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**COMPETITIVE DETERMINANTS OF TECHNOLOGY
DIFFUSION IN THE
WOOD HOUSEHOLD FURNITURE INDUSTRY**

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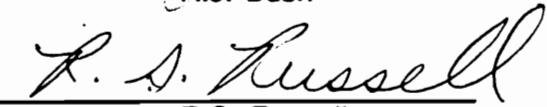
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(ABSTRACT)

Adoption of manufacturing technologies have been cited as an important competitive strategy for successful firms. This study assessed the wood household furniture industry for its current level of technology adoption, examined the impact of competitive variables on technology adoption and strategy formation, as well as, characteristics of innovators or early adopters within the industry. The results provide both insight into the technological direction of this industry and factors influencing the adoption of innovations by industrial organizations.

The U.S. wood household furniture industry was surveyed concerning their recent equipment purchases, future purchase plans, and adoption of a list of 21 innovative technologies. Respondents listed recent equipment purchases within the finish machining area of the mill, particularly with automatic controls, as providing them with the most important benefits of increased efficiency and product quality. Respondents indicated that the functional areas of finish machining and the rough mill will receive the majority of new equipment over the next five years with automatic controls increasing in importance over time.

A competitive-policy contingent model of technology adoption was developed and empirically tested. Innovativeness of firms was accessed by the number of

technologies adopted from a set developed by industry experts. Empirical results suggest that organizational policy is dependent on the competitive conditions under which it was formed and that policy has an important effect on the innovativeness of an organization. Communication variables (signal frequency, cosmopolitanism, and professionalization) were found to exhibit greater direct and indirect effects on innovation than industry structural variables with the exception of firm size.

Characteristics of early adopters were contrasted with those of later adopters of technologies within the furniture industry based upon their adoption of thirteen processing technologies. Early adopters were found to differ significantly from later adopters on firm size, technological expertise, technological progressiveness, opinion leadership, information sources, and cosmopolitanism of the decision making group.

The influence of technology push versus marketing pull strategies on firms was examined in an empirical study. Results of cluster analysis indicate that firms do align themselves along these strategic dimensions and can be contrasted on key characteristics; such as, demographics, company performance and environmental uncertainty.

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PREFACE

This dissertation is divided into two major sections. The first section, or Introductory Section, introduces the research project, reviews applicable literature and presents an overview of the materials and methods. The next four sections are the results written in manuscript format. Each manuscript has been designed for a different journal; therefore, styles and formats may differ and duplication of some information was unavoidable.

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INTRODUCTION

Manufacturing in the United States has experienced a deterioration in competitiveness in the past decade. Scholars have suggested that success in most industries today requires an organizational commitment to compete in the marketplace on technological grounds (Hayes and Abernathy 1980). In other words, to compete over the long run may require offering superior products, increasing product value, offering better customer service, and/or getting new products to the market place ahead of competitors; all made possible through innovative technologies.

Providing the market with a product that is perceived by the consumer as being superior has been termed the "product value concept" (Bennett and Cooper 1981). Product value implies comparison. A higher value product must meet the needs of a consumer better than the competitor's product. Product value is directly determined by its attributes. However, it is the technology behind the design and manufacture of many products that is a major determinant of their attributes, which in turn contributes to creating product value.

Increasing customer satisfaction and the ability to introduce new products to the market ahead of the competition may also be aided by implementing new technologies in processing, product design, and manufacturing control. Automation of the manufacturing process may provide producers with production flexibilities, increased quality control, and the ability to respond quickly to changes in market demand. Introduction of new technologies can certainly be one solution to a manufacturer's competitive problems.

If technology would allow U.S. manufacturing to be more competitive then why is the U.S. lagging behind other nations in implementing these technologies? For

example, the U.S. was behind Europe, Japan and Asia in average annual spending growth for factory automation, during the period of 1982 to 1986 (Pennar 1988). In addition, projected annual spending growth for the U.S. from 1988 to 1992 declines while Asia (including Japan) increases.

The question of why organizations adopt technologies is studied by researchers of technology diffusion. This topic was first studied by sociologists (Rogers 1962). To date, over 3000 diffusion studies have been conducted by various disciplines (Rogers 1983). Although many scholars have studied technology diffusion, very little research which focuses directly on the importance of the competitive environment has been conducted. This research study is particularly interested in how the competitive environment affects technology adoption.

By and large, the U.S. has been a world leader in producing and marketing manufactured goods. However, in the past 20 years this country has experienced increasing competition from other industrial nations rebuilt since WW II. The auto, steel and textile industries are examples, which have been confronted with a competitive challenge from abroad. As a result, these industries have adopted new processing and automation technologies in order to produce a competitive product.

More recently the wood household furniture industry has experienced increased competition from foreign competitors. In 1976, imports claimed 6.6 percent of U.S. consumption of wood household furniture. By 1986, they had reached 22.6 percent of U.S. consumption of wood household furniture according to U.S. Commerce Department statistics (Araman 1987). Because the wood household furniture industry has so recently experienced a drastic change in their competitive environment, it makes an interesting subject for technology diffusion research.

RESEARCH JUSTIFICATION

Importance to the Industry

The response to increased competition has initially been to cut costs by reducing the work force and closing inefficient plants. These practices have definite short term benefits. Once the fat has been trimmed; however, manufacturers must look elsewhere to boost competitiveness. Introduction of innovative technologies usually follows to achieve higher quality goods and services, increased productivity, added flexibility, and reduced inventories and lead times (Pennar 1988; Port, King and Hampton 1988).

The wood household furniture manufacturing industry appears to have arrived at the stage of technology adoption as a competitive solution. Until the past decade, this industry has been insulated from foreign competition because of high transportation costs, a plentiful raw materials base, product quality, and superior knowledge of U.S. markets (Kaiser 1984; Urban 1984; Urban 1985b; U.S. Dept. of commerce 1985). However, innovations in production and shipping techniques employed by overseas competition have eliminated the transportation cost barrier. Furniture which can be shipped in knock-down form and in container loads can be delivered to the U.S. at very reasonable costs. In addition, importers have gained market knowledge using U.S. designers and marketing firms. These advances have allowed foreign suppliers to penetrate the U.S. market especially in the middle price range of wood household furniture (U.S. Dept. of Commerce 1985).

Compounding this problem is the fact that furniture manufacturing is generally a labor intensive process involving a large number of repetitive tasks. The U.S. workforce demands higher wages than many of its foreign competitors, especially Asian importers. This puts the U.S. at a relative disadvantage. This problem is also compounded by the

fact that, in general, U.S. producers are operating with old, outdated equipment. In 1981, Ross Associates, Inc., consulting management engineers, found that the average age of 50-60 percent of woodworking machinery in the U.S. is 25 years or older (Kaiser 1983a). The furniture industry has been slow to adopt such automation technologies as CAD/CAM systems, robotics and automatic processing equipment, introduced in the 1970's.

However, a recent trend has developed in the furniture industry that could help individual manufacturing facilities to finance investment in new manufacturing technologies. Since 1980, this industry has experienced a flurry of mergers and acquisitions (Jaffe 1986). This activity could lead to consolidation of this highly fragmented industry. Larger companies typically have more financial resources with which to invest in capital projects.

There does appear to be an increased interest by furniture manufacturers in adopting new manufacturing technologies. According to Saul (1987), this industry has installed more than twice as many automation systems in the past year and one-half as many it has in the past five years. It is hypothesized that the major thrust behind this interest in adopting new technologies by the furniture industry is a change in the competitive environment due to increased foreign competition and increased economic base due to consolidation of resources.

Marketing Implications

If this hypothesis can be empirically supported, a new approach to studying technology diffusion is proposed. In the past, diffusion research has been interested in how to get a new idea adopted. Researchers have primarily looked at the characteristics of the adopters or the characteristics of the innovation as they have

sought to establish a correlational relationship between them. Diffusion itself has been defined as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 1983, p. 10). An innovation is merely any "idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers 1983, p.11). The newness aspect of an innovation is not measured by the time of its discovery or invention or even the first time an adopter know of it. "Newness" refers to the first time an adopter makes the decision to adopt or reject an innovation (Rogers 1983).

Innovation research is a multi-disciplinary body of inquiry. The predominant fields of study in innovation diffusion have been sociology, political science, economics and industrial engineering (Rogers 1983). Diffusion research has enjoyed wide spread use and application, particularly in the areas of sociology, communication and policy making. Interest by marketing researchers in diffusion began in the 1960's and 1970's (Rogers 1983, p.74). Emphasis by the field of marketing has been placed on the introduction of new products. Because most of this information is proprietary, scholarly access has been restricted. Also, because the sources of the innovations have been close to the research, source bias has been introduced in many marketing studies (Rogers 1983, p.77). As a result, marketing researchers know more about consumer preferences for specific products than about how to advance the theory of innovation diffusion (Hisrich and Peters 1984; Webster 1984).

A major criticism of diffusion research, in general, is that it lacks causality. The focus of diffusion research is to trace the spread of an innovation through a social system over time. There is a general lack of research focusing on understanding the motivations for adopting an innovation. It is often just assumed that economic factors are of primary importance in adopting an innovation, particularly in the private sector,

but they are rarely incorporated as explanatory variables (Rogers 1983, p.99). Therefore, this study takes a closer look at the influence of the competitive environment on the adoption of innovative technologies. Innovations, which can improve productivity and/or result in higher quality goods and services, have the potential to increase an organization's competitiveness.

A study which examines an organization's behavior cannot ignore the strategies or policies, which direct decision making. Of specific interest is which entity within an organization has a major influence on the decision to adopt new manufacturing technologies - technology push or marketing pull. Implications for the firm differ with the force influencing adoption. These differences may be expressed in differing strategies employed by the firm.

An ongoing controversy exists over which of these two forces is the major influence behind technology innovation or adoption. Technological innovation alone is not the ultimate solution to an industry's competitive problems. Market application should be considered when implementing technology or the firm risks wasting resources. However, many argue that over reliance on "the marketing concept" or a market pull approach results only in short term success (Bennett and Cooper 1981; Capon and Glazer 1987; Kiel 1984). Bennett and Cooper (1981) assert that emphasis on a marketing pull strategy to new product development has contributed to the end of true product development by North American companies. They maintain that historically, major technological breakthroughs have occurred more often as the result of technology push.

Technology push is the antithesis of market pull. It occurs when "the ongoing process of science and research produces major technological breakthroughs, independent of market requirements" (Kiel 1984). In other words, "scientific discovery

or the availability of new technology leads to the development of a new product" (Bennett and Cooper 1981). Computerized numerically controlled (CNC) routers and flat line processing provide examples of technology push creating innovative manufacturing machinery that have, in turn, allowed the furniture industry to develop new products. However, this approach to innovation is associated with lengthy innovation periods (Rosenberg 1976). The longer it takes to get a product to market, the greater the risk of failure due to changing market conditions. This is particularly true for the furniture industry. Manufacturers introduce new products and product line changes at furniture shows. Many attend two or more of these shows each year.

Empirical studies on technological innovation clearly show that marketing and related production factors are important influences on innovation (Utterback 1974). Research and development or technology push are very important components of the innovation process. Therefore, those firms incorporating both of these forces have a greater chance to achieve long term success. Bennett and Cooper (1981) suggest a solution to the market pull versus technology push conflict. They term it the "product value" concept. This alternative entails providing the market with a product that is perceived by the consumer as being superior. A product value strategy incorporates technology and engineering with marketing to produce what the market needs and/or desires.

Summary

This study is interested in determining the strength of competition as a force behind innovation adoption and whether technology related or marketing related strategies promote innovative behavior within the wood household furniture industry. The conceptual model this research project utilizes is a modification of the Robertson and

Gatignon (1986) model and incorporates the variables discussed above. The conceptual model for this project is depicted in Figure 1.

OBJECTIVES

- 1. Develop and validate measures and scales for categorizing a firm's level of innovativeness.**
- 2. Investigate the ability of competitive variables to explain variance in the level of technology exhibited in the wood household furniture industry.**
- 3. Investigate the degree to which marketing related forces and technology forces provide the impetus to innovate in the wood furniture industry.**
- 4. Determine characteristics that differentiate between firms employing different levels of technology.**
- 5. Document the degree of technology change in the wood household furniture industry.**

REVIEW OF LITERATURE

Technology Diffusion Theoretical Framework

The first part of this study will address technology diffusion within the wood furniture industry. It has been indicated that the historical diffusion rate of innovations for wood furniture producers is very low resulting in outdated manufacturing systems across the entire industry. Robertson and Gatignon (1986) provide a paradigm for studying the effects of the competitive environment on the diffusion of innovations among organizations. This model is unique in the literature of technology diffusion because it incorporates a competitive framework in the model and considers the influence of the environments of both adopter and supplier. To date, very little empirical research incorporating competitive factors as explanatory variables has been published on diffusion. The following is a review of the variables included within this model.

Supplier Environment

The competitive environment of suppliers directly influences the adoption diffusion process. Robertson and Gatignon propose that both structural characteristics of the industry and the resource commitments of supplier firms are also determinants of the rate of diffusion. Structural characteristics include the competitiveness of the supplier industry, the reputation of supplier firms, the competitive standardization of the technology and the level of vertical coordination. Porter (1980) provides a basis for analyzing industry competitiveness as measured by the number of competitors, the industry concentration ratio and barriers to entry and exit. Benefits from technology standardization have been realized in the furniture industries of Taiwan and Denmark

(Dept. of Commerce 1985). Vertical coordination of the marketing effort increases diffusion but depends on the nature of competition and technical knowledge required (Webster 1984).

Resource commitments by suppliers to R&D and marketing programs positively affect diffusion. Expenditures in R&D have a positive correlation with the innovation process, which leads to enhanced technologies to meet the needs of the industry and expand market potential leading to rapid diffusion (Kamien and Schwartz 1982; Robertson and Gatignon 1986). Both the quality and quantity of marketing effort are critical to the success and adoption of technological innovations (Mansfield, et al. 1977; Webster 1984).

While it is recognized that suppliers have a direct effect on technology diffusion, it is believed that the competitive characteristics of the adopters are most important in the furniture industry. Many excellent suppliers of woodworking equipment and systems exist. In general, woodworking has been standardized for the industry. New technologies are well communicated to furniture manufacturers through several major national and international woodworking supply fairs, trade press publications and other events. For these reasons and because of constraints on the scope of this project, only characteristics of furniture manufacturers (adopters) and their competitive environment were investigated in this study.

Adopter Environment

Characteristics of the adopter industry directly affect innovation adoption and the rate of technology diffusion. The Robertson and Gatignon (1986) model considers two sets of variables- structural and communication factors. Adopter structural factors influencing diffusion include industry homogeneity, competitive intensity and demand

uncertainty. Communication research suggests that a social systems heterogeneity affects the rate of diffusion (Rogers and Shoemaker 1971). Heterogeneity is defined as the degree to which pairs of individuals differ (Rogers 1983). The concept of homophily and its opposite, heterophily, was first called to attention by Lazarsfeld and Merton (1964). When there is a high degree of homophily present, new ideas or innovations do not "trickle down" through the entire social system (Rogers and Shoemaker 1971). At extremely high degrees of heterogeneity, it is difficult for effective communication to occur because the source and receiver do not share a common culture (Rogers and Shoemaker 1971). Therefore, it appears that diffusion of innovations is maximized at some intermediate level of heterogeneity.

Competitive intensity is a measure of the degree of competition within the industry. At some intermediate level, competitive intensity leads to performance that is optimal. Loury (1979) studied this relationship by comparing industrial concentration and firm investment in R&D and found it to be curvilinear. Technological innovation provides a firm with an important mechanism with which to achieve a competitive advantage. Technology may be used to build barriers to entry and establish cost advantages (Porter 1980; Levin 1978).

High degrees of demand uncertainty create more intense competition between firms in an industry (Porter 198). Demand uncertainty or the uncertainty about competitive environment has been investigated by several empirical studies (Baldrige and Burnham 1975; Ettlir 1983; Downey, Helriegel, and Slocum 1975). At a higher level of competition, firms are more likely to adopt innovations where strategy requires new technology for cost reduction or for gaining new market segments.

Adopter communication factors within the diffusion model include signal frequency and clarity, level of professionalism and the cosmopolitanism of the industry. Within the

wood furniture industry, the most important of these is the amount and clarity of signalling which communicates intentions and explanations of production processes, pricing systems and product introductions. Communication openness and information sharing increase information availability and promotes the adoption decision process (Robertson and Gatignon 1986; Shramm and Roberts 1971). Signalling refers to the amount of communication that occurs between competitors (Rogers and Shoemaker 1971). A market signal may be considered "any action by a competitor that provides a direct or indirect indication of its intentions, motives, goals, or internal situation" (Porter 1980, 75). Clarity can be judged as the truthfulness of signals received from a competing firm (Robertson and Gatignon 1986).

Cosmopolitanism is the degree to which an individual's orientation is external to his immediate social system (Rogers 1983). The Iowa hybrid corn innovators that Ryan and Gross (1943) studied were more likely to travel to urban centers than the average farmer. Most studies of cosmopolitanism have been at the individual level (Rogers 1983). However, Robertson and Gatignon (1986) believe that industry cosmopolitanism can be measured by the level of international sales, numbers of markets targeted, and percent of employees who have worked in other industries.

Professionalization has been included as a key variable in many diffusion models (Rogers 1983; Robertson and Gatignon 1986). Professionalization is the amount of social influence transmitted within an industry to the extent that a firm's employees identify with their profession (Ettlie and Bridges 1982). This increases the likelihood of accessing extraorganizational information about innovations (Leonard-Barton 1985).

Traditional Technology Diffusion/Adoption Research

A brief review of the development of technology diffusion research is provided in

this section, particularly as it has been applied to the marketing discipline. There has been quite an interest in diffusion of innovations since the "revolutionary paradigm" for diffusion research was developed by two sociologists, Bryce Ryan and Neal Gross, in the early 1940's (Rogers 1979). Ryan and Gross (1943) published a seminal study of the diffusion of hybrid seed corn among Iowa farmers. Hybrid corn was an important new farm technology introduced to Iowa farmers in the late 1920's that revolutionized agriculture by increasing productivity by 20 percent per acre. Ryan and Gross interviewed 259 farmers living in two small communities. All but 2 of these farmers had adopted hybrid corn between 1928 and 1941. The cumulative adoption rate formed an S-shaped curve over time. Farmers were assigned to adopter categories based on time of adoption of the new seeds. Compared to later adopters, the innovators (first to adopt) had larger sized farms, higher incomes, and more years of formal education (Rogers 1979). From its early roots in rural sociology, diffusion research has grown to be widely recognized and applied. The study of innovation diffusion is actually interdisciplinary in scope. It has been studied and applied by such disciplines as Anthropology, Sociology, Communication, and Public Health; and more recently by Education and Marketing (Rogers 1983). Table 1 lists the kind of topics and units of analyses examined by these various behavioral disciplines. By 1981 over 3000 diffusion publications had been identified (Rogers 1983). The main elements in the "classical model" of diffusion of innovations that emerged from this body of research include: (Rogers 1962, Rogers & Shoemaker 1971, Robertson 1971, Rogers 1983)

1. The innovation, defined as an idea, practice or object perceived as new by the adopter
2. Communication of the innovation through formal or informal channels by individuals

3. The relevant social system of which these individuals are a part
4. The time dimension in the process

The Innovation

Defining an innovation as new is a subjective measure, not meant to be measured by time lapse since its first use or discovery. The "newness" aspect of an innovation may be expressed from the perspective of the company or organization producing or marketing the innovation. Thus, if it is new to the company, it is considered to be "new." This definition ignores whether the product is new to the marketplace. This definition is useful if the objective is to research the impact that production or distribution of a "new" product has on the firm (Schiffman & Kanuk 1983). However, when the objective of the research is to investigate adoption or diffusion of an innovation another approach must be applied.

A product-oriented approach focuses on changes required in the adopter's behavior (including attitudes and beliefs) if the innovation is utilized, not on technical or functional changes in the product. In other words, this framework considers the extent to which a new product is likely to be disruptive to the adopter's behavior. It defines innovations as continuous, dynamically continuous, and discontinuous (Robertson 1967).

1. **Continuous Innovation** has the least disrupting influence on established patterns. Adoption requires only minor changes in behavior. It involves introduction of a modified product, rather than an entirely new one.
2. **Dynamically Continuous Innovation** is more disruptive than a continuous one, but does not alter established behavioral patterns. Adoption requires major change in an area of behavior that is relatively unimportant to the individual. It may involve creation of a new product or the modification of an existing one.

- 3. Discontinuous Innovation** requires establishment of new behavioral patterns. Adoption causes major changes in behavior in an area of importance to the individual or group.

Within another product-oriented framework, the "newness" of a product may be defined in terms of how much impact its physical features or attributes are likely to have on user satisfaction (Donnelly & Etzel 1973). The higher an innovation ranks on the scale of "newness," the more satisfaction the adopter gets from it. Under this framework, products are classified as artificially new, marginally new, or genuinely new. A genuinely new product would have features that satisfy the adopter in ways that differ significantly from that of an older product. A market-oriented approach judges the newness of a product in terms of how much potential exposure adopters have to an innovation. Two market oriented definitions of product innovation have been used quite extensively in consumer studies (Schiffman & Kanuk 1983). A product may be considered "new" if it has not been purchased by more than a relatively small (fixed) percentage of the potential market. Another method of evaluating "newness" of a product is the length of time it has been available on the market.

Both of these market-oriented definitions are subjective. It is left up to the researcher to call the product new. Both of these approaches have been used by consumer researchers in their attempts to study the diffusion of innovations; however, the consumer-oriented approach to defining an innovation depends upon the adopter's perceptions (Rogers & Shoemaker 1971). If a product is judged to be new by a potential adopter, then it is a new product. This approach does not depend on physical features or market realities to define newness. Therefore, since the primary variable of interest in this study is the level of technology of the furniture manufacturing company, this definition of newness will be applied.

The wood household manufacturing process is very complex. The entire process

from treatment of the raw lumber stock through the manufacture of component parts and the assembly and finishing of the final product is ordinarily carried out in the same plant. The level of technology or innovativeness of this segment of the furniture industry cannot be measured merely by the adoption of a single innovation. This is true for many manufacturing processes. Instead, the level of technology must be assessed by adoption (or lack of adoption) of several technologies. Multiple innovations across multiple organizations (furniture companies) were considered for this research project.

Innovation Characteristics Influencing Diffusion

The characteristics of the innovation as perceived by individuals influence the adoption rate. Not all innovations gain widespread acceptance in the same amount of time. Some never do catch on. Diffusion researchers have identified five factors or perceived attributes which affect the rate of diffusion the most (Rogers & Shoemaker 1971, 138-55). All of these factors have been found to have a significant effect on the diffusion process (Rogers & Starfield 1968). These are listed below:

1. **Relative Advantage** This is the degree to which an innovation is perceived as being superior to the one it supercedes or competes within the marketplace. Relative advantage may be measured in economic terms; but, social-prestige factors, convenience, and satisfaction are also often important components (Rogers 1983, 15). Advantage is not an objective measure; it depends extensively on the perception of the members of a given social system. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption.
2. **Compatibility** This refers to the degree to which an innovation is consistent with existing values, experiences, and needs of potential adopters (Rogers 1983). An idea, whose perceived image is not consistent with cultural norms, will diffuse less rapidly than one that is consistent. Also, innovations that are similar to others that have been failures will negatively affect the rate of diffusion (Hisrich & Peters 1984). Prior adoption of a new value system is often required for the adoption of an incompatible innovation.

3. **Complexity** This term refers to the degree of difficulty in understanding or using an innovation (Rogers 1983). Some innovations are readily understood by most members of a social system. Others are more complex and difficult to understand, taking longer to diffuse. Innovations requiring new knowledge will also be adopted more slowly.
4. **Trialability** This is the degree to which an innovation may be tried on a limited basis. The easier it is to have a low-cost or low-risk trial of the innovation, the more rapid the diffusion. An innovation that is trialable represents less uncertainty to the potential adopter, as it is possible to learn by doing (Rogers 1983).
5. **Observability** This may be referred to as communicability. It is the degree to which an innovation's attributes or benefits can be observed or communicated to potential adopters (Rogers 1983). The more visible the results of an innovation, the more likely it is to be adopted. High visibility stimulates discussion of a new idea among members of a social system.

Communication Channels

Communication may be defined as "the process by which participants create and share information with one another in order to reach a mutual understanding" (Rogers 1983, 17). The diffusion process involves interaction between individuals where information regarding an innovation is passed to another individual. Information that is exchanged concerns the new idea or innovation. How quickly an innovation spreads through a social system depends to a great extent on this communication.

A communication channel is "the means by which messages get from one individual to another" (Rogers & Shoemaker 1971). The nature of the information-exchange relationship between individuals determines the conditions under which the innovation is or is not communicated. For this reason, marketing researchers interested in diffusion have paid particular attention to the transmission of product-related information through various channels of communication, and to the impact of the messages and the channels on the adoption or rejection of new products (Schiffman & Kanuk 1983, 509). Mass media channels are the most efficient means

to create awareness and knowledge of an innovation in a large audience of potential adopters. Interpersonal channels (those involving face-to-face exchanges) are more effective in persuading an individual to adopt a new idea (Rogers & Shoemaker 1971).

One major stream of communication research has focused on the relative importance of certain types of information sources on early-versus-later adoption of innovations. The following generalizations derived from the general diffusion literature are important to marketing (Rogers & Shoemaker 1971, 371-375):

1. Early adopters have more change-agent contact (e.g., with salespeople) than later adopters.
2. Early adopters have greater exposure to mass-media communication channels than later adopters.
3. Early adopters seek information about innovations more frequently than later adopters.
4. Early adopters have greater knowledge of innovations than later adopters.
5. Early adopters have a higher degree of opinion leadership than later adopters.

The Social System

The diffusion of innovations takes place within a social system; defined as "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (Rogers 1983, 24). These members or units may be individuals, informal groups, organizations and/or subsystems. A social system may be considered a physical, social, or cultural environment to which people belong and within which they function.

Because diffusion occurs within a social system, the structure of that system affects the innovation's diffusion in several ways. If the social system is "modern" in orientation, the acceptance of innovations is likely to be high. However, if a social system is "traditional" in nature, innovations perceived as infringements on established

custom are likely to be avoided (Rogers & Shoemaker 1971). The following characteristics describe a "modern" social system (Rogers & Shoemaker 1971, 32-33; Hirschman 1980):

1. A positive attitude toward change;
2. An advanced technology and skilled labor force;
3. A general respect for education and science;
4. An emphasis on rational and ordered social relationships rather than on emotional ones;
5. An outreach perspective, in which members of the system frequently interact with outsiders; thus, facilitating the entrance of new ideas into the social system; and,
6. The system's members can readily see themselves in different roles.

Time

Time is an important and fundamental element in the diffusion process. It has been included as a variable in diffusion research in (1) the innovation-decision process (2) the identification of adopter categories, and (3) the rate of diffusion.

The Innovation-Decision Process is the process through which an individual passes from first knowledge of an innovation to a decision to adopt or reject and confirmation of this decision. The five main steps in this process have been conceptualized by Rogers (1983, 20) as the following:

1. Knowledge - occurs when an individual is first aware of an innovation's existence and gains some understanding of how it functions;
2. Persuasion - occurs when the individual adopter forms a favorable or unfavorable opinion of the innovation;
3. Decision - occurs when an individual engages in activities that lead to adoption or rejection of the innovation;
4. Implementation - occurs when the innovation is put to use; and,

5. Confirmation - occurs when an individual seeks confirmation of an innovation decision. The decision may be reversed at this time if conflicting messages about the innovation are received.

The Innovation-Decision process that leads to purchase of a product is an important concept. The average time it takes for a product to be purchased is a good predictor of the overall length of time that will be required for the new product to be diffused through the market (Schiffman & Kanuk 1983). Thus, individual adoption time is an indicator of the total amount of time necessary for an innovation to achieve widespread adoption.

Adopter Categories

Adopter Categories have been derived from the diffusion curve partitioned into categories of adopters over time. The distribution of adoption of any innovation over time has been found to resemble a normal distribution. This is supported by Rogers (1962, 158), who found that in eight different studies adopter distributions all approached normal.

Researchers have found it useful to divide the adopters of any given innovation into five groups based on the relative time at which they adopt (Rogers 1962, 185). Each category is represented as an area under the normal curve that is a specified number of standard deviations from the mean. Thus, the area under the curve is used to determine the percentage of people or units who have adopted in that time span. These adopter categories are defined and described below: (Rogers & Shoemaker 1971, 183-85; Rogers 1983, 248-259)

1. Innovators: The first 2.5 percent to adopt an innovation; described as venturesome risk-takers. They are capable of absorbing the financial and social costs of adopting an unsuccessful innovation, cosmopolitan in outlook and use other innovators as a reference group. They tend to be younger,

better educated, and more socially mobile than their peers. They make extensive use of commercial media, sales personnel, and professional sources in learning of new products.

