THE ADOPTION OF INNOVATIVE WOOD PROCESSING TECHNOLOGIES IN THE BUILDING PRODUCTS INDUSTRY

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(ABSTRACT)

The strategic importance of the adoption of innovative processing technologies was analyzed for building products businesses. This study examined the two components of wood building products businesses: the structural panel industry and the softwood lumber industry. To ensure that the relevance of adopting of innovative processing technologies was examined within an accurate contextual environment, additional important strategies and performance were also measured.

A mail survey of the seventy-five largest North American producers of these two products provided the primary data necessary to investigate the strategic importance of process technology adoption, forward vertical integration, relative market share, grade sector focus, and investment intensity on firm performance as measured by profitability surrogates and changes in relative market share. This survey collected direct measures of the proportion of 1987 production produced by respondent firms that used controlled distribution channels and each of twenty-three processes indicative of innovative technologies in the manufacture of building products. Information concerning the other strategic and performance factors was collected from secondary data sources.

Results indicate that the adoption of innovative processing technologies has a positive impact on firm profitability. Investment intensity and grade sector focus also contributed to superior profitability. Forward vertical integration, and relative

market share had no impact in differences between performance levels for the firms studied.

Technologies were examined for underlying dimensions that group different process technologies together. Firms were clustered according to their level of adoption of innovative processing technologies and these clusters were then described according to a variety of firm-dependent characteristics, strategies and performance measures. A strategy-performance model was developed for standardized, industrial product-markets and empirically tested using the data collected for the building products industry as an industry representative of this type of competitive environment.

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PREFACE

This dissertation is divided into two major sections. The first section titled Introductory Section introduces the research project, reviews pertinent literature and presents an overview of the materials and methods. The second section, titled Results, is written in manuscript format and presents the research results prepared as three distinct journal articles. The first of these examines the present state of processing technology adoption in the building products industry in North America. The second article reports on the strategic impact of adopting these technologies on building product firms. The third article, prepared for a business journal, develops a strategy-performance model for standardized industrial product-markets and tests this model using the information collected for the building products industry.

Each firm in the building products industry faces fierce internal competition for the limited financial resources that they possess. Wages, security of log supply, new facilities, innovative processing technologies, marketing, distribution and new product development all compete for the same limited financial resources. It is critical that firms invest these scarce financial resources into areas which will positively impact their performance. Little research has empirically explored the effect of various strategies on a firm's performance in the building products industry. This research evaluates several strategic options and assesses their impact on firm performance.

Within strategic market research, there has been little examination of standardized (commodity-like) product-markets. These competitive environments remain unexplored due to the difficulty of operationalizing and measuring the degree of adoption of innovative processing technologies. This study attempts to establish

the theoretical importance of this construct and develop measures that adequately reflect this construct.

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SECTION 1: INTRODUCTION

INTRODUCTION

The forest products industry has undergone dramatic changes since 1980. Corporate takeovers, new product introductions, divestment, shifts in geographical centers of production, changes in customer needs and corporate restructuring are examples of the transformations the industry has experienced this decade (Dickerhoof 1986; Bingham 1986; Haygreen et al. 1986). One of the fundamental changes has been a shift in the factors perceived to limit and direct growth. For many years companies thought their growth and success relied on the availability of raw materials i.e. logs (Rich 1986). Rinehart (1986, page 13) stated *"The commonly held view is that a high degree of fee ownership is -- a key factor in success."* During the past decade, changing customer demand and growing international competition have gained importance as critical limiting factors. No longer is production solely limited by the restricted availability of raw material (Bingham 1986).

This was demonstrated, during the first half of this decade, by record demand concurrent with excess supply which led to the adoption of new management strategies. These changes *".. have already resulted in an acceleration of innovation in our industry simply because companies have had to innovate to assure their survival"* (Bingham 1986, page 12). Companies have been implementing innovative process and product technology at a rapid pace. New products, often made possible by new processing technologies, such as oriented strand board (OSB), waferboard, laminated veneer lumber (LVL), parallel strand lumber and CCA treated wood products were unavailable to most consumers little more than a decade ago (Pease

1987). This explosion of new products has emerged from new business strategies adopted by many wood products firms.

A recent corporate strategy has been to de-emphasize commodity production --a production orientation-- and emphasize the development of specialty products to better meet customer needs --the marketing concept-- (Rich 1986). This has encouraged the adoption of innovative process technologies which facilitates the manufacture of new products designed for specific end user groups (Bayless 1986; Griffin 1986 and 1987; Rich 1986; Sommers et al. 1987). It has also encouraged stronger forward integration which leads to captive wholesalers and/or retailers (Rich 1981; Barnes and Sinclair 1985a). Proximity to the end user can encourage faster responses to changing customer needs (Gold 1986; Balakrishnan 1986). Adopting new technologies and increasing forward integration to strengthen distribution have been two of the leading trends in the forest products industry that can serve to increase a firm's competitive advantage (Rich 1986).

A third trend in the forest products industry has been an attempt by some companies to capture market share. Strategic market research has shown a link between profitability and market share (Buzzel et al. 1975; Newton 1983; Wakerly 1984; Ramanujam and Venkatraman 1984; Day 1986). However, recent research has demonstrated that this link might not be positively correlated along the entire range from low market share to high market share (Hamermesh et al. 1978; Woo and Cooper 1982; Unger 1983). Some results have reported that the market share and profitability link may be specific to the competitive industry environment (Jacobson and Aaker 1985; Prescott 1986; Markell et al. 1988).

Forest products firms recognized that the adoption of technological innovation is an important element of corporate strength (Rich 1986, Wilson 1986). Some management personnel considered it a required stratagem to ensure their firm's survival (Bingham 1986). Quinn (1985) considered continuous adoption of innovations and utilizing global technology sources as two of the three possible options for firms to successfully compete in the global market place. Scherer (1974) considered the adoption of new processes and products to be more important to a manufacturing firm's profitability than economies of scale. However, the linkage between forward vertical integration or market share with the adoption of innovative technologies is relatively unexplored.

First, the macro-structure of the wood products industry, with consideration of process technologies, is examined. This permits the segmentation of the broad industry category of wood products into homogeneous units, more suitable for meaningful examination.

Second, the research to date on the two business factors under consideration (market share and forward vertical integration) is reviewed. Available information on the relationship of each business factor with the industry segments being studied and with new process technologies within each industry segment is examined.

A summary will reassess the major points of the literature review and highlight questions evolving from the literature review. A brief section will then outline the overall materials and methodology of this research.

STUDY OBJECTIVES

The prime objective of this study is to determine if there are any connections between the adoption of innovative processing technologies and two business factors (market share and forward vertical integration) for building products firms. A secondary objective is to determine if there is a correlation between a firm's level of adoption of new process technologies and its profitability which can be reflected by a variety of financial performance measures such as Return on Assets (ROA), Return on Sales (ROS) and Operating Profit Margin (OPM). This research determines what, if any, linkages exist between financial performance (as surrogates for profitability) and the adoption of innovative processing technologies.

A third objective is to provide base line data for future time series analysis to determine the causality of linkages found by this research. It provides the necessary data to conduct further research to ascertain whether the adoption of innovative technologies today is correlated to future levels of technology adoption and financial performance.

REVIEW OF LITERATURE

JUSTIFICATION

Maturity, Technological Innovation and the Wood Products Industry

The dramatic changes since 1980 reflect an industry struggling to survive in an uncertain environment. Adopting the life cycle concept, these trends could be explained by the industry's entry into a mature stage. The forest products industry exhibits many of the symptoms by which a mature industry is recognized such as inelastic demand, over-capacity, over-staffing and increasing sophistication of distribution channels (Porter 1980; Rich 1981; Barnes and Sinclair 1985a; Downdy and Nikolchev 1986). In the early 1980's, previously successful operating strategies contributed to declining profits and increasing debt. Wood products companies seeking to prosper in the uncertain market place started changing strategic directions, reducing staffing levels and restructuring their organizations (Doyle and Saunders 1985; Bingham 1986; Rich 1986). These are all signs of an industry adapting to a maturing market.

Downdy (1986) contended that the development and adoption of new process technologies can aid in the revitalization of a mature industry. Managing innovative technology can lead to the development of new products or product attributes to serve needs not presently met by the firm's product line. One result can be a change in the life cycle of a company's product line from maturity and decline to maturity and renewal (Downdy 1986).

Porter (1985, page 174) recognized that the adoption of innovative process technologies by an industry can create entirely new products or product uses that

can substitute for existing products and expand the market. Porter (1985, page 175) states that *"Technological change plays an important role in altering industry boundaries."* For example, treated wood products, utilizing CCA preservative, have expanded the role of wood for construction outdoors. Sales for these products have tripled since 1980 by substituting treated lumber for masonry (Anonymous 1987a).

Product line renewal, often a result of process innovations, can contribute to corporate growth and help a company meet rapidly changing customer needs. The expansion of market boundaries for the wood products industry could change the industry structure and improve North America's competitive position in the global forest products market as has been suggested for generic, mature industries by Porter (1985), Burgelman (1985) and Quinn (1985). Adoption of innovative technologies during the past decade has been rapid and many companies are now prospering in this mature market. Hearne (1982, page 4) states that *"Repeatedly, we see examples of innovation creating growth segments in seemingly mature industries."* However, levels of adoption have not been uniform throughout the firms that make up the building products industry.

The successful adoption of new process technologies is becoming more complex. As Leenders and Wood (1983, page 121) state *"Early adoption of process innovations is not always an attractive proposition."* Porter (1985, page 176) agrees that *"... it is sometimes believed that technological change always improves industry structure, ... it is just as likely to worsen industry structure."* Adoption of innovative technologies can increase competition as well as lead to early obsolescence of valuable equipment. The adoption of new technologies can be a two edged sword and must be judged on their impact on a firm's profitability.

INDUSTRY SEGMENTATION AND NEW TECHNOLOGIES

Building Products

The forest products industry consists of two major segments: wood products and pulp & paper. Major structural differences between these two segments include markets served, channels of distribution, industry concentration and capital required for expansion (Tillman 1985).

Adopting innovative technologies in the wood products segment generally requires lower capital investment than in the pulp & paper segment. This can lead to lower entry barriers and more rapid diffusion and adoption of new technologies (Bayless 1986; Tillman 1985). The wood products segment is also more diversified with respect to ownership, product line and size of companies. For example, in pulp the top eight producers command 83% of the market --exemplary of oligopolistic competition--, while in lumber and boards the top eight producers command less than 21% of the market --exemplary of pure competition-- (Tillman 1985, page 23).

Since 1929, the pulp & paper industry has downgraded the productivity of capital by a factor of sixteen while increasing the productivity of labor by only a factor of four (Drucker 1985). This minimizes financial benefits from process innovations that are continuous in nature and replace labor inputs with capital. However, within the wood products industry segment process innovations have replaced expensive labor inputs with capital (in the guise of automated equipment) which has led to long term productivity growth (Greber and White 1982).

Within the wood products segment the vast majority of goods fall into two categories: softwood lumber and structural panels. Remaining products account for

less than 20% of the wood products industry (Tillman 1985). This study examines softwood lumber and structural panels, the major components of the building products industry.

Structural Panels

Extensive research in composite panels has been followed by introduction of new process methodology resulting in an increasing capacity for new product lines (Haygreen et al. 1985; Anonymous 1986a). These new structural panels include oriented strandboard (OSB), waferboard and oriented waferboard. Worldwide capacity for these products increased 30% from September 1985 to September 1986 (Anonymous 1986a). The capacity of North America, the major producing area for OSB and waferboard, has grown at a rate of 21% from 1983 to 1987, compounded annually. Ten years ago capacity was less than ten million square feet (three eights inch basis) while in 1987 capacity was over ten billion square feet. This explosive growth demonstrates both the industry and market acceptance of products resulting from the use of this new processing technology.

The introduction of composite panels provided the impetus for rapid technological innovation in the production of plywood (Baldwin 1987). One example is the spindleless lathe which allows the use of smaller, less expensive logs to produce veneer for plywood manufacture by greatly reducing the core size. This decrease in cost enables plywood to better compete with non-veneered structural panels on a price basis and can increase the use of plywood in presently cost prohibitive products (Sorenesen 1985; Griffin 1986 and 1987). Several firms in Canada and the United States are modifying their facilities to utilize this new process.

Other technological innovations that modify the more traditional peeling methods include X-Y charging, powered nose bars, power core drives and retractable chucks (Baldwin 1987; Knokey 1986). These innovations can decrease the cost of production and/or increase the ability to control the consistency of product quality (Spelter and Sleet 1989). New technologies in the manufacture of plywood are spreading rapidly. For example, 15 powered nose bars were installed in 1985, their first year of introduction, while in 1986 there were an additional 40 installations planned (Sleet 1986).

New technologies have contributed to changing market share for different types of structural panels (Anonymous 1986a). For example, non-veneered panels have increased their market share from less than 5% to over 14% of the U.S. structural panel market from 1983 to 1987. New technologies have also contributed to increasing the market size for structural panels as demonstrated by record sales of structural panels in both 1985 and 1986 without the traditional corresponding increase in new housing starts. This demonstrates how the adoption of innovative processing technologies may expand market boundaries for product lines (Porter 1985).

Softwood Lumber

Technological innovation in lumber production has focussed partly on the inclusion of computer production controls to ensure the maximum desired end product (Anonymous 1987c; Tillman 1985). This has allowed a change from the traditional objective of quantity maximization in a supply driven market to value maximization in a demand driven market.

An example of the adoption of new processing technologies is the rapid acceptance and implementation of electronic scanners to control the product mix of lumber produced from an individual log. Computerization of the lumber manufacturing process not only replaces labor inputs with capital inputs but can also improve lumber recovery rates and/or the consistency of product attributes.

These computerized scanning devices, often called wood optimizers, have expanded along the processing chain. There now exists scanners for optimizing production at the head rig (primary log breakdown), the trim saw and the edger. Optimization can be based on maximizing the gross volume produced or on maximizing the dollar value produced. Results have included lower production costs, improved product quality and/or increased product versatility (Anonymous 1987c). This illustrates how process innovation could lead to changing product lines which may improve a firm's ability to respond to the changing needs of their customers.

Development of new products in the lumber industry has been as dramatic as in the panel industry. These new products include studs and boards for the Do-It-Yourself (DIY) market, radius edge decking, finger jointed lumber, machine stress rated (MSR) lumber and CCA treated lumber. Many of these new products resulted from process innovations and encouraged market boundary growth by substituting wood products for non-wood products. An example of this is CCA treated lumber, which is produced using a pressure cylinder to treat wood with Chromated Copper Arsenate (CCA), and is sold for exterior usage. Sales have risen dramatically over the past decade. In 1987, over 50% of southern pine lumber was CCA treated prior to sale to the end consumer (Anonymous, 1987a). CCA lumber is substituting for masonry and expanding the market for softwood lumber.

A driving force behind process innovation in lumber manufacturing has been the acceptance of a marketing orientation. Some companies have targeted specific consumer groups such as the DIY'ers (Do-It-Yourself) and have differentiated their products using marketing methods such as brand naming (Bingham 1986; Seward 1986). The adoption of new processing technologies can contribute to more consistent quality in a product line, a necessary attribute for a differentiated product aimed at a specific user group. Some firms may adopt innovative process technologies to broaden their product line. Other companies may adopt new processing technologies in an attempt to lower cost and gain a competitive cost advantage over their competitors.

Porter (1985) suggested that these two business strategies, differentiation and low cost production, are the major methods of achieving a competitive advantage. These generic strategies can be applied either in a broad or a focussed approach (Porter 1985). In the building products industry, the selective adoption of innovative processing technologies is necessary to successfully implement either strategy.

VERTICAL INTEGRATION

Vertical Integration and the Building Products Industry

Utilizing technological change as a method of revitalization is an established trend in building products. This trend, combined with a marketing orientation, could aid in restoring industry growth. However, to implement a marketing orientation, a firm must become familiar with end users and their needs. Forward vertical integration can position a company closer to the customer to allow better

understanding of their needs. Robertson and Gatignon (1986) suggest that there is a direct relationship between the level of forward integration and the rapid diffusion of new technologies, both of which can lead to expanded market potential.

Vertical integration has most frequently been defined as a measure of the value that is added to a product by a particular business (Vesey 1978). This can be interpreted in two ways, quantitatively and qualitatively. It can be a quantitative measure of the value of end products leaving a production facility, relative to the value of the inputs (Buzzel et al. 1983). The higher the number calculated to measure vertical integration, the greater the value that the firm adds to a product. Much research has examined quantitative vertical integration as the "make versus buy" decision.

Qualitatively, it reflects the control by one company at different levels of channel activity (McCarthy 1985). Backward integration means control of raw material inputs; forward integration means control of distribution channels. A decision to integrate vertically (qualitatively) often requires firms to acquire business units outside their core businesses which results in diversification as well as vertical integration (Harrigan 1986b).

Forest products companies have historically practiced vertical integration as an operational technique. Most frequently, this integration has been back towards the source of the raw material to ensure access to inputs (Rich 1986; Rinehart 1985). During the early and mid 1980's, raw material supply had temporarily surpassed demand and the impetus to secure stability of inputs decreased (Rich 1986; Bingham 1986). With decreasing industry concern over raw material supply there was an increasing industry consideration of forward integration (Rich 1981; Barnes and

Sinclair 1985a, 1985b). Controlling distribution channels can put a company closer to the end user and sensitize management to changing consumer needs. This can lead to increased awareness of new product needs or changes in present product attributes which often requires new processing technologies.

Harrigan (1986b) suggested that vertical integration can result in improved marketing and technological intelligence, increased retention of high value-added margins and strong product differentiation to establish a sustainable competitive advantage. Firms that have adopted a forward vertical integration strategy may be seeking these competitive benefits. Harrigan (1986b) summarized the risks of vertical integration as a loss of outside intelligence, an exacerbation of excess capacity and a reduction of strategic flexibility due to resource commitment.

Vesey (1978) found that in a mature industry there was a trend for companies with high competitive advantage to have high degrees of forward vertical integration. Balakrishnan and Wernerfelt (1986) suggested that vertical integration was a means of erecting entry barriers to minimize the threat of new entrants, particularly in industries where technology is non-proprietary. Building products firms who have adopted a strategy of forward vertical integration may be attempting to use this strategy to assist in developing a competitive advantage.

Vertical Integration and New Process Technologies

The correlation between the degree of forward vertical integration and the level of adoption of new process technologies has not been clearly established in the literature. No clear recommendation concerning the advisability of vertical integration exists for firms in industries where the adoption of new technologies is rapid.

Some research suggested that vertical integration is an unsuccessful strategy in industries in which new technologies are being implemented. Balakrishnan (1986, page 348) stated *".. we would expect vertical integration to be less desirable in industries with more participants (less specialized assets, lower profits) and more frequent technical change."* This infers that frequent technical change (the adoption of new process technologies) and forward vertical integration would be negatively correlated. Gold (1986, page 172) concurs with this assessment by stating *"The advantages of increasing the span of vertical integration tend to grow in proportion to the expansion of total output only so long as there is relative stability in the supply and prices of needed inputs, in the basic technology employed and in the product-mix. Deviations from one or more of these conditions may not only decrease the advantages of a given level of integration, but may encourage reducing it."*

The building products industry exhibits traits such as frequent technical change, large numbers of participants and a changing product mix. This implies that vertical integration would impede the adoption of innovative technologies and place a firm at a competitive disadvantage. Forward vertical integration requires a commitment of corporate resources that are difficult to recover. The resultant reduction in available capital, combined with the high exit cost of forward integration, could lead to a risk adverse corporate position which would impede the adoption of capital intensive, innovative process technologies (Balakrishnan 1986).

While there is a substantial body of work that suggested a negative correlation between these two business strategies (vertical integration and technological adoption), there is roughly an equal body of literature which suggested a positive correlation. Buzzel (1983), using the Profit Impact of Marketing Strategies (PIMS)

database, found a significant positive correlation between vertical integration and new product introduction within mature industries. He (1983, page 100) wrote *".. the need to innovate might justify a vertical integration strategy even if the move exacted some penalty in short-term profitability".* Haygreen et al. (1985) found that implementing innovative process technologies in the wood products industry resulted in new product development and introduction. Combining Buzzel's and Haygreen's results imply a positive link between vertical integration, new product introductions and the adoption of innovative process technologies in the building products industry.

Barnes and Sinclair (1985b) found a positive correlation between operating profit margins and forward vertical integration in the wood products industry. These results were from a statistical study of 11 forest products firms and were based on data for 1970-81. The study was selective in terms of companies examined and excluded financial data since the recession of the early 1980's. Since then, many wood products companies have undergone changes in their strategic direction, ownership and level of adoption of new process technologies.

Many firms have accepted that the industry life cycle stage has entered maturity. The intensive research of the 1960's and 70's has led to the rapid introduction of innovative technologies during the 1980's (Haygreen et al. 1985). Gold (1986) found that adopting innovative process technologies can increase a firm's effectiveness to adjust to changing product mixes or designs. Shrivastava (1987) found that increasing forward vertical integration could encourage the successful adoption of innovative process technologies.

Some research indicated that forward integration encourages the adoption of new process technologies, while other research indicated the opposite. Harrigan (1986a)

suggested that the industry environment determines which of the alternative scenarios will occur. The changing environment of the forest products industry does not neatly fit into any of Harrigan's suggested categories. The relationship between forward vertical integration and adoption of innovative technologies within the forest products industry is relatively unexplored.

Both technological innovation and forward vertical integration are techniques that companies are practicing to survive and grow in the mature industry that produces solid wood products. Given the literature's differing viewpoints and the dramatic changes in the wood products industry since 1980, it is not known whether a company that implements forward vertical integration is more or less likely to adopt new process technologies. The relationship between the level of forward vertical integration and the adoption of new process technologies in the wood products industry needs to be established from primary data collection. Financial measures (reflecting profitability) would be a key determinant in measuring the success or failure of these two strategies, both as independent strategies and in concert with each other.

MARKET SHARE

Market Share and the Building Products Industry

The link between market share and profitability is a concern of continuing research, especially the PIMS (Profit Impact of Marketing Strategies) research at Harvard University. While the existence of a link has been verified, it has not been resolved whether the relationship is spurious or direct (Rumelt 1981; Day 1986).

