-way analysis of variance (ANOVA). A significance level of 0.05 was used throughout the study. SPSS™ 8.0 for Windows™ (1997) software package was utilized to perform the Kruskal-Wallis tests and SAS™ System for Windows™ Release 6.12 (1996) software was utilized to perform multivariate analysis.
Results and Discussions

AHP analysis was utilized to identify preferred channels and construct an information flow diagram for transferring portable timber bridge technology. Priority (relative) weights produced from AHP analysis indicated that loggers received most new technology information from companies producing the new technology (0.218), followed by trade shows (0.193), industry foresters (0.176), trade associations (0.167), state agencies (0.108), extension personnel (0.072), and the WIT personnel (0.066), respectively (Table 5.1). Priority weights also indicated that technology developers preferred companies producing 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 (Table 5.1). This indicates that private companies’ promotional efforts may have a greater effect than those of non-profit organizations. A certain bias may have existed in this question, for example, loggers answered the questionnaires primarily at trade shows. This could be the reason that trade shows were rated high by loggers. Technology developers were primarily from universities and overlapped with extension personnel. Some extension personnel may have been colleagues with portable timber bridge developers and most developers had a certain degree of association with the WIT Program (e.g., designed bridges for the WIT Program). If these apparent biased variables were removed, both groups had identical results. Companies producing new technology were the number one preferred channel, followed by industry foresters, trade associations, and state agencies.
However, both groups (using the previous rating question) rated trade shows as one of the preferred channels in receiving or disseminating new technology information and most trade shows were sponsored by trade associations. This indicates that companies, industry foresters, and trade associations should be the preferred channels for transferring new technology information to the logging industry and the information flow diagram was constructed (Figure 5.3).

With the information flow diagram identified, we can conclude that in order to successfully transfer portable timber bridge technology or other logging-related technologies, utilizing these channels will be necessary. However, this information flow diagram only provided a “big picture” of transferring technology to the industry. Technology transfer processes and efforts are far more complex than this diagram. Therefore, the following research further discusses the differences and problems associated with technology transfer participants within the information flow diagram.

For important sources in receiving (loggers), learning (intermediaries), and disseminating (technology developers) new technology information, respondents were asked to rate which sources [on the scale of one (below average importance) to seven (above average importance)] were important. However, in order to eliminate certain biases, which may have existed in this question, and to fit each group’s unique situation or preferences, the three groups were not asked to rate identical variables contained in each questionnaire.

For loggers, the number one rated source was personal contact with other loggers, followed by personal contact with industry foresters, logger education or training
programs, trade shows, and trade magazine articles (Table 5.2). For intermediaries, the most highly rated sources were seminars or meetings, followed by trade shows, trade journal articles, technical or peer-reviewed journal articles, advertisements in magazines, and personal calls from technology developers (Table 5.2). For important sources in disseminating new technology innovation to the logging industry, technology developers rated personal calls to loggers as the number one source for disseminating new technology innovation, followed by personal calls to industry foresters, loggers education programs, trade magazine articles, and companies producing new technology (Table 5.2).

The results indicate that end-users and developers (in the logging industry) preferred personal contact as the preferred source for transferring technology information. However, intermediaries preferred seminars or meetings, trade shows, and trade journal articles for learning about new technology information. Although personal contact with others is considered the best source for transferring technology information, it is expensive and time consuming. Utilizing other sources for transferring new technology information could be more feasible than personal contact. The results also indicate that other more economical sources (channels) could useful in the transfer of new technology information to the logging industry. They were trade shows, trade magazine articles, and advertisements in magazines. These variables were rated highly in each survey, therefore, they can be utilized to determine if differences exist between technology transfer participants.

In order to determine if differences existed between technology transfer participant groups, a Kruskal-Wallis test was performed. The null hypothesis tested was
“There are no differences between technology transfer participant groups in terms of important sources for receiving, learning, or disseminating new technology information”. This analysis resulted in at least one variable’s p-value (asymptotic) being less than 0.05 (Table 5.3). Therefore, we reject the null hypothesis and conclude that there were significant differences between technology transfer participant groups (in terms of important sources for receiving, learning, or disseminating new technology information). Follow up statistical analysis was utilized to discern for group differences (e.g., technology developer vs. loggers, technology developers vs. intermediaries, and intermediaries vs. loggers).

A Kruskal-Wallis test was performed to test for differences between technology developers and loggers. The null hypothesis tested was “There are no differences between loggers and technology developers in terms of important sources for receiving or disseminating about new technology information”. No significant differences were found between loggers and technology developers (no variable’s p-value was less than 0.05) (Table 5.4). This indicates that there were no gaps between loggers and technology developers in the important sources for receiving or disseminating new technology information.

