Modeling Factors that Influence Firm Performance in the Eastern Hardwood Lumber Manufacturing Industry

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Abstract

This research investigated the relationship between several firm-controlled, marketing and management factors and firm performance. Hypotheses describing the relationship between the strategic, geographic, tactical, technological and organizational factors and firm performance of hardwood lumber manufacturers were tested. These factors were operationalized, measured in a mail survey and used in statistical analysis to identify relationships among the variables. An adjusted response rate of 19.8% was obtained from the mail survey. Non-response bias was not found to be a significant problem in the data.

A twelve measure performance indicator was developed and utilized to evaluate the performance of hardwood lumber manufacturers who were predominantly privately-held companies. The averages for the profit and costs performance measures were the lowest of all twelve performance measures and this suggested that firms should focus improvement on these measures. The current marketing tactics, including species mix, product mix, customer mix, and promotion mix was determined. The utilization of advanced production technology has increased in the industry since it was last measured in 1999. The majority of respondents (60%) had dry kiln operations and 49% had a surfacing mill. Thirty five percent of respondents indicated that their company was certified by either forest, chain-of-custody, or both.

Of the five firm-controlled factors investigated in this research, four of them were found to be related to firm performance. Geographic location was not found to be related to the performance of hardwood sawmills. Firms who were backward integrated and firms who were both backward integrated and forward integrated performed significantly better than firms who were not vertically integrated or forward integrated. Higher performance scores were associated with larger firms, firms who had multiple sawmills and firms who were members of the NHLA.

There was no relationship found between diversification of the product mix, species mix, customer mix variables and performance. The diversification of a firm's

promotion expenditures was positively correlated to performance. Firms that used optimized headrigs, optimized edgers and optimized trimmers performed significantly better than did firms not using all three of these technologies. Firms that used computer based log tallying, lumber tallying or inventory control performed significantly better than firms utilizing none of these technologies.

An increase in the use of business strategy from previous studies along with a shift towards the use of a differentiation strategy was discovered. Firms interpreted to be following a hybrid differentiation/cost leadership strategy performed better than firms following a cost leadership, focus, or differentiation strategy.

The implication of these results is that larger, vertically integrated firms are likely to perform better than smaller, non-integrated hardwood lumber manufacturers. It is recommended that firms diversify their use of promotion media and venues in order to attract new customers. Adoption of production and information technology will help some hardwood lumber manufacturers improve their performance. It is recommended that hardwood lumber manufacturers control costs and differentiate their products in order to gain competitive advantage.

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Chapter 1. Introduction & Literature Review

This research project applied business research methods to the hardwood lumber industry to measure firm performance, determine variables that influence performance, and describe current marketing tactics and strategy. This introductory chapter reviews the state of the hardwood lumber industry and relevant literature on business performance measurement. The report was written with the intention of the main chapters being a peer-reviewed publishable article. The second chapter provides an overview of the development of the performance indicator used in the main survey. The third chapter describes the mail survey and summarizes the current profile of the industry including its marketing tactics and overall performance. The fourth chapter determines which factors influence performance. The fifth chapter examines changes in business strategy and technology utilization over time. The final chapter draws conclusions, limitations, and recommendations from the work.

In this chapter, first an overview of the hardwood lumber manufacturing process along with general information on product types produced, distribution channels and promotion media utilized is presented. Next, a market analysis and economic snapshot of the hardwood lumber industry is presented followed by a literature review on firm performance. Then factors that potentially influence performance are reviewed and a number of hypotheses are developed relating these factors to performance. Finally, the goals and objectives of the project are described.

Hardwood Lumber Industry

The hardwood lumber industry is an amalgamation of lumber manufacturers, their suppliers such as loggers and forestland owners, and their customers such as brokers, wholesaler distributors, concentration yards, and exporters. Once the lumber is made into finished goods such as furniture and cabinetry it is classified as a separate industry. The focus of this research project was on hardwood lumber manufacturers, also referred to as hardwood sawmills. The results of the research project are applicable to lumber manufacturers and not other firms within the industry. The following section provides an overview of the processes and products of a hardwood sawmill.

Hardwood lumber manufacturers produce lumber from hardwood logs. The logs are purchased from loggers or landowners who harvest timber on forestland. The logs can be from a variety of tree species including red oak, white oak, yellow poplar, hard maple, soft maple, black cherry, ash, black walnut, aspen, basswood, beech, hickory, birch, gum, pecan, cottonwood, elm, or other species depending on what is available to the mill in that region. The species and grade of log chosen for purchasing and sawing depends on the type of mill and its equipment, what types of lumber are selling in the market and what is available. The delivered logs are measured for volume, grade and species (a process known as log tallying) and then stored on the log yard until they are sawn by the mill.

The first step in the sawmilling process is to debark the log and pass it through a metal detector. The log may be cut to length or bucked before it is sent to the primary saw. The primary saw can be a band headrig, circle headrig, or a scragg headrig. Flitches of wood up to 4" thick are sawn from the log as it is turned by the carriage. Each pass of the carriage through the saw produces another flitch. In general, higher quality lumber is sawn from the outer portion of the log as compared to inner part of the log where knots and other defects are more common. The log is sawn until it has 2 or 4 flat sides and then it is termed a cant. The cant and lumber may be resawn at a secondary saw such as a gang saw or a band resaw. The flitches are typically edged by an edger which cut parallel to the length of the board. The ends of the board or cant are then end trimmed by trimmers parallel to the width of the board to create a rectangular shaped board. The boards range in thickness from ¾" to 4" thick and range in length from four feet to 16 feet long. The width can be from 4" wide to 20" wide. The lumber is often graded according to grade rules established by the National Hardwood Lumber Association (NHLA). The grading system is designed so that as the lumber grade increases then there are fewer defects such as knots, splits, decay, wane, cup, crook and other defects in the lumber. The higher grades of lumber are more valuable than lower grades of lumber for the same species because more defect free wood is available to end-users. The cants, which are not typically graded, may be sized for sale as railway ties or as pallet cants. The lumber and cants are tallied and sorted by thickness, species, and

grade. The sawn lumber and cants are then stored until they are sold or further processed at the facility.

Lumber may be sold green, air dried, or kiln dried. Pallet lumber and pallet cants along with railway ties are not kiln dried. Their end uses are in exterior applications so they don't have to be kiln dried. Kiln dried wood is necessary for the production of interior wood products such as flooring, furniture, millwork, and cabinetry. Kiln drying exposes stacked lumber to high temperature, high humidity and circulating air in order to drive moisture out of the wood by gradually reducing the humidity level. This process increases the value of the lumber but also costs more money due to the additional machinery, inventory, and energy needed for kiln drying. After kiln drying the lumber maybe sold to an end-user; surfaced on two edges or all four sides; cut into custom dimensions, sorted for color, or custom graded as required by the customer, or packaged and loaded into containers for exporting.

The main distribution channels of hardwood lumber manufacturers include secondary wood manufacturers, concentration yards, wholesale distributors, exports, retail operations, and other customers. Secondary wood manufacturers include flooring, cabinetry, millwork, furniture, dimension and pallet manufacturing. Concentration yards purchase green or air-dried lumber and then dry and possibly sort, surface, or dimension it before selling to other end-users. Wholesale hardwood distributors generally purchase dried hardwood lumber and sometime surface, machine, sort or package special sizes of lumber and then distribute it to smaller manufacturers who are geographically dispersed. Hardwood lumber may be dried and sold directly to customers in Canada, Mexico, Europe, Asia or South America. Hardwood lumber may also be sold to retail operations and local users.

The edgings and trimmings of the lumber and cants are often collected via conveyors and then chipped for sale to paper mills and other wood residue users. At mills without chippers the slabs may be sold for firewood or burned onsite. The sawdust from each saw is often collected by vacuum systems to be collected into a bin. This sawdust, which is a smaller residue than chips, are then sold to composite wood mills or used for creating steam and power for kiln drying or electricity production. Mills with cogeneration boilers are able to create both steam and power for their operations. The

bark from the outside of the log is typically sold for landscaping mulch. The next section provides an overview of the macroeconomic environment of the hardwood lumber industry as a whole.

The hardwood lumber industry is important to the economic vitality of rural areas in the eastern U.S. According to the U.S. Census Bureau (2005), this industry employed an estimated 26,168 workers in 2002 and the total value of shipments was $4.4 billion. The hardwood sawmill industry is highly fragmented, geographically dispersed, and considered a mature industry as demonstrated by low or declining sales growth. Hardwood lumber shipment value, after adjusting for inflation, has remained nearly flat increasing approximately 18% from 1992 to 2005 (USCB 2007a). This stagnant growth is a result of flat or declining real lumber prices of important lumber species such as red oak, white oak, and yellow poplar (Luppold and Bumgardner 2007). At the same time manufacturing costs such as energy, health care, and transportation have increased. These stagnant sales and rising costs have decreased profitability in the industry. This in turn has led to an increase in the number of firms exiting the industry. The softwood and hardwood sawmill industry as a whole (NAICS 321113) has seen a general decline in profitability that oscillates with the overall business cycle (RMA 1995-2006).

Coinciding with the conditions of low profitability has been a decrease in production and shifts in markets for hardwood lumber. Hardwood lumber production has decreased 11% from 1999 to 2007 (USCB 2007b). The market for hardwood lumber in the furniture industry has changed due to a general decline in its traditional manufacturing base (Bumgardner et al. 2004) and material substitution (Cumbo et al. 2001; USCB 2004). The domestic furniture manufacturing industry has declined and this was one of the main customer groups of the hardwood lumber industry. In addition, hardwood lumber has been replaced by engineered wood products in many furniture manufacturing applications. According to the Hardwood Market Report data (2006), from 1999 to 2007, consumption of hardwood lumber in all market segments declined by 20% and use by the domestic furniture industry declined 61% (Figure 1).

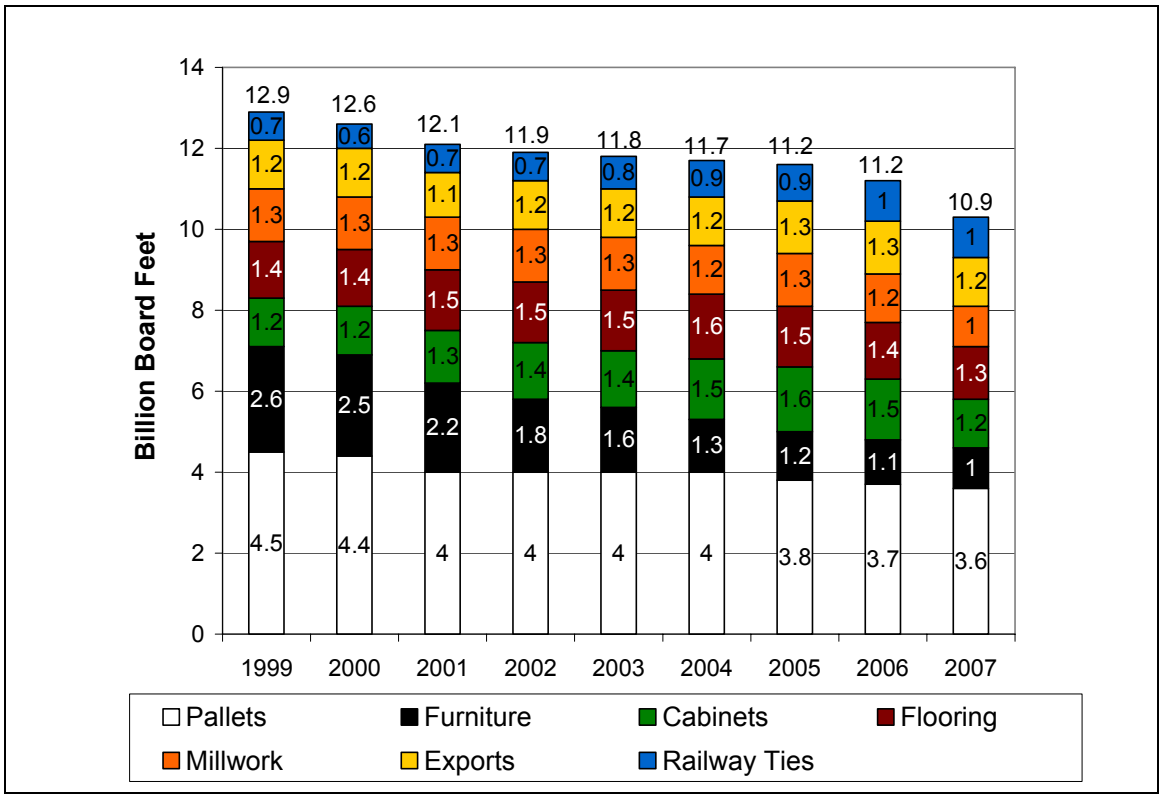

Figure 1. U.S. Hardwood Lumber Consumption by Market Segment

The consumption of hardwood lumber in the pallet industry has decreased 20% from 1999 to 2007 (HMR 2006), due mainly to the recycling of pallet parts (Bush et al. 2002). The consumption decline in these two important market segments has created highly competitive conditions in the industry. During this same time period, other market segments have declined less such as flooring (7% decrease), or not changed as in cabinets or exports. One market segment has shown growth in hardwood lumber consumption, railway ties increased 43%. These trends of decreasing production and consumption along with shifting markets have created adverse business conditions for the eastern hardwood lumber industry.

The response of hardwood lumber companies to these challenging conditions could determine their success or failure. Indeed, a number of companies have gone out of business or have been acquired by other hardwood lumber companies. According to statistics by the U.S. Census Bureau, there was a 36% decrease in the number of establishments producing hardwood lumber from 1997 to 2002 (USCB 1999; USCB 2005).

In summary, two trends have greatly impacted this industry. First, stagnant sales and increasing costs have led to decreasing profitability. Second, the changing markets have led to a decrease in production and consolidation. These two main trends are likely to continue for the foreseeable future and will continue to impact the hardwood lumber industry. These trends are being driven by globalization, decreasing demand in the housing and transportation sectors, and other macroeconomic factors. It would help the industry to better understand the competitive response needed by hardwood lumber manufacturers. It was within this context that this research project sought to discover opportunities for improvement of firm performance in the hardwood lumber industry.

The competitive position of each firm is determined by how well it performs in the market. This in turn is influenced by its efficient and effective use of resources, technology, human resources, strategy, tactics, geographic location, and organizational structure. Much of the research in the hardwood lumber industry has focused on the efficient conversion of logs into lumber so that the forest resource could be conserved. This research on increasing lumber yield and lumber grade recovery from hardwood logs has helped sawmills become more competitive. Increasing the efficiency of sawmill processes and technology has been the focus of a number of mill studies. At the same time, other researchers have focused on how the hardwood lumber industry has changed due to changing global markets and the available forest resources. In this study, we are focused on investigating the influence of firm-controlled factors such as technology utilization, strategy, tactics, business organization, and geographic diversity on overall firm performance.

Performance

The performance of organizations, specifically businesses, has been the interest of management researchers since the advent of the field. Business performance has traditionally meant profitability and financial measures such as return on investment, return on assets, and return on sales are prevalent in previous studies (Booth and Vertinsky 1991; Cohen and Sinclair 1992; O'Laughlin and Ellefson 1981; Palepu 1985; Rich 1986; Rumelt 1982). Zinkhan (1988) investigated the financial performance of forest product firms using a market value risk adjusted approach. This technique is

limited to publicly trade companies since dividends and share prices are needed to calculate the metric and therefore it can't be used in this research project because hardwood lumber manufacturers are privately held. Other studies have used non-traditional measures of firm performance such as market share and customer satisfaction; and subjective rating scales such as performance relative to competitors (Covin et al. 1990; Narver and Slater 1990; Pelham 1997). Over time companies and researchers have increasingly relied on multiple measures of performance and moved away from strictly using financial performance measures. This is because these financial measures are generally not available from private firms.

Venkatraman and Ramanujam (1986) developed a 2 x 2 classification matrix (Figure 2) of business performance measurement based on the data source (primary, secondary or both) and the metric type (financial, operational or both). This matrix succinctly describes all potential performance measurement approaches available to researchers. The authors identified four approaches corresponding to the 4 cells and four approaches that are combinations of adjacent cells.

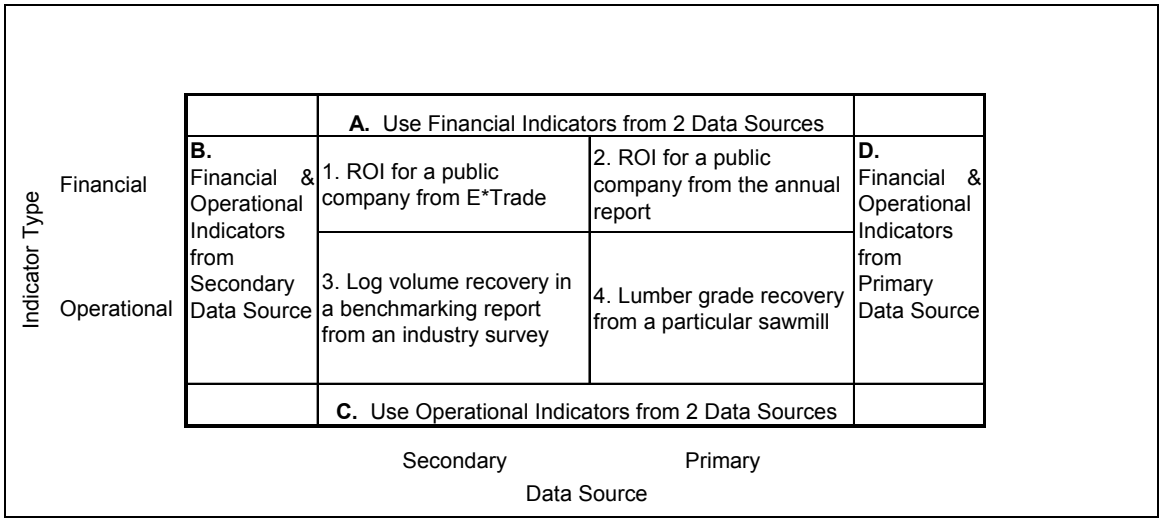

Figure 2. Data Sources and Indicator Types for Business Performance Measurement

An example of each approach is shown in cells 1 – 4. The limitations of using just one of these four approaches are evident when attempting to measure business performance. Venkatraman and Ramanujam (1986) suggested that business performance consists of both financial and operational performance. The authors recommended that researchers should avoid using only one source and one indicator. They suggested using

one of the approaches labeled A-D in Figure 2. that combines two cells. A limitation of applying the A, B, and C approach to the hardwood lumber industry is that secondary sources of data are non-existent since it is predominantly privately held. The D approach where both operational and financial performance metrics are obtained directly from the company appears to be the only performance measurement strategy for this project. Therefore, financial and operational performance data was collected directly from eastern hardwood lumber manufacturers.

This research measured performance from a number of different perspectives and avoided the weaknesses of traditional financial measures such as their lack of strategic focus, short-term historic bias, and lack of information on quality, continuous improvement, customer needs, or competitor actions (Neely 1999). As a result of their observations about the limitations of traditional financial measures, Kaplan and Norton (1996) developed the balanced scorecard.

The balanced scorecard developed by Kaplan and Norton (1998) measures performance from four distinct perspectives of a business: financial, internal, customer and innovation. There is a balance between leading and lagging indicators of firm performance. The financial and internal metrics indicate the results of previous time periods while the customer and innovation metrics are indicators of potential future results. The financial perspective includes the traditional measures of business performance such as return on investment, return on sales and others. The internal perspective measures business processes needed to fulfill their mission and in hardwood lumber manufacturing this is synonymous with production. The customer/marketing perspective metrics focus on how well the company is satisfying their customers by utilizing marketing techniques. Finally, the innovation/learning perspective measures knowledge growth through employee training and retention. This perspective was customized as human resources for hardwood lumber manufacturers since there is little innovation in the industry.

The dimensions of the balanced scorecard are linked following a logical casual sequence of events (Anonymous 2004). The measurement of learning, innovation and human resources is intended to improve employee performance. As employees perform better the internal processes of a firm are fulfilled better and there is less down time and

defects. The increase of the effectiveness and efficiency of internal processes, the production process in the case of the hardwood lumber manufacturers, can lead to better fulfillment of customer expectations and fewer customer service issues. The satisfaction of customers can increase customer loyalty and repeat business. The sales increases from satisfied customers and the cost savings from better internal processes help to increase profitability in the financial dimension. All of these dimensions are but one aspect of business performance that the balanced scorecard framework measures and this concept is depicted graphically in Figure 3.

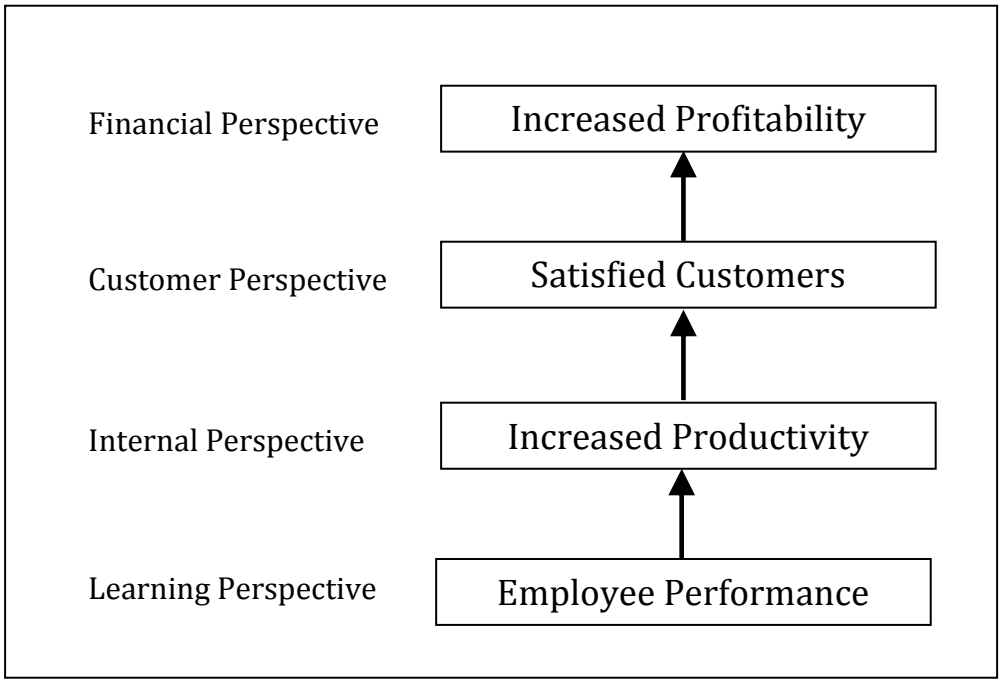

Figure 3. Relationship Between Balanced Scorecard & Performance Improvement

The balanced scorecard has been widely implemented by large corporations but not by small manufacturing firms. (Paranjape et al. 2006). A number of performance metrics from the balanced scorecard framework have been empirically validated (Jusoh et al. 2006; Maiga and Jacobs 2003). The balanced scorecard framework was customized for the hardwood lumber industry because the performance literature reviewed indicated that measuring performance from multiple perspectives was valid, current, and the most effective way given the constraints of the hardwood lumber industry. Metrics from each perspective were developed and incorporated into a multiple-measure performance indicator.

The frequency of companies utilizing formal, integrated, multiple measures of performance is low among manufacturing firms (Gosselin 2005). However, there is at least one hardwood lumber company that had implemented a balanced scorecard (Miller 2006). Hardwood lumber mills measure their operational performance by a number of metrics including: log volume recovery (overrun, lumber recovery factor), lumber grade recovery, lumber dimensions, costs, productivity, and production (Mayer and Wiedenbeck 2005; Rappold 2006) Financial performance in the industry is judged by measures of profitability including return on sales, and return on investment. The hardwood lumber industry already measures performance from two perspectives. Evidence within the trade journal literature suggests that hardwood lumber manufacturers cite customers and employees as important to their company's success (Miller 2006). The inclusion of metrics on these dimensions of firm performance (customer and human resource) to the existing ones enabled us to see how firms perform in these increasingly critical areas.

From the background information on the hardwood lumber industry and the review of literature on performance, it was evident that there was a need to find out what influenced performance in the industry. Literature from previous research and personal knowledge of the industry were utilized to develop testable hypotheses in the next section.

Theoretical Development

In the following section it is theorized that numerous marketing and management factors, such as strategic, geographic, tactical, technological and organizational factors influence firm performance of hardwood lumber manufacturers. These factors are all within the control of the firm. Ellefson and Stone (1984) list all of these factors and more as influencing firm and industry performance. Strategic factors could influence firm performance since one strategy may perform better than others (Rich 1986). Geography could influence firm performance because the forest resource changes from region to region and species are valued differently in the market (Luppold and Dempsey 1994). The use of advanced technology could improve productivity and firm performance (West and Cooper 1996). Different product, promotion and customer tactics may be related to

performance (Ellefson and Stone 1984; Palepu 1985). Finally, firms that are vertically integrated are likely to perform better than non-integrated firms (Cohen and Sinclair 1992).

Other factors that are beyond the control of the firm certainly impact firm performance such as economic growth, demand, supply, substitutes, industry structure, regulation, taxes, trade policy, natural resources, etc (Ellefson and Stone 1984; Martin et al. 1991). These external factors are assumed to affect firms equally. Therefore, these factors are not within the purview of this research project.

Several research studies have been conducted to investigate the link between marketing strategies and profitability (Buzzell and Gale 1987). The profit impact of marketing strategy (PIMS) as the project became known demonstrated that market structure and competitive position influence strategy and tactics which in turn influence firm performance. West and Cooper (1996) suggested that firms who rate marketing and technology as important perform better than those who view marketing and technology as less important. The firm-controlled factors that could impact firm performance were chosen by reviewing literature. The following review was organized by each of the five factors and from this hypotheses were developed.

Strategic Factors

Research into the performance and strategy of the forest products industry is limited. Porter's (1980) three generic strategies have been used extensively in academia and industry. These strategies act as protection from the competition. The cost leadership strategy is characterized by a focus on reducing costs, gaining market share and maintaining economies of scale. The differentiation strategy is characterized by a focus on the customer, differentiating the product or service, and brand loyalty. The focus strategy is achieved by applying either or both the cost leadership or differentiation strategy to a particular market segment, geographic area or customer group. Porter's three generic strategies were used in this research in order to build upon past research, and because strategy is one factor that is controllable by firms that likely impacts firm performance.

Green et al (2005) investigated the relationship of market orientation to performance and found that a market orientation is positively related to firm and

marketing performance. Rich (1986) used Porter's three generic strategies (cost leadership, differentiation, and focus) to analyze competitiveness in a survey of the strategies and profitability of 42 major forest products companies. Results indicated that companies following a focus and/or differentiation strategy were more profitable. Therefore, the first hypothesis is as follows:

H1: Firms with a focus or differentiation strategy perform better than firms with a cost leadership strategy.

Bush and Sinclair (1991) modeled the competitive strategy of the 100 largest hardwood lumber manufacturers using Porter's model. Their results predicted a strategy shift towards increased differentiation. In commodity markets, a production orientation with its focus on low costs has been suggested to be a greater source of competitive advantage versus market orientation (Pelham 1997). However, Pelham also suggested that market orientation might be a viable strategy to compete in a cost-based marketplace. In order to corroborate results from previous research (i.e.: Bush & Sinclair) and to discover whether there has been a shift towards differentiation in the industry, the second hypothesis is as follows:

H2: The hardwood lumber industry has shifted towards a differentiation and focus strategy from a cost leadership strategy

Geographic Factors

The eastern hardwood lumber producing region is composed of many forest cover types and the species composition of these cover types vary from sub-region to sub-region (Luppold and Dempsey 1994). Each region has multiple cover types and the availability of a certain species is region dependent. The market value of hardwood lumber varies between species and even within species from region to region. For example, red oak growing in the Northern region tends to be valued higher for its color when compared to red oak growing in the Southern region. The two major hardwood lumber market publications, the *Hardwood Market Report* (Johnson 2007) and the *Hardwood Review* (Barrett 2007), publish prices for 3 distinct regions: Northern, Southern and Appalachian. The gentle topography, long growing season and relatively lower diversity of hardwood species in the Southern region may orient lumber producers

toward production and cost. Conversely, the greater species diversity, mountainous topography, and shorter growing season in the Appalachian and Northern regions may orient lumber producers toward marketing and differentiation. Hypotheses three and four follow based on these two statements.

H3: More Southern hardwood lumber producers have a cost leadership strategy than a focus or differentiation strategy

H4: More Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy.

Booth and Vertinsky (1991) investigated the impact of a number of factors on the performance of the major, public North American forest product companies. Their results indicated that geographic diversification reduced variability in returns on assets and also reduced political and environmental risks. Given the variability in demand for hardwood lumber species, a company utilizing a geographic diversification strategy, in which a company operated in multiple regions (Northern, Southern, Appalachian), would intuitively perform better than a company with geographically limited operations. Hence, hypothesis five:

H5: Hardwood lumber producers who are geographically diversified perform better than those firms who have geographically limited operations.

Technological Factors

Bowe et al (2001) surveyed the national hardwood lumber industry and their results indicated that most of the companies did not use scanning or optimizing technology. Of the mills that had adopted new technology, they tended to be comparatively larger companies. The use of advanced technology could improve productivity and firm performance (West and Cooper 1996). Research has shown that lumber value could be increased by 25% - 50% by optimally edging and trimming hardwood lumber (Kline et al. 1991). The results from the Booth and Vertinsky (1991) research indicated that technology, as represented by capital intensity, significantly and positively impacted profit margins. The use of technology in the forest industry has increased productivity and performance of companies (Hetemäki and Nilsson 2005).

These empirical studies indicate that firms that use more advanced technology perform better. The relationship between technology and performance in the hardwood lumber industry is unknown. Therefore, the following hypotheses are presented in order to assess the current use of production and information technology by the eastern hardwood lumber industry and its impact on performance.

H6: Hardwood lumber producers who utilize advanced production technology perform better than firms who do not utilize advanced production technology.

H7: Hardwood lumber producers who utilize advanced information technology perform better than firms who do not utilize advanced information technology.

Tactical Factors

Marketing tactics vary from company to company and from industry to industry. Booth and Vertinsky (1991) reported that a related diversification strategy was unable to reduce risk. However, they acknowledge that their results are in contrast to other studies and furthermore, their research focused on the largest forest products companies. The marketing strategy of softwood lumber manufacturers in three major producing regions was investigated by Niemelä and Smith (1995). Their results indicated that 55% of companies used a combination of customer strategies and 58% of companies used a combination of product strategies. Palepu (1985) investigated 30 firms in the food products industry and found that firms with greater related diversity perform better financially than those who are less diversified. The following hypotheses are to be tested in order to investigate the relationship between diversification and performance:

H8: Product diversification is positively related to performance of hardwood lumber producers.

H9: Customer diversification is positively related to performance of hardwood lumber producers.

H10: Promotion diversification is positively related to performance of hardwood lumber producers.

Organizational Factors

Many hardwood lumber producers are vertically integrated organizations in that they own forestland, logging, sawmill, drying, and secondary machining operations. The degree of vertical integration within the eastern hardwood lumber industry is unknown. Anecdotal evidence and personal experience suggest that some companies are either backward integrated or forward integrated or both. Cohen and Sinclair (1992) modeled multiple strategies and firm profitability and found that forward integration had positive impacts on firm profitability (return on sales). Wiedenbeck (2002) surveyed vertically integrated hardwood manufacturers and results suggested that they could obtain more value. The degree of organizational integration and its relationship to firm performance in the eastern hardwood industry is unknown. Therefore, the subsequent hypothesis is offered:

H11: Vertically integrated firms perform better than non-vertically integrated firms.

As shown by the literature review, firm performance is influenced by a number of factors some of which are outside of the firm's control. The focus of this research project was on firm-controlled factors. The five factors that were chosen for investigation were strategic, geographic, technological, tactical, and organizational. These factors were relevant to the hardwood lumber industry and built upon past research in the industry. The performance of hardwood lumber manufacturers was largely unknown and warranted study. This raised the question of how well companies were performing and how these factors influenced their performance? How have strategy and tactics changed in response to adverse market and economic conditions? Discovering answers to these questions formed the basis for the goals of this project.

Goals

The purpose of this project was to identify and disseminate opportunities for performance improvement of the eastern hardwood lumber industry. By investigating factors that influence firm performance in the hardwood lumber industry, this research identified opportunities for performance improvement. A number of hypotheses were developed and tested in order to achieve this purpose. The secondary purpose was to disseminate this knowledge to the hardwood lumber industry. Results and recommendations will be distributed via publications, presentations and a workshop. The following are the specific objectives needed to accomplish the goals of this research project.

1. Develop multiple measures of firm performance for eastern hardwood lumber manufacturers.
2. Determine the influence of firm-controllable factors on the firm performance of eastern hardwood lumber manufacturers.
3. Determine the current marketing tactics and strategy of eastern hardwood lumber manufacturers.

The measures developed in objective one were used to measure performance in objective two. The methods used to develop these measures are described in the next chapter.