Positive correlation between market share and profitability measures does not infer that the inverse is true -- i.e. low market share leads to low profits (Woo 1982). Hammermesh et al. (1978) suggested that market segmentation and a focus on a specific market segment can lead to both low market share and high profitability. While research has questioned the causal nature of market share and profitability, many firms still use market share growth for corporate objectives.

Woo (1982) stated *"The specific strategy of any business must be tailored to its capabilities and the requirements of its competitive environment."* This suggests that market share alone is insufficient for business success. The interrelation of market share with other business strategies, such as degree of forward integration and the level of technology adoption might affect the profitability of various levels of market share (Woo 1982).

The building products industry is highly diversified with respect to the size of firms. Tillman (1985, page 23) states that *"In lumber and board manufacturing the top four producers command less than 20% of the market and the top eight producers command little more."* One result of this diversity of company size is the lack of a dominant industry leader in building products. This mitigates the relevancy of market share data. However, relative market share adjusts an individual firm's performance to the competitive industry structure and is therefore more useful in an analysis of a single industry.

Market Share and New Process Technologies

Research has found a positive correlation between market share, new product introductions and profit (Craig and Douglas 1982). They equated profit with Return

on Investment (ROI) as measured by the ratio of Net Income to Average Investment. Haygreen et al. (1985) established a connection between new product introductions and the adoption of innovative process technologies. Wakerly (1984, page 96) showed that high relative market share, in combination with high product quality, represented the best combination for high profitability as measured by ROI. One result of adopting innovative process technologies has been improved quality control and improved product quality consistency. These research results imply a positive correlation between adopting new process technologies and high market share.

Newton (1983) considered both market share and profit surrogates to be a function of technological capability. He (1983, page 40) stated *"High management and technological capability will result in either a high level of ROI or a large market share or both."* Because technological capability frequently leads to new process technologies, market share and the level of process technology adoption could be positively correlated.

Research also suggested the possibility of a negative correlation. Woo (1981, page 7) reported *"A high volume-high market share strategy .. reduces the ability to respond to product changes and technological developments".* This suggests that firms with large market share are less likely to adopt new process technologies. Vesey (1978, page 15) supported this theory by stating *" .. that a higher cost of share is associated with a change to newness in plant and equipment."* This implies that firms implementing new process technologies will experience a higher cost of capturing market share, which would inversely affect profitability and impede the adoption of innovative technologies.

The link between market share and the adoption of new process technologies cannot be established from the existing literature. High market share firms could be more likely to adopt new process technologies because they would have the necessary financial resources. Alternatively, their high level of investment in existing facilities could provide barriers to implementing process innovations. Within the forest products industry, it is unknown if market share and the level of technological adoption is correlated, and if so, whether it is positive or negatively correlated.

SUMMARY

The majority of the strategic marketing literature has examined the impact of various generic business strategies across a wide spectrum of industries. However, as Porter (1985) stipulated, the successful application of business strategies is directly influenced by the structure of the specific industry. Thus, a strategy that is successful in one industry may be a failure in another industry with a different structure (Zeithaml et al. 1988). Concentrating on a single specific industry (building products) and its two major categories (structural panels and softwood lumber) will improve the validity and applicability of the research results.

Harrigan (1986b) recognized that not only is the desirability and success of forward vertical integration dependent on an industry's structure, but also that it's contribution to a firm's profitability changes as the industry structure changes. Previous research examined the effects of vertical integration across broad industry groups and provided differing viewpoints concerning the profitability of this strategy.

It does little to clarify the effects of forward vertical integration in a specific industry. This research examines forward vertical integration exclusively within the building products industry.

Market share and its affects on business performance has been an important topic of research. However, there exists differing viewpoints in the literature regarding the benefits or losses of various levels of market share (Buzzel et al. 1975; Hammermesh et al. 1978; Newton 1983; Rumelt 1981; Wakerly 1984 and Woo 1981). The examination of market share, specific to the building products industry, is examined in this study.

The importance of adopting innovative process technologies has been well established in the literature (Bayless 1986; Burgelman 1985; Dickinson et al. 1984; Downdy and Nikolchev 1986; Hearn 1982; Quinn 1985 and Wilson 1986). However, little empirical research exists that measures a firm's level of adoption of innovative process technologies and how it impacts performance. By focussing on the level of innovative technology as an independent variable, this study tests the hypothesis, accepted in most of the literature, that the adoption of innovative process technologies will lead to improved business level performance as measured by profitability surrogates. This will determine the relationship between process technology adoption and profitability as well as provide baseline data for future studies to determine longer term results from the adoption of innovative process technologies.

MATERIALS AND METHODS

INTRODUCTION

To ensure that all pertinent research studies were identified, an extensive literature review continued during the research process in the fields of Forest Products, Marketing, Management and Statistics. This assisted in accumulating secondary data and prevented the inefficient duplicate collection of existing information. Computerized retrieval systems were utilized in securing all relevant publications. Journals from both the United States and several foreign countries were examined to ensure a complete literature review. In addition to scientific, business and forest products journals; trade publications, magazines and newspapers were reviewed.

Due to the lack of empirical research on the correlation between different business strategies and the implementation of new processing technologies in the building products industry, the accumulation of primary data provided a significant portion of the research work. There were four distinct parameters that required measurement for each firm in the sample. They were:

1) the level of adoption of innovative technologies in the manufacturing process of both structural panels and softwood lumber;
2) the degree of forward vertical integration;
3) the relative market share in both structural panels and softwood lumber; and
4) the relative profitability of the building products unit, reflected by selected financial ratios.

SAMPLE DESIGN

Sample Frame

The population consisted of all firms in North America that produced building products (i.e. structural panels and/or softwood lumber) in 1987. The sample frame was developed by combining listings in the "Forest Industries 1987-88 North American Factbook" (Corlett 1987), published by Miller Freeman Publications in cooperation with the National Forest Products Association (NFPA). Duplicate listings were deleted to provide a single mutually exclusive sample frame. This sub-population represented the vast majority, but not all, of the North American production of structural panels and/or softwood lumber.

Several problems arise when using this sample frame since listings in the Factbook do not represent 100% of the softwood lumber production in North America. However, data collected by Miller Freeman for 1986 North American softwood lumber production did account for over 92% of the production in the United States and over 82% of the production in Canada (Corlett 1987). This alleviated many of the problems associated with an incomplete sample frame.

The lack of a complete sample frame could have affected research validity due to frame error. However, as Adler (1967, page 91) stated: *"The remainder of the industry may comprise comparatively numerous firms, but is rather unimportant from the point of view of the total market."* Schoner (1975, page 338) recognized that *"the sample population is often necessarily different from the population in which we are interested."* Cox (1979), as well as Tricker and McIntosh (1973), recognized that a sample frame in industrial marketing research can rarely include the total

population. This sample frame does include all the major producers -- ones that could conceivably utilize the business strategies under study. It is necessary to recognize not only the limitations of the sample frame but also the irrelevancy of these limitations to the validity of the research.

Where the listings for structural panel producers had capacity figures, but lacked production figures, the facilities capacity was used for production, if this information was not available from alternative sources. These alternative sources included annual reports, industry reports, and/or direct contact with individual companies. Examination of the 1986 production and capacity figures demonstrated that where both figures were available, production was within 10% of capacity (Corlett 1987). The sample frame consisted of firms that produce the great majority of structural panels and softwood lumber in North America in 1986. It represented an overwhelming majority of firms that could conceivably implement strategies such as increasing market share or forward vertical integration.

Sampling Method

Sampling was done on a purposive basis. The best rationale for this procedure is stated by Adler (1967, page 91):

> *"It is not only the size of the universe but also its composition which have to be considered carefully when drawing up a sample for industrial research. Consumer research makes the tacit assumption that each unit of the universe has a purchasing power which does not differ too widely from any other unit; and where it does differ -- this is in itself a problem for the research findings and not for the sample. This is not so in industrial market research. An industry is*

usually dominated by a small number of firms whose aggregate output covers the majority of the market, often 80 or even 90 percent. The remainder of the industry may comprise comparatively numerous firms, but is rather unimportant from the point of view of the total market.

In this case -- and it has to be repeated that this state of affairs is the rule rather that the exception -- it would be quite wrong to use a pure random sample."

This supports the rejection of using a traditional random sampling procedure. The remaining choices are between a purposive sample based on size, or a random sample of a clustered population. These options are discussed by Karmal and Jain (1987). They state:

"The added efficiency appears to come from purposive sampling, which is more efficient at testing the ratio than random, systematic or balanced sampling. This raises the possibility of taking the approach of choosing the largest units in each stratum to its logical conclusion by collapsing the size strata and taking the largest units in each industry. .. Thus we infer that purposive sampling gives the strategy power and size stratification gives robustness."

The ratio referred to is the comparison between Mean Squared Error (MSE) terms calculated by different sampling techniques and the actual MSE of the entire industry population. Purposive sampling, using size as the judgement criteria, should give the results of this study sufficient power for meaningful analysis.

The validity of using purposive sampling is supported by Schoner and Uhl (1975, pages 338-340), Churchill (1987, pages 436-440) and Adler (1967, pages 91-92). Zehnoff (1973) makes a strong case for the superiority of purposive sample,

compared to probabilistic sampling, in industrial market research due to the differing size and importance of population members. While purposive sampling gives the study statistical power, the sample size, and its representation of firms responsible for a large part of the production of the building products industry, gives the study robustness.

Use of a purposive sample instead of a probabilistic sample both creates and solves several problems that arise when carrying out research among building products firms. It precludes an assessment of "sampling error" and the placement of bounds (confidence intervals) on estimate precision (Churchill 1987). Schoner and Uhl (1975) suggested that non-sampling errors can be more important than sampling errors. They listed measurement, nonresponse, process and frame as sources of errors not measured by the standard sampling error. Careful control of these non-sampling error sources can provide the accuracy required for valid research results.

The most serious problem is stated succinctly by Churchill (1987, page 435), "*.. we have no way of knowing if those included are representative of the target population.*" The analysis and results of the research were limited to the firms sampled: all inference of sample results to the general population were made with adequate disclaimers. However, as succinctly reported by Martilla and Carvey (1975) it is a "sin" to equate statistical significance with practical importance. Ensuring that respondent firms represented a substantial proportion (over 25%) of North American production in 1986 not only improved the practical importance of the results but also increased their robustness.

Sampling Procedure

Building products firms are extremely diverse in size and no single firm or small group of firms dominate the industry. There is a substantial number of very small firms that produce softwood lumber. A firm must be of sufficient size to have the resources necessary to implement the business strategies under study. Both integrating towards the end user and capturing market share requires the expenditure of substantial corporate resources (Harrigan 1986b; Day 1986; Rumelt 1981). It would serve no purpose to have included in the sample those firms that did not have the necessary resources to implement the strategies under study (Adler 1967). For this reason the sampling procedure isolated those firms to whom the implementation of the business strategies under study were relevant (i.e. the larger firms).

While no small group of firms dominate the industry, there is a concentration of production among the largest firms in both structural panels and softwood lumber production. While O'Laughlin and Ellefson (1981, page 25) reported *"The top 10 wood-based companies dominate the industry with one-fourth of all sales revenue."*, these firms included those that focus on pulp, paper, packaging and specialty products. Tillman (1985) recognized that the concentration of the top eight firms in pulp & paper constituted a dominance with 83% of the market while in lumber and boards they did not dominate, with a market share of slightly more than 20%.

Forest Industries (1986c) reported that the top 5 firms, in both Canada and the United States, accounted for 24% of the softwood lumber production in each country, during 1985. This illustrated that in building products industry segment the largest firms, while important, do not dominate the industry. Because of this importance the ten firms that produced the largest quantity of structural panel and/or softwood

lumber in 1986 were singled out for the use of additional techniques to ensure a high response rate. Other large firms, to bring the total sample size to 75, were included in the sample to ensure that firms producing a substantial proportion of the 1986 building products production were represented in the sample. Sampling techniques were chosen to ensure a response rate to provide adequate quantities of data for meaningful analysis.

Tull and Hawkins (1976, page 140) suggested a five-contact system for increasing the response rate to mail surveys. They state:

> *"This system includes: (1) a prerequisite letter,*
> *(2) a questionnaire with cover letter,*
> *(3) a follow-up letter,*
> *(4) a second questionnaire, and*
> *(5) a third follow-up letter."*

They reported a response rate of 77.8 percent using this technique. Disadvantages of this five-contact system are high costs and a relatively long time frame for data collection. The six contact system used to collect data from the majority of the respondents in this research was derived from the above, to alleviate the stated disadvantages. Procedures for all but the largest 10 firms were as follows:

(1) telephone contact with each firm to establish the appropriate contact person,

(2) advance, prerequisite letter (mailed one week prior to survey mailing), mailed to appropriate contact person,

(3) a questionnaire with cover letter and free gift,

(4) a follow-up letter, one week after questionnaire, and

(5) a second questionnaire, with different covering letter, to be mailed to non-respondents 3 weeks after the initial survey.

(6) a follow up telephone call to all nonrespondents encouraging response

This procedure contributed, not only to a high response rate, but also to improving the accuracy of the information collected (Hansen et al. 1983). Several incentives were used to encourage response. These included a free gift that was mailed with each questionnaire and an offer of a summary of survey findings available to all respondents.

The survey procedures for the top 10 producers followed the same system with one additional step. Prior to the advance letter, telephone contact with the firm's respondent established personal prenotification in an effort to ensure adequate response from the largest firms. Research by Hansen et al. (1983) provided empirical evidence to support the contention that a prenotification telephone call increases response rates in industrial surveys. Increasing the response rate from the largest producers assisted in contributing to the practical importance of this research.

Sample Size

Cox (1979, page 293) recognized that using nonprobability sampling methods results in no objective basis for determining sample size. Tull and Hawkins (1980, page 426) suggested that a Bayesian-type approach be adopted that balances the value and cost of information for various sample sizes to determine final sample size

selection. They stress the trade-off between the marginal cost of sampling and the marginal value of the information received.

The sample size of 75 respondents was based on combining the data requirements for a variety of multivariate statistical techniques with the decreasing value of the collected information as the firm size decreased. The subjective evaluation of these two criteria led to a requirement of 38 responses. A conservative response rate of 50% results in a sample size of 75 firms. This ensured that two constraints were met; (1) there was sufficient information on each variable to utilize appropriate statistical techniques, and (2) a substantial proportion of the building products industry (by volume produced) was included in the sample to allow meaningful conclusions concerning the building products industry.

The sampling procedure sampled the largest (by volume produced) 75 firms producing building products in North America. Eight of the seventy-five firms no longer existed as separate entities and of the remaining sixty-seven firms, forty-four responded resulting in a 67% response rate, well within the minimum desired.

Sampling Instrument

Primary data was collected from a structured-undisguised questionnaire. This questionnaire was standardized for each firm being sampled, meaning that questions were presented with exactly the same wording, and exactly the same order. Using a standardized, structured questionnaire simplifies tabulation and analysis of data as well as increasing the reliability of the answers (Churchill 1987, pages 228-9).

The questionnaire was administered through the mail, in Canada and the United States, to provide the most efficient and cost effective vehicle for securing primary

data from such a geographically dispersed population. Major advantages of mail surveys, over alternative methods, include elimination of interviewer bias, increased geographical flexibility, improved accuracy of response to questions requiring thought to answer and centralized control (Erdos 1970). This survey required that respondents provide information from more than one source within the company. A mail survey provided individual respondents with the time necessary to access various sources of information within a company; thus improving the accuracy of their answers to the survey questions.

Major disadvantages of mail surveys include incomplete or biased mailing lists, information requirements that cannot be obtained through structured questions and low response rates (Erdos 1970). Utilizing a purposive sampling technique eliminates the first drawback. Exploratory research has obtained the information required for this study that could not be provided by structured questions. Low response rates were avoided by using the sampling procedures outlined above.

Questions were open-ended, equal-appearing interval and multichotomous. In multichotomous questions alternative answers were mutually exclusive. Equal-appearing interval questions had an underlying interval scale. A sample questionnaire can be found in Appendix 1.

Sampling Instrument Verification

The questionnaire was verified in two different ways. First, the data was collected in a scaler form, suitable for the desired statistical analysis. Second, it was necessary to ensure that the questions themselves were in a form that can and will be answered by industry personnel. To ensure statistical appropriateness, each

question was reviewed by a statistician ensuring that their format was suitable for univariate, bivariate and multivariate statistical analysis.

The survey was reviewed by knowledgeable industry personnel, as a pre-test, to ascertain the appropriateness of the questions. Four individuals, representing four firms in the sample, and four additional researchers acted as survey instrument advisors. Comments concerning the appropriateness of the survey instrument were obtained both over the telephone and in writing. .

DATA COLLECTION

Level of Adoption of New Processing Technologies.

Exploratory research, in the form of a focus group, was carried out to determine the technological processing innovations presently being implemented in the manufacture of structural panels and softwood lumber. Appendix 2 contains the report on the focus group held June 22, 1987, in Louisville, Kentucky. Planning and implementation of this focus group followed the guidelines of both Bellenger et al. (1976) and Wells (1974). Knowledgeable representatives of industry firms and trade associations, academe and government attended the focus group to determine which innovative technologies have been/were being implemented in the production process for structural panels and/or softwood lumber.

One of the objectives of the focus group was to differentiate between processing innovations which have been/were being implemented and those, despite reports in the literature, that were not yet sufficiently developed to be implemented. The proceedings were tape recorded and the report was produced from the transcript of the taped proceedings. Results of this exploratory research not only provided direction to the continuing literature review, but also contributed to the formation of a list of new process technologies implemented since 1980. This list included the most relevant innovations that were adopted and enabled the formation of a question to quantitatively measure a firm's degree of adoption of innovative process technology.

The survey question was framed as a equal-appearing interval question, instead of an open ended question, to allow the use of an interval scale measurement for

the level of technological adoption. This broadened the analytical scope of the study and allowed multivariate analysis of the survey results pertaining to this variable.

Degree of Forward Vertical Integration

Two types of information were collected regarding a firm's level of forward vertical integration; first, annual use of controlled wholesale distribution channels from 1983 to 1987, and; second, annual use of controlled retail distribution channels for the five year study period. These data were collected as primary data using the mail survey composed of structured-undisguised questions (Appendix 1). Data was collected using an equal interval format to utilize an interval scale that facilitated the statistical analysis of responses.

Annual usage of controlled distribution channels was measured as the proportion of a firm's production that was distributed using controlled channels. Using proportion, instead of volume, prevented a high rating for firms using controlled distribution channels for large volumes of building products that represent only a small proportion of their overall production. It also enabled quantification of a firm's use of forward vertical integration as an operational strategy.

Controlled channels of distribution were defined as wholesalers or retailers either owned by the firm or controlled by them through contractual agreements. This allowed recognition of smaller firms, that did not have the resources necessary to own channel members, but that could still control them as part of their operating strategy.

Relative Market Share

These data were collected for each category of building products, for each year of the study period, from secondary data sources. Annual market share for building products was derived by taking the weighted average of each firm's production (by volume) of structural panels and softwood lumber. A thousand square feet of structural panel (three eighth inch basis) was considered equivalent to a thousand board feet of softwood lumber because of similar market prices. Each firm's average market share for the five year study period was calculated by taking the arithmetic average of the five years of market share data for building products.

Relative market share was calculated as the ratio of a firm's production volume compared to the three largest firms. This compensated for the structure of the building products industry, which has large, but not dominant, producers. The resultant single interval number measured the relative market share in the building products industry for each firm in the sample. This method of data collection allowed the analysis of market share trends over the study period and a measure of each firm's market strength.

A variety of sources were used to determine annual production volumes for each firm and for each industry segment. Where gaps existed in the Factbook, alternative sources, such as annual reports and industry trade figures, were explored. Using these three sources to fill in gaps and to validate published production figures minimized the use of biased data.

Relative Profitability

Profitability, as a theoretical concept, cannot be directly measured. However, there are many surrogate measures that represent the profitability of a firm. These include Return on Assets (ROA), Operating Profit Margin (OPM), Return on Equity (ROE), Net Income Margin (NIM) and Return on Sales (ROS). The criteria to choose appropriate measures for this study were as follows:

1) the information required to calculate the measure(s) must be available for the building products business unit of each public firm in the sample;
2) the measures used should reflect financial changes resulting from the adoption of new process technologies.

While no single measure completely satisfied both criteria, the use of several carefully chosen surrogate measures of profitability assisted in meeting these criteria as closely as possible. Two surrogate measures of a firm's profitability, that were chosen for this study were ROS and ROA.

In both cases Return was calculated as contribution to earnings plus depreciation (referred to as operating profit) for the building products segment. This alleviated possible biasing affects of interest expenses, corporate overhead costs and differing consolidation reporting procedures.

Return on Assets and Return on Sales for the building products unit of each firm was calculated as follows:

Return on Assets (ROA) = Operating Profit from Building Products / Segment's Total Assets

Return on Sales (ROS) = Operating Profit / Gross Sales for building products segment

Data for financial calculations came from the building products segment within each firm's annual report for public companies. Operating Profit was used to exclude the impact from taxation policies and/or extraordinary items which could distort this surrogate measure's reflection of a firm's profitability. While this is a simple and well recognized method of calculating comparative profitability surrogates, there are problems inherent in this approach (Chakravarthy 1986).

Prior to calculating ROA and ROS for each sample firm, differing accounting procedures were examined to ensure that these measures were comparable between firms. Accounting procedures such as depreciation and/or assignment of expenses incurred by the head office can vary widely from firm to firm. Each firm's method of depreciation and inventory valuation were examined to ensure that where different methods were used they had no significant impact on the profitability surrogates.

In addition, the composition of the building products section of each firm was examined to confirm that profitability measures for building segments were indicative of softwood lumber and structural panels. If softwood lumber and structural panels accounted for less than 50% of building product segment sales then they were deemed to be unrepresentative of these two product groups and the firm was removed from the analysis data base.

Including a profitability surrogate (ROS) which excludes asset information compensated for problems inherent in differing asset valuation methods since assets are not a factor in the calculations. However, problems of asset valuation and

differing accounting practices still required rationalization because they do affect operating profit calculations (due to depreciation inclusion).

While there exists many surrogate measures of profitability, it must be recognized that as surrogates, no single approach accurately reflects the term called profitability, which cannot be directly measured. Surrogate measurements for profitability included ROS and ROA to facilitate comparison as a validation technique.