A Kruskal-Wallis test was performed to test for the differences between technology developers and intermediaries. The null hypothesis tested was “There are no differences between technology developers and intermediaries in terms of important sources for learning or disseminating new technology information”. This analysis resulted in significant differences between technology developers and intermediaries (Table 5.5).
One variable, the WIT Program, appears to result in group differences. Rating means for the WIT Program by group were technology developers (4.2) and intermediaries (3.1). This indicates that the awareness level of the WIT Program was relatively low among transfer intermediaries and intermediaries were not preferred for learning about new technology information from the WIT Program.

MANOVA analysis was performed to test for differences between loggers and intermediaries. The null hypothesis tested was “There are no differences between loggers and intermediaries in terms of important sources for receiving or learning about new technology information”. This analysis resulted in significant differences between loggers and intermediaries (Hotellings T²-test = 0.12, F 5, 479 = 12.23; p-value = < 0.01). All variables are involved in group separation (Table 5.6). This indicates that, in terms of important sources for receiving or learning about new technology information, loggers and intermediaries have quite differing views from each other. Rating means for advertisements in magazines by each group were loggers (4.8) and intermediaries (4.0). This indicates that loggers preferred receiving or learning about new technology information by reading advertisements in magazines, but this source was not preferred by intermediaries. Rating means for trade shows by each group were loggers (5.1) and intermediaries (4.8). This indicates that trade shows could be a preferred source for loggers in receiving or learning about new technology information. Rating means for trade journal articles by each group were loggers (5.1) and intermediaries (4.7). This indicates that trade journal articles could be a good channel for transferring new technology information to loggers. Rating means for the WIT Program by group were
loggers (3.8) and intermediaries (3.1). This could indicate, that in terms of the awareness level of the WIT Program, loggers rated the WIT Program slightly higher than intermediaries. Although these variables indicate significant differences between the two groups, trade shows and trade journal articles were ranked highly as important sources for receiving or learning about new technology information by both groups.

In summary, in terms of important sources for transferring technology to the logging industry, most differences occurred at the intermediary level, especially between loggers and intermediaries. There were no significant differences between loggers and technology developers. The awareness level of the WIT Program was relatively low among transfer intermediaries and intermediaries did not prefer advertisements in magazines as an important source for learning about new technology information. Therefore, in order to utilize the information flow diagram of transferring technology to the logging industry, technology promoters should notice the differences at the intermediary level.

When respondents were asked what the important factors were in the choice to use (loggers), promote (intermediaries), and design (technology developers) portable timber bridge technology, the factors (variables) in this question were environmental consideration, ease of operation, availability of design information, low cost, and regulations (Table 5.7). Loggers indicated that the most important factor in the decision to use portable timber bridge was ease of operation, which was followed by environmental considerations. The most important factor for intermediaries to promote portable timber bridge technology was regulations, followed by environmental
considerations and ease of operation. Technology developers indicated that ease of
operation was the most important factor in the design of portable timber bridges,
followed by low cost (Table 5.7).

To determine if differences existed between technology transfer participant groups,
a Kruskal-Wallis test was employed. The null hypothesis tested was “There are no
differences between technology transfer participant groups in terms of important factors
in the choice to use, promote, or design portable timber bridge technology”. This
analysis resulted in at least one variable’s p-value (asymptotic) being less than 0.05
(Table 5.7). Therefore, we reject the null hypothesis and conclude that there were
significant differences between technology transfer participant groups (in terms of
important factors in the choice to use, promote, or design portable timber bridge
technology).

Follow up statistical analysis was utilized to discern for group differences (e.g.,
technology developer vs. loggers, technology developers vs. intermediaries, and
intermediaries vs. loggers). A Kruskal-Wallis test was performed to test for differences
between technology developers and loggers. The null hypothesis tested was “There are
no differences between loggers and technology developers in terms of important factors
in the choice to use or design portable timber bridge technology”. This analysis resulted
in significant differences between technology developers and loggers. Three variables
maximized group separation: environmental considerations, ease of operation, and
regulations (Table 5.8). Rating means for environmental considerations by group were
technology developers (5.0) and loggers (5.8). Rating means for ease of operation by
group were technology developers (6.7) and loggers (5.9). Rating means for regulations by group were technology developers (4.4) and loggers (5.5). This indicates that technology developers focused on low cost timber bridges and enhanced product performance when designing portable timber bridges. End-users focused on regulation issues and environmental consideration when making the decision to adopt portable timber bridge technology.