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Chapter 2. Development of a Multiple-Measure Performance Indicator

Introduction

The purpose of developing a performance indicator was to accurately, and quickly assess firm performance. Business performance has traditionally meant profitability and financial measures such as return on investment, return on assets, and return on sales are prevalent in previous studies (Booth and Vertinsky 1991; Cohen and Sinclair 1992; O'Laughlin and Ellefson 1981; Palepu 1985; Rich 1986; Rumelt 1982). More recent studies have used non-traditional measures of firm performance such as market share and customer satisfaction; and subjective rating scales such as performance relative to competitors (Covin et al. 1990; Narver and Slater 1990; Pelham 1997). Over time companies and researchers have increasingly relied on multiple measures of performance and moved away from strictly using financial performance measures. This trend formed the basis of developing a multiple-measure performance indicator for hardwood lumber manufacturers.

Companies within the hardwood lumber industry are predominantly privately held and there is no publicly available performance data. Due to the highly competitive nature of the hardwood industry, companies historically have not shared performance data. The reluctance of companies to share performance data and the time required to develop and provide the information would have likely caused a low response rate and so an alternative approach was needed. This approach was to utilize subjective self-rated operational and financial performance metrics directly from the company's president, owner or chief executive. Studies have shown that subjective measures of performance correlate well to objective measures (Dess and Robinson 1984; Dawes 1999; Toby et al. 2004). Therefore, subjective performance measures from multiple perspectives were developed.

The multiple perspectives that form the basis for the performance indicator were based on the balanced scorecard which was developed by Kaplan and Norton (1998). It measures performance from four distinct perspectives of a business: financial, internal, customer and innovation. The financial perspective includes the traditional measures of business performance such as return on investment, return on sales, and others. The

internal perspective measures business processes needed to fulfill their mission and in hardwood lumber manufacturing this is synonymous with production. The customer/marketing perspective metrics focus on how well the company is satisfying their customers by utilizing marketing techniques. Finally, the innovation/learning perspective measures knowledge growth through employee training and retention. This perspective was customized as human resources for hardwood lumber manufacturers since there is little innovation in the industry. The balanced scorecard framework was customized for the hardwood lumber industry because the performance literature reviewed indicated that measuring performance from multiple perspectives was valid, current, and the most effective way given the constraints of the hardwood lumber industry.

Metrics from each perspective were developed and incorporated into a multiple-measure performance indicator specific to hardwood lumber manufacturers. Hardwood lumber mills measure their operational performance by a number of metrics including: log volume recovery (overrun, lumber recovery factor), lumber grade recovery, lumber dimensions, costs, productivity, and production (Mayer and Wiedenbeck 2005; Rappold 2006) Financial performance in the industry is judged by measures of profitability including return on sales, and return on investment. Evidence within the trade journal literature suggests that hardwood lumber manufacturers cite customers and employees as important to their company's success (Miller 2006). The inclusion of metrics on these dimensions of firm performance (customer and human resources) to the existing ones enabled us to see how firms perform in these increasingly critical areas. The methods used to develop the performance indicator are described in the following section.

Methods

The performance indicator was developed by collecting information on performance from hardwood lumber manufacturers. In order to find out which performance measures hardwood lumber manufacturers used most frequently and the importance of these measures a pilot survey was initiated. The pilot survey addressed the first objective of the research project which was to develop multiple measures of performance in the hardwood lumber industry. The pilot survey was broken into two

parts: preliminary phone interviews to determine what performance means in the industry and what measures they use. Then a fax survey was conducted to find out the importance and use of performance measures. With these two techniques, a performance indicator specific to the industry was developed and subsequently utilized in the main mail survey.

First, phone interviews with a random sample of hardwood lumber manufacturers were conducted. The available database was split into NHLA members and non-members. A 5% random sample without replacement was generated by Microsoft Excel. A total of 70 National Hardwood Lumber Association (NHLA) members representing 10% of the NHLA member database were contacted. A 10% sample of NHLA members was conducted instead of the planned 5% sample because there was a problem with the non-member phone numbers initially which was subsequently corrected. A total of 72 non-member hardwood lumber manufacturers representing 5% of the non-member database were contacted. As a result, 142 hardwood lumber manufacturers were contacted instead of the 107 that would have been contacted.

The interviewees were asked open-ended questions to determine the measures they used to measure performance of their company; how important they thought it was to measure performance from multiple perspectives; what influences the performance of their company; and how they go about to improving the performance of their company (Appendix C. Phone Survey Questions). Respondents were able to give multiple responses. The results of the open ended questions were analyzed using text analysis. The frequency of words was tallied for questions two, four and five. Based on these results, the literature review, and personal knowledge of the hardwood lumber industry a list of performance measures were developed for use in the fax survey.

A random sample of companies was selected from the sample frame to participate in the performance measure fax survey. A 10% sample from a database of NHLA members yielded an initial sample size of 70 firms. A 10% sample from a database of non-NHLA companies yielded an initial sample size of 144. The database for non-NHLA companies didn't contain fax numbers. An attempt was made to cross-reference each company record with another database of wood products companies. This resulted in a failure to obtain fax numbers for the majority of the non-NHLA company sample.

Therefore, a 144 company sample was obtained from the other database which contained fax numbers. The total sample for the performance measure survey was 214.

A list of 48 performance measures specific to the hardwood lumber industry was developed in four areas that correspond to the four dimensions of the balanced scorecard: financial, production, customer, and human resource. All of the performance measures from the phone interviews were included and the remainder came from the literature review of previous research. The fax survey consisted of a cover page explaining the purpose of the survey and a two page (Appendix D. Fax Survey Questionnaire) questionnaire on which respondents rated the performance measures. Respondents rated on a scale from one (don't use) to four (use often) how frequently their company used these measures and also rated from one (not important) to four (very important) how important these performance measures were to the success of their company. The fax survey was administered via fax over a three day period. The fax machine made up to 3 attempts to transmit the fax. After the third attempt, the fax transmittal was considered a failure and an error report was printed. The ratings were averaged across all respondents. The top three rated performance measures in each of the four dimensions were used for the multiple-measure performance indicator.

Results & Discussion

The adjusted response rate for the phone interviews was 40.7% for NHLA members and 11.1% for non-members after adjusting for unusable sample units. Some companies could not be interviewed and therefore that sampling unit was unusable for a variety of reasons including: disconnected phone number, duplicate record, wrong number, changes in area codes, no answer, busy signal, not being a hardwood lumber producer, no number available and the company not being in operation anymore. The number of unusable interviews were subtract from the initial sample size to get adjusted sample size. The number of usable samples included those where the attempted contact resulted in a completed interview, a message left, or an answering machine.

The results of the open ended questions were analyzed using text analysis. The frequency of words was counted for all respondents on each question. These counts were then divided by the total number of respondents for each question to get a proportion of

respondents citing that particular word. All respondents indicated that they used profit as an measure of performance, followed by sales (42%), production (42%), quality (33%), costs (33%) and grade recovery (17%). The responses to question two show that the hardwood lumber industry has a larger conception of business performance than just financial performance. When asked about what influences the performance of their company, respondents cited the marketplace/economy (75%), costs (75%), lumber prices (33%), and efficiency (25%). These responses indicated that a majority think that the economy, which is outside of their control, has a large influence on their performance. Hardwood lumber manufactures need to actively take control of costs which were the second most frequently cited variable that influences performance. Finally, companies indicated that in order to improve performance they lower/control costs (50%), increase yield/grade recovery (40%), use new technology/equipment (30%) and increase machine productivity (30%). These suggestions by respondents are ones that all hardwood lumber manufacturers should implement to improve their performance.

The responses to the third question about the importance of measuring from multiple perspectives were variable and there were some differences in how the question was asked so a text analysis was not performed. However, most responses emphasized that it was important to look at everything but some performance dimensions get more attention than others. For example, one company said that quality was the top concern and production was second. The use of different performance measures may depend upon a company's strategy and their product market(s) and customer mix.

The results from the phone interviews were incorporated into the performance measure fax survey. Out of the 214 faxes attempted, 92, representing 43% of the sample, were unable to be faxed. This could be due companies who changed their fax number, companies that went out of business or companies that no longer have a fax machine. Besides the three attempts made by the fax machine, no other attempt was made to refax these questionnaires.

The sample size was further reduced by 3 duplicate listings within the sample and 23 companies who were not hardwood lumber producers. A follow-up call was made one week after the fax was sent in order to determine if the fax was received and to encourage participation. During this time, 23 companies indicated that they were not

hardwood lumber producers. Some companies were concentration yards, timber harvesting companies and some were softwood sawmills. Since our population of interest was hardwood sawmills these companies were removed from the sample. After removing the non-hardwood lumber producers and the duplicates, the final sample size was 96. Five companies replied but weren't operating anymore and they didn't complete the survey. Eleven companies returned questionnaires that were useable for a response rate of 11.4%.

The respondents' ratings were averaged and the results are shown in Table 1**Error! Reference source not found.**. The seven most frequently used performance measures were costs of goods sold, selling price, quality, cost per board feet, net profit, total sales, and yield. The seven most important performance measures were cost per board feet, gross profit margin, quality, selling price, costs of goods sold, number and length of downtime, and accounts receivable turnover. The four least frequently used performance measures were sales per salesperson, training expenses, number of new customer contacts, and market share. The four least important performance measures were sales per employee, training expenses, sales per salesperson and tonnage of bark produced.

The use ratings were equally distributed above and below the scale midpoint of 2.5. The majority (87.5%) of the importance ratings were above the scale midpoint of 2.5. This suggests that these performance measures are believe to be important to a company's success but than they aren't used as much. The performance measures with the greatest difference between importance and use ratings offer opportunities for hardwood lumber manufacturers to improve their use of these measures and ultimately their performance in this area. The top four performance measures that were rated important to success but weren't used frequently by hardwood lumber manufacturers were number of new customers, percent of employees trained, costs by department, and number of new customer contacts. These results suggest the industry needs to measure performance in these areas. By measures these variables companies can track how well they are developing new customers and training their employees which in turn will lead to higher performance.

Table 1. Performance Measure Use and Importance Ratings

Performance Measure	Use Average	Importance Average
costs of goods sold	3.89	3.82
selling price	3.88	3.89
quality	3.75	3.89
cost per board feet	3.75	4.00
net profit	3.70	3.60
total sales	3.50	3.67
yield	3.50	3.55
number of worker injuries	3.44	3.50
number of customer complaints	3.44	3.59
customer satisfaction	3.40	3.73
gross profit margin	3.38	4.00
orders received	3.38	3.45
accounts receivable turnover	3.38	3.78
board feet per shift	3.25	3.33
number and length of downtime	3.25	3.78
board feet/man hour	3.25	3.67
efficiency	3.00	3.11
inventory turnover	3.00	3.22
log utilization	2.89	3.00
grade recovery	2.75	3.22
employee satisfaction	2.75	3.00
new product sales / total sales	2.63	3.06
quantity of energy consumed	2.50	2.82
tonnage of chips produced	2.50	2.78
employee hours	2.50	3.11
return on investment	2.50	3.10
lumber recovery	2.44	2.89
current ratio	2.44	2.56
% on time delivery	2.40	2.82
amount of capital investment	2.40	3.10
plant hours used	2.38	2.88
employee turnover rate	2.38	2.56
delivery schedule backlog	2.33	2.91
costs by department	2.33	3.22
% on grade	2.29	3.00
absence level	2.29	2.65
tonnage of sawdust produced	2.25	2.56
production defects	2.13	2.75
length of employment	2.10	2.60
number of new customers	2.00	3.00
% of employees trained	2.00	2.91
average sales order	1.90	2.20
tonnage of bark produced	1.89	2.20
sales per employee	1.89	1.78
market share	1.88	2.22
number of new customer contacts	1.75	2.56
training expenses	1.71	1.88
sales per salesperson	1.50	1.90

The three performance measures that were rated the most frequently used and the most important in each of the four dimensions (financial, production, customer, human

resources) were used to form the multiple-measure performance indicator. This twelve measure performance indicator (Figure 4) consisted of the following metrics: costs, sales and profit in the financial dimension; quality, yield and board feet per shift in the production dimensions; selling price, customer satisfaction and orders received in the customer dimension; and number of worker injuries, employee satisfaction and employee turnover rate in the human resource dimension. The performance indicator was designed with subjective performance ratings where respondents self-rated their company's performance on a scale from one to five for each of these 12 metrics. This performance indicator was used in the main survey in order to measure firm performance of hardwood lumber manufacturers.

	Low Performance			High Performance		
Lumber yield	1	2	3	4	5	Don't know
Number of orders received	1	2	3	4	5	Don't know
Employee Satisfaction	1	2	3	4	5	Don't know
Sales	1	2	3	4	5	Don't know
Product quality	1	2	3	4	5	Don't know
Employee turnover rate	1	2	3	4	5	Don't know
Costs	1	2	3	4	5	Don't know
Customer satisfaction	1	2	3	4	5	Don't know
Profit	1	2	3	4	5	Don't know
Board feet per shift	1	2	3	4	5	Don't know
Number of worker injuries	1	2	3	4	5	Don't know
Selling Price	1	2	3	4	5	Don't know

Figure 4. Hardwood Lumber Business Performance Indicator

The indicator was tested for reliability using both internal consistency and split half reliability in SPSS. The results of these two reliability tests were good. A Cronbach's alpha of .81 was obtained which is considered good. This means that the indicator correlated highly with all possible 12-item indicators measuring the same variables (Garrison 2008). The total item correlations were all positive and ranged from 0.3 to 0.55 indicating that each performance measure was measuring part of the same construct, business performance. The split half reliability analysis resulted in a Spearman-Brown coefficient of 0.82 which is also considered good. Performance measures from each perspective were distributed equally within the performance

indicator which gave the indicator balance and helped with the reliability. The split half reliability analysis measured the reliability of half of a scale and then predicted the reliability of the whole scale. The split half reliability was increased by equally distributing the three performance measures from each of the four dimensions within the performance indicator. From these tests it can be concluded that the performance indicator was reliable.

The performance indicator was utilized during the mail survey (Chapter 3). The twelve performance ratings of each company were summed to provide an overall performance score for each company and the possible range for this index was from 12 to 60. This approach of developing an overall performance composite from performance measures has been used in previous research (Pitt et al. 1996, Hoque and James 2000, Hayes 2002, Van der Stede et al. 2006). Since the performance measures correlated well with each other and they were measuring the same construct, it was appropriate to sum the individual performance ratings. The distribution of total performance scores was evaluated for normality and the degree of skewness and kurtosis was determined before utilizing parametric statistical techniques (Chapter 4).

Conclusions

The purpose of developing a performance indicator for this research was to accurately and unobtrusively assess firm performance. Phone interviews and a fax survey were conducted to develop a performance indicator specific to the industry and it was subsequently utilized in the mail survey. Metrics from each perspective were developed and incorporated into a multiple-measure performance indicator specific to hardwood lumber manufacturers. The performance indicator reliably and unobtrusively measured performance within the hardwood lumber industry.

The use and implementation of performance indicators like the one developed should help hardwood lumber manufacturers to improve their performance. The research has identified these twelve key performance measures. Companies can take the performance indicator and customize it to their operation, begin measuring and tracking this information.

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Chapter 3. Profile of the Hardwood Lumber Manufacturing Industry

Introduction

The hardwood lumber industry is an amalgamation of lumber manufacturers, their suppliers such as loggers and forestland owners, and their customers such as brokers, wholesaler distributors, concentration yards, and exporters. Once the lumber is made into finished goods such as furniture or cabinetry, it is classified as a separate industry. The focus of this research project was on hardwood lumber manufacturers, also referred to as hardwood sawmills. The results of the research project are applicable to lumber manufacturers and not other firms within the industry. The following section provides an analysis on the hardwood lumber industry.

The hardwood lumber industry is important to the economic vitality of rural areas in the eastern U.S. According to the U.S. Census Bureau (2005), this industry employed an estimated 26,168 workers in 2002 and the total value of shipments was $4.4 billion. The hardwood sawmill industry is highly fragmented, geographically dispersed, and considered a mature industry as demonstrated by low or declining sales growth. Total hardwood lumber shipment value, after adjusting for inflation, has remained nearly flat increasing approximately 18% from 1992 to 2005 (USCB 2007a). At the same time manufacturing costs such as energy, health care and transportation have increased. These stagnant sales and rising costs have decreased profitability. The softwood and hardwood sawmill industry as a whole (NAICS 321113) has seen a general decline in profitability that oscillates with the business cycle (RMA 1995-2006).

Coinciding with the conditions of low profitability has been a decrease in production and shifts in markets for hardwood lumber. Hardwood lumber production has decreased 11% from 1999 to 2007 (USCB 2007b). The market for hardwood lumber in the furniture industry has changed due to a general decline in its traditional manufacturing base (Bumgardner et al. 2004) and material substitution (Cumbo et al. 2001; USCB 2004). The domestic furniture manufacturing industry has declined and this was one of the main customer groups of the hardwood lumber industry. In addition, hardwood lumber has been replaced by engineered wood products in many furniture manufacturing applications. According to the Hardwood Market Report data (2006),

from 1999 to 2007, consumption of hardwood lumber in all market segments declined by 20% and use by the domestic furniture industry declined 61% (Figure 5).

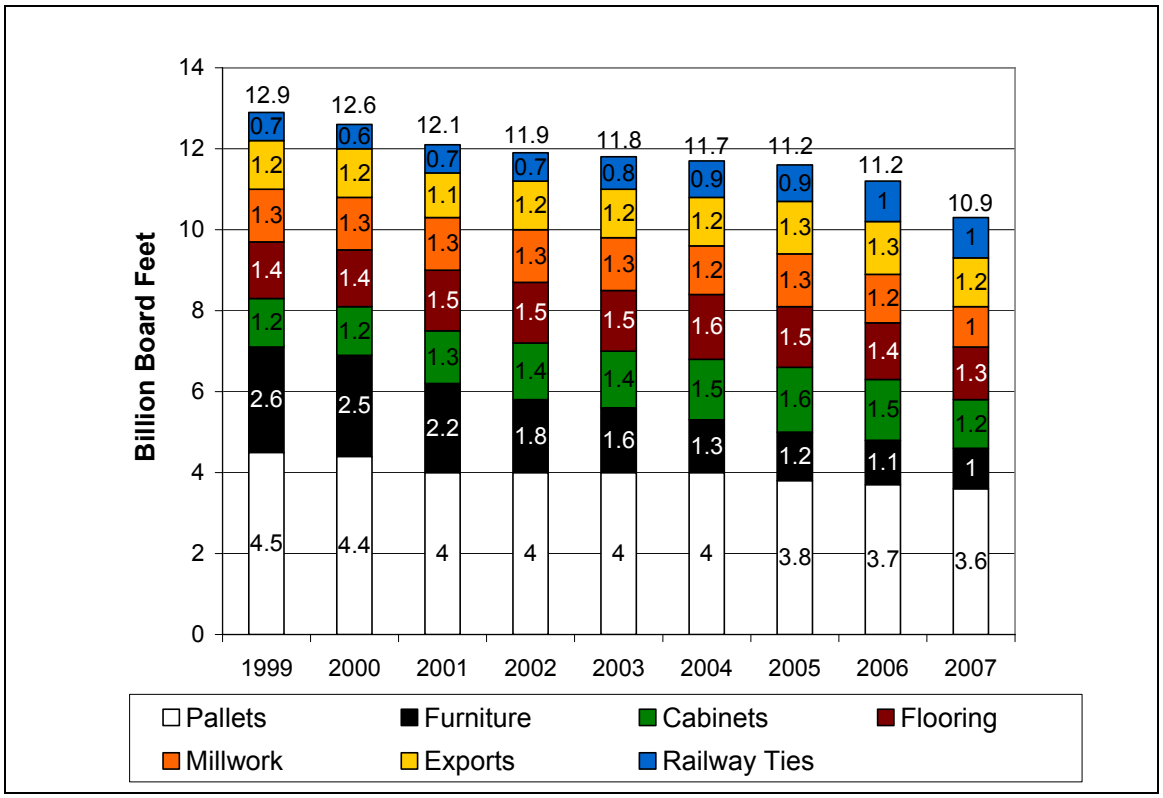

Figure 5. U.S. Hardwood Lumber Consumption by Market Segment

The consumption of hardwood lumber in the pallet industry has decreased 20% from 1999 to 2007 (HMR 2006), due mainly to the recycling of pallet parts (Bush et al. 2002). The consumption decline in these two important market segments has created highly competitive conditions in the industry. During this same time period, other market segments have declined less such as flooring (7% decrease), or not changed as in cabinets or exports. One market segment has shown growth in hardwood lumber consumption, railway ties increased 43%. These trends of decreasing production and consumption along with shifting markets have created adverse business conditions for the eastern hardwood lumber industry.

The response of hardwood lumber companies to these challenging conditions could determine their success or failure. Indeed, a number of companies have gone out of business or have been acquired by other hardwood lumber companies. According to statistics by the U.S. Census Bureau, there was a 36% decrease in the number of

establishments producing hardwood lumber from 1997 to 2002 (USCB 1999; USCB 2005).

In summary, two trends have greatly impacted this industry. First, stagnant sales and increasing costs have led to decreasing profitability. Second, changing markets have led to a decrease in production and consolidation. These two trends are likely to continue for the foreseeable future and will continue to impact the hardwood lumber industry. These trends are being driven by globalization, decreasing demand in the housing and transportation sectors, and other macroeconomic factors. It would help the industry to better understand the response needed to improve competitiveness. It was within this context that this research project sought to discover opportunities for improvement of firm performance in the hardwood lumber industry.

Objectives

The objectives for this chapter were to measure the current demographics, company characteristics, marketing mix, operations, technology, strategy and overall performance of hardwood lumber manufacturers. The specific objectives met in this chapter include:

1. Determine the current marketing tactics of eastern hardwood lumber manufacturers.
2. Determine the performance of the industry and develop benchmarks that industry can utilize.

Methods

The primary method for the research project was a mail survey. This was chosen as it is a cost effective manner to collect large quantities of information from a large population. The sampling strategy is detailed next, then the research instrument and the development of metrics and questions for inclusion in the questionnaire. Following the methods section are the results and discussion.

Sampling Strategy

The population of interest was eastern hardwood lumber manufacturers. The unit of analysis was hardwood lumber companies and not individual hardwood lumber mills.

The actual number of companies in the eastern hardwood lumber sector was unknown, but according to Luppold's (2006) estimates there are over 2,000 companies that produce between 1/2 to 50 million board feet of lumber annually. Previous research (Booth and Vertinsky 1991; Bush and Sinclair 1991; Cohen and Sinclair 1992; Niemela and Smith 1995; O'Laughlin and Ellefson 1981; Rich 1986) into strategy and performance in the forest products industry has utilized purposive sampling. Bush and Sinclair's (1991) population was the 100 largest hardwood lumber producers and Bowe's (2001) population was all eastern hardwood lumber producers. The sampling frame for this research was all members of the National Hardwood Lumber Association (approximately 1,100+) and approximately 500 randomly selected non-members who were predominantly located in the eastern hardwood region. While falling short of a complete census of the industry due to database availability and mailing costs, this sampling coverage was more than adequate for this research project.

Research Instrument

The data for the project was collected via a mail survey. The research instrument was a questionnaire and these have been used extensively in forest products business research. In order to increase response rates and reduce error, the survey followed principles outlined in the Tailored Design Method (Dillman 2000). This method is an adaptation of the Total Design Method. The former acknowledged that different surveys require different methods. The latter used multiple contacts in order to increase survey response. Elements from both methods were used in the mail survey.

The intent of the Tailored Design Method is to increase the quality and quantity of survey response. According to social exchange theory, information exchange could be increased by providing rewards, reducing costs, and establishing trust (Dillman 2000). In order to establish trust, companies were informed that their responses were confidential and that Virginia Tech has a long history of conducting confidential surveys of the industry. Companies were provided a reward via a summary of the results and a short benchmarking report showing their companies performance versus the respondents as a whole. Potential costs were reduced by keeping the survey convenient and avoiding subordinating language.

Each hardwood lumber company in the sample frame was mailed a personalized cover letter and a self-administered questionnaire. The questionnaire had pre-paid return postage. A follow-up post card reminder was sent approximately two weeks after the initial mailing. A second mailing to non-respondents was sent approximately 1 month after the initial mailing. A second postcard reminder was sent approximately 2 weeks after the second mailing. A third mailing to non-respondents was sent approximately one month after the second mailing. These five contacts ensured that the highest possible response rate was achieved.

The questionnaire was designed to be easily understood and more sensitive information (performance ratings) was sought towards the end of the questionnaire. Input on the questionnaire design was sought from the research committee. Next, the questionnaire was pre-tested in order to eliminate poorly worded questions and to prevent misunderstanding of information sought. In order to do this, a very small number of companies (less than 10) were faxed the questionnaire and asked to review it. Comments and suggestions from these respondents were incorporated into a revised questionnaire in order to improve survey response.

After the collection of the survey responses, non-response bias was monitored by calling non-respondents and asking them two demographic questions and two ratings questions (15 variables) from the self-administered survey. The responses from the respondents and the non-respondents were compared for significant differences. The wave analysis method was also used to detect bias between the early and late respondents. In this method, the group means of the first 30 respondents and the last 30 respondents were compared on technology importance ratings and performance scores along with firm size.

The mail survey (Appendix E. Mail Questionnaire) had a number of general demographic questions that were prevalent in previous surveys (Bowe et al. 2001; Bush and Sinclair 1991). First, companies were asked if they manufactured hardwood lumber. This eliminated the possibility of including companies within the database that were brokers, distributors, or concentration yards. The population of interest was eastern hardwood lumber manufacturers. Next, companies were asked to estimate their

production volume, number of employees and annual sales. Information about their residue production and selling price were also sought.

Measures and questions for each of the five factors (geography, strategy, technology, tactics, and organizational) were developed or used from previous research where appropriate. The geographic factor was measured by the firm's location within in the eastern hardwood region. Mills indicated on a map the number of mills that they had in each of the three hardwood regions: Appalachian, Southern and Northern. The firms' geographic diversification was measured by the number of sawmills in each region.

Three tactical marketing factors were measured: product, customer and promotion diversification. Three attributes of product were measured by the species distribution (i.e.: % of red oak, hard maple, etc), product category distribution (% of lumber, cants, pallet parts, etc.), and lumber grade distribution. Firms with more species, more product categories, and more lumber grades were indicative of greater diversification. The customer diversification was measured by the production volume that was sold to different distribution channels (i.e.: % of export, end-users, wholesalers, etc.). The promotion diversification was measured by the expenditure that was used in different promotion and advertising mediums (i.e.: magazines, tradeshows, brochures, giveaways, and websites).

The organizational factor was measured by asking firms to identify other business operations from a list. The strategy factor was measured using Bush and Sinclair's (1991) 20 business area variables. The companies were asked to rate the importance of the 20 variables on a 7 point Likert scale. Two technological factors were measured: information and production technology. A list of advanced production and information technology was developed. Firms indicated whether they used certain technology, how long they have used it and how important it was to their performance.

Given that most if not all of the eastern hardwood lumber manufacturers are privately held and previous researchers (Cohen and Sinclair 1992) have had difficulty obtaining accurate and complete financial performance information from companies, this research project used multiple measures of business performance. Hardwood companies weren't likely to share performance data and the respondent's time required to look up the information would have likely caused a low response rate and so an alternative approach

was needed. This approach was to utilize subjective self-rated operational and financial performance metrics directly from the company owner, president, or chief executive. Studies have shown that subjective measures of performance correlate well to objective measures (Dess and Robinson 1984; Dawes 1999; Toby et al. 2004). In the questionnaire, companies were asked to rate their performance on a multiple-measure performance indicator. This indicator was previously developed and summarized in Chapter 2. Firms were also asked to rate how well their company has performed in response to a number of external trends affecting hardwood lumber manufacturers. Two open-ended questions were asked at the end of the questionnaire to determine what they would change to improve the performance of their company and to solicit any comments and suggestions about performance and the questionnaire. Finally, the respondents were asked if they wanted to receive a summary of the results.

Upon completion of the survey, data was inspected and analyzed using spreadsheets and summary statistics for each question were developed. The sales, employment and production data were combined in various ratios to provide an overall measure of production efficiency, sales efficiency, and revenue per output for the respondents. The results in the next section follow the order of the questions in the questionnaire.

Results & Discussion

Response

The responses from the hardwood lumber industry were adequate as compared to other surveys in the forest products industry. Many mills were not operating during the data collection time period (Fall 2008) due to very weak lumber demand and general unprofitability due to uncontrollable energy and transportation costs and the housing recession. However, a number of mills did respond and complete the questionnaire as shown in Table 2.

Table 2. Mail Survey Response Summary

	Total	NHLA Members	Generic NHLA Members	Non-Members
Initial Sample Size	1638	1005	135	498
Undeliverable	181	40	10	131
Declined to Participate	6	5	0	1
Duplicates	26	19	7	0
Not a Hardwood Sawmill	406	261	22	123
Incomplete	9	8	0	1
Usable	200	169	7	24
Adjusted Response Rate	19.8%	25.1%	7.3%	9.9%

Of the 1638 questionnaires mailed, 181 were returned undeliverable. A large number of companies (406) indicated that they were not hardwood sawmills and they were removed from the sample frame and not included in any further mailings. A few companies declined to participate and were removed. The adjusted sample size (after removing undeliverable, non-sawmill, duplicates, and decline-to-participate companies) was 1010 and the adjusted response rate was 19.8%. The response rate for NHLA members, generic NHLA, and non-NHLA companies was 25.1%, 7.3% and 9.9%, respectively. The vast majority of the respondents were NHLA members (88%) and the remainder were not members of the NHLA. The generic NHLA members were companies who were members of the NHLA but no chief executive officer (CEO) information was available. This group had a lower response rate since the cover letter and envelope were addressed generically to the president, CEO or owner. The overall

response rate was satisfactory given the private nature of the industry, the sensitivity of sharing performance data, and the difficult economic conditions that the industry faced. In order to achieve this response rate a third mailing was conducted and this brought in a significant number of completed questionnaires (Figure 6).

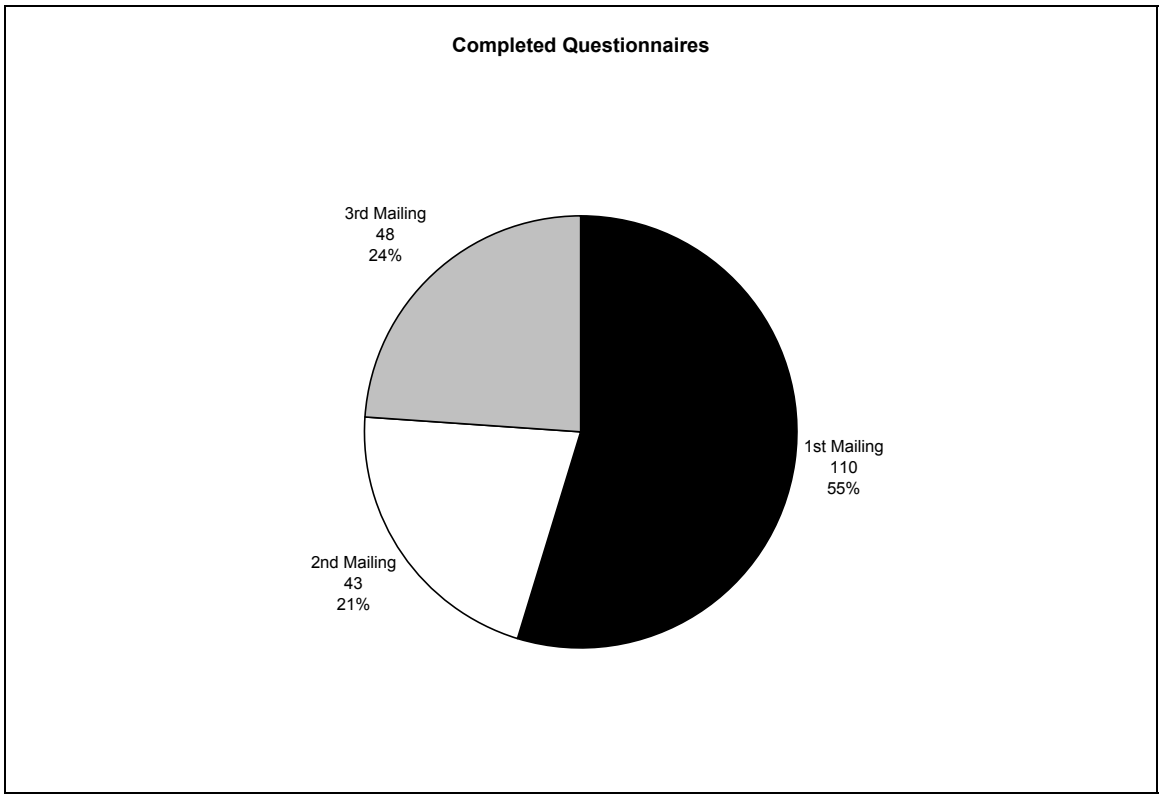

Figure 6. Completed Mail Questionnaires by Mailing.