DATA EVALUATION

The majority of the data was collected using either a direct interval scale or multichotomous questions based on an underlying metric scale to facilitate statistical analysis. Analysis of the data was accomplished primarily using parametric and multivariate statistical procedures.

Multivariate analysis techniques were the major statistical tools used to explored relationships among variables. Principal Component Analysis, Hierarchical Clustering and Multiple Regression were the major multivariate procedures used to analyze the data. This type of analysis was suitable since there was a set of independent variables (designated p) and one or more dependant variables (designated n) or all the variables are considered dependant ($p = 0$).

Principal Component Analysis was used to determine the underlying dimension of technologies being adopted by sample firms to explore different groups of technologies which were adapted as a package. Cluster analysis was used to derive

homogeneous groups that exhibited differences in levels of adoption of innovative processing technologies. These groups were then profiled using Analysis of Variance with Tukey HSD post hoc testing to examine significant differences between group means for a number of firm dependent characteristics. Multiple Regression was used to explore strategy and performance linkages.

Since these multivariate analysis techniques require metric data, a priori decisions on statistical methodology ensured the development of survey questions which collected data in the required scaler form to facilitate the use of these statistical techniques.

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APPENDIX 1: SURVEY QUESTIONNAIRE

SURVEY ON NEW WOOD PROCESSING TECHNOLOGIES AND BUSINESS STRATEGIES

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
DEPARTMENT OF FOREST PRODUCTS

Does your firm produce structural panels, either softwood plywood, OSB or waferboard?

YES _____ If YES please answer the following question on structural panels.
NO _____ If NO please go to page 2 and answer the questions on softwood lumber.

STRUCTURAL PANELS

The following questions refer to your 1987 production of either plywood or non-veneered structural panels.

1. Please indicate the approximate proportion of your firm's panel production (by volume, to the nearest 10%) that was sold through captive wholesalers. Captive wholesalers are either owned or controlled by your firm.

	0%	20%	40%	60%	80%	100%
1983						
1984						
1985						
1986						
1987						
Projection for 1990						

2. Please indicate the approximate proportion of your firm's panel production (by volume, to the nearest 10%) that was sold through captive retailers. Captive retailers are either owned or controlled by your firm.

	0%	20%	40%	60%	80%	100%
1983						
1984						
1985						
1986						
1987						
Projection for 1990						

3. Please list 3 companies (excluding your firm) that have been the leaders in adopting new technologies in the production of structural panels.

1. _____
2. _____
3. _____

4. Please list the 3 companies (excluding your firm) that produce the highest quality panels.

1. _____
2. _____
3. _____

5. Please rate the quality of the structural panel products you manufacture against your competitor's by circling the appropriate category below.

quality much below competition — quality similar to competition — quality much above competition

----- 1 ---------- 2 ---------- 3 ---------- 4 ---------- 5 -----

6. Please list 3 companies (excluding your firm) that have been the leaders in selling panels through captive wholesalers and/or retailers.

1. _____
2. _____
3. _____

7. Please indicate the proportion (by volume, to the nearest 10%) of your firm's annual production of structural panels that is produced using each of the following technologies. Those marked by an asterisk (*) are defined on page 4.

	0% . 20% . 40% . 60% . 80% . 100%
LOG MERCHANDISING *	
PLYWOOD	
ROUND UP LATHE	
XY CHARGERS	
POWERED NOSE BAR *	
POWERED CORE DRIVER *	
RETRACTABLE CHUCK	
SPINDLELESS LATHE	
COMPUTERIZED CLIPPER *	
AUTOMATED LAYUP LINE	
HIGH M.C. GLUING	
PRESS DRYING OF VENEER *	
COMPUTERIZED VENEER DRY *	
NON-VENEERED STRUCTURAL PANELS	
% THAT ARE MULTI-LAYERED *	

8. Does your company produce softwood lumber?

YES _____ If YES please answer the following questions on softwood lumber.
NO _____ If NO please go to page 4 Question A.

****

SOFTWOOD LUMBER

****

The following questions refer to your 1987 production of softwood lumber.

****

1. Please indicate the approximate proportion of your firm's lumber production (by volume, to the nearest 10%) that was sold through captive wholesalers.

	0% . 20% . 40% . 60% . 80% . 100%
1983	
1984	
1985	
1986	
1987	
Projection for 1990	

2. Please indicate the approximate proportion of your firm's lumber production (by volume, to the nearest 10%) that was sold through captive retailers. Captive retailers are either owned or controlled by your firm.

	0%	20%	40%	60%	80%	100%
1983						
1984						
1985						
1986						
1987						
Projection for 1990						

3. Please list 3 companies (excluding your firm) that have been the leaders in adopting new technologies in the production of softwood lumber.

1. _____
2. _____
3. _____

4. Please list the 3 companies (excluding your firm) that produce the highest quality softwood lumber.

1. _____
2. _____
3. _____

5. Please rate the quality of the softwood lumber products you manufacture against your competitor's by circling the appropriate category below.

quality much below competition — quality similer to competition — quality much above competition

----- 1 ---------- 2 ---------- 3 ---------- 4 ---------- 5 -----

6. Please list 3 companies (excluding your firm) that have been the leaders in selling softwood lumber through captive wholesalers and/or retailers.

1. _____
2. _____
3. _____

7. Please indicate the proportion (by volume, to the nearest 10%) of your firm's annual production of softwood lumber that is produced using each of the following technologies. Those marked by an asterisk (*) are defined on page 4.

	0%	20%	40%	60%	80%	100%
LOG MERCHANDISING *						
COMPUTERIZED LOG CARRIAGE						
LOG SCANNING AT HEADRIG *						
SMALL KERF HEADRIG *						
COMPUTERIZED EDGER						
AUTOMATED SORTER/STACKER						
MACHINE STRESS RATING *						
ABRASIVE PLANER *						
TEMP DROP ACROSS LOAD DRY*						
CONT RISING/HIGH TEMP DRY*						

A. Name of your firm. _____

B. Please list the titles of the personnel who provided information in completing this questionnaire.

_____

_____

_____

_____

C. Would you like a copy of the research results?

YES _____ NO _____

THANK YOU FOR YOUR ASSISTANCE !

PLEASE RETURN THIS SURVEY IN THE ENCLOSED ENVELOPE. POSTAGE IS PRE-PAID.

****

DEFINITION OF TERMS

LOG MERCHANDISING The use of computer scanning or other mechanized log grading techniques that direct a log to the manufacturing facility which will produce products with the highest return for the company.

STRUCTURAL PANELS

POWERED NOSE BAR A nose bar which is powered to add torque in the rotation of the peeler block resulting in less spin-outs and smaller chuck size.

POWERED CORE DRIVE A device whereby part of the torque that rotates the peeler block is provided by a powered roller, for example the Coe M-1380 Core Drive.

COMPUTERIZED CLIPPER Clipping of the veneer ribbon is controlled by a computerized, programmable scanning device.

COMPUTERIZED VENEER DRY The use of a computerized system, such as the Delta T system, to control the moisture content of veneer prior to exiting the dryer.

VENEER PRESS DRYING The use of a press-platen dryer to reduce power requirements and/or improve raw material recovery by reducing width shrinkage.

% THAT ARE MULTI-LAYERED Non-veneered structural panels composed of layers of furnish oriented much like veneer in a plywood panel.

SOFTWOOD LUMBER

LOG SCANNING AT HEADRIG The use of computerized scanning of the log to determine the primary breakdown that will be most profitable using techniques such as "best opening face".

SMALL KERF HEADRIG The use of thermo-tensioning of saws, spline and guide saws or specialized teeth alloys (such as stellite) to reduce kerf and increase lumber recovery.

MACHINE STRESS RATED Lumber is tested, using a specialized machine, to determine strength characteristics for a specific piece of lumber. This allows the upgrading of some of the lumber produced from variable density species.

ABRASIVE PLANER Rough lumber is sanded, instead of being planed, from its rough size to its finished size.

TEMP. DROP ACROSS LOAD DRY A technique whereby the drop in temperature of of the air as it passes through the lumber is monitored. Kiln parameters are adjusted to control this drop which is a relatively direct measure of the rate of evaporation.

CONT. RISING or HIGH TEMP. DRY Lumber is dried using continuously rising temperatures and/or with dry bulb temperatures above 100°C to improve dryer efficiency and reduce drying time.

APPENDIX 2: REPORT ON FOCUS GROUP

(JUNE 22, 1987)

on

TECHNOLOGICAL INNOVATION IN THE BUILDING PRODUCTS INDUSTRY

ATTENDEES: Steven A. Sinclair, Virginia Polytechnic Institute and State University

Darrell E. Pierson, Weyerhaeuser Forest Products Company

Kenneth R. Peterson, Georgia-Pacific Corporation

Frederick T. Kurpiel, American Plywood Association.

Kenneth E. Skog, Forest Products Laboratory

MODERATOR: David H. Cohen, Graduate Research Assistant, Virginia Polytechnic Institute and State University

INTRODUCTION

On Monday June 22, 1987, a focus group was held with industry, academic and government personnel in the wood products industry to discuss technological innovation in building products. The following people were present:

Darrell E. Pierson, Manager, Plywood and Veneer, Research and Engineering, Weyerhaeuser Forest Products Company;

Kenneth R. Peterson, Director Technical Services-Wood Products, Georgia-Pacific Corporation;

Frederick T. Kurpiel, Director Industry Affairs, American Plywood Ass.;

Kenneth E. Skog, Forest Economist, Forest Products Laboratory;

Steven A. Sinclair, Associate Professor, Forest Products Marketing, Virginia Tech.

The intent of this informal meeting was to assist David Cohen, Graduate Research Assistant, in delineating the important technological innovations that had recently been implemented in the manufacture of softwood lumber and structural panels. The discussion lasted about one and a half hours with active participation from all members.

Summary of this informal group discussion is organized into 3 sections. The first section is the technological innovations in structural panels (plywood and composites). The second section addresses technological processing innovation in the manufacture of softwood lumber. This is followed by a third section concerning miscellaneous comments of interest. A personal evaluation of this group discussion ends the report.

STRUCTURAL PANELS

Veneered Structural Panels

Following is a list of the major technologies that are presently being implemented by innovative firms:

- XY positioning
- power roller bars
- spindleless lathes
- retractable chucks.

High moisture gluing is the major technology while not yet developed for implementation, is in the final stages of application research. The emphasis on quality, which applies to all three building product segments, was stressed the most for plywood panels. The general feeling was that competition (particularly from non-veneered panels) has forced increased technological innovation to decrease costs and improve quality. This adoption is necessary for firms to survive.

There was confirmation that the period of this study, 1983 to 1987, was the time when the development and adoption of innovative process technologies was at a peak.

Non-veneered Structural Panels

Oversupply has hindered the development of technological innovations. The two most frequently mentioned, continuous pressing and steam injection pressing, were initially developed and implemented in Europe. Continuous pressing is not being used to produce structural panels, but to produce particleboard.

SOFTWOOD LUMBER

Some of the innovations mentioned concentrated on increasing the value of the end products. The most important of these was the computerization of primary log breakdown. This can include a log merchandising system, which determines the facility and end product category a log enters to maximize dollar recovery. Computer control of the headrig incorporates Best Opening Face technology and is often called a wood optimizer. Another innovation to increase the value of the sawmill products is Machine Stress Rating (MSR). This is used predominantly for wood that is targeted for trusses or non-residential use. High temperature drying and temperature drop across load drying are also technologies to increase the value of the final product.

Some of the innovations concentrated on either lowering the cost of producing end products or increasing the yield. These include sanding instead of planing, reduction of fan speeds in drying, thermo-tensioning of saws and the development of new saw blade alloys.

Much of the impetus behind the development of new processing technologies come from global, especially Canadian, competitors as well as the need to expand the market for lumber to decrease the existing importance of residential construction.

MISCELLANEOUS INFORMATION

There was a general feeling that competitive and market forces were driving technological innovation in various sectors of building products. For example the competitive forces of composite structural panels initiated the adoption of new technologies in the veneered panel industry. Entry into the non-residential and truss

market initiated technological innovation such as MSR in lumber manufacturer. While market forces and customer satisfaction are recognized as important drivers of innovation, the consensus was that industry has not yet fully accepted a marketing orientation. The industry is in transition from a production orientation to a market orientation.

Interesting comments regarding the recent and predicted increase in the price of phenol based adhesives demonstrated the power of the suppliers of this structural panel raw material. The oil industry has a small number of powerful firms and are capturing a substantial portion of the profits the strong market for structural panels has generated. This suggests that alternative adhesives should continue to be a prime area of research for future cost reductions.

Research and technology innovations will continue to change the nature of the building products industry. Hardwood construction lumber could provide the impetus for a sunburst of softwood lumber innovations in much the same manner as composite panels have driven innovation in the manufacture of plywood. Changing demographics will lead to a reduction in new residential construction needed in the U.S. and is forcing the industry to enter new markets. There was a strong sense of a continually changing industry environment and market which will require change and innovation in order to offer a superior product to traditional and new customers.

Research Benefits

I found that the focus group was of great benefit in my research effort. Following is a list of the major benefits:

1. It greatly expanded my awareness of which technologies were

sufficiently advanced to be implemented and which were still in the applied research phase.

2. It expanded my knowledge of innovative technologies. I was able to focus my research on specific technologies, mentioned in trade journals, to better understand them.
3. The group provided substantial support to the idea that the adoption of new technologies is a requirement for survival in the wood products industry.
4. The constant mention of market forces and the burgeoning importance of marketing in our industry was a repeating theme in all participants discussions.
6. The sense of sharing and the necessity to strengthen the industry, and its structure, was a positive sign of growth in this mature industry. This sharing did not reduce the strong competitive nature of the two firms represented on the panel.

SECTION 2: RESULTS

AN INVENTORY OF INNOVATIVE TECHNOLOGY USE IN NORTH AMERICAN PROCESSING OF WOOD STRUCTURAL PANELS AND SOFTWOOD LUMBER

ABSTRACT

During 1988 wood products firms responsible for over one third of the structural panel production and two thirds of the softwood lumber in Canada and the United States were surveyed to produce an inventory of new processing technologies adopted for each of these wood products segments. Included in structural panels were softwood plywood and non-veneered panels (oriented strandboard and waferboard).

Technology usage, for each segment, was evaluated by a Use Intensity index, which measured the proportion of 1987 production that used each surveyed technology. Use Intensity ranged from less than 1% to more than 90% for different technologies surveyed.

Multivariate statistical analysis was used to investigate which technologies were most compatible with each other and what underlying qualities linked different technologies together.

Knowledge of these changes in wood processing can be advantageous in developing different directions for forest and wood science research. In addition, this inventory is a useful tool to explore areas for future technological innovation in the processing of the forest resource.

INTRODUCTION

Research into the adoption of new technologies to produce softwood lumber and structural panels has produced a current inventory of processing technology. This inventory provides a picture of North American use of innovative processing technologies during 1987. Knowledge of wood processing technologies is important to forestry practices since manufacturing techniques can directly impact such things as species preference (for harvesting and reforestation), utilization levels, desired wood fiber characteristics and revenues generated from the use of forest resources.

Awareness of North American processing techniques is critical to evaluate the competitiveness of our wood products industry in a global context. A picture of the present use of innovative processing technologies facilitates and focusses the search for future innovative techniques.

DATA COLLECTION

A questionnaire was mailed to 75 of the largest producers of structural panels and/or softwood lumber in Canada and the United States. The judgmental sampling technique selected the largest producers based on 1986 production figures in the "Forest Industries 1987-88 North American Factbook" (Corlett 1987)[1]. The largest

---

[1] The use of a judgmental (also called purposive) sample for industrial research is well documented in the literature (Adler 1967; Schoner 1975; Cox 1979; and Churchill 1987). Sufficient embodiment of an industry in

(continued...)

firms were chosen from the two lists until the sample totalled 75, which included the 50 largest softwood lumber producers and the 40 largest structural panel producers.

Of these 75 firms, 8 no longer existed as separate entities and 44 returned usable surveys for a response rate of 66% (44/67). Respondents accounted for 36.5% of 1987 North American softwood lumber production and 75.2% of structural panel production as shown in Figure 1. Eight of the ten largest producers of softwood lumber (based on volume) and five of the six largest producers of structural panels responded ensuring that firms with important impact on either industry segments were in the data base.

Of the 44 acceptable responses, a third (15) were from Canadian based companies and two thirds (29) were from U.S. based companies. Many of the firms operate facilities in both countries. Responses represented production facilities from a broad geographical cross section of North America; from New Brunswick to the Southeastern U.S.; from British Columbia to California.

RESULTS

Softwood Plywood

Twenty-six firms, responsible for 63.3% of 1987 North American plywood production, supplied data on the adoption of specific technologies. Technology usage ranged from a single company using the spindleless lathe to all but one firm

---

[1](...continued)

a purposive sample can allow meaningful inference to the population, despite the lack of specific statistical tests.

using computerized clippers. The Use Intensity index represents the proportion of respondents' 1987 plywood production that was manufactured using each technology (see Figure 2). Calculations used the following formula:

$$U_i = \Sigma(X_{ji}P_j)$$

U_i is Use Intensity index for technology i

X_{ji} is the proportion of production for firm j using technology i

P_j is the 1987 production volume for firm j

Over two thirds of the softwood plywood production used at least one of the following technologies: automatic lay-up lines; XY chargers; power nose bars; retractable chucks; and computerized clippers. The latter two, with a Use Intensity of over 90%, could be considered as industry standards. Alternatively, the spindleless lathe with a Use Intensity of less than 1% could be considered a technology still in the developmental stage. Press drying of veneer and the round-up lathe could be considered emerging technologies with Use Intensity ratings between 5 and 15%. It would be of interest to re-survey the same firms at a later date to determine how the Use Intensity of specific technologies changes over time.

A multivariate statistical technique, Principal Component Analysis, was used to examine the structure within the technologies surveyed [2]. This technique explores

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[2] For those familiar with Principal Component Analysis, a scree plot of the eigenvalues was used to determine the number of factors and orthogonal (Varimax) rotation was used prior to interpretation. The correlation matrix and

(continued...)

interrelationships among the technologies and explains them in terms of common qualities. These qualities (called dimensions or factors) define the way firms differ based on their technology usage. It uses the multicollinearity (correlation) between variables to reduce the technologies to a user-defined number of latent descriptive dimensions.

Of the 12 possible technologies, the spindleless lathe was deleted due to its small Use Intensity (< 1%). The proportion of every firm's production that used each of the remaining 11 technologies were analyzed, using Principal Component Analysis, to yield the 5 factors shown in Figure 3. These 5 factors accounted for almost 80% of the total variation between firms due to the 11 technologies. Loadings in this figure are the correlations between the technology and the factor. Following is a brief, subjective description of the characteristics each factor represents.

One factor included log merchandising and computerized drying of veneer. This represents the manufacturing operation at transition points in the production process. Log merchandising is the transition phase from log yard to green end processing while computerized drying of veneer is the transition process from the green end to the finish end. Both technologies contribute to ensuring a higher return for the final products.

---

[2](...continued)

the matrix of residuals were examined to ensure the suitability of the data for Principal Component Analysis. Since the ratio of observations to variables is less than the recommended 4:1 the findings were interpreted cautiously (Hair et al 1987).

Another factor represents recently introduced technologies which were mentioned above as emerging technologies.

Automatic layup of veneers and high moisture content gluing were the major influences in the factor representing a cost saving dimension. Automatic lay-up reduces labor costs while high moisture content gluing reduces drying costs.

Power nose bars and power core drives constitute a factor that represents innovation in powering the peeling process to supplement the torque provided by the lathe. Both of these technologies are methods to decrease veneer degrade, core size and spinouts by focussing on the dynamics of the mechanical peeling process.

Technologies that could be considered industry standards made up a separate and distinct dimension. Component technologies were heavily adopted with Use Intensities greater than 67%.

These results suggest that there are three areas (transition processes, cost reduction and peeling processes) where firms have most recently concentrated their efforts in the adoption of new processing technologies. Emerging technologies appear to focus on the round-up lathe and press drying of veneer.

Non-veneered Structural Panels

Structural panels in the forest products include not only softwood plywood but non-veneered panels, such as oriented strandboard and waferboard. From 1983 to 1987, North American production of non-veneered structural panels (excluding structural particleboard) has grown at an annual rate of almost 21% (compounded annually). This compares to a comparable growth rate for softwood plywood of 3.3% for the same time period (Statistics Canada 1988 and American Plywood Association

1988). No technology inventory would be complete without recognizing the increasing importance of non-veneered panels (see Figure 4).

Most North American manufacturing facilities are relatively new (as shown by the strong five year production growth) or recently modernized. One result is that the majority of North American production capacity utilizes similar technology. Disk flakers, orientation of the strands or wafers and improved adhesive blendings are now the industry norm (Spelter 1987). The time period of this study excluded consideration of a possible shift from phenolic based resins to isocyanate based adhesives and the introduction of continuous presses. Both technologies may have entered the adoption process during 1987.

Softwood Lumber

Thirty-six firms, responsible for 30.5% of North American softwood lumber production supplied data on the adoption of specific technologies. Figure 5 shows that Use Intensity varied dramatically by technology.

The only technology with a Use Intensity over 75% is automatic sorting of lumber, which could be considered an industry standard. There are 4 technologies with Use Intensities of 25% or less and could be considered emerging technologies. They are: machine stress rating of lumber; abrasive planing; temperature drop across load (TDAL) drying; and computerized edging. As with softwood plywood, it would be of interest to determine if the Use Intensity of these technologies change over time.

Abrasive planers had little impact in the Principal Component Analysis of the 10 softwood lumber technologies surveyed and were dropped from the final solution

shown in Figure 6. Despite a Use Intensity of 8% they were used by only 1 firm and had little importance when included in the Principal Component Analysis (loadings < .3 on all factors). The 4 factors, shown in Figure 6, accounted for over 70% of the total variation among the surveyed firms resulting from different usage rates of these 9 technologies.

Log merchandising, computerized log carriages, log scanning at the headrig and computerized edgers comprised one factor. These technologies exemplify the computerization of the manufacturing process, which could be the underlying dimension of this factor.