2. **Early adopters:** The next 13.5 percent to adopt; described as respectable opinion leaders. They tend to be successful, well educated, and somewhat younger than their peers. They are willing to take a calculated risk on an innovation but are also concerned with failure. They utilize commercial and professional information sources.
3. **Early majority:** The next 34 percent to adopt; described as deliberate but cautious. They adopt prior to most of their social group but after the innovation has proven successful with others. They are socially active but seldom are leaders. They tend to be somewhat older, less well educated, and less socially mobile than the early adopters. They rely heavily on interpersonal sources of information.
4. **Late Majority:** The next 34 percent; described as skeptical. They often adopt more in response to social pressures or a decreased availability of the previous product than because of a positive evaluation of the innovation. They tend to be older and have less social status and mobility than those who adopt earlier.
5. **Laggards:** The final 16 percent that adopt; described as traditional. They are locally oriented and engage in limited social interaction. They tend to be relatively dogmatic and oriented toward the past. Innovations are adopted only with reluctance.

This categorization, developed by rural sociologists, assumes a normal curve and that 100 percent of the members of the social system under study will eventually accept the product innovation (Rogers 1962, 152-59). However, it is difficult for these assumptions to be met in most marketing research studies. Categories may be chosen using different percentages or concerned with distinguishing innovators from non-innovators (Hisrich & Peters 1984, 258; Schiffman & Kanuk 1983,512).

The use of any percentage to categorize is strictly arbitrary and chosen for its convenience to the researcher. However, there is not as yet any generally accepted alternative procedure for defining adopter categories (Peterson, 1973; Hisrich & Peters 1984).

Rate of Adoption is the third distinct way that time is involved in the diffusion of

innovations. It is concerned with how long it takes for an innovation to be adopted by members of a social system (Rogers 1983, 23). Most innovations have an s-shaped rate of adoption. The diffusion process appears to follow a similar pattern over time: a period of relatively slow growth followed by a period of rapid growth followed by a final period of slower growth. There is some variation in the slope of the "s" from innovation to innovation. Some new ideas diffuse rapidly and the s-curve is quite steep. Others follow at a slower rate and have an s-curve that is more gradual. There are exceptions to this pattern. In particular, it appears that for continuous innovations; such as, new ready-to-eat cereals, the initial slow growth stage may be skipped (Robertson 1971).

The rate of adoption is usually measured by the length of time required for a certain percentage of the members of a system to adopt an innovation (Rogers 1983, 23). The rate of adoption is measured using an innovation or a system as the unit of analysis.

The Marketing Tradition In Diffusion Research:

Marketing diffusion research came on strong in the 1960's and especially in the 1970's (Rogers 1983, 75). According to Rogers (1983) 10 percent of the total diffusion publications are in marketing. Studies have focused on both consumer and industrial products. However, the majority of these studies are concerned with consumer goods. The interest in this area is due to the introduction of large numbers of consumer products.

Consumer Goods

The adoption process stages have been researched extensively by rural

sociologists. Some consumer research has focused on validating the existence of stages in the adoption of consumer goods. Robertson (1968) found that stages did exist and that innovators and non-innovators responded differently to information in each of these stages. Coleman, Katz, and Manzel (1957) also found that stages did exist in their study of a new drug, Gammanym. However, contrary to rural sociologists findings, personal sources of information were more important at the awareness stage. The existence of stages in the adoption of consumer goods provides insight for the introduction of new products.

Marketing research of innovation diffusion has focused on the correlates relevant to the adoption process for the purpose of profiling consumers based on their time of adoption (e.g. innovators or early adopters) (Rogers 1983; Hisrich & Peters 1984; Schiffman & Kanuk 1983). These studies have found significant differences between innovators, early adopters, later adopters, early majority, and laggards. Major differences have been found in demographic variables; such as, age, occupation, education, income, spouse's employment status, family size, and ethnic group (Bell 1963). Differences found in shopping variables include stores shopped in, amount of product purchased, number of shopping trips, and influence of advertising (Frank & Massy 1963). Social characteristics found to correlate with innovativeness include venturesomeness, social mobility, cosmopolitanism, social integration, social class and perceived risk (Robertson & Kennedy 1968; Popielarz 1967; Ostlund 1971). Adopter categories provide a basis for market segmentation in consumer goods research. When one category significantly differs from another, marketers can develop strategies to reach each segment.

Industrial Goods

Little research has focused on the diffusion process in the purchasing of new industrial products. Two studies support the existence of stages in the industrial product process. Ozanne and Churchill (1971) found some evidence to validate the five-stage adoption model. They also found that personal sources of information were more prevalent in the later stages, a reversal of the findings of previous studies. The second study by Peters and Venkatesan (1973a) also supported the existence of stages. Their study, which involved adoption of a small computer, found personal sources of information were important in all stages.

It appears that most of the research in this area is concerned with identifying significant variables in the industrial adoption process. Robinson, Faris, and Wind (1967) indicated that determinants in the industrial buyer's behavior include psychological and behavioral characteristics, as well as, organizational and environmental variables. They also found that attitude towards the supplier and perceived risk were relevant to new industrial product adoption. Cardozo (1968) found that the buyer's perceived risk and self-confidence, and environmental factors; such as, profit margin, competitive advantage, and type of firm, were related to adoption behavior. Webster (1969) also supports these findings; behavioral variables are important in industrial product diffusion. Peters and Venkatesan (1973b) were able to describe industrial adopters of a small computer by such demographic variables as buyer's education, knowledge of computers and number of prior jobs held.

Theories of Technical Change - Demand Pull and Technology Push

In the economic literature, substantial effort has been made to develop a theoretical framework which describes the prime mover of innovative activity. Two different

approaches have been defined. The first points to market forces as the main determinants of technical change and are generally described as Demand-Pull Theories. The second approach is categorized as Technology-Push Theories which define technology as an "autonomous factor, at least in the short run" (Dosi 1984, 7). The fundamental difference between these two approaches is the role attributed to market signals in directing innovative activity and technical changes.

Demand-Pull Theories

Mowery and Rosenberg (1979) describe the prime mover in Demand-Pull Theories as some supposed "recognition of needs by the production units in the market". Consumers express their preferences about the features of the good they desire through their patterns of demand. As this demand function changes, producers realize the needs of consumers. At this point, the innovation process begins and the successful firms will in the end bring to the market their new/improved goods. The market in turn, continues to monitor their capability to fulfill consumers needs.

There are difficulties with using pure demand-pull theories to explain why innovation occurs. The range of "potential needs" of the market is nearly infinite; therefore, it would be difficult to argue that these would-be demands can explain why at a definite point in time, an innovation occurs (Rosenberg 1976; Mowery and Rosenberg 1979). In addition, demand-pull theory neglects changes over time in which innovative capability does not bear any direct relationship with changing market conditions.

Empirical studies on the determinants of innovation reflect the theoretical ambiguities of demand-pull theories (Mowery and Rosenberg 1979). Most of the studies find that the market is important in determining successful innovations. However, most of the studies with a demand-pull approach failed to produce sufficient evidence that

"needs expressed through market signalling" are prime movers of innovative activity (Mowery and Rosenberg 1979).

The market-pull approach to new product development has also been criticized in practical application by firms. Bennett and Cooper (1981) made initial charges against marketing. They stated that market-pull approaches to product innovation result from the application of the marketing concept by firms. Bennett and Cooper (1981) made one of the initial charges against marketing. They stated that market-pull approaches to product innovation result from the application of the marketing concept-identifying consumers' needs and wants prior to product development. Bennett and Cooper (1981) believe that reliance on the marketing concept, with its market- pull approach to new product development, has contributed to the end of true product innovation. Marketing has been accused of stifling creativity and moving product development toward more cosmetic changes in the product line (Kiel 1984).

Technology-Push Theories

Technology push theories are the antithesis of market-pull theories and are most associated with Phillips (1966). Technology push places major emphasis on the role of underlying scientific knowledge in innovation. Major technological breakthroughs are produced through the ongoing process of science and research, independent of market requirements (Bennett and Cooper 1981).

When applying technology push to an organization, a firm's research staff may be regarded as the initiator of innovations. Advances in basic scientific knowledge are brought to the attention of the organization by the research staff for possible commercialization (Kamien and Schwartz 1982). Application of this scenario to the innovation process implies two things. First, firms that are able to finance a large

research staff are favored over ones that are not. Secondly, the degree of innovative activity within an industry will depend on advances in the scientific base that are applicable to that particular industrial area (Kamien and Schwartz 1982). Industries with a growing scientific base would have more opportunities for developing or improving products or processes.

Difficulties in using technology push theories result from the fact that "economic factors are important in shaping the direction of the innovative process" (Dosi 1984, 11; Bennett and Cooper 1981; Capon and Glazer 1987; Kiel 1984). Empirical studies using technology push models have revealed that there are actually feedbacks between the economic environment and the directions of technical change (Dosi 1984, 11). Therefore, reliance on technology push to explain differences in innovative activity may mask other explanations.

Summary

This study will use the pool of traditional diffusion research as a basis to study technology adoption among manufacturing organizations. The relationships between the competitive environment, organizational policy and technology adoption will be explored within a competitive-policy paradigm. In addition, results of this research will add to the limited empirical knowledge available pertaining to innovation adoption within the industrial sector.

While general adopter characteristics are available for contrast, they are difficult to apply to specific industries not included within these studies. Characteristics will be developed for the wood household furniture industry. To date, few wood products industries have received attention in technology diffusion research.

Finally, the controversy over the influence of technology push versus marketing pull strategies on firms will be empirically studied. There is a running commentary within the literature on the advantages and disadvantages of relying on one set of strategies over the other; however, few studies have tried to empirically contrast firms on the basis of these dimensions.

METHODOLOGY

The purpose of this section is to describe the type of data collected, the sample selection and method of data collection. A brief discussion on the availability and use of secondary data is included. Also included in the methodology section are descriptions of the sample population and details on the method of data collection used.

Secondary Data

Secondary data provided descriptive information on the furniture industry, which aided in development of the questionnaire and aided in data interpretation. The Department of Commerce provided economic and trade information. The American Furniture Manufacturers Association reported marketing trends and industry statistics obtained from its membership through trade journals such as *Wood and Wood Products*, *Furniture Design and Manufacturing*, and *Furniture/Today*.

Sample Design

Sample Frame

The population consisted of U.S. wood household furniture manufacturing firms. This population is defined as those manufacturing companies who are included under the SIC 2511 designation. These manufacturers produce the following categories of furniture: wood living room furniture, library, family room and den furniture (excluding sewing cabinets), wood dining room and kitchen furniture (Excluding cabinets), wood bedroom furniture, infant's and children's wood furniture, wood outdoor furniture and

unpainted, unassembled wood furniture.

According to the U.S. Bureau of the Census (1982) there were approximately 2430 individual manufacturing companies which produce furniture products under SIC 2511. However, only 32 percent of the establishments reporting under this SIC code employ more than twenty persons. An industrial mailing list of 1500 firms served as the primary sample frame. The American Furniture Manufacturers Association membership list and the index of the top 300 furniture manufacturing firms published by *Furniture Design and Manufacturing* were used to verify that the mailing list provided adequate coverage of the industry as measured by value of shipments. It was assumed that missing population elements are minor producers. Omission of these elements should not affect the validity of this research since they would account for a minor proportion of production for the industry.

The population of wood household furniture manufacturers is comprised of many small manufacturing companies. Therefore, it was necessary to sample across the entire population regardless of size. The concentration ratio in this industry is described by Table 2.

Sampling

Because the sample frame is small (2400) and to reduce the risk of missing an important adopter, the sample frame served as the sample. This sampling method may be considered a census, although a complete list of all firms is not available (Adler 1967, 93). A complete list of all firms belonging to an industry rarely exists because of the difficulty of defining an industry precisely. Adler (1967, 93) states that "If a list is otherwise comprehensive and the definition of the industry on which it is based does not differ substantially from that of the research project, it may be adequate for the

purpose of the survey and therefore adopted as the sampling frame."

Data collection consisted of administration of a mail survey directed to the decision making group concerning capital acquisitions. It was determined, through interviews with several manufacturing firms and industry experts, that this group would be headed by the vice president of manufacturing or company president, in the case of small firms. Therefore, surveys were addressed to these persons.

In order to verify that the research instrument was reliable and comprehensive, the survey was evaluated prior to mailing. Virginia Tech faculty members evaluated the questionnaire on its ability to achieve research objectives. Following this evaluation, the survey was pretested by personal interviews on five furniture manufacturers in Virginia, during May of 1989, to determine if any part of the survey caused confusion or proprietary concern.

Because a census is a non probability sample, an assessment of sampling error is precluded. Without some knowledge of the error that can be attributed to a sampling procedure, bounds cannot be placed on estimate precision (Churchill 1987, 435). Therefore, non response bias and/or non sampling error is of primary importance. This is particularly true when the universe is small. Thus particular care was taken to increase the response rate.

The initial response rate for the survey can be increased by a variety of procedure. These included: (1) a guarantee of confidentiality, (2) inclusion of a personalized cover letter, (3) provision of a stamped return envelope, (4) the use of official sponsorship, and (5) a follow up mailing (Dillman, 1978; Jones 1964). The system used to collect data incorporated these recommendations. The procedures used were as follows:

- (1) A personally signed cover letter was attached to the survey instrument identifying the University, detailing the purpose of the research and assuring confidentiality.

- (2) A stamped return envelope was enclosed.
- (3) A separate self addressed and stamped card was enclosed for firms to request a respondents' report summarizing the data collected from the research project.
- (4) A personally signed follow up letter was sent approximately one week after the questionnaire.
- (5) A second questionnaire, with a different signed cover letter, return envelope and report request card was mailed approximately 3 to 4 weeks after the first survey.

Data Collection

The nature of this study is exploratory as it seeks to determine if causal factors affecting technology diffusion in the wood household furniture industry exist. Multi-variable explanations of innovative activity were sought. These include competitive factors, demand pull versus technology push variables, and adopting firm characteristics. Technology was defined as any new continuous or discontinuous process innovation introduced to the industry over the last ten years which may provide cost reductions in production, achieve higher quality goods and services, increase productivity, add flexibility, and/or reduce inventories and leadtimes.

The survey instrument was developed after initial exploratory research was conducted. Because the furniture manufacturing is so complex, exploratory research was conducted to determine those significant processing innovations that had been implemented by this industry in the past ten years. A focus group discussion with several vice presidents of manufacturing and an industry consultant was held at the International Woodworking Machinery and Furniture Supply Fair in Atlanta during August of 1988. This group was asked to list manufacturing technologies that met the criteria of this research project. Follow up interviews with several other manufacturers and

academicians verified and expanded this initial list of technologies.

The sampling instrument, developed after interviews with industry personnel and experts, is included in the appendix.

Dependent Variable - Innovativeness

There are basically four ways by which innovativeness has been measured. Application of these methods have been given considerable discussion by Robertson (1971) and Rogers (1983) in their extensive reviews of diffusion literature research. The following discussion of the applications and merits of these measurements is based on these two reviews.

Judges or Sociometric Method has been used primarily by rural sociologists. This method depends on the competence of experts or judges in determining innovativeness. It is of value in a small social system in which members are well known to each other. This method is subjective in nature and relies on how well the judges know the individuals they are rating and on their own definition of "innovator".

Self-Designated Method asks the individual to indicate whether he perceives himself as an innovator. Respondents may be asked to rate themselves as "earlier," "about the same time," or "later," relative to others in the social system in adopting an innovation. In some cases correlations between this perceived measure and actual behavioral measures have been quite low. Therefore, caution must be taken when using this method.

Longitudinal Method is the most widely used for classifying innovators based on the first X percent of individuals to adopt a new product over time. This method depends on recall for adoption dates. Discrepancies have been found in reported adoption dates and actual dates. The longitudinal method depends on measuring

innovativeness based on adoption of a single item. This reduces validity of the measurement.

Cross-Sectional Method uses an instantaneous categorization along a continuum of number of items adopted (as opposed to a time continuum). This approach applies when a number of innovations within a category can be used to measure innovativeness. The cross-sectional method increases validity in measurement over the longitudinal method since past innovative behavior is indicative of continuing behavior.

For this study, the level of innovation or innovativeness of a firm was measured by adoption of several technological innovations. A set of innovations introduced and adopted by the wood household furniture industry over the past ten years were developed by a focus group discussion and interviews with furniture manufacturing executives and experts. Care was taken to develop a set of technologies that are unambiguous and independent in order to reduce measurement bias.

This technology set was used to measure innovativeness of a firm by applying the cross-sectional method described by Robertson (1971, 90). This measurement methodology uses an instantaneous (versus a time continuum) categorization of a number of innovations adopted at a given point in time. The use of a set of technologies is advantageous since it allows some latitude for individual preference and would therefore be more reliable in arriving at general innovator profiles (Robertson 1971, 91). Therefore, innovativeness for this study was measured by the number of technologies adopted by the firm at the time the questionnaire was administered.

Robertson (Robertson 1971) used the cross-sectional method to measure fashion innovativeness. Only minor differences in the classification of individuals by adopter category when the time factor was incorporated with total ownership of fashion items. They suggest that by choosing items which vary somewhat by degree of newness

(diffusion level) the time dimension should not affect final adopter categorization. Therefore, adopter categories will be developed and tested with and without the time of adoption dimension.

Independent Variables

Industry Heterogeneity: It is hypothesized that communication of new technologies is maximized at an intermediate level of industry heterogeneity. Those attributes of firms in the furniture industry that could be selected for measurement are based on employment, production, and products produced. Measures used to access levels of employment and production asked for number of employees and sales. Questions concerning products produced utilized standard SIC nomenclature.

Competitive Intensity: It is hypothesized that technological adoption is maximized at an intermediate level of competitive intensity. This relationship has been studied by comparing industrial concentration and firm investment in R&D (Loury 1979). This study compares a firm's investment in production equipment and R&D and attitudes towards both R&D and new technology adoption. Opinions and attitudes towards technology policy have been measured by Ettlie and Bridges (1982) using a 5-point Likert response format (strongly disagree to strongly agree).

Demand Uncertainty: It is hypothesized that demand uncertainty is positively related to the acceptance of innovation (Robertson and Gatignon 1986). For the purpose of this study, demand uncertainty was defined as perceived uncertainty about the competitive environment which may stimulate a change in strategy or policy and ultimately lead to innovation (Ettlie 1983). Perceived environmental uncertainty can be measured with the Downey, Hellriegel, and Slocum (1975) modification of the Duncan (1972) instrument which asks respondents to select three of the most important external

environmental factors from a list of thirteen. These three factors are then scaled separately for each of three uncertainty questions - (1) How often is the information adequate for decision making? (2) How difficult is it for the firm to get the minimum information needed in decision making? (3) How difficult is it for the firm to get additional information?

Signal Frequency and Clarity: It is hypothesized that signal frequency and clarity positively affects technology diffusion. This study is interested in the amount of signalling about the adoption and implementation of new technologies by member firms. Comparative research uses an interview format to gather information communication within an industry. However, questions regarding information sources and frequency of use were included based on interview question used by Czepiel (1974) in an investigation of communications involved in industrial buying decisions.

Cosmopolitaness: It is hypothesized that cosmopolitaness of an industry increases access to new information and positively influences the rate of diffusion. Several measures of cosmopolitaness have been suggested by current literature. Travel, especially outside of the country, is cited as an operational way to approximate cosmopolitaness (Ozanne and Churchill 1971). Rogers and Shoemaker (1971) include attendance of out of town professional meeting and hiring of consultants as measures. Cosmopolitaness can be accessed by the level of international sales and percent of employees who have worked in other industries (Robertson and Gatignon 1986).

Professionalization: It is hypothesized that professionalization positively affects technology adoption. For the purpose of this study, professionalization was measured by affiliations with professional associations, such as the American Furniture Manufacturing Association and attendance at trade shows, such as the International Woodworking Machinery and Furniture Fair, and the existence of an internal technical

group.

Technology Push and Demand Pull Measures

Technology push and demand pull factors were investigated as prime movers of innovation and as characterizing different adopter groups. These theoretical relationships have not been as completely researched as those described above. Therefore, this area of the research project is more exploratory in nature as it seeks to discover and describe relationships between level of innovation in the firm and technology push or marketing pull theories.

Technology strategy and marketing strategy have generally not been given formal consideration in diffusion research within the marketing discipline. The specific question under study is whether market pull or technology push is the force behind new process development or adoption. Market pull occurs when buyers' needs are identified prior to new product development, using the marketing concept. Technology push occurs when new processes and products are developed independent of market concerns.

Market oriented decision making is made after the consumers' (buyers') needs have been identified. Bennett and Cooper (1979) first discussed how over reliance on the marketing concept has contributed to the decline of true product innovation by North American companies. Others have, in turn, echoed their beliefs (Mottur 1979; Bennett and Cooper 1981; Hayes and Abernathy 1980; Kiel 1984; Capon and Glazer 1987). Since this is a study of process innovation, it must be pointed out that the product (in this case furniture) is limited by both the designer's imagination and the capabilities of the production system and processes available.

Product modifications and extensions or imitations of competitors' products are used by many marketing oriented companies to insure short term profits (Bennett and

Cooper 1981; Kiel 1984). Market driven new product strategy provides little encouragement for technological discoveries. According to a U.S. Senate report, product strategies which emphasize short term returns do not lead to innovations (Mottur 1979). Under a marketing pull strategy, industrial R&D has become a technical response to requests from the marketing department (Bennett and Cooper 1981). It is this type of marketing oriented R&D strategy that leads to low risk product modifications. For these companies, the result is reflected in low spending levels for R&D versus advertising and promotion.

There are various means by which market requirements can be translated into technological innovation (Kiel 1984; Capon and Glazer 1987). A competitor may develop a technically superior product which then requires a competitive response. Alternatively, increasing price competition in a market may induce a firm to develop or adopt a new process technology to provide substantial cost reductions.

Firms using a marketing pull strategy tend to focus on satisfying market wants using the tools of advertising and promotion (Bennett and Cooper 1979; Hayes and Abernathy 1980; Bennett and Cooper 1981). For these companies, satisfaction of customer needs is the key to their corporation's profitability.

The following set of behaviors that describe a marketing or demand pull orientation were tested:

1. The firm prefers low risk product modification, extension and style changes to new product introduction.
2. Consumers' needs are identified prior to product development.
3. The firm allocates more resources to advertising, selling and promotion than to product development.
4. Process investment is made in response to changes in market demands.
5. New product ideas come from successful offerings of competitors.

Technology oriented companies use the technology push approach to new product and process development. Availability of technology leads to the development of a new product or process. Ideas come from scientists and engineers not from consumers (Bennett and Cooper 1981; Kiel 1984). Technology oriented decision making occurs independent of market requirements.

Support of technological innovation is described by studies about what makes a new product a success (Cooper 1979). Production and technological skills were found to be assets. Characteristics which separated successes from failures included a unique and superior product versus a product extension.

A better and more highly valued product is dependent on the technology which goes into its manufacture and design (Capon and Glazer 1987). This suggests a company with an inward focus on R&D, engineering, design, and production. Such a company tends to coordinate activities of these areas to achieve a more valued product. More effort is spent to develop the product rather than to sell it.

The following set of behaviors that describe a technology oriented company were tested:

1. The firm focuses on new product development not cosmetic changes tot he product or product line.
2. New product ideas come from designers or furniture engineers.
3. The firm invests substantially in process R&D.
4. Market research is used to determine the success of new products not market requirements prior to product development.
5. The firm allocated more resources to product development than to advertising, selling and promotion.

SUMMARY

The chapters that follow describe the results of this body of research. Each chapter provides additional theoretical justification and describes more fully the specific methodology utilized. These are written in manuscript form and cover the objectives of listed earlier. Chapter 2 satisfies Objective 5 by generally evaluating and describing technology adoption and capital equipment purchase plans for the industry. Chapter 3 fulfills Objectives 1 - 3 by empirically determining the effects of competitive and policy variables on technology adoption. Chapter 4 describes characteristics differentiating innovative or early adopters within the wood household furniture industry and thus satisfies Objective 4. Finally, Chapter 5 explores the use of technology-push versus marketing-pull strategies by the furniture industry and fulfills Objective 3.

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Table 1. Type of Diffusion Studies Undertaken by Discipline

<i>Discipline</i>	<i>Number of Diffusion Publications</i>	<i>Typical innovations Studied</i>	<i>Main Unit of Analysis</i>
1. Anthropology	134	Technological ideas (e.g. steel ax)	Tribal or peasant villages
2. Early sociology	10	City manager, government, postage stamps, ham radios	Communities or individuals
3. Rural sociology	791	Mainly agricultural ideas (weed sprays, hybrid seed fertilizers)	Individual farmers in rural communities
4. Education	336	Teaching/learning innovations (e.g. kindergartens, modern math)	School systems, teachers, or administrators
5. Medical sociology	226	Medical and health ideas (e.g. vaccinations, drugs, CAT scanner)	Individuals or organizations like hospitals
6. Communication	372	News events, technological innovations	Individuals or organizations
7. Marketing	304	New products	Individual consumers
8. General sociology	382	Wide variety of new ideas	Individuals
9. Other traditions ¹	500		
TOTAL	3085		

¹ Includes economics, political science, geography, industrial engineering etc.

Source: Rogers (1983)

Table 2. Wood Household Furniture Industry Concentration Estimates

<i>Number of Companies</i>	<i>4 Largest Companies</i>	<i>8 Largest Companies</i>	<i>20 Largest Companies</i>	<i>50 Largest Companies</i>
----- Percent Sales Accounted for By -----				
2430	16	23	37	54

Source: U.S. Department of Commerce (1982)

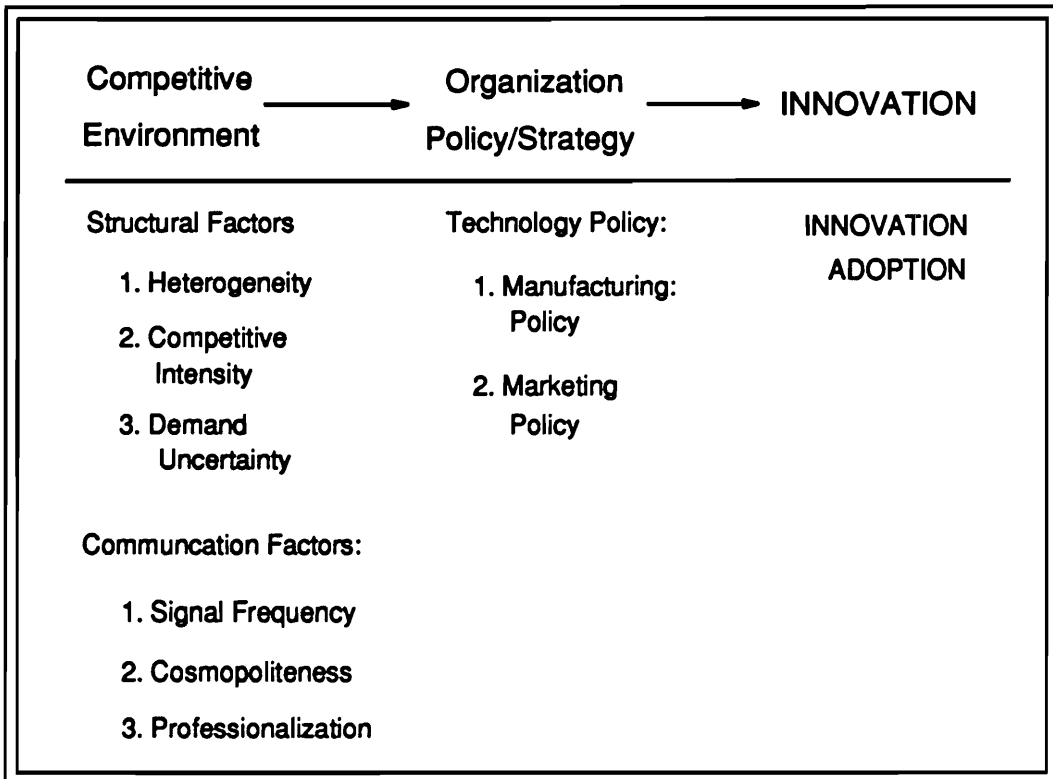


Figure 1. Competitive-Policy Model of Innovation

TECHNOLOGICAL ASSESSMENT OF THE WOOD HOUSEHOLD FURNITURE INDUSTRY

ABSTRACT

Implementation of state-of-the-art technologies is one strategy to increase a firm's competitive position. Innovative manufacturing technologies have the potential to improve product quality, reduce manufacturing costs, and/or provide better customer service. The U.S. wood household furniture industry currently faces stiff competition from abroad. In 1986, imports claimed 22.6 percent of consumption. U.S. furniture producers have been criticized for failing to implement new processing technologies which have the potential to improve their competitive situation. This paper evaluates the technological situation within this industry through primary data collection on technology adoption and equipment purchase plans. Respondents listed recent finish machining equipment purchases as providing them with the most important benefits of increased efficiency and product quality. Almost 50 percent of this equipment was NC or CNC controlled. The functional areas of finish machining and the rough mill will receive the majority of new equipment over the next five years with NC and CNC controls increasing in importance over time. Foreign suppliers were listed as the most likely source for this type of equipment.