Forty-eight completed questionnaires were returned after the third mailing accounting for 24% of the total. The second mailing resulted in 43 completed questionnaires or 21% of the total. Clearly, the multiple contact attempts improved the overall quantity of survey response. The majority of completed questionnaires were returned from the first mailing. The number of responses and returns were greatest after the first mailing (Figure 7).

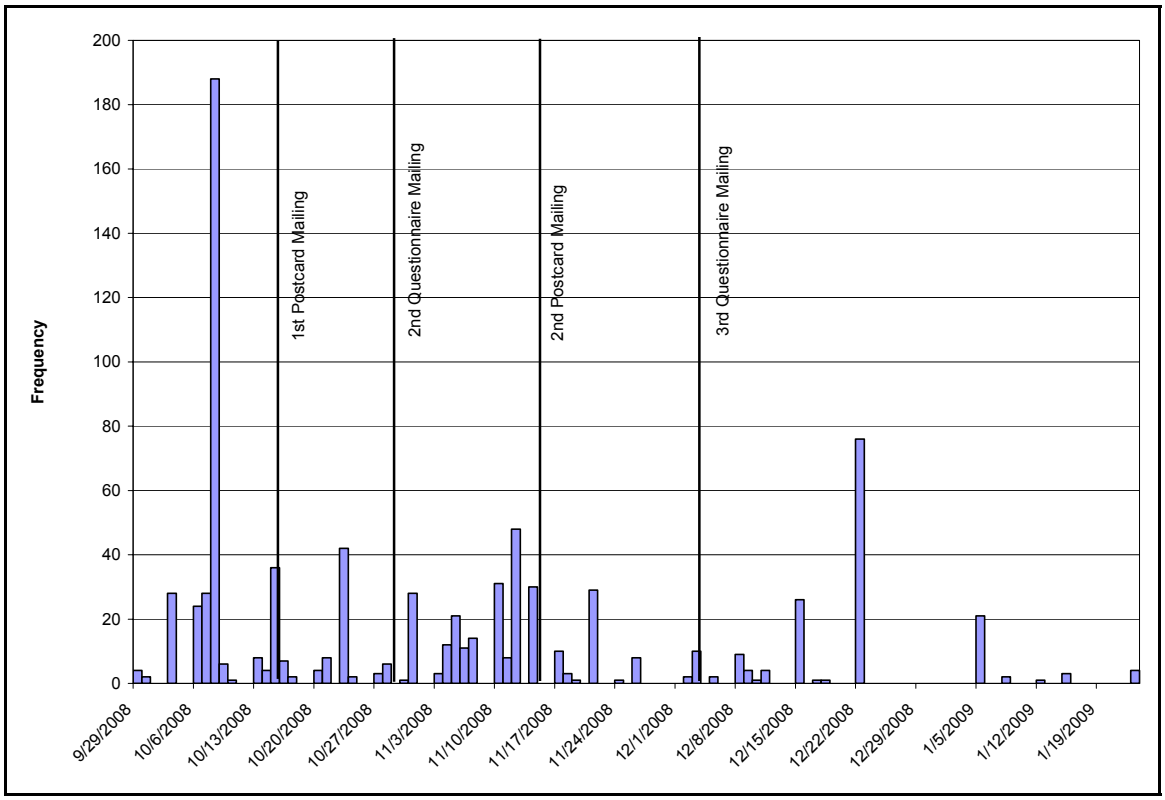

Figure 7. Timeline of Returns & Responses

The initial questionnaire mailing occurred September 24-26, 2008. The majority of responses and returns occurred in the 3 week period before the first reminder postcard was mailed. The third mailing generated a large number of response and returns shortly before the holiday period. The data collection period was closed in the middle of January 2009. The third mailing and the four month data collection period was necessary to achieve the good response rate and the success of the mail survey.

Due to unprecedented mill closures, the number of completed non-response calls was only nine. Contacted non-respondents were asked about their volume, mill region, production technology importance ratings and performance ratings. A comparison (t-test) of means between the available non-respondents and respondents indicated no significant differences between means. A t-test was used despite the low sample size because the variables exhibited a normal distribution when analyzed by the Kolmogorov-Smirnov test (Garrison 2008).

Non-response bias was also monitored by comparing the means using a t-test of a number of variables from early respondents (n=30) and late respondents (n=30). Any of

the means that were significantly different could indicate non-response bias. A significance level of 0.05 was used for the entire family of 21 t-tests. The Bonferonni correction was utilized to achieve this family wise error rate and the significance level of each test was 0.002 (Abdi 2007). A p-value below this level would indicate a significant difference between means. The results of this non-response wave analysis are shown in Table 3.

Table 3. Non-Response Bias Comparison

Variables	Early Respondents Mean	Late Respondents Mean	p-value
Production Volume	15.48	9.69	0.127
Sales	16.56	9.45	0.345
Importance Ratings			
Optimized Headrig	4.71	4.08	0.444
Ring Debarker	3.78	3.38	0.937
Bucking Optimizer	3.25	3	0.471
Optimized Edger	4.29	3.89	0.823
Optimized Trimmer	3	3.38	0.918
Automated Sort Bins	2.67	3.25	0.674
Lumber Dimension Control	2.25	3.17	0.955
Performance Ratings			
Lumber yield	4.34	3.9	0.031
Orders received	3.61	3.5	0.671
Employee satisfaction	3.83	3.85	0.933
Sales	3.63	3.78	0.569
Product quality	4.37	4.11	0.165
Employee turnover rate	3.7	3.61	0.758
Costs	3.33	3.66	0.195
Customer satisfaction	4.38	4.34	0.84
Profit	2.5	3.52	0.01
Board feet per shift	3.67	3.46	0.466
Number of Worker Injuries	4.13	4.25	0.694
Selling price	3.5	3.79	0.246

This wave analysis indicates that there was not any non-response bias found in the data. All of the t-tests were non-significant at the individual test significance level of 0.002. The results suggest that the responses were representative of all segments of the population and were not biased in any direction.

Company Demographics

In this section, summary statistics for each question in the questionnaire are presented. The results are segmented by company type, either a single sawmill or a multiple sawmill company and by geographic region, Northern, Southern, or Appalachian where appropriate. The average production volume, number of employees and sales in 2007 for responding companies are shown in Table 4.

Table 4. Average Volume, Employees & Sales of Hardwood Lumber Manufacturers

	Single Sawmill	Multiple Sawmill Company	NHLA Member	Non-Member
2007 Production (million BF)	7.6	26.0	14.7	3.2
2007 Sales ($million)	8.5	24.9	13.5	1.7
2007 Employees	37	119	72	16

A typical single sawmill company produced 7.6 million board feet, had $8.5 million in sales and employed 37 people. An average multiple sawmill company produced 26 million board feet, had $25 million in sales and employed 119 people. The multiple sawmill companies had on average 3 sawmills. Companies that were members of the National Hardwood Lumber Association (NHLA) had greater production, sales, and number of employees as compared to non-member companies.

The average lumber production for single sawmills was similar to those reported by Bowe (2000). The sum of the responding sawmills lumber production was 2.675 billion board feet. This represented about 25% of the estimated hardwood lumber production in 2007 and indicates a good representative sample from the industry. The single sawmill companies accounted for 165 of the respondents and multiple sawmill companies accounted for 40 of the respondents. This indicates that the majority of firms in the industry are single sawmill companies. The company type was corroborated by the respondent's report of the number of sawmills in each region. A single sawmill company reported only one mill whereas a multiple sawmill company reported more than one mill.

The majority (52%) of responding sawmills were located in the Appalachian hardwood lumber producing region (Figure 8). Northern and Southern hardwood sawmills accounted for 31% and 15% of responding sawmills. A total of four respondents had sawmills in multiple regions.

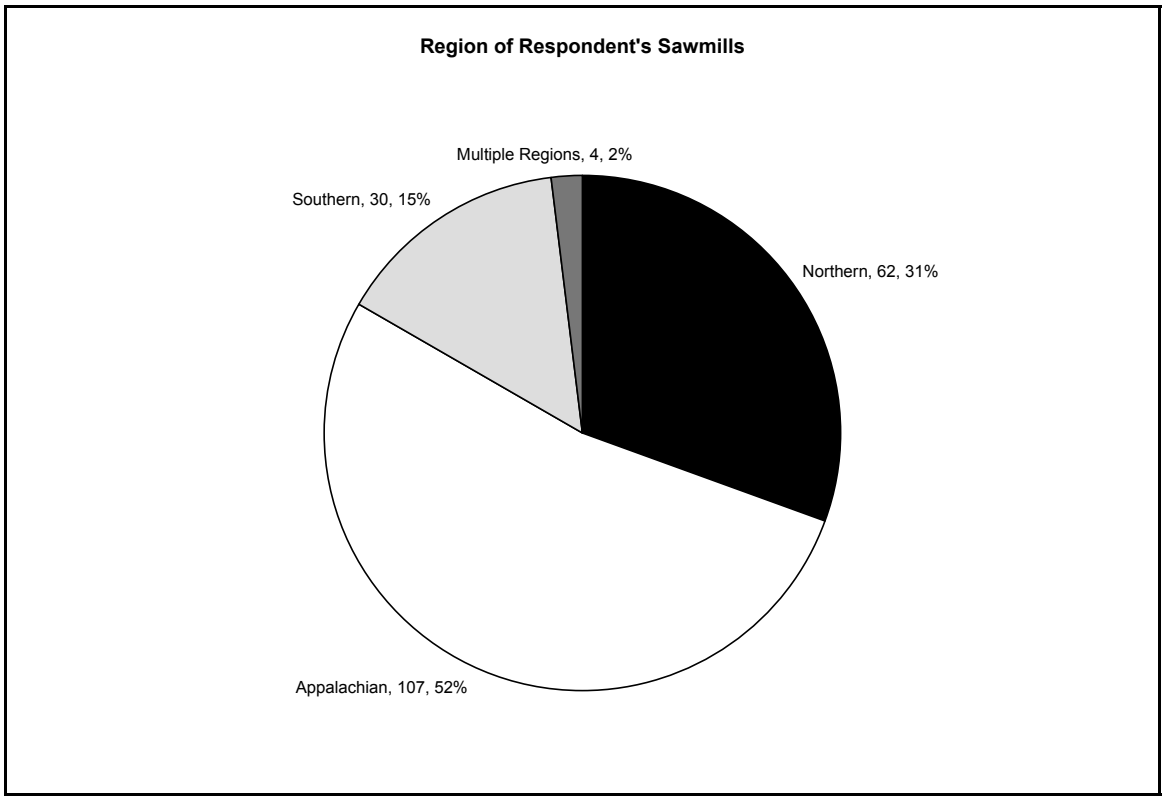

Figure 8. Region of Respondent's Sawmills

The three regions don't coincide with geographic, political, botanical, or cultural regions of the eastern U.S. Rather, they are based on the characteristics of the lumber produced and sold and the species available in that region. The large proportion of mills in the Appalachian lumber region indicates a concentration of hardwood lumber producers and the forest resource available in that region.

The sawmills were asked about which region that they generally market and label their lumber as. The results show that a majority of mills market and label their lumber as Appalachian (56%), followed by Northern (31%) and Southern (13%). These proportions are similar to those in Figure 8 and verify that the majority of respondents were located in the Appalachian lumber producing region.

The firms were asked to indicate the types and prices of wood residues that they produced in 2007. The average selling price at the mill and the proportions of sawmills selling each wood residue is shown in Table 5.

Table 5. Proportion of Firms Selling Wood Residues & Reported Prices

	Chips	Sawdust	Bark	Shavings
Proportion of Sawmills Selling	92.9%	89.1%	86.2%	29.6%
Average Selling Price ($/ton)	$27.86	$17.24	$18.88	$25.36
Maximum Selling Price ($/ton)	$90.00	$60.00	$60.29	$68.59
Minimum Selling Price ($/ton)	$2.00	$1.00	$1.00	$2.00

The vast majority of sawmills sell their chips, sawdust and bark while only 30% of mills sell shavings. Mills that don't sell their wood residues are generally smaller than the industry average and their lumber production volume averaged between 2.2 and 4.2 million board feet depending on the residue type not sold. These results signify that there are wood residues available from sawmills who currently don't sell them. This may be due to lack of markets, inadequate machinery, low inventory holding capacity, or inconsistent supply. Technical assistance could help these mills in generating revenue from their wood residues and improve their performance.

The average selling price for the wood residues is similar to industry norms. The large variability in selling prices is an indication of the high demand for wood residues some mills have experienced. The data collection period occurred at the end of a large increase in energy prices which spurred demand for wood residues. The utilization of wood residues from a sawmill's operation is an important source of revenue. While the results indicate that most mills were fully utilizing their wood residues, there is potential for improvement in this area. Above and beyond wood residues, hardwood lumber is the main product that hardwood sawmills sell and it is reported on next.

Marketing Mix

Three elements of hardwood lumber company's marketing mix were measured: product mix, distribution channels, and promotion expenditures. Three aspects of the hardwood lumber product were measured during the mail questionnaire: species mix, product type and lumber grade distribution. Lumber is sold in species groups and this varies from region to region depending upon the forest resource and tree species available in that region. Firms were asked to report their 2007 lumber production for each species group as a proportion of total lumber production. The typical species mix for a mill in each region is presented in Figure 9.

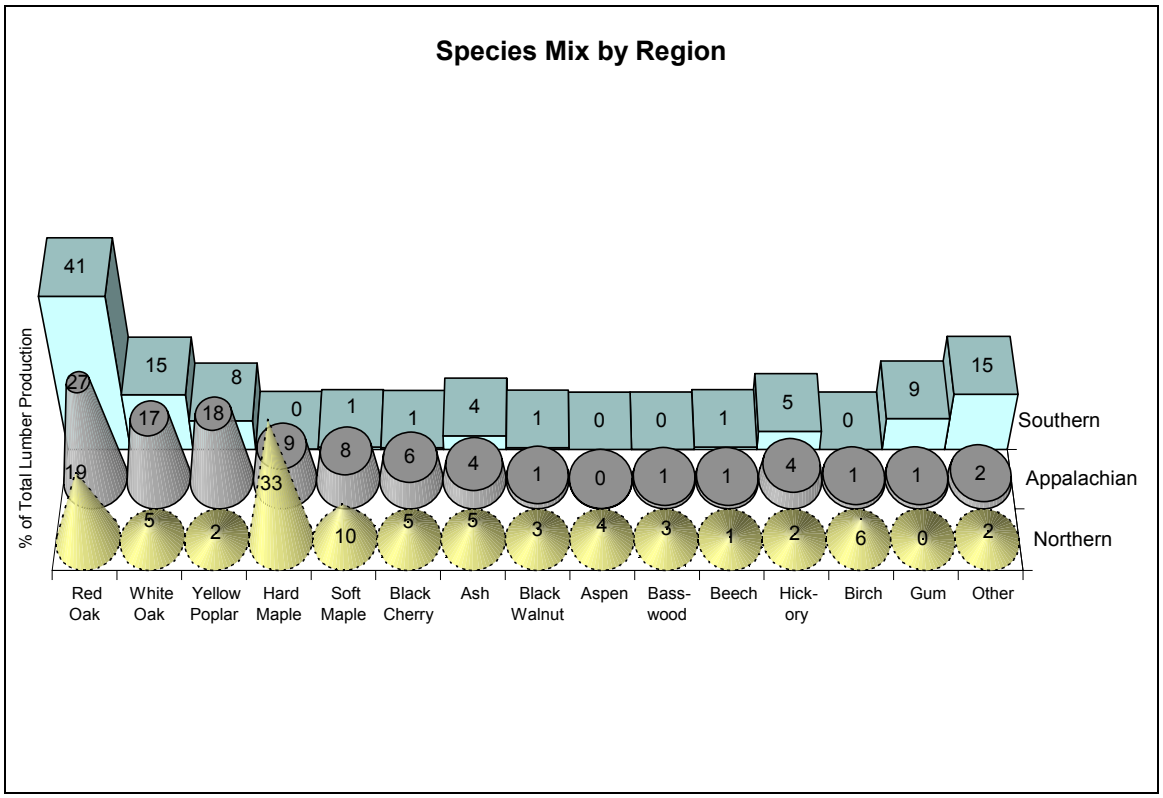

Figure 9. Proportion of Lumber Species Produced by Region

In the Southern region, the predominant species mix consists of red oak, white oak, other, and gum. It is evident from the chart that in this region mills utilize a smaller number of species as compared to other regions. In the Appalachian region, the predominant species mix is red oak, yellow poplar, white oak, hard maple and soft maple. In the Northern region, sawmills typically produce hard maple, red oak, and soft maple lumber among many other species. These results are similar to those reported by Bowe (2000) indicating that the species mix in the industry has not changed.

Hardwood lumber companies produce different grades of lumber which are utilized for different applications. The grades are developed, regulated and enforced by the National Hardwood Lumber Association. The sawmills reported their 2007 lumber grade distribution as a proportion of total grade lumber production (Figure 10).

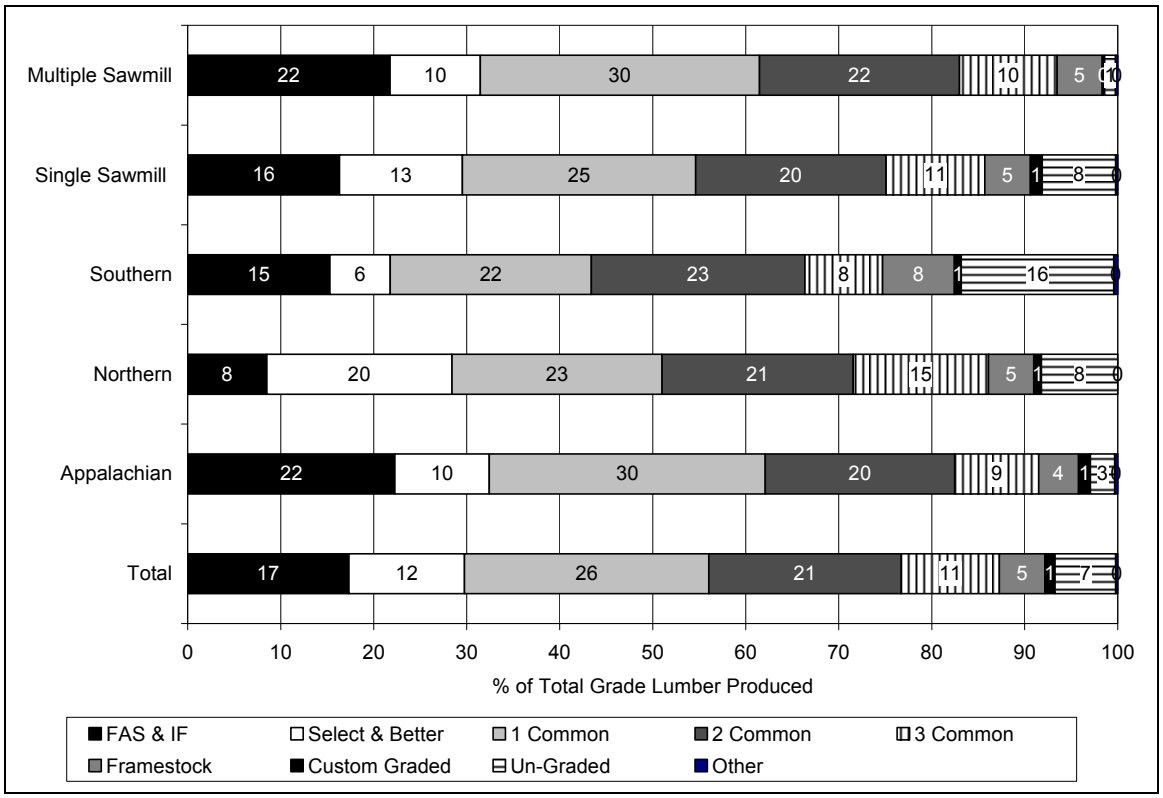

Figure 10. Proportion of Grade Lumber Produced by Region & Mill Type

Overall, sawmills reported that 1 common accounted for 26% of production, 2 common 21%, and FAS & 1F 17%. These proportions are similar to other studies (Smith et al 2004) and reflect the grade yield that was produced by the responding sawmills. The common grades of lumber accounted for approximately 60% of grade lumber production and the upper grades accounted for about 30% of production in nearly all cases with the exception being Southern mills. Southern mills reported that 16% of their lumber production was un-graded. Framestock, custom graded and un-graded lumber accounted for small proportions of a mill's lumber production. In the Northern region, mills produced more Select and Better grade lumber than FAS & 1F. Multiple sawmill companies produced more FAS & 1F lumber (22%) than single sawmill companies (16%). These results indicated that grade mix varies depending upon region and mill type.

Hardwood lumber companies produce lumber in different sizes and with different levels of processing for various markets. For secondary manufacturing markets, lumber is typically dried in a kiln whereas pallet cants and railway ties are not kiln dried. This

kiln drying adds value to the lumber as does surfacing the lumber. Firms were asked to report the type of hardwood lumber that they sold in 2007 as proportion of total lumber sales (Figure 11).

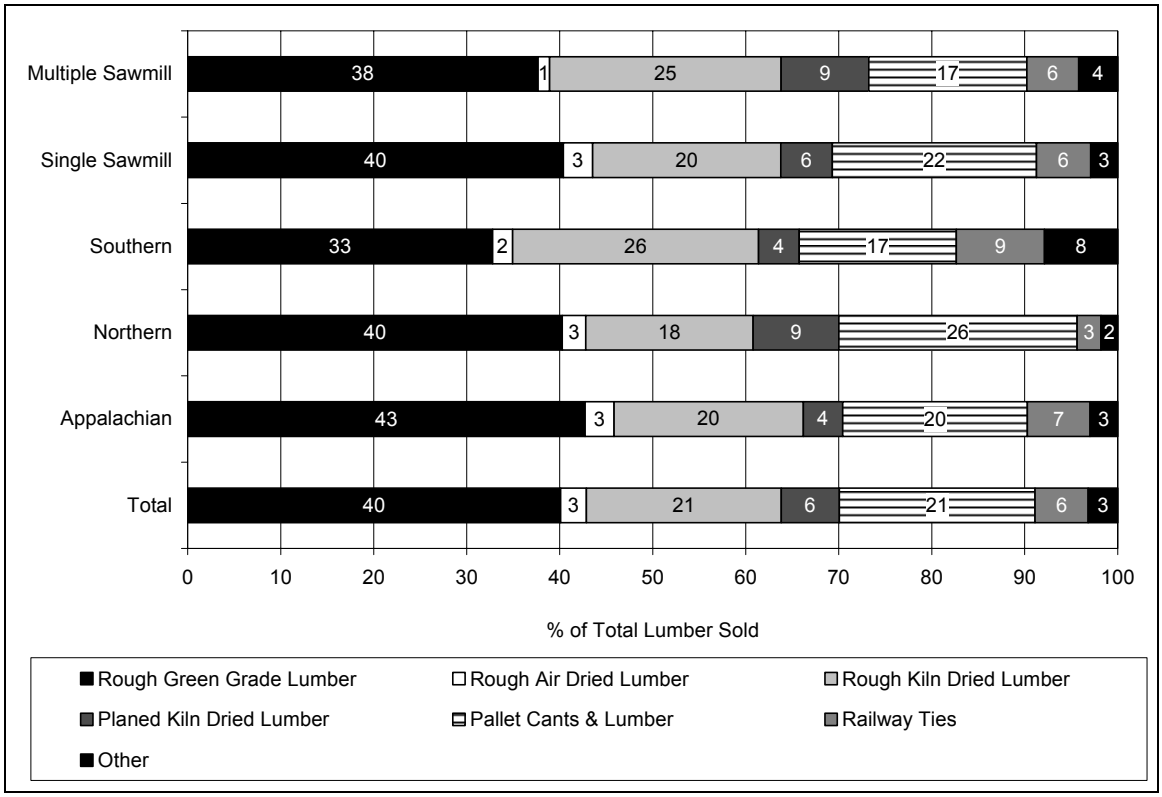

Figure 11. Proportion of Lumber Product Type Sold by Region & Mill Type

The majority of lumber (61%) sold by the lumber manufacturers in this study was rough green lumber or pallet cants and lumber which are also green and not surfaced. Only 27% of lumber sold had been kiln dried or planed. Southern mills and multiple sawmill companies reported selling more kiln dried lumber. Pallet cants accounted for 26% of lumber sold for Northern region mills. Pallet cants and lumber and railway ties are an important product type for all mills, consisting of over one quarter of all lumber sales in 2007.

Planed kiln dried lumber accounted for less than 10% of all lumber sold. There is an opportunity for some sawmills to add more value to the lumber by drying and surfacing it. A proportion of mills already dry their lumber and some have dimensioning and concentration yards as part of their operations. These operations are reported on and discussed in Table 12. The drying and surfacing function is also performed by

concentration yards who are one of the customer segments that sawmills sell to. The proportion of lumber sales in each distribution channel in 2007 is shown in Figure 12.

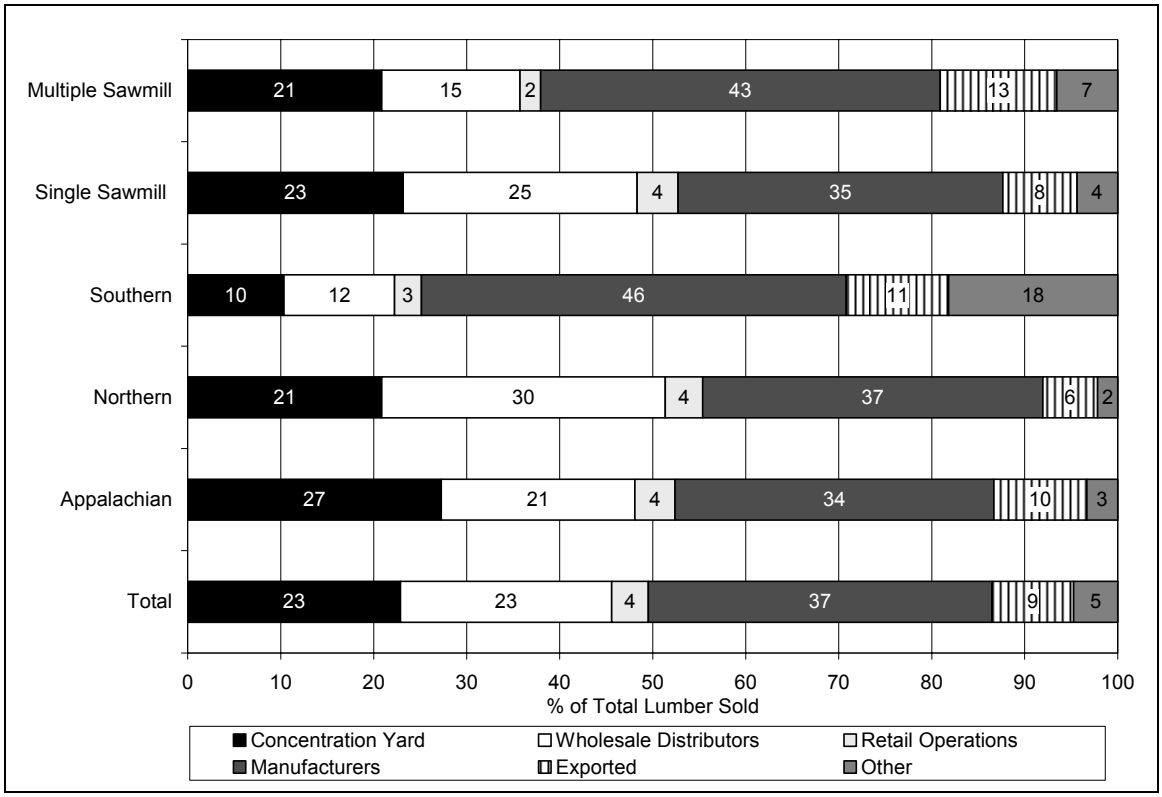

Figure 12. Proportion of Lumber Sold to Distribution Channels by Region & Mill Type

Manufacturers accounted for 37% of lumber sold in 2007, followed by concentration yards and wholesale distributors at 23% each. Exported lumber accounted for 9% of the lumber sold in 2007. Retail operations continue to be an underutilized distribution channel for most sawmills. This is likely due to the need to dry and surface the lumber and stock and service the retail customers. Multiple sawmill companies and Southern mills sold more lumber to manufacturers as compared to other firms. The responding Southern mills sold to concentration yards and wholesale distributors much less than the other mills. Multiple sawmill companies exported more than single sawmill companies. These results indicated that manufacturers were the primary customers of sawmills.

In addition to hardwood lumber distribution channels, information was gathered on promotion expenditures. Promotion was the next element of the marketing mix that was measured in this study. The price of hardwood lumber is tracked by market report

services and hence not measured in this study. Promotion expenditures have not been measured in any other study yet and it is an important part of the marketing mix. The proportion of expenditures in each promotion type is shown in Figure 13.

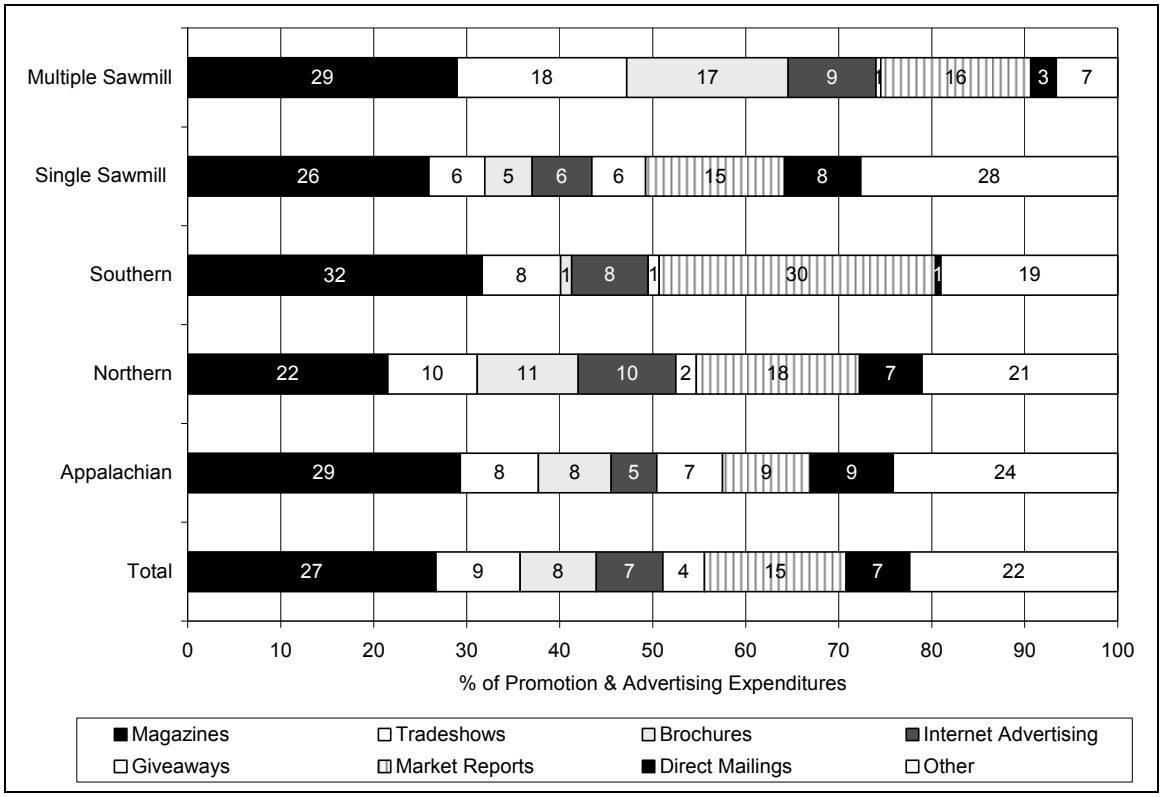

Figure 13. Proportion of Promotion & Advertising Expenditures by Region & Mill Type

The hardwood lumber manufacturers reported their promotion expenditures went to magazines (27%), other (22%) and market reports (15%). The other category consisted of local, lower expense advertising mediums such as newspaper, radio, and telephone books. Multiple sawmill companies reported a large proportion of their expenditures are used for tradeshows and brochures. Market reports accounted for 30% of promotion expenditures for Southern mills. Of the respondents, only 60% reported promotion expenditures and this suggests that the remaining 40% don't promote or advertise their products or that data wasn't available. An increase in promotion and advertising spending in the industry could help mills to better reach more customers.

Technology Utilization

The adoption and use of advanced production and information technology in the hardwood lumber industry has the potential to increase productivity and performance. The relationship between technology utilization and performance will be tested in Chapter 4. Firms were asked about their use of information and production technology. Firms indicated whether they used certain technology, how long they have used it and how important it was to their performance. The results for production technology are shown in Table 6.