Temperature drop across load drying and log scanning at the headrig constitute the another dimension. One technology monitors the shape of the raw material (logs) to improve value or production volumes while the other monitors the drying process to reduce power costs, increase dry kiln throughput and enhance lumber quality. Log scanning at the headrig was important to two factors suggesting that it is used in a variety of manufacturing conditions and mill designs. This factor could represent the dimension of process monitoring.

Another factor was made up of small kerf headrigs and continuous or high temperature drying. The first improves lumber recovery, while the second increases drying throughput. Together these could be considered productivity boosters. Automatic sorting of lumber was of moderate importance to 3 of the 4 factors (loading > .3) and is therefore omitted from this factor's descriptors.

Machine stress rating (MSR) of lumber, despite its relative low Use Intensity (3%) explained 11% of the differences (variance) between firms due to the technologies

surveyed. Since MSR lumber is used primarily for engineered wood products, this dimension could be considered technology to produce wood for engineered use.

These four areas, computerization, process monitoring, productivity increases and testing wood for engineered use, are where firms have concentrated their efforts in process technology adoption.

SUMMARY

The results of this research show that plywood producers have concentrated their investment in new processing technologies in transition processes, cost reduction and the peeling process. In addition, the structural panel industry has invested substantially in the addition of non-veneered production capacity during the past five years.

Softwood lumber producers have concentrated their investment in new processing technologies in computerization, process monitoring and efforts to increase productivity. They also have focussed on machine stress rating of their product for use in engineered wood products.

Inventories of the present adoption of processing technologies can help explore areas where new technologies are not being adopted. Comparison of these results with technologies in use in other parts of the world, such as Europe, may highlight areas for additional process improvement.

A technology inventory is the first step in determining whether the North American wood products industry has, or can attain, a technological competitive advantage in the global market for wood products. As countries with less stringent

environmental guidelines and lower wage rates increase their wood products production it becomes increasingly important for Canada and the United States to develop and sustain a technological advantage. Coordination of forest management, processing innovation and wood science research in North American can help our industry survive and flourish as the globalization of markets continues.

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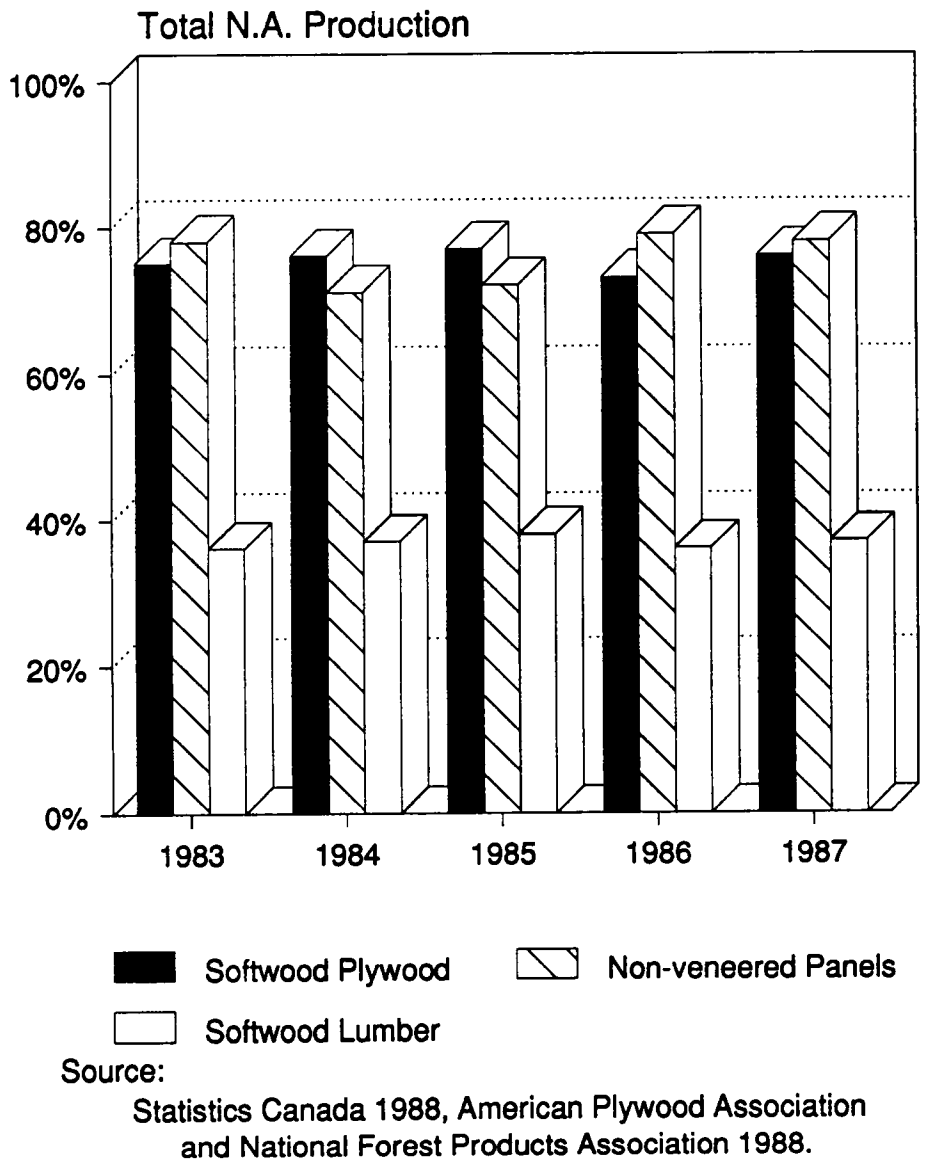


Source:
Statistics Canada 1988, American Plywood Association and National Forest Products Association 1988.

Figure 1: Proportion of 1983-87 North American Production Represented by Survey Respondents

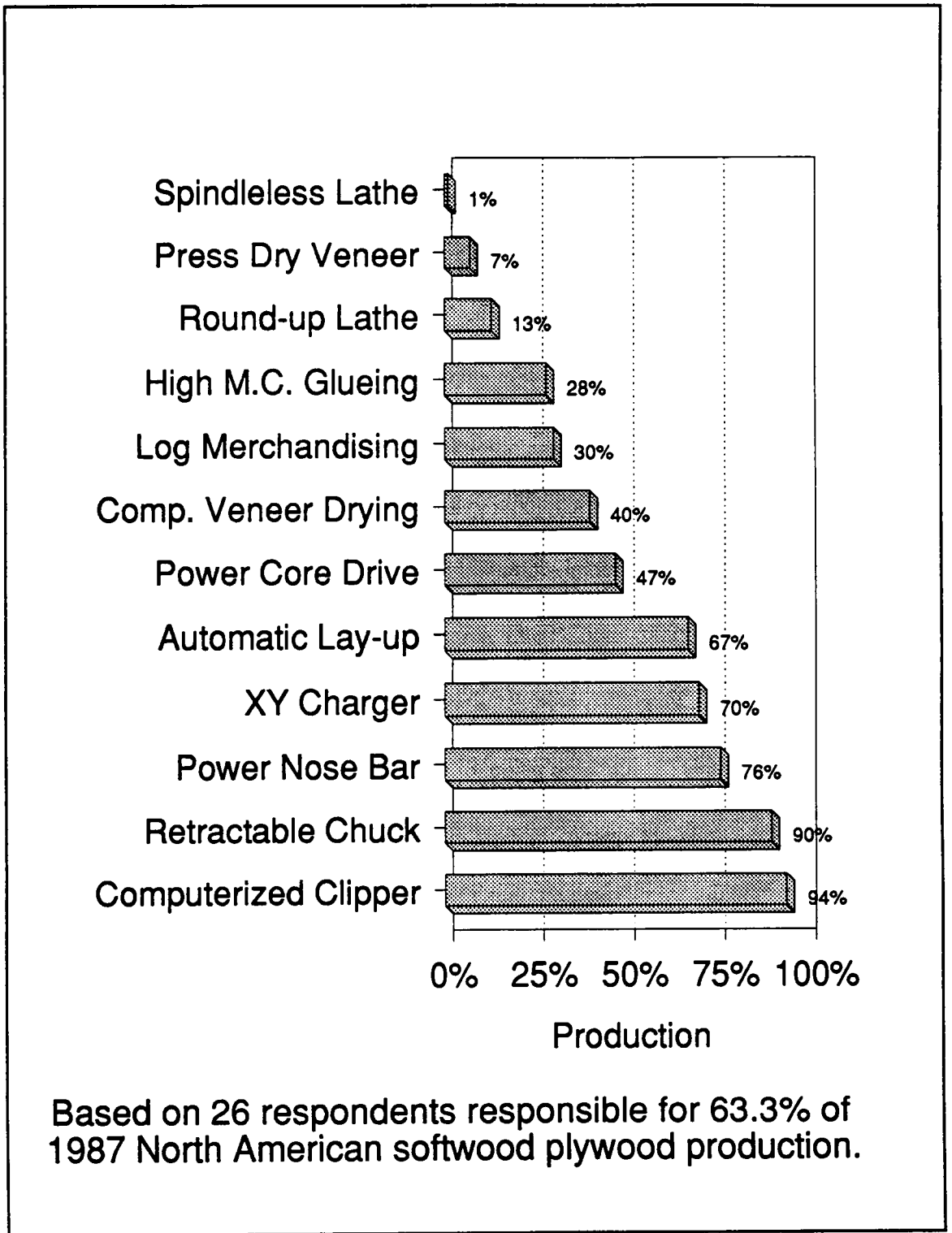


Figure 2: Softwood Plywood Technologies - Use Intensity (1987)

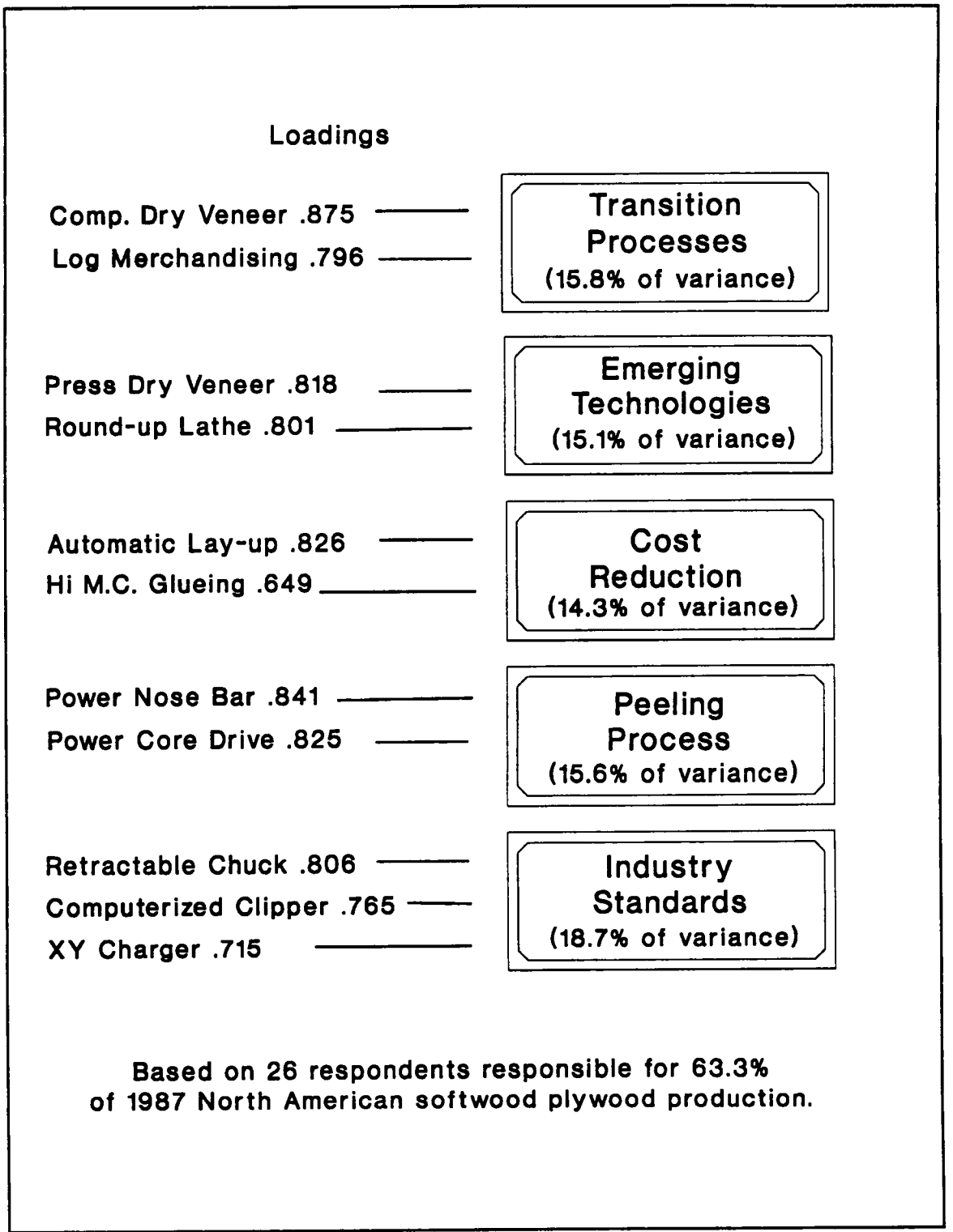
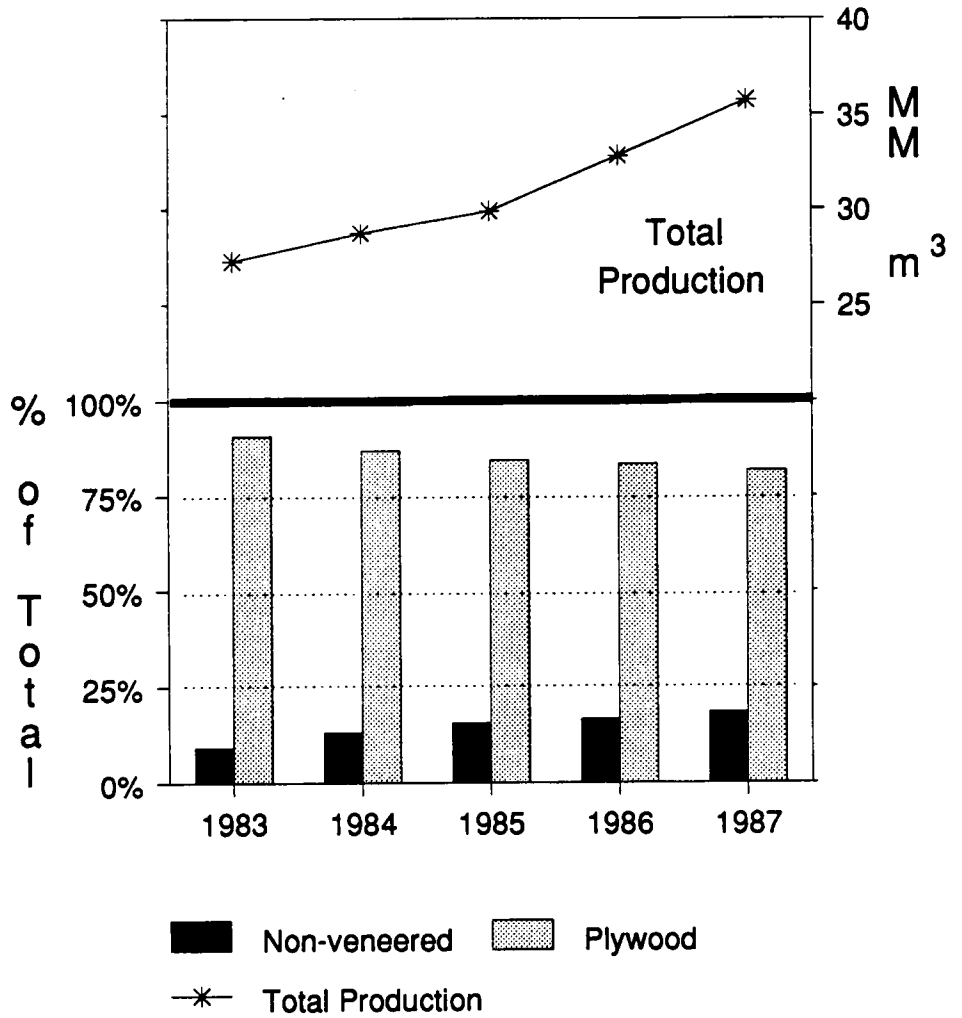
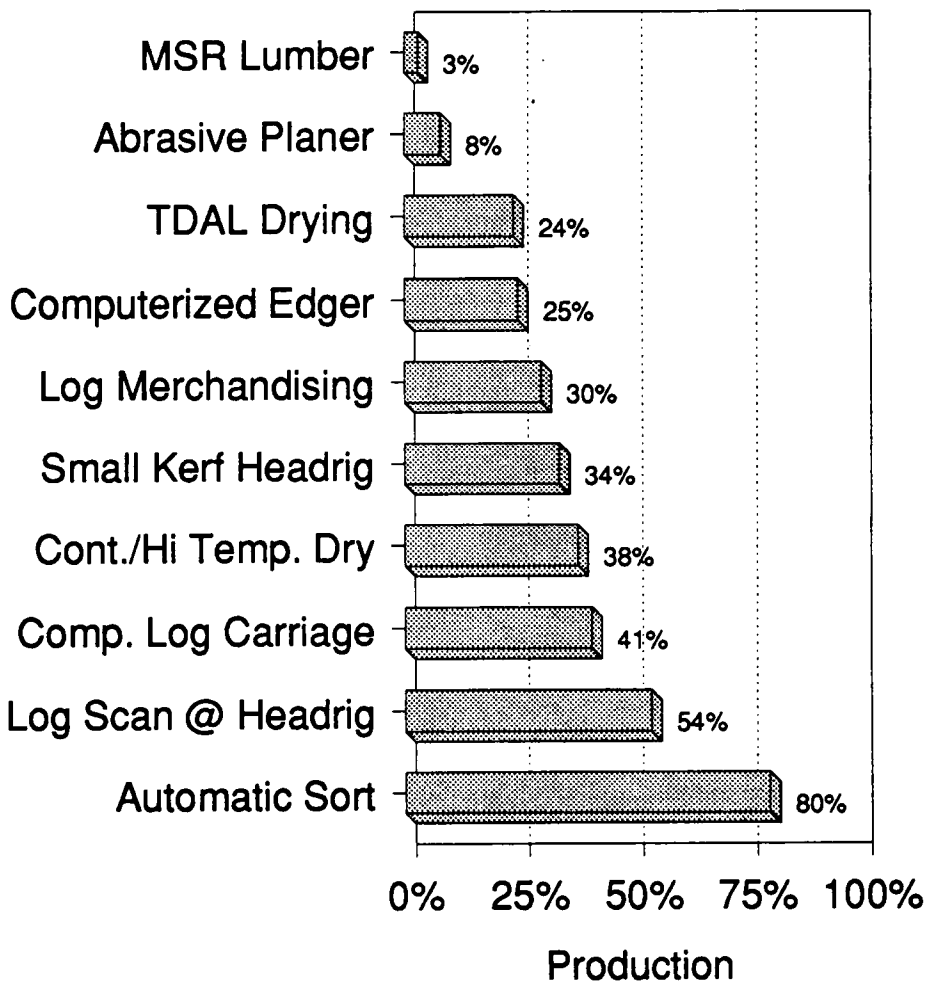


Figure 3: Factor Analysis of 11 Softwood Plywood Technologies



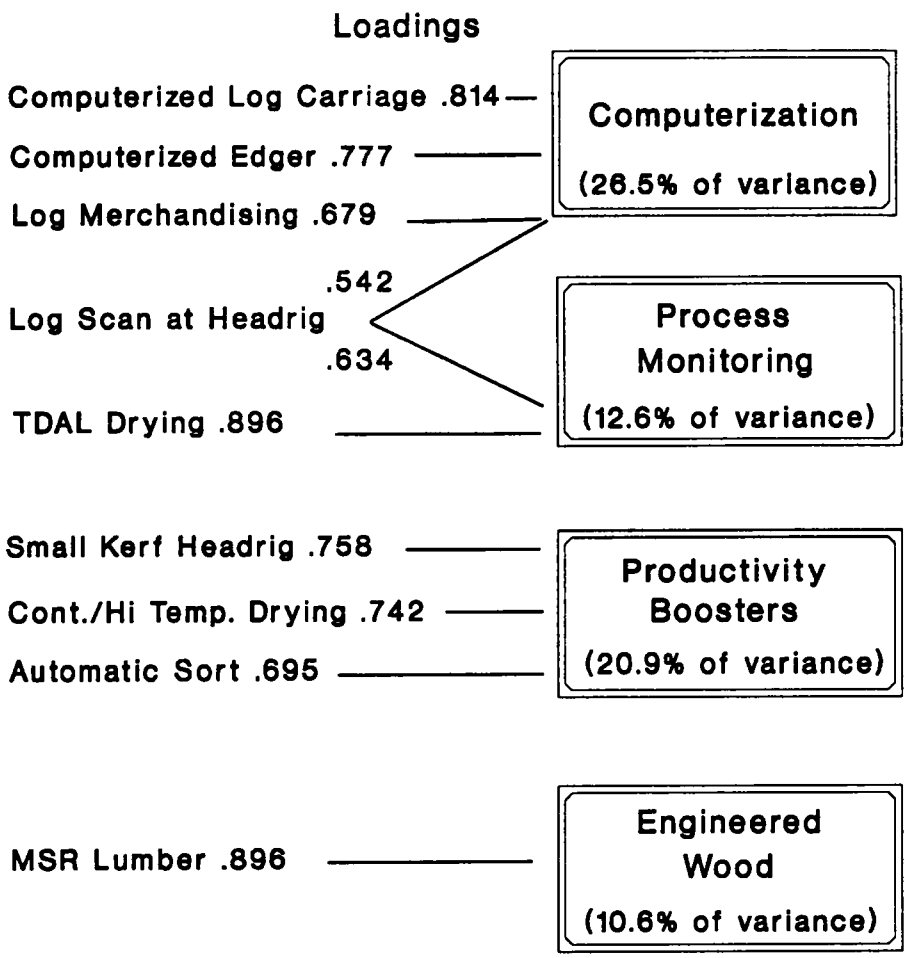
Sources: Statistics Canada 1988 and the American Plywood Association 1988

Figure 4: North American Structural Wood Panel Production (1983 - 1987)



Based on 36 respondents responsible for 30.5% of 1987 North American softwood lumber production.