INTRODUCTION

Scholars have suggested that success in most industries today requires an organizational commitment to compete in the marketplace on technological grounds (Hayes and Abernathay 1980; Capon and Glazer 1987). In other words, to compete over the long-run may require offering superior products, increasing product value, offering better customer service, and/or getting new products to the marketplace ahead of competitors. Innovation in manufacturing technologies is one means to accomplish this goal (Bennett and Cooper 1981; Kiel 1984).

By and large, the U.S. has been a world leader in producing and marketing manufactured goods (Pennar 1988). However, in the past 20 years, this country has experienced increasing competition from other industrial nations rebuilt since WW II. The auto, steel and textile industries are examples which have been confronted with a competitive challenge from abroad (Anon. 1982; Byrne 1982). As a result, these industries have adopted new processing and automation technologies in order to produce a competitive product (Seamonds 1984; Ramirez 1988; Kuntz 1987).

Until recently the wood household furniture industry has been insulated from foreign competition by high transportation costs, poor knowledge of U.S. markets and weaker product designs (Kaiser 1984b, Urban 1984, Urban 1985a, U.S. Dept. of Commerce 1985a). In 1976, imports claimed only 6.6 percent of U.S consumption of wood household furniture, however, by 1986 they had reached 22.6 percent of consumption (Araman 1987). Innovations in production and shipping techniques employed by overseas competition lowered the transportation cost barrier. Furniture shipped by the container load in knock-down form can be delivered to the U.S. at very reasonable costs. In addition, importers have gained market knowledge using U.S. designers and

marketing firms. These advances have allowed foreign suppliers to penetrate the U.S. market especially in the middle price range of wooden household furniture (U.S. Dept. of Commerce 1985a).

Furniture trade has become more complex and competitive as Third World countries acquire modern production facilities and seek foreign markets. U.S. furniture manufacturers have been criticized in the popular press for allowing facilities and production machinery to become outdated (Anon. 1984; Urban 1985b) and for lacking well planned, effective research and development efforts (Yates 1986). Some believe it is essential that the U.S. furniture industry improve its productivity through automation (Urban 1985b). Other analysts believe U.S. producers can enhance their competitive position by using the best in technology and worker enhancement programs (Kaiser 1984b).

The import situation has made the U.S. furniture industry aware of the need for developing and adopting new manufacturing technologies to increase the value of their products and improve customer service. However, there has not been a comprehensive public domain study evaluating the actual utilization by the industry of available technology or capital purchase intentions. This type of information would provide the industry and others with a competitive assessment on a technological basis and guide equipment developers on the needs of an important wood products industry.

This paper reports on a mail survey, which examined the level of technology currently employed by the wood household furniture industry, as well as short-term and long-term capital investment plans. The results paint a competitive picture of this segment of the furniture industry on technological grounds.

METHODOLOGY

Data collection began with a focus group discussion with several vice presidents of manufacturing and an industry consultant at the International Woodworking Machinery and Furniture Supply Fair in Atlanta during August of 1988. This group was asked to list those manufacturing technologies, introduced over the past ten years, which have been most beneficial to the industry. Interviews with several other manufacturers and academicians verified and expanded the initial list of technologies.

A survey was developed to determine the degree of adoption of this set of technologies and the amount and type of capital equipment investments planned by the industry. The survey was pretested by personal interview on five furniture manufacturers to determine if any part of the survey caused confusion or proprietary concern.

Approximately 2430 firms have been classified by the Bureau of Census in this group of manufacturers under SIC 2511 (U.S. Dept. of Commerce 1985b). However, only 32 percent of the establishments in SIC 2511 employ more than twenty persons. A complete list of manufacturing firms was unavailable, therefore a nation-wide industrial mailing list of 1500 firms served as the sample frame. It was assumed that missing population elements are minor producers. Omission of these elements should not affect the validity of this research since they would account for a minor proportion of production for the industry. The American Furniture Manufacturers Association membership list and the index of the top 300 furniture manufacturing firms published by *Furniture Design and Manufacturing* were used to verify that the mailing list provided adequate coverage of the industry as measured by value of shipments. Two surveys and a follow up letter addressed to the vice president of manufacturing or president of

the company were sent to all 1500 firms over a five week period during May and June of 1989.

Table 1 summarizes the response to the survey. The high rate of companies going out of business is indicative of an industry with many small producers. After adjusting for non-deliverables and firms, which were either out of business or did not produce wood furniture, the response rate for the survey was 20 percent, which is about average for industrial type surveys (Rawnsley 1978, Walker, Kirchman and Conant 1987). Effective coverage for the industry, as measured by sales, is approximately 45 percent.¹

Non-response bias is a concern when using surveys. It is generally believed that later respondents are similar to non-respondents (Churchill 1987). Therefore, to detect the possibility of a non-response bias, respondents responding to the initial survey mailing were compared with those responding to the follow up mailing on key demographic variables and the total number of new technologies adopted. A chi-square goodness-of-fit test was used to determine if the proportion of later respondents falling within each category could be predicted from the proportions of earlier respondents. No significant differences ($p < .05$) were found in the frequency of respondents within the categorical demographic variables of corporate level (e.g. single company or multi-company corporation) or geographic location. Likewise, the Mann-Whitney U test revealed no significant differences in categories of total corporate sales. No significant differences were found in the means of total number of technologies adopted, capital equipment budgets, sales and number of production employees based on a t-test at the

¹The figure of 45 percent was derived by comparing the total 1988 sales for respondents to the 1988 value of shipments reported for the industry of \$8.42 billion (Nolley 1989).

.05 level. While the results of these tests show no evidence of non-response bias in the data, it is clear that a greater proportion of large firms responded to the survey than smaller firms. Since these firms account for a greater proportion of sales and are major investors in capital equipment, this should not present a problem in interpreting the results of this survey. In addition, where appropriate, results are reported across firm size categories.

RESULTS

Respondent Profile

Not surprisingly, the majority of responses (75 percent) came from the areas where furniture manufacturing is concentrated, the Southeast, Northeast and Midwest. Figure 1 provides a geographic breakdown of responses.

The industry is characterized by many small firms and the respondents were similar with 71 percent being single plant companies (Figure 2). A summary of firm size for the respondents is provided by Table 2 using the Bureau of Census production employee size classification system. As expected, firms with less than 20 employees made up almost half of the sample. The average firm size across respondents was 266 production employees, with a median of 30.

Respondents were asked to indicate on a scale of 0 to 10 the average price of the furniture they produced. Few respondents indicated that they produced low end furniture. Figure 3 summarizes responses by average product price. Companies were categorized based on the average price of furniture they produced as low, medium-low, medium, medium-high, and high priced. Table 3 provides average sales values

and firm size for each price group. These figures indicate that the wood household furniture market is dominated by mid-priced furniture, produced by large companies.

Respondents were also asked what type of products they produced and in what form. Factory assembled furniture made up 84 percent of the production of these firms. RTA and knock-down each contributed to 8 percent of production. RTA furniture was defined as "assembled by the final consumer" and knock-down was defined as "assembled prior to sale by a distributor or retailer." The approximate percentage breakdown of the major wood furniture product categories produced by the sample firms is summarized in Figure 4. Furniture products listed under SIC 2511 were used as the basis for categorization. These included: living room/occasional, dining room, bedroom, chairs, desks/secretaries, infant/juvenile, curios and accessories, and wall units. An other category was also provided. On the average, living room, bedroom and dining room accounted for 52 percent of production for all firms. Major differences were seen between very small firms and very large firms. Many of the smaller producers are custom furniture makers or craftsmen, who produce a wide variety of furniture products including kitchen and bath cabinets. Larger firms tend to manufacture products for the three dominant groups of household furniture - living room, dining room and bedroom.

Equipment Purchase and Benefits

Furniture manufacturers were asked about recent equipment purchases and purchase plans to gain insight into what benefits manufacturers sought in processing equipment and the degree of investment in each functional area. Responses were coded using a three digit code (Table 4). The first digit represents a process code indicating manufacturing or functional area of the plant. The second digit indicates the general type of equipment. The last digit is an automation code, specifying whether or

not the equipment is numerically or computer controlled, used to gather information, or to aid the furniture design process. This equipment code was cross tabulated with purchase time frame and firm size.

The manufacturers were first asked to indicate what piece of equipment purchased over the last five years had been the most beneficial to their company and why. Forty percent of the respondents found the greatest benefit from investing in finish machining equipment. Forty-nine percent of this equipment was NC or CNC controlled. The most frequently mentioned benefits derived from this equipment were increased production efficiency (33%) and improvements in product quality (29%). Following finish machining in investment importance were the rough mill (16%), veneer and panel production and processing (14%) and sanding (13%). Increased efficiency appeared to be the most important benefit derived from machinery in the rough mill and in panel production and processing. Both efficiency and quality improvements were the most important benefits gained from investments in the sanding area.

Next, manufacturers were asked to list the three "most needed" pieces of equipment they planned to purchase: (1) over the next twelve months and (2) over the next five years (excluding those listed under twelve months). The most significant results are summarized in Figure 5. It appears that the finish machining area will receive the majority of new equipment during each planning period. The drying, assembly, and packaging and warehousing functions receive the least amount of new investment. The rough mill appears to be second in importance to finish machining. An average of 41-42 percent of equipment purchased in the rough mill will be some type of electronic glue up system for edge glued panels and 44-47 percent will be saws for both purchasing periods.

Only the finish machining area received much attention in the area of automation (numerically or computer controlled) equipment. Figure 6 reveals that approximately 23 percent of individual equipment purchases over the next twelve months will be NC or CNC controlled (based on the three most needed pieces of equipment listed by respondents). This figure indicates an increasing interest in automation by the furniture industry. Even more significant is the increase in planned purchases of automated equipment over the next five years with forty-four percent of the finish machining equipment purchased over the next five years including automated controls.

Respondents were also asked to indicate the most important benefit sought from equipment they planned to purchase within the next twelve months. The three most important benefits are summarized in Table 5 by functional area. Although increasing production capacity and replacement of old equipment were listed as important reasons for capital investment in new manufacturing machinery, two other benefits emerged as very important. These include product quality improvement and increasing production efficiency. In combination, these benefits have the ability to increase product value and in turn a company's competitive position.

Respondents were asked to indicate whether they were likely to purchase new equipment over the next five years from a domestic or foreign supplier. This information was cross tabulated with the appropriate functional area of the mill. The results indicate that a significant proportion of finish machining, panel construction and laminating, and sanding equipment will be purchased from foreign suppliers. Please remember that planned purchases in finish machining equipment represent a major portion of capital equipment investment plans. In addition, an increasing proportion of this equipment will be bought with automated controls. Table 6 shows that the majority of the equipment sales in this area will be claimed by foreign equipment manufacturers. A high

percentage (69 %) of equipment in the area of panel processing will also be purchased from foreign suppliers. Panel saws make up the majority of equipment in this area to be purchased outside the U.S. It appears that equipment needs in other parts of the mill are adequately being met by domestic equipment manufacturers.

Technology Adoption

Twenty-four process technologies were identified through discussion and interviews with manufacturing executives, industry consultants and academicians. This set was determined to be the most important technologies to be introduced and adopted by the industry over the past 10 years.

- Machine vision system
- Robotic palletizer
- Robotics use in finishing
- Membrane press
- Automatic parts finishing system (prior to assembly)
- Die cutting process for parts
- Wrap around/ soft forming/ post forming process
- Laser machining
- Automatic tool changers
- Automatic gang rip system
- Electrostatic finishing system
- Computerized dry kiln
- Automatic cross cut system
- Bar coding
- Computerized back gauges
- CAD system
- Multi-functional numerically controlled (NC) equipment
- Feed through moulders
- Embossing process
- Materials requirements planning (MRP) system
- Electronic glue up system
- Computerized numerically controlled (CNC) equipment
- Single process numerically controlled (NC) equipment
- Wide belt sander

The objective in creating this list was to assess the technological direction of the industry and determine the level of technology of this industry.

Utilization of these technologies by respondents is depicted by Figure 7. As expected, the wide belt sander is the most widely adopted technology. It has been available to manufacturers for a long period of time and is adaptable to a variety of manufacturing situations. NC and CNC equipment have been adopted by a moderate number of manufacturers. Highly automated processes in the rough mill and finishing room have only been adopted by a few. Automation is likely to be concentrated in finish machining in the near future according to the purchase plans indicated by respondents.

As expected, larger firms with the benefits of multiple manufacturing facilities, higher production volumes, and better access to capital markets have adopted a higher proportion of new technologies (Table 7). More than 60 percent of firms with more than 1000 employees have adopted a third of the technologies from the original list. This indicates that, on average, the larger manufacturers enjoy a technological advantage. There is a general trend of increasing adoption for each technology as firm size increases.

Capital Expenditures and Technical Expertise

A distinct pattern of differences emerged from the examination of the data. The very small companies (under ten production employees) can be viewed as custom craftsmen. The very largest companies (over 1000 production employees) are projected as super companies in an industry traditionally skewed to many small and medium sized firms. Reviewing the data on capital expenditures highlighted these differences.

Table 8 summarizes capital expenditures based on firm size. Planned equipment expenditures increase with firm size. Firms with more than 1000 employees spend significantly more on new equipment than smaller firms. However, on an expenditure

per production employee basis there are no significant differences between firm size categories for either budget period. It might be expected that larger firms have substantially greater levels of capital to spend, however, it has also been shown that these firms have spent more on the newer technologies than smaller firms. This type of capital investing could provide a technological advantage for these firms over smaller competitors.

Analysis of R&D expenditures reveals no significant differences in R&D spending between firm size categories. Only 41 of the 226 respondents reported expenditures on manufacturing R&D. These companies averaged \$34,000 in 1988 on R&D. Only the larger firms (over 500 employees) indicated that expenditures in this area would increase in the next year. A possible explanation for this apparent disinterest in manufacturing R&D is that furniture producers leave process innovation and improvements up to the equipment manufacturers. Closer examination of the ratio of R&D expenditures to sales reveals that less than 0.3 percent of sales is invested into R&D.

Respondents were asked for the number of manufacturing engineers and product design engineers they employed. These numbers can be indicators of the technical expertise exhibited by an industry (Ettlie and Bridges 1982). Sixty-seven percent of the sample did not employ any manufacturing engineers and 72 percent did not employ any product design engineers. Over 60 percent of the firms with 100 or more employees indicated they had at least one manufacturing engineer on their staff. On average, firms employed less product design engineers than manufacturing engineers.

The total number of engineers employed by a firm is moderately positively correlated with firm size and number of innovative processing technologies.² It is possible that firms, which employ engineers, possess the expertise to implement the newer, more complex manufacturing technologies.

SUMMARY & CONCLUSIONS

Utilization of new manufacturing technologies can provide a firm with a competitive advantage. In the highly competitive furniture industry, adoption of new technologies may provide firms with the means to recapture market share given up to foreign competitors. The variety of new technologies available to this industry over the past ten years provides a number of ways for a firm to gain technological advantage.

This survey of furniture producers reveals that a current segment of the furniture industry are craftsmen. This group of small individual firms will provide customized, highly crafted furniture for a product/market willing to pay for these services and highly priced products. However, from the larger portion of the industry, it appears that large super companies have emerged which are investing heavily in new processing technologies. On a technological basis, these companies have the potential to lead the industry.

Capital investment intentions across the industry appear to be heaviest in the finish machining manufacturing area. The survey results indicate that purchases of NC or CNC equipment will double in the next five years. Automation can provide

²Pearson correlation coefficient for number of technologies adopted with number of engineers employed is .54 ($p < .001$).

manufacturers the means to increase product value through lowered manufacturing costs and/or increased quality. These advantages were cited by respondents as the most important benefits derived from recent equipment purchases over the past five years. In addition, furniture manufacturers also listed improvements in manufacturing efficiency and product quality as major reasons for capital equipment purchases. Increased product value could enable U.S. firms to regain market share from foreign competitors.

Finally, survey results indicate that firms which employ engineers are more likely to implement new processing technologies. It is likely that firms which possess engineering expertise have an advantage in understanding the complexities of today's new technologies and are more likely to utilize them. Many of the new manufacturing technologies require a higher level of technical support than the standard equipment used in the past. In order to take advantage of new sophisticated processing technologies, the furniture industry must have a workforce with the necessary technical skills.

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Table 1: Questionnaire Response Rate Summary

Non-Deliverables:

Wrong address	38
Out of business	190

Responses:

Out of business	31
Part time custom producer	27
Did not produce wooden furniture	90
Against company policy to respond	3
Provided useable replies	236

Non-Respondents:	886
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TOTAL:	1500
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Table 2. Distribution of Respondents by Firm Size

# Production Employees	Respondents (%)	
0 - 19	96	(43)
20 - 49	36	(16)
50 - 99	21	(10)
100 - 249	21	(10)
250 - 499	23	(10)
500 - 999	15	(7)
1000 +	10	(4)
TOTAL:	222	(100)

Table 3. Respondent Summary of Sales, Employees and Product Price

Price Category	Number of Respondents	Average Sales (millions)	Total Sales (millions)	Average Production Employees
Low	11	8.75	96	141
Med-Low	24	12.63	303	196
Medium	53	37.24	1974	430
Med-High	64	13.70	877	248
High	43	12.35	531	164
TOTAL:	195^a	19.39	3870	270

^a For respondents reporting sales value

Table 4. Equipment Purchase Codes

Process Codes:

- 1 Drying
- 2 Rough mill (including edge gluing)
- 3 Finish machining
- 4 Veneer, laminate and panel construction
- 5 Sanding
- 6 Assembly
- 7 Finishing
- 8 Packaging and warehousing
- 9 Computers and FAX machines
- 0 Other (including capital improvements)

Equipment Codes:

- 0 Not specified or applicable
- 1 Saws
- 2 Cutterheads
- 3 Panels (press and cut)
- 4 Gluing
- 5 Sanding
- 6 Material handling
- 7 Finishing
- 8 Multi-functional
- 9 Quality control

Automation Codes:

- 0 Not specified
- 1 Automated (NC or CNC)
- 2 Information processing
- 3 Design aid

Table 5. Benefits Sought from Equipment Purchases Over Next 12 Months

Functional Area	Benefits	(% responses)
Drying	Quality improvement	(38)
	Increased capacity	(25)
	Replacement	(12)
Rough mill	Increased capacity	(52)
	Replacement	(20)
	Production efficiency	(14)
Finish machining	Increased capacity	(29)
	Quality improvement	(24)
	Production efficiency	(19)
Veneer & panel production/processing	Quality improvement	(37)
	Production efficiency	(27)
	Increased capacity	(19)
Sanding	Increased capacity	(37)
	Quality improvement	(28)
	Replacement	(15)
Assembly	Increased capacity	(67)
	Replacement	(33)
Finishing	Quality improvement	(37)
	Increased capacity	(33)
	Production efficiency	(10)
Packaging & Warehousing	Increased capacity	(50)
	Operator reduction	(50)
Computers	Production control	(29)
	Information	(29)
	Production efficiency	(14)

Table 6. Supplier Preference for Equipment Purchased Over the Next Five Years

Functional Area:	Supplier Selection	
	<i>Domestic</i>	<i>Foreign</i>
	-----%-----	
Drying	100	0
Rough Mill	85	15
Finish Machining (NC or CNC equip.)	53 (35)	47 (65)
Vaneer, Laminates, & Panel construction	31	69
Sanding	50	50
Assembly	100	0
Finishing	100	0
Packaging & Warehousing	100	0
Computers	100	0

Table 7. Utilization of Technologies by Different Sized Firms

Technology	FIRM SIZE (Production employees)												
	1-19	20-49	50-99	100-249	250-499	500-999	1000+	%	(#)	%	(#)	%	(#)
Robotics in finishing	0	3	0	0	4	7	0	0	0	0	0	0	0
Membrane press	1	3	0	0	0	0	0	0	0	0	0	0	0
Automatic parts finishing	0	3	5	0	17	0	0	0	0	0	0	0	10
Dye cutting	1	3	0	0	0	0	0	0	0	0	0	0	40
Wrap/soft/post forming	3	0	0	5	13	7	0	0	0	0	0	0	20
Laser machining	1	0	5	0	9	0	0	0	0	0	0	0	30
Automatic tool changers	3	0	5	9	9	7	0	0	0	0	0	0	0
Automatic gang rip	2	3	9	5	17	0	0	0	0	0	0	0	20
Electrostatic finish	1	3	0	9	13	13	0	0	0	0	0	0	30
Computerized dry kiln	1	6	0	5	0	33	0	0	0	0	0	0	20
CAD system	15	14	9	24	39	33	0	0	0	0	0	0	10
Multiple NC equipment	10	25	29	24	22	33	0	0	0	0	0	0	60
Feed thru moulder	1	11	14	43	43	60	0	0	0	0	0	0	90
Embossing	6	8	24	29	39	87	0	0	0	0	0	0	90
MRP system	8	19	43	48	52	47	0	0	0	0	0	0	60
Electronic glue up	5	17	33	71	48	93	0	0	0	0	0	0	80
CNC equipment	4	23	38	38	78	67	0	0	0	0	0	0	90
Single NC equipment	2	33	48	43	52	55	0	0	0	0	0	0	80
Wide belt sander	41	69	62	76	78	93	0	0	0	0	0	0	100
Group Members:	110	36	21	21	23	15	10						

Table 8. Respondent Summary of Equipment and R&D Expenditures

Firm Size	--Equipment Budget--		----R&D Budget----		\$R&D/\$Sales
	12 month (\$10,000)	5 year (\$10,000)	1988 (\$10,000)	1986-88 (\$10,000)	
< 10	4.7	4.6	0.1	0.6	----
10-99	5.6 [*]	25.7 [*]	2.2	7.8	.005
100-499	41.2 [*]	155.8 [*]	5.1	21.9	.002
500-999	92.0 [*]	421.2 [*]	8.7	28.7	.002
1000+	356.3 ^{**}	1590.0 ^{**}	7.5	120.0	.001
TOTAL:	36.3	154.4	3.4	7.4	.003

^{*} Differences between these groups at $p < .05$ based on Duncan's multiple range test.
^{**} Differs from all groups at $p < .05$ based on Duncan's multiple range test.