Table 6. Production Technology Use, Years Utilized, & Importance

Production Technology	Proportion Utilizing	Years Utilized	Importance[1]
Optimized Headrig	49.0%	7.5	4.3
Optimized Edger	26.0%	5.4	4.1
Ring Debarker	22.7%	8.0	3.7
Optimized Trimmer	13.2%	4.7	3.4
Automated Sort Bins	12.2%	8.2	3.1
Real-time Lumber Dimension Control	5.6%	7.8	2.6
Bucking Optimizer	3.6%	7.8	2.4
[1] 1 = not important, 5 = very important			

An optimized headrig was utilized by nearly one half of all respondents. An optimized edger and ring debarker were the next most frequently utilized technologies. An optimized trimmer and automated sort bins were used by 13% and 12% of respondents. Bucking optimizers and real time lumber dimension control were not used frequently by companies. Ring debarkers were the longest utilized technology with an average of 8 years in use. Optimized trimmers and optimized edgers were the newer technologies utilized by sawmills as indicated by the number of years in use. Companies with bucking optimizers and lumber dimension control averaged 7.8 years in use. Optimized headrigs and edgers were rated the most important technologies to a company's performance. Real time lumber dimension control and bucking optimizers were rated as not important to a company's performance. These results suggest that firms believe that they should adopt optimized headrigs and edgers to improve their performance.

Theses results when compared to previous research (Bowe 2000) indicate that a larger proportion of hardwood sawmills have adopted advanced production technologies.

The proportion of mills with a given technology has nearly doubled in many cases. For example, mills with optimized edgers increased from 10.1% in 1999 to 26% in 2007 and mills with optimized headrigs increased from 27% in 1999 to 49% in 2007. The goal of these production technologies is to increase grade recovery, lumber recovery, and productivity. Based on empirical evidence, the adoption of these technologies has been shown to improve production, grade and lumber yield, and lumber value, in turn leading to improved overall performance (Anonymous 2009; Kline et al 1991). The exact amount of improvement in lumber yield, productivity and grade recovery is generally not disclosed by mills. The utilization of these production technologies differs according to firm size (Table 7).

Table 7. Production Technology Utilization by Firm Size

Firm Size (Annual Production)	N	Optimized Headrig	Optimized Edger	Ring Debarker	Optimized Trimmer	Automated Sort Bins	Real-time Lumber Dimension Control	Bucking Optimizer
0-0.99 Million BF	18	26.3%	5.3%	10.5%	10.5%	0.0%	0.0%	0.0%
1-4.99 Million BF	51	41.8%	30.9%	27.3%	16.4%	9.1%	5.5%	7.3%
5-9.99 Million BF	60	55.6%	25.4%	15.9%	7.9%	11.1%	4.8%	3.2%
10-19.99 Million BF	32	57.6%	27.3%	15.2%	12.1%	18.2%	6.1%	0.0%
20+ Million BF	36	40.5%	24.3%	32.4%	16.2%	16.2%	8.1%	2.7%

The use of advanced production technology by the smallest firms (production below 1 million board feet) is low or non-existent as compared to the larger firms in the industry. The advanced production technologies require large capital investments costing millions of dollars which are often larger than the yearly sales of these smaller mills. In order to achieve a return on their investment in these technologies, mills need a high production rate which are also lacking in the smaller mills. The use of optimized edgers was similar across the four largest groups. The larger mills were more likely to use automated sort bins and real-time lumber dimension control than the smaller mills. These results show that in general larger mills are more likely to use advanced production technology.

The use of information technology is also important to the performance and productivity of firms and the hardwood lumber industry is no exception. Firms were asked about their use of information technology and its importance to their performance. The results for information technology are shown in Table 8.

Table 8. Information Technology Use, Years Utilized & Importance

Information Technology	Proportion Utilizing	Years Utilized	Importance[1]
Email	84.0%	7.2	4.0
Internet	83.0%	7.3	3.7
Computer-Based Lumber Tallying	62.9%	9.5	4.5
Computer-Based Log Tallying	59.4%	9.8	4.3
Website	57.8%	5.9	3.5
Computer-Based Inventory Control	46.0%	9.1	4.3
Internet Selling	23.2%	5.1	2.8
[1] 1 = not important, 5 = very important			

The Internet and email are the most widely used information technologies in the industry. Internet selling of lumber is only used by 23% of responding companies. The majority of companies utilize computer-based log and lumber tallying and have a website. The computer-based log tallying, lumber tallying and inventory control technologies have been in use for an average of over 9 years. The Internet and email have been used on average for about 7 years. Firms rated the computer-based log, lumber, and inventory technologies as the most important to their performance. This suggested that firms believe that performance can be improved by adopting these technologies. Since logs and lumber are sawmills most expensive inputs and outputs it is important to be able to track them effectively. Email, Internet and website were also rated important whereas Internet selling was not as important. The results are similar to other research on information technology in the industry. Vlosky and Smith (2003) reported that 90% of companies in the hardwood industry used the Internet and 55% had a website. These results indicate that a small majority of hardwood lumber manufacturers have adopted information technology.

The use of information technologies by firm varied depending on the size of the firm as shown in Table 9.

Table 9. Information Technology Utilization by Firm Size

Firm Size (Annual Production)	N	Email	Internet	Computer-Based Lumber Tallying	Computer-Based Log Tallying	Website	Computer-Based Inventory Control	Internet Selling
0-0.99 Million BF	19	68.4%	89.5%	10.5%	15.8%	36.8%	26.3%	15.8%
1-4.99 Million BF	55	65.5%	58.2%	50.9%	49.1%	34.5%	29.1%	12.7%
5-9.99 Million BF	63	85.7%	85.7%	61.9%	57.1%	54.0%	33.3%	19.0%
10-19.99 Million BF	33	90.9%	90.9%	84.8%	78.8%	69.7%	57.6%	24.2%
20+ Million BF	37	94.6%	89.2%	81.1%	75.7%	86.5%	81.1%	40.5%

Larger sized firms were more likely to use computer based lumber tallying, computer based inventory control and computer based log tallying. The large firms may benefit the most from these technologies since they have a large volume of logs, lumber and inventory to track as compared to smaller firms. The differences in the proportion of firms using email, Internet, and website were smaller between the smaller firms and larger firms. It is possible that the adoption and use of email, Internet and website is easier than the adoption and use of the product tracking technologies. These results show that in general large firms utilize information technology more than smaller firms.

Firms were asked to identify the type of technology used for log tallying, lumber tallying, and inventory control. The results are shown in Table 10.

Table 10. Type of Information Technology Used for Log, Lumber, & Inventory Tracking

Technology Type	Log Tallying	Lumber Tallying	Inventory Control
Hand-Held Device	95.7%	83.8%	65.5%
Voice Recorder	4.3%	4.5%	1.7%
Scanner	0.0%	5.4%	6.9%
Spreadsheets	0.0%	1.8%	8.6%
Other	0.0%	4.5%	17.2%

Of the companies that utilized computer-based log, lumber and inventory tracking the majority used hand-held devices. Information is manually input or bar codes are scanned with this type of device. A small proportion utilized voice recorders or automated scanners. Almost one quarter of companies indicated that they used manual entry into spreadsheets or other unspecified methods for inventory control. The use of these technologies in hardwood lumber companies has increased over time but no direct comparison of proportions is available for the hardwood lumber industry.

Firms were asked to identify functions that they used the Internet for and their responses are shown in Table 11.

Table 11. Proportion of Firms Utilizing Various Internet Functions

Internet Function	Proportion Utilizing
Purchasing Products	65.5%
Customer Inquiry	59.1%
Market Research	56.4%
Sales Promotion	46.3%
Data Transfer	41.4%
Internet Sales	29.8%
Shipping Notice	29.6%
Logistics	25.3%
Order Status	24.1%
Order Tracking	17.8%
Inventory Tracking	14.1%

The main uses of the Internet were for purchasing products, customer inquiry, and market research followed by sales promotion and data transfer. Internet sales were used by 30% of responding companies. Inventory tracking and order tracking functions were not used by many respondents. If more hardwood lumber companies export their lumber in the future, then use of the Internet for logistics, order tracking, and order status functions is likely to increase.

Business Operations & Performance

Hardwood lumber companies were asked about their auxiliary operations, forest certification, business area focus, and business performance. These topics are important in order to monitor the degree of vertical integration, the transition of companies to greater sustainability, the prevalence of types of business strategy, and the overall performance in the industry. First, the hardwood sawmills were asked to list operations other than their sawmill. The number and proportion of mills having a particular operation is shown in Table 12.

Table 12. Additional Operations of Firms

Additional Operation	Frequency	Percentage
Dry Kilns	120	59.7%
Planer/Surfacing Mill	98	48.8%
Trucking Operations	96	47.8%
Forest Holdings	92	45.8%
Logging Operations	61	30.3%
Dimension Manufacturing	41	20.4%
Concentration Yard	40	19.9%
Pallet Manufacturing	24	11.9%
Other	21	10.4%
Flooring Manufacturing	20	10.0%
Other Secondary Mfg.	18	9.0%
Distribution Facilities	14	7.0%
Cogeneration Boiler	13	6.5%
Mulch Coloring Operation	7	3.5%
Treating Facility	3	1.5%
Pellet Mill	3	1.5%

The majority of respondents (60%) had dry kiln operations and 49% had a surfacing mill. The proportion of mills indicating that they utilized dry kilns has increased from 43.4% in 2000 (Bowe 2000) to 60% found in this research. These results suggest that hardwood lumber manufacturers are adding more value to their lumber by kiln drying it. Slightly less than one half of respondents indicated that they had trucking operations and forest holdings. Logging operations were reported by 30% of firms. Concentration yards and dimension manufacturing operations were prevalent in one in five firms. Despite the recent growth of pellet mills, only 3 sawmills indicated that they had pellet mill operations. Thirteen sawmills reported that they had a cogeneration boiler. The lack of bioenergy production and bioenergy products among sawmills is an

opportunity for them to diversify their revenues and take control of an important cost component. These operations on the output side add value to lumber through drying, surfacing, or dimensioning. The operations such as logging and forest holdings are an attempt to control inputs to the sawmill (i.e.: raw material supply and costs). Sawmills who don't have these auxiliary operations have an opportunity to diversify their revenues, add value to their lumber and control raw material characteristics.

The firms were asked if their company was certified by a forest or chain-of-custody certification scheme and which scheme they were certified by. Thirty five percent of respondents (71 companies) indicated that their company was certified by either forest, chain-of-custody, or both. The type of certification by each forest certification scheme is shown in Figure 14.

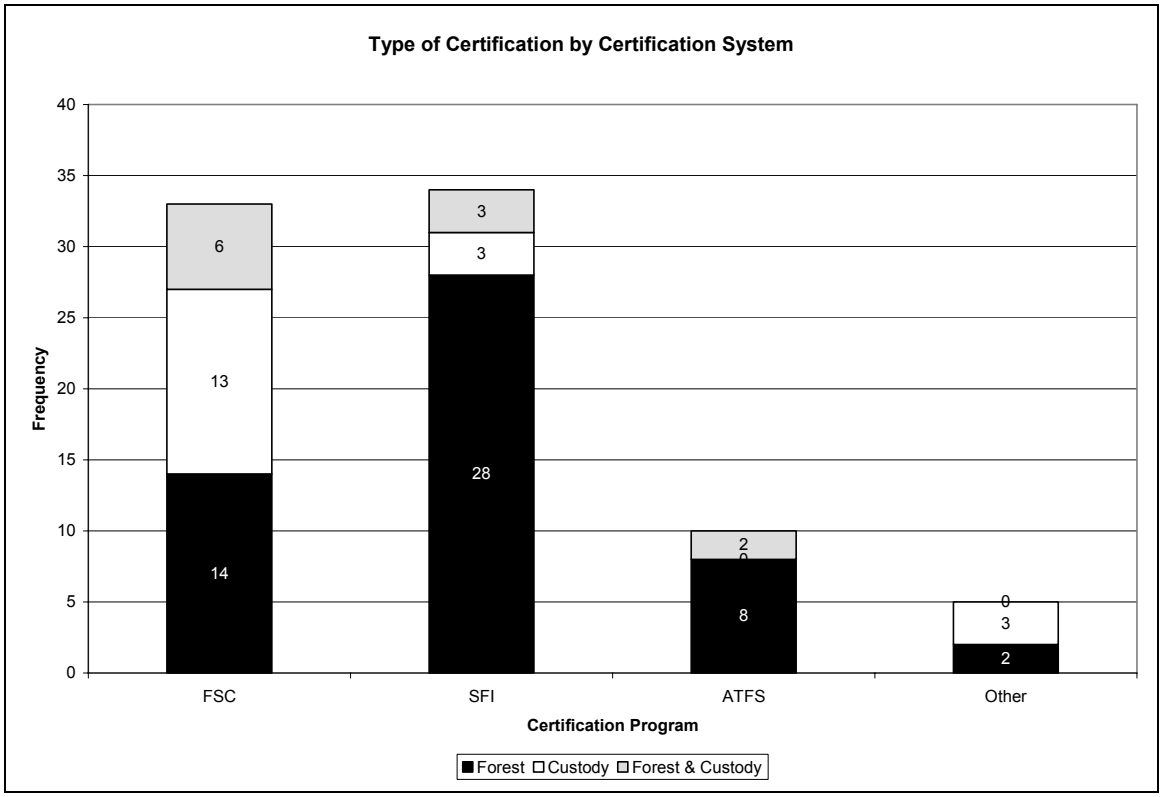

Figure 14. Frequency of Mills Certified by Certification Type & Certification Scheme

The companies that reported that they were certified were about evenly split between the Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) certification schemes. The American Tree Farm System (AFTS) was only used by 10 companies and other schemes were used by 5 companies. The companies using the FSC

scheme were evenly divided between forest certification and chain-of-custody certification and 6 companies had both certifications. The SFI certified companies mainly had forest certification and not chain-of-custody. The AFTS scheme is used for forest certification but can be used with other chain-of-custody certification schemes. The results indicate that a sizable portion of hardwood lumber manufacturers are certified. Forest certification is a "green" trend in the industry and is required by some green building systems.

Firms were asked to rate the importance of twenty business areas on a scale from 1 (not important) to 7 very important. These business area variables were developed and measured by Bush (1989). The ratings for each area are shown in Table 13.

Table 13. Importance Ratings of Business Area Variables

Focal Business Area	Importance Rating
Product quality control	6.3
Efficient operation of production facilities	6.3
Providing customer service	6.3
Reputation within the industry	6.2
Procurement of raw materials	6.0
Providing rapid delivery	5.7
Employing trained/experienced personnel	5.6
Competitive pricing	5.3
Ability to manufacture specialty products	4.8
Serving particular customer groups	4.5
Investment in new processing equipment	4.5
Developing brand identification	4.2
Using new marketing techniques/methods	4.1
Owning timberlands and/or logging operations	4.0
Serving special geographic markets	4.0
Developing new products	4.0
Controlling channels of distribution	3.9
Market research	3.8
Maintaining a company sales force	3.8
Promotion and advertising	3.7

Respondents rated product quality control, efficient operations, customer service and reputation as the most important areas that they concentrated on. Many of the variables associated with marketing such as promotion and advertising, sales force, market research, distribution, and new products received comparatively lower ratings. However, all of the business areas were rated above the scale midpoint of 3.5 indicating

that they are all important. The hardwood lumber industry doesn't place much importance on promotion and advertising as shown by its low importance rating and the promotion expenditures. In a hardwood lumber market where customer attrition is increasing, promoting and advertising to new potential customers is imperative.

Firms were asked to rate their business performance from 1 (low performance) to 5 (high performance) on 12 separate measures relating to production, finance, sales and human resources. These performance measures were developed in Chapter 2 through phone interviews and a fax survey of hardwood lumber companies. The performance ratings were averaged for the 12 performance measures to give an overview of industry performance. These averages are shown in Table 14.

Table 14. Average Performance Measure Ratings

Performance Measure	Average Rating	Standard Deviation
Customer satisfaction	4.4	0.7
Product quality	4.3	0.8
Lumber yield	3.9	0.9
Number of Worker Injuries	3.9	1.3
Employee satisfaction	3.8	0.8
Sales	3.7	0.9
Orders received	3.6	1.0
Board feet per shift	3.6	1.0
Selling price	3.6	1.0
Employee turnover rate	3.5	1.2
Costs	3.5	1.0
Profit	2.9	1.3

The responding firms rated their performance highest in customer satisfaction and product quality. Performance on lumber yield and worker injuries were also rated as high. The mills rated their performance on profit the lowest just slightly under neutral. These results indicated that the industry must improve their performance in costs and profit. The industry as a whole performed the lowest on the financial performance dimension. The distribution for the summation of the three scores comprising the financial dimension is shown in Figure 15.

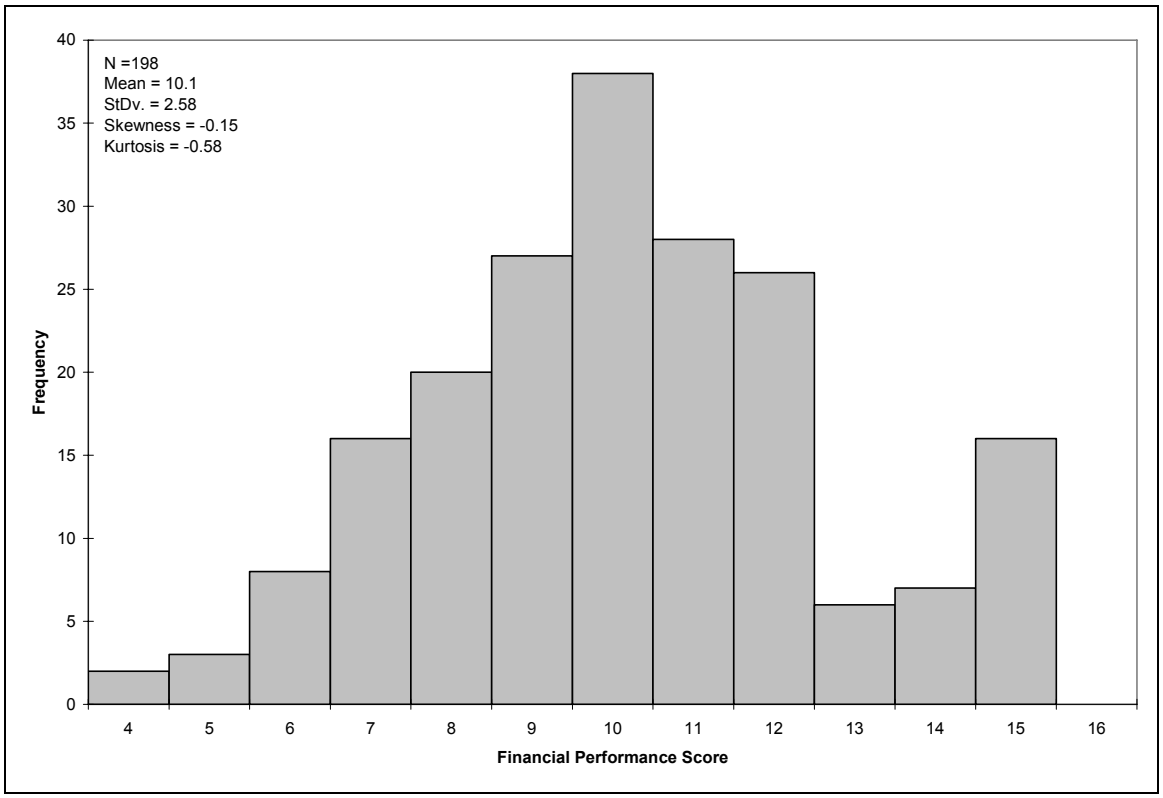

Figure 15. Financial Dimension Performance Score Distribution

The financial dimension consisted of the sales, cost and profit performance measures. The average was 10.1 on a possible range of 3 to 15 and the standard deviation was 2.58. This average was the lowest of all four dimensions and also had the highest variability. The distribution was normal as indicated by its low skewness and kurtosis, however, there were an unusual number of high performance scores. The financial dimension is a lagging indicator of performance and reflected past financial performance. The relatively low average score on the financial dimension may be an indication that firms have not concentrated on improving performance in this area. It is imperative that hardwood lumber manufacturers improve performance by increasing sales, lowering costs, and this will increase profitability. The distribution of performance scores for the production dimension is shown in Figure 16.

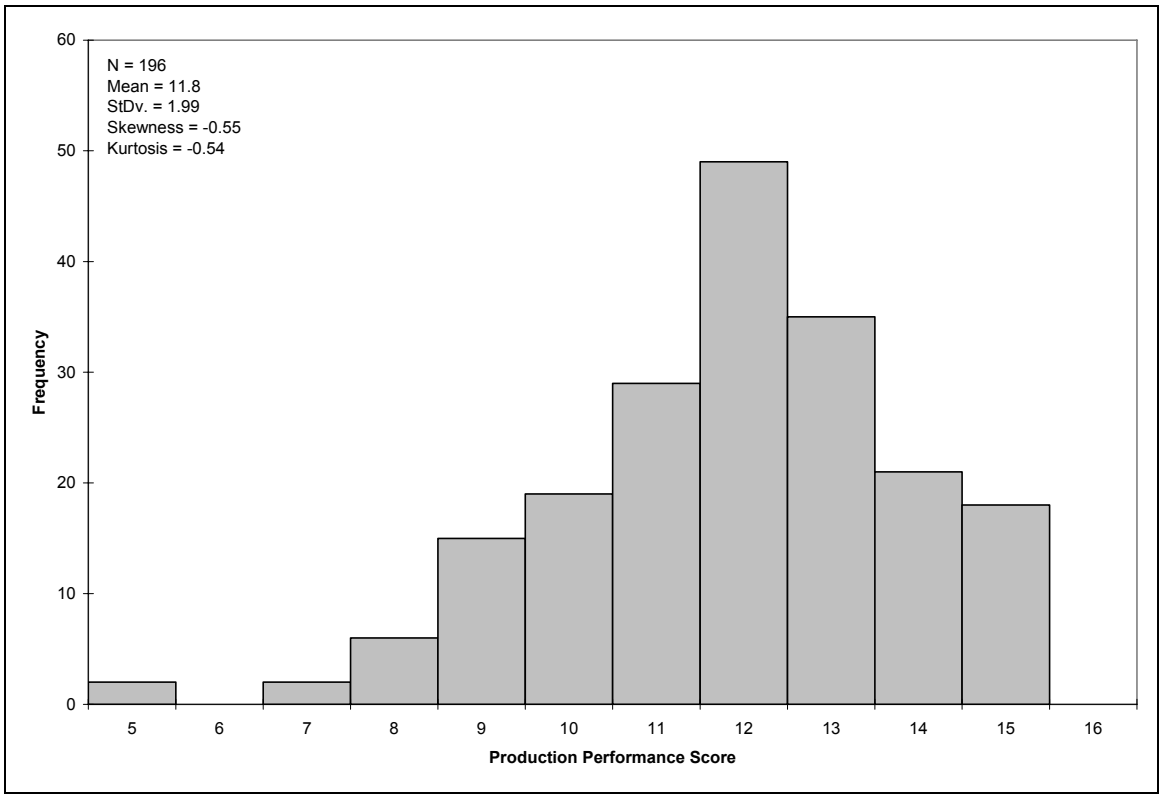

Figure 16. Production Dimension Performance Score Distribution

The production dimension consisted of the lumber yield, product quality and board feet per shift performance measures. The average was 11.8 with a standard deviation of 1.99. This average was the highest of all four dimensions. The distribution was normal as indicated by its low skewness and kurtosis, however, the distribution is quite peaked with a high number of firms near the average. The production dimension is a lagging indicator of performance and reflected past production performance. The high average score on the production dimension may be an indication that firms have concentrated on improving performance in this area. Lumber yield, product quality and production rate are all important to overall firm performance for hardwood lumber manufacturers. These results in conjunction with the financial dimension suggest that firms should focus performance improvement activities upon the financial dimension and not on the production dimension. The distribution of performance scores for the marketing dimension is shown in Figure 17.

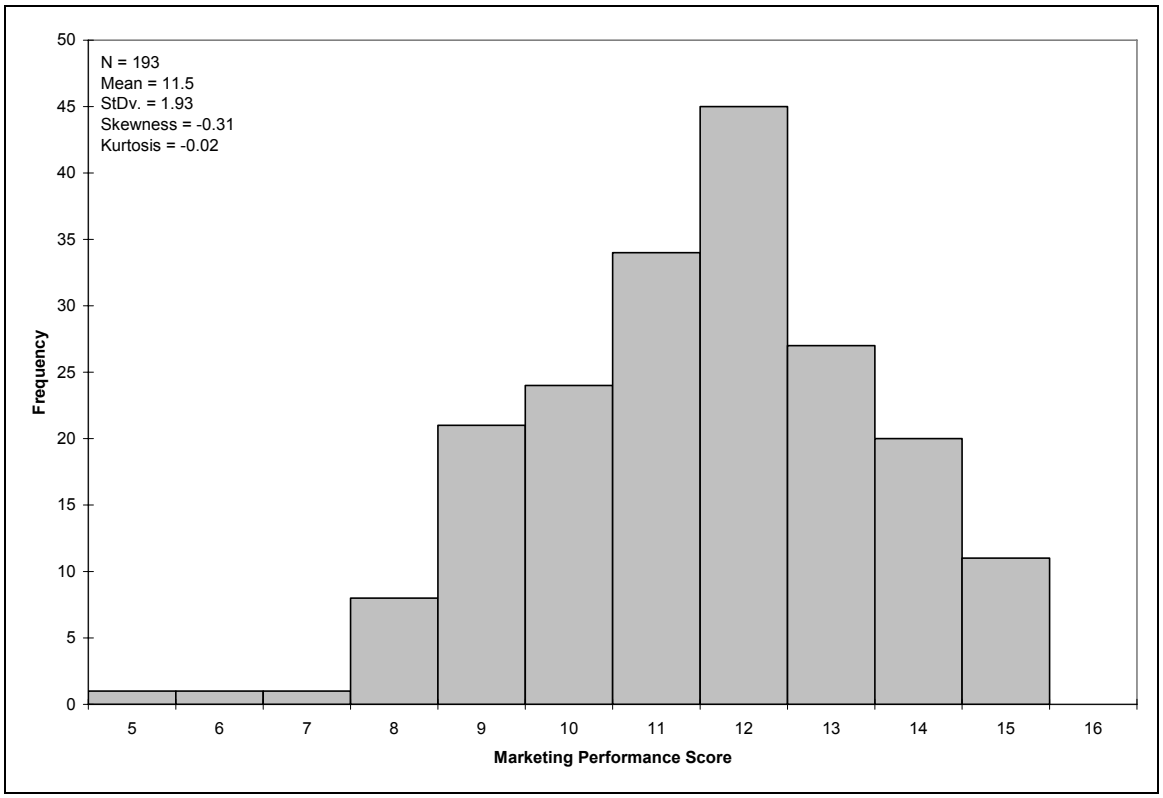

Figure 17. Marketing Dimension Performance Score Distribution

The marketing dimension consisted of the orders received, customer satisfaction, and selling price performance measures. The average was 11.5 with a standard deviation of 1.93. This average was the second highest of all four dimensions. The distribution was normal as indicated by its low skewness and kurtosis, however, there were a few firms who had very low scores on this dimension. These firms in particular would benefit from technical marketing assistance. The marketing dimension is considered a leading indicator of performance since satisfying customers is associated with repeat sales. These results suggest that firms were performing well in the marketing dimension. The distribution of performance scores for the human resources dimension is shown in Figure 18.

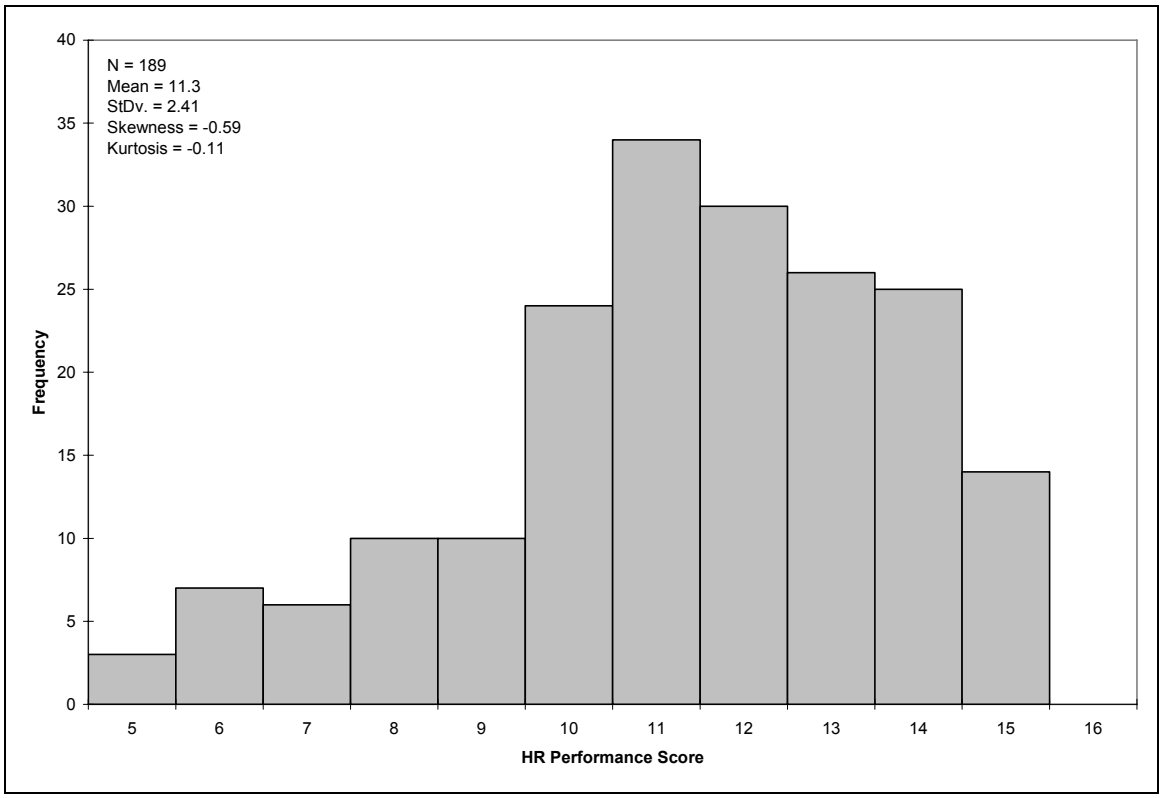

Figure 18. Human Resource Dimension Performance Score Distribution

The human resource dimension consisted of the employee satisfaction, employee turnover rate, and number of worker injuries performance measures. The average was 11.3 with a standard deviation of 2.41. The distribution was normal as indicated by its low skewness and kurtosis, however, there were a number of firms who had relatively low scores on this dimension. These firms in particular would benefit from increasing the importance of the human resource function within their organization. Techniques to increase employee satisfaction and reduce employee turnover would benefit the bottom line in the long term. The human resource dimension is considered a leading indicator of performance since satisfied employees is associated with worker productivity. These results suggest that firms were performing relatively well in the human resource dimension.

The performance ratings of each company were then summed for all twelve measures to provide an overall measure of performance for the company and the possible range for this index is from 12 to 60. These score were used as the dependent variable for statistical tests in Chapter 4. The distribution of performance scores is shown in Figure 19.

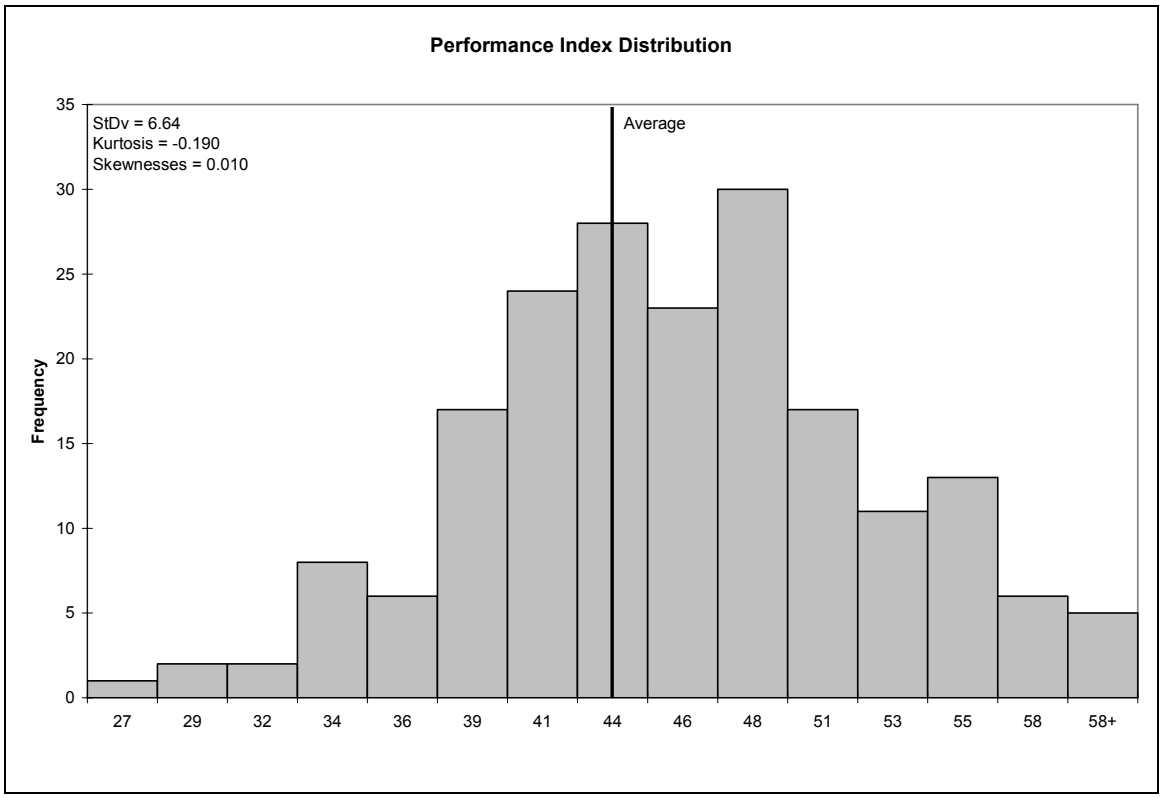

Figure 19. Performance Index Distribution

The distribution is normal based on the low kurtosis and slight positive skewness. The normality of the distribution was tested in SPSS by the Kolmogorov-Smirnov goodness-of-fit test and found to be non-significant meaning that the distribution is normal. The average score was 44 and the observed range was 27 to 60. These performance scores were used to determine how different factors influence performance. The performance scores were plotted against firm size (Figure 20) and it is evident that there is no relationship between firm size and the scores.