Figure 5: Softwood Lumber Technologies - Use Intensity (1987)



Based on 36 respondents responsible for 30.5% of 1987 North American softwood lumber production.

Figure 6: Factor Analysis of 9 Softwood Lumber Technologies

THE ADOPTION OF INNOVATIVE PROCESSING TECHNOLOGIES: ITS STRATEGIC IMPACT ON THE BUILDING PRODUCTS INDUSTRY

ABSTRACT

For a firm to remain competitive it must allocate its limited financial resources into areas which will maintain or improve its performance. One area that always competes for these resources is the adoption of innovative process technologies in the manufacture of softwood lumber and plywood. Adoption has frequently been discussed but its impact on a firm's performance has never been empirically examined. This paper looks at the importance of adopting innovative processing technologies on a firm's performance by grouping firms producing softwood lumber and plywood using a hierarchical clustering technique and then profiling these firms using descriptive statistics. This technique, using firm controllable strategic variables as clustering criteria, is used in strategic marketing research but has rarely been applied to the forest products industry .

Results from examining thirty-eight firms, responsible for over 30% of 1987 North American softwood lumber production and over 70% of softwood plywood production provided empirical evidence that increased adoption of innovative processing technologies was linked to superior performance. Companies with high levels of adoption exhibited average to better than average profitability and were gaining market share. Firms with low levels of adoption exhibited below average to average levels of profitability and were losing market share. Firm size and degree of forward vertical integration had no bearing on whether a firm was a process technology adopter. Strategic implications of this research include strong support for building products firms to allocate resources for the development and adoption of new and innovative processing technologies.

INTRODUCTION

Managers of building products firms need to allocate their limited financial resources among a variety of alternative company needs. These competing needs include inventories of timber and log supplies, marketing expenditures, improving distribution centers, new product development, pollution abatement and new facility construction. To remain competitive in the production and sale of building products, a firm must strategically choose to focus its expenditures in areas which will best maintain or improve its business performance. Building products firms who allocate their scarce resources, without considering the impact on performance, risk reduced competitiveness which can lead to plant closures, takeovers and even bankruptcy. One area that always zealously competes for a firm's limited resources is the adoption of new and/or innovative processing technologies[1].

Business strategy writers have recognized the adoption of innovative processing technologies as a key ingredient to compete successfully in mature industrial markets, such as the one for building products (33, 22, page 53; 37). Rapid development and operationalization of new processing technologies in both softwood lumber and softwood plywood have been reported in a variety of publications. The Wall Street Journal considered process technology as the driving force in the re-structuring of the softwood lumber industry (5). Spelter concluded that plywood processing innovations can not only reduce the diameters of required timber supply but also help companies adapt to changing markets and competitive environments

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[1] The terms innovative and new will both be used to mean technologies which have gained some industry acceptance within the past decade.

(34, 35). Changes in technology have been credited for most of the productivity growth in the lumber and wood products industry (16). Industry commitment to innovative technologies is illustrated by North American capital expenditures in the softwood lumber and structural panels industry averaging over a third of a billion U.S. dollars annually since 1985 (28, 29). Considerable proportions of these expenditures were for new process technologies.

While the importance of using new processing technologies has been discussed in the literature (e.g. 20, 35), there has been no empirical examination of the impact this strategy has on firm performance or on differences between adoptive and non-adoptive companies. Frequently, productivity improvements and/or production cost savings are reported with little consideration for the cost of implementation, firm characteristics or the competitive environment; all of which can influence the impact of technology adoption on firm performance.

This research examines the impact of new process technology adoption on firm performance. It uses actual industry data to examine three aspects of technology adoption for firms producing softwood lumber and plywood. These three aspects are: 1) the characteristics of firms most likely to adopt new processing technologies, 2) differences in performance between adoptive and non-adoptive firms and, 3) strategies associated with technology adoption. This paper examines the impact of adopting new processing technologies among North American firms producing softwood lumber and/or softwood plywood to help managers of building products firms better allocate their limited resources.

BACKGROUND

To evaluate the affect of adopting new processing technologies on a firm's performance, it is first necessary to group firms based on their degree of adoption. This paper groups building products companies using a hierarchical clustering technique and then profiles the groups using descriptive statistical techniques. These procedures are used in market segmentation and strategic management research but have seldom been applied to the building products industry. Clustering has been used to group firms from different industries with similar strategies for strategic analysis, to develop customer segments according to benefits sought and to determine the relative importance of firm-controllable decision variables on firm performance (19, 6, 7). While the level of technology adoption is the grouping criteria for this paper, the technique could also be used to group firms based on a variety of criteria, such as geographical location, sources of raw materials, product mixes or customer segments serviced.

O'Laughlin and Ellefson analyzed the wood products industry according to corporate diversification strategies and sales revenues of wood-based products (27). Cleaves and O'Laughlin grouped corporations that produced southern plywood based on product lines, company size and land holdings (12). This paper will consider the use of new processing technology as the business-level[2] strategic grouping criteria.

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[2] Business-level strategies operate at a single product-market, (e.g. building products) while corporate-level strategies refer to the top level of a company which may include an assortment of product-markets (23).

Rich reported that low cost production is the most favored forest products company strategy and often required state-of-the art processing equipment (31). Therefore, strategic segmentation based on a firm's level of adoption of innovative technologies is an appropriate means of differentiating between strategic groups in the building products industry.

Profile information will describe characteristics of firms with similar technology strategies and evaluate the success of these strategies by performance measures, such as changing market share and profitability. Characteristics of firms include degree of forward vertical integration, defined as the development of captive channels of distribution (3). Rich reported that 36% of the firms he surveyed listed distribution as one of their three most important company strengths (31). Cleaves and O'Laughlin reported that forward integration was the most variable strategic factor among southern plywood producers (12). Barnes and Sinclair suggested that captive distributors would play an increasing important role in the lumber and building products industry (4). The importance of this factor in the building products industry necessitated its inclusion in this study to determine what, if any, relationship it had with the adoption of innovative processing technologies.

METHODOLOGY

To date, no research has measured levels of adoption of innovative process technologies among building products firms. To ensure an accurate reflection of this variable, primary data had to be collected. Also collected as primary data was a firm's level of forward vertical integration since a metric measure, necessary for the

statistical techniques being used, was unavailable from previous research. The remainder of the required data was collected from secondary data sources, including trade association publications, company annual reports and Statistics Canada (36).

Primary Data Collection

The Questionnaire

Primary data was collected using a mail survey, the most efficient means of collecting complex data from such a geographically dispersed sample (11, pages 241-258). Two important objectives of the questionnaire were: 1) to determine each respondent's level of processing technology adoption and 2) to gauge their degree of forward vertical integration.

Degree of forward vertical integration was measured as the proportion of a firm's lumber and plywood production that was sold through wholesalers and retailers that they owned or controlled. Measuring the proportion instead of the actual volumes enabled this measure to reflect a firm's commitment to forward integration regardless of its size.

Degree of innovative technology use is a more difficult variable to accurately measure. Respondents were asked the proportion of their 1987 production that used each processing technology considered new and innovative. Development of a comprehensive list of these technologies was critical in obtaining an accurate measure of a firm's degree of adoption of innovative technologies. A multi-stage procedure, adapted from strategic marketing methodology, was used to ensure reliability (10). The four step procedure was:

1) Relevant literature from trade magazines, corporate annual reports and academic research articles were reviewed to develop a comprehensive list of new processing technologies for the production of softwood lumber and softwood plywood.

2) The list was narrowed by review with selected practitioners, academics and researchers in the wood products field to remove technologies under development but not yet implemented.

3) A focus group was held in June, 1987 with a panel of experts from industry, trade associations, research laboratories and academia to further refine this list by determining the most critical process technologies.

4) The short list was pre-tested to confirm that no critical technologies were omitted. The questionnaire was mailed to selected industry executives and wood product researchers for comments and suggested revisions. The resultant list of process technologies formed the basis of the survey questions.

The proportion of production from each firm's use of technologies on the final list was collected to remove the bias of firm size. Because large firms could use each technology in a single manufacturing facility without an overall commitment to adopting new processes. The two survey questions used to measure the adoption of innovative processing technologies are shown in Tables 1 and 2.

Sample

The sample frame for this study consisted of the 500 largest North American firms producing softwood lumber and plywood based on 1986 production figures. The sample was composed of the largest 75 companies (13). While a non-random sample inhibits the ability to make statistical inferences to the population, the appropriateness of using a size-based judgmental sample for industrial marketing

research is well documented in the literature (e.g. 1, 11, 25). This method ensures that larger firms, that may directly impact the industry environment, are included in the sample. Sufficient embodiment of the larger building product firms in this non-random sample suggests that results could be presumed to be representative of a dominant segment of the industry. Procedures for sampling followed an extensive five step process since a high response rate was desired due to the small sample size. These were:

1. A telephone call to identify the most suitable individual within each firm.
2. A prenotification letter.
3. The survey with a cover letter and an accompanying gift.
4. Three follow up mailings as reminders and to provide additional copies of the actual questionnaire.
5. A telephone call to all non-respondents to encourage response and/or determine why they had not responded.

Responses

Of the seventy-five firms, eight no longer existed as separate entities and forty-four returned surveys. Of these forty-four firms, three produced mostly non-veneered structural panels and two did not complete all relevant questions resulting in thirty-eight usable questionnaires. These thirty-eight firms represent a 56% response rate (38/67) and were responsible for over 30% of North American softwood lumber production from 1983 to 1987 and 70% of softwood plywood production (see Figure 1). Twenty seven firms were U.S. based and eleven were based in Canada. Nine firms produced only lumber, four produced only plywood and twenty-five produced both products. All major geographical production regions of North America were represented.

Secondary Data

Secondary data were collected for firm characteristics and performance measures. Relative firm size was calculated using production volumes for 1983 to 1987 supplied by each firm either from annual reports, by direct contact or through industry association published figures. Industry production figures were obtained from Statistics Canada (36), the American Plywood Association (2) and trade journal publications (13). Financial data used to calculate profitability surrogates was collected from audited annual reports of public companies.

Firm Characteristics

Profiles of differences between clusters were examined for the following firm controllable characteristics: investment intensity, degree of forward vertical integration and market strength. Investment intensity, as measured by capital expenditures from 1983 to 1987 relative to sales (and also assets), reflects a firm's prior commitment to reinvest in the building products industry. Market strength was measured as the average market share from 1983 to 1987 relative to the three largest competitors. Measuring forward vertical integration was discussed previously.

Performance Measures

Groups were also profiled on two performance measures: profitability and changes in market strength. Profitability was measured by both Return on Sales and Return on Assets, both derived from accounting data. Chakravarthy lists four problems with using accounting measures as surrogates for profitability: 1) scope for manipulation, 2) undervaluation of assets, 3) differences in depreciation, inventory

and corporate expenditures and 4) differences in accounting practices between countries (8). Return was considered the contribution to earnings (plus depreciation) for the building products segment of each firm. Calculating return in this fashion compensated for problems due to corporate overhead, interest and tax expenses; problems associated with 1 above. To address problems outlined in 3, each firm's method of depreciation and inventory evaluation was compared. The great majority of the firms used the same methods of calculations and where differences did exist they had minimal impact on profitability measures. Since Canada and the United States have very similar accounting practices, problem 4 presented no impediment to using accounting based profitability surrogates. Return on Assets, often an unreliable reflection of profitability due to undervalued assets, was used only to corroborate Return on Sales to offset problems associated with undervalued assets.

Change in market strength was measured as the change in a firm's relative market share from the average of 1983 to 1985 to the average of 1985 to 1987. Relative market share is each firm's market share expressed as a percent of the share held by the three largest competitors.

Analysis Technique

Cluster analysis consists of a family of algorithms used to group similar entities. It is a method that seeks patterns within data by examining similarities and dissimilarities among a matrix of independent variables. The technique develops meaningful groups of respondents based on their similarity across specified characteristics. In this study, technological innovations were the characteristics used

to cluster firms into groups that exhibited within group similarities and between group differences. Clustering provides a series of levels between all sample members being in the same group (total homogeneity) and each firm being independent and unique (total heterogeneity). It is frequently used in strategic marketing research to group firms with similar strategic thrusts (e.g. 18, 19). It has also been used in both consumer and industrial research for market segmentation (32, 30, 6).

To guard against "spurious" clustering, a hold out sample is traditionally recommended to validate the group structure (30). In industrial marketing research sample sizes are too small to accommodate this approach and alternative, less powerful procedures, such as comparing different clustering techniques, are needed to ensure valid groupings (14).

The first decision when clustering is to determine which data will form the basis of membership since the inclusion of non-influential variables can invalidate hierarchical clustering results (32). Of the twelve plywood technologies (see Table 1), two had usage levels too low to discriminate between groups. These were the spindleless lathe and press drying of veneer. Two of the ten lumber technologies (see Table 2) also proved to be non-influential to clustering techniques; machine stress rating and abrasive planing. The thirty-eight building products firms were clustered on the remaining eighteen technologies.

The second clustering decision is to determine which linkage technique is suitable and how the similarities and differences will be measured. Galbraith and Schendel recommend an agglomerative hierarchical procedure where each observation is initially considered a group (15). Clustering proceeds by a series of stages, in which two groups are merged, until only a single group exists. Wards'

method was used to measure distances between clusters since it minimizes within group variation, outperforms alternative methods and is recommended when the data set has a small number of observations (30, 17). The resultant dendrogram (clustering tree structure) is shown in Figure 2.

The third decision is to determine the number of clusters to use. The recommended method is to examine several levels of cluster solutions and chose that level which exhibits stability and fits the needs of the research (32). The number of clusters must be large enough to allow meaningful within group analysis and small enough to reflect differences between groups. A variety of solutions were compared based upon the significance for each technology between groups. Significance tests between group means for all technologies were compared to aid in determining which level of cluster was appropriate (see Table 3)[3]. All 38 respondent firms were used to develop strategic groups based on process technology adoption.

Once groups were formed based on process technology usage, profiles of the groups across a variety of firm dependent variables and performance measures were examined using descriptive statistics[4]. Group means were compared to explore differences in characteristics and performance. Profile information was generated solely for the 21 public firms since complete performance data was unavailable for the remaining 17 private companies.

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[3] Significance testing (ANOVA with Tukey HSD) among the same variables used to derive the clusters is not an appropriate statistical technique. However, this technique was used for exploratory, comparative purposes only.

[4] The descriptive technique used was Analysis of Variance (ANOVA) with a Tukey HSD post hoc test. Unlike multiple t-tests, this technique controls for familywise error rate when comparing more than two groups (17).

RESULTS

Clusters

The five and six cluster solutions both produced substantial differences between groups for both lumber and plywood technologies. However, one of the groups in the six cluster solution had only two members, rendering it impractical for further analysis and the five group solution was chosen as most suitable to delineate differences among firms based on processing technologies. Further clustering produced what appeared to be superfluous fragmentation and solutions with fewer groups (e.g. 3 and 4 group solutions) resulted in considerably less homogeneity within groups. Table 4 shows the means for each technology by group membership.

To check classification validity, five cluster solutions for alternative clustering techniques were examined[5]. There was a high level of agreement between all three solutions which indicates that the group structure is stable (14).

Groups' positions with respect to lumber and plywood technology use and selected profile results are shown in Figure 3. Group 1 was composed of firms who either did not produce lumber or did so with little use of new technologies. However, these firms had slightly higher than average use of innovative plywood technologies. Sixty-nine percent of the firms in group 2 produced only lumber and the remainder produced panels with relatively little use of innovative processes. Their use of new lumber technologies was slightly higher than average. All of the seven firms in Group 3 produced both lumber and plywood with average levels of technology use for lumber and high levels for plywood. Group 4, composed of firms

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[5] The two alternative methods were complete and average linkage.

producing both products, used high levels of technology for both products. Group 5, also composed of firms producing both products, was average in its technology use for both lumber and plywood.

Profiles

Differences between groups of firms were examined for two performance criteria: profitability and changes in relative market share, and three firm characteristics: investment intensity, degree of forward vertical integration and firm size (based on production volumes). Table 5 shows group means, overall means and statistical significance for each profile variable. There were substantial differences among groups across all variables except for forward vertical integration.

It is probable ($p>.65$) that there was no difference in levels of forward vertical integration between groups (see Table 5). This suggests that channel control has little bearing on whether a firm adopts innovative processing technologies.

For simplification, "usage" will refer to the degree of adoption of innovative processing technologies. As shown in Table 6 and graphically illustrated in Figure 4, firms in cluster 1 had a slightly above average usage for plywood and a very low usage for lumber. Average levels of profitability were maintained most likely due to low re-investment as shown by their low levels of investment intensity. Firms in this group were mid-sized but losing relative market share. These firms are most likely following Galbraith and Schendel's industrial strategy of low commitment (15). Firms following this strategy are not necessarily exiting the industry, but are not concerned with growth or market share maintenance.

Firms in cluster 2, predominantly producers of softwood lumber, had average usage for lumber and very low usage for plywood. These relatively small firms exhibited high levels of investment intensity which may account for their low levels of profitability. Results suggest that capital is being spent on new facilities, as opposed to upgrading the technology base of existing plants, which would account for their increasing relative market share. These firms used no controlled channels of distribution at either the wholesale or retail level and could be described as production oriented, small manufacturers.

Companies in cluster 3 had the highest level of usage for plywood while only average level of usage for lumber. These large firms had the highest levels of profitability. Their emphasis on plywood technologies, possibly due to increased competition from non-veneered structural panels, and only moderate levels of lumber usage suggests a focussed strategy. Increasing relative market share, despite only average levels of investment intensity, combined with high levels of profitability indicate a much better than average performance for these firms. Their generic strategy could be considered a focussed growth strategy.

The smaller firms in cluster 4 had high levels of usage for both plywood and lumber. High levels of investment intensity were reflected in increasing market share but seemed to have little impact on their better than average profitability. These firms are successfully following a technical oriented, growth strategy.

The large firms in cluster 5 had moderate usage in both plywood and lumber. They had low levels of investment intensity which was reflected by their loss of relative market share. While these firms exhibited average profit performance, they were losing market share. These firms seem to be following no specific strategy,

other than operations as usual and would fit in the shortage strategy classification of Chrisman et al. which included firms with no competitive weapons to offer their customers other than just "being there" and survive by serving excess demand (9).

Adoption of Innovative Processing Technologies

Groups 3 and 4 had the highest levels of technology adoption. Compared to the other 3 groups, they exhibited higher levels of profitability and were gaining relative market share. Figure 4 shows different performance levels based on degree of adoption of technological innovation. This supports the widely held belief that utilizing new processing technologies is critical to a manufacturing firm's success in mature industries (e.g. 33, 21, 37). Rich reported that over half the firms he surveyed in 1984 stated that either technology or production (i.e. processing) were their most important strength (31). The results of this study demonstrate that those firms who accurately evaluated these strengths exhibited better than average performance from 1983 to 1987. One of the two high performance clusters (group 3) was composed of firms, on average, five times larger than the other cluster (group 4). Therefore, among these larger companies firm size appeared to have limited impact on a company's ability to adopt innovative technologies. Since these two groups had the highest levels of adoption for plywood technologies, these results support Spelter's model which implied that adopting innovative technologies in plywood production can improve a firm's performance in the commodity structural panel market (35).

SUMMARY AND CONCLUSIONS

Caution must be exercised in making broad generalizations from these results since the data base was composed of a small sample of the larger producers of building products. However, these firms were responsible for a substantial proportion of North American production and in strategic marketing research statistical significance is not synonymous with practical importance (26). Thus, the consistent linkage of above average performance (i.e. market share growth and superior profitability) with the adoption of innovative technologies provides strong pragmatic support for firms to adopt strategies that incorporate the continuing development and adoption of new processing technologies.

The implementation of any single strategic factor, such as the adoption of innovative processing technologies, cannot ensure business success. However, the results of this study suggest that one of the variables to include in a firm's strategic mix is the adoption of new process technologies. Further research into other important strategic variables can help firms understand the multi-faceted and complex nature of strategic management.

Adopting these technologies did not require higher than average levels of investment intensity yet, even over a relatively short five year period, was positively associated with above average profitability. Processing technology adoption was not related to either firm size or to degree of forward vertical integration. This suggests that technology adoption, as a strategic option, is not overly constrained by a firm's positional limitations.

The time frame of this study coincides with a growth period in the building products industry. While all firms operated within a similar competitive environment, it is unknown whether the strong performance associated with adopting new technologies would also be evident during a downturn in the industry. In addition there were several technologies that were introduced in the latter part of this study's time frame and were excluded from examination because of minimal adoption prior to 1987. A firm's adoption of the technologies surveyed may have no impact on their decision on whether to adopt these newer technologies, such as radio frequency redrying and foamed gluing. It would be of interest to determine if the more adoptive firms from 1983-1987 remain the leaders in adoption as new technologies are introduced.

Clustering firms based on their adoption of innovative process technologies is only one use of this technique in examining the impact of resource allocation on firms in the building products industry. Future research could use this procedure to examine other firm controllable strategies that require scarce financial resources, such as commitment to marketing, breadth of product lines, diversity of markets (e.g. export markets served) or timber procurement policies. Continuing examination of the impact different strategic resource allocations have on a firm's performance can provide information that would aid managers in better allocating financial resources to improve their firm's competitiveness. Broadening the knowledge of the industry's structure, strategies and characteristics can help improve the global competitiveness of the North American building products industry.

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Table 1: Survey Questions Concerning Softwood Plywood Process Technologies

Please indicate the proportion (by volume, to the nearest 10%) of your firm's annual production of structural panels that is produced using each of the following technologies.

	0% . 20% . 40% . 60% . 80% . 100%
Log Merchandising *	
PLYWOOD	
Round Up Lathe	
XY Chargers	
Powered Nose Bar *	
Powered Core Drive *	
Retractable Chuck	
Spindleless Lathe	
Computerized Clipper	
Automated Layup Line	
High M.C. Gluing	
Press Drying of Veneer	
Computerized Veneer Dry *	

Table 2: Survey Questions Concerning Softwood Lumber Process Technologies

Please indicate the proportion (by volume, to the nearest 10%) of your firm's annual production of softwood lumber that is produced using each of the following technologies.