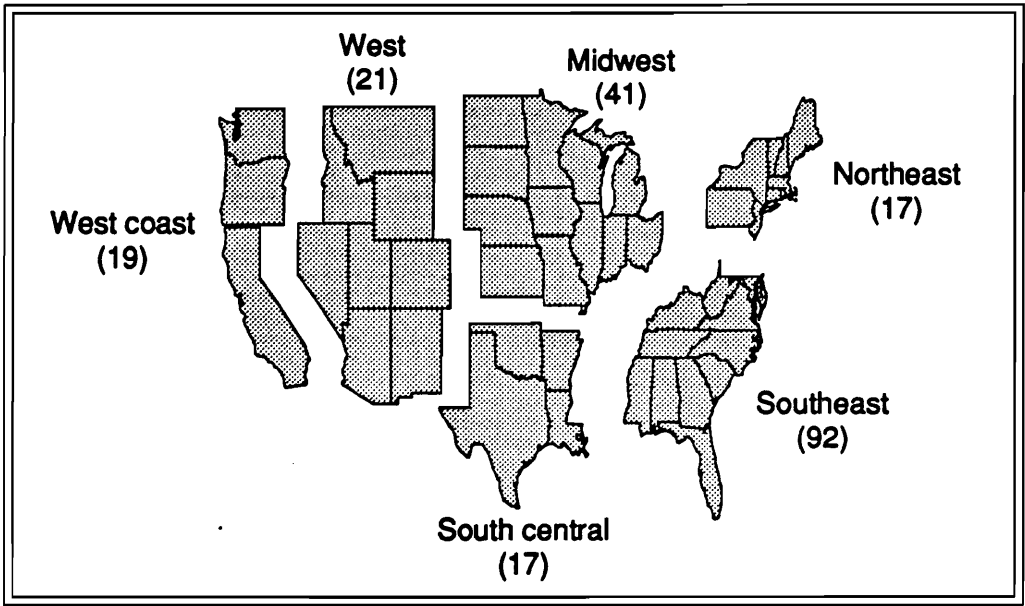


Figure 1: Number of respondents by major facility location

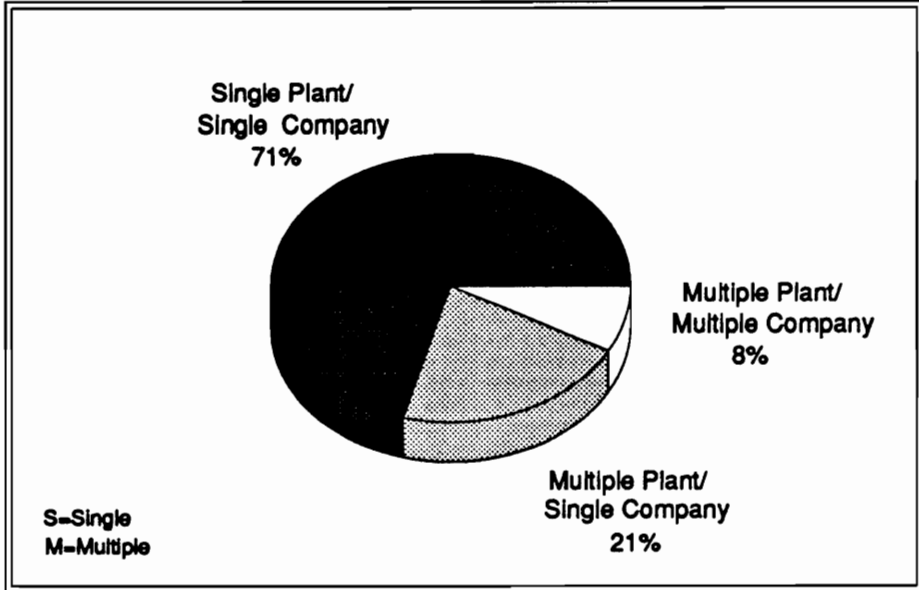


Figure 2: Respondents by company structure

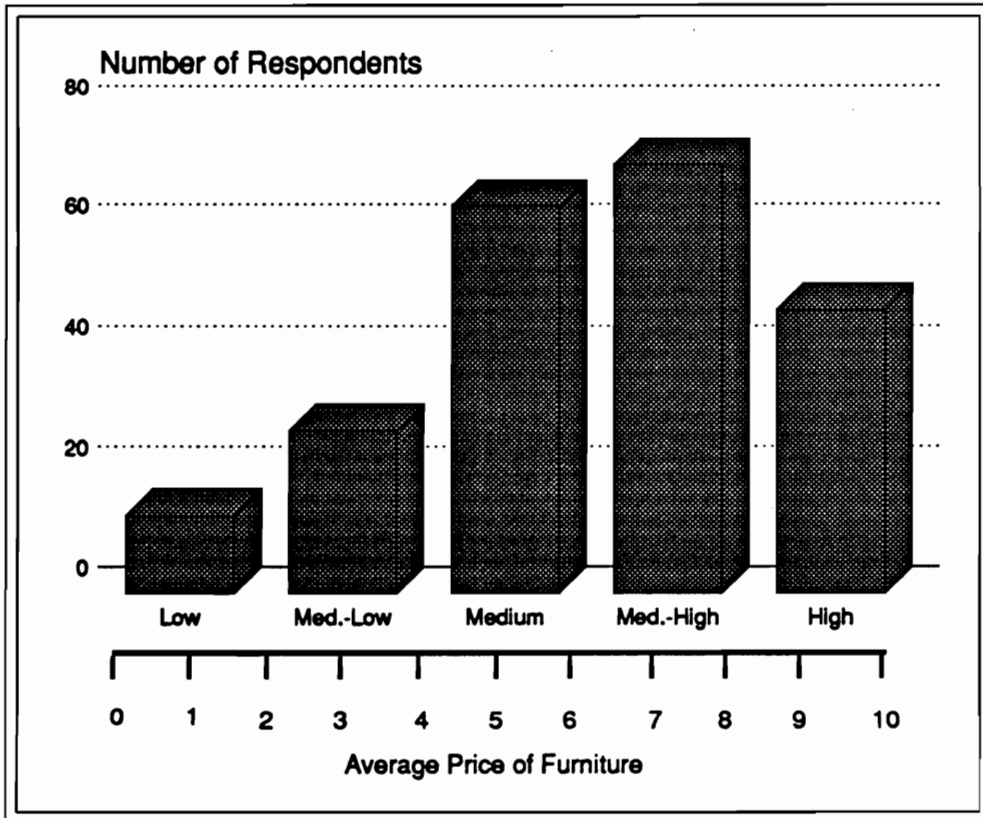


Figure 3: Average scaled price of furniture produced by respondents

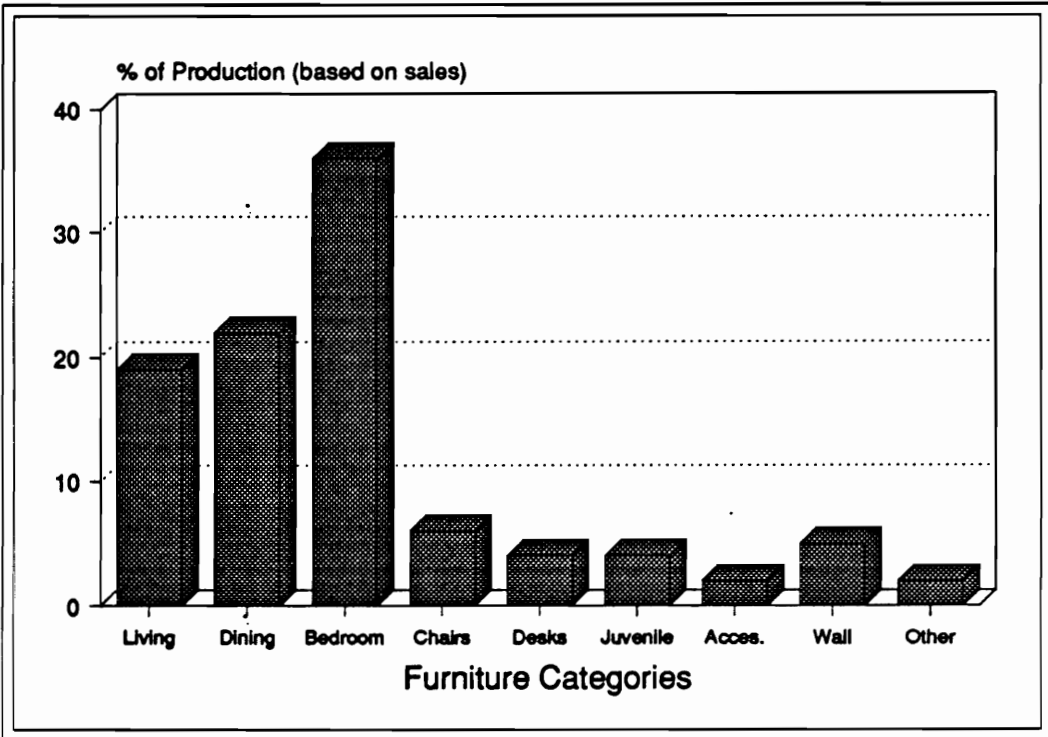


Figure 4: Respondents' average furniture production by product type

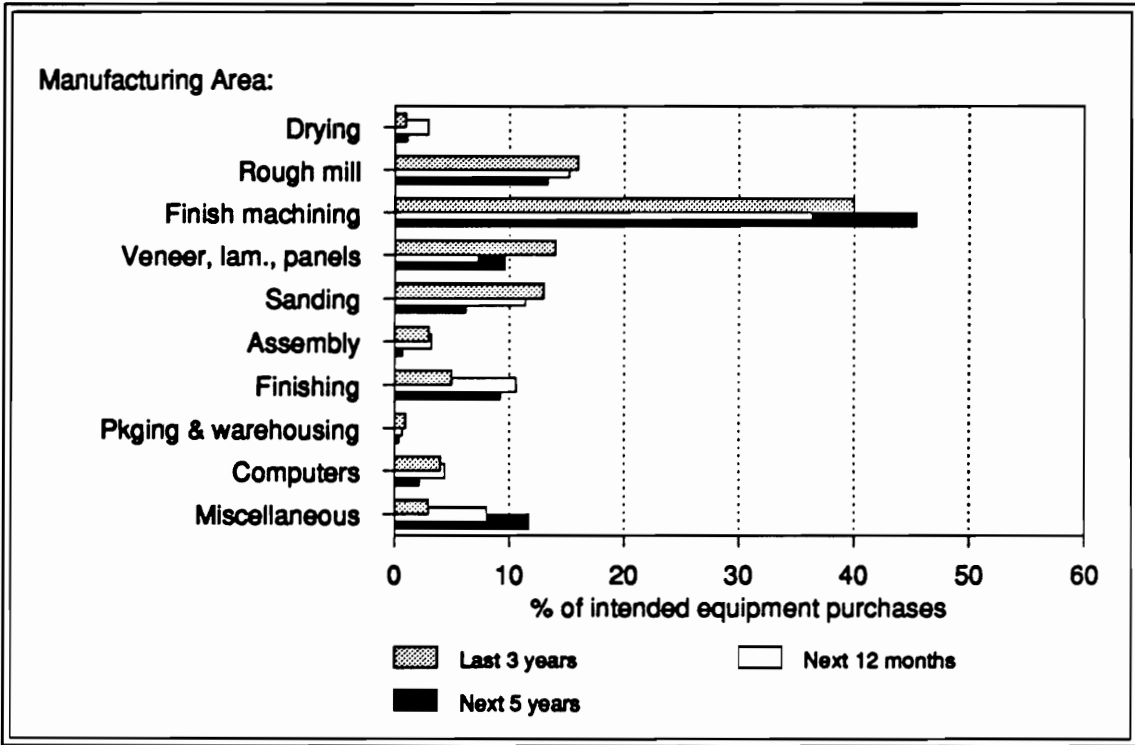


Figure 5: Equipment purchase behavior & plans within manufacturing area

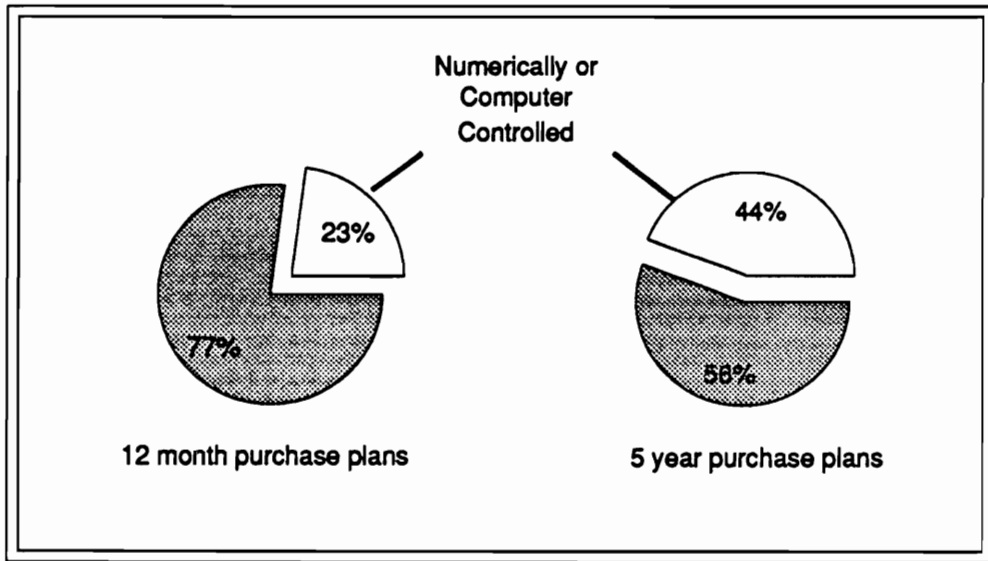


Figure 6: Percent of finish machining equipment planned for purchase with automatic controls

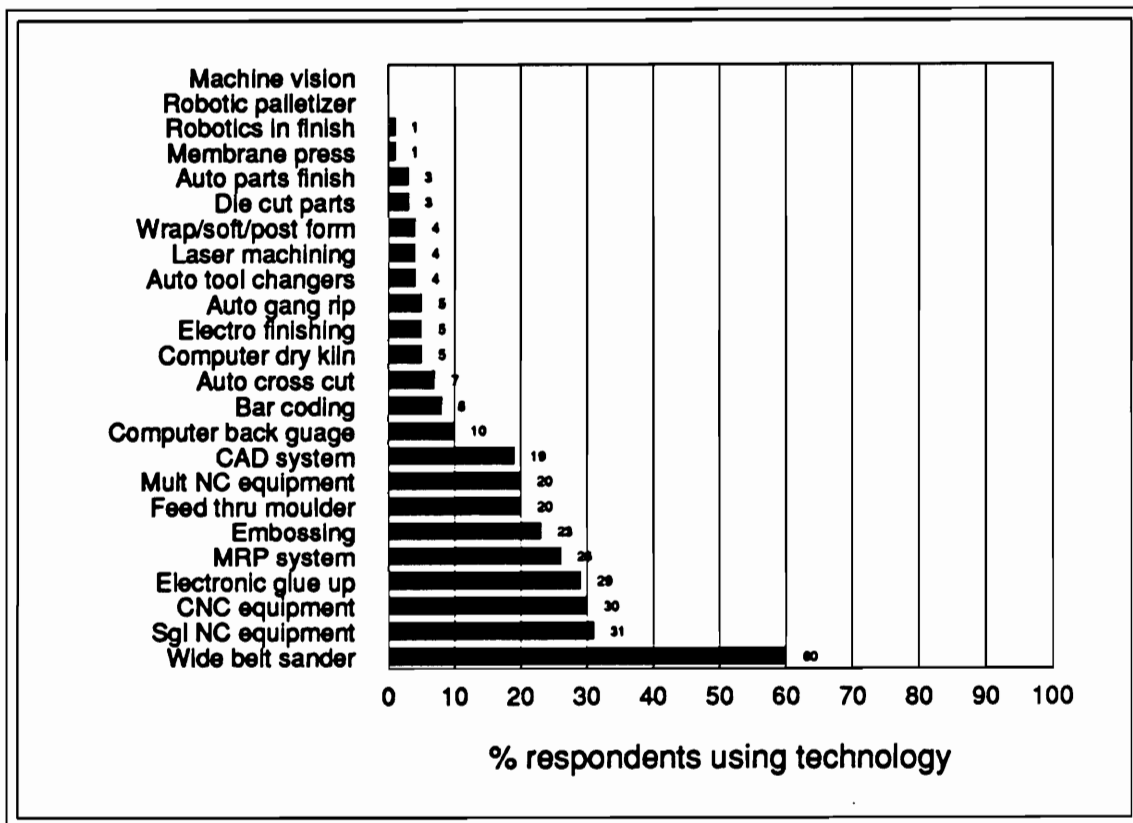


Figure 7: Technology utilization by respondents

COMPETITIVE-POLICY PARADIGM OF TECHNOLOGY ADOPTION

ABSTRACT

Adoption of manufacturing technologies have been cited as an important competitive strategy for successful firms. This paper examines the impact of competitive variables on an aggressive technology policy formation which in turn promotes technology adoption by a manufacturing organization. A recursive path model was used to determine the adequacy of these variables to explain adoption of 23 manufacturing technologies by a sample of firms from the wood household furniture industry.

Results indicate that both manufacturing technology policy and marketing technology policy, analagous to technology push and market pull, are important factors in promoting technology adoption. In addition, for the furniture industry, it appears that communication of adoption intentions by competitive firms and of the availability and advantages of new process technologies helps promote adoption. Firms possessing technical expertise in the form of manufacturing engineers are also more innovative than those without. It is believed that technical expertise is important in interpreting the communications concerning these new processes and in providing assistance during implementation.

INTRODUCTION

The study of technological innovation adoption among organizations has evolved through a multi-disciplinary effort. Within the marketing discipline, the majority of research has been conducted at the individual consumer level while comparatively little research has been focused on adoption of technological innovations by industrial organizations. It has been recognized that the process of diffusion of innovations in industrial markets is both a social influence process among the various participants in the using industry and an economic process in which costs, revenues, market structure and competitive conditions are altered (Webster 1984; Ozanne & Churchill 1971; Rogers 1983; Robertson & Gatignon 1986). These two sets of factors have generally been described by Robertson and Gatignon (1986) as communication and structural factors within the competitive environment of the adopting industry.

To the extent that competitive variables and industrial adoption of technological innovations have been studied, the results have been interpreted as the result of some overall strategic policy within that firm (Ettlie & Bridges 1982; Ettlie, Bridges and O'Keefe 1984; Zmud 1984). However, few attempts have been made to explain and empirically test this relationship.

In addition, adoption of new technologies by organizations differ from that of individual consumers. No one person in an organization is likely to assume full responsibility for the adoption decision and implementation, especially when a major technological innovation is being proposed. Diverse groups within a firm exist which are likely to influence adoption decisions, and their power to direct the decision making influence is likely to also be expressed at the policy level.

This article seeks to explore the relationships between industrial adoption of new technologies, competitive factors, and technology policy of the firm by: (1) employing a causal model of relationships, (2) deriving and applying a valid measure of innovativeness, (3) and assessing the innovativeness of a single, highly competitive industry. Our underlying purpose is to advance industrial adoption research by studying a combination of factors which are important to technology adoption and suggesting an operational model for exploring the exceedingly complex process of technology adoption within an organization.

CONCEPTUAL FRAMEWORK

Robertson and Gatignon (1986) consolidated a variety of competitive factors into a single paradigm for studying the effects of the competitive environment on the adoption of innovations among organizations. This competitive model examines how both the supply-side competitive environment and the adopter-side competitive environment affect innovation diffusion. Their model was developed to extend the extant conceptualization for technological diffusion research within marketing at the organizational level since empirical research, from a behavioral perspective, has almost totally ignored competitive factors (Robertson and Gatignon 1986). The model forms a theoretical base from which to empirically examine organizational acceptance of new technologies.

Two sets of adopter competitive factors, communication factors and structural factors, are included in the adoption model proposed by Robertson and Gatignon (1986). Adopter structural factors influencing diffusion include industry homogeneity,

competitive intensity, and demand uncertainty. Adopter communication factors include signal frequency and clarity, level of professionalism and the cosmopolitanism of the industry. The relationship between technology adoption and the adopter variables of competitive intensity, demand uncertainty and communication openness was examined in an empirical test of this model across several industries (Gatignon and Robertson 1989). The characteristic factors examined within the adopter industry received limited confirmation. Industry concentration and competitive price intensity were investigated under the broader construct of competitive intensity. It was found that the greater the concentration ratio of the industry, the more likely the adoption. The negative relationship hypothesized between competitive price intensity and adoption was also supported. However, the expected positive relationship between adoption and higher demand uncertainty and higher communication openness was not confirmed.

The relative innovativeness of a firm has been interpreted as the result of some overall strategic policy within that firm (Ettlie and Bridges 1982; Ettlie, Bridges and O'Keefe 1984; Zmud 1984). It was found that a global measure of perceived environmental uncertainty had a significant effect on firm innovativeness when it was mediated by an aggressive technology policy for major process innovations (Ettlie and Bridges 1982). In another study of the organizational innovation process, environmental uncertainty and organization size were shown to be directly related to organizational policy formation which in turn promoted innovation (Ettlie 1983).

The focus of this study is to incorporate these organizational policy variables into a policy contingent competitive model of technology adoption for adopting firms. The organizing framework of this study views innovation within an organization as dependent upon strategic policy as influenced by the competitive environment. The model is described in Figure 1 and consists of three categories of factors, the competitive

environment, strategic policy, and innovation. In this model, it is hypothesized that the competitive environment causes strategic policy which influences technology adoption or lack of adoption which may help to explain the limited findings concerning the adopter variables examined by Gatignon and Robertson (1989).

This study examines adoption of multiple technologies across organizations within a single industry while that of Gatignon and Robertson (1989) examined adoption of a single technology, a laptop computer, by the salesforce across several industries. Examination of multiple manufacturing technologies offers an advantage over the adoption of a single technology. Assessment of technology adoption across multiple innovations provides a better estimate of an organization's general pattern of adoption or innovativeness. Strategic variables will be limited to technology policy related to manufacturing and marketing functions within the firm.

Organizational Policy

Findings in a number of adoption and diffusion studies have been interpreted as reflecting the importance of an organization's strategic policy on its relative innovativeness (Ettlie and Bridges 1982). Bessant (1982) concluded that a variety of policy related factors influence adoption of manufacturing innovation, such as the presence of technically-oriented management, effective planning and control of projects, an innovation strategy which includes a portfolio of projects ranging from short-term maintenance to long-term projects, and consideration of training policies. Rosenbloom & Abernathy (1982) explored the existence of policy factors that may have systematically influenced the innovative vitality of U.S. firms in the consumer electronics industry during the post World War II period. Case studies of leaders in this industry revealed that corporate strategy, shaped by managerial attitudes, influenced

technological superiority and market leadership within this industry more frequently than external or macroeconomic factors such as inflation, industry structure, government regulation, etc. Zmud (1984) generally related managerial attitudes to company policy in a study of the adoption of six technical innovations in which top management attitudes and organizational receptivity toward change were generally found to positively influence the acceptance of technical innovations.

Despite discussion of the role of policy related variables in the diffusion process, only a few studies have made systematic attempts to specify *a priori*, strategic factors or tendencies that influence the rate of adoption of innovations.

Ettlie (1973) found the commitment of the organization to the concept of computer aided manufacturing, and not necessarily the attitude toward the particular machine or supplier of the innovation, to be the best correlate of degree of implementation success of numerically controlled machine tools. It was also found that "in very successful installations of this new manufacturing process technology , plans were made even before a relatively productive steady state had been reached to continue expanding the scope of impact and number of pieces of equipment in the organization".

Romeo (1977) reports that competitive pressures in an industry seem to lead to high rates of diffusion of numerically controlled manufacturing technology. McFachern and Romeo (1978) show that when dominant control of the firm is in the hands of outside stockholder interest, more of the firm's resources tend to be allocated to R&D to protect market position. Mansfield and Wagner (1975) found that integration of R&D and marketing functions had a positive impact on commercial success of new products.

Ettlie and Bridges (1982) described and empirically tested the mediating effect of technology policy on the innovative activity of 54 organizations. Within this study, technology policy was described as an organization's long-range strategic plan that

affects the development or adoption of innovations. It was found that perceived environmental uncertainty significantly influenced the adoption of major process innovations through an aggressive technology policy. In another study, Ettlie (1983) found technology policy to promote introduction of radical process innovations by equipment and packaging suppliers to the food processing industry.

Technology policy may be thought of as a subset of organizational policy reflecting innovative means to achieve company goals. It includes process, product and administrative technology strategies. In the previous studies, technology policy has been given empirical consideration under the overall umbrella of organizational policy. However, it has been pointed out that marketing policy should be included in this discussion (Capon and Glazer, 1987; Hayes and Abernathy, 1980; Mowery and Rosenberg, 1979). It has been found that the innovation process is more effective when market need and technological opportunities are integrated at the organizational level of analysis (Mansfield and Wagner 1975).

In fact, an ongoing controversy exists over whether market demand or technology push exerts the dominant influence upon the adoption of innovations. The relationship between the marketing efforts of supplier firms and diffusion of new products or processes has been given limited empirical attention. However, little attention has been given to the empirical treatment of market influences on the adoption of process innovations, although, the process has direct impact on the product a company produces. In a critical review of the role of market demand and technology push factors in technology change, Mowery and Rosenberg (1979) criticize exclusive preoccupation with only one set of these forces and conclude that both demand and supply side influences are crucial to understanding the innovation process.

In general, there seems to exist both theoretical and empirical support for a positive relationship between an aggressive technology policy and technology adoption within organizations. It appears that technology policy may arise from technology related factors within the firm and/or market related or economic derived factors within the market place. The relative importance of these factors would vary among firms, depending on company strategies and managerial attitudes, however, the following general relationship may be proposed:

Proposition 1. An aggressive technology policy promotes technology adoption within organizations.

The following sets of structural and communication variables, proposed by Robertson and Gatignon (1986), are generally descriptive of the competitive environment. They will be investigated for their ability to influence technology adoption through technology policy associated with the manufacturing and marketing functions of the firm.

Competitive Structural Factors

Industry heterogeneity

Communication research suggests that a social system's heterogeneity affects the rate of diffusion (Rogers and Shoemaker 1971). Heterogeneity can be defined as the degree to which pairs of individuals differ (Rogers 1983). However, heterogeneity can also refer to differences between firms or plants, and to the differing conditions under which a single product is manufactured. Because of the heterogeneity of inputs and outputs and because of the possibility of different technological approaches to production, it is possible to find vastly different types of firms coexisting (and prospering) in the same industry (Rosegger 1980, p.75). These differences concern

both the size of firms and plants and the degree of specialization or diversity in production. For example, there may be a few large firms succeeding with low-cost mass production of products; a group of medium-sized firms capitalizing on differentiated products and technologies; and another group of small firms which manage to succeed by producing products with special features on a small scale.

Of the various features mentioned above that may be used to describe industry heterogeneity, size has consistently been found to be positively related to innovation adoption (Mansfield 1963; Mohr, 1969; Baldrige and Burnham, 1975; Armour and Teece, 1980). Large firms are generally believed to be more innovative because of slack resources, access to capital markets, and organizational structure (Rogers, 1983). Increasing firm size necessitates integration of organizational functions within a formal organizational structure to harness resources and foster efficiency. A highly integrated firm will tend to promote an effective structure, climate and planning process that makes it successful with technological innovation and adoption (Souder 1977; Souder 1983; Shrivastava and Souder 1987).

Proposition 2: Increasing firm size generally promotes technology adoption and an aggressive technology policy.

Competitive Intensity

Intense rivalry between firms has been attributed to several interactive structural factors: numerous or equally balanced competitors, slow industry growth, high fixed or storage costs, and lack of product differentiation (Porter 1980). Potential competitors present a major source of uncertainty for the firm. Increasing number of competitors increases uncertainty regarding the continued success of current product; uncertainty about competing innovations and uncertainty about profitability (Kamien and Schwartz

1982). Therefore, acceptance of technological innovation by an industry may be particularly important in achieving or maintaining competitive advantage.

The number of companies competing in a firm's product/market appears to influence adoption of technology adoption. Nasbeth and Ray (1974) tentatively concluded that the dispersion of the brick industry accounted for differences in adoption of tunnel kilns among six countries under investigation. Those industries exhibiting many small competitors were slower to adopt than industries with relatively few competitors. However, few competitors in a product/market with large market shares allow participants to more closely monitor each other's competitive moves and firms are more likely to have the financial resources which to innovate than firms in product/markets with many competitors and small market shares (Davies 1979; Dosi 1984). Loury (1979) found that at some intermediate level of competitive intensity, performance was optimized when he compared industrial concentration and investment in R&D. Therefore, it is believed that the relationship between competitive intensity and innovation receptivity is curvilinear and maximized at some optimal point, much like the relationship described by Loury (1979).

Proposition 3: Increasing number of perceived competitors in a firm's product/market generally promotes an aggressive technology policy and technology adoption to a maximum point.

Demand Uncertainty

Uncertainty about a firm's competitive environment has been studied using multi-scaled measures (Duncan 1972; Downey, Hellriegel, and Slocum 1975; Baldrige and Burnham 1975; Ettlie 1983). Environmental variability and change encourages adoption of innovations by organizations by causing increased uncertainty about demand and

supply of scarce resources (Baldrige and Burnham 1975). Ettlie (1983) found that at higher levels of uncertainty, firms are more likely to adopt innovations where strategy requires new technology for cost reduction or for gaining new market segments.

Demand uncertainty is a component of environmental uncertainty as proposed by Lawrence and Lorsch (1967) and Duncan (1972). Difficulty in predicting demand is expected to increase a firm's feeling of vulnerability making it more susceptible to innovation as it seeks competitive advantage (Robertson and Gatignon 1986). Therefore, uncertainty in predicting demand may stimulate innovation adoption particularly when a firm's strategy requires product quality improvement, cost reductions or new market development.

Proposition 4: Demand uncertainty is positively associated with an aggressive technology policy and technological adoption.

Competitive Communication Factors

Signal Frequency

Communication in industrial markets focuses on the relationship and influences among firms in the market for the innovation and is motivated by a search for relative advantage by those firms (Webster 1968; Webster 1971). Purchasing decisions for major industrial innovations involve a large amount of risk for most firms which is related to capital investment requirements for the innovation. Information seeking and opinion leadership serve to reduce perceived risk and promote adoption (Lancaster and White 1979).

For the potential adopter, information sources are used to reduce uncertainty and risk. The quality of information is directly related to the credibility of the source, content and presentation (Czepial 1974). Therefore as risk increases, the buyer is

likely to turn to those who have had experience with the product or are experts in the field, since they are perceived to be more trustworthy and objective than the innovation supplier. Both word of mouth activity and opinion leadership are attempts to overcome the deficiencies of information provided by the supplier. Communication openness and information sharing increase information availability which is likely to reduce perceived risk and promote innovation acceptance (Shramm and Roberts 1971). In general, it would also be expected that communication of intentions and explanations of production processes and opinion leadership would support a strong manufacturing technology policy within a firm.

Proposition 5: Communication between firms concerning adoption intentions and experiences of process innovations promotes an aggressive technology policy and technology adoption.

Cosmopolitanism

Cosmopolitanism is the degree to which an individual's orientation is external to his immediate social system (Rogers 1983). It has been widely recognized in diffusion research that innovators are more likely to have reference groups outside rather than within their social system (Rogers 1983). They are more likely to travel widely and become involved in issues outside a local social system. The Iowa hybrid corn innovators that Ryan and Gross (1943) studied were more likely to travel to urban centers than the average farmer. It was also shown that innovators within the medical profession were more likely to exhibit cosmopolitan traits (Coleman, Katz and Menzel, 1966; Kimberly and Evanisko, 1981; Robertson and Wind 1983).

Most studies of cosmopolitanism have been at the individual level. Robertson and Wind (1983) point out that it is important to assess cosmopolitanism for the relevant

participants concerned with purchase decision making in the organization. Robertson and Gatignon (1986) believe that industry cosmopolitanism can be accessed by the level of international sales, number of markets targeted, and percent of employees who have worked in other industries.

Proposition 6: Increasing cosmopolitanism of members of the decision making organization promotes an aggressive technology policy and the adoption of technologies.

Professionalization

Professionalization has been included as a key variable in diffusion models (Rogers, 1983; Robertson and Gatignon, 1986). Professionalization is the amount of social influence transmitted within an industry to the extent that a firm's employees identify with their profession (Ettlie and Bridges 1982). This increases the likelihood of accessing extraorganizational information about innovations (Leonard-Barton 1985).

Proposition 7: Increasing professionalization of members of the decision making organization promotes an aggressive technology policy and the adoption of technologies.

In addition, it has been found that firms possessing internal technical expertise are more innovative than firms without such expertise (Bigoness and Perreault, Jr. 1981). Organizations with a technical engineering group or managers with technical expertise are better able to recognize and evaluate communications concerning the appropriateness to their firm of new process innovations. Their technical expertise also enables a firm to overcome implementation problems connected with the innovation.

Proposition 8: Firms possessing engineering expertise are more likely to support an aggressive technology policy and promote the adoption of innovations than firms without this expertise.

RESEARCH METHODS

The Industry

The wood household furniture industry was selected for study because of recent changes in its competitive structure vis-a-vis international competitors. This industry is highly fragmented with several large multi-plant corporations at the top and many small single plant firms at the lower end of the size distribution. Because of the large number of firms in this industry, it can be characterized as highly competitive. The extent of competition is further increased by the rapid rise in imports. In 1976, imports claimed only 6.6 percent of U.S. consumption of wood household furniture, however, by 1986 they had reached 22.6 percent of consumption (Araman 1987).

Historically, the furniture industry has been characterized by labor intensive production techniques and a dismal record of productivity advances (U.S. Dept. of Commerce 1985). Because of the massive increase in imports, the industry is under pressure to increase its production efficiency. Traditionally, machinery suppliers have dominated the innovation process. However, furniture firms have a greatly expanded set of opportunities to lower production costs and increase product quality because of the development of new processing technologies (Cox 1990; Evans 1988; Society of Manufacturing Engineers 1987).