A Kruskal-Wallis test was performed to test for the differences between technology developers and intermediaries. The null hypothesis tested was \textit{“There are no differences between transfer intermediaries and technology developers in terms of important factors in the promotion or design of portable timber bridge technology”}. This analysis resulted in significant differences between technology developers and intermediaries (Table 5.9). Three variables maximized group separation: environmental considerations, ease of operation, and regulations. These results were identical to the differences between loggers and technology developers. Rating means for environmental considerations by group were technology developers (5.0) and intermediaries (6.1). Rating means for ease of operation by group were technology developers (6.7) and intermediaries (6.0). Rating means for regulations by group were technology developers (4.4) and intermediaries (6.1). This indicates that technology developers focused more on design, but intermediaries focused more on environmental and regulation issues when making their decisions to promote portable timber bridge technology.

MANOVA analysis was performed to test for the differences between loggers and intermediaries. The null hypothesis tested was \textit{“There are no differences between}
loggers and intermediaries in terms of important factors in the choice to use or promote portable timber bridge technology”. This analysis resulted in significant differences between loggers and intermediaries (Hotellings $T^2$-test = 0.06, F $5, 226 = 2.75$; p-value = 0.02). The variable which maximized group separation was regulations (Table 5.10). Rating means for regulations at each group were loggers (5.5) and intermediaries (6.1). This indicates that regulation is an important factor for intermediaries to consider when promoting portable timber bridge technology.

In summary, for both loggers and transfer intermediaries, environmental considerations and regulations were the most important factors in the choice to use and promote portable timber technology. Conversely, technology developers focused on providing low-cost and enhanced performance products to the industry. Therefore, marketing efforts should consider utilizing both tactics (environmental and a user-friendly product) as useful promotional tactics when promoting portable timber bridges.

Respondents (loggers and intermediaries) were asked to rate the important materials in the selection of a portable bridge. Variables in this question were timber, steel, aluminum, and concrete (Table 5.11). A MANOVA analysis was performed to test for differences between loggers and intermediaries. The null hypothesis tested was “There are no differences between loggers and intermediaries in terms of important material in the selection of a portable bridge”.

This analysis resulted in significant differences between loggers and intermediaries (Hotellings $T^2$-test = 0.06, F $4, 462 = 7.35$; p-value = < 0.01). The variables which maximized group separation were steel and concrete (Table 5.11). Rating means for steel
at each group were loggers (4.7) and intermediaries (4.0). Rating means for concrete at each group were loggers (2.9) and intermediaries (2.3). Although the ratings for both variables were different, both groups rated timber much higher than other materials. This result indicates that steel may be an alternative material (to timber) in the selection of a portable bridge.

Technology developers and technology intermediaries were asked to rate effective methods in disseminating new technology information to loggers. Intermediaries indicated that personal visits were the most effective method, followed by trade shows, workshops, and short courses. Technology developers reported that personal visits were the most effective method, followed by trade shows, videos, and conferences. There were twelve variables in this question, which included manuals, trade journals, reviewed journals, videos, the Internet, short courses, conferences, regional workshops, trade shows, newsletters, personal visits, video, and conferencing (Table 5.12). A Kruskal-Wallis test was performed to test for the differences between technology developers and intermediaries. The null hypothesis tested was “There are no differences between transfer intermediaries and technology developers in terms of effective methods in disseminating portable timber bridge technology”. This analysis resulted in significant differences between technology developers and intermediaries (Table 5.12). Two variables result in group separation, the Internet and conferences. Rating means for the Internet (by group) were technology developers (4.2) and intermediaries (2.8). Rating means for conferences (by group) were technology developers (5.3) and intermediaries (4.1). This indicates that technology developers preferred the Internet and conferences as
effective methods for disseminating new technology information to the logging industry, but these methods were not preferred by transfer intermediaries. This research found that personal computers have been reported by loggers as the second most frequently used technology in the logging industry. When personal computers become more popular, the Internet could affect the information transfer process in the logging industry, however, intermediaries appear to not recognize the trend.