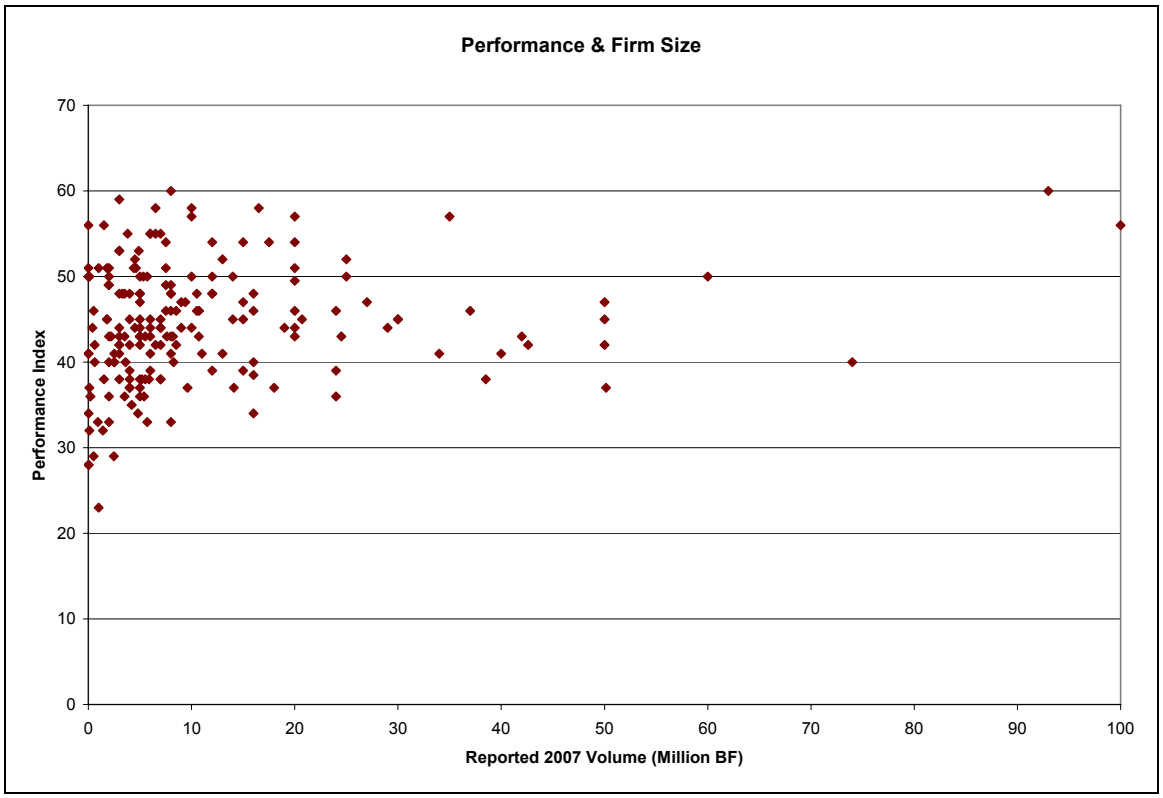

Figure 20. Performance Scores & Firm Size Scatter Plot

The lowest scores were reported by smaller firms. However, when a linear regression was performed a very small R^2 value was obtained (0.01) which indicates no relationship between firm size and performance scores. These results suggest that hardwood lumber companies of all sizes perform equally well.

In addition to the performance indicator, firms were asked to rate from 1 (low performance) to 5 (high performance) how well they have responded to external macro-environmental trends outside of their control. The ratings were averaged for each of the 13 trends to give an overview of how well the industry is performing. These averages are shown in Table 15.

Table 15. Performance Ratings in Response to External Trends

Performance in Response to:	Average Rating	Standard Deviation
Shortage of loggers	3.3	1.1
Loss of domestic customers	3.3	1.0
Lack of skilled labor	3.3	1.0
Increased operating costs	3.3	1.1
Decrease in lumber production	3.3	1.0
Increased transportation costs	3.2	1.1
High raw material prices	3.2	1.1
Increasing energy prices	3.2	1.1
Stagnant/declining lumber prices	3.1	1.0
Changes in secondary manufacturing	3.0	1.1
Demands of international customers	3.0	1.3
International competition	2.8	1.2
Demand for certified lumber	2.4	1.2

The ratings which range from 3.3 to 2.4 fall mostly around the scale midpoint and indicate that the industry has performed neither good nor bad in response to these external trends. The lowest average performance ratings are for demand for certified lumber and international competition. These observed results contradict the known, negative effects of these trends on the industry. It is possible that those firms that have been most severely impacted by these trends have already gone out of business and hence are not among the respondents. During data collection, a number of firms replied that they did go out business and a number of the questionnaires were returned undeliverable suggesting that the firm no longer existed at that location. Without being able to gather data from failed firms and potentially failed firms, the interpretation of the results are limited to just the responding companies. They have exhibited average performance in response to the external trends.

The responding firms reported their sales, production volume and number of employees in 2007. These three variables were combined in ratios to measure their production efficiency (volume per employee), sales efficiency (sales per employee), and revenue per output (sales per volume). These three ratios were then plotted by firm size to detect any trends.

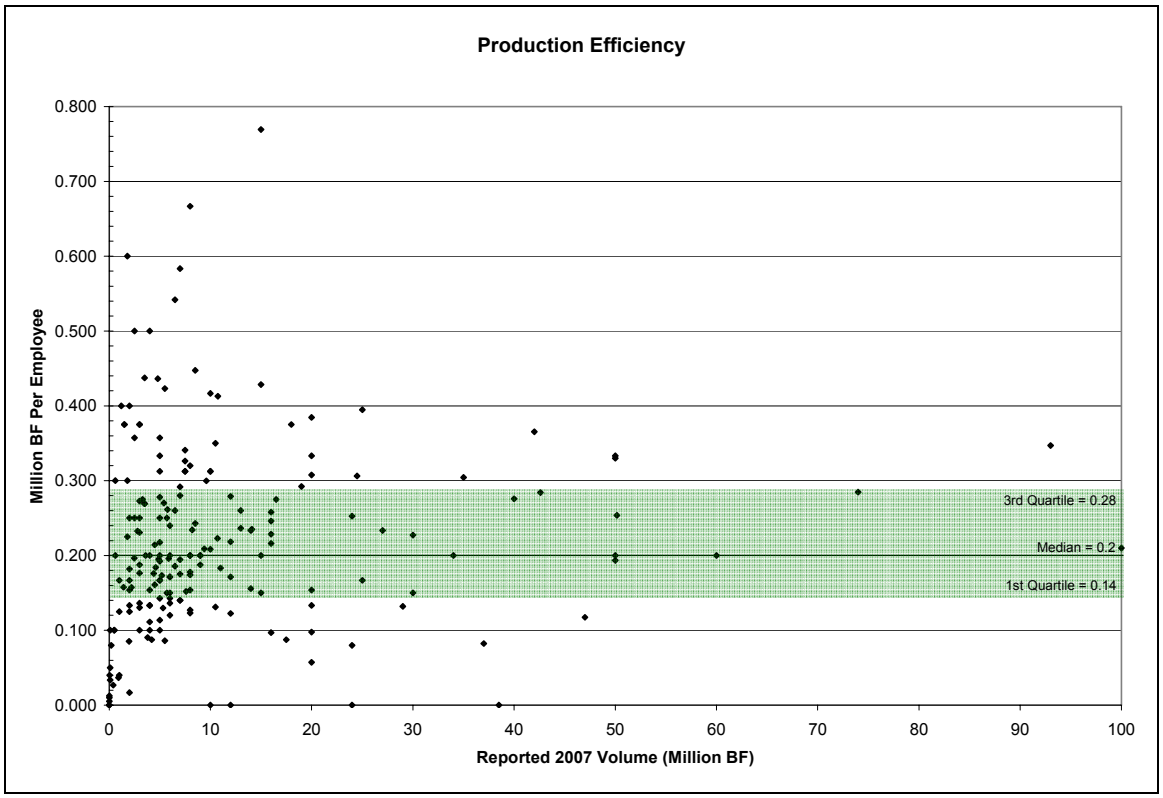

Figure 21. Production Efficiency Ratio & Firm Size Scatter Plot

The median production efficiency as measured by the production volume per employee was 0.2 million board feet per employee (Figure 21). This ratio describes how much volume was produced for each employee. The inter quartile range (IQR) between the 3rd quartile (0.28) and the 1st quartile (0.14) is shaded on the chart. This shaded region contains the middle 50% of the observed values. These results suggest no relationship between firm size and production efficiency. The firms below the 1st quartile should be aware that their production efficiency is low compared to the rest of the industry and they can improve their performance by producing more with less people. These production efficiency values serve as a benchmark for the industry to measure themselves against. The next ratio is sales efficiency as measured by sales per employee (Figure 22).

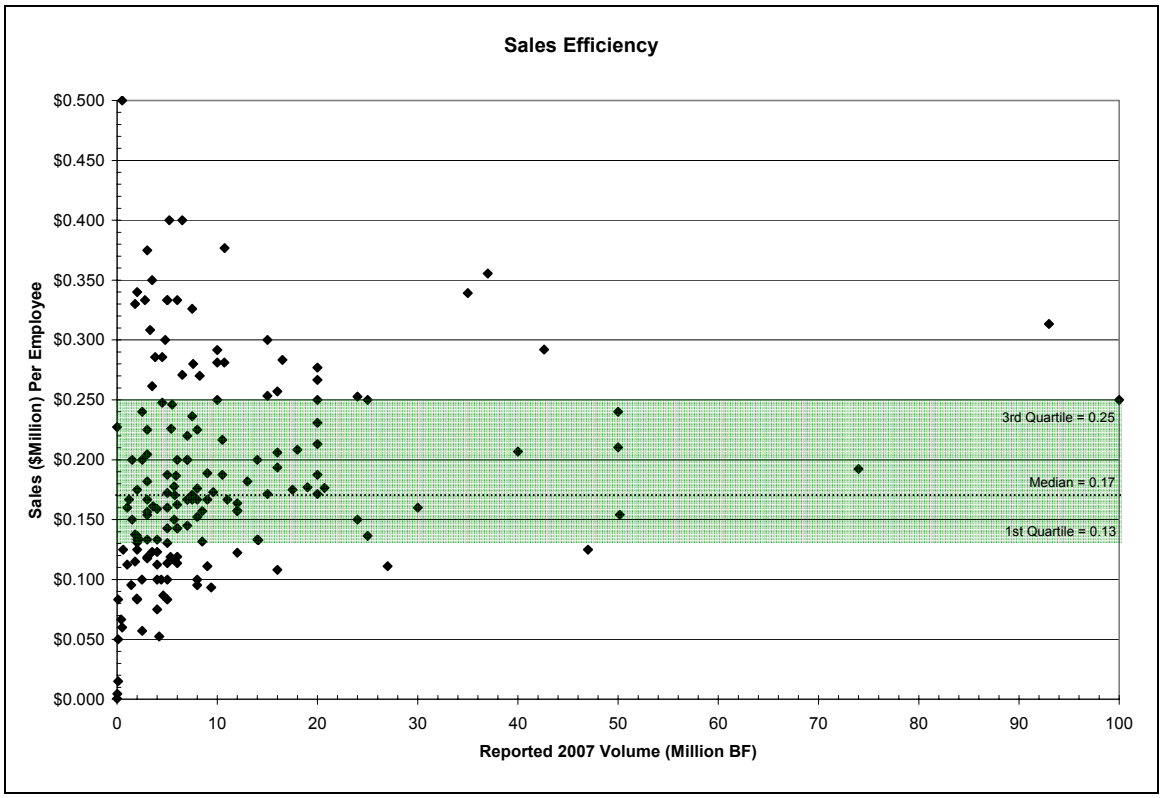

Figure 22. Sales Efficiency Ratio & Firm Size Scatter Plot

The median sales efficiency as measured by sales per employee was $0.17 million per employee. This means that in the industry each employee generates about $170,000 worth of sales. The inter quartile range between the 3rd quartile (0.25) and the 1st quartile (0.13) is shaded on the chart. There is no relationship evident between firm size and sales efficiency either. The median sales efficiency can serve as a benchmark for the industry to measure themselves against. The firms below the 1st quartile should be aware that their sales efficiency is low compared to the rest of the industry and they can improve their performance by generating more revenue or reducing their number of employees. The preferred choice would be to generate more revenue and add more value to their products. The next ratio is revenue per output. This measure includes all sales not just lumber sales. However, this ratio provides a view of how valuable each mill's output was in the market. Figure 23 shows the sales per volume.

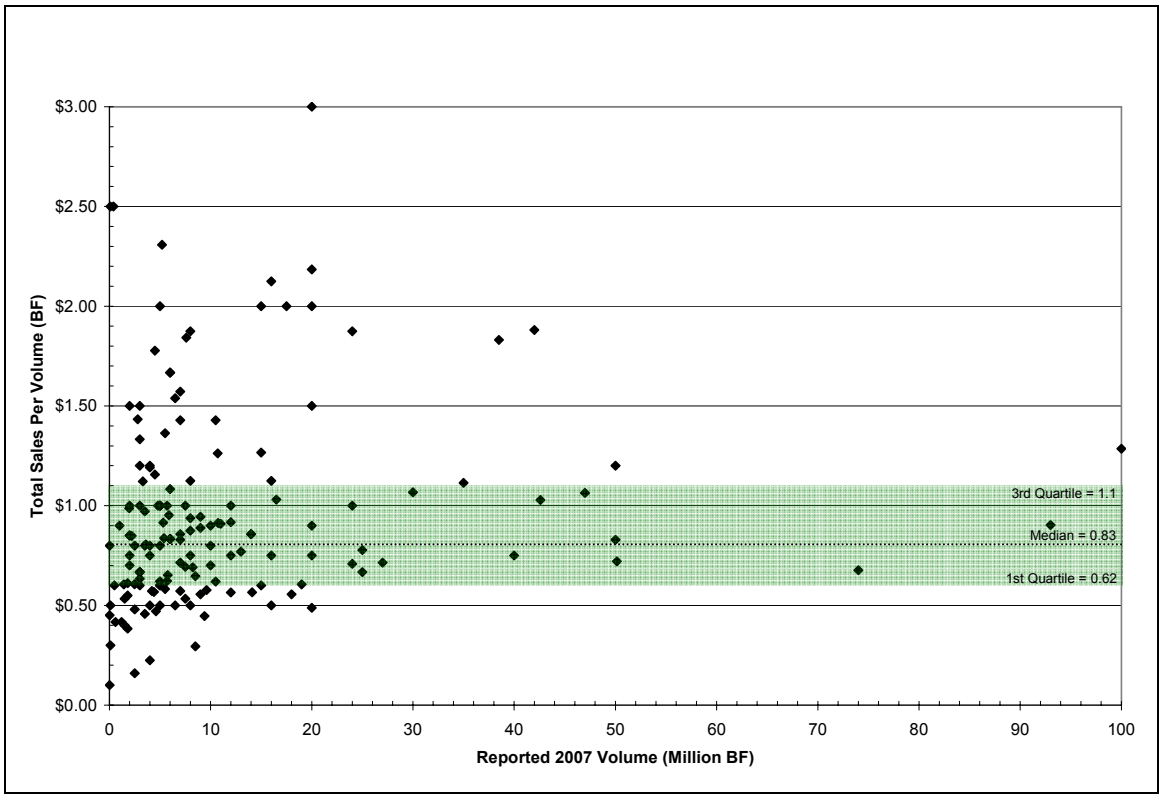

Figure 23. Sales per Volume Ratio & Firm Size Scatter Plot

The median revenue per output as measured by sales per volume was $0.83 per board foot. This means that in the industry each board foot generates $0.83 worth of revenue. This ratio is a consequence of each mill's product types and species mix. The inter quartile range between the 3rd quartile ($1.1) and the 1st quartile ($0.62) is shaded on the chart. This shaded region contains the middle 50% of observed values. There is no relationship evident between firm size and sales per volume either. The firms below the 1st quartile should be aware that their revenue per output is low compared to the rest of the industry and they can improve their performance by adding more value to their products (i.e.: selling planed or rough kiln dried lumber) and/or switching to higher valued species. Mills can measure their progress in improving performance by setting goals using this information.

The ratios have been plotted against firm size and no relationship has been exhibited. The next figure shows production efficiency plotted against sales per volume.

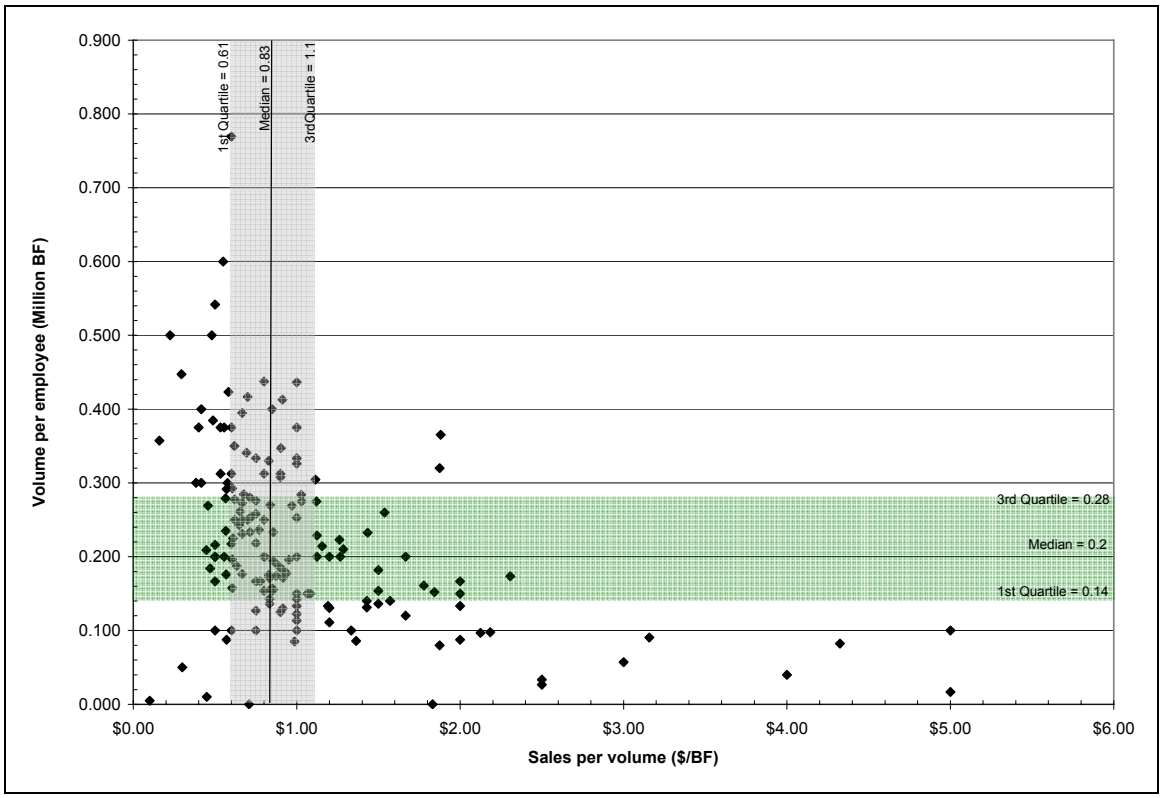

Figure 24. Production Efficiency Ratio & Revenue per Output Ratio Scatter Plot

The majority of responding firms are within the inter quartile ranges (IQR) at the intersection of the shaded areas (Figure 24). These shaded areas contain the middle 50% of all observed values. This plot does seem to suggest a trade off between revenue per output and production efficiency at least for some firms. The six firms that are below the 1st quartile (lower left) on both measures have exhibited poor revenue per output and poor sales per volume. A number of firms (23, 11% of respondents that are plotted in the lower right of the figure) have high sales per volume but sub-1st quartile production efficiency. The firms with these characteristics would benefit from an improvement in production efficiency. Another group of companies have high production efficiency but sub-1st quartile sales per volume and these firms should improve their performance on the latter measure. These results indicate that most responding sawmills are very competitive in their production efficiency and revenue per output. These measures give mills a way to benchmark their performance against the industry average.

Firms were asked what they would change to improve the performance of their company. The responses were summarized, categorized, and then tallied to provide frequencies and proportions. Roughly one half of responding companies (96) provided

responses to the open ended question. The responses to this question are shown in Table 16.

Table 16. Responses to Open-Ended Performance Improvement Question

Changes Needed to Improve Performance	Frequency	Percentage
Upgrade Equipment or Technology	31	30%
Lower Costs (Logs, Energy, Labor & Transportation)	27	26%
Improve Markets/Economy	13	13%
Training & Improve Workforce/Sales/Management	13	13%
Increase Efficiency/Recovery	12	12%
Increase Sales & Sales Price	11	11%
Decrease or Stop Production	7	7%
Other Production Related	7	7%
Other Marketing Related	7	7%
Increase Specialty Products/Customers	5	5%
Other Regulation Related	5	5%
Diversify	4	4%
Increase Log Supply	4	4%
Better Communication & Coordination	3	3%
Increase Value Added	3	3%
Adapt to & Focus on Industrial Timber Market	2	2%
Enter new markets	2	2%
Increase Retail Sales	2	2%
Nothing	2	2%
Own & Invest in Timberland	2	2%
Unknown	2	2%

Thirty percent of respondents suggested that they would upgrade equipment or technology to improve their performance. Many of these respondents cited the need for large amount of capital as a limitation. Reducing costs in general and log costs specifically were the next most frequently mentioned change needed. Other suggested changes were to improve the markets and economy, improve the workforce, sales force and management, increase efficiency, and increase sales and sales price. A number of suggestions were categorized as relating to either production, marketing, or regulation. The results suggest that mills should focus on upgrading equipment, lowering costs, increasing efficiency and sales, and improving their workforce in order to improve their performance. Improving the market and economy along with modifying regulation are outside of an individual firm's control.

Conclusions

The vast majority of the respondents were NHLA members (88%) and the adjusted response rate was 19.8%. Response rates were much lower for generic NHLA members and non-members. The results from this research are most applicable to companies with demographics similar to the average sized company. A third mailing and a four month data collection period was needed to achieve satisfactory response rates. A comparison of means between the available non-respondents and early respondents and the early respondents and late respondents did not detect non-response bias. The lumber production, sales and number of employees were all similar to previous studies (Bowe 2000). Most of the responding companies were located in the Appalachian hardwood region and a large majority sold their wood residues.

The marketing mix of hardwood lumber companies including product, distribution and promotion was measured. The species mix consisted mainly of oak, maple and poplar. The common grades of lumber accounted for approximately 60% of lumber production and the upper grades accounted for about 30% of production. The majority of lumber (61%) sold was rough green lumber or pallet lumber and cants. The sawmill distribution channels in order of sales percentage were manufacturers, concentration yards and wholesale distributors. Magazines, market reports, and other mediums were where hardwood sawmills spent most of their promotion expenditures despite 40% of respondents not having any promotion expenditures. Based on this information, there is potential for hardwood lumber companies to: sell more value added products (i.e. dried lumber); advertise and promote their mills better; diversify their species mix; and explore retail distribution channels. Mills would need to place increased emphasis on marketing, identify new customers, and target new markets.

The utilization of advanced production technology has increased in the industry. The proportion of mills utilizing a given technology has doubled in many cases. The industry should adopt optimized headrigs, optimized edgers, and optimized trimmers to improve performance. A large majority of respondents are utilizing the Internet and email whereas a small majority are utilizing log, lumber and inventory information technology. Information technology was rated important to performance and should be adopted by firms.

The majority of respondents (60%) had dry kiln operations and 49% had a surfacing mill. The proportion of mills indicating that they utilized dry kilns has increased from 43.4% in 2000 (Bowe 2000) to 60% found in this research. This suggests that the amount of kiln capacity in the industry has increased and that companies are seeking to add more value to their lumber by drying it. Thirty five percent of respondents (71 companies) indicated that their company was certified by either forest, chain-of-custody, or both. These firms are well positioned to take advantage of demand for certified lumber being created by green building systems. Respondents rated product quality control, efficient operations, customer service and reputation as the most important areas that they concentrated on. The changes in auxiliary operations and certification were important trends for companies to be cognizant of.

The distribution of tallied performance scores on the indicator was normal and evidence suggested that there was no relationship between firm size and performance scores. Industry wide profit and costs performance was rated the lowest and this suggest areas for firms to improve upon. There was no relationship between the three ratios (production efficiency, sales efficiency, and revenue per output) and firm size. These ratios provided benchmarks for mills to measure themselves against. The results from the open-ended question suggested that mills should focus on upgrading equipment, lowering costs, increasing efficiency and sales, and improving their workforce in order to improve their performance. In the next chapter, performance and its relationship to firm-controlled factors are investigated.

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Chapter 4. Firm-Controlled Factors that Influence Business Performance

Introduction

Hardwood lumber manufacturers have been impacted by stagnant sales and increasing costs which have led to decreasing profitability. Changes in hardwood lumber markets such as the decline in consumption by furniture and pallet manufacturers have led to decreases in production. These trends have resulted in mill closures and consolidation in the industry and were driven by globalization, decreasing demand in the housing and transportation sectors, and other macroeconomic factors. It would benefit firms in the industry to understand how to improve their performance. It was within this context that this research project sought to discover opportunities for improvement of firm performance in the hardwood lumber industry.

The business literature suggests that numerous marketing and management factors, including strategic, geographic, tactical, technological, and organizational factors, may influence firm performance. These factors were all within the control of the firm. Ellefson and Stone (1984) listed all of these factors and more as influencing firm and industry performance. Strategic factors could influence firm performance since one strategy may perform better than others (Rich 1986). Geography could influence firm performance because the forest resource changes from region to region and species are valued differently in the market (Luppold and Dempsey 1994). The use of advanced technology could improve productivity and firm performance (West and Cooper 1996). Different product, promotion and customer tactics may be related to performance (Ellefson and Stone 1984; Palepu 1985). Finally, firms that were vertically integrated could perform better than non-integrated firms (Cohen and Sinclair 1992). These factors were measured in a mail survey and used in statistical analysis to identify relationships among the variables.

Other factors that were beyond the control of the firm certainly impact firm performance such as economic growth, demand, supply, substitutes, industry structure, regulation, taxes, trade policy, natural resources, etc (Ellefson and Stone 1984; Martin et

al 1991). These external factors were assumed to affect firms equally. Therefore, these factors were not within the purview of this research project.

Business performance has traditionally meant profitability and financial measures such as return on investment, return on assets, and return on sales are prevalent in previous studies (Booth and Vertinsky 1991; Cohen and Sinclair 1992; O'Laughlin and Ellefson 1981; Palepu 1985; Rich 1986; Rumelt 1982). More recent studies have used non-traditional measures of firm performance such as market share and customer satisfaction; and subjective rating scales such as performance relative to competitors (Covin et al. 1990; Narver and Slater 1990; Pelham 1997). Over time, companies and researchers have increasingly relied on multiple measures of performance and moved away from strictly using financial performance measures. This trend formed the basis of developing a multiple-measure performance indicator for hardwood lumber manufacturers (Chapter 2).

Companies within the hardwood lumber industry are predominantly privately held and there was no publicly available performance data. The reluctance of companies to share performance data and the time required to develop and provide the information would have likely caused a low response rate and so an alternative approach was needed. This approach was to utilize subjective self-rated operational and financial performance metrics directly from the company's president, owner, or chief executive. Studies have shown that subjective measures of performance correlate well to objective measures (Dess and Robinson 1984; Dawes 1999; Toby et al. 2004). Therefore, subjective performance measures from multiple perspectives were developed.

The multiple perspectives that formed the basis for the performance indicator were based on the balanced scorecard which was developed by Kaplan and Norton (1998). It measured performance from four distinct perspectives of a business: financial, internal, customer and innovation. The financial perspective included the traditional measured of business performance such as return on investment, return on sales and others. The internal perspective measures business processes needed to fulfill their mission and in hardwood lumber manufacturing this was synonymous with production. The customer/marketing perspective metrics focused on how well the company was satisfying their customers by utilizing marketing techniques. Finally, the

innovation/learning perspective measured knowledge growth through employee training and retention. This perspective was customized as human resources for hardwood lumber manufacturers since there was little innovation in the industry. The balanced scorecard framework was customized for the hardwood lumber industry because the performance literature reviewed indicated that measuring performance from multiple perspectives was valid, current, and the most effective way given the constraints of the hardwood lumber industry.

Metrics from each of the four perspectives were developed and incorporated into a multiple-measure performance indicator specific to hardwood lumber manufacturers. The three performance measures that were rated the most frequently used and the most important in each of the four dimensions (financial, production, customer, human resources) were used to form the multiple-measure performance indicator. This twelve measure performance indicator (Figure 25) consisted of the following metrics: costs, sales and profit in the financial dimension; quality, yield and board feet per shift in the production dimensions; selling price, customer satisfaction and orders received in the customer dimension; and number of worker injuries, employee satisfaction and employee turnover rate in the human resource dimension.

	Low Performance			High Performance		
Lumber yield	1	2	3	4	5	Don't know
Number of orders received	1	2	3	4	5	Don't know
Employee Satisfaction	1	2	3	4	5	Don't know
Sales	1	2	3	4	5	Don't know
Product quality	1	2	3	4	5	Don't know
Employee turnover rate	1	2	3	4	5	Don't know
Costs	1	2	3	4	5	Don't know
Customer satisfaction	1	2	3	4	5	Don't know
Profit	1	2	3	4	5	Don't know
Board feet per shift	1	2	3	4	5	Don't know
Number of worker injuries	1	2	3	4	5	Don't know
Selling Price	1	2	3	4	5	Don't know

Figure 25. Hardwood Lumber Business Performance Indicator

The performance indicator was designed with subjective performance ratings where respondents self rated their company's performance on a scale from one (low

performance) to five (high performance) on each of these 12 metrics. This performance indicator was used in the main survey in order to measure individual firm performance of hardwood lumber manufacturers.

The performance indicator was tested for reliability using both internal consistency and split half reliability using SPSS. The results of these two reliability tests were good. A Cronbach's alpha of .81 was obtained which was considered good. This meant that the indicator correlated highly with all possible 12-item indicators measuring the same variables (Garrison 2008a). The split half reliability analysis resulted in a Spearman-Brown coefficient of 0.82 which was also considered good. From these tests it can be concluded that the performance indicator was reliable.

From the background information on the hardwood lumber industry and the review of literature on performance, it was evident that there was a need to find out what influenced performance in the industry. The performance of the hardwood lumber manufacturers was largely unknown and warranted study. This raised the question of how well companies were performing and what influenced their performance? Discovering answers to these questions formed the basis of the goals for this chapter.

Objectives

The purpose of this chapter was to identify opportunities for performance improvement of eastern hardwood lumber manufacturers by investigating factors that influenced firm performance. A number of hypotheses were developed and tested in order to achieve this purpose. The main objective of this chapter is to determine the influence of firm-controllable factors on the firm performance of eastern hardwood lumber manufacturers. The completion of this objective will identify opportunities for performance improvement. The next section describes the methods needed to achieve the objective.

Methods

A mail survey of hardwood lumber manufacturers was conducted during the fall of 2009. An adjusted response rate of 19.8% was obtained and the questionnaire measured demographics, business performance, marketing mix, operations, strategy, technology, and geographic region. The 12-item performance indicator developed in

Chapter 2 was used by respondents to subjectively self-rate their performance. The questions and performance indicator can be found in Appendix E. Mail Questionnaire. The responses to the questionnaire were summarized in Chapter 3. The methods for this chapter involved utilizing response data in various statistical tests in order to: detect factors within the data (factor analysis), identify homogeneous groups within the population (cluster analysis), and detect the presence or absence of relationships between the independent and dependent variables.

Factor analysis and correspondence analysis were utilized to reduce data into components. Factor analysis was utilized for the strategy factor where numerical data was measured and correspondence analysis was utilized for the organizational factor where categorical data was measured. These analyses reduced the number of variables into a smaller number of components, dimensions or factors. The results of the factor and correspondence analysis were then used to classify or cluster firms into groups.