Sampling

The wood household furniture industry is the object of this study, as discussed above. Data was collected from a mail survey directed towards top executives identified as key decision makers in the capital acquisition process of the firms. The

firms included in the study comprise a census of 1500 manufacturers developed from an industrial mailing list and the American Furniture Manufacturing Association's membership list. The survey was pretested prior to mailing on a small group of manufacturers followed by a personal interview to determine if any parts of the survey caused confusion or proprietary concern. After adjusting for non-deliverables, the response rate for the mail survey was approximately 20 percent, which is about average for industrial type surveys (Rawnsley 1978; Walker, Kirchman and Conant 1987). However, effective coverage for the industry, as measured by sales, is approximately 45 percent.¹

To detect the possibility of a non-response bias, respondents of the initial survey mailing were compared with those responding to the follow up mailing on key demographic variables and the total number of new technologies adopted. A chi-square goodness-of-fit test was used to determine if the proportions of later respondents falling within each category could be predicted from the proportions of earlier respondents. No significant differences ($p < .05$) were found in the frequency of respondents within the categorical demographic variables of corporate level (e.g. single company or multi-company corporation) or geographic location. Likewise, the Mann-Whitney U test revealed no significant differences in categories of total corporate sales. T-tests showed no differences in the means of total number of technologies adopted, capital equipment budgets, sales and number of production employees at the .05 level. While the results of these tests show no evidence of non-response bias in the data, it is clear that a greater proportion of large firms responded to the survey

¹ The figure of 45 percent was derived by comparing the 1988 value of shipments reported by the respondents to the industry total of \$8.42 billion (Nolley 1989).

than smaller firms. However, since these firms account for a greater proportion of sales and are major investors in capital equipment, this should not present a problem in interpreting the results of this survey.

Dependent Measure

For the purpose of this study, the term innovativeness refers to "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system" (Rogers 1983, 22). This definition is commonly used in the area of diffusion research. In this case, diffusion is concerned with the relative adoption of manufacturing technologies by organizations. Although the term 'technology' is usually taken to denote the set of physical processes, methods, techniques, tools and equipment by which products are made or services rendered, this study is primarily concerned with manufacturing technology in the wood household furniture industry.

A composite measure of manufacturing innovativeness was developed as suggested by Bigoness and Perreault (1981) to insure that the innovativeness domain is adequately specified and homogeneous. Studies employing a single innovation as the criterion for innovativeness have been criticized because the adoption of a single innovation may be idiosyncratic and, therefore, not a representative measure of innovativeness in general (Mohr, 1969; Walker, 1969; Bigoness and Perreault, Jr. 1981). An organization may be innovative with respect to a certain area of production technology which it uses, but may not be innovative at all in other areas. Therefore, a firm that may be identified as innovative in one study might logically be termed non-innovative in a concurrent study concerned with a different innovation.

Different types of innovations exhibit different diffusion patterns (Rogers 1983), therefore, it follows that an organization's general innovativeness will be a function of its adoption across a number of innovations. However, studies based on traditional composite scores of innovativeness inappropriately assume that different innovations are homogeneous (Downs and Mohr 1976). To develop a reliable and valid measure of innovativeness, it has been suggested that the homogeneity and representativeness of the items sampled must first be appraised (Bigoness and Perreault, Jr. 1981).

A set of new manufacturing technologies currently available to furniture producers and potentially representative of innovativeness within this industry were initially identified. Twenty-three process technologies were initially identified through discussions and interviews with manufacturing executives, industry consultants and academicians. This set was determined to contain the most important technologies to be introduced and adopted by the industry over the past 10 years. Respondents were asked to indicate if they had implemented any of these technologies. The frequency of adoption of each of these products was computed. Two technologies that had been adopted by none of the firms were deleted from the initial set.

Correlations were computed for the remaining 21 innovations to determine the extent to which the adoption of one innovation was related to the adoption of the other innovations. Innovations with negative correlations were perceived to be inconsistent with the innovation domain described by the other innovations and would violate the homogeneity assumption. Negative correlations would suggest that the innovation's adoption was idiosyncratic and/or not generally applicable across the industry referenced for study.

After applying this criterion, 13 innovations remained and were used to compute a summative innovativeness scale. The scale was evaluated for reliability and internal

validity. Table 1 summarizes the statistics relevant to this analysis. The interproduct correlations are all positive and not too large, suggesting that they depict a generalized pattern of manufacturing innovativeness. The innovations are neither adopted as sets nor directly complementary. In addition, this subset of technologies on which the total innovativeness score is based is internally consistent. The Kudar-Richardson (1937) KR-20 estimate of reliability is .78 indicating that the innovations are homogeneous.

Independent Measures

The measures for the study are reported in Table 2. Most variables were assessed by using multi-item measures and the alpha coefficients are reasonable.

Policy Constructs

A 21-item scale with a balanced 5-point response format (strongly agree to strongly disagree) was used to evaluate policy variables. Ten items concerning technology and manufacturing policy were adopted from Ettlé and Bridges (1982). Measures for a technology oriented marketing policy were suggested largely by the theoretical works of Bennett and Cooper (1981), Capon and Glazer (1987), and Kiel (1984). A factor analysis, using Principle components, of the 21 scale items resulted in three meaningful factors approximated by 15 of the items (Table 3). The first factor to emerge is termed General Technology Policy with a Chronbach alpha of .73. It includes five general questions on whether technical groups within the firm routinely participate in decision making. The second factor represents manufacturing technology policy with a Chronbach alpha of .68 on four items concerning a tradition of using the newest process technologies. The final meaningful factor to emerge is comprised of six items with a Chronbach alpha of .65. It is termed Marketing Technology and

includes questions on new product development and recruiting the best technical and marketing personnel available. A total of 4 factors emerged with eigen values greater than one and that explained approximately 60 percent of the variance. The fourth factor was dropped because only two variables loaded on it and it lacked interpretation. The scores are summed for each policy scale with a high score representing an aggressive technology policy.

Structural Factors

Firm size was measured by the number of production employees. *Competitive intensity* is a measure of the degree of competition within an industry. It is a reflection of the number of competitors within a firm's product/market and the degree of uncertainty associated with a firm's competitors. Therefore, competitive intensity was measured by the number of perceived competitors in a firm's primary market and by the competitor uncertainty subscale of the Downey, Hellriegel and Slocum (1975) adaptation of the Duncan (1972) instrument. *Demand uncertainty* or difficulty in predicting demand was also measured using Downey, et al. (1975) subscale for uncertainty in decision making concerning both final consumers of furniture products as well as furniture distributors and retailers.

Communication Factors

Signal frequency was measured using items to assess the amount of information received by a firm from a variety of sources concerning new process technologies. Each item used a 5-choice Likert scale (Never to Always). *Cosmopolitanism* within an industrial organization may be expressed as the degree to which decision makers have opportunities to gather information outside their particular industrial environment.

Therefore, cosmopolitanism for key decision makers was accessed by measuring international travel and participation in professional meetings outside the furniture industry. *Professionalization* pertaining to the amount of extraorganizational information about new technologies accessed by decision makers within the furniture industry was measured by membership to professional organizations. Membership to professional organizations provides decision makers with opportunities to attend professional meetings and receive information through organization publications. Internal technical expertise, another dimension of professionalization, increases an organization's ability to recognize and evaluate the information it receives concerning new processes. This dimension was measured by the number of manufacturing engineers employed by the firm.

Analysis

The data was analyzed using path analysis, a recursive causal modeling technique which allows examination of the causal processes underlying industrial organization adoption of new process technologies. Path coefficients reported are standardized regression coefficients estimated by ordinary least squares. The model in Figure 2 is over-identified with only those variables retained in each equation up to the point where the adjusted R begins to decline. This selection criterion results in the inclusion of some paths that are nonsignificant. A goodness-of-fit test for the overall restricted model, however, was performed (Land 1973) with the resulting Chi-square statistic indicating a satisfactory fit of model data (fail to reject, $p > .5$).

For the purpose of this analysis, firm size, competitive intensity, demand uncertainty, signal frequency, cosmopolitanism, and professionalization were considered exogenous to the system. Correlations between these variables have been omitted

from the model, but can be obtained from Table 4, which reports the correlations, means and standard deviations of the variables specified in the model. Relationships between the endogenous variables, innovativeness, general technology policy, manufacturing technology policy, and marketing technology policy, were treated recursively with innovativeness regarded as dependent on the technology policy variables.

RESULTS

A major criticism of technology adoption studies has been that results are difficult to generalize to specific industries and situations. Therefore, the study results reported here will address both the general application of the model as well as its explanatory power of technology adoption within the wood household furniture industry. This industry may be characterized as a mature industry that is generally labor intensive and highly competitive, with frequent new product introductions and strongly influenced by fashion.

Proposition 1, regarding the influence of technology policy to promote technology adoption, is supported. Although three of the exogenous variables exhibit direct influence on innovativeness of the firm, half of the variance in technology adoption explained by this model is accounted for by the policy variables. In addition, it appears that the influence of the exogenous variables is strongly mediated by technology policy.

Increasing firm size, Proposition 2, has a strong positive direct effect ($\beta=0.36$, $p<.01$), and indirect effect on technology adoption through manufacturing technology policy ($\beta=0.49$, $p<.05$). However, it would initially appear that firm size has a

confounding negative effect on innovativeness mediated by general technology policy and marketing technology policy. This result can be explained within the context of the industry. Larger firms generally have the capital assets to invest in expensive new process technology which in many cases requires long production runs to justify high fixed costs. Therefore, these firms are less likely to introduce many radically new products which may, at least initially, require short production runs.

Proposition 3, concerning competitive intensity, is not supported within this industry, which should not be surprising. The wood household furniture industry is not highly concentrated. Many firms make up this industry and competitive intensity is generally considered high by most producers. Therefore, it would be unlikely that this variable would differentiate between different levels of innovativeness or technology policy.

Turning to Proposition 4, demand uncertainty appears to weakly promote technology adoption through marketing technology policy. Uncertainty about consumers (actual users) of the furniture product is positively associated with marketing technology policy ($\beta=0.18$, $p<.05$), while uncertainty about retailers and distributors of furniture is positively associated with general technology policy ($\beta=.018$, $p<.10$). Although small, it appears that uncertainty about actual consumers has a stronger indirect effect on innovativeness than uncertainty about retailers and distributors. Considering that furniture sales are subject to fashion trends and disposable income, it is not surprising that a high degree of demand uncertainty exists for many firms in this industry that is non-differentiating.

Proposition 5 is strongly supported by the results. Communication within the furniture industry concerning new process technologies promotes innovativeness directly ($\beta=.22$, $p<.01$) and indirectly through an aggressive technology policy ($\beta=0.37$, $p<.01$). It is most likely that communication openness and information sharing promotes

innovation acceptance by reducing the perceived risk of a new process while communication of adoption intentions by competitive firms encourages an aggressive technology policy.

Increasing cosmopolitanism of members of the decision making group promotes the adoption of new technologies through an intervening technology policy variable, supporting Proposition 6. Increasing levels of international travel ($\beta=0.36, p<.01$) and attendance at professional meetings outside the furniture industry ($\beta=0.28, p<.05$) are both positively associated with an aggressive technology policy.

Proposition 7 concerning the relationship between professionalization and innovativeness is supported. Membership in professional organizations is positively related to technology policy through both the manufacturing technology policy ($\beta=0.23, p<.05$) and marketing technology policy ($\beta=0.17, p<.10$) and indirectly promotes technology adoption through these variables.

Finally, Proposition 8 is strongly supported. Possession of engineering expertise is directly and positively related to innovativeness, ($\beta=0.22, p<.01$).

In addition, engineering expertise indirectly promotes innovativeness through general technology policy ($\beta=0.33, p<.05$) and marketing technology policy ($\beta=0.39, p<.01$). Technical expertise allows firms to recognize and evaluate communications concerning new process technologies and to facilitate implementation.

SUMMARY AND FUTURE RESEARCH

The major intent of this paper was to gain a better understanding of technology adoption by industrial organizations through the application of an appropriate model of technology adoption by organizations. A competitive policy contingent model was proposed for the study of adoption of process innovations. The overall results of this study provide support for inclusion of policy level variables within organizational technology adoption models. The overall results of this study suggests that organizational policy is dependent on the competitive conditions under which it was formed and that policy has an important effect on the innovativeness of an organization. While support for the relationship between organizational strategy and adoption of manufacturing technologies was found, it was not overwhelming. It is felt that the lack of strong support is not due to the existence of these relationships but in the measurement of them. It seems that development of better measures for the various dimensions of organizational policy would improve model results. The management literature is abundant with ideas for pursuing these measures.

In addition, the results provide a better understanding of the motivation of organization adoption by examining organization forces underlying process innovation. These forces are both complex and varied. Two of these, the marketing function and the manufacturing function, were examined within the narrow context of technology policy. The results of this study indicate that marketing technology policy or the firm's strategy to compete by introducing new products, as opposed to modifications or copies, and by entering new markets, has a slightly stronger influence on technology adoption than manufacturing technology adoption. The furniture industry is a mature industry with a market driven product. Therefore, it appears that the desire to compete with a new

or better value product provides more incentive to innovate than the desire to have the newest manufacturing technologies available.

Communication variables are found to exhibit greater direct and indirect affects on innovation than industry structural variables for the furniture industry. It is not surprising that in a highly competitive mature industry where competitive intensity and demand uncertainty are high for most firms that communication of intentions and process adoption is important. In particular, for this industry the amount of signalling or communication concerning new process adoption intentions and experiences coupled with the technical personnel to interpret this information and provide implementation support are very important to successful technology adoption. However, only perceived competitive characteristics were measured. It was assumed that innovative behavior is in response to the perceived competitive environment. It may benefit future research to use objective measures of actual competitive conditions as well as perceived characteristics.

The findings of this study are based on a composite measure of innovativeness utilizing a cross-sectional methodology. It is felt that this type of general measure of innovativeness is superior to a single adoption criteria because it accounts for variations in individual adoption patterns and conditions. The results should thus be more generalizable and not specific to the conditions of any single innovation adoption.

The organizational forces that underlie process innovation are both complex and varied. Our current understanding of these behaviors is increasing but remains at a general level. As the context within which innovations are examined becomes more specific, however, the understanding of organizational innovation becomes incomplete. Therefore, more complete research models with a wider spectrum of organizational

contexts and comparable research designs are required before robust models of innovation behaviors begin to emerge.

MANAGEMENT IMPLICATIONS

There are three major interpretive conclusions of these results which have managerial implications concerning technology adoption for a highly fragmented and competitive industry, like the furniture industry. First, both manufacturing and marketing forces within the firm provide impetus to innovate and should be given consideration within the context of a firm's technology strategy. The results of this study indicate that the market influences technology decisions to a somewhat greater extent than production. However, the results also indicate that innovative firms consider long term investment in new process technologies to be of critical importance to their firm. Considering the competitive nature of this industry, it would seem that those firms who are guided by marketing to obtain technological advantage will be in the best position to both protect and enhance competitive position.

Second, it appears to be very important for firms to take advantage of various sources of communication concerning competitive intentions and the availability and advantages of new process technologies available. Communication sources should not be limited to domestic producers or organizations. Understanding the international business climate and operation can assist domestic producers in developing effective competitive strategies against imports and to expand their own market beyond the U.S. In addition, there are numerous sources of information outside the furniture industry

concerning new processing technologies, such as professional engineering organizations and foreign equipment manufacturers.

Finally, the results of this study make it apparent that firms with technical expertise in the form of manufacturing engineers are in the best position to innovate. Therefore, it would certainly benefit the industry to advocate for training of technical personnel and hiring of professional engineers. Operation of many of the new processing technologies available are beyond the skills of the average hourly worker. Additional training of workers will be necessary to take full advantage of these technologies and mechanisms should be put in place to help producers re-train their workers. It will also be essential for managers to understand the application and potential of new technologies.

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Table 1. Relationships Among Different Manufacturing Processes

Process	Interproduct Correlations ¹													Percent Adopting		
	1	2	3	4	5	6	7	8	9	10	11	12	13			
1. Computer aided design	1.00															19%
2. NC equipment	.17	1.00														31%
3. CNC equipment	.30	.69	1.00													30%
4. Embossing process	.13	.21	.30	1.00												23%
5. Computerized back guages	.10	.22	.24	.21	1.00											10%
6. Automatic cross cut system	.01	.09	.26	.20	.20	1.00										7%
7. Electrostatic finishing	-.01	.07	.13	.18	.19	.10	1.00									5%
8. Wide belt sander	.09	.25	.28	.20	.19	.04	.15	1.00								60%
9. Electronic glue up system	.08	.32	.42	.34	.28	.07	.13	.37	1.00							29%
10. Computerized dry kiln	.05	.07	.08	.23	.19	.02	.23	.15	.23	1.00						5%
11. Feed-through moulder	.14	.39	.49	.31	.36	<.01	.25	.34	.58	.20	1.00					20%
12. Bar coding system	.06	.12	.25	.28	.28	.31	.16	.04	.18	.08	.10	1.00				8%
13. MRP system	.19	.24	.40	.31	.11	.21	.06	.16	.37	.10	.21	.24	1.00			26%

¹. These correlations suggest the extent to which the adoption of one process is predictive of the adoption of another process and are based on phi coefficients.

Table 2. SUMMARY OF MEASURES

VARIABLE	CHRONBACH ALPHA	MEASURE ITEMS	SUPPORTING LITERATURE
Policy Technology Policy	.73	Most of our development projects are based on ideas FROME technical staff in R&D or production. (EXPERT3) In our firm, production (operations) people have a big say in critical decisions. (EXPERT4) In our firm, a representative of R&D signs off on all development projects. (EXPERT5) In our firm, a representative of production signs off on all development projects. (EXPERT6)	Ettlie & Bridges (1982) Ettlie (1983)
Manufacturing Policy	.68	Our company believes it is important to use the most up-to-date production (operations) technologies available. (RD1) We are willing to make plant floor space available for experimentation with new equipment. (RD2) In spite of market uncertainties, we are going ahead with plans to evaluate new equipment. (RD3) Our manufacturing organization tries to be the first in our industry to implement new production technologies and methods. (RD4)	Ettlie & Bridges (1982) Ettlie (1983)
Marketing Policy	.65	Our firm focuses on new product development rather than modification to our current products and product lines. (NEWPROD) We are actively engaged in a campaign to recruit the best qualified marketing personnel available. (EXPERT2) Our firm believes that truly new product design ideas come from furniture designers and engineers not consumers. (DESIGN) We actively recruit the best qualified technical personnel available (production and engineering). (EXPERT1) Our firm uses market research primarily to determine the success of new products. (MKTRES)	Bennett & Cooper (1981) Capon & Glazer (1987) Kiel (1984)
Structural Factors Firm Size		Number of production employees	
Competitive Intensity: (1) Number of competitors		Number of perceived competitors in a firm's primary market	

Table 2 -cont.

(2) Competitive uncertainty	.96	<p>How often do you believe that information available to you about competitors for customers is adequate for decision making?</p> <p>How difficult is it for your firm to get the minimum necessary information about competitors for customers for decision making?</p> <p>How difficult is it for your firm to obtain additional information (above the minimum necessary) about competitors for customers when you need the information for decision making?</p>	<p>Downey, Hellriegel, & Slocum (1975) Ettlie & Bridges (1982)</p>
<p>Demand Uncertainty: (1) Consumers</p>	.96	<p>How often do you believe that information available to you about consumers (actual users) of your firm's products is adequate for decision making?</p> <p>How difficult is it for your firm to get the minimum necessary information about consumers of your firm's products for decision making?</p> <p>How difficult is it for your firm to obtain additional information (above the minimum necessary) about consumers of your products when you need the information for decision making?</p>	<p>Downey, Hellriegel, & Slocum (1975) Ettlie & Bridges (1982)</p>
(2) Retailers & Distributors	.97	<p>How often do you believe that information available to you about furniture retailers or distributors is adequate for decision making?</p> <p>How difficult is it for your firm to get the minimum necessary information about furniture retailers or distributors for decision making?</p> <p>How difficult is it for your firm to obtain additional information (above the minimum necessary) about furniture retailers or distributors when you need the information for decision making?</p>	<p>Downey, Hellriegel, & Slocum (1975) Ettlie & Bridges (1982)</p>
<p>Communication Factors Signal Frequency</p>	.88	<p>When deciding to purchase a piece of equipment, how often do you rely on the following sources for information?</p> <ol style="list-style-type: none"> (1) Advertising in trade journals (2) Trade/equipment shows (3) Manufacturer or dealer's sales personnel (4) Other manufacturers' experience <p>During your initial search for information on a new process or piece of equipment how often do you contact competitive firms for information?</p>	<p>Moriarty & Spekman (1984)</p>

Table 2 - cont.

Cosmopolitanness:	
(1) Travel	How often do other competitive firms contact you for information concerning a process or innovation that you have adopted? Ozanne & Churchill (1971)
(2) Professional meetings	How many times do you and/or your staff typically travel outside of the country on business each year? Ozanne & Churchill (1971)
Professionalization:	
(1) Professional memberships	How many out of town business meetings or professional association meetings (other than furniture markets, trade shows and association meetings) do you and/or your staff attend per year? Robertson & Wind (1983)
(2) Technical expertise	Please list the professional and trade associations you are a member of. Ozanne & Churchill (1971) Leonard-Barton (1985) Bigoness & Perreault (1981)
	How many manufacturing (process) engineers does your firm employ? Ozanne & Churchill (1971)

Table 3. Factor Loadings for Policy Variables¹

Variable ²	Factor 1	Factor 2	Factor 3
Expert6	0.796	0.126	0.084
Expert5	0.766	-0.054	0.211
Expert4	0.570	0.338	-0.202
Tecmkt1	0.556	-0.018	0.313
Expert3	0.531	0.294	0.229
RD1	0.345	0.719	0.252
RD4	0.184	0.703	-0.134
RD2	-0.005	0.647	0.156
RD3	0.154	0.634	0.176
Newprod	0.246	0.074	0.600
Expert2	0.404	0.113	0.583
Design	-0.152	0.073	0.566
Expert1	0.310	0.191	0.530
Adver	0.000	0.058	0.480
Mktres	0.086	0.054	0.475
Description:	General Technology Policy	Manufacturing Technology Policy	Marketing Technology Policy
Cumulative variance explained (%):	23.9	32.6	41.1

¹ After Varimax rotation

² Refer to Table 2 for measures

Table 4. Correlation Matrix and Descriptive Statistics

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Innovativeness	1.0													
2. General technology policy	0.26**	1.0												
3. Manufacturing technology policy	0.39**	0.34**	1.0											
4. Marketing technology policy	0.34**	0.43**	0.30**	1.0										
5. Firm size	0.51**	0.05	0.20**	0.15**	1.0									
6. Number of competitors	-0.80	0.09	-0.01	-0.80	-0.10	1.0								
7. Competitive uncertainty	-0.03	0.13**	0.18**	0.10	0.12	-0.06	1.0							
8. Consumer demand uncertainty	0.16	0.10	0.08	0.12	0.14	-0.01	-0.11	1.0						
9. Retailer/distributor demand uncertainty	-0.05	0.11	-0.12	0.02	-0.90	0.04	0.01	-0.16	1.0					
10. Signal frequency	0.40	0.34**	0.36**	0.31**	0.13	-0.03	0.12	-0.03	0.04	1.0				
11. Travel	0.37**	0.13	0.16**	0.14	0.53**	0.09	0.13	0.11	-0.09	0.02	1.0			
12. Professional meetings	0.38**	0.04	0.11	0.16**	0.20**	-0.01	0.00	0.09	-0.02	0.23**	0.16**	1.0		
13. Professional memberships	0.38**	0.18**	0.24**	0.24**	0.09	-0.05	0.09	0.02	-0.17	0.41**	0.01	0.24**	1.0	
14. Technical expertise	0.51**	0.09	0.16	0.31**	0.65**	-0.03	0.65**	0.15	-0.13	0.18	0.23**	0.16	0.26**	1.0
Mean	2.7	14.6	12.5	14.1	267	30.8	3.2	3.1	4.2	17.8	0.7	1.8	1.3	1.1
S.D.	2.6	4.0	3.3	3.5	910	84.8	4.3	4.5	4.8	4.2	1.8	4.2	1.1	2.7

* p < .05

** p < .01

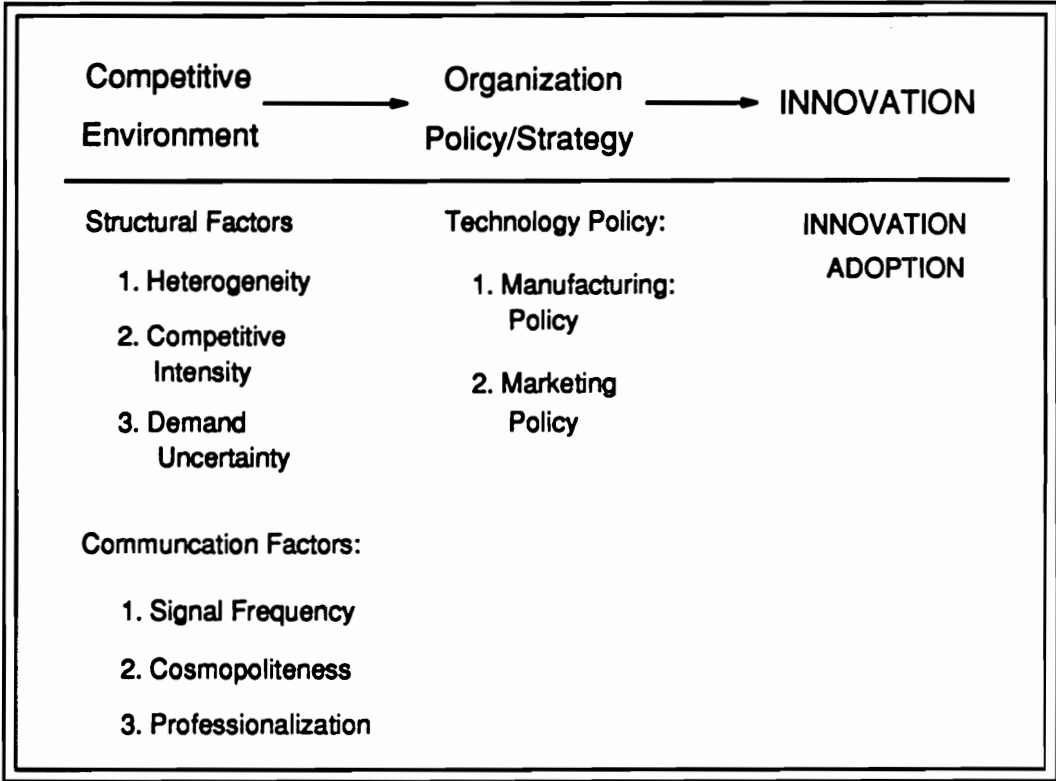


Figure 1. Competitive-Policy Model of Innovation

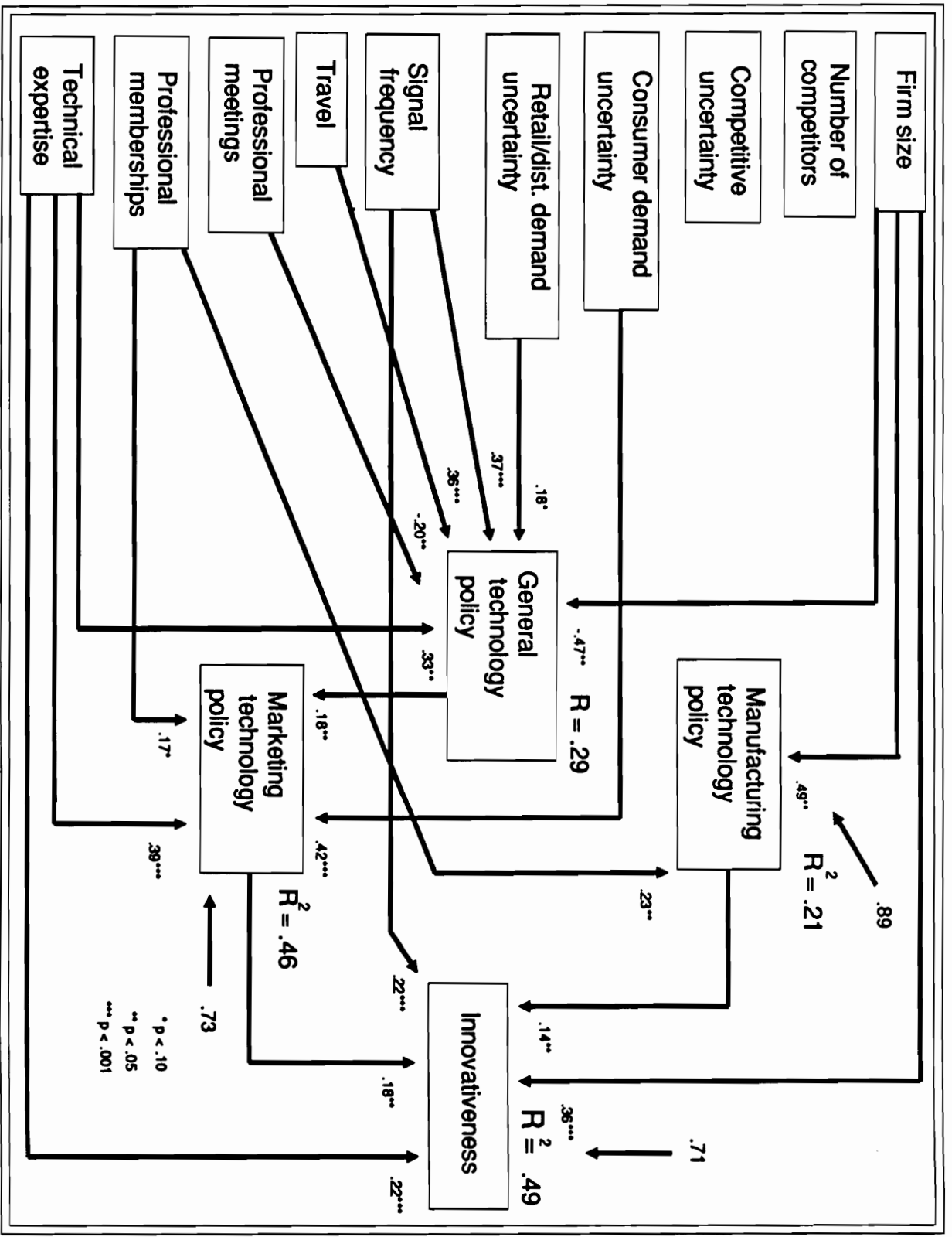


Figure 2. Causal Path Analysis Description of Significant Path Coefficients

CHARACTERISTICS OF INNOVATIVE FIRMS IN THE WOOD HOUSEHOLD FURNITURE INDUSTRY

Abstract

Characterization of early adopters of technological innovations can benefit promoters of new technologies. Marketing research has found correlates between characteristics of adopters and their time of adoption which have been helpful in identifying those firms most likely to adopt and targeting them with the appropriate marketing mix. Firms in the wood household furniture industry were segmented based upon their adoption of thirteen processing technologies into an early adopter group and a late adopter group. These groups were contrasted on a variety of characteristics. Early adopters were found to differ significantly from late adopters on firm size, technological expertise, technological progressiveness, opinion leadership, information sources, and cosmopolitanism of the decision making group. This information can be used by equipment suppliers and promoters of the furniture industry to encourage adoption of new processing technologies.