Intermediaries were asked what were the important factors influencing their decisions to disseminate new technology information to loggers, respondents rated the reduction of environmental damage(s) to the forest as the most important, followed by increased adoption of Best Management Practices (BMP’s), and increased efficiency of logging practices. Technology developers indicated that reduction of environmental damages to the forest was the number one factor influencing their decisions to provide new technology to the logging industry, followed by increased adoption of BMP’s and to meet market demand(s). Variables in this question were: to meet market demands, increase efficiency of logging practices, reduce environmental damages to the forest, to increase adoption of BMP’s, promote the use of low-grade timber, and to increase safety of forest operations (Table 5.13). A Kruskal-Wallis test was performed to test for the differences between technology developers and intermediaries. The null hypothesis tested was “There are no differences between transfer intermediaries and technology developers in important factors influencing the decision(s) to provide or disseminate new technology information”. This analysis resulted in significant differences between technology developers and intermediaries (Table 5.13). One variable results in group
separation, to meet market demands. Rating means for to meet market demands, by group, were technology developers (5.4) and intermediaries (3.9). This indicates that when technology developers design their products, to meet market demand plays an important role in the design process. However, this factor was not preferred by transfer intermediaries in their decisions to disseminate portable timber bridge technology.

When asked what methods were needed to increase the use of portable timber bridges in logging operations, loggers indicated that word-of-mouth (logger to logger) communication, field demonstrations, videos, and trade shows were needed. Intermediaries stated that availability of portable timber bridges, low-cost bridges, incentives, mandatory regulations, and field demonstrations were necessary to increase the use of portable timber bridges. Technology developers indicated that light-weight construction (but still maintaining load capacities), low-cost design, and better marketing techniques were needed to increase portable timber bridge utilization. This indicates that a low-cost product, combined with intensified marketing efforts, and regulations are needed for increasing the use of portable timber bridges in the logging industry.
Conclusions

AHP analysis indicated that loggers received most new technology information from the companies producing the new technology, followed by trade shows, industry foresters, trade associations, state agencies (foresters), extension personnel, and the WIT personnel. Technology developers preferred the companies producing 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 (foresters). If apparent biased variables were removed from analysis (extension personnel, trade shows, and the WIT Program personnel), this resulted in both groups having identical results. Companies producing new technology was the number one preferred channel, followed by industry foresters, trade associations, and state agencies (foresters). It indicates that companies, industry foresters, and trade associations may be the preferred channels for the transfer of new technology information to the logging industry. In order to successfully transfer technology to the logging industry, utilization of these channels or the information flow diagram will be necessary.

A follow-up study was conducted to discern differences and problems associated with technology transfer participants within the information flow diagram. For important sources in the transfer of technology information in the logging industry, this study indicates that personal contact is the most preferred source among transfer participants, followed by logger education or training programs, trade shows, and trade journal articles. However, there were significant differences between transfer participant groups and most differences occurred at the intermediary level, especially between loggers and
intermediaries. There were no significant differences between loggers and technology developers.

This study identified that there were significant differences between transfer participant groups in terms of important factors in the choice to use, promote, or design portable timber bridge technology. Loggers and transfer intermediaries reported that environmental considerations and regulations were the most important factors in the choice to use and promote portable timber technology. However, technology developers focused on low-cost design and increased performance of products for the industry. Portable timber bridge promoters should consider utilizing both of them as promotional tactics (environmentally-sound and user-friendly product) to increase the utilization of promote portable timber bridges.

This study identified that personal visits were the most effective method for disseminating new information in the industry. There were significant differences between intermediaries and technology developers for effective methods in the dissemination of new information to loggers. Two variables resulted in group separation, the Internet and conferences. Technology developers rated these two variables much higher than intermediaries. This research found that personal computers have been reported by loggers as the second most frequently used technology in logging operations. When personal computers become more popular, the Internet could impact the information transfer process in the logging industry, however, this study found that intermediaries did not recognize the trend.
There were significant differences between technology developers and intermediaries in terms of important factors influencing their decision to disseminate or provide new technology information to loggers. Both groups reported that reduction of environmental damages to the forest and increased adoption of BMP’s regulations were the major factors influencing their decision to disseminate and provide new technology to the industry. However, one variable resulted in group separation, to meet market demand. This variable was rated much higher by technology developers than intermediaries. This indicates that when technology developers design their products, to meet market demand plays an important role in their design processes. However, this factor was not preferred by transfer intermediaries in their decision to disseminate portable timber bridge technology.

In conclusion, the results of this study indicate that differences at the intermediary level (e.g., between intermediaries and loggers, intermediaries and technology developers) may be the major transfer obstacles in the information flow diagram. And the differences found in this study may be one reason that the adoption process of portable timber bridge technology has been slow. In order to successfully transfer technology to the logging industry, technology promoters should notice the differences between transfer participants in the information flow diagram.


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