	0% . 20% . 40% . 60% . 80% . 100%
Log Merchandising *	
Computerized Log Carriage	
Log Scan at Headrig *	
Small Kerf Headrig *	
Computerized Edger	
Automated Sorter/Stacker	
Machine Stress Rated *	
Abrasive Planer *	
Temp. Drop Across Load Dry *	
Cont. Rising/High Temp Dry *	

Table 3: Comparison of Significance Levels for Technologies at Various Clustering Levels

	Number of Clusters[1]				
	2	3	4	5	6
SOFTWOOD LUMBER					
log merchandising	-	*	*	*	*
computerized log carriage	-	-	*	*	*
log scan @ headrig	-	*	*	*	*
small kerf headrig	-	*	*	*	*
computerized edger	-	-	-	-	-
automated sorting	-	-	-	*	*
TDAL drying	-	*	-	*	-
cont. or high temp. drying	-	-	-	-	-
Sub total # of sig. technologies	0	4	4	6	5
PLYWOOD					
log merchandising	-	*	*	*	*
roundup lathe	-	-	-	-	-
XY charger	*	-	*	*	*
powered nose bar	*	-	*	*	*
powered core drive	*	*	*	*	*
retractable chuck	*	*	*	*	*
computerized clipper	*	*	*	*	*
automatic veneer layup	*	*	*	*	*
high moisture content gluing	*	*	*	*	*
computerized veneer drying	*	*	*	*	*
Sub total # of sig. technologies	8	7	9	9	9
Total # of significant technologies	8	11	13	15	14

[1] * denotes significant difference between groups ANOVA with Tukey HSD ($p<.10$).
- denotes no significant difference between groups using ANOVA with Tukey HSD ($p>.10$).

Table 4: Means and Statistical Significance for Lumber and Plywood Technologies (Five Cluster Solution)

		CLUSTER NUMBER				
	F prob.[1]	1	2	3	4	5
Number in Sample		(7)	(13)	(7)	(5)	(6)
PROCESS						
SOFTWOOD LUMBER						
log merchandising	.000	4.28[2]	26.15	47.14	98.00	16.17
computerized log carriage	.000	5.43	36.31	52.43	90.00	82.83
log scan @ headrig	.050	7.14	53.08	65.29	90.00	79.17
small kerf headrig	.345	8.86	41.31	52.86	40.00	42.50
computerized edger	.067	5.71	35.00	20.00	60.00	29.17
automated sorting	.032	41.71	87.31	59.29	80.00	86.67
TDAL drying	.231	0.00	19.23	43.57	30.00	5.33
continuous/high temp. drying	.198	29.29	42.69	2.86	56.00	37.50
SOFTWOOD PLYWOOD						
log merchandising	.001	10.71	4.77	84.29	60.00	3.33
roundup lathe	.895	29.29	0.00	28.57	40.00	17.50
XY Charger	.025	33.57	0.00	95.00	32.80	50.17
powered nose bar	.017	80.00	0.00	95.00	0.00	36.83
powered core drive	.001	53.57	3.08	79.29	12.80	71.00
retractable chuck	.000	79.57	6.31	99.29	80.00	100.00
computerized clipper	.000	93.57	6.31	96.43	80.00	99.17
automatic veneer layup	.040	41.43	4.62	50.71	52.00	15.00
high M.C. gluing	.107	14.29	0.00	57.86	59.00	0.00
computerized veneer drying	.000	14.29	4.77	79.29	33.00	20.41

[1] F prob is the probability that there is no difference between group means (excluding groups with mean = 0).

[2] Numbers in table are average proportion of company production in 1987 that was produced using each technology

No significance test is appropriate to test differences between group means and these results were used only for comparing different cluster solutions.

Table 5: Means and Statistical Significance of Profile Data for Five Cluster Groups

		CLUSTER NUMBER					
	F prob[1]	1	2	3	4	5	Overall Mean
PROFILE VARIABLES							
PROFITABILITY SURROGATES (in %)							
Sample size		4	5	5	3	4	
Return on Sales 1985-7	.138	13.3	11.1*	20.8*	16.7	16.6	15.7
Return on Assets 1985-7	.008	20.0*	18.3*	43.4***	21.3*	26.3	26.6
INVESTMENT INTENSITY (in %)							
Sample size		4	4	5	5	4	
Capital Exp. relative to Sales 1983-7	.165	6.0	9.9	9.6	9.9	5.2	8.3
Capital Exp. relative to Assets 1983-7 (%)	.212	4.2	8.0	5.5	8.4	4.4	6.2
MARKET STRENGTH (as measured by % relative market share)							
Sample size		7	13	7	5	6	
Relative Market Share 1983-7	.113	7.6	2.2	11.7	2.5	8.8	6.0
Change in Rel. M. S. 1983-5 to 1985-7	.158	-0.7	0.2	0.3	0.2	-0.7	-.001
FORWARD VERTICAL INTEGRATION (in % of production)							
Sample size		4	5	5	3	6	
Wholesale 1983-7 [2]	.723	21.5	0.00	23.4	2.8	24.1	15.5
Retail 1983-7 [2]	.657	0.9	0.00	4.3	0.4	6.9	3.0

* indicates the number of groups the mean is significantly different from using Tukey HSD with overall p<.10

[1] F prob is the probability that there is no difference between group means

[2] ANOVA with Tukey HSD statistically examined only those groups with non-zero means.

Table 6: Profiles of Five Technology Clusters Based on Product Mixes, Profitability, Investment Intensity and Market Strength

	CLUSTER NUMBER				
VARIABLE	1	2	3	4	5
Plywood Production	all firms	31 % of firms	all firms	all firms	all firms
Lumber Production	57 % of firms	all firms	all firms	80% of firms	all firms
Plywood Tech. Adoption	slightly above average	below average	highest level of adoption	high level of adoption	average
Lumber Tech. Adoption	below average	average	average	highest level of adoption	slightly above average
PROFIT	average	lowest	highest	above average	average
INV. INTENS.	low	high	average	high	low
MARKET STRENGTH					
Relative Strength	average	low	high	low	above average
Change in Mkt. Strength	losing share	gaining share	gaining share	gaining share	losing share
APPARENT STRATEGY	low commitment	production orientation	focussed growth	technical orientation and growth	no strategy (shortage)

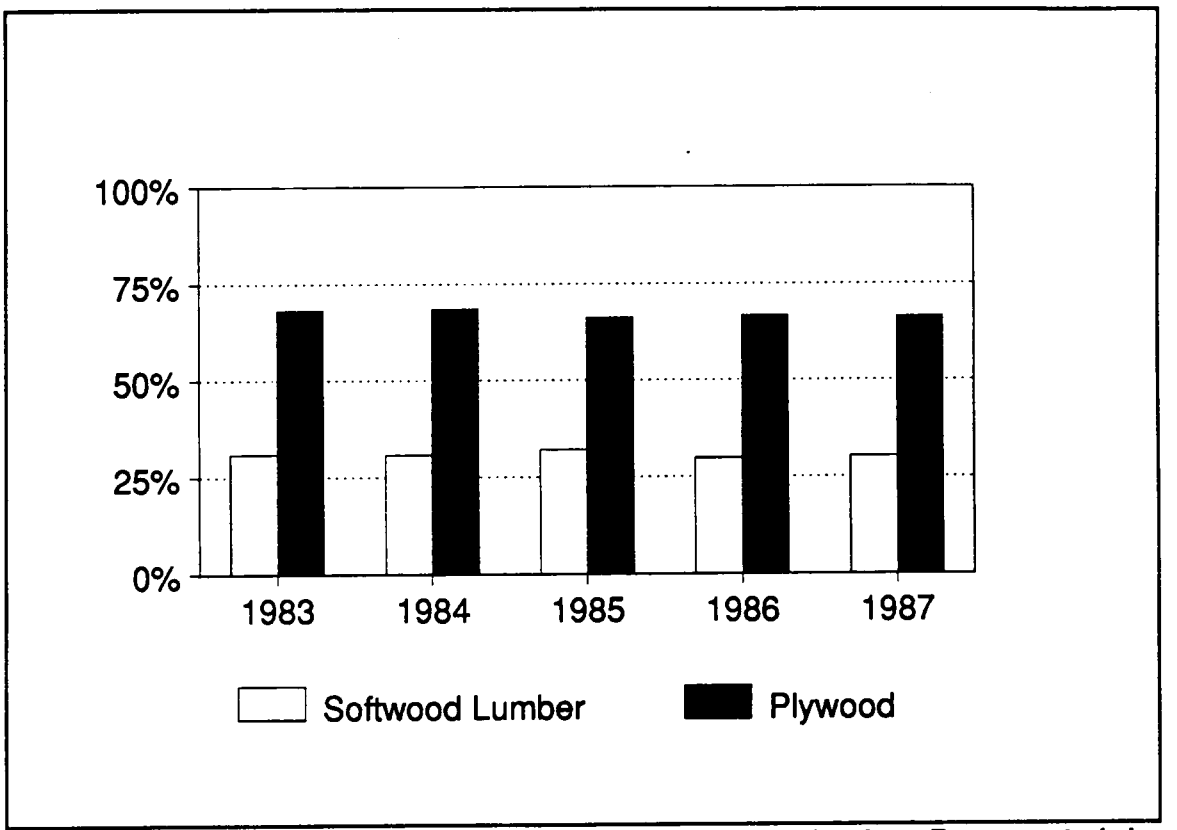

Figure 1: Proportion of 1983-87 North American Production Represented by Survey Respondents

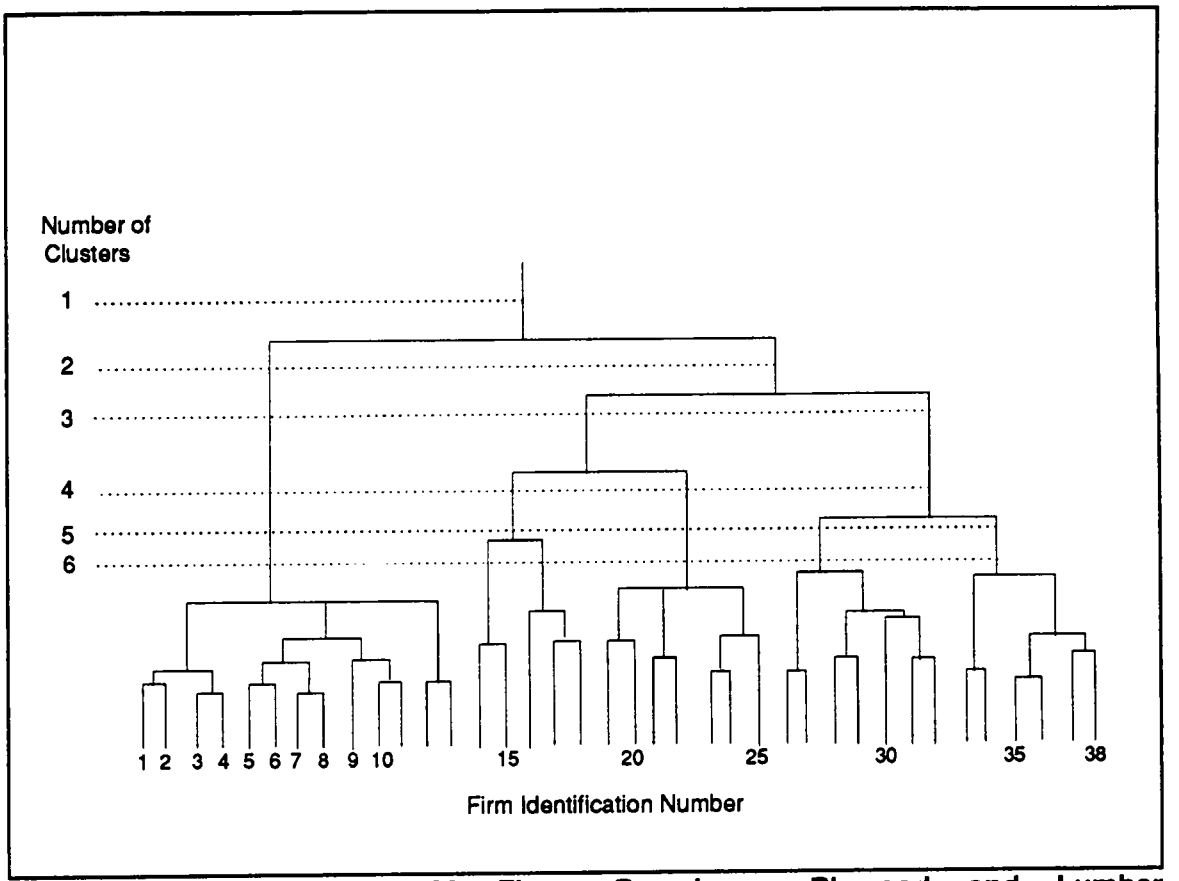

Figure 2: Dendrogram of 38 Firms Based on Plywood and Lumber Technologies

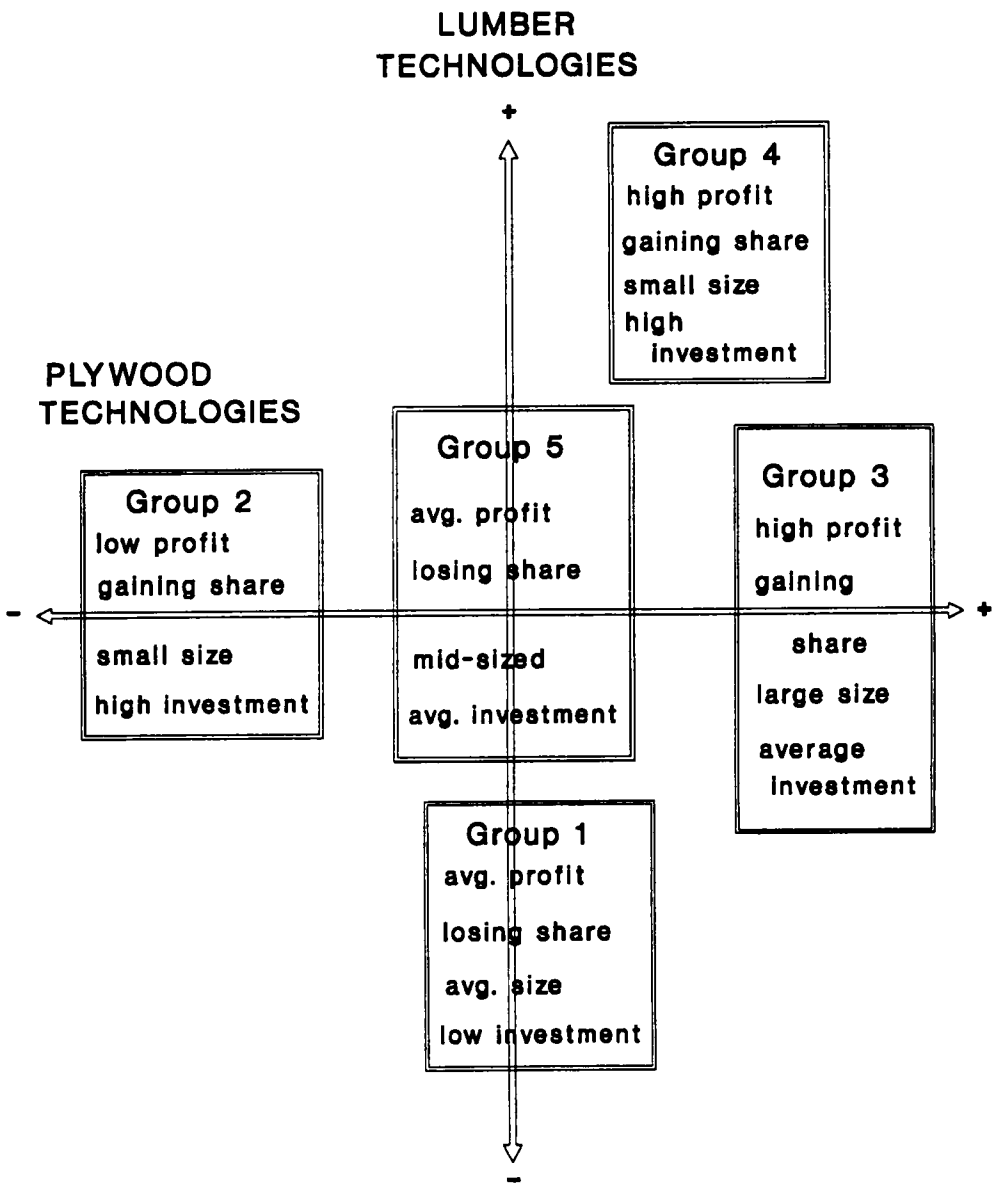

Figure 3: Graphic Presentation of Cluster Groups with Profile Information

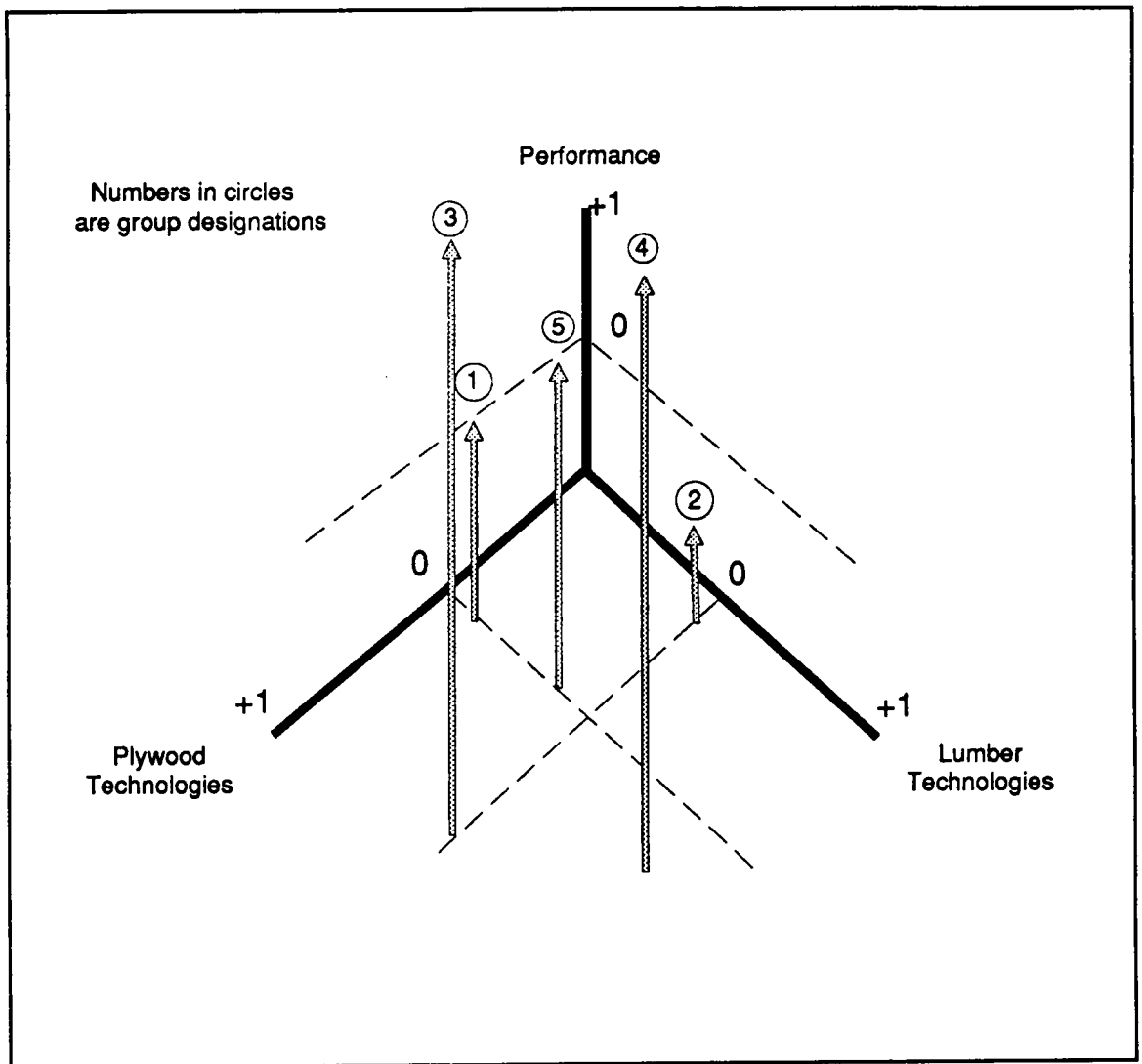

Figure 4: Vector Diagram of Cluster Groups Based on Technological Adoption and Performance

STANDARDIZED INDUSTRIAL PRODUCT MARKETS:

A MODEL OF STRATEGIES AND PERFORMANCE

ABSTRACT

Strategic market research has evolved from an examination for "universal truths" concerning all businesses to an examination of strategic impacts within broad competitive environments. The next evolutionary step is to examine specific competitive environments which necessitates the development and operationalization of new strategic constructs.

The standardized industrial product market has rarely been examined in strategic market research. A model of strategies and performance is developed for this competitive environment. Measures for previously untested variables, degree of innovative processing technology adoption and grade sector focus are developed and measurement systems defined. The model is then tested using the wood building products industry as an archetypical example of this environment.

INTRODUCTION

Initial research on marketing strategy used inter-industry data to probe for "universal truths" concerning successful strategies across broad industry types (e.g. Schoeffler, Buzzell and Heany 1974, Buzzell, Gale and Sultan 1975, and Buzzel and Wiersema 1981). This research was criticized because it lacked adequate recognition of different competitive environments (Porter 1980 page 34-36, Wensley 1982, Lubatkin and Pitts 1983, and Ramanujam and Venkatraman 1984). Strategic researchers reacted to this criticism by grouping inter-industry data into broad categories of industries with similar competitive environments (e.g. Phillips, Chang and Buzzell 1983, Hambrick 1983a, Jacobson and Aaker 1985 and Prescott, Kohli and Venkatraman 1986). Continuing strategic research in more context-specific environments is required to both verify broad inter-industry research results and to explore strategic factors which may only be significant within distinctive competitive environments (Wensley 1982, Lubatkin and Pitts 1983, Ramanujam and Venkatraman 1984, Harrigan 1985, Prescott, Kohli and Venkatraman 1986, and Calori and Ardisson 1988.