INTRODUCTION

The diffusion of innovations is a topic that is of value to all types of manufacturers, but little research has been conducted on technological innovation, with the exception of the work of Mansfield (1977) and Nasbeth and Ray (1974). However, adoption of manufacturing technologies is becoming an increasing concern, especially for those in the wood products community who are becoming uneasy with changes in the competitive environment (Greber & White 1982; Anderson 1987; Spelter 1987; Spelter & Sleet 1989; Cohen 1989). Although implementation of process innovations is not the only strategy a firm may employ to compete effectively, development and adoption of new process technologies offer the means for a firm to increase productivity, reduce costs, improve product quality, offer better customer service, and allow products to get to the market place ahead of competitors (Bennett & Cooper 1981; Kamien & Schwartz 1982; Nasbeth & Ray 1974, Dosi 1984).

This paper describes the results of an adoption study of innovative process technologies within the wood household furniture industry. Characteristics of firms labeled as early adopters are identified for this industry. Few studies exist describing adopter characteristics in an industrial setting and those specific to a wood products industry are extremely rare. While previous studies of this type provide guidance as to the characteristics of new product adopters, they are most applicable to the specific industries under study (Utterback 1974; Midgley & Dowling 1978; Bigoness & Perreault 1981). Therefore, the results of this research project provides one of the first attempts to specifically identify early adopters within a wood products industry, the wood household furniture industry, and should have greater applicability to other areas of wood products manufacturing than studies devoted to dissimilar industries.

Understanding the characteristics of firms with the greatest potential for early use of new technologies is an important strategy for the successful introduction of innovative processes.

The Wood Household Furniture Industry

The wood household furniture industry is highly fragmented with several large multi-plant corporations at the top and many small single plant firms at the lower end of the size distribution. Because of the large number of firms in this industry, it can be characterized as highly competitive. Competition has been increased by the rapid rise in imports. In 1976, imports claimed only 6.6 percent of U.S. consumption of wood household furniture; however, by 1986 they had reached 22.6 percent of consumption (Araman 1987).

Innovations in production and shipping techniques employed by overseas competition have been credited with lowering the transportation cost barrier that prohibited penetration of U.S. furniture markets in the past (Kaiser 1984; Urban 1984; U.S. Dept. of Commerce 1985). Furniture, which can be shipped in knock-down form and reassembled prior to distribution, can be delivered to the U.S. at very reasonable costs.

Historically, the furniture industry has been characterized by labor intensive production techniques and a dismal record of productivity advances (U.S. Dept. of Commerce 1985). Because of increasing imports and domestic competition, the industry is under pressure to increase its production efficiency. Traditionally, machinery suppliers have dominated the innovation process and today's furniture firms have a greatly expanded set of opportunities to lower production costs and increase product

quality because of the development of new processing technologies (Cox 1990; Evans 1988; Society of Manufacturing Engineers 1987).

DIFFUSION THEORY FRAMEWORK

Innovation diffusion has traditionally been described as a process in which members of a social system influence one another in a variety of direct and subtle ways - through demonstrations that create awareness, by providing information that shows the viability of the new product in use and through creating pressure to adopt the innovation (Webster 1984; Rogers 1983). In industrial markets that pressure is likely to be derived, in part, from the need to compete with earlier adopters of the new product, who have improved their competitive effectiveness (Porter 1980; Webster 1984; Utterback 1974).

The process of diffusion of innovations in industrial markets is both a social influence process among the various participants in the using industry and an economic process in which costs, revenues, market structure, and competitive conditions are altered (Webster 1984; Ozanne & Churchill 1971; Rogers 1983; Robertson & Gatignon 1986). Two rather distinct research traditions in the diffusion of innovations in industrial markets exist. One stresses economic factors and consequences as the prime movers of innovation adoption (Nasbeth & Ray 1974; Mansfield 1977; Davies 1979; Dosi 1984) while the other emphasizes the social process (Rogers and Shoemaker 1971; Robertson 1971; Rogers 1983). The marketing literature concerning adoption of innovations by industrial organizations, while quite limited, has tended to balance these two approaches, recognizing both the process and the results of diffusion. Figure 1 consolidates the major relationships identified by other researchers as characterizing the

industrial adoption process. It includes the industrial adoption process (Ozanne and Churchill 1971) and the factors which impinge on it - communication factors (Rogers and Shoemaker 1971), decision makers identity (Rogers 1983; Utterback 1974), environmental factors (Webster 1984; Robertson and Gatignon 1986), and characteristics of the innovation (Rogers 1983).

Adopter Categorization

The innovation diffusion process is typically illustrated by plotting the distribution of the number of adopters of a new product or process over time and expressed as a percentage of all potential adopters of the innovation. Studies of the diffusion process suggest that adoption demonstrates a fairly normal distribution over time (Rogers 1983). As a result, adopters can be placed into categories based on how long they wait to try an innovation, relative to other adopters, and defined in terms of variation from the mean time of adoption for all firms in the using industry (Figure 2). The first 2.5 percent to adopt are called innovators, the next 13.5 percent are early adopters, the following 34 percent are termed the early majority, the next 34 percent are the late majority and the final 16 percent are called laggards. Studies providing these standard definitions for adopter categories are based on diffusion of pharmaceutical, farming innovations, and other consumer products (Rogers 1983). Because of the relatively small number of potential adopters in the typical industrial market, these precise categories can have variations. In general, industrial diffusion research makes a distinction between earlier and later adopters with "earlier adopters" including both the innovators and early adopter categories (Hisrich and Peters 1984). The "later adopters" category would include the remaining segments.

It is the early adopters and innovators that are of particular interest to promoters of innovation. These are the organizations or individuals that tend to be more innovative and more willing to try something new. Once these firms experience success with a new process or product, they influence the later adopters through word of mouth and example.

Innovativeness

Rogers (1983, p.22) defines innovativeness as "the degree to which an individual is relatively earlier in adopting an innovation than other members of his system". This is essentially an operational definition since it is expressed directly in terms of the measurement of innovativeness; i.e. the time taken for an individual to adopt an innovation. Such a definition of innovativeness confines the definition to a single product or process innovation. Studies employing a single innovation as the criterion for innovativeness have been criticized because the adoption of a single innovation may be idiosyncratic and; therefore, not a representative measure of innovativeness in general (Mohr, 1969; Walker, 1969; Midgley and Dowling 1978; Bigoness and Perreault, Jr. 1981).

An alternative approach is to employ a cross-sectional technique. This method basically involves determining how many of a pre-specified list of new processes or products a firm has adopted at a given point in time. This measure provides a more meaningful construct of innovativeness, since innovative behavior is more complex than a single adoption decision. Firms, whose average time to adoption is shorter tend to own more products or processes. Therefore, innovativeness scores can be based on the number of products or processes adopted at any point in time (Summers 1971; Robertson 1971).

The "early adopters" of any one innovation are those individuals or firms prepared to adopt this new product or process early in its diffusion, without the personal or social support gained from discussions with prior users.¹ It is widely accepted that the messages these innovators transmit to others initiate the adoption process for later adopters, because earlier adopters are more likely to be opinion leaders (Rogers and Shoemaker 1971; Utterback 1974; Lancaster and White 1979; Rogers 1983). Therefore, a composite measure of innovativeness provides for control of some of the situational and communication effects associated with the adoption of an individual product or process. This technique also controls for respondent interest in the product category as a whole.

Observing adoption behavior over a set of innovations provides a more relative measure of the innovativeness of a firm (Midgley and Dowling 1978) and may be expressed as:

$$I = \sum_{i=1}^n w_i s_i \quad (1)$$

where I = the firm's innovativeness score,

n = the number of selected (significant) items,

w_i = the weight attached to the i th item, and

s_i = the individual's score on the i th item.

Persistent adoption behavior infers that earlier adopters possess a greater degree of innovativeness than other firms within an industry. It is this behavior that the following study describes and profiles.

¹ Evidenced by the eight studies cited by Rogers (1983, p. 208), "Mass media channels are relatively more important than interpersonal channels for earlier adopters than for later adopters."

RESEARCH METHODS

Sampling

Data was collected from a mail survey directed towards key decision makers of 1500 wood household furniture manufacturers developed from an industrial mailing list and the American Furniture Manufacturing Association's membership list. A pretest of five furniture manufacturers followed by personal interviews was conducted prior to mailing. Those parts of the survey that caused confusion or proprietary concern were eliminated. After adjusting for non-deliverables, the response rate for the mail survey was 20 percent, which is about average for industrial type surveys (Rawnsley 1978; Walker, Kirchman and Conant 1987).

A subsample of wood household furniture manufacturing firms employing more than 20 production employees was then selected from the respondents to provide the basis for analysis. Smaller firms were eliminated from the analysis because careful examination of the data revealed there was a large portion of craftsman shops within this group. Because of the highly crafted nature of their product, these small firms are unlikely to be potential adopters of automatic processing equipment. Since this study is specifically interested in assessing differences between early adopters and later adopters and size is not directly controlled for, the smaller firms were not included in the analysis. This resulted in a total of 116 respondents selected for analysis in this study. Average firm size for the sub-sample was 439 production employees (s.d. of 1056) while the median was 128. Average sales for 1988 were 32.7 million dollars (s.d.

of 83.3) with a median sales figure of 9 million dollars. Total sales from this sample accounted for 42 percent of the 1988 value of shipments for the industry.²

To detect the possibility of a non-response bias, early respondents within the subsample were compared to later respondents on key demographic variables. Appropriate non-parametric tests were applied to detect differences in proportions of respondents in each group on the categorical variables of corporate level (e.g. single company or multi-company corporation), geographic location, and total corporate sales. T-tests were performed to detect differences in the means of total number of technologies adopted, capital equipment budgets, sales and number of production employees. No significant differences were found between early and late respondents in the sample on these variables at the .05 level of significance. While the results of these tests show no evidence of non-response bias in the data, it is clear that a greater proportion of large firms responded to the survey than smaller firms. However, since these firms account for a greater proportion of sales and are major investors in capital equipment, this should not present a problem in interpreting the results of this survey.

Innovativeness Measure

Because a general construct of innovativeness, as described above, was desired, a composite variable of manufacturing innovativeness was developed under the guidelines developed by Bigoness and Perreault (1981). Application of a composite measure of innovativeness based on the number of technologies adopted explicitly assumes homogeneity among the technologies (Robertson 1971; Downs & Mohr 1976;

² The figure of 42 percent was derived by comparing the 1988 sales value summed across respondents to the 1988 value of shipments reported for the industry of \$8.42 billion (Nolley 1989).

Bigoness & Perreault 1981). To develop a reliable and valid measure of the innovativeness construct, correlations were computed for 21 innovations identified as representative of innovativeness within the furniture industry by manufacturing executives, industry consultants and academicians. Innovations with negative correlations were perceived to be inconsistent with adoption of the other innovations and in violation of the homogeneity assumption.

Thirteen innovations remained after applying this criterion and were evaluated for reliability and internal validity. Table 1 summarized the statistics relevant to this analysis. The interproduct correlations are all positive and not too large, suggesting that they describe a generalized construct of innovativeness. The innovations are neither adopted as sets nor directly complementary, therefore, adoption or non adoption of each technology was equally weighted and summed to provide the composite measure of innovativeness (Equation 1). This summative measure of innovativeness appears to be internally consistent with a KR-20 estimate of reliability of .72. The KR-20 coefficient, introduced by Kuder and Richardson (1937) estimates the reliability of scales composed of dichotomously scored items.³ It is simply a special case of coefficient alpha (Chronbach 1951) and has the same interpretation as alpha; that is it is an estimate of the expected correlations between a one test and a hypothetical alternative form containing the same number of items (Carmines and Zeller 1979).

Frequency of adoption of these innovations approximates a normal curve with a mean of 4.2 and standard deviation of 2.6.⁴ Twenty-one firms adopting seven or more

³ $KR20 = N / (N - 1) [1 - \sum_{i=1}^n p_i q_i / \sigma^2]$, where N is the number of dichotomous items; p_i is the proportion responding "positively" to the i th item; q_i is equal to $1 - p_i$; and σ^2 is equal to the variance of the total composite.

⁴ The Kolmogorov-Smirnov goodness of fit test for a normal distribution was performed, failed to reject ($p=.23$).

technologies (at 1 s.d. from the mean) are considered the early adopters. The remaining 95 firms adopting less than six technologies make up the later adopter category. Only seven firms adopted zero technologies. These firms are considered to be characteristic of the later adopters and are combined in this category.

RESULTS

Early and late adopters within the furniture industry are contrasted on a variety of characteristics provided by the general diffusion model (Figure 1). These are described below. The statistical results of this comparison are summarized in Table 2.

Demographics

Firm size has frequently been associated with innovativeness. Larger firms have been found to be more innovative than smaller firms (Mansfield 1963; Mohr, 1969; Baldrige and Burnham, 1975; Armour and Teece, 1980). Large firms are believed to be more innovative because of slack resources, access to capital markets, and organizational structure (Rogers, 1983). Firm size appears to be significantly related to innovativeness in this sample of furniture firms. Larger firms adopted more manufacturing innovations than did smaller firms. Although a surrogate for available resources, sales per employee, did not significantly differentiate between these two groups, it was found that the majority of these large firms were members of a much larger corporation.

Previous research studies have found that younger companies were more likely to innovate than older, established ones (Ozanne & Churchill 1971; Davies 1979).

However, this relationship did not appear to hold true for the furniture industry with a mean age of 68 years for early adopters and 60 years for later adopters.

There was a significant difference found in the average price of the product line produced by each group based on a ten point scale from 0 to 10 (low priced to high priced). Innovative firms produced a slightly higher priced line of furniture.

Communication Behavior

Studies of the use of information sources by industrial buyers indicate manufacturers sales representatives are the most important source of information at all stages, except awareness, in the buying decision process (Webster 1984, p.139; Webster 1971, pp. 166-174). This relationship appears to be generally true for the furniture industry. Respondents were asked to indicate how often they relied on a variety of information sources using a 5-point Likert scale (1=never to 5=always). Both groups indicated that equipment salesmen were the most important source of information when deciding to purchase a piece of equipment and print readership to be the least important.

The only significant difference between these two groups was in their dependence on trade and equipment shows for information. Early adopters indicated these to be a more important source of information than did later adopters. Overall, it appears that the early adopters depended more heavily on a variety of information sources than do later adopters.

Decision Maker Characteristics

Characteristics of the decision making group within an organization have been associated with innovativeness (Cardozo, 1968; Robinson, Faris, & Wind, 1967; Peters

& Venkatesan, 1973). Three characteristics of the decision making group were examined, cosmopolitanism, professionalism, and opinion leadership. Cosmopolitanism, frequently regarded as a major determinant of adoption, is the degree to which an individual's orientation is external to his immediate social system (Rogers 1983). Travel is often the operational way to approximate cosmopolitanism (Ozanne & Churchill 1971; Robertson & Wind 1983). The present study used international travel as an indicator of the decision maker's orientation outside the domestic furniture market. A significant difference in the amount of international travel was found. Early adopters traveled out of the country an average of 2.8 times per year while late adopters made a trip out of the country on business less than once a year.

Professionalism is the amount of social influence transmitted within an industry to the extent that a firm's employees identify with their profession (Ettlie & Bridges 1982). This increases the likelihood of accessing extra-organizational information about innovations (Leonard-Barton 1985) and was measured by the number of furniture markets, trade shows and association meetings the decision making group attended each year. Early adopters attended significantly more of these (6.3 per year) than did late adopters (4.4 per year).

Early adopters have generally been perceived by other adopters as opinion leaders and serve as models for innovative behavior (Rogers 1983). They are more likely to assume the risk of being the first to adopt (Lancaster & White 1979; Utterback 1974; Cohn 1981). Respondents were asked to indicate how often other firms contacted them for information concerning a new process or innovation they had adopted on a 5-point Likert scale (1=never to 5=always). Early adopters indicated they were contacted significantly more often than late adopters.

External Environmental Characteristics

A firm's environment may dictate its choice of technologies. In general, there are two sources of environmental influences, the external environment, which the firm has limited control over, and the internal environment in which the firm must make decisions concerning origination, development, and implementation of innovations. There is empirical evidence that uncertainty over competitive factors in a firm's external environment influences a firm's innovative behavior (Baldrige & Burnham 1975; Ettlie 1983; Shrivastava & Souder 1987). Environmental variability and change encourages adoption of innovations by organizations by causing increased uncertainty about demand and supply of scarce resources (Baldrige & Burnham 1975).

Three characteristics of the furniture industry's external environment were investigated - demand uncertainty, perceived number of competitors, and average annual sales growth. Respondents were asked to indicate how difficult it was to predict customer demand for their products on a 5-point Likert scale (1=extremely difficult to 5=extremely easy) as evidence of demand uncertainty. No significant differences emerged between the two adopter groups on this variable or on the perceived number of competitors for their firm's major product group. These results are not surprising, considering the highly competitive nature of this industry and its degree of fragmentation. In addition, there did not appear to be any significant difference in average annual sales growth over a three year period (1985-1988).

Internal Environmental Characteristics

A greater number of significant differences emerged within the firms' internal environment. These differences were expressed through technical expertise and progressiveness of the firms. Early adopters employed more manufacturing engineers

(3.4) and product design engineers (3.4) than did late adopters (1.3 and 1.0 respectively). In addition, early adopters expressed a greater degree of technical progressiveness than later adopters. A dimension of technical progressiveness was indicated by responses to the statement "Our manufacturing organization tries to be the first in our industry to implement new production technologies and methods," measured on a 5-point Likert scale (1=strongly disagree to 5=strongly agree) (Ettlie and Bridges 1982; Ettlie 1983). There were no significant differences between groups in capital expenditures per production employee planned over a twelve month period (1989) or over a five year period (1989-1993).

CONCLUSIONS AND DISCUSSION

This study found statistical differences between early adopters or innovators and late adopters in the furniture industry. Several significant and intuitively meaningful differences emerged between these groups.

Large firms were found to be more innovative than smaller firms. These companies generally belonged to multi-company corporations with better access to capital resources. Although they planned to invest more money in capital equipment over a twelve month and five year period, they did not plan to spend more per production employee than smaller firms. It would appear that these firms are willing to take the risk of early adoption of new process innovations. In fact, these firms directly expressed a willingness to be the first in the industry to actually implement these new technologies. This attitude is expected and found in opinion leaders of an industry, which is the role that these firms appear to serve. This innovative group was contacted more often by other firms concerning a new manufacturing process or innovation than later adopters within the industry. It could be assumed that once these

firms adopted a new technology and reported a favorable opinion of it, other firms would then be more likely to adopt. Therefore, convincing an innovative firm to implement a new manufacturing technology could hasten its adoption by others seeking the same manufacturing advantage.

Innovative firms seek information concerning new technologies from a wide variety of sources. These firms expressed a preference for direct sources of information through equipment shows and from representatives of equipment manufacturers. These sources are particularly important in communicating relative advantages of highly technical and complex products and processes. Therefore, personal selling and demonstrations would provide the most influential means of advancing these early adopters through the adoption decision process.

Another factor that enables innovative firms to interpret and apply information concerning new processing technologies is their employment of a significantly greater number of manufacturing engineers. Firms which possess engineering expertise have an advantage in understanding the complexities of today's new technologies which reduces the risk of implementing them. In fact, providing firms lacking in engineering support with technical expertise is one means to change a late adopter into an early adopter. Through personal interviews, smaller firms have expressed a desire to utilize the latest manufacturing technologies, but felt they did not have the in-house expertise to appropriately evaluate or implement them. Equipment manufacturers could influence the adoption decision process in these smaller firms by providing technical assistance and allow them to use a new technology on a trial basis. Once a few of these firms became early adopters, they could in turn serve as opinion leaders for similar firms and encourage earlier adoption among this group of firms. Actions such as this could potentially shorten the diffusion time of new processing technologies within the industry.

The results of this study should provide the wood products community with both a new approach to understanding technology adoption and an idea of firm specific variables that may influence adoption. Timely adoption of new process technologies, which have the potential to increase an individual firm's competitiveness, ultimately increases an industry's ability to assume a leadership position within the global marketplace. Understanding the factors, which influence adoption of new processes, should assist the wood products industry and developers and suppliers of wood processing equipment in reducing the time it takes for innovative technologies to diffuse through an industry.

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Table 1. Relationships Among Different Manufacturing Processes

Process	Interproduct Correlations ¹													Percent Adopting		
	1	2	3	4	5	6	7	8	9	10	11	12	13			
1. Computer aided design	1.00															19%
2. NC equipment	.27	1.00														31%
3. CNC equipment	.71	.66	1.00													30%
4. Embossing process	.11	.10	.18	1.00												23%
5. Computerized back gauges	.06	.15	.13	.14	1.00											10%
6. Automatic cross cut system	-.01	.01	.21	.11	.16	1.00										7%
7. Electrostatic finishing	-.01	.01	.06	.15	.16	.07	1.00									5%
8. Wide belt sander	.07	.20	.14	.10	.13	-.09	.11	1.00								60%
9. Electronic glue up system	.11	.19	.29	.25	.20	-.08	.08	.35	1.00							29%
10. Computerized dry kiln	.06	.01	<.01	.22	.16	.02	.23	.11	.20	1.00						5%
11. Feed-through moulder	.15	.31	.39	.22	.28	.11	.22	.35	.54	.15	1.00					20%
12. Bar coding system	.07	.04	.17	.25	.23	.30	.13	-.04	.05	.05	<.01	1.00				8%
13. MRP system	.19	.12	.33	.22	<.01	.13	<.01	-.05	.23	.06	.07	.15	1.00			26%

¹ These correlations suggest the extent to which the adoption of one process is predictive of the adoption of another process and are based on phi coefficients.