Cluster analysis was utilized to identify groups so that their performance means could be tested with ANOVA or t-tests. Cluster analysis has been widely utilized in business research and the social sciences. It has been used to identify homogeneous groups within a larger data set based on a given variable. Similar cases or respondents are grouped into clusters based on their response to a given variable. Clusters formed by statistical should be homogeneous and easy to interpret. Cluster membership was used as the independent variable in an ANOVA or t-test.

In most statistical tests that were conducted to test hypotheses, the dependent variable was the performance score variable (Appendix B. Statistical Test Summary). The comparison of performance means was accomplished by utilizing t-tests or analysis of variance (ANOVA). The t-test and ANOVA tested for differences between group means and a significant difference was customarily indicated by an alpha (p-value) of 0.05 or less. The test results of the ANOVA or t-test were used as evidence for rejecting or accepting hypotheses. The calculation of performance scores is described next followed by a detailed explanation of the statistical analyses and tests for each of the five factors and the associated hypotheses.

Statistical Techniques

Once data was collected and examined it was entered into SPSS. In nearly all cases the dependent variable was performance as measured by the performance indicator previously described. The twelve performance ratings of each company were summed to provide an overall performance score for each company and the possible range for this index was from 12 to 60. This approach of developing an overall performance composite from performance measures has been used in previous research (Pitt et al. 1996, Hoque and James 2000, Hayes 2002, Van der Stede et al. 2006). The distribution of total performance scores was evaluated for normality and the degree of skewness and kurtosis was determined (Figure 26).

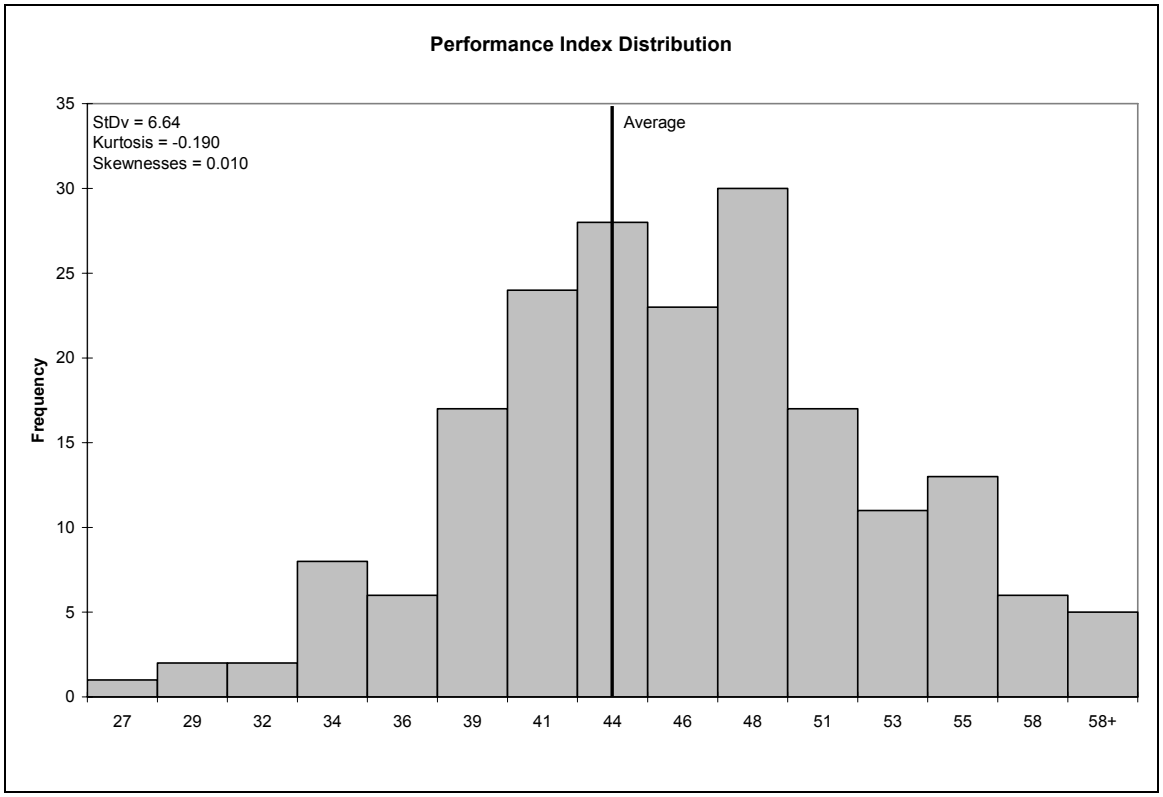

Figure 26. Performance Index Distribution

The average score was 44 and the observed range was 27 to 60. The distribution was normal based on the low kurtosis and slight positive skewness. Highly skewed (greater than 3) or highly kurtosis (between 8 and 20) distributions require non-parametric statistical techniques (Kline 1998). The normality of the distribution was tested in SPSS by the Kolmogorov-Smirnov goodness-of-fit test and found to be non-

significant meaning that the distribution was normal. These performance scores were the dependent variable used to determine how different factors influenced performance. In addition to the performance indicator, the sales, employment and production data were combined in various ratios to provide an overall measure of production efficiency, sales efficiency, and revenue per output for the respondents. Comparison of performance on these three additional performance variables was conducted in some instances. In the next section, a description of the statistical procedures and tests that were utilized for each factor (i.e. organization, geography, technology, tactics, and strategy) is presented.

Organizational Factor

Hardwood lumber producers could be vertically integrated organizations in that they own forestland, logging, sawmill, kiln drying, and secondary manufacturing operations. The degree of vertical integration within the eastern hardwood lumber industry was measured by asking companies to identify their auxiliary operations. The most frequently cited operations were dry kilns (60%), surfacing mills (49%), trucking operations (48%), forest holdings (46%), and logging operations (30%). Vertically integrated firms were hypothesized to perform better than non-vertically integrated firms (Hypothesis 11). In order to compare performance between these firm types the vertical integration dimension within the data had to be confirmed and then the firms had to be classified. A correspondence analysis was used to identify the integration dimension.

Correspondence analysis is a data reduction technique used to identify factors from categorical data. The categorical data for the auxiliary operations was input into SPSS and analyzed. A two factor solution was generated which represented backward integration (Factor 2) with forest holdings and logging operations loading onto this factor (shown in bold) and not loading onto the first factor. The first factor represented forward integration (Factor 1) with dry kilns, surfacing mill and dimension manufacturing loading on to this factor (shown in bold) as shown in Table 17.

Table 17. Factors Loadings for Auxiliary Operation Variables

	Factor	
Operations Variable	1 "Forward Integrated"	2 "Backward Integrated"
Forest Holdings	.036	**.464**
Logging Operations	.003	**.408**
Dry Kilns	**.434**	.025
Planer/Surfacing Mill	**.540**	.003
Trucking Operations	.118	.132
Dimension Manufacturing	**.447**	.154
Pallet Manufacturing	.089	.049
Treating Facility	.021	.066
Concentration Yard	.280	.025
Cogeneration Boiler	.212	.009
Flooring Manufacturing	.210	.069
Other Secondary Manufacturing	.198	.008
Pellet Manufacturing	.001	.114
Distribution Facilities	.238	.003
Mulch Coloring Operation	.056	.004
Other	.001	.006

The dimension manufacturing variable and the other operational variables were dropped from further use as classifiers as they were used by a small percentage of respondents (20% or less) and they didn't correlate highly (above 0.4) with the factors. Dimension manufacturing didn't discriminate either backward or forward integration as well as the other variables because it loaded onto the second factor and the first factor. The two factors represented firms that were backward integrated and forward integrated. A third and fourth possible level of vertical integration was constructed consisting of those companies who were both backward and forward integrated and those who weren't integrated at all. Each company was then classified depending upon their yes or no responses as backward integrated, forward integrated, backward and forward integrated or not integrated. An analysis of variance (ANOVA) was conducted with the performance scores as the dependent variable and the categories as the independent variable.

Three other organizational related performance comparisons were possible with the data that was collected. Two types of firms were identified in the mail questionnaire: those with a single sawmill and those with multiple sawmills. Firms were classified as either belonging to the National Hardwood Lumber Association (NHLA) or not. The firm type and membership type comparisons were made using a t-test. The last comparison was of firm size and performance. Respondents were classified into five groups based on their reported production volume and then the group means were compared with an ANOVA.

Geographic Factor

During the theoretical development (Chapter 1), Hypothesis 5 (H5) was developed and stated hardwood lumber producers who are geographically diversified perform better than those firms who have geographically limited operations. Companies with at least one mill in two different regions were to be considered geographically diversified. The responses to the mail survey indicated that only 4 companies had mills in more than one region. Therefore, H5 couldn't be tested due to a lack of mills with this requisite characteristic. In lieu of the planned test, a comparison of performance between mills in the Appalachian, Southern, and Northern regions was conducted. The performance scores of firms in each region were compared using ANOVA.

Production Technology Factor

Firms were initially classified into two categories based on their yes or no responses of utilizing production technologies: high technology users or low technology users. Firms who indicated that they used all of the following: optimized headrigs, optimized edgers and optimized trimmers were considered high technology users. This classification was warranted given the frequency of companies utilizing optimized headrigs (49%), optimized edgers (26%) and optimized trimmers (13%). These three technologies were the main lumber manufacturing technologies and were also rated important to performance. The performance scores of firms in each category were compared using ANOVA.

The number of firms classified as high technology users was low with only 18 out of 197 firms utilizing all three technologies. This classification didn't adequately capture the diversity of responses and adoption levels by responding firms. For example, some

firms didn't utilize all three technologies and only utilized only one or two of them. Therefore, a cluster analysis was conducted to identify homogeneous groups within the results. A two-step cluster analysis was used because of the categorical data type and the large sample size. All seven production technology variables were analyzed and a 3 cluster solution was identified. The homogeneity of responses within the clusters was low and the practical rationale of the clusters was confusing. Therefore, another cluster analysis was conducted with only 3 production technology variables: optimized headrig, optimized edger, and optimized trimmer. A four cluster solution based on these three variables is shown Table 18.

Table 18. Cluster Analysis of Production Technology Users

	Use Optimized Headrig				Use Optimized Edger				Use Optimized Trimmer			
	No		Yes		No		Yes		N		Y	
Cluster	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
1 (n=32)	5	16%	27	**84%**	0	0%	32	**100%**	32	**100%**	0	0%
2 (n=26)	4	15%	22	**85%**	6	23%	20	**77%**	0	0%	26	**100%**
3 (n=48)	0	0%	48	**100%**	48	**100%**	0	0%	48	**100%**	0	0%
4 (n=92)	92	**100%**	0	0%	92	**100%**	0	0%	92	**100%**	0	0%

This 4 cluster solution provided both high homogeneity within the clusters and a practical interpretation of the results. All Cluster 1 firms utilized optimized edgers and most used optimized headrigs but none used optimized trimmers. All cluster 2 firms utilized optimized trimmers and most but not all used the other two technologies. All firms in cluster 3 utilized optimized headrigs but none used optimized edgers or trimmers. Firms in cluster 4 didn't utilize any of these advanced production technologies. A cluster variable was generated by SPSS and this represented the firm's membership in a particular cluster. This variable was used in ANOVA as the independent variable to compare performance means between groups.

Information Technology Factor

For information technology, firms who indicated that they used one or more of the log, lumber, or inventory measurement information technologies listed were considered high technology level firms. This classification was warranted given the results in Chapter 3 which show that these technologies were important to firm performance and a large majority of firms already utilized email and the Internet and therefore these technology variables weren't useful for classifying firms. A two-step cluster analysis was also conducted to identify homogeneous clusters and verify the classification utilized. A 7 cluster solution based on the computer based log tallying, lumber tallying, and inventory control variables was identified in SPSS (Table 19).

Table 19. Cluster Analysis of Information Technology Users

	Use CB Log Tallying				Use CB Lumber Tallying				Use CB Inventory Control			
	N		Y		N		Y		N		Y	
Cluster	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
1 (n=63)	0	0%	63	**100%**	0	0%	63	**100%**	0	0%	63	**100%**
2 (n = 36)	0	0%	36	**100%**	0	0%	36	**100%**	36	**100%**	0	0%
3 (n = 13)	5	38%	8	62%	13	**100%**	0	0%	0	0%	13	**100%**
4 (n = 13)	0	0%	13	**100%**	13	**100%**	0	0%	13	**100%**	0	0%
5 (n = 50)	50	**100%**	0	0%	50	**100%**	0	0%	50	**100%**	0	0%
6 (n = 13)	13	**100%**	0	0%	0	0%	13	**100%**	13	**100%**	0	0%
7 (n = 15)	15	**100%**	0	0%	0	0%	15	**100%**	0	0%	15	**100%**

The cluster analysis identified 7 homogeneous groups based on these three variables. All of the groups except cluster 5 utilized some combination of either computer based log tallying, lumber tallying or inventory control. Cluster 5 firms didn't utilize any of these three information technologies and this cluster was the same size (n=50) as the low tech group utilizing the initial classification (Table 36). This meant that the initial classification and the cluster analysis were in agreement. Cluster 1 had 63 firms that utilized all three information technologies. These results indicated that firms had adopted varying levels of information technology and that a slight majority (56%) utilized two or more of these technologies. The performance scores and performance ratios of high and low information technology firms were compared utilizing ANOVA.

Marketing Tactics Factor

In the theoretical development section, three hypotheses (H8, H9, & H10) were proposed and stated a positive relationship existed between product, customer and promotion diversification and firm performance of hardwood lumber manufacturers. The null hypothesis was that these three variables were not related to firm performance. In order to determine this, a linear regression analysis was conducted. The amount of variance of the dependent variable (performance score) explained by each of the independent variables (R^2) was determined. The independent variables entered the model and an ANOVA was used to determine if the independent variables explained a significant portion of the variance in the dependent variable.

First, the diversification level of each firm on each marketing mix variable was computed. This measure was computed by using the following measure of diversification adapted from Palepu (1985) which was also used by Booth and Vertinsky (1991).

$$D = \sum P_i * \ln(1 / P_i)$$

Where:

D = diversification

P_i = share of ith segment

ln = natural log

i = segment or category

This computation was conducted for species, product type and grade mix in the product category and for distribution channels and promotion expenditures. This measure of diversification increased as the firm has more types of products, distribution channels, or promotion venues. The minimum diversification value is zero and it is reached when a firm had all of its products, distribution channels or promotions in one segment. The maximum diversification was reached when the firm's sales or production were equally distributed among all possible segments. For example, if a company had their production split equally among 10 species their total diversification would be 2.302 whereas a company with their production split equally among 3 species would be 1.0986.

The mean diversification score, adjusted R^2, and significance level for each marketing mix variable are shown in the results section.

In addition to testing for a relationship between marketing mix diversification and firm performance, a comparison of firm performance between different groups based on a firm's market mix was also conducted. Firms were grouped utilizing two-step cluster analysis for each of the following marketing mix variables: product type, species mix, grade mix, and distribution channel. Promotion expenditures were not able to be clustered due to the low proportion of firms reporting this information or having these expenditures. The values shown in bold are the largest in that category and serve as a basis for interpretation and description of the clusters. A cluster variable was generated for each cluster analysis and then an ANOVA was conducted to detect differences between groups on performance scores and ratios for each marketing mix variable. The cluster profiles for each variable are presented next.

Table 20. Cluster Analysis of Firms based on Proportions of Product Type Sold

Cluster	N	Rough Green Grade Lumber Percent	Rough Air-Dried Grade Lumber Percent	Rough Kiln-Dried Grade Lumber Percent	Planed Kiln-Dried Grade Lumber Percent	Pallet Cants & Lumber Percent	Railway Ties Percent
1 "green"	116	**59.1**	**4.2**	2.1	0.7	**24.7**	**8.2**
2 "dry"	87	14.8	0.9	**46.0**	**13.7**	16.1	2.4

As shown in Table 20, Cluster 1 mainly sold rough green grade lumber and pallets cants and lumber in 2007. Cluster 2 mainly sold rough kiln dried grade lumber and nearly equal parts rough-green and planed kiln-dried grade lumber and pallets cants and lumber. The performance of these two clusters was compared with ANOVA in the results section.

A cluster analysis on the grade mix variable was conducted next. The custom graded and un-graded variables were excluded due to the low percentage of lumber produced in these categories. A two cluster solution was identified by SPSS (Table 21).

Table 21. Cluster Analysis of Firms based on Lumber Grade Type Produced

Cluster	N	FAS Percent	Select & Better Percent	1 Common Percent	2 Common Percent	3 Common Percent	Framestock Percent
1 "lower grade"	98	7.2	**17.5**	20.4	**22.1**	**13.0**	**6.6**
2 "higher grade"	87	**28.8**	6.7	**32.8**	19.1	7.8	3.0

The firms in cluster 1 had a relatively low percentage of lumber production in the upper grades and a lumber grade distribution that was skewed toward the lower grades. Cluster 1 firms also had a higher percent of ungraded lumber (11%) as compared to cluster 2 firms (1%). The firms in cluster 2 had higher proportions of lumber production in the upper grades and a lumber grade distribution that was skewed toward the upper grades. The performance of these two clusters was compared with ANOVA.

A cluster analysis on the distribution channel variable was conducted next. A three cluster solution was identified by SPSS (Table 22).

Table 22. Cluster Analysis of Firms based on Distribution Channel Sales

Cluster	N	Concentration Yard Percent	Wholesale Distributors Percent	Retail Operations Percent	Manufacturers Percent	Exported Percent
1 "intermediaries"	106	**34.6**	**33.3**	1.9	20.3	1.7
2 "exporters"	34	13.5	14.2	**14.4**	20.5	**36.1**
3 "manufacturers"	59	7.2	8.7	1.6	**76.3**	5.8

Cluster 1 firms distributed their lumber mainly through concentration yards and wholesale distributors with the remainder going to manufacturers. Firms in cluster two exported 36% of their lumber sold in 2007, then 20% went to manufacturers, and nearly equal proportions went to the other three distribution channels. This cluster had a large proportion of their lumber sales to retail operations. Firms in the third cluster sold 76% of their lumber directly to manufacturers and nearly equal parts going to concentration yards, wholesale distributors and exports. The performance of these three clusters was compared with ANOVA.

A cluster analysis on the species mix variable was conducted next. A three cluster solution was identified by SPSS (Table 23).

Table 23. Cluster Analysis of Firms based on Species Mix

	Cluster		
Species	1 "Northern Hardwoods"	2 "Appalachian Hardwoods"	3 "Southern Hardwoods"
N	66	105	16
Red Oak Percent	15.0	**32.6**	14.4
White Oak Percent	3.9	**18.2**	8.4
Yellow Poplar Percent	1.9	**18.0**	4.3
Hard Maple Percent	**33.3**	5.0	1.0
Soft Maple Percent	**15.6**	3.3	1.6
Black Cherry Percent	**10.9**	2.2	0.9
Ash Percent	**6.1**	3.9	2.8
Black Walnut Percent	0.4	2.3	**8.4**
Aspen Percent	3.2	0.2	0.0
Basswood Percent	2.7	0.8	0.0
Beech Percent	0.6	0.9	0.1
Hickory Percent	0.7	3.6	**13.1**
Birch Percent	**4.6**	0.6	0.1
Gum Percent	0.0	1.4	**12.8**
Other Species Percent	1.1	2.3	**32.0**

Cluster 1 firms produced mainly hard maple, soft maple, red oak, black cherry, ash, and birch. Firms in cluster 2 produced mainly red oak, white oak, and yellow poplar. Companies in the third cluster produced other species, red oak, hickory, gum and black walnut. The performance of these three clusters was compared with ANOVA.

Strategy Factor

The first hypothesis that was developed (H1), stated that firms with a focus or differentiation strategy perform better than firms with a cost leadership strategy. The measurement of business strategy was conducted by utilizing the focal business area variables developed by Bush (1989). These variables were designed to be an operationalization of Porter's three generic strategies (differentiation, focus and cost leadership). Firms rated the importance of each variable from 1 (not important) to 7 (very important) and these variables are shown in Appendix E. Mail Questionnaire. The importance ratings for all respondents were used in a factor analysis.

Factor analysis is a data reduction technique used to find latent dimensions or components (i.e.: factors) within a large number of variables. Variables that are related to the same factor will be highly correlated with each other and load onto that factor more so than other factors. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.897 which indicated that the correlation matrix was suitable for factor analysis. Bartlett's Test of Sphericity was also significant (<0.01) which indicated that the variables in the correlation matrix were related and hence suitable for factor analysis. The variable abbreviations (Table 24) and correlation matrix between each variable is shown in Table 25.

Table 24. Business Area Variable Abbreviations

Developing new products (DNP)	Serving special geographic markets (SSGM)
Providing customer service (PCS)	Ability to manufacture specialty products (AMSP)
Efficient operation of production facilities (EOPF)	Promotion and advertising (PA)
Product quality control (PQC)	Maintaining a company sales force (MCSF)
Employing trained/experienced personnel (ET/EP)	Owning timberlands and/or logging operations (OTLO)
Competitive pricing (CP)	Providing rapid delivery (RD)
Developing brand identification (DBI)	Market research (MR)
Using new marketing techniques/methods (NMT/M)	Investment in new processing equipment (INPE)
Controlling channels of distribution (CCD)	Serving particular customer groups (SPCG)
Procurement of raw materials (PRM)	Reputation within industry (RWI)

Table 25. Correlation Matrix of Business Area Variables

	DNP	PCS	EOPF	PQC	ET/EP	CP	DBI	NMT/M	CCD	PRM	SSGM	AMSP	PA	MCSF	OTLO	RD	MR	INPE	SPCG	RWI
DNP	1.000																			
PCS	.268	1.000																		
EOPF	.216	.413	1.000																	
PQC	.175	.655	.485	1.000																
ET/EP	.220	.412	.428	.500	1.000															
CP	.194	.226	.290	.301	.314	1.000														
DBI	.396	.314	.147	.280	.204	.135	1.000													
NMT/M	.522	.305	.213	.208	.226	.323	.588	1.000												
CCD	.403	.181	.160	.116	.270	.343	.468	.569	1.000											
PRM	.118	.307	.456	.385	.480	.378	.159	.147	.250	1.000										
SSGM	.382	.163	.213	.184	.223	.325	.404	.494	.578	.289	1.000									
AMSP	.407	.356	.273	.282	.301	.221	.318	.425	.321	.342	.446	1.000								
PA	.416	.151	.051	.118	.180	.321	.356	.589	.484	.156	.454	.399	1.000							
MCSF	.420	.298	.150	.202	.304	.301	.499	.552	.569	.201	.419	.319	.580	1.000						
OTLO	.058	.151	.152	.161	.134	.210	.064	.137	.198	.245	.004	.086	.253	.251	1.000					
RD	.253	.483	.359	.537	.409	.314	.306	.392	.332	.329	.322	.369	.349	.398	.225	1.000				
MR	.434	.305	.071	.285	.173	.257	.418	.618	.549	.179	.478	.429	.608	.546	.191	.442	1.000			
INPE	.334	.308	.201	.239	.306	.252	.375	.443	.438	.227	.361	.308	.441	.550	.244	.514	.505	1.000		
SPCG	.299	.354	.142	.259	.219	.315	.291	.415	.386	.200	.437	.363	.325	.354	.120	.471	.484	.485	1.000	
RWI	.157	.634	.382	.618	.356	.261	.304	.240	.139	.409	.204	.245	.147	.249	.198	.434	.238	.300	.366	1.000

SPSS was utilized to conduct the factor analysis where the correlation matrix was analyzed with the principal components extraction method. A three factor solution was chosen beforehand in order to identify the variables associated with the differentiation, focus and cost leadership strategies. Prior to the three factor solution a factor analysis based on a minimum eigenvalue of 1 and with unrestricted number of factors resulted in a four factor solution with only one variable loading onto the fourth factor. Given the similarity between the two solutions and that the three factor solution explained 55% of the variance within the data; the three factor solution was utilized. Furthermore, the scree plot indicated that a three factor solution adequately accounted for the variability within the data. The component matrix was rotated with varimax rotation which is the most common type of rotation (Garrison 2008b). This technique was utilized to interpret factor loadings easier. The component loadings, which are the correlation coefficient between the variable and factor, are shown in Table 26.

Table 26. Factor Loadings of Business Area Variables

	Component (Factor)		
Business Area Variable	1	2	3
Developing brand identification (DBI)	**0.658**	0.255	-0.163
Using new marketing techniques/methods (NMT/M)	**0.809**	0.142	0.045
Controlling channels of distribution (CCD)	**0.724**	0.000	0.313
Developing new products (DNP)	**0.642**	0.160	-0.073
Serving special geographic markets (SSGM)	**0.667**	0.112	0.161
Ability to manufacture specialty products (AMSP)	**0.516**	0.338	0.070
Promotion and advertising (PA)	**0.735**	-0.059	0.288
Maintaining a company sales force (MCSF)	**0.721**	0.108	0.247
Market research (MR)	**0.783**	0.126	0.095
Investment in new processing equipment (INPE)	**0.604**	0.229	0.233
Serving particular customer groups (SPCG)	**0.555**	0.306	0.073
Reputation within industry (RWI)	0.164	**0.768**	0.067
Providing customer service (PCS)	0.241	**0.804**	-0.061
Efficient operation of production facilities (EOPF)	0.032	**0.630**	0.306
Product quality control (PQC)	0.116	**0.843**	0.085
Providing rapid delivery (RD)	0.422	**0.557**	0.211
Employing trained/experienced personnel (ET/EP)	0.154	**0.576**	0.365
Procurement of raw materials (PRM)	0.072	0.484	**0.586**
Owning timberlands and/or logging operations (OTLO)	0.094	0.055	**0.654**
Competitive pricing (CP)	0.264	0.220	**0.606**

The largest values (shown in bold) of each variable was allotted to one factor and no other factor. The interpretation of each factor is based upon all of the variables that

load onto it. The first component was interpreted as the differentiation strategy since marketing and specialty business area variables loaded onto it. The second component was interpreted as the focus strategy since these variables are core functions of a hardwood sawmill and were similar to Bush's (1989) focus factor. The third component was interpreted as cost leadership since the competitive pricing and procurement of raw materials variables loaded onto it. Firms that employed this strategy compete upon price and place importance upon raw material costs which are the largest cost of a sawmill. These component loadings are similar to those found by Bush (1989) with only minor differences. A comparison of changes in strategy over time was conducted in Chapter 5.

The factor analysis generated standardized factor scores which are the scores of each firm on each of the three factors. These standardized factor scores had a total mean of zero and a standard deviation of 1. These factor scores were analyzed utilizing cluster analysis to identify strategic groups. Hierarchical cluster analysis was used with the Ward method and squared Euclidean distance as the measure. A range of cluster solutions from 2 to 6 was chosen for this clustering method. The cluster variables that were generated were then analyzed by comparing means. The cluster variables were the independent variables and the factor scores were the dependent variables. A four cluster solution was found to adequately classify firms between different strategic orientations (Table 27).

Table 27. Factor Scores for the Strategic Clusters

Cluster	Statistic	Differentiation Score	Focus Score	Cost Leadership Score
1 (n = 83)	Mean	**0.548**	0.071	-0.144
	Std. Deviation	0.611	0.714	0.522
2 (n = 43)	Mean	-1.018	0.175	**0.825**
	Std. Deviation	0.572	0.745	0.526
3 (n = 24)	Mean	**0.962**	0.172	**1.135**
	Std. Deviation	0.618	0.34	0.304
4 (n = 45)	Mean	-0.51	**0.111**	-1.088
	Std. Deviation	0.921	0.768	0.752

Positive factor scores denoted that the firms in that cluster rated the variables important that loaded onto that factor and negative factor scores indicated that the firms in that cluster rated the variables not important that loaded onto that factor. The

magnitude, direction (positive/negative) and pattern of means on all three strategic factors were interpreted to infer the strategic orientation of that cluster. The four clusters each represented a distinct strategic orientation. Cluster 1 had a high mean differentiation score and low scores on the other two strategic factors. Firms in this cluster were considered to be employing a differentiation strategy. Cluster 2 firms had a high mean cost leadership score and a highly negative differentiation score and a low focus score. Firm in this cluster were considered to be employing a cost leadership strategy. Firms in the third cluster were found to be utilizing a differentiation and cost leadership strategy due to the high positive mean scores on both factors. The final cluster of firms was interpreted to be utilizing a focus strategy since they scored negatively on both differentiation and cost leadership but positive on the focus factor. A cluster variable was generated by SPSS and this was utilized as the dependent variable. The performance of these strategic groups was then compared utilizing ANOVA.

Results & Discussion

The results were grouped by each factor and were in order as presented in the methods section. The first set of results was for the organizational factor.

Organizational Factor

A one-way ANOVA of the vertical integration level of hardwood lumber companies was significant with a p-value of 0.042. The backward integrated firms had the highest performance score mean at 47.7 and non-integrated companies had the lowest performance score mean at 43.7 (Table 28).

Table 28. Vertical Integration Performance Score Post-Hoc Comparison

Integration Level	Performance Mean	N	Std. Deviation	Mean Differences*
Backward	47.7	18	7.39	A
Backward & Forward	47.0	18	7.42	A
Forward	43.9	60	6.36	B
Not Integrated	43.7	101	6.78	B
* Means with same letter are not significantly different.				
LSD (alpha 0.05)				

Since the ANOVA found a significant difference, the means were compared with Fisher's LSD post comparison tests. The LSD showed a difference in performance between the backward and backward & forward firms and the forward and not integrated firms. These results suggested that the first group of firms performed better than the latter group. This evidence strongly supported the hypothesis (H11) which stated that vertically integrated firms performed better than non-vertically integrated firms and therefore H11 was accepted. The results indicated that backward integrated and backward and forward integrated firms performed better than non-integrated or forward integrated firms. The backward integration may allow firms to control log costs which are a critical component of a sawmill's total cost.

The performance scores of single sawmill (SS) firms were compared to multiple sawmill (MS) firms using a t-test. The latter firms performed better than the single

sawmill companies. A p-value of 0.072 was weak evidence for a significant difference between the two firm types (Table 29).

Table 29. Firm Type & Performance Score T-test

Firm Type	N	Performance Mean	Std. Deviation	p-value
Single Sawmill	157	44.0	6.69	0.072
Multiple Sawmill	39	46.2	7.39	

These results indicated that multiple sawmill firms did perform better however; the statistical significance was relatively weak. The multiple sawmill firms had on average three sawmills. These companies may have greater economies of scale and more bargaining power over suppliers and customers.

The performance scores of NHLA members were compared to non-members using a t-test. Members of the NHLA reported higher firm performance scores as compared to non members (Table 30).

Table 30. Membership Type & Performance Score T-test

Membership Type	N	Performance Mean	Std. Deviation	p-value
NHLA Member	172	45.1	6.50	<0.01
Non-Member	25	40.3	7.91	

NHLA member companies had significantly higher performance scores than non-members. One explanation for the NHLA member companies' higher performance was that they were more efficient in production, sales, and revenue per output than non member companies. The non-member firms were smaller as compared to NHLA firms and this suggested that there were some economies of scale advantages in the industry. It was likely that NHLA membership was also a proxy for a long term commitment to producing hardwood lumber whereas non-members could enter and exit lumber production more readily.

Responding companies were grouped based on their production volume. The groups were then compared utilizing an ANOVA and it was significant with a p-value of 0.024 (Table 31).

Table 31. Firm Size & Performance Score Post-Hoc Comparison

Firm Size	N	Performance Score Mean	Std. Deviation	Mean Differences	
0 - 0.99 MMBF	18	40.7	7.9	A	
1 - 4.99 MMBF	51	43.8	7.1	A	B
5 - 9.99 MMBF	60	44.9	6.0	A	B
10 - 19.99 MMBF	32	46.4	6.3		B
20 + MMBF	36	46.1	5.8		B
Means with the same letter are not significantly different.					
Tukey's (alpha 0.5)					

The smaller firms, who produced less than 1 million board feet, had the lowest performance score at 40.7. These firms were significantly different than firms in the two largest groups. The firms in the two largest groups had the highest performance scores. These results showed that larger firms performed better than smaller firms. This again suggested that there are some economies of scale within the industry. These results suggested that large firms are more competitive than small firms. As competitive pressures increase, this could lead to fewer sawmills who are larger in size.

Geographic Factor

As was stated in the methods, the responses to the mail survey indicated that only 4 companies had mills in more than one region. Therefore, Hypothesis 5 couldn't be tested due to a lack of mills with these requisite characteristics. In lieu of the planned test, a comparison of performance between mills in the 3 different regions was conducted. The performance scores of firms in each region were compared using ANOVA as shown in Table 32.

Table 32. Geographic Region Performance Score ANOVA

Region	Performance Mean	N	Std. Deviation	p-value
Appalachian	45.2	107	6.66	0.322
Northern	43.8	60	6.26	
Southern	43.4	24	8.65	

The performance means between the three groups were not significantly different. These results suggested that performance doesn't vary that greatly from region to region.

Hardwood lumber producers in a given region were able to perform just as effectively as those in other regions despite differences in forest resources and species availability.