Strategy-performance relationships are relatively unexplored for firms that produce standardized (i.e. commodity-like) industrial products. This may due to a different set of critical, firm-controllable, decision variables than those developed from inter-industry research. Collecting data from a broad group of industries obfuscates the distinctive characteristics which separate industry types. Therefore, to explore distinctive decision variables that affect firm performance within a commodity-like industrial market requires a model and data set specific to this market.

This paper presents a model of strategies and performance specific to standardized industrial product markets. The conceptualization portion of this paper first establishes the need for context specific strategic market research. Then the development of this model is traced through previous strategic market research. The operationalization of this model is then tested using the wood building products industry to examine its empirical validity. Using a single representative industry provides the increased precision and utilitarianism of contextually-sensitive strategic studies without the inherent complexity of using environmental variables.

THE EVOLUTION OF STRATEGIC MARKET RESEARCH

Initial research on marketing strategy used cross-sectional, inter-industry data to probe for "universal truths" concerning strategies and reported simple relationships between profitability (as measured by ROI) and individual firm-controllable variables. Buzzel, Gale and Sultan (1975) used the inter-industry data base of the Profit Impact of Market Strategies (PIMS) to suggest that for all industries increasing market share led to higher profitability. Many of the original PIMS findings focussed on describing apparent universal relationships between individual strategies and performance (Ramanujam and Venkatraman 1984).

As strategy research evolved, the field was partitioned into different levels or fields of study to facilitate both empirical and normative research. This partitioning promoted the development of clear construct definitions and measures, the lack of which Hambrick (1980) postulated was one of the limiting factors in the advancement of strategy research. He recognized two separate streams of strategy research;

corporate or grand strategy and business level research. The preponderance of strategic market research focussed on the latter stream. For example, Buzzel and Wiersema (1981) probed business level generic strategies by examining the role of product quality, new product introductions and marketing expenditures in the performance of a firm as measured by relative market share.

Despite the separation of corporate level and business level strategies, the majority of research continued to focus on exploring generic strategies using inter-industry data. Wensley (1982) criticized the use of cross-sectional, inter-industry research results to derive practical strategic prescriptions because they lacked adequate recognition of the competitive environment. Porter (1980, pages 34-46), while acknowledging the utility of inter-industry strategies, stressed that industry and firm structure determined the effectiveness of different strategies. Wensley (1982), Lubatkin and Pitts (1983), and Ramanujam and Venkatraman (1984) questioned the economic significance of generic strategies since they fail to reflect the industry structure and competitive environment within which firms operate. Hitt, Ireland and Stadter (1982) demonstrated that industry environment can determine which functional areas (representing strategic decision variables) were critical to success.

Researchers reacted to this criticism by using broad contextual factors to group inter-industry data into different environmental categories or by focussing on a single, broad, industry environment. To control for differing industry structures, Phillips, Chang and Buzzel (1983) categorized inter-industry data using six broad categories of business environments, as defined by PIMS researchers, to examine the role of product quality on both cost and performance. They found that the direct positive influence of product quality on profitability was dependent on the broad industry

structure which challenged previous contentions that product quality was a universal requirement for business success, regardless of industry environment (Buzzel and Wiersema 1981, and Craig and Williams 1982). Hambrick (1983a) examined generic strategies within a specific industry context, the mature industrial-product environment. The importance of industry context was supported by Prescott's (1986) contention that market environments determined the strength of strategy-performance relationships.

Additional research examined the impact of a variety of strategic variables within specific industry contexts (e.g. Jacobson and Aaker 1985, Prescott, Kohli and Venkataman 1986, and Markell, Strickland and Neeley 1986). Variables examined included vertical integration, product quality, new product introduction, and capacity utilization. Empirical research into context specific strategies and performance is a current and important domain of study for the refinement and advancement of strategy research.

Strategic research has evolved from a single, broad field of study searching for all-encompassing successful stratagems to a contextually-sensitive study of strategy-performance linkages (Zeithaml 1988). This contingency approach to strategy research increases the complexity of strategy-performance models by adding a set of environmental variables. However, this increased complexity is offset by improved precision and utilitarianism of the results. Examining a single industry environment, such as commodity-like industrial product-markets, maintains the additional precision without the added complexity.

STRATEGIC VARIABLES IN STANDARDIZED INDUSTRIAL PRODUCT-MARKETS

The realm of strategies and performance in mature industries that produce standardized, industrial products (commodities) is relatively unexplored in marketing research. Turnbull and Valla (1986) presented a generic framework for strategic planning in industrial markets that differed in several ways from those developed primarily for non-industrial markets. Building on these differences, this paper develops a model of strategy-performance relationships, shown in Figure 1, specific to commodity-like industrial product markets.

Adoption of Innovative Processing Technology

Turnbull and Valla (1986) included the adoption of technological innovation, in both processing and products, as a key strategic variable in industrial markets. The critical importance of process technology as a strategic variable in mature industrial markets is well supported in strategy theory (e.g. Doyle and Saunders 1985, and Butler 1988). Scherer (1974) and Jacobson (1988) contended that adopting new processing technologies, for industrial firms, is more important to profitability than exploiting economies of scale for production, distribution or promotion. Hill and Utterback (1979) contended that, for mature industries, incremental innovations are the most important type of innovation a firm can adopt because of their competitive impact. Hearn (1982) postulated that to prosper in mature industries a firm must invest in developing technologies to implement strategies of either differentiation or low cost producer. Hutt and Speh (1984) contended that, for industrial firms, "the marketing/manufacturing relationship assumes a fundamental role in the development

and implementation of marketing strategy". Hitt and Ireland (1985), Haas (1987) and Calori and Ardisson (1988) considered the adoption of innovative technologies as a key factor in the performance of industrial firms. Quinn (1985) and Glazer (1987) considered that technology adoption was a critical component of a manufacturing firm's strategy.

Thus, a measure that reflects a firm's commitment to adoption of innovative processing technologies is an essential component of a strategic model specific to standardized industrial product-markets. Despite the recognition of this factor as a key strategic variable, it is absent from most strategy-performance models. This absence results from the difficulty of operationalizing this construct for empirical examination. There are several reasons why measures for the construct the adoption of innovative process technologies are often excluded from empirical research. First, empirical process-oriented research cannot be conducted on technological information obtained from inter-industry data due to the multi-faceted, context-specific nature of processing technologies (Ramanujam and Venkatraman 1984). Many of the data bases used for strategic market research (e.g. PIMS), are inter-industry in nature, which impedes an accurate measurement of this construct. Second, the omission of this construct often results from the difficulty in defining and measuring this construct in research, given the rapid dissemination of technology information (Capon and Glazer 1987). This limits the temporal scope of empirical research, since technologies adopted as continuous innovations are in a state of incessant change. For a specific industry environment, innovative process technologies of ten years ago may be outdated today. Therefore, empirical examinations of the adoption of innovative processing technology must not only be

restricted to a relatively short time frame but also focus on a single industry segment within a well-defined competitive environment. In addition, the industry to be studied must use innovative processes that utilize non-proprietary technology so each firm has the opportunity to adopt the processing technologies (Calori and Ardisson 1988).

Examination of the importance of process technology as a strategic variable requires a further refinement of the scope of strategic research. Strategy research has evolved from a cross-sectional search for generic stratagems to an examination of business unit strategic variables and their impact on performance within broad, homogeneous industry segments (Zeithaml, Varadarajan and Zeithaml 1988). The most frequent method of empirical research has examined strategy-performance models using inter-industry data and segmenting firms into several broad industry groups (e.g. Buzzel and Wiersema 1981, Craig and Douglas 1982, Phillips, Chang and Buzzel 1983, Hitt and Ireland 1985, Balakrishnan and Wernerfelt 1986, Chakravarthy 1987, and Markell, Strickland and Neeley 1988). To assess the importance of process technology, the scope of the research must be narrowed even further. Developing reliable measures of this construct that recognize the rapid change and industry specific nature of new process technologies, requires examination of a single industry, representative of a specific competitive environment.

Examining a single industry to test a strategic model has several advantages other than the operationalization of the adoption of innovative processing technologies. Using data from a single industry, indicative of commodity-like industrial product markets, alleviates the need to account for context specific or contingency variables, common to all firms within a homogeneous product-market (Zeithaml, Varadarajan and Zeithaml 1988). Much of the criticism of strategic

marketing research has centered around the lack, or misrepresentation, of these variables (e.g Wensley 1982).

Grade Sector Focus

Within standardized, industrial, competitive environments, product quality is not a viable firm dependent decision variable. Buzzel and Wiersema (1981), and Varadarajan (1985) found that relative product quality was an ineffective firm dependent decision variable within commodity-like product markets. Turnbull and Valla (1986) omitted product quality in their generic industrial strategic framework. Roberts (1986) contended that if all competitors within an industry meet the same standardized product specifications (e.g. commodities) then product quality is strategically irrelevant. The unimportance of product quality, as a strategic variable in certain industrial markets, is supported by the empirical research of Phillips, Chang and Buzzel (1983) who found no direct relationship between product quality and profitability in the raw materials and semi-finished goods businesses. Quality was considered the difference in product attributes within similar grade classifications.

However, in commodity-like markets, higher product quality is frequently reflected by increases in grade designation and corresponding increases in unit price which would not be reflected in relative quality measures within the same grade. Many firms use a grade sector focus (representing the grade levels upon which a firm concentrates its production) to impact their performance. Within commodity-like markets, higher product quality is frequently reflected by an increase in both grade designation and unit price. Grade sector focus is an important firm-controllable decision variable for firms producing industrial commodities.

Investment Intensity

Investment intensity reflects a firm's prior commitment to reinvest in its existing area of operations. Chrisman, Hofer and Boulton (1988) contended that investment intensity was one of four distinctive, major strategy components. Prescott, Kohli and Venkatraman (1986) found that investment intensity was important in almost all the business environments they examined. They contended that it was a major contributor to the spuriousness of the market share-ROI relationship. Markell, Strickland and Neeley (1988) found that investment intensity was a critical strategic variable for three different industries they studied. The importance of investment intensity was supported by Schoeffler, Buzzell and Heany (1974), Lubatkin and Pitts (1983) and Phillips, Chang and Buzzell (1983) and Hambrick (1983b). The importance of investment intensity as a firm-controllable strategic decision variable necessitates its inclusion in this model of strategies and performance.

Forward Vertical Integration

Initial research reported by Vesey (1978) highlighted the importance of vertical integration on a business's performance. Harrigan (1986) recognized that environmental diversity contributed to the impact vertical integration has on a firm's success. She found that for firms producing commodity-like products use of controlled distribution channels contributed to poor performance. Balakrishnan and Wernerfelt (1986) considered forward vertical integration as a key strategic variable and concluded that the optimal level of forward vertical integration is inversely related to the degree of competition.

Research in the building products industry suggested that forward vertical integration is a critical strategic variable. Barnes and Sinclair (1985) reported that forward vertical integration had either a positive or negligible impact on a variety of performance measures. Rich (1986) reported that distribution was considered by many building products firms as one of their most important company strengths. The importance of forward vertical integration in commodity-like product markets is well established and thus must be included in this model.

Market Position

Buzzel, Gale and Sultan (1975) used the PIMS's cross-sectional data base to suggest that increasing market share led to higher profitability. There is a substantial body of supporting literature (Buzzel and Wiersema 1981, Craig and Douglas 1982, Phillips, Chang and Buzzel 1983, and Day and Wensley 1988). Prescott, Kohli and Venkataman (1986) contended that industry environments determined whether the association between market share and profitability was spurious or direct. This assertion was supported by Markell, Strickland and Neeley (1986) who contended that industry structure determined the importance of strategic factors. Rather than grouping inter-industry data, they examined three dissimilar industries and reported that the impact of market share on profitability was context specific. The potential importance of market strength (as measured by relative market share) necessitates its inclusion as a firm-controllable decision variable in this model.

Several variables common to strategy-performance models are absent. Standard variables omitted from this model are shown in Table 1, with reasons for omission and supporting literature.

RESEARCH METHODOLOGY

Measures

The five constructs considered firm-controllable variables are adoption of innovative process technology, grade sector focus, investment intensity, forward vertical integration and market position. All variables were measured using interval scales to facilitate statistical analysis. Table 2 shows the measures used to reflect these constructs.

Since the construct, the adoption of innovative processing technologies, has rarely been measured in empirical research, it was necessary to exercise caution in developing a reliable measure to accurately reflect this construct. A multi-stage procedure, shown in Table 3, was adapted from Churchill (1979) to determine the key innovative processing technologies, specific to the building products industry. This facilitated a relatively direct measure of this construct to improve measurement validity and reliability.

Each firm's proportion of production that utilized each technology was directly measured to compensate for two potential problems. First, it was necessary for the data to remain unbiased for firm size since a large firm with a multitude of production facilities might use many of the technologies, but in only a few of their facilities. By measuring the proportion of production, a business unit's overall commitment to new processing technologies would be measured, regardless of firm size. Second, the problems associated with using industry perceptions of technology users (i.e. biases towards large sized or well known companies) would be avoided.

The two principal segments of the wood products industry that produce wood building products are softwood lumber and structural panels. For the production of structural panels, the refinement procedure identified ten continuous innovations and one discontinuous innovation as indicators of the adoption of new process technologies. There were nine continuous innovations identified in the production of softwood lumber as suitable construct indicators. Rather than using expert judgments to further refine the list and risk excluding important sources of differentiation between firms, a Principal Component Analysis was used to identify important, innovative, processing dimensions. Using the sum of the resultant factor scores as measures for the adoption of innovative processing technologies precludes the overemphasis of highly correlated technologies (Hair, Anderson and Tatham 1987). Factor scores, after a Varimax Rotation are shown in Table 4.

Overall production cost is used as the surrogate measure for grade sector focus and includes the expense of raw material procurement. Higher levels of overall production costs produce superior grades of product with a corresponding higher price in competitive, standardized product-markets (Bosworth and Lawrence 1982, pages 82-3, McElroy et al. 1983, Phillips, Chang and Buzzel 1983 and Abratt and Pitt 1985). Grade sector focus may be akin to "quality" in more traditional strategic market research.

Table 2 also shows the performance variables used in this model. Contribution to earnings (including depreciation) is used to measure return and moderates the effects of differing taxation policies between countries, interest payments, and parent company decisions (grand strategies) that could distort the evaluation of business unit performance. Criticism of the use of accounting financial data to develop

performance measures focusses on differing accounting methods in areas such as depreciation and inventory valuation (Chakravarthy 1986). To compensate for this potential error, each firm's method of depreciation and inventory evaluation was examined. The great majority of firms (both in the United States and Canada) used the same method of calculations. Where differences did exist they had minimal impact on profitability measures.

Day and Wensley (1988) criticized the use of accounting measures for performance, since they often reflect past strategic decisions; a criticism applicable to many of the variables in the strategy-performance equation. To compensate for this time sensitivity, precautions were taken in choosing the time frame over which the decision and performance variables were measured. The study examined data collected for a five year period from 1983 to 1987. The surrogate profitability measures used as indicators of performance were calculated as the average of the last three years of the study (1985-1987). Change in market strength (as measured by change in relative market share) was measured as the change from the average for 1983-1985 to the average for 1985-1987 as recommended by Buzzel and Wiersema (1981). Relative adoption of innovative processing technologies was measured in 1987 to reflect the results of decisions made throughout the five year study period. Average investment intensity was measured for a five year period (1983-1987). The additional two years (1983 and 1984) incorporated expenditures for capital investments which often require several years to impact performance. The final two years (1986 and 1987) are retained in this measure to adequately reflect the influence of investments which can have an immediate impact on performance. These two variables, adoption of innovative technologies and

investment intensity, require different measurement time frames to recognize the delay between a firm's commitment (as gauged by expenditures), strategic implementation and the resultant performance effects. The other decision variables (forward vertical integration, grade sector focus and relative market position) are not as sensitive to implementation time delays and were calculated for the same three year period as the performance measures, 1985-1987. This recognizes that while some strategic decisions take several years to affect performance others have a more immediate impact and attempts to address the criticisms of Day and Wensley (1988) concerning current performance measures reflecting past strategic decisions.

Data Base

A survey was mailed to the seventy-five largest producers of wood building materials in North America. Use of a judgmental sample in industrial research has both theoretical and empirical support (Zehnoff 1973, and Karmel and Jain 1987). Of the seventy-five firms, eight no longer existed as separate entities and forty-four returned usable surveys for a response rate of 66% (44/67). The 44 respondent firms were responsible for over one third of 1987 North American production of softwood lumber and three quarters of 1987 wood structural panel production suggesting that the sample was representative of the industry. Information collected from the mail survey was used to measure the following two constructs: forward vertical integration and relative adoption of innovative processing technology.

There were 22 responding firms with accessible and accurate financial information required to explore the model. These 22 firms were responsible for over 28% of softwood lumber production and over 60% of North American wood structural

panel production from 1983 to 1987 (see Figure 2). Financial information was accumulated from annual reports and production volumes were collected from annual reports and verified with data from industry associations and private publications.

Hypotheses

The Effects of Adoption of Innovative Processing Technology on Performance. Management theory supports the contention that the adoption of innovative processing technologies has a positive direct influence on a firm's performance (Scherer 1974, Hill and Utterback 1979, Hutt and Speh 1984, and Calori and Ardisson 1988). This relationship may be due to its affect on the cost of production, uniformity of product quality, product innovation or a combination of these factors. That is,

H_1: The higher the degree of adoption of new processing technologies, the better a business unit's performance.

The Effects of Grade Sector Focus on Performance. A higher measure for grade sector focus reflects the amount of higher priced commodity products a firm produces, i.e. it reflects which segment of the market the firm is targeting. The production of higher priced grades, reflected in grade sector focus, should improve firm performance due to higher margins often associated with superior grades. That is,

H_2: Grade sector focus is positively correlated with price and has a positive direct impact on performance.

The Effects of Investment Intensity on Performance. Strategic marketing research has supported a direct, positive effect of investment intensity on a firm's performance (Schoeffler, Buzzell and Heany 1974). Prescott, Kohli and Venkataman (1986) and Markell, Strickland and Neeley (1988) reported on a positive, direct relationship between investment intensity and performance. That is,

H_3: Investment intensity has a direct, positive impact on performance.

The Effects of Forward Vertical Integration on Performance. Barnes and Sinclair (1985) reported inconclusive results in examining forward vertical integration and its impact on performance for selected forest products firms. Marketing theory suggests little advantage in forward vertical integration in mature industrial markets. Harrigan (1986) contended that vertical integration is rarely a successful strategy in commodity-like markets. Woo (1981) contended that when market stability was eroded by rapid technological change then higher degrees of integration led to low relative performance. This suggests that forward vertical integration will not positively impact performance. That is,

H_4: Forward Vertical Integration has no positive direct impact on performance.

The Effects of Market Strength on Performance. The continuing controversy concerning the effects of market strength (as measured by relative market share) on a firm's performance can often be attributed to differences in market environments (Prescott, Kohli and Venkataman 1986). Based on the results reported by Phillips, Chang and Buzzel (1983), and Prescott, Kohli and Venkataman (1986) there appears

to be no relationship between relative market share and performance for firms operating in commodity-like industrial markets. That is,

H_6: Market strength has no positive, direct impact on performance.

Multiple regression analyses will use the five decision variables shown in Table 4 to predict performance as measured by Return on Sales and Change in Market Share. A reduced model will be developed that includes all decision variables with significant beta coefficients as predictor variables to examine stability of regression results.

RESULTS

Correlations and standard statistics for the five predictor variables and the two performance measures are shown in Table 5. When change in relative market share was considered as the performance variable the model exhibited no significant predictive power ($p>.4$) as shown in Table 6. These empirical results support Williams (1983) contention that in mature manufacturing industries "technological change dominate scale economies and market share does not convey an automatic competitive advantage". Day and Wensley (1988) contended that market strength was an inappropriate measure of performance since each firm may define its competitive arena (market) differently. They questioned whether a single market share measure can adequately reflect a firm's performance. Market strength proved

to be an inappropriate measure of performance in industrial commodity-like product markets.

The model, using Return on Sales as a surrogate for profitability, was not only highly significant ($p<.001$), but there were no problems with correlation among the residuals. Hypotheses will be reported based on this performance measure. A reduced model, using the three significant decision variables, produced the following equation;

ROS = .14 (Adoption of Technologies) + .45 (Grade Sector Focus) + .45 (Investment Intensity)

The adjusted R^2 was .797, the Standard Error of the Estimate was .085, and all beta coefficients were significant at $p<.20$. The plot of estimate by residuals was random. The stability of the beta coefficients, compared to the full model, lends credence to the results of the full model.

Hypothesis 1: The higher the degree of adoption of new processing technologies, the better a business unit's performance. The adoption of innovative processing technologies had a positive impact on profitability with a beta coefficient of .162 which remained relatively stable in the reduced model. Of the three decision variables that had significant beta coefficients, the adoption of innovative processing technologies had the lowest value; however, it was the only decision variable which did not incorporate financial measures in its calculation. This positive influence on profitability supports the contention of Hitt and Ireland (1985) that production activities are positively related to performance for firms operating in stable industrial product markets. Their measure was based on managers' perceptions and not a

direct measure. These results are the first empirical substantiation of the importance of adopting new processing technologies that uses direct measures and not perceptions.

Hypothesis 2: Grade sector focus is positively correlated with price and has a positive direct impact on performance. As expected, price was highly correlated with cost (Pearson r=.984). Those firms with a higher grade sector focus exhibited a higher degree of profitability as measured by Return on Sales. In commodity-like markets, higher grades are often in shorter supply and frequently provide superior profit margins relative to the lower grades. The significant beta coefficient (.525 at $p<.05$) supports the hypothesis as stated.

Hypothesis 3: Investment intensity has a direct, positive impact on performance. Investment intensity (as measured by the average ratio of capital expenditures to assets) had a significant beta coefficient of .477 ($p<.05$). This supports Prescott, Kohli and Venkataman's (1986) contention that investment intensity is a key decision variable in most industry environments. Rapid change in technologies combined with increasing global competition in many standardized industrial product markets requires a relatively high level of capital expenditures to maintain or increase profitability.