Table 2. Summary of Means, Standard Deviations¹ and t-statistic for Adopter Characteristics

Characteristic	Early Adopters	Later Adopters	t Value	p^2
Demographics				
Production employees	1243 (2010)	261 (573)	-4.11	<.01
Sales per employee	722,800 (296,000)	761,200 (804,000)	0.21	.83
Product line price	7.1 (2.6)	6.0 (2.3)	-2.09	.04
Company age	68 (32)	60 (25)	-0.18	.86
Communications Behavior				
Trade journal readership	2.8 (1.0)	2.7 (0.9)	-0.51	.61
Trade/equipment shows	4.0 (0.7)	3.5 (1.0)	-1.77	.08
Equipment salesmen	4.0 (0.9)	3.7 (1.0)	-1.39	.17
Other manufacturers	3.8 (0.8)	3.3 (1.2)	-1.58	.12
Decision Maker				
Cosmopolitanism	2.8 (4.2)	0.8 (1.5)	-3.69	<.01
Professionalism	6.3 (5.3)	4.4 (3.5)	-2.08	.04
Opinion leadership	3.2 (0.8)	2.4 (1.0)	-3.46	<.01

External Environment				
Demand uncertainty	2.7 (0.8)	2.4 (0.9)	-1.22	.23
Perceived competitors	14 (21)	34 (67)	1.33	.19
Average sales growth	12.4 (8.5)	17.0 (19.8)	1.03	.31
Internal Environment				
Manufacturing engineers	3.4 (3.9)	1.3 (2.2)	-2.89	.01
Product engineers	3.4 (3.2)	1.0 (3.0)	-2.78	.01
Capital expenditures per employee (12 mo.)	1585 (1623)	1323 (1449)	-0.71	.48
Capital expenditure per employee (5 yr.)	6924 (7031)	5661 (5559)	-0.83	.41
Technical progressiveness	3.2 (0.9)	2.5 (1.2)	-2.27	.02

¹ Numbers in parentheses reflect standard deviations

² Probability values are for a 2-tailed test

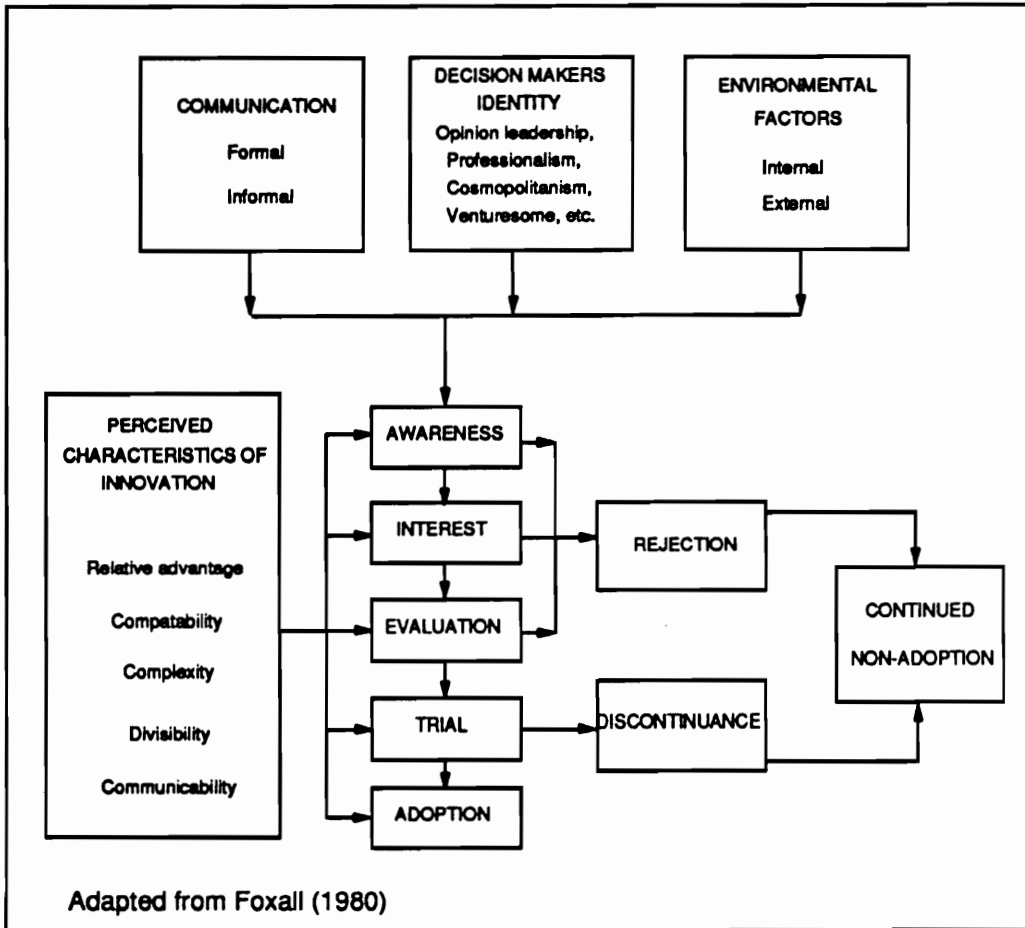


Figure 1. Fundamental Components of the Adoption Process

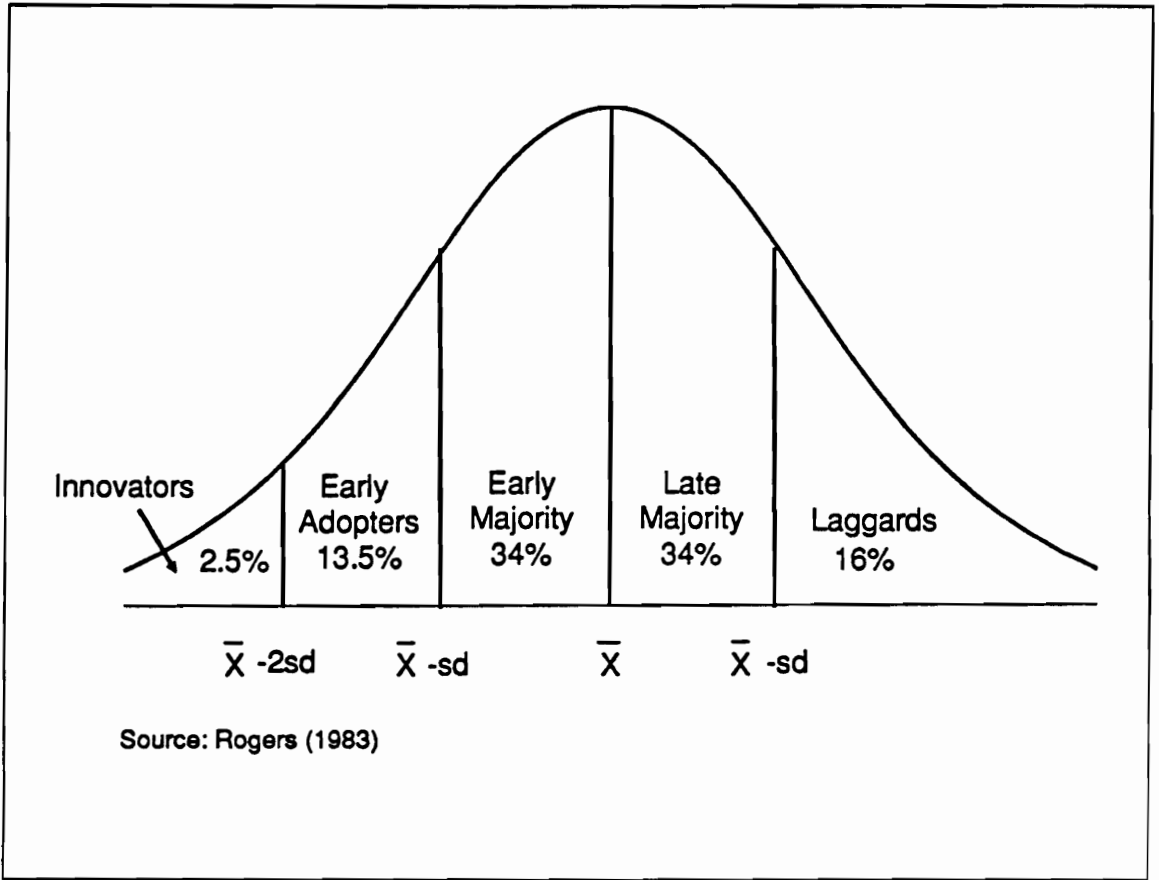


Figure 2. Adopter Categorization on the Basis of Innovativeness

THE RELATIONSHIP BETWEEN MARKETING AND MANUFACTURING TECHNOLOGY STRATEGIES: AN EMPIRICAL STUDY

Abstract

The controversy over technology push versus marketing pull strategies was reviewed and an alternative, the product value concept, was recommended. Application of the product value concept requires co-alignment of both technology and marketing strategies. Emphasis on these two strategies by firms was examined in an empirical study of the wood household furniture industry. Results of cluster analysis indicate that firms do align themselves along these strategic dimensions and can be contrasted on such key characteristics as demographics, company performance and environmental uncertainty.

INTRODUCTION

Manufacturing in the United States has experienced a deterioration in its competitive position over the past decade (Pennar 1988). Hayes and Abernathy (1980) led the criticism of American business' sluggish economic performance. They argued that a lack of technological innovation and a short-sighted view of the future are to blame for its decline in competitiveness. Since these arguments were set forth by Hayes and Abernathy (1980), the debate over how to regain market position has ensued.

Technology strategy and marketing strategy have been recognized as two paths that a firm can take to achieve success in the market place (South 1981; Ansoff 1984). However, there has been a preoccupation with promoting one set of strategies over the other. The argument has developed due to a general lack of understanding of the complementary roles played by technological development and marketing in successful business strategy (Kiel 1984). Technological innovation without market application wastes a firm's resources. On the other hand, long-term market success is very difficult to achieve without technological innovation.

This article will make a case for integrating technology and marketing strategy as key elements that affect a firm's success, particularly in rapidly changing environments. Results of an exploratory study of firms' dependence on technology or the marketing concept are reported. The resulting analysis provides a profile of the particular environmental forces and firm specific characteristics associated with different business strategies involving technology and marketing. Such a profile can provide additional insight into the interface between the marketing and technology strategies actually employed by firms. In addition, a study of this kind can serve as a norm or benchmark

against which any individual firm can assess its own position within an industry and make decisions about the interface between marketing and technology strategy.

The Case Against the Market Pull

Bennett and Cooper (1979) made one of the initial charges against marketing. They stated that market pull approaches to technological innovation, directed by the marketing concept have led to the demise of innovation by North American companies. The marketing concept relies on identification of buyers' needs and wants prior to new product or process development or implementation which shifts the strategic focus away from the product, its design, development, and manufacture.

A market driven R&D strategy has been accused of leading to low-risk product modifications, extensions, and style changes (Bennett and Cooper 1981). Because consumers talk in terms of the familiar when verbalizing wants and needs, market derived products usually result in the ordinary. They contend that original and creative new products, which help to ensure continued competitive success, are rarely the result of consumer research.

Reitz (1980) added evidence to the charges by pointing out that a decline in American research and development expenditures as a percentage of GNP, and the shift away from basic research toward developmental research has accompanied the decline in American international competitiveness. Marketing was again accused of being the major contributory factor by stifling creativity and moving product development towards more cosmetic changes in the product line.

These arguments against marketing were also cited by Hayes and Abernathy (1980) in a strong denunciation of the attitudes and business strategies of American managers. Technological superiority was advocated as the key to competitive success,

particularly in international markets. In a study of more than twenty European companies, they found European competitors felt the long-run survival of their companies depended on producing technologically superior products at competitive prices. These companies were, therefore, careful to invest in product and process technology today to ensure their continued competitiveness tomorrow.

Characteristics of an over emphasis in the marketing concept are summarized in Table 1.

Alternatives to Market Pull

The antithesis to market pull is technology push, which places major emphasis on the role of underlying scientific knowledge in innovation. Technology push occurs when the ongoing process of science and research produces a major technological breakthrough, independent of market requirements (Bennett and Cooper 1981; Kiel 1984). Technology can be thought of as the knowledge of how to convert inputs into outputs (Rosegger 1980). This definition emphasizes the application of technology in production, directed by the objectives of the individual or organizations undertaking the research.

Although Schumpeterian thinking economists perceive technical change as involving major breaks, giant discontinuities or disruptions with the past (Rosenberg 1976), the process of science and the process of technological innovation primarily consists of countless small incremental additions rather than single major breakthroughs (Davies 1979; Rogers 1983). Therefore, technological change is also a continuous stream of innumerable minor adjustments, modifications and adaptations (Kiel 1984).

The power of such a managed technological growth strategy is demonstrated by the Japanese in the consumer electronics industry. Japanese producers, led by Sony,

were able to enter the U.S. television market by developing the small screen T.V. (Rosenbloom and Abernathy 1982). The Japanese were able to use this base in small-screen sets to expand to larger models and even color (an American innovation, pioneered by RCA) to establish a dominant market position. The same story is true for the audio tape cassette and consumer videocassette recorder, American inventions. The Japanese were able to become leaders in these industries by furthering the technological development of their products and investing in improved manufacturing processes (Rosenbloom and Abernathy 1982). These two steps proved to be a competitive advantage in the long-run.

However, in defense of marketing, considerable empirical evidence on the innovation process proves that market related forces are the primary influence on technological innovation (Mowery and Rosenberg 1979). Utterback (1974) provides a summary of studies covering more than 1800 innovations in which marketing and related production factors were found to be the most important influences on innovation. Between 60 and 80 percent of the technological innovations over a wide variety of different products and markets were determined to be the result of market related forces.

The view that the application of the marketing concept requires extensive consumer research and that the approach is constrained by the consumer's limited vision of the technological future ignores other means by which market requirements can be translated into technological innovation (Kiel 1984; Capon and Glazer 1987). One of the most important and frequently-cited studies purporting to demonstrate the primacy of demand in the innovative process is that by Myers and Marquis (1969). They applied a very broad definition to market demand or market pull by including production related influences and empirically validated that a firm may respond to a competitor's

technically superior product with an innovation of their own or that increasing price competition in a market may lead a firm to develop or adopt a new process technology to provide substantial cost reductions and obtain a price advantage in the market.

Thus, it would appear that relatively successful firms are actually applying an alternative to market pull and to technology push. This has been defined as the product value concept and requires the firm to integrate marketing and technology strategies (Bennett and Cooper 1981; Gilbert and Strebel 1987). Product value implies a comparison, meaning a product must do more than merely satisfy a need. It must meet the needs of the consumer better than the competitors' products (Bennett and Cooper 1981). In other words, the key to long-run business success is to provide a product with superior value at competitive costs (or the same value at lower costs). Table 1 summarizes behaviors associated with a product value strategy.

The product value concept requires a firm to compete on the basis of both product features and price. Gilbert and Strebel (1987) term this strategic integration an outpacing strategy. Companies that are able to maintain a high perceived value while reducing costs effectively are described as "outpacing" competitors that stick to an unidimensional strategy.

A better and more highly valued product is a function of its attributes. These, in turn, depend on the design and engineering that shape the product and the product's manufacture, which determines product quality and reliability. Factors that contribute to superior value are the resources of the firm - R&D, engineering, design and manufacturing. Thus a firm must do more than cater to market whims, it must build strength through excellence in technical design and manufacturing to achieve product value.

Competing on the basis of cost requires firms to direct their attention towards process improvement in order to reduce costs and maintain pricing flexibility. Holding superior product performance constant while reducing costs is difficult for most companies to achieve, as this relationship usually implies a tradeoff. Currently, rapid developments in production technology are occurring in a wide range of manufacturing industries (Blois 1986). The benefits of these developments include both cost reduction and improved quality, as well as, manufacturing flexibility.

However, many managers, especially in mature industries, are reluctant to invest heavily in the development of new manufacturing processes (Hayes and Abernathy 1980; Capon and Glazer 1987). The reasons most frequently recited for this reluctance include affordability of new equipment design, too risky to be the first firms to implement new manufacturing processes, and capital equipment producers do a better job and can amortize development costs. These assumptions are not as widely shared abroad as in the U.S. American managers tend to restrict investments in process development to only those items likely to reduce costs in the short-term (Hayes and Abernathy 1980; Rosenbloom and Abernathy 1982; Pennar 1988). While it may be recognized that competitive success tomorrow depends on development of new processes, new markets and superior products today, companies cannot become more innovative simply by increasing R&D investments or by conducting more basic research. Each technologically directed decision and strategy directly affects other functional areas of management, particularly marketing. Thus, for technology strategies to be the most effective they must become integrated with marketing strategy.

Integration of Technology and Marketing Strategies

Technology is of particular concern when the technological environment is no longer stable. Therefore, the management of technology is really concerned with the management of technology change and technology strategy begins with understanding the effects of changing technology on the strategic and operational decisions of the firm which involves numerous areas of corporate strategy and structure. This is particularly important within the marketing functions of a firm as it seeks opportunities for growth. However, traditional opportunities for corporate growth are closing. Few firms are able to follow the historic pattern of systematic expansion outward from a basis of strength in a set of product markets (Roberts 1980). Markets and products are less proprietary and entry barriers that firms have relied upon to protect their positions are coming down (Capon and Glazer 1987).

There is a lack of understanding of the complementary roles played by technological development and marketing in successful business strategy. Failure to understand the technology-marketing interface has fueled the charges that the marketing pull processes leading to technological innovation are inferior to technology push processes. A clearer understanding of how marketing and technology strategies interface, what forces direct the alignment and what firm specific characteristics are associated with different attitudes toward technology and marketing is needed to better understand technological development and marketing in successful business strategy. The remainder of this paper reports an exploratory study of these questions.

METHODOLOGY

The Industry

The wood household furniture industry was selected for study because of recent changes in its competitive structure vis-a-vis international competitors. In 1976, imports claimed only 6.6 percent of U.S. consumption of wood household furniture, however, ten years later they had reached 22.6 percent of consumption (Araman 1987).

The furniture industry may be considered a mature industry. It is characterized by labor intensive production techniques and a dismal record of productivity advances (U.S. Dept. of Commerce 1985). However, because of the success of imports in the U.S. market, the industry is under extensive pressure to increase production efficiency, lower costs, and increase product quality. In other words, to succeed under today's competitive pressure, U.S. furniture firms must develop strategies to improve product value.

Data Collection

Data was collected from a mail survey directed towards key decision makers of 1500 wood household furniture manufacturers developed from an industrial mailing list and the American Furniture Manufacturing Association's membership list. A pretest of five furniture manufacturers followed by personal interviews was conducted prior to mailing. Those parts of the survey that caused confusion or proprietary concern were eliminated.

After adjusting for non-deliverables, the response rate for the mail survey was 20 percent. Average firm size for the sample was 266 production employees (s.d. of 910) while the median was 30. Averages sales of responding firms for 1988 was \$17.1

million (s.d. of 60.2) with a median sales figure of \$2.0 million. Total sales for this sample accounted for 46 percent of the 1988 value of shipments for the industry.¹

To detect the possibility of a non-response bias, respondents to the initial survey mailing were compared with those responding to the follow-up mailing on key demographic variables. A chi-square goodness-of-fit test was used to determine if the proportions of later respondents falling within each category could be predicted from the proportions of earlier respondents. No significant differences ($p < .05$) were found in the frequency of respondents within the categorical demographic variables of corporate level (e.g. single company or multi-company corporation) or geographic location. Likewise, the Mann-Whitney U test revealed no significant differences in total corporate sales. T-tests showed no significant differences ($p < .05$) in the means of total number of technologies adopted, capital equipment budgets, sales and number of production employees between early and late respondents. While the results of these tests show the likelihood of a non-response bias in the data to be very low, it is clear that a greater proportion of large firms responded to the survey than smaller firms. However, this should not present a problem in interpreting the results of this survey since firm size is reported within the results as a descriptive variable.

Measures

The degree to which a firm is committed to an innovative strategy within manufacturing was measured with the four items listed in the Appendix under Technology and based on a five point Likert scale anchored by "strongly agree" and

¹ The figure of 46 percent was derived by comparing the 1988 sales value summed across respondents to the 1988 value of shipments reported for the industry of \$8.42 billion (Nolley 1989).

"strongly disagree". This measure was adapted from Ettlé and Bridges (1982) measure of technology policy. Principle component analysis was used to determine if these items formed a common dimension. A single component was extracted using a cutoff eigenvalue of 1.0 which accounted for 51 percent of the variance. An index of technology strategy applied to manufacturing was computed using the factor loadings and indicates a tradition of using the newest process technologies.

The construct representing the degree to which a firm adheres to the marketing concept, as defined in Table 1, was operationalized based on a principle components analysis of six variables (Table 2) measured on a five point scale (strongly agree to strongly disagree). These variables were derived from the literature pertaining to the behavior of the organization following the marketing concept versus a product value concept. This resulted in two factors, with an eigenvalue greater than 1.0, as shown in Table 2, which accounted for 56 percent of the variance. Because the variables representing dimensions of the marketing concept consistently loaded together on the same factors, as assessed by split sample factor analysis, a single index of a firm's commitment to the marketing concept was computed from both factors with each weighted equally.

The measures of manufacturing strategy and marketing strategy represent the two dimensions used in subsequent cluster analysis to classify respondent firms. The factor loadings of the principle component analysis were considered to be the reliability coefficient between each indicator and the true measure because each factor loading is both a correlation coefficient and a regression weight (Kim and Mueller 1978). Using the principle component analysis to compute factor scores ensures at least as high a reliability as achievable by using more conventional methods (Armor 1974). In addition,

use of factor scores based on orthogonal rotation in cluster analysis corrects for interdependencies between dimensions (Punj and Stewart 1983).

Clustered firms are compared on three sets of variables: (1) environmental uncertainty factors, (2) demographics, and (3) firm performance. Uncertainty about the competitive environment which may stimulate a change in strategy or policy was measured by the Downey, Hellriegel, and Slocum (1975) modification of the Duncan (1972) instrument which asks respondents to select three of the most important external environmental variables from a list of thirteen. These variables are then subscaled by three uncertainty questions. Demographic comparisons are limited to firm size, age, corporate structure, product price, capital investment, and engineering support. Company performance is compared on the basis of sales and average annual growth over a three year period.

Analysis

Cluster analysis was used to sort the respondent firms into groups with similar attitudes toward technology and marketing strategies. A two stage clustering approach was used because empirical studies on the performance of clustering algorithms suggest that one of the non-hierarchical or iterative partitioning methods is preferable to the hierarchical methods (Punj and Stewart 1983). Non-hierarchical clustering methods require a non-random starting point for grouping similar objects and prior specification of the number of clusters desired. In the absence of a priori descriptions of expected clusters, a two-stage procedure must be employed.

In the first stage, a hierarchical method is used on a subsample of respondents to obtain a first approximation of a solution. Wards minimum variance method was

the algorithm chosen for joining observations because it is generally considered to outperform other hierarchical clustering algorithms, except in the presence of outliers (Punj and Stewart 1983; Hair, et al. 1987). Squared euclidean distance was selected as the similarity measure.

Outliers were eliminated from the data because the extremity of outliers may have an effect on the stability of the final solution (Punj and Stewart 1983). This was accomplished by standardizing the criterion variables and eliminating those observations that were greater than 2.5 standard deviations from the mean. Next, observations on these two variables were plotted to determine if all outliers had been identified.

Since a probabilistic statistic does not exist to assist in selecting the appropriate number of clusters, several clustering solutions were examined. Individual scores were plotted around cluster means of a 50 percent analysis sample to determine which solutions produced the most cohesive plots. Because random data will produce clusters, internal validity of the cluster solution was assessed using discriminant analysis. This involved deriving a discriminant function on the hold out sample and then classifying respondents into one of the clusters determined from the first step. The degree to which the assignments made with the discriminant functions agree with assignments made by the cluster analysis serves as an estimate of the stability of the cluster solution across samples (Rogers and Linden 1973).

In the second stage, a non-hierarchical cluster analysis was performed on the complete sample using FASCLUS within SPSSx. The starting points or "seeds" for this procedure were obtained from the discriminant analysis procedure in the first stage. The final cluster solution was again accessed for internal validity based on discriminant functions.

The final step in the analysis was profiling the resulting clusters on: (1) demographic similarities and/or differences to provide a base line for comparison by firms within the industry, (2) environmental uncertainty variables to provide insight into factors contributing to a firm's choice of strategies and (3) performance measures to gain confirmation on the outcome of strategy choice. ANOVA was used to determine if the clusters differed on the measures described above. Where appropriate, post hoc comparisons provided follow-up analyses for the ANOVA procedures.

RESULTS

Four, five, and six cluster solutions produced from the analysis sample were examined for meaningful clusters. Examination of the cluster plots revealed that the six cluster solution produced superfluous fragmentation, therefore, validation of the five cluster solution was sought. The clustering criterion variables of technology and marketing substantially differentiated the groups (Table 3). Two significant discriminant functions emerged from these variables in the holdout sample and were able to correctly classify respondents in 93 percent of the cases, indicating the cluster solution to be valid. However, since discriminant functions may be poor estimators of population values and need to be cross-validated themselves, a second cross-validation technique was applied. This procedure is recommended by McIntyre and Blashfield (1980). Centroids were obtained from the analysis sample for the five cluster solution. Objects in the holdout sample were assigned to one of the identified clusters on the basis of the smallest Euclidean distance to a cluster centroid vector using a non-hierarchical

clustering method. Results were compared to the Wards method of clustering for the holdout sample. The degree of agreement between the results of these two methods when group assignments were cross tabulated revealed a clear structure to the solution. Thus, the five cluster solution developed using Wards method was selected for further analyses. Non-hierarchical clustering of the entire sample produced final group assignments which were interpreted and profiled.

Cluster Interpretation

Table 3 and Figure 1 describe the group assignments. Group A exhibited a moderate score on attitude towards utilization of new technology and scored high on agreement with the marketing concept. This group agrees somewhat that it is important to use the most up-to-date production technologies, however, they do not want to be the first in the industry to experiment with them. Groups A and D scored highest on adherence to the marketing concept. Both groups agree strongly that it is important to identify consumer needs prior to product development and to confirm acceptance of a new product prior to market introduction. Given these practices, it is not surprising to find that both groups agree it is important to follow the market closely and incorporate successful new product introductions by other firms into their product lines. Finally, both groups indicated that they actively recruit the best qualified marketing personnel available. Group D differs from A on the technology dimension. Group D firms scored highest on all variables factored into this dimension, indicating that they not only believe it is important to keep production processes up-to-date but are willing to assume the risks of process development.

Groups B and C are both positioned within the moderate range on adherence to the marketing concept. They both agree it is somewhat important to seek consumer opinions prior to product development, however, they do not follow the market as closely as groups A and D and they do not actively seek the best qualified marketing personnel. Groups B and C differ, however, in the technology dimension. Firms making up Group B are in the lowest position on this dimension and strongly disagree that it is important to invest in or develop the most up-to-date processes. Group C falls in the moderate range of the technology dimension, similar to Group A. These firms slightly agree that it is important to consider new processes but do not want to be among the first to innovate in this area.

Group E scored in the low range along the marketing dimension. They disagree on the importance of identifying consumer needs prior to product development and do not seek consumer opinions prior to new product introduction. In addition, they exhibited the least interest in following the market closely and are not seeking the best in terms of marketing personnel. Group E did score moderately high in the technology dimension, just below Group D. These firms agree it is important to incorporate new processes into the manufacture of their products and even agree that they are willing to experiment with new process development. However, Group E firms are not quite as willing as Group D to accept the risk of being the first in the industry to implement new production technologies and methods.

Cluster Profiles

Differences in groups were examined for three categories of characteristics - demographics, company performance and competitive uncertainty. The results of the demographics and company performance comparisons are reported in Table 4.

Group D, scoring the highest on both dimensions, also appears to differ from all other groups across most significant variables in the demographic and company performance categories. This group may be described as consisting of large corporations with a high level of technical expertise, exhibited by the number of engineers employed by these firms. Group D also had the second highest average sales growth (23.8 %) over a three year period, although this variable did not demonstrate a significant difference, at the .10 level of probability, across groups.

Group E also scored highly on the technology dimension, but lowest in regards marketing. This group is comprised of moderately sized firms belonging to multi-company corporations. Group E firms were willing to invest more capital into processing over the next year than any other group of firms, however, they possess less technical expertise than the leading technology based firms in Group D. Average corporate sales growth was among the lowest at 13.5 percent, although a significant difference was not demonstrated.

Group A, within the moderate range of the technology dimension, and high on adherence to the marketing concept, was made up of the smallest firms. However, these small firms exhibited the highest average sales growth, 31 percent.

Group C falls within the moderate range on both dimensions and is next to the smallest in terms of production employees and sales. Although, not demonstrating a

significant difference, these firms also report among the lowest annual sales growth (15.1 percent).

Group B, scoring lowest on the technology dimension, is made up of larger firms than Groups A, C, and E, however, they are only significantly different in size to group D with the largest firms. As expected, these firms indicated that they would spend much less on capital equipment investments than other groups, differing significantly, again, with high technology Group D firms.

Groups were also contrasted for major areas of business uncertainty and competitiveness (Table 5). The three subscale scores did not express differences across groups. All groups seemed to feel a high level of uncertainty in decision making. There were some differences, however, in the areas of uncertainty.

Group B expressed the widest range of uncertainty variables, consumers, labor, material supply, and technology requirements of the industry. Group A expressed the greatest concern over consumers and raw material supply. Group C was the only group to express uncertainty over their distributors/retailers which appeared to be their most important concern, followed by labor and new product and process development. Both Groups D and E expressed uncertainty in the areas of consumers and labor with E demonstrating the greatest concern over labor. Firms in Group D exhibited the greatest uncertainty over competition.

DISCUSSION

The relative stability of the cluster solution indicates that firms can be classified based on their adherence to the marketing concept and their technology strategy, based on process technologies. The discussion at the beginning of this paper suggested that firms needed to place importance on both these dimensions to achieve long-term success and that management of these functions involved management of change within the competitive environment. Therefore, firms were profiled based on these variables.

Firms scoring highest on both dimensions were significantly larger firms possessing technical and marketing expertise with which to develop an integrated corporate strategy. Although the variables selected to measure corporate performance did not suggest strong significant differences, the direction of increasing sales growth suggests that firms must integrate strong marketing and technology strategies to be successful. This relationship did not seem to favor firm size which indicates that effective application of these strategies may not depend on large capital bases.

It is interesting to note the differences in perceptions of environmental uncertainty expressed by the groups. Firms scoring within the high range on at least one dimension expressed concern or uncertainty concerning consumers and competitors, supporting the notion that the competitive environment and change influences the choice of strategies. Those firms scoring the lowest on the technology dimension expressed uncertainty on a wide variety of environmental variables and possessed the lowest average annual sales growth. These firms give the impression of facing a number of uncertainties without a clear strong strategic direction. It would be interesting to determine causality, but such an analysis is well beyond the scope of this study.

FUTURE RESEARCH

The results of this study were not meant to resolve the conflict over the appropriate selection of business strategies, marketing versus technology. However, they do suggest support for the product value concept of integrating both marketing and technology. This study was conducted within a single, very competitive and highly fragmented industry. Opportunities for future research exist for cross industry studies of these variables, particularly contrasting competitive structure and relative performance.

The performance variables within this study were, admittedly, limited. Additional measures of performance would provide a clearer picture of the advantages or disadvantages of strategy selection. Also, it was assumed that the attitudes and practices measured reflected the tradition of the firm, however, explicit empirical evidence was not examined to support this assumption. Therefore, it is difficult to discuss "long-term" consequences of the strategies of these firms.

Finally, only one aspect of technology strategy was examined. This involved the development and application of process technologies. Therefore, opportunities exist to examine additional aspects of technology.

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Table 1. Behaviors associated with the marketing concept and product value concept

Marketing Concept

The firm prefers low risk product modifications, extensions and style changes to new product introduction. (PMD)^a

Consumers needs are identified prior to product development. (MKTNEDS)

The firm allocates more resources to advertising, selling and promotion than to product development. (ADVER)

Process investment is made in response to changes in market demand.

New product ideas come from successful offering of competitors. (MKTF)

Product Value Concept

The firm focuses on new product development not cosmetic changes to the product or product line.

New product ideas come from designers or engineers.

The firm invest substantially in process R&D.

Market research is used to determine the success of new products not market requirements prior to product development.

The firm allocates more resources to product development than to advertising, selling and promotion.

Sources: (Hayes and Abernathy 1980; Bennett and Cooper 1981; Kiel 1984)

^a Variable notation used to describe measures in Table 2.