Production Technology Factor

The performance scores of firms who utilized all of the following: optimized headrigs, optimized edgers and optimized trimmers were higher than firms who didn't use these technologies as shown in Table 33.

Table 33. Production Technology Level & Performance Score ANOVA

Production Technology Level	Performance Mean	N	Std. Deviation	p-value
High	48.1	18	6.12	0.02
Low	44.1	179	6.84	

These results indicated that firms who utilized all three advanced production technologies performed better than those who didn't use advanced production technology. These results provided strong evidence for the support of Hypothesis 6. These results were further corroborated by comparing the high and low technology firms on the three additional measures of performance measured in the survey: production efficiency, sales efficiency and revenue per output (Table 34).

Table 34. Production Technology Level & Performance Ratio ANOVA

Production Technology Level		Sales Per Employee ($Million/employee)	Volume Per Employee (Million board feet/employee)	Sales Per Volume (dollar/board foot)
High	Mean	0.234	0.202	1.386
	N	17	17	17
	Std. Deviation	0.073	0.092	0.870
Low	Mean	0.188	0.226	1.008
	N	154	180	152
	Std. Deviation	0.098	0.123	0.735
	p-value	0.061	0.439	0.050

The results indicated that firms who utilized all of the following: optimized headrigs, optimized edgers and optimized trimmers had significantly higher sales per

employee and sales per volume. There wasn't a significant difference between high and low tech firms in volume per employee and low technology firms had a higher average ratio. These results indicated that high tech firms captured more value of their products by utilizing advanced production technology.

As stated in the methods section, the number of firms classified as high technology users was low with only 18 out of 197 firms meeting the criteria. This classification didn't adequately capture the diversity of responses and adoption levels by responding firms. For example, most firms didn't utilize all three technologies and only utilized only one or two of them. Therefore, a cluster analysis was conducted to identify homogeneous groups within the responses. A four cluster solution based on the optimized headrig (OH), optimized edger (OE), and optimized trimmer (OT) variables was identified (Table 18). The four clusters were as follows: cluster 1 were firms with OH and OE but not OT; a majority of cluster 2 firms had OH, OE and OT; cluster 3 firms had OH only and cluster 4 firms had no OH, OE or OT. These clusters were compared on performance scores and performance ratios as shown in Table 35.

Table 35. Production Technology Clusters & Performance ANOVA

Performance Variable	Cluster	N	Mean	Std. Deviation	p-value
Performance Score	1 "OH & OE"	31	45.1	6.95	0.635
	2 "OH, OE, & OT"	23	43.6	5.30	
	3 "OH only"	47	45.5	6.59	
	4 "No Tech"	87	44.1	7.59	
Sales Per Employee ($Million/employee)	1 "OH & OE"	25	0.191	0.11	0.268
	2 "OH, OE, & OT"	21	0.232	0.098	
	3 "OH only"	43	0.191	0.080	
	4 "No Tech"	73	0.184	0.102	
Volume Per Employee (Million board feet/employee)	1 "OH & OE"	31	0.234	0.1050	0.144
	2 "OH, OE, & OT"	24	0.208	0.108	
	3 "OH only"	46	0.251	0.133	
	4 "No Tech"	86	0.205	0.111	
Sales Per Volume (dollar/board foot)	1 "OH & OE"	24	0.932	0.485	0.319
	2 "OH, OE, & OT"	22	1.188	0.858	
	3 "OH only"	41	0.911	0.400	
	4 "No Tech"	73	1.137	0.947	

These results showed no significant difference between the performance means of the four clusters. While not significant, cluster 2 firms had the highest sales efficiency and revenue per output. Cluster 2 (OH, OE & OT) firms had the lowest mean performance score and cluster 4 (No Tech) firms had the lowest sales and production efficiency. These results indicated that firms who hadn't adopted advanced production technology performed just as well as firms who had adopted some or all of this technology. Due to the high cost of these advanced production technologies, high tech firms may be burdened with large debt payments which could hinder their performance. This contrasted the results from the earlier technology classification and performance comparison which showed high tech firms performed better.

These conflicting results prohibited the acceptance of Hypothesis 6 which stated that firms with advanced production technology perform better than firms without this

technology. Firms that have adopted this technology must ensure that they are utilizing it to it fullest potential. An examination of the differences between the first production technology classification and the second production technology classification revealed that 4 firms in cluster 2 didn't utilize optimized headrigs and 6 firms in cluster 2 didn't utilize optimized edgers. The inclusion of these firms in cluster 2 of this second classification reduced the performance score mean from 48.1 to 43.6. These firms that utilized optimized trimmers but not optimized headrigs and edgers performed poorly. It is recommended that these firms adopt optimized headrigs and edgers in order to improve their performance. These results demonstrated that higher performance is associated with use of all three production technologies. However, the results from the second classification indicated that low tech firms performed just as good as high tech firms.

Information Technology Factor

The performance scores and performance ratios of high information technology and low information technology firms were compared utilizing ANOVA. Firms comprising the high technology category (Clusters 1, 2, 3, 4, 6, & 7) utilized one or more of the computer based log tallying, lumber tallying or inventory control information technologies. Firms comprising the low technology category (Cluster 5) didn't utilize any of these information technologies. The results of this comparison are shown in Table 36.

Table 36. Information Technology Level & Performance ANOVA

Information Technology Level	Statistic	Performance Score	Sales Per Employee ($Million/employee)	Volume Per Employee (Million board feet / employee)	Sales Per Volume (dollar / board foot)
High	Mean	45.2	0.209	0.220	1.178
	N	147	126	145	126
	Std. Deviation	6.61	0.098	0.105	0.808
Low	Mean	42.3	0.144	0.237	0.651
	N	50	44	51	42
	Std. Deviation	7.21	0.077	0.158	0.365
	p-value	0.01	<0.01	0.384	<0.01

The results showed that high information technology firms had significantly higher performance than low technology firms on nearly every measure. The firms didn't significantly differ on the volume per employee performance ratio. The results provided strong evidence for the acceptance of Hypothesis 7. From these results, it can be concluded that firms that utilized either computer based log tallying, lumber tallying, or inventory control performed better than those that did not use these technologies. The implications of these results are that firms should adopt these technologies in order to improve their performance. Logs and lumber are sawmill's most costly and valuable inputs and outputs and therefore, being able to identify and track these materials is of vital importance to sawmill performance.

Marketing Tactics Factor

Linear regression was conducted to see if a positive relationship existed between product, customer and promotion diversification and firm performance. The mean diversification score, adjusted R^2, and significance level for each marketing mix variable are shown in Table 37.

Table 37. Marketing Mix Diversification & Performance Correlation

Diversification Variable	Mean	Std. Deviation	N	Adjusted R^2	Significance
Product Type Diversification	0.832	0.393	194	0.002	0.233
Species Diversification	0.324	0.190	166	-0.004	0.537
Grade Diversification	1.352	0.364	178	-0.004	0.573
Distribution Channel Diversification	0.749	0.435	191	-0.004	0.629
Promotion Expenditure Diversification	0.543	0.528	121	0.026	0.043

Lumber grade had the highest mean diversification followed by product type and distribution channel. Species diversification was the lowest of the variables. The marketing mix diversification variables explained essentially none of the variance in the performance score dependent variable as shown by the low adjusted R^2 values. These diversification variables were not significantly related to firm performance with the exception of promotion expenditures. This latter variable did significantly increase the amount of dependent variable variance that it explained. The promotion expenditure diversification variable was positively correlated ($r = 0.185$) with performance scores meaning that performance increased as promotion expenditure diversification increased.

These results indicated that diversification of a firm's marketing mix was generally not related to their performance with the notable exception of promotion expenditure. Promotion expenditure diversification was positively correlated with performance. Therefore, Hypothesis 8 and 9 were rejected and Hypothesis 10 which stated that promotion diversification is positively related to performance was accepted. Hardwood lumber sawmills should diversify their promotion expenditures in order to target new customers and increase their performance.

Firms were grouped utilizing two-step cluster analysis for each of the following marketing mix variables: product type, species mix, grade mix, and distribution channel. A cluster variable was generated for each cluster analysis and then an ANOVA was conducted to detect differences between groups on performance scores and ratios for each marketing mix variable. The cluster analysis generated a two cluster solution for the product type variable (Table 20). The first cluster, labeled green, sold mainly rough green grade lumber and the second cluster, labeled dry, mainly sold rough kiln dried lumber. The ANOVA between these two clusters is shown in Table 38.

Table 38. Product Type Clusters & Performance ANOVA

Performance Variable	Cluster	N	Mean	Std. Deviation	p-value
Performance Score	1 "green"	112	44.4	6.99	0.951
	2 "dry"	82	44.5	6.71	
Sales Per Employee ($Million/employee)	1 "green"	94	0.183	0.095	0.124
	2 "dry"	74	0.206	0.099	
Volume Per Employee (Million board feet/employee)	1 "green"	111	0.244	0.122	0.011
	2 "dry"	82	0.199	0.116	
Sales Per Volume (dollar/board foot)	1 "green"	92	0.775	0.368	<0.01
	2 "dry"	74	1.388	0.965	

The two clusters did not differ significantly on the performance score variable nor on the sales per employee ratio suggesting that firms in either cluster perform equally well despite differences in the product types that they sell. However, cluster 1 firms had significantly higher volume per employee ratios and cluster 2 firms had significantly

higher sales per volume ratios. Firms that sell mainly rough green grade lumber (cluster 1) had higher production efficiency than those firms that sell mainly rough kiln dried grade lumber. Firms in cluster 2 should focus on increasing the production efficiency associated with kiln drying lumber. Firms that sell mainly rough kiln-dried grade lumber (cluster 2) had higher revenue per output than those firms that sell mainly rough green grade lumber. Firms in cluster 1 should focus on increasing revenue per output associated with rough green grade lumber. These results suggested a tradeoff between production efficiency and revenue per output associated with the product type produced.

The cluster analysis generated a two cluster solution for the grade mix variable (Table 21). The first cluster (lower grade) produced comparatively lower grade and more ungraded lumber and the second cluster (higher grade) produced higher grade lumber and almost no ungraded lumber. The results of the ANOVA between these two clusters are shown in Table 39.

Table 39. Lumber Grade Mix Clusters & Performance ANOVA

Performance Variable	Cluster	N	Mean	Std. Deviation	p-value
Performance Score	1 "lower grade"	93	43.8	6.79	0.089
	2 "higher grade"	85	45.6	6.55	
Sales Per Employee ($Million/employee)	1 "lower grade"	83	0.193	0.107	0.866
	2 "higher grade"	71	0.195	0.089	
Volume Per Employee (Million board feet/employee)	1 "lower grade"	94	0.223	0.123	0.622
	2 "higher grade"	83	0.232	0.126	
Sales Per Volume (dollar/board foot)	1 "lower grade"	83	1.009	0.647	0.578
	2 "higher grade"	69	1.077	0.862	

Cluster 2 firms performed better than cluster 1 firms on all performance variables however the differences were not significant. The performance score comparison p-value was nearly significant (0.089) and provided weak evidence for a significant difference. These results suggested that firms in cluster 1, who had a lower grade lumber mix along with a large proportion of un-graded lumber, should increase their production of higher grade lumber in order to increase their performance. The results also reinforced the widespread industry perspective that hardwood sawmills must improve grade yield in

order to improve performance. Research and technology that improve grade yield will help to improve the performance of firms in the industry.

A cluster analysis resulted in the identification of a three cluster solution for the distribution channel variable (Table 22). Cluster 1 firms which were labeled intermediaries since they distributed their lumber mainly through concentration yards and wholesale distributors with the remainder going to manufacturers. Firms in cluster two which were labeled exporters since they exported 36% of their lumber sold in 2007, then 20% went to manufacturers, and nearly equal proportions went to the other three distribution channels. Firms in the third cluster which were labeled manufacturers since they sold 76% of their lumber directly to manufacturers and nearly equal parts going to concentration yards, wholesale distributors and exports. The performance of these three clusters was compared with ANOVA (Table 40).

Table 40. Distribution Channel Clusters & Performance ANOVA

Performance Variable	Cluster	N	Mean	Std. Deviation	p-value
Performance Score	1 "intermediaries"	101	44.1	6.59	0.768
	2 "exporters"	32	45.0	8.08	
	3 "manufacturers"	58	44.7	6.54	
Sales Per Employee ($Million/employee)	1 "intermediaries"	81	0.194	0.090	0.327
	2 "exporters"	31	0.214	0.122	
	3 "manufacturers"	52	0.180	0.093	
Volume Per Employee (Million board feet/employee)	1 "intermediaries"	100	0.230	0.115	0.647
	2 "exporters"	32	0.207	0.107	
	3 "manufacturers"	57	0.228	0.142	
Sales Per Volume (dollar/board foot)	1 "intermediaries"	80	1.000	0.761	0.309
	2 "exporters"	31	1.242	0.795	
	3 "manufacturers"	51	1.018	0.766	

The results indicated that there was no significant difference between the three clusters of firms. While not statistically significant, it was interesting to note that firms in cluster 2, who exported and retailed the highest proportion of their lumber of any cluster, had the highest sales per employee and sales per volume. This suggested that firms in

this cluster were able to capture more value from their lumber by utilizing these two distribution channels. These results indicated that firms perform equally well irrespective of the distribution channels utilized.

A cluster analysis identified a three cluster solution for the species mix variable (Table 23). Cluster 1 firms, labeled Northern hardwoods, produced mainly hard maple, soft maple, red oak, black cherry, ash, and birch. Firms in cluster 2, labeled Appalachian hardwoods, produced mainly red oak, white oak, and yellow poplar. Companies in the third cluster, labeled Southern hardwoods, produced other species, red oak, hickory, gum and black walnut. The performance of these three clusters was compared with ANOVA (Table 41).

Table 41. Species Mix Clusters & Performance ANOVA

Performance Variable	Cluster	N	Mean	Std. Deviation	p-value
Performance Score	1 "Northern hardwoods"	64	45.0	6.71	0.608
	2 "Appalachian hardwoods"	98	43.9	6.59	
	3 "Southern hardwoods"	16	44.2	9.34	
Sales Per Employee ($Million/employee)	1 "Northern hardwoods"	46	0.231	0.115	<0.01
	2 "Appalachian hardwoods"	92	0.172	0.084	
	3 "Southern hardwoods"	14	0.176	0.093	
Volume Per Employee (Million board feet/employee)	1 "Northern hardwoods"	60	0.230	0.100	0.898
	2 "Appalachian hardwoods"	104	0.221	0.133	
	3 "Southern hardwoods"	13	0.225	0.148	
Sales Per Volume (dollar/board foot)	1 "Northern hardwoods"	48	1.095	0.467	0.813
	2 "Appalachian hardwoods"	91	1.018	0.865	
	3 "Southern hardwoods"	13	1.123	1.126	

The three clusters did not perform significantly different on the performance variables except in the case of sales per employee. Cluster 1 performed significantly better than the other two clusters on this variable. Firms in this cluster produced large proportions of their lumber in species groups such as hard maple, soft maple and black cherry that were highly valued in the marketplace. The results also suggested that despite

differences in species mix across the eastern hardwood region, firms were able to compete and perform equally well.

Strategy Factor

The business area variables were reduced to three strategic factors. The factors scores were then clustered to identify strategic groups. The performance scores and performance ratios of the strategic clusters were then compared utilizing ANOVA (Table 42).

Table 42. Strategic Clusters & Performance ANOVA

Performance Variable	Cluster	N	Mean	Std. Deviation	p-value
Performance Score	1 "differentiation"	82	43.7	6.29	0.016
	2 "cost leadership"	43	43.9	7.31	
	3 "differentiation & cost leadership"	24	48.6	7.17	
	4 "focus"	43	43.9	6.90	
Sales Per Employee ($Million/employee)	1 "differentiation"	62	0.198	0.118	0.821
	2 "cost leadership"	37	0.196	0.089	
	3 "differentiation & cost leadership"	22	0.189	0.075	
	4 "focus"	40	0.179	0.083	
Volume Per Employee (Million board feet/employee)	1 "differentiation"	76	0.204	0.110	0.112
	2 "cost leadership"	43	0.260	0.163	
	3 "differentiation & cost leadership"	21	0.217	0.095	
	4 "focus"	45	0.217	0.095	
Sales Per Volume (dollar/board foot)	1 "differentiation"	61	1.218	0.928	0.219
	2 "cost leadership"	36	0.927	0.473	
	3 "differentiation & cost leadership"	23	1.029	0.625	
	4 "focus"	40	0.953	0.779	

There were significant differences between the strategic clusters on the performance score variable. Cluster 3, the differentiation and cost leadership strategic group, performed better than the other three clusters. The differences between the means of the other three performance variables were not statistically significant. Cluster 2, the cost leadership strategic group, performed the best (mean = 0.260) on the volume per employee performance variable. This result was logical since economies of scale provide firms with lower costs per unit and these firms have achieved that by employing the cost leadership strategy. Cluster 1, the differentiation strategic group, performed the best

(1.218) on the sales per volume performance variable. Again, this result was logical since more value can be captured by understanding customer needs and these firms have done that by employing the differentiation strategy. There were no large differences between groups on the sales per employee performance variable. These results do not provide evidence for acceptance of H1 which stated that firms with a differentiation or focus strategy perform better than firms with a cost leadership strategy and therefore the null hypothesis is accepted. The only strategy that performed significantly better was a combination of differentiation and cost leadership. The cost leadership and differentiation strategies perform well on performance variables that are aligned with their strategy. The implications of these results are that firms should employ both a differentiation and cost leadership strategy. By seeking to control costs and marketing their products effectively firms can gain competitive advantage.

Conclusions

The influence of firm controlled factors on performance yielded useful results. On the organizational factor, a number of findings were discovered. The statistical evidence strongly supported the hypothesis (H11) that vertically integrated firms performed better than non integrated firms and therefore H11 was accepted. The results indicated that backward integrated and backward and forward integrated firms performed better than non-integrated or forward integrated firms. The backward integration may allow firms to control log costs which are a critical component of a sawmill's total cost. The results from the company type comparison indicated that multiple sawmill firms performed better than single sawmill companies however; the statistical significance was relatively weak. These multiple sawmill companies may have greater economies of scale and more bargaining power over suppliers and customers. NHLA member companies had significantly higher performance scores than non-members. One explanation for the NHLA member companies' higher performance was that they were more efficient in production, sales, and revenue per output than non member companies. The comparison of performance and firm size showed that the largest two groups of firms, those producing 10 million board feet or more, performed better than smallest group of firms, those producing less than 1 million board feet. These results suggested that large firms

are more competitive than small firms. As competitive pressures increase, this could lead to fewer sawmills who are larger in size. From these results it was concluded that vertical integration, membership in the NHLA, having multiple sawmills and larger firms were all associated with higher business performance. The implications for hardwood sawmills is that they should improve performance by vertically integrating, consolidating with other sawmills, joining the NHLA and capture more market share to become larger firms.

The geographic factor was not able to be tested as originally designed. The responses to the mail survey indicated that only 4 companies had mills in more than one region. Therefore, Hypothesis 5 couldn't be tested due to a lack of mills that were geographically diversified. The performance means between mills in the three geographic regions (Appalachian, Northern, Southern) were not significantly different. These results suggested that performance doesn't vary that greatly from region to region. Hardwood lumber producers in a given region were able to perform just as well as those in other regions despite differences in forest resources and species availability. Firms should exploit all potential tree species available and develop niche markets within that region.

The results on the production technology factor were mixed with one analysis indicating support for H6 and the other analysis lacking support. First, the results of the performance score comparison between high tech and low tech firms indicated that firms who utilized *all three* advanced production technologies performed better than those who didn't use any advanced production technology. The results also indicated that high tech firms captured more value of their products by utilizing advanced production technology. This first analysis provided strong support for acceptance of H6. The results from the performance comparison between the four clusters (the second classification) indicated that firms who hadn't adopted advanced production technology performed just as well as firms who have adopted some or all of this technology. Due to the high cost of these advanced production technologies, high tech firms may be burdened with large debt payments which could hinder their performance. This contrasted the results from the earlier technology classification and performance comparison which showed high tech firms performed better. These contrasting results prohibited the acceptance of

Hypothesis 6 which stated that firms with advanced production technology perform better than firms without this technology. Firms that have adopted this technology must ensure that they are utilizing it to its fullest potential. The firms that utilized optimized trimmers but not optimized headrigs and edgers performed poorly. It is recommended that these firms adopt optimized headrigs and edgers in order to improve their performance. This recommendation is reinforced by responses on the open-ended question where the most frequently cited suggestion for improving performance was to upgrade equipment and technology. These results demonstrated that higher performance was associated with use of all three production technologies.

The results on the information technology performance comparison showed that high information technology firms had significantly higher performance than low technology firms on nearly every measure. The results provided strong evidence for the acceptance of Hypothesis 7. From these results, it was concluded that firms that utilized either computer based log tallying, lumber tallying, or inventory control performed better than those that did not use these technologies. These technologies enable better tracking of inputs (logs) and outputs (lumber) which represent large working capital outlays. The implications of these results were that firms should adopt these technologies in order to improve their performance.

The results on marketing mix diversification indicated that diversification of a firm's marketing mix was generally not related to their performance with the notable exception of promotion expenditure. Promotion expenditure diversification was positively correlated with performance. Therefore, Hypothesis 8 and 9 were rejected and Hypothesis 10 was accepted. Hardwood lumber sawmills should diversify their promotion expenditures in order to target new customers and increase their performance. On the product type variable, cluster 1 firms, who sold mainly green lumber, had significantly higher volume per employee ratios and cluster 2 firms, who sold mainly kiln dried lumber, had significantly higher sales per volume ratios. Cluster 1 firms should maximize production efficiency and cluster 2 firms should maximize revenue per output. On the lumber grade mix variable, Cluster 2 firms, the higher lumber grade producers, performed slightly better than cluster 1 firms, the lower grade lumber producers, on the performance score variable. Research and technology that improve grade yield will help

to improve the performance of firms in the industry. No significant difference was found between the clusters of firms based on differences in their distribution channel mix. While not statistically significant, it was interesting to note that firms in cluster 2, who exported and retailed the highest proportion of their lumber of any cluster, had the highest sales per employee and sales per volume. This suggested that firms in this cluster were able to capture more value from their lumber by utilizing these two distribution channels. Cluster 1 firms, labeled Northern hardwoods, performed significantly better than the other two clusters on the sales per employee variable but there weren't significant differences on the other performance variables. It can be concluded that despite differences in species mix firms performed equally well.

The results on the strategic factor were interesting. Cluster 3, the differentiation and cost leadership strategic group, performed significantly better than the other three clusters on the performance score variable. These results do not provide evidence for acceptance of H1 and therefore the null hypothesis is accepted. The only strategy that performed significantly better was a combination of differentiation and cost leadership. The implications of these results were that firms should employ both a differentiation and cost leadership strategy. By seeking to control costs and marketing their products effectively to customers, firms can gain competitive advantage.

Of the five firm-controlled factors investigated in this research, four of them were found to impact firm performance. The geographic factor was not found to influence the performance of hardwood sawmills. It was recommended that firms vertically integrate, diversify promotions, adopt all three optimizing production technologies, adopt information technology, and adjust their marketing mix and business strategy to fit the markets they serve and the forest resources that are available.

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Chapter 5. Changes in Strategy and Technology Over Time

Introduction

The macro-environment, within which the hardwood lumber industry operates, has changed dramatically over the past two decades. Globalization and the loss of domestic furniture manufacturing have severely impacted the industry. The material substitution of engineered wood products for solid hardwood lumber and the recycling of pallets have also impacted the industry. The ability of hardwood lumber companies to adapt to changes was important to their survival. Strategy and technology were two important factors found to impact hardwood lumber company performance. Therefore, detecting changes in strategy and technology within the industry over time were important to understanding its competitive position.

Research into business strategy of the hardwood lumber industry was limited. Porter's (1980) three generic strategies have been used extensively in academia and industry. These strategies acted as protection from the competition. The cost leadership strategy was characterized by a focus on reducing costs, gaining market share and maintaining economies of scale. The differentiation strategy was characterized by a focus on the customer, differentiating the product or service, and brand loyalty. The focus strategy was achieved by applying either or both the cost leadership or differentiation strategy to a particular market segment, geographic area or customer group. Porter's three generic strategies were used in this research in order to build upon past research (Bush 1989) and to detect any changes in strategy over time.

Research into the utilization of production technology in the hardwood lumber industry was limited. Bowe (2000) surveyed the hardwood lumber industry and their results indicated that most of the companies did not use scanning or optimizing technology. Of the mills that had adopted new technology, they were found to be comparatively larger companies. The use of advanced production technologies of hardwood sawmills was measured in order to detect changes in its use over time.

Objectives

The objectives for this chapter were to compare strategy and technology within the hardwood lumber industry to previous research to detect trends and to determine if the marketing strategy varies from sub-region to sub-region with the eastern hardwood region. The following are the specific objectives of this chapter:

1. Compare business strategy and technology utilization of hardwood lumber companies over time.

2. Determine the geographic distribution of business strategy in the eastern hardwood region.

Methods

A mail survey of hardwood lumber manufacturers was conducted during the fall of 2009. An adjusted response rate of 19.8% was obtained and the questionnaire measured demographics, business performance, marketing mix, operations, strategy, technology, and geographic region. A 20 item business area importance question developed by Bush (1989) was utilized to measure business strategy. Respondents rated each business area from 1 (not important) to 7 (important). A factor analysis was then conducted to identify strategies and generate factor scores. A hierarchical cluster analysis then grouped firms into strategic clusters using the factors scores. The number of firms in a given group was divided by the total number of firms to calculate the proportion of firms utilizing that strategy.

The production technology was measured by utilizing an equipment list originally developed by Bowe (2000). Companies indicated whether or not they utilized each piece of equipment. The proportion of firms utilizing a given technology was calculated by dividing the number responding yes by the total number of firms. The results from both Bush and Bowe were compared to results from the mail survey that was conducted.

The proportions of firms considered to be utilizing a particular strategy such as cost leadership, differentiation or focus were compared with a normal z test. The second hypothesis (H2) which stated that the hardwood lumber industry has shifted towards a differentiation and focus strategy from a cost leadership strategy was tested. The null hypothesis was that there was no change in the proportion of firms utilizing a given

strategy. The proportions of firms considered to be utilizing a given strategy from Bush (1989) and the current research is shown in Table 43. These were the proportions that were tested.

Table 43. Proportion of Firms Following a Strategy in Past and Current Research

Generic Strategy Type	Bush Proportion	Current Proportion
None	0.250	0
Differentiation	0.220	0.426
Cost Leadership	0.324	0.220
Cost Leadership & Differentiation	0.206	0.231
Focus	0	0.123

The proportions were tested by calculating a z value and then referencing that z value to a standard normal distribution. The following formula (Garrison 2008) was utilized to calculate the z value:

$$z = (P_1 - P_2)/ \sqrt{[(P_1Q_1/n_1) + (P_2Q_2/n_2)]}$$

Where:

P_1 = proportion from 1st sample
P_2 = proportion from 2nd sample
Q_1 = $1-P_1$
Q_2 = $1-P_2$
n_1 = sample size from 1st sample
n_2 = sample size from 2nd sample

The two-tailed probability of the calculated z value was the p-value shown in the results. A significant p-value was interpreted to indicate a change in strategy over time.

In a similar fashion, the proportion of firms who utilized a particular production technology was compared with a normal z test. A significant difference between each proportion indicated a change in technology over time. No hypothesis was developed in association with this test. However, the null hypothesis would be that no change has occurred. The proportion of firms utilizing a given technology from Bowe (2000) and the current research is shown in Table 44. These were the proportions that were tested in the same manner as the strategy proportions.

Table 44. Proportion of Firms Utilizing a Production Technology in Past & Current Research

Production Technology	Bowe Proportion	Current Proportion
Bucking Optimizer	0.05	0.036
Headrig Optimizer	0.271	0.490
Edger Optimizer	0.101	0.260
Trimmer Optimizer	0.045	0.132
Automated Sort Bins	0.071	0.122

During the theoretical development, it was theorized that geography may influence strategy. Hypothesis three was developed and it stated that more Southern hardwood lumber producers have a cost leadership strategy than a focus or differentiation strategy. Hypothesis 4 was developed and it stated that that more Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy. In order to test these hypotheses, a chi-square test of independence was conducted. A test of independence compares the frequencies for different categorical variables to those that would be expected under the null hypothesis (McDonald 2007).

The frequencies of firms in each category were compared to the null hypothesis. The null hypothesis in this case was that firms in a particular region would be distributed equally between the different strategies. For example, there were 24 respondents who indicate their mills were in the Southern region. The null hypothesis is that there is no difference between the strategies of firms in this region and therefore, the 24 mills should be evenly split between the strategies. The frequencies of firms found to be utilizing a given strategy from each region (Chapter 4) and the frequency of firms expected under the null hypothesis is shown in Table 45.

Table 45. Frequency of Strategy Utilization by Firms in each Region

	Appalachian		Northern		Southern	
Strategy	Actual (n)	Null (n)	Actual (n)	Null (n)	Actual (n)	Null (n)
Differentiation	41	26	30	15	10	6
Cost Leadership	25	26	13	15	3	6
Cost Leadership & Differentiation	15	26	5	15	4	6
Focus	25	26	12	15	7	6

The chi-square test compared the observed (actual) and expected (null) values. The calculated chi-square statistic was then compared to the chi-square distribution. All of these functions were completed by utilizing the chi-square test function in a spreadsheet for each region. The results of these tests are shown in the results section.

Results

The results from the strategy comparison are shown in Table 46.

Table 46. Change in Strategy Utilization Z-test

Strategy	Bush Proportion	Current Proportion	Calculated z-value	p-value
None	0.25	0	4.7610	<0.01
Differentiation	0.22	0.426	-3.3629	<0.01
Cost Leadership	0.32	0.22	1.6275	0.10
Cost Leadership & Differentiation	0.206	0.231	-0.4353	0.66
Focus	0	0.123	-5.2830	<0.01

The results indicated that there has been a change in strategy over time. The proportion of companies with no strategy decreased to zero. There has been a significant shift to a differentiation strategy in the industry with approximately 43% of firms following this strategy now. The proportion of firms utilizing a focus strategy has also increased significantly to 12%. There were no significant changes in the firms following a cost leadership and differentiation strategy. There was a decrease in the proportion of firms following a cost leadership strategy but it wasn't significant (p-value = 0.103). The results provided support for the acceptance of Hypothesis 2 and it can be concluded that the industry has shifted towards a differentiation and focus strategy. These results

implied that the industry has made progress in understanding their customers and pursuing market-driven marketing initiatives.

The results from the technology comparison are shown in Table 47.

Table 47. Change in Technology Utilization Z-test

Production Technology	Bowe Proportion	Current Proportion	Calculated z-value	p-value
Bucking Optimizer	0.05	0.036	0.4738	0.64
Headrig Optimizer	0.271	0.49	-3.3950	<0.01
Edger Optimizer	0.101	0.26	-3.3139	<0.01
Trimmer Optimizer	0.045	0.132	-2.5034	0.01
Automated Sort Bins	0.071	0.122	-1.3132	0.19

The results showed that there has been a significant increase in the proportion of hardwood lumber sawmills that utilize headrig, edger, and trimmer optimizers. There were no significant changes in bucking optimizers and automated sort bins. These results indicated that more and more firms are utilizing advanced production technology. The utilization of all three of these technologies was shown to have a positive impact on firm performance.

The results from the comparison of strategy across each region are shown in Table 48.

Table 48. Strategy & Region Chi-Square Test

	Appalachian		Northern		Southern	
Strategy	Actual	Null	Actual	Null	Actual	Null
	(n)	(n)	(n)	(n)	(n)	(n)
Differentiation	41	26.5	30	15.5	10	6
Cost Leadership	25	26.5	13	15.5	3	6
Cost Leadership & Differentiation	15	26.5	5	15.5	4	6
Focus	25	26.5	12	15.5	7	6
Chi-square	13.09		22.53		5.0	
p-value	<0.01		<0.01		0.17	

The results showed that there were significant differences between the observed distribution of strategies in each region and the distribution that was expected under the null hypothesis. In the Appalachian and Northern region there were a significantly larger number of firms employing a differentiation strategy than was expected under the null

hypothesis. Therefore, Hypothesis 4 can be accepted and it can be concluded that more Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy. There were no significant differences between the observed and expected distribution of strategies in the Southern region. Therefore, Hypothesis 3 is rejected and it can be concluded that there is no difference in the prevalence of each strategy among the Southern region. These results indicated that Northern and Appalachian hardwood sawmills utilized a differentiation strategy more often than the other types of strategies.

Conclusions

Hypothesis 2 which stated that the hardwood lumber industry has shifted to a differentiation and focus strategy from a cost leadership strategy was accepted. An increase in the utilization of generic strategies and the accompanying decrease in no strategy within the industry is an important development. There has been a significant increase in the proportion of firms utilizing optimizing headrigs, edgers, and trimmers and this will help improve performance.

Hypothesis 4 which stated that more Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy was also accepted. Appalachian and Northern mills are more likely to employ a differentiation strategy. Outreach and extension activities that promote strategic development and technology adoption would be beneficial for the hardwood lumber industry.