Hypothesis 4: Forward vertical integration has no positive direct impact on performance. The lack of a positive direct effect for this variable supports the assertion by Balakrishnan and Wernerfelt (1986), that in markets where competition

is high and distribution margins are low (such as the building materials market) then vertical integration will not improve performance. Another possible explanation of these results could be Harrigan's (1986) contention that forward vertical integration is a form of diversification and successful implementation is critical to its positive impact on profitability. There may be a balance between firms using controlled distribution to their advantage and those with improper implementation which negatively impacts performance. This could explain the inconclusive results of Barnes and Sinclair (1985) concerning the impact of forward vertical integration on the financial performance of selected building products firms.

Hypothesis 5: Market strength has no positive direct impact on performance. The results show that market strength (as measured by relative market share) had no significant direct impact on profitability. This supports Phillips, Chang and Buzzel's (1983) contention that relative market strength has no direct impact on profitability in raw and semi-finished materials businesses. Within a commodity-like industrial product market, there appears to be little profit advantage in building share beyond a minimum efficient size.

LIMITATIONS

The sample frame consisted of the 75 largest firms producing softwood lumber and/or wood structural panels. The use of a non-random sample inhibits the ability to statistically infer results to the population as a whole. In industrial marketing research it is necessary to include larger firms that may directly influence the

industry environment (Adler 1967, Karmal and Jain 1987); however, the omission of smaller firms may obfuscate the impact of the market strength of the largest firms. The sample size of 22 firms used to test the model may or may not be indicative of the industry as a whole. However, the substantial proportion of total North American production volumes produced by these 22 firms, shown in Figure 2, alleviates some of the problems inherent with a small sample size.

As with all strategic marketing research, only a subset of decision variables were be examined and excluded factors may have a significant impact on firm performance. While theory supports the omission of the some of the excluded decision variables in stable commodity-like markets, empirical examination of their importance using environment-specific, direct measures would lend credence to their omission. However, the direct evaluation of some of these variables requires the development of new measures. For example, accurately measuring product quality within a grade specification requires an evaluation of what quality means to the major customer groups.

Should the single industry, used to represent the commodity-like industrial product market, deviate in structure so as to be unrepresentative then the results may not be indicative of the industry environment. To alleviate this concern the building products industry was chosen because of its archetypal characteristics. These attributes include those listed by Calori and Ardisson (1988) such as; 1) the decrease of scale economies after optimal size is reached, 2) technology is available for all competitors in the industry, 3) cumulated experience is not a barrier to entry and 4) products are well defined and standardized. To insure that all major participants in the total product market were examined, the sample frame included all

building products firms operating in both Canada and the United States. While these steps should moderate concerns regarding the representative nature of the building products industry for the industrial product market, the applicability of the results to other industries within similar environments can only be confirmed by empirical research in additional commodity-like industrial industries.

Since market strength was an ineffective measure of firm performance, a surrogate profitability measure derived from accounting information was the only meaningful gauge of performance. This results in the multitude of problems associated with the sole use of accounting measures to represent firm performance as outlined by Chakravarthy (1986) and Day and Wensley (1988). These problems include scope for manipulation of data, undervaluation of assets, differences in accounting methods between Canada and the United States and dissimilar methods of depreciation and inventory valuation. While many of the concerns have been previously addressed, they cannot be totally discounted.

DISCUSSION

These empirical results support marketing theory on the importance of adopting innovative processing technologies in stable, industrial product markets. The low beta coefficient for the adoption of innovative process technologies could mean that this construct functions more as a failure preventer than a success producer (Varadarajan 1985). The difficulty of developing a measure to accurately operationalize this construct and the associated need to focus on a single industry

may be one of the reasons that empirical examination of the importance of this construct has been neglected. Additional industry specific research is needed to confirm the importance of this construct and to quantify the impact it has on performance.

The meaningful impact of investment intensity on performance was corroborated supporting the findings of Williams (1983), Prescott, Kohli and Venkataman (1986), and Markell, Strickland and Neeley (1988). Within commodity-like markets, firms that geared their production towards the higher grades and corresponding higher prices demonstrated a higher profitability. However, not all firms are geographically located to be able to economically secure the raw materials necessary to produce the higher grades. Grade sector focus is analogous to product quality between grade classifications. Further research is needed to establish whether intra-grade quality can affect a firm's performance or if firms gravitate towards producing the lowest possible quality product within a standardized grade as contended by Keating (1985).

The role of market strength in commodity-like industrial markets, as measured by market share, was questionable. Results suggest that increasing market share has little impact on profitability perhaps because the sample was composed of the larger firms, all of which may have surpassed minimum efficient size. If Calori and Ardisson's (1988) contention that scale economies decrease after optimal size is reached is true, the sample of the larger producers may not reflect the industry as a whole. However, relative market share for the firms included in the sample ranged from 45.3% to 1.1%. This suggests a sufficient representation of firms with both high and low market strength to support the results. Research by Woo and Cooper

(1982) found that successful low market share firms produced standardized industrial products for markets with stable established product lines.

The empirical investigation of the importance of strategic decision variables for firms operating in industrial markets has received little emphasis. Inter-industry research has developed strategy-performance models which have then been modified to reflect broad industry environments. Results have often indicated that industrial markets have distinct strategy-performance relationships (e.g. Varadarajan 1985 and Zeithaml, Varadarajan and Zeithaml 1988). The increasing importance of the competitive environment to strategic decision making requires models that are not only more sensitive to an industry's competitive setting but also more utilitarian. There is a need to examine industrial markets as a group of distinct environments, contextually different from consumer markets. This would encourage the development of decision variable measures with greater validity within the limited industrial context. For example, quality is an elusive construct to measure and then determine its impact on performance in industrial commodity-like markets. A measure of quality developed for a multitude of different industries provides a less than meaningful measure within a specific business context. For commodity-like industrial products, quality within grades and quality between grades represent two different management decisions and cannot be reflected by a single measure.

The scope of strategic market research needs further refinement with a focus on specific industries indicative of homogeneous environments in order to improve the validity and specificity of construct measures. This would further enhance the preciseness and utilitarianism of strategic marketing research.

Strategic market research has evolved from a search for "universal truths", to an examination of the importance of generic strategic factors within broad industry environments. Continuing evolution suggests the development of constructs and strategic models specific to well defined industry environments. This requires the development of new and valid measures to adequately reflect these constructs. Adoption of innovative technologies and grade sector focus are examples of previously unmeasured constructs that exhibit substantial strategic impact in the commodity-like industrial product market.

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Table 1: Strategic Firm-Dependent Decision Variables Omitted from Model

Latent Measure	Typical Type of Measure	Reason for Omission	Supporting Literature
Product Quality	Informants opinion of customers perceptions	In stable product-markets (commodities) quality has little strategic impact.	Buzzel and Wiersema 1981; Mathur 1984 and; Varadarajan 1985.
Relative Price and Relative Cost	Informant report based on response to standardized question	Price and cost are not firm-controllable decision variables in commodity-like industrial markets since they approach classic economic pure competition.	Stigler 1966; Scherer 1970 and; Calori and Ardisson 1988
Backward Integration	Informant report based on response to standardized question	Backward integration in mature industries is an unpopular and unsuccessful strategy.	Harrigan 1986; Gold 1986 and; Balakrishnan et al. 1986.
Marketing and Advertising Expenditures	Informant report based on response to standardized question	Expenditures in advertising or marketing have no impact on performance in mature, industrial goods markets.	Hitt and Ireland 1985; Jacobson and Aaker 1985 and Prescott, Kohli and Venkataman 1986.
Relative Productivity per Employee	Informant report based on data from organizational records	Labor is of decreasing importance in manufacturing industries	Chakravarthy 1986 and; Capon and Glazer 1987.

Table 2: Measures of Variable Used in Model

Latent Variable	Type of Measure	Measure(s)	Supporting Literature
Firm-Controllable Decision Variables			
Adoption of innovative processing technologies	Informant report based on response to standardized questions.	Sum of factor scores derived from 20 processing technologies.	Hitt & Ireland 1985; Turnbull & Valla 1986; Calori & Ardisson 1988.
Grade sector focus	Informant report based on data from organizational records.	Average unit production cost (1985-7)	McElroy et al. 1983; Phillips, Chang & Buzzell 1983; Abratt & Pitt 1985.
Investment intensity	Informant report based on data from organizational records.	Average capital expenditures relative to assets (1983-7)	Hambrick 1983b; Markell, Strickland & Neeley 1988.
Forward vertical integration	Informant report based on response to standardized questions.	Proportion of production sold through captive wholesalers (1985-7)	Vesey 1978; Harrigan 1986; Barnes & Sinclair 1985.
Market Position	Informant and industry report based on data from organizational records.	Average relative market share (1985-7)	Buzzel & Wiersema 1981; Prescott, Kohli & Venkataman 1986; Day & Wensley 1988.
Performance Measures			
Return on investment	Informant report based on data from organizational records.	Average contribution to earnings relative to sales (1985-7)	Chakravarthy 1988.
Change in relative market share	Informant and industry report based on data from organizational records.	Change in relative market share from average of 1983-5 to average of 1985-7	Buzzel & Wiersema 1981; Day & Wensley 1988.

Table 3: Procedure to Develop Measure of Degree of Adoption of Innovative Processing Technologies

Procedure	Operational Methodology	Technique	Results
Specify Domain	Review of industrial marketing theory to corroborate importance of continuous and discontinuous processing change.	Literature review	Confirmed importance of construct in strategy.
Generate Sample	Extensive literature review of trade journal, association publications and company reports.	Literature review	Large list of new processes within building products segment.
Purify Measure	Narrow list by review with researchers in wood products. Refine list in focus group with experts from industry, associations and academia.	One on one telephone review. Focus group	List of important, operational processes.
Assess Validity and Reliability	Review list of innovative processes with industry personnel.	Mail list to industry executives for comment.	Final list of reliable measures for construct.

Table 4: Factor Loadings for Processing Technologies (after Varimax Rotation)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
PANEL PROCESSING TECHNOLOGIES					
Log Merchandising	0.796	0.085	0.163	-0.059	0.369
Computer Drying of Veneer	0.875	-0.045	-0.091	0.323	0.009
Press Drying of Veneer	-0.222	0.818	0.209	0.090	-0.262
Round-up Lathe	0.176	0.801	-0.161	-0.047	0.112
Automatic Lay-up	-0.119	0.112	0.826	0.174	-0.097
High Moisture Gluing	0.372	-0.195	0.649	-0.231	-0.035
Powered Nose Bar	0.097	0.242	0.201	0.841	0.154
Powered Core Drive	0.118	-0.212	-0.147	0.825	0.232
Retractable Chuck	0.154	-0.277	-0.357	0.202	0.806
Computerized Clipper	-0.001	0.307	-0.294	0.283	0.765
Descriptive Title	Transition	Recently Introduced	Cost Reduction	Log Breakdown	Industry Standards
Variance Explained (%)	15.8	15.1	14.3	15.6	18.6
LUMBER PROCESSING TECHNOLOGIES					
Log Merchandising	0.679	0.214	0.003	-0.356	
Computerized Log Carriage	0.814	0.079	-0.164	0.080	
Computerized Edger	0.777	-0.109	0.126	0.224	
Log Scanning	0.542	0.634	-0.101	0.088	
TDAL Drying	-0.044	0.896	0.129	0.037	
Small Kerf Headrig	0.144	0.157	0.758	-0.081	
Cont. High Temp. Drying	-0.181	-0.297	0.742	0.066	
Automated Sorting	-0.086	0.216	0.695	0.349	
Machine Stress Rating	0.111	0.074	0.108	0.896	
Descriptive Title	Computeri-zation	Monitoring	Increase Productivity	Engineered Products	
Variance Explained (%)	23.3	15.9	18.8	12.5	

NOTE: Factor scores were weighted by production volumes and summed to derive initial technology rating. This was adjusted for discontinuous processing change of non-veneered panel production (considered equivalent to highest plywood factor score) to derive overall score of technological adoption.

Table 5: Correlation Matrix and Statistical Information for Seven Variables

	ROS 85-7	Ch. RMS	TECH.	G.S.F.	INV.	F.V.I.	R.M.S.
Ch. RMS	-0.067						
TECH.	0.395	0.282					
G.S.F.	-0.108	-0.229	-0.077				
INV.	0.028	0.270	0.197	-0.121			
F.V.I.	-0.044	-0.216	0.062	0.220	0.064		
R.M.S.	-0.061	0.036	0.180	0.403	0.229	0.533	
Means	0.174	-0.003	0.467	0.364	0.085	15.561	0.101
S.D.	0.064	0.021	1.619	0.170	0.041	23.139	0.108

Definitions of Terms

ROS 85-7	Average Return on Sales for 1985 to 1987
Ch. RMS	Change in Relative Market Share from the average of 1983-5 to 1985-7
TECH	Adoption of Innovative Process Technologies
G.S.F.	Grade Sector Focus
INV	Investment Intensity
F.V.I.	Forward Vertical Integration
R.M.S.	Relative Market Share

Table 6: Beta Weights and Other Statistics of Full Model

Predictor variable	Criterion variable: Return on Sales		Criterion variable: Change in Rel. M.S.	
	Stand. Coeff.	P(2 tail)	Stand. Coeff.	P (2 tail)
Adoption of Technologies	0.162	0.158	0.220	0.351
Grade Sector Focus	0.525	0.014	-0.554	0.185
Investment Intensity	0.477	0.016	0.353	0.359
Forward Vertical Integration	0.045	0.758	-0.368	0.240
Relative Market Position	-0.175	0.349	0.288	0.460
Regression prob.	0.000		0.404[1]	
Degrees of Freedom	5,17		5,17	
Adjusted R^2	.785		.063	
Standard Error of Estimate	0.088		0.020	
Sample Size	22		22	

[1] Using Change in Market Position did not produce a significant model.

NOTE: All estimate-residual plots, eigenvalues, variance proportions and leverage values were within acceptable limits (Weisberg 1980 and Wittink 1988) for the model using Return on Sales as the Criterion variable.

Figure 1: Model of Strategic Decision Variables-Performance Being Tested

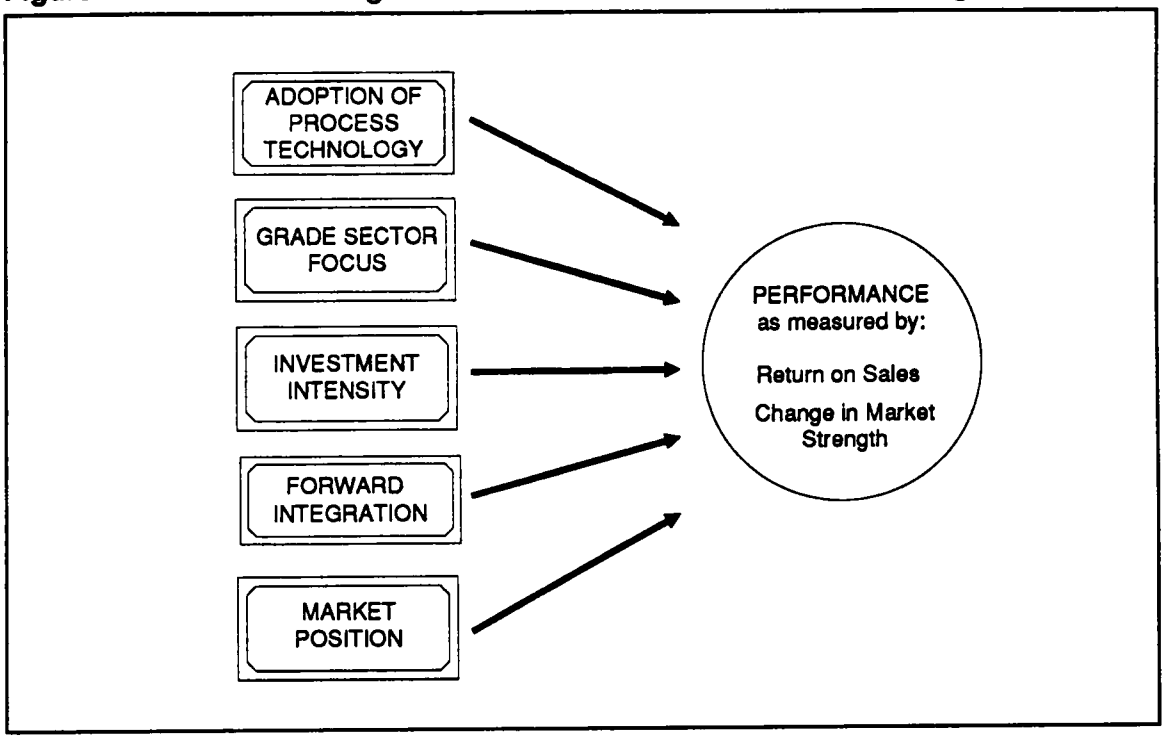
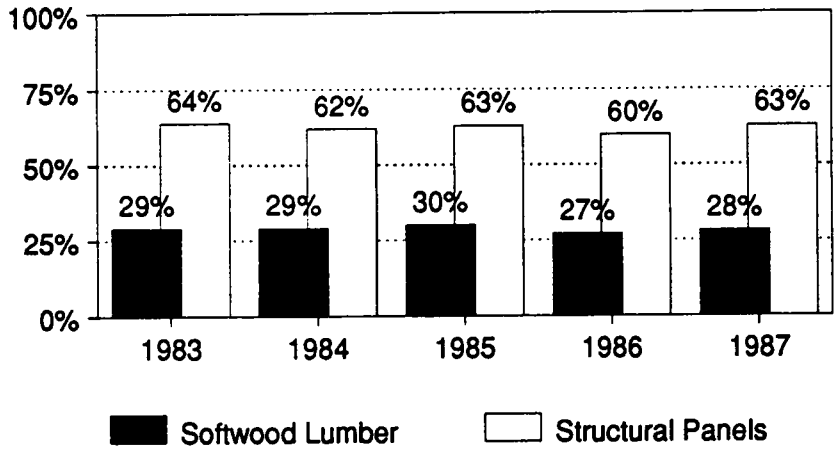


Figure 2: Proportion of North American Production Produced by 22 Firms in Sample (1983-1987)



Source: Statistics Canada, American Plywood Association, National Forest Products Association and Annual Reports

SUMMARY

SUMMARY

The strategic importance of the adoption of innovative processing technologies was analyzed on two different levels. On the first level, the importance of this strategy was examined specific to the building products industry (composed of structural panel producers and softwood lumber producers). Additional important strategies, as well as a variety of performance indicators were also measured to ensure that the importance of adopting innovative processing technologies was examined within an accurate contextual environment. The second level was broader and more theoretical in nature. A strategic model for firms operating in standardized industrial product-markets was created which required the development of previously unmeasured strategic constructs and the creation of valid interval measurements of these. The model was then tested with data from the wood building products industry since this environment is typical of standardized industrial product markets.

A mail survey of the seventy-five largest North American producers of structural panels and softwood lumber provided the primary data necessary to investigate the strategic importance of process technology adoption, forward vertical integration, relative market share, grade sector focus, and investment intensity on firm performance (as measured by profitability surrogates and changes in relative market share). This survey collected direct measures of the respondent's proportion of 1987 production that used each of twenty-three processes indicative of innovative technologies in the manufacture of building products. Additional information concerning the other strategic and performance factors was collected from secondary data sources.

For the first level of research, results indicated that the adoption of innovative processing technologies had a positive impact on firm profitability. Building product firms were clustered according to their level of adoption of innovative processing technologies and these clusters were then described according to a variety of firm-dependent characteristics, strategies and performance measures. Companies that had a greater degree of innovative process technology adoption exhibited higher levels of investment intensity (as measured by capital expenditures relative to assets), higher profitability (as measured by Return on Sales) and improving market strength (as measured by changes in relative market share). Firm size (based on volume produced) and degree of forward vertical integration (based on use of controlled distribution channels) were not appreciably different between adoptive firms and non-adoptive firms.

For the second level of research, a strategy-performance model was developed for standardized, industrial product-markets and then tested using the data collected for the building products industry as a representative industry typical of this competitive environment. The environment-specific model was generated from an extensive review of strategic marketing theory and required the development of new firm-controllable, strategic, decision variables. Because these new variables, the adoption of innovative technologies and grade sector focus, had not been previously measured it was necessary to develop accurate means of operationalizing these constructs. The development of valid and reliable measures to accurately reflect these latent variables was a significant component of this research.

Regression analysis indicated that the adoption of innovative processing technologies, grade sector focus and investment intensity had a direct, positive

impact on firm profitability. However, forward vertical integration and market strength (as measured by relative market share) had little impact on firm profitability. These results suggest significant structural differences between consumer and industrial markets that determine which strategic decision variables have a critical effect on firm performance.

Continuing strategic market research into specific competitive environments will enhance the applicability of strategic research. An environment specific strategic model recognizes the significant contextual differences between competitive environments without the need for a set of environmental variables that attempt to differentiate competitive environments from inter-industry data. Environment specific modelling further refines the research procedure and increases the utilitarianism of the results.

OPPORTUNITIES FOR FURTHER RESEARCH

Specific to Building Products Industry

1) The results of this research provides strong empirical support for building products firms to allocate some of their limited financial resources to the adoption of innovative processing technologies. However, in the allocation of scarce resources it is necessary to compare alternative areas of expenditures. Thus, strategic alternatives need to be explored further to assist the industry in allocating their resources. These investment alternatives include procurement of forest land, log and finished good inventories, marketing, distribution, functional support and development of export markets.
2) In addition, answers to survey questions indicated that there are several measures of "quality" in the building products industry. Some of the quality attributes are consistency of grade, within grade quality, diversity of grades offered, promptness of delivery and grade level. An analysis and comparison of the importance of different quality attributes between the producers and purchasers of wood products would enhance the definition and measure of the strategic importance of product quality to firm performance.

Strategic Market Research

Two unique and evolutionary aspects of strategic market research were explored in this research: 1) the development of strategic models for specific industry environments and, 2) the examination of standardized industrial product-markets. Each of these fields of study open up further opportunities for research.

1) Strategic models could be developed for specific industry environments atypical of the more traditional consumer goods industries. These include competitive environments indicative of raw material production, international standardized products and high technology markets where industrial and consumer goods are the same (e.g. computers). Each of these fields warrants a distinctive model of strategy-performance relationships applicable to its unique competitive environment.

2) The standardized industrial product-market requires further research to expand the model developed in this research. Additional strategic variables, such as backward integration, within-grade product quality and organizational structure would enhance and expand the utility and validity of this model.

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