Table 2. Marketing Factor Structure and Loadings¹

<i>Variables²</i>	<i>Factor 1</i>	<i>Factor 2</i>
EXPERT2	.74³	.21
MKTF	.69	.04
NEWPROD	.66	.04
ADVER	.51	.02
MKTOP	.05	.89
MKTNEDS	.11	.87
Cumulative Explained Variance:	(.34)	(.56)

¹ Principle components factor loadings with varimax rotation

² Variables defined in Appendix

³ Factor loadings in bold are used to construct marketing concept variable

Table 3. Group Means, Centroids, and Statistical Significance of Clustering Dimensions

<i>Dimension</i>	<i>Group Means</i>					<i>F-Prob.</i> ¹
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	
<u>Technology</u>						
T1	3.02	1.96	3.30	4.25	3.69	< .01
T2	3.21	2.06	3.70	4.28	4.31	< .01
T3	2.35	1.21	2.51	3.38	2.92	< .01
T4	2.75	1.54	3.23	3.78	3.09	< .01
(Centroids) ²	(8.15)	(4.88)	(9.15)	(11.29)	(10.31)	
<u>Marketing</u>						
MKTOP	4.04	2.79	3.09	4.08	1.77	< .01
MKTNEDS	4.31	3.63	3.77	4.37	2.38	< .01
MKTF	3.42	2.42	2.45	3.18	1.69	< .01
EXPERT2	3.25	1.96	2.23	3.52	1.85	< .01
ADVER	3.06	2.54	2.45	3.30	2.31	< .01
(Centroids)	(13.16)	(9.72)	(10.24)	(13.36)	(7.11)	

¹ The probability that there is no difference between group means.

² Final cluster solutions for non-hierarchical analysis, based on factor loadings.

Table 4. Group Means and Statistical Differences of Profile Variables for Cluster Groups

Characteristic	Group Means					F-Ratio	p	Differing Groups ¹
	A (n=48)	B (n=24)	C (n=53)	D (n=60)	E (n=13)			
<u>Demographics</u>								
Production employees	102	267	145	613	209	2.54	.04	D from A & B
Firm age	28	36	28	25	39	0.99	.41	
Product price ²	6.5	6.7	6.5	6.5	6.8	0.12	.97	
Capital budget ³	1590	1130	1136	2128	38306	3.86	.01	E from all (A-D)
Corporate level ⁴	1.3	1.3	1.3	1.7	1.4	3.71	.01	D from A-C
Manufacturing engineers	1.0	1.0	0.6	2.1	0.3	2.13	.08	D from A,C,E
Product design engineers	0.9	0.3	0.4	1.4	0.8	1.18	.32	
<u>Company Performance</u>								
Sales (\$1 million)	8.1	19.7	9.9	35.6	15.7	1.97	.10	D from A & C
Corporate sales ⁵	1.8	1.8	2.1	2.8	2.4	4.47	<.01	D from A,B,C
Average sales growth ⁶	31.1	12.3	15.1	23.9	13.5	1.51	.20	

¹ Using the Duncan procedure at the .10 level of significance

² Based on a 11-point scale (0=low to 10=high priced)

³ 1990 capital equipment budget, expressed per production employee

⁴ Scale of 1=single plant, single co.; 2=multi-plant, single co.; 3=multi-co. corporation

⁵ Scale of 1=< \$1 million; 2=\$1-9.9 million; 3=\$10-49.9 million; 4=\$50-99.9 million; 5=\$100-499.9 million; 6=\$500-999.9 million; 7=> \$1 billion

⁶ Average annual sales growth (1985-1988)

Table 5. Environmental Uncertainty Factors for Cluster Groups¹

Variable	<i>Area of Uncertainty (%) For Cluster Groups</i>				
	A	B	C	D	E
1	Consumers (38%)	Consumers (24%)	Distributors/ Retailers (27%)	Consumers (26%)	Labor supply (46%)
2	Raw material suppliers (27%)	Consumers (14%) Parts supply (14%) Labor supply (14%) Meeting tech. requirements of industry (14%)	Labor supply (20%)	Competitors for customers (25%)	Consumers (31%)
3	Raw material suppliers (10%)	Raw Material suppliers (10%)	Improving & developing new products with new technologies (18%)	Labor supply (21%)	Consumers (23%)

¹ Three variables causing the most uncertainty in decision making were chosen from a list of 14 with Variable 1 causing the most uncertainty.

TECHNOLOGY/MARKETING MATRIX

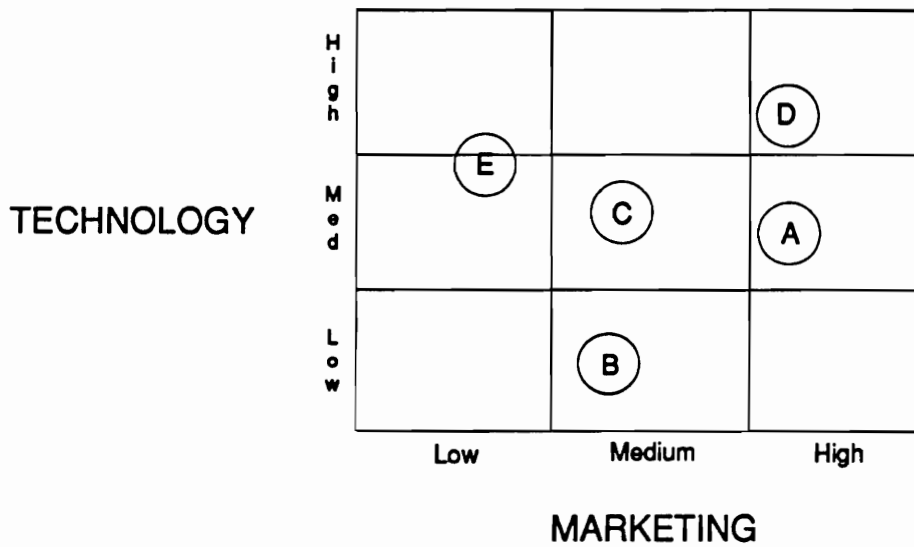


Figure 1: Technology/Marketing matrix description of cluster groups

Appendix - Measurement Summary

Variable	Question	Scale
<u>Technology</u>		
T1	"Our company believes it is important to use the most up-to-date production (operations) technologies available."	1=Strongly disagree 2=Disagree 3=Neutral 4=Agree 5=Strongly agree
T2	"In spite of market uncertainties, we are going ahead with plans to evaluate new equipment."	
T3	"Our manufacturing organization tries to be the first in our industry to implement new production technologies and methods."	
T4	"We are willing to make plant floor space available for experimentation with new equipment."	
<u>Marketing Concept</u>		
MKTOP	"Our firm routinely seeks consumer opinions on new products before formal introduction to the market."	
MKTNEDS	"Our firm feels that it is important to identify consumer needs prior to development of new products."	
MKTF	"Our firm follows the market closely. If another company introduces a new product that sells well, we quickly incorporate that product design concept into our product line."	
EXPERT2	"We are actively engaged in a campaign to recruit the best qualified marketing personnel available."	
PMOD	"Our firm prefers to invest in product modifications to those products that are selling well rather than investing in totally new product development."	
ADVER	"The advertising and promotion budget in our company is larger than the product development budget."	
<u>Business Uncertainty</u>		
INFO1 INFO2 INFO3	"How often do you believe that information available to you about each of the 3 variables you have selected is adequate for decision making?"	1=Never 2=Rarely 3=Sometimes 4=Frequently 5=Always

MIN1 "How difficult is it for your firm to get the 1=Very difficult
MIN2 minimum necessary information about each of 2=Difficult
MIN3 the 3 variables you selected?" 3=Neutral
4=Easy
5=Very easy

ADD1 "How difficult is it for your firm to obtain
ADD2 additional information (above the minimum
ADD3 necessary) about each of the 3 variables you
have selected when needed for decision making?"

Variable List: Distributors/retailers
Actual users of product (consumers)
Raw material suppliers
Equipment suppliers
Product parts supply
Labor supply
Competitors for suppliers
Competitors for customers
Government regulations
Public attitude towards industry
International trade policies
Relationship with trade unions
Meeting new technological requirements in production of products
Improving and developing new products by implementing new
technologies

SUMMARY

SUMMARY

This research project examined technology adoption as an important competitive strategy for the wood household furniture industry. First, a list of new technologies available to this industry was developed from a focus group discussion and interviews with industry experts. This list was used to evaluate the general level of adoption or innovativeness for individual firms within this industry. A mail survey was used to gather data concerning use of technology and related variables from firms across the industry. This information was then used to assess the wood household industry for its current level of technology adoption, to examine the impact of competitive variables on technology adoption and strategy formation and to determine the characteristics of innovators or early adopters within the industry. The results provide both insight into the technological direction of this industry and factors influencing the adoption of innovations by industrial organizations.

The first segment of the research looked at the current level of technology for the industry by asking respondents about recent capital equipment purchases and future purchase plans. Capital investment, in the past and future, appears concentrated in the finish machining area of the furniture manufacturing process. There is an increasing interest in utilization of automated equipment in this area. The advantages cited as the most important benefits derived from recent equipment purchases over the past five years included lower manufacturing costs and improvements in product quality. In addition, results indicate that firms which possess engineering expertise are more likely to implement new processing technologies.

The second segment of the research project investigated factors which could explain differences in technology adoption among firms in this industry. Both

competitive variables and strategy variables were examined within a causal model of adoption. The research results provided both insight into factors important to technology adoption within the furniture industry and adoption by organizations. Empirical results of the causal model provide evidence that competitive factors have both a direct and indirect effect, through policy formation, on technology adoption within organizations. The overall results suggest that organizational policy is dependent on the competitive conditions under which it was formed and that an aggressive technology policy has an important positive affect on the innovativeness of a firm. Specifically, communication variables exhibited the strongest influences on aggressive technology policy, rather than industry structural variables. This is not surprising, since the wood household furniture industry is a mature and highly competitive industry. Communication of new process adoption intentions and experiences appears to play an important role in promoting technology policy and subsequent technology adoption. A likely explanation for this relationship is that communication of technology advantages and competitive moves reduces the risk of adoption and thus promotes technology adoption. Communication of intentions and experiences, as measured in this study, was positively related to technology policy through signal frequency, international travel, professional memberships, attendance at professional meetings and technical expertise possessed by adopting firms.

These findings are based on a composite measure of innovativeness utilizing a cross-sectional methodology. This type of general measure is superior to a single adoption criteria because it accounts for variations in individual adoption patterns and conditions. Therefore, the results should be more generalizable and not specific to the conditions of any single innovation adoption.

Firms were segmented based upon their adoption of thirteen processing technologies into an early adopter group and a late adopter group. It was found that larger firms adopted more of the new process innovations than smaller firms. However, they did not indicate they planned to invest more in new capital equipment per production employee than smaller firms. These firms expressed a willingness to be the first to adopt and a preference for direct sources of information concerning new processes. Early adopter firms also possessed more technical expertise than later adopters, which confirms earlier findings. Technical expertise reduces risk of implementation of new technologies and encourages adoption.

Finally, firms were clustered on two strategic dimensions - technology and marketing strategies. Profiles of five groups based on corporate performance did not suggest strong significant differences. However, it was found that firms scoring highest on both dimensions expressed concern or uncertainty concerning consumers and competitors more often than other groups, supporting the notions that the competitive environment and change influences the choice of strategies.

OPPORTUNITIES FOR FURTHER RESEARCH

Any research project must be limited by time and resources. Therefore, there will remain unanswered questions and research opportunities. This is the case at the conclusion of this particular research effort. Listed below are remaining opportunities for research within industrial marketing and specific to the furniture industry.

Specific to the Wood Household Furniture Industry

- 1) The sample of furniture firms and research focus favored larger companies. Opportunities exist for technology evaluation and needs of smaller firms which make up a large portion of companies in this industry.
- 2) In addition, investigation of the adoption process through which firms pass to final adoption can provide further insight into barriers to adoption within this industry. This should include evaluation of the decision to reject adoption as well.
- 3) Finally, it appears that while many firms may consider adopting new technologies, they are not able to implement them. Investigation of implementation problems should provide additional insight into barriers to technology diffusion within this industry.

Industrial Marketing Research

- 1) Inclusion of policy or strategy variables within organization adoption models appears to offer a new research direction within marketing research. Future research opportunities exist in the development of valid measures of these constructs.

- 2) In addition, while many studies have been published concerning adopter characteristics, these results may not be generalizable across all industries or competitive situations. Therefore, opportunities exist to contrast adopter characteristics based on industry competitive characteristics and strategies.
- 3) Finally, further opportunities exist for cross industry studies on the selection of business strategies, marketing versus technology, particularly linking these to business performance.

APPENDIX

WOOD HOUSEHOLD FURNITURE MANUFACTURER QUESTIONNAIRE



VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

DEPARTMENT OF WOOD SCIENCE & FOREST PRODUCTS
Blacksburg, Virginia 24061-0503

**Survey of Wood Household Furniture Manufacturing
Technology Diffusion**

For more information or questions, please contact:

Cynthia D. West
(703)231-5876

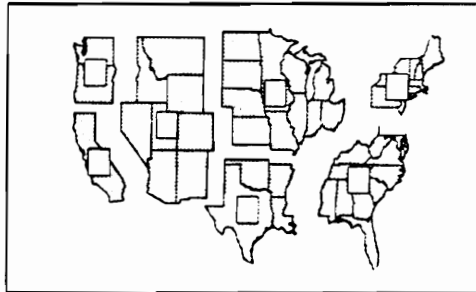
1. What is your position or title? _____

2. Please indicate which best describes your company's situation.

- Single plant, single company
 - Plants at multi-locations, single company
 - Plants at multi-locations; multi companies within the corporation
 - Other (Please specify below)
- _____

If your company is part of a multi-company corporation, please answer the remainder of this questionnaire for your company only unless otherwise requested.

3. Please indicate the region in which the majority of your furniture manufacturing facilities are located.



4. What piece of equipment purchased during the last 5 years has been the most beneficial to your company?

How has this equipment been beneficial?

5. What are the three most important pieces of equipment or process system technologies your company plans to purchase within the next 12 months? List the piece of equipment needed the most on the first line and indicate the most important reason it is needed:

Equipment	Reason Equipment Is Needed								
	To increase production capacity	To improve product quality	To reduce the number of operators	To replace worn-out equipment	To produce a new product	For production control or information retrieval	For manufacturing flexibility	Other (Please specify)	
(1) _____	_____	_____	_____	_____	_____	_____	_____	_____	_____
(2) _____	_____	_____	_____	_____	_____	_____	_____	_____	_____
(3) _____	_____	_____	_____	_____	_____	_____	_____	_____	_____

6. What are the most important pieces of equipment that your company plans to purchase in the next 5 years? (Not including the equipment listed above.) Please write the most important equipment name or type on the first line below and indicate whether it is likely to be produced by a domestic or a foreign equipment manufacturer.

	Domestic	Foreign
(1) _____	_____	_____
(2) _____	_____	_____
(3) _____	_____	_____

The next series of questions will be used to determine the level of technology currently used by the wood household furniture industry. Please answer each question even though the manufacturing process may not apply to your company.

1. Does your firm currently use a CAD (computer aided design) system to design furniture (parts)?

___ NO → GO TO # 4

___ YES

→ What year did you purchase your first CAD system?

19___

2. What computer base is used with your CAD system. (For firms with multiple plants, indicate the number of plants using each system)

- ___ Micro computer
- ___ Mini computer work station
- ___ Main frame computer

3. Does your firm use its CAD system to control production machines?

___ NO ___ YES

4. How many pieces of single process (or operation station) NC equipment does your firm operate? (For multi-plant firms, please estimate the total number to the best of your ability).

___ (#) single process NC machines

5. How many NC machine centers (multiple operations on one machine base) does your company operate? (For multi-plant firms, please estimate the total number to the best of your ability).

___ (#) NC machine centers

6. How many pieces of CNC equipment does your company operate?

___ (#) CNC machines

Approximately, what year did your company purchase its first CNC machine?

19___

7. Does your company use an embossed part(s)?

___ NO → GO TO # 10 BELOW

___ YES

8. Please indicate below which type(s) of embossing your company uses:

- ___ Platen embossing
- ___ Carving embossing
- ___ Double cavity dye embossing
- ___ Other (Please specify below)

9. Does your company contract out embossed part production?

___ NO ___ YES

10. Please indicate if your company uses any of the following process technologies by writing the approximate year it was first purchased on the blank line:

- ___ Computerized back gauges
- ___ Automated optimization system for cross cutting
- ___ Automated gang rip system
- ___ Machine vision system for lumber cut up
- ___ Electrostatic finishing
- ___ Robotics applications in finishing
- ___ Automated finishing system for parts prior to assembly
- ___ Wide belt sander
- ___ Wrap around/Soft forming/Post forming process
- ___ Laser machining
- ___ Electronic glue up system
- ___ Computerized dry kiln controls
- ___ Robotic palletizer
- ___ Die cutting process for parts
- ___ Membrane Press

11. Does your firm operate a feed through moulder with more than four heads?

NO → GO TO # 12 BELOW

YES

How is your moulder controlled?

Numerically controlled

Computer controlled

12. Does any of the process equipment your company operates use automatic tool changers?

NO YES

13. Does your company use bar coding?

NO → GO TO #14 BELOW

YES

→ Please indicate below how bar coding is used in your company:

Finished goods inventory control

Work in process inventory control

Parts inventory control

Machine set up

Other _____
(Please specify)

14. Does your company use an MRP (material requirements planning) system?

NO → GO TO # 17 BELOW

YES

15. Please check the elements listed below that are contained in your current MRP system:

Master production scheduling

Bill of materials structuring

Inventory status records

Capacity requirements planning

Other _____

(Please specify)

16. Is your MRP system computerized?

NO YES

17. How much money do you estimate your company will spend for equipment during the next 12 months and the next 5 years? Please include the 12 month total in the 5 years estimate. (Assume business conditions remain the same as 1988)

Next 12 months Approximately \$ _____

Next 5 years Approximately \$ _____

We would like to know more about your firm's investment in and attitude towards Process R & D. Please answer each of the following.

1. Does your firm have a formal product R&D department?

NO

YES

2. Does your firm have a formal production R&D department?

NO → GO TO # 5

YES

3. Estimate the total amount spent by your firm on Process R&D during 1988 and over the last 3 years. Include the amount spent in 1988 in the 3 year estimate.

\$ _____ Last year (1988)

\$ _____ Last 3 years

4. Do you expect the level of spending for R&D to increase or decrease next year?

1 Decrease Substantially

2 Decrease Somewhat

3 Remain Constant

4 Increase Somewhat

5 Increase Substantially

— GO TO Question #6 —

5. If your firm does not have a formal R&D department, how many engineers do you employ?

_____ # Manufacturing (process) engineers

_____ # Product design engineers

6. What is the degree to which you agree with each of the following statements? Please circle your response.

Strongly Disagree = 1

Disagree = 2

Neutral = 3

Agree = 4

Strongly Agree = 5

Our company believes it is important to use the most up-to-date production (operations) technologies available. 1 2 3 4 5

In spite of market uncertainties, we are going ahead with plans to evaluate new equipment. 1 2 3 4 5

Our manufacturing organization tries to be the first in our industry to implement new production technologies and methods. 1 2 3 4 5

We are willing to make plant floor space available for experimentation with new equipment. 1 2 3 4 5

Our company maintains our furniture plants with preeminently standard equipment for the industry. 1 2 3 4 5

This next series of questions are concerned with accessing the amount and type of business uncertainty faced by firms in the furniture industry.

1. Below is a list of some factors that can cause your firm uncertainty in decision making. Please choose the three factors that cause your firm the most uncertainty and rank them by numbering 1 to 3 with 1 being the most important factor. (3 = Least Important)

- ___ Furniture distributors or retailers
- ___ Actual users (consumers) of your firm's furniture products or services
- ___ Raw material suppliers
- ___ Equipment suppliers
- ___ Product parts (e.g. dimension parts, fasteners, drawer pulls)
- ___ Labor supply
- ___ Competitors for suppliers
- ___ Competitors for customers
- ___ Government regulatory control over the industry
- ___ Public political attitude towards industry and its particular product
- ___ International trade policies and practices
- ___ Relationship with trade unions
- ___ Meeting new technological requirements of your industry and related industries in production of products and services
- ___ Improving and developing new products by implementing new technological advances in the furniture industry

Please answer the next three questions about each of the 3 factors selected above by marking your response based on the scales provided:

2. How often do you believe that information available to you about each of the 3 factors you have selected is adequate for decision making?

	Never	Rarely	Sometimes	Frequently	Always
	1	2	3	4	5
FACTOR 1	1	2	3	4	5
FACTOR 2	1	2	3	4	5
FACTOR 3	1	2	3	4	5

3. How difficult is it for your firm to get the minimum necessary information about each of the 3 factors you selected for decision making?

	Very Difficult	Difficult	Neutral	Easy	Very Easy
	1	2	3	4	5
FACTOR 1	1	2	3	4	5
FACTOR 2	1	2	3	4	5
FACTOR 3	1	2	3	4	5

4. How difficult is it for your firm to obtain additional information (above the minimum necessary) about each of the 3 factors you have selected when you need the information for decision making?

	Very Difficult	Difficult	Neutral	Easy	Very Easy
	1	2	3	4	5
FACTOR 1	1	2	3	4	5
FACTOR 2	1	2	3	4	5
FACTOR 3	1	2	3	4	5

5. On average, would you say that your product line is basically, low, medium, or high priced? (Please indicate by circling the appropriate number)

Low Priced	Medium Priced	High Priced
0	1 2 3 4 5 6	7 8 9 10

6. Please indicate the approximate percentage breakdown of total shipped product form in 1988 (by value):

Product Form	Percentage
Ready-to-assemble (RTA)	___ %
Knock-down (KD)	___ %
Factory assembled	___ %

RTA = assembled by final consumer at home
 KD = assembled prior to sale by distributor

7. Please indicate the approximate percentage breakdown of the major wood furniture product categories your company produced in 1988 (by value).

Products	Percentage
Living room/occasional	_____ %
Dining room	_____ %
Bedroom	_____ %
Chairs	_____ %
Desks/secretaries	_____ %
Infant/juvenile	_____ %
Cupboards & Accessories	_____ %
Wall units/shelves	_____ %
Other (Please specify)	_____ %
_____	_____ %
_____	_____ %
TOTAL	100 %

8. How many significant competitors are involved in the market for your company's major product group (listed above)?

_____ #

9. How difficult is it for your company to predict customer demand? Please circle the best answer below.

- 1 Extremely Difficult
- 2 Fairly Difficult
- 3 Neither Difficult nor Easy
- 4 Fairly Easy
- 5 Extremely Easy

The following questions are concerned with accessing the amount of communication that occur between your firm and its competitors.

1. When deciding to purchase a piece of equipment, how often do you rely on the following sources for information. Please indicate your response for each of the following:

- Never = 1
- Rarely = 2
- Sometimes = 3
- Usually = 4
- Always = 5

Advertising in trade journals	1 2 3 4 5
Trade/equipment shows	1 2 3 4 5
Manufacturer or dealer's sales personnel	1 2 3 4 5
Other manufacturers' experience	1 2 3 4 5
Other _____ (Please specify)	1 2 3 4 5

2. Please indicate the frequency of the following:

- Never = 1
- Rarely = 2
- Sometimes = 3
- Usually = 4
- Always = 5

During your initial search for information on a new process or piece of equipment how often do you contact competitive firms for information? 1 2 3 4 5

How often do other competitive firms contact you for information concerning a process or innovation that you have adopted? 1 2 3 4 5

3. On average, how often do you have contact with other furniture manufacturing firms to discuss a new manufacturing process or piece of equipment?

_____ times per year

OR

_____ times per month

The following questions measure your firm's experience outside of the furniture industry.

1. How many out of town business meetings or professional association meetings do you and/or your staff attend per year? Please specify for:

Furniture markets, trade shows, & association meetings: _____ times per year

Any other meetings: _____ times per year

2. How many times do you and/or your staff typically travel outside of the country on business per year?

Please specify: _____ times per year

3. What percent of your firm's sales are currently to export markets?

Please specify: _____ %

4. What percent of your firm's purchases of raw materials, parts and equipment are from foreign suppliers? Please specify for each:

Raw materials	_____ %
Wooden Parts	_____ %
Manufacturing Equipment	_____ %
Finished furniture	_____ %

6. What percent of your firm's production employees have worked in industries other than the furniture industry?

Please specify: _____ %

The next two questions measure the technical expertise possessed by the furniture industry.

Continued.....

- Strongly Disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly Agree = 5

1. In the following section, please indicate the extent to which you agree with the following statements. Indicate your response by marking the appropriate space.

- Strongly Disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly Agree = 5

- | | |
|--|-----------|
| Our firm feels that it is important to identify consumer needs prior to developing new products. | 1 2 3 4 5 |
| Our firm routinely seeks consumer opinions on new products before formal introduction to the market. | 1 2 3 4 5 |
| The advertising and promotion budget in our company is larger than the product development budget. | 1 2 3 4 5 |
| Our firm focuses on new product development rather than modification to our current products and product lines. | 1 2 3 4 5 |
| Our firm believes that truly new product design ideas come from furniture designers and engineers not consumers. | 1 2 3 4 5 |
| Our firm uses market research primarily to determine the success of new products. | 1 2 3 4 5 |
| When purchasing new technologies we consult with product development specialists in our company. | 1 2 3 4 5 |
| Current market and product trends influence decisions concerning new process equipment. | 1 2 3 4 5 |
| New product development in our company is limited by current manufacturing processes in our plant(s). | 1 2 3 4 5 |
| Many of the new products our company introduces are copied by other producers. | 1 2 3 4 5 |

2. Please list below the professional and trade associations you are a member of:

2. How often do new product design ideas your company uses come from the following sources? Please answer for each of the following:

- Never = 1
- Rarely = 2
- Sometimes = 3
- Usually = 4
- Always = 5

1. Please indicate your agreement with the following statements:

- Strongly Disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly Agree = 5

- | | |
|---|-----------|
| Our firm follows the market closely. If another company introduces a new product that sells well, we quickly incorporate that product design concept into our product line. | 1 2 3 4 5 |
| Our firm prefers to invest in product modifications to those products that are selling well rather than investing in totally new product development. | 1 2 3 4 5 |
| Competitor offerings | 1 2 3 4 5 |
| In house designers | 1 2 3 4 5 |
| Contract designers | 1 2 3 4 5 |
| Consumer research | 1 2 3 4 5 |
| Retailers | 1 2 3 4 5 |
| Manufacturing/Production needs | 1 2 3 4 5 |

This next set of questions measures how marketing and technology relate in your firm.

3. Please indicate the relative importance of the following factors when you made your most recent purchases of new process technologies/equipment?

Very Unimportant=1
Unimportant=2
Neutral =3
Important=4
Very Important=5

Flexibility to respond to market demands. 1 2 3 4 5
Reduction in manufacturing costs in order to be more price competitive. 1 2 3 4 5
Better quality control of the manufacturing process. 1 2 3 4 5
Increase in the quality of our products. 1 2 3 4 5
Product design flexibility 1 2 3 4 5
Control of production costs 1 2 3 4 5
Production efficiencies 1 2 3 4 5

5. What year did your company start producing wood furniture?

Thank you for your time and effort in completing this questionnaire!

This last group of questions ask for information about your firm.

1. What was your company's total sales in furniture in 1988? (Individual company, NOT total corporation)

\$ _____

2. What was your company's average annual sales growth over the last three years (1985-1988)?

_____ %

3. Please indicate your company's total sales (for the Total Corporation from all locations) in 1988:

___ Less than \$ 1 million
___ \$ 1 million to \$ 9.9 million
___ \$ 10 million to \$ 49.9 million
___ \$ 50 million to \$ 99.9 million
___ \$ 100 million to \$ 499.9 million
___ \$ 500 million to \$ 999.9 million
___ Over \$ 1 billion

4. What was the average number of people employed by your company (not Corporation) in 1988? (Answer this question for furniture only, if your company manufactures other products.

_____ Number of full-time production employees

_____ Number of full-time employees (all types)

VITA

Cynthia Susan Doyle received a B.S. in Forestry and Wildlife from Virginia Polytechnic Institute and State University in June of 1981. She worked for Weyerhaeuser Company in Plymouth, North Carolina over the next four years in raw materials procurement. The last position Ms. Doyle held was as Raw Materials Planning Coordinator for the Plymouth mill facilities. While living in North Carolina, Ms. Doyle married Franklin D. West. Mrs. West returned to graduate school at Virginia Polytechnic Institute and State University and received a MBA in 1988 and a PhD. in Forest Products and Wood Science in 1990.