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Chapter 6. Conclusions, Contributions, Limitations and Recommendations

Conclusions

The purpose of developing a performance indicator for this research was to accurately, confidentially, and quickly assess firm performance of hardwood lumber manufacturers. As indicated by the internal consistency and the split half reliability tests, the performance indicator reliably measured performance within the hardwood lumber industry.

The use and implementation of performance measurement systems like the one developed should help hardwood lumber manufacturers to improve their performance. The use of performance measurement systems has been associated with higher performance. Each of the four dimensions within the performance indicator is linked to the other levels from employees through production and marketing to financial. Hardwood sawmills that set goals to improve performance and then measure performance in each dimension will improve overall firm performance. The research has identified twelve key performance measures that can form the basis of a performance measurement system. Companies can take the performance indicator, customize it to their operation, and then begin measuring and tracking their company's performance information.

The marketing mix of hardwood lumber companies including product, distribution and promotion was measured. The species mix consisted mainly of oak, maple and poplar. The common grades of lumber accounted for approximately 60% of lumber production and the upper grades accounted for about 30% of production. The majority of lumber (61%) sold was rough green lumber or pallet lumber and cants. The sawmill distribution channels in order of highest sales percentage were manufacturers, concentration yards and wholesale distributors. Magazines, market reports, and other mediums were where hardwood sawmills spent most of their promotion expenditures despite 40% of respondents not having any promotion expenditures. Based on this information, there is potential for hardwood lumber companies to: sell more value added products (i.e. dried lumber); advertise and promote themselves better; diversify their species mix; and consider adding retail distribution channels.

The utilization of advanced production technology has increased in the industry. The proportion of mills utilizing a given technology since the previous study has doubled in many cases. The results suggested that firms believe that they should adopt optimized headrigs and optimized edgers to improve their performance. A large majority of respondents are utilizing the Internet and email whereas a small majority are utilizing log, lumber and inventory information technology. Information technology was rated important to performance and firms believe that they should this technology to improve performance.

The majority of respondents (60%) had dry kiln operations and 49% had a surfacing mill. The proportion of mills indicating that they utilized dry kilns has increased from 43.4% in 2000 (Bowe 2000) to 60% found in this research. This indicates that firms have tried to capture more value associated with higher levels of lumber processing. Thirty five percent of respondents (71 companies) indicated that their company was certified by either forest, chain-of-custody, or both certification schemes. Respondents rated product quality control, efficient operations, customer service and reputation as the most important areas that they concentrated on.

The distribution of tallied performance scores on the 12 measure performance indicator was normal and analysis suggested that there was no relationship between firm size and performance scores. The performance averages for profit and costs were the lowest of all twelve performance measures and this suggested that firms should focus improvement upon these measures. There was no apparent relationship between the three ratios (production efficiency, sales efficiency, and revenue per output) and firm size based on the scatter plots. These ratios provided benchmarks against which mills may measure themselves. The results from the open-ended question suggested that mills should focus on upgrading equipment, lowering costs, increasing efficiency and sales, and improving their workforce in order to improve their performance.

The influence of firm controlled factors on performance yielded interesting results. On the organizational factor, a number of findings were discovered. The statistical evidence strongly supported the hypothesis (H11) that vertically integrated firms performed better than non integrated firms. The results indicated that backward integrated firms and firms that were both backward and forward integrated performed

better than non-integrated or forward integrated firms. Backward integration may allow firms to control log costs which are a critical component of a sawmill's total cost. The results from the company type comparison indicated that multiple sawmill firms performed better than single sawmill companies. These multiple sawmill companies may have greater economies of scale and more bargaining power over suppliers and customers. NHLA member companies had significantly higher performance scores than non-members. One explanation for the NHLA member companies' higher performance was that they were more efficient in production, sales, and revenue per output than non member companies or that successful companies join the NHLA. From these results it was concluded that vertical integration, membership in the NHLA, and having multiple sawmills were all associated with higher business performance.

The performance means among mills in the three geographic regions (Appalachian, Northern, Southern) were not significantly different. These results suggested that performance doesn't vary that greatly from region to region. Hardwood lumber producers in a given region were able to perform just as well as those in other regions despite differences in forest resources and species availability.

The results on the production technology factor were mixed with one analysis indicating support for H6 and the other analysis lacking support. First, the results of the performance score comparison between high tech and low tech firms indicated that firms who utilized *all three* advanced production technologies performed better than those who didn't use any advanced production technology. The results also indicated that high tech firms captured more value of their products by utilizing advanced production technology. This first analysis provided strong support for acceptance of H6. The results from the performance comparison between the four clusters (the second classification) indicated that firms who hadn't adopted advanced production technology performed just as well as firms who have adopted some or all of this technology. Due to the high cost of these advanced production technologies, high tech firms may be burdened with large debt payments which could hinder their performance. This contrasted the results from the earlier technology classification and performance comparison which showed high tech firms performed better. These contrasting results prohibited the acceptance of Hypothesis 6 which stated that firms with advanced production technology perform better

than firms without this technology. Firms that have adopted this technology must ensure that they are utilizing it to its fullest potential. Firms that are utilizing only optimized trimmers and not optimized headrigs and edgers should adopt these latter technologies because utilizing all three technologies was associated with higher performance.

The results on the information technology performance comparison showed that high information technology firms had significantly higher performance than low technology firms on nearly every measure. The results provided strong evidence for the acceptance of Hypothesis 7. From these results, it was concluded that firms that utilized either computer based log tallying, lumber tallying, or inventory control performed better than those that did not use these technologies. These technologies enable better tracking of inputs (logs) and outputs (lumber) which represent large working capital outlays. The implications of these results were that firms should adopt these technologies in order to improve their performance.

The results on marketing mix diversification indicated that diversification of a firm's marketing mix was generally not related to their performance with the notable exception of promotion expenditure. Promotion expenditure diversification was positively correlated with performance. Therefore, Hypothesis 8 and 9 were rejected and Hypothesis 10 was accepted. Hardwood lumber sawmills should diversify their promotion expenditures in order to target new customers and increase their performance. On the product type variable, cluster 1 firms, who sold mainly green lumber, had significantly higher volume per employee ratios and cluster 2 firms, who sold mainly kiln dried lumber, had significantly higher sales per volume ratios. Cluster 1 firms should maximize production efficiency and cluster 2 firms should maximize revenue per output. On the lumber grade mix variable, Cluster 2 firms, the higher lumber grade producers, performed slightly better than cluster 1 firms, the lower grade lumber producers, on the performance score variable. Research and technology that improve grade yield will help to improve the performance of firms in the industry. No significant difference was found between the clusters of firms based on differences in their distribution channel mix. While not statistically significant, it was interesting to note that firms in cluster 2, who exported and retailed the highest proportion of their lumber of any cluster, had the highest sales per employee and sales per volume. This suggested that firms in this cluster

were able to capture more value from their lumber by utilizing these two distribution channels. Cluster 1 firms, labeled Northern hardwoods, performed significantly better than the other two clusters on the sales per employee variable but there weren't significant differences on the other performance variables. It can be concluded that despite differences in species mix firms performed equally well.

The results on the strategic factor were interesting. Cluster 3, the differentiation and cost leadership strategic group, performed significantly better than the other three clusters on the performance score variable. These results do not provide evidence for acceptance of H1 and therefore the null hypothesis is not rejected. The only strategy that performed significantly better was a combination of differentiation and cost leadership. The implications of these results were that firms should employ both a differentiation and cost leadership strategy. By seeking to control costs and marketing their products effectively to customers, firms can gain competitive advantage.

Of the five firm-controlled factors investigated in this research, four of them were found to impact firm performance. The geographic factor was not found to influence the performance of hardwood sawmills. It was recommended that firms vertically integrate, diversify promotions, adopt all three optimizing production technologies, adopt information technology, and adjust their marketing mix and business strategy to fit the markets they serve and the forest resources that are available.

There have been a number of important changes in the hardwood lumber industry. Hypothesis 2 which stated that the hardwood lumber industry has shifted to a differentiation and focus strategy from a cost leadership strategy was accepted. An increase in the utilization of strategies and the accompanying decrease in no strategy within the industry is an important development. There has been a significant increase in the proportion of firms utilizing optimizing headrigs, edgers, and trimmers and this will help improve performance.

Hypothesis 4 which stated that more Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy was also accepted. Appalachian and Northern mills are more likely to employ a differentiation strategy. Outreach and extension activities that promote strategic development and

technology adoption would be beneficial for the hardwood lumber industry. A summary of all eleven hypothesis is shown in Table 49.

Table 49. Hypothesis Testing Summary

Hypothesis Number	Hypothesis Description	Rejected / Accepted
1	Firms with a focus or differentiation strategy perform better than firms with a cost leadership strategy.	Rejected
2	The hardwood lumber industry has shifted towards a differentiation and focus strategy from a cost leadership strategy.	Accepted
3	More Southern hardwood lumber producers have a cost leadership strategy than a focus or differentiation strategy.	Rejected
4	More Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy.	Accepted
5	Hardwood lumber producers who are geographically diversified perform better than those firms who have geographically limited operations.	Not able to be tested
6	Hardwood lumber producers who utilize advanced production technology perform better than firms who do not utilize advanced production technology.	Not accepted
7	Hardwood lumber producers who utilize advanced information technology perform better than firms who do not utilize advanced information technology.	Accepted
8	Product diversification is positively related to performance of hardwood lumber producers.	Rejected
9	Customer diversification is positively related to performance of hardwood lumber producers.	Rejected
10	Promotion diversification is positively related to performance of hardwood lumber producers.	Accepted
11	Vertically integrated firms perform better than non-vertically integrated firms.	Accepted

Contributions

The contribution of this research to the understanding of business performance of hardwood lumber manufacturers is significant. It was discovered that the utilization of production and information technology influence business performance. This discovery is congruent with knowledge from the broader scientific community. Larger firms, vertically integrated firms, and those with multiple sawmills performed better. The empirical confirmation of this information will be beneficial to those who suspected this based on anecdotal evidence. The increased utilization of strategy and technology in the industry is an important trend along with the shift in the type of strategy utilized. The utilization of a cost leadership and differentiation strategy was associated with higher

performance. The use of strategy varied from region to region giving support to the idea that forest resource availability influences strategy.

This study was unique in connecting to previous studies so that longitudinal data on the industry could be developed. The use of the same measurement variables enables direct comparisons with previous research. The theoretical driven approach of this study will enable future researchers to examine new variables and their relationship to business performance. Likewise researchers can develop new measurement methods and data collection techniques to retest hypotheses that were rejected. The research also demonstrated that the collection of sensitive information was possible from privately held firms in a highly competitive industry. The research has likely spurred many firms to realize that business performance is a larger concept than previously thought.

Limitations

There are important limitations to the interpretation and generalization of the results of this study. First, hardwood lumber manufacturers (i.e.: sawmills) were the target respondents and no information was collected from other manufacturers or distributors within the hardwood value chain. The performance indicator was developed specifically for hardwood sawmills and therefore can't be utilized for other types of hardwood lumber companies. The performance measurement of the responding firms was limited by its temporal nature. The measurement of performance on a sustained yearly basis in conjunction with firm-level changes in technology, strategy, tactics, and organizational factors would provide more robust findings. The ability and resources to carry this out was beyond the scope of this research. The performance indicator measured subjective performance data that was self-reported by respondents. While previous research has shown a high correlation between subjective and objective performance measurement, the level of correlation between these two types of data is unknown for this research. The vast majority of respondents were NHLA members and therefore caution is urged in interpreting the results for non-member sawmills and companies dissimilar to the typical respondent. Despite these limitations, the findings of the research are widely applicable to hardwood lumber manufacturers. The limitations of this research also serve to inform future research opportunities as described next.

Recommendations

Continued research into performance in the hardwood lumber industry is imperative to enable firms to improve their performance. First, similar studies on firm performance for other segments of the hardwood lumber value chain such as concentration yards and distributors should be conducted. Performance indicators for these segments should be developed. Research into the relationship between the subjective performance indicator and objective performance measures would yield productive results. A longitudinal and more in-depth study on the use of performance measurement systems in the industry could detect frequency of and changes in use. Firm performance and the use of multiple measure performance indicators are likely to become more important for hardwood lumber companies.

Future research in this industry may want to revisit these and other factors and attempt to collect more business performance information. Case studies comparing the performance of firms in each of the identified clusters would yield interesting results. In relation to the geographic factor, forest resource availability, transportation efficiency, market size and customer base are variables that could be related to firm performance. A case study of sawmill utilization of the log tallying, lumber tallying and inventory control information technologies could determine exactly how firm performance is improved. Is it through greater working capital efficiency, less inventory, more inventory turnover? A longitudinal study on firm performance of hardwood lumber manufacturers is important for all stakeholders. The firms studied in this research project were all in business and therefore performance comparisons were relative. A study on failed hardwood sawmills could identify new knowledge about factors that influence performance not covered here.

Hardwood sawmills have the potential to utilize this information in order to improve their operations. They can utilize the 12 key performance measures in their operations. Mills should understand the relationship of improving all areas of performance. Employee satisfaction leads to improved productivity leads to better customer fulfillment and customer loyalty. These can in turn increase profitability by reducing costs and increases sales. It is important that hardwood lumber manufacturers see this linkage. Hardwood sawmills can utilize the up-to-date information on the current marketing mix, demographic profile, technology utilization, strategy utilization, and

operations information in this report to make decisions about their company. Mills should utilize the production efficiency, sales efficiency, and revenue per output ratios to benchmark the performance of their company. After knowing where they stand in comparison to the industry average, mills can set goals to increase their efficiency. If there is a fit with their company, mills can vertically integrate operations; acquire other mills to gain economies of scale; increase the diversity of their promotions; increase their use of production technology; increase the use of information technology; and pursue a cost leadership and differentiation strategy in order to improve their performance.

Appendix A. List of Hypotheses

H1: Firms with a focus or differentiation strategy perform better than firms with a cost leadership strategy.

H2: The hardwood lumber industry has shifted towards a differentiation and focus strategy from a cost leadership strategy.

H3: More Southern hardwood lumber producers have a cost leadership strategy than a focus or differentiation strategy.

H4: More Northern and Appalachian hardwood lumber producers have a focus or differentiation strategy than a cost leadership strategy.

H5: Hardwood lumber producers who are geographically diversified perform better than those firms who have geographically limited operations.

H6: Hardwood lumber producers who utilize advanced production technology perform better than firms who do not utilize advanced production technology.

H7: Hardwood lumber producers who utilize advanced information technology perform better than firms who do not utilize advanced information technology.

H8: Product diversification is positively related to performance of hardwood lumber producers.

H9: Customer diversification is positively related to performance of hardwood lumber producers.

H10: Promotion diversification is positively related to performance of hardwood lumber producers.

H11: Vertically integrated firms perform better than non-vertically integrated firms.

Appendix B. Statistical Test Summary

Hypothesis	Comparison	Independent Variable	Dependent Variable	Statistical Test	Signifance Levels
H1	Means	Strategy	Performance	ANOVA	0.1 - 0.01
H2	Proportions	Time	Strategy	normal z-test	0.1 - 0.01
H3	Frequencies	Geographic Region	Strategy	chi-square test of independence	0.1 - 0.01
H4	Frequencies	Geographic Region	Strategy	chi-square test of independence	0.1 - 0.01
H5	Means	Geographic Region	Performance	ANOVA	0.1 - 0.01
H6	Means	Production Technology	Performance	ANOVA	0.1 - 0.01
H7	Means	Information Technology	Performance	ANOVA	0.1 - 0.01
H8	Coefficients	Product Diversification	Performance	Linear Regression	0.1 - 0.01
H9	Coefficients	Customer Diversification	Performance	Linear Regression	0.1 - 0.01
H10	Coefficients	Promotion Diversification	Performance	Linear Regression	0.1 - 0.01
H11	Means	Vertical Integration	Performance	ANOVA	0.1 - 0.01

Appendix C. Phone Survey Questions

1. Do you manufacture hardwood lumber? YES NO

2. What indicator(s) do you used to measure the performance of your company?

3. Do you think it is important to measure performance from different viewpoints?

4. What influences the performance of your company?

5. What things would you change to improve the performance of your company?

Appendix D. Fax Survey Questionnaire

VirginiaTech
College of Natural Resources

Department of Wood Science & Forest Products
Center for Forest Products Marketing and Management
1650 Ramble Road
Blacksburg, Virginia 24061
Phone: 540/231-4406 Fax: 540/231-8868
E-mail: perkinsb@vt.edu
www.cfpmm.vt.edu

The Use and Importance of Performance Indicators by Eastern Hardwood Lumber Manufacturers

To: «CONTACT» **Fax:** «FAX»

From: Brian Perkins **Date:** 4/29/2008

Re: Performance Indicator Survey **Pages:** 3 (including this page)

Message:

Your company has been randomly selected to participate in a survey of performance indicators used by eastern hardwood lumber manufacturers. The purpose of the survey is to determine which performance indicators are used most frequently in the industry and how important those indicators are to the overall success of eastern hardwood lumber producers. The results from this survey will be used later as part of a larger survey of the industry. Will you help us with this important research by completing the following short survey? Your answers will be confidential and no individual company information will be disclosed. The results of the survey will be made available to responding companies who which to receive them. Once you have completed the survey please fax back to Brian Perkins at 540-231-8868. Please indicate if you would like to receive a summary of the results.

Thank you,

Brian Perkins

If you have any questions, please contact me:
Brian Perkins
Phone: 540-231-4406
Fax: 540-231-8868
Email: perkinsb@vt.edu

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

1. Some companies use multiple indicators to measure different aspects of business performance. For example, a company may use profit margin to measure financial performance and also use production per day to measure how well the mill is operating. Please rate the following list of performance indicators on how frequently your company uses each one. (Please *circle* the number that best corresponds to how frequently you use each performance indicator)	2. Some performance indicators may be more important to a company's success than others. For example, the number of orders received may be less important than total sales. Please rate the following list of performance indicators based on how important they are to your company's success. (Please *circle* the number that best corresponds to how important each performance indicator is.)

Don't use → Use Often				Performance Indicator	Not Important → Very Important			
1	2	3	4	net profit	1	2	3	4
1	2	3	4	total sales	1	2	3	4
1	2	3	4	board feet per shift	1	2	3	4
1	2	3	4	quality	1	2	3	4
1	2	3	4	costs of goods sold	1	2	3	4
1	2	3	4	grade recovery	1	2	3	4
1	2	3	4	yield	1	2	3	4
1	2	3	4	selling price	1	2	3	4
1	2	3	4	number of worker injuries	1	2	3	4
1	2	3	4	cost per board feet	1	2	3	4
1	2	3	4	log utilization	1	2	3	4
1	2	3	4	efficiency	1	2	3	4
1	2	3	4	% on time delivery	1	2	3	4
1	2	3	4	% on grade	1	2	3	4
1	2	3	4	average sales order	1	2	3	4
1	2	3	4	number of new customer contacts	1	2	3	4
1	2	3	4	lumber recovery	1	2	3	4
1	2	3	4	number of new customers	1	2	3	4
1	2	3	4	quantity of energy consumed	1	2	3	4
1	2	3	4	tonnage of chips produced	1	2	3	4
1	2	3	4	tonnage of bark produced	1	2	3	4
1	2	3	4	tonnage of sawdust produced	1	2	3	4
1	2	3	4	sales per salesperson	1	2	3	4
1	2	3	4	training expenses	1	2	3	4

Next page please.

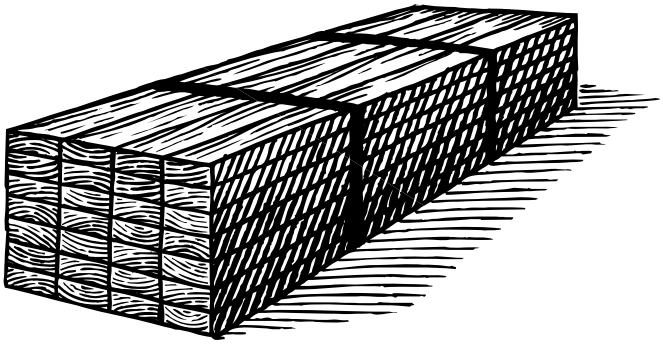
1. Some companies use multiple indicators to measure different aspects of business performance. For example, a company may use profit margin to measure financial performance and also use production per day to measure how well the mill is operating. Please rate the following list of performance indicators on how frequently your company uses each one. (Please *circle* the number that best corresponds to how frequently you use each performance indicator)	2. Some performance indicators may be more important to a company's success than others. For example, the number of orders received may be less important than total sales. Please rate the following list of performance indicators based on how important they are to your company's success. (Please *circle* the number that best corresponds to how important each performance indicator is.)

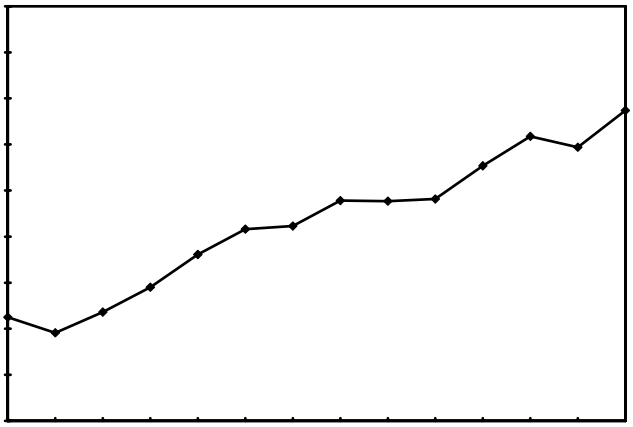
Don't use → Use Often	Performance Indicator	Not Important → Very Important
1 2 3 4	customer satisfaction	1 2 3 4
1 2 3 4	number and length of downtime	1 2 3 4
1 2 3 4	sales per employee	1 2 3 4
1 2 3 4	board feet/man hour	1 2 3 4
1 2 3 4	current ratio	1 2 3 4
1 2 3 4	plant hours used	1 2 3 4
1 2 3 4	% of employees trained	1 2 3 4
1 2 3 4	gross profit margin	1 2 3 4
1 2 3 4	absence level	1 2 3 4
1 2 3 4	production defects	1 2 3 4
1 2 3 4	orders received	1 2 3 4
1 2 3 4	employee hours	1 2 3 4
1 2 3 4	number of customer complaints	1 2 3 4
1 2 3 4	accounts receivable turnover	1 2 3 4
1 2 3 4	delivery schedule backlog	1 2 3 4
1 2 3 4	inventory turnover	1 2 3 4
1 2 3 4	costs by department	1 2 3 4
1 2 3 4	employee turnover rate	1 2 3 4
1 2 3 4	return on investment	1 2 3 4
1 2 3 4	new product sales / total sales	1 2 3 4
1 2 3 4	amount of capital investment	1 2 3 4
1 2 3 4	market share	1 2 3 4
1 2 3 4	length of employment	1 2 3 4
1 2 3 4	employee satisfaction	1 2 3 4

Thank you!

Appendix E. Mail Questionnaire

Opportunities for Improving the Performance of Eastern Hardwood Lumber Manufacturers





Center for Forest Products Marketing and Management
Department of Wood Science and Forest Products
Virginia Tech
Blacksburg, VA 24061

If you have any questions, please contact
Brian Perkins
Phone: 540-231-4406
Cell: 540-558-8320
Fax: 540-231-8868
Email: perkinsb@vt.edu

The purpose of this study conducted by Virginia Tech is to find out how factors that companies control influence their business performance. By better understanding how companies perform, we shall identify opportunities for the entire industry to improve its business performance. Your responses to this survey are confidential because no company information will be disclosed. Filling out the survey will only take a few minutes. Thank you for your time and willingness to participate.

1. Does your company manufacture hardwood lumber?

___ No Stop. Thank you, please return questionnaire.

___Yes Continue to next question.

2. Is your sawmill a single facility or part of a larger multi-facility company?

_____ Single Sawmill

_____ Multiple Facility Company

3. Please estimate the total volume of hardwood lumber your sawmill (single facility) and/or corporation (multiple facilities) produced in 2007.

Single Sawmill _____BF

Whole Company _____BF

4. What is the total number of employees at your single sawmill and/or in the entire corporation in 2007?

Single Sawmill _____

Whole Company _____

5. Please estimate the total sales at your sawmill (single facility) and/or corporation (multiple facilities) in 2007.

$ _____ Single Sawmill

$ _____ Whole Company

6. Which of the following wood residues does your company sell and what is their selling price at the mill?

Yes	No	**Chips**	_____$/ton
Yes	No	**Sawdust**	_____$/ton
Yes	No	**Bark**	_____$/ton
Yes	No	**Shavings**	_____$/ton

7. What is the percentage of hardwood lumber produced in 2007 in each of the following species as part of total lumber production?

Red Oak	_____%
White Oak	_____%
Yellow Poplar	_____%
Hard Maple	_____%
Soft Maple	_____%
Black Cherry	_____%
Ash	_____%
Black Walnut	_____%
Aspen	_____%
Basswood	_____%
Beech	_____%
Hickory	_____%
Birch	_____%
Gum	_____%
Other	_____%
TOTAL	**100%**

8. What percentage of hardwood lumber sold in 2007 was in each of the following products as part of total solid wood production?

Rough, green grade lumber	_____%
Rough, air-dried grade lumber	_____%
Rough, kiln-dried grade lumber	_____%
Planed, kiln-dried grade lumber	_____%
Pallet cants and/or lumber	_____%
Railroad ties	_____%
Other: _____	_____%
TOTAL	**100%**

9. Which region do you primarily label and market your lumber as?

Appalachian	_____
Southern	_____
Northern	_____

10. What percentage of hardwood lumber produced in 2007 was sold through each distribution channel?

Sold to concentration yards	_____%
Sold to wholesale distributors	_____%
Sold to retail operations	_____%
Sold to manufacturers	_____%
Exported	_____%
Other: _____	_____%
TOTAL	**100%**

11. What percentage of hardwood grade lumber produced in 2007 was in the following grades?

FAS/1F	_____%
Select & Better	_____%
No. 1 Common	_____%
No. 2 Common	_____%
No. 3 Common	_____%
Framestock	_____%
Custom Graded	_____%
Un-graded	_____%
Other _____	_____%
TOTAL	**100%**

12. Please indicate with an X if your company is certified by one of the following certification programs:

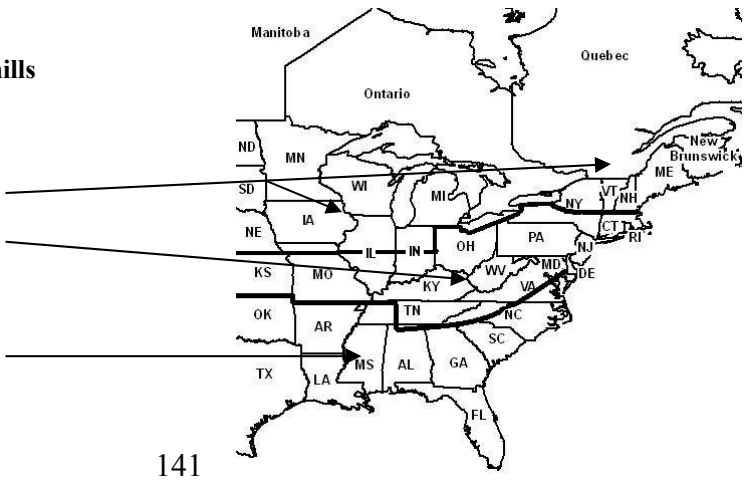
	Forest | Custody
Forest Stewardship Council	_____|_____
Sustainable Forestry Initiative	_____|_____
American Tree Farm System	_____|_____
Other:_____	_____|_____
Our company is not certified	_____|_____

15. Please indicate the number of sawmills your company has in each region.

Northern Region _____

Appalachian Region _____

Southern Region _____



13. What percentage of promotion and advertising expenditures in 2007 was spent in:

Magazines	_____%
Tradeshows	_____%
Brochures	_____%
Internet Advertising	_____%
Giveaways	_____%
Market Reports	_____%
Direct Mailings	_____%
Other _____	_____%
TOTAL	**100%**

14. Please indicate with an X which operation(s) other than the sawmill your company has.

Forestland Holdings	_____
Logging Operations	_____
Dry Kilns	_____
Planer/Surfacing Mill	_____
Trucking Operations	_____
Dimension Manufacturing	_____
Pallet Manufacturing	_____
Treating Facility	_____
Concentration Yard	_____
Cogeneration Boiler	_____
Flooring Manufacturing	_____
Other Secondary Mfg.	_____
Pellet Mill	_____
Distribution Facilities	_____
Mulch Coloring Operation	_____
Other_____	_____

16. Please indicate by circling Yes (Y) or No (N) which type of advanced production technology your company uses and how long it has been in use. Also, please estimate how important that piece of equipment is to your company's performance.

Equipment/Technology			Years in Use	Not Important				Very Important
Optimized Headrig	Y	N	_____	1	2	3	4	5
Ring Debarker	Y	N	_____	1	2	3	4	5
Bucking Optimizer	Y	N	_____	1	2	3	4	5
Optimized Edger	Y	N	_____	1	2	3	4	5
Optimized Trimmer	Y	N	_____	1	2	3	4	5
Automated Sort Bins	Y	N	_____	1	2	3	4	5
Real-time Lumber Dimension Control	Y	N	_____	1	2	3	4	5

17. Please indicate by circling Yes (Y) or No (N) which type of advanced information technology your company uses and how long it has been in use. Also, please estimate how important that piece of equipment/technology is to your company's performance.

Equipment/Technology			Years in Use	Not Important				Very Important
Computer-Based Log Tallying	Y	N	_____	1	2	3	4	5
Computer-Based Lumber Tallying	Y	N	_____	1	2	3	4	5
Computer-Based Inventory Control	Y	N	_____	1	2	3	4	5
Internet	Y	N	_____	1	2	3	4	5
Website	Y	N	_____	1	2	3	4	5
Email	Y	N	_____	1	2	3	4	5
Internet selling	Y	N	_____	1	2	3	4	5

18. If your company uses computer based log tallying, lumber tallying, or inventory control please indicate with an X which type of device you use. If you don't use these technologies, go to the next question.

	Log Tallying	Lumber Tallying	Inventory Control
Hand Held Device	_____	_____	_____
Voice Recorder	_____	_____	_____
Other: _____	_____	_____	_____

19. If your company uses the Internet, please circle which functions it is used for. If you don't use the internet, go to the next question.

Sales Promotion	Y	N	Logistics	Y	N
Market Research	Y	N	Purchasing Products	Y	N
Order Status	Y	N	Data Transfer	Y	N
Shipping Notice	Y	N	Customer Inquiry	Y	N
Order Tracking	Y	N	Internet Sales	Y	N
Inventory Tracking	Y	N	Other:_____	Y	N

20. Most companies do not have the resources to become the industry leader in every area of doing business. Instead they concentrate on a few key areas that are important to their company. Which of the following areas are presently the most and least important to your company?

(Please *circle* the number that best corresponds to the importance of each area.)

	Not Important						Very Important
Developing new products	1	2	3	4	5	6	7
Providing customer service	1	2	3	4	5	6	7
Efficient operation of production facilities	1	2	3	4	5	6	7
Product quality control	1	2	3	4	5	6	7
Employing trained/experienced personnel	1	2	3	4	5	6	7
Competitive pricing	1	2	3	4	5	6	7
Developing brand identification	1	2	3	4	5	6	7
Using new marketing techniques/methods	1	2	3	4	5	6	7
Controlling channels of distribution	1	2	3	4	5	6	7
Procurement of raw materials	1	2	3	4	5	6	7
Serving special geographic markets	1	2	3	4	5	6	7
Ability to manufacture specialty products	1	2	3	4	5	6	7
Promotion and advertising	1	2	3	4	5	6	7
Maintaining a company sales force	1	2	3	4	5	6	7
Owning timberlands and/or logging operations	1	2	3	4	5	6	7
Providing rapid delivery	1	2	3	4	5	6	7
Market research	1	2	3	4	5	6	7
Investment in new processing equipment	1	2	3	4	5	6	7
Serving particular customer groups	1	2	3	4	5	6	7
Reputation within the industry	1	2	3	4	5	6	7

21. Companies measure performance in many different areas and below is a list of 12 performance measures. Please think of how well your company has performed on each measure and then rate it from low to high The responses to these questions are confidential and will not be disclosed.

(Please *circle* the number that best corresponds to your company's performance.)

	Low Performance			High Performance		
Lumber yield	1	2	3	4	5	Don't know
Number of orders received	1	2	3	4	5	Don't know
Employee Satisfaction	1	2	3	4	5	Don't know
Sales	1	2	3	4	5	Don't know
Product quality	1	2	3	4	5	Don't know
Employee turnover rate	1	2	3	4	5	Don't know
Costs	1	2	3	4	5	Don't know
Customer satisfaction	1	2	3	4	5	Don't know
Profit	1	2	3	4	5	Don't know
Board feet per shift	1	2	3	4	5	Don't know
Number of worker injuries	1	2	3	4	5	Don't know
Selling Price	1	2	3	4	5	Don't know

22. A company's performance is influenced by numerous external factors such as the economy among many others. Please think of how well your company has performed in response to each external factor and then rate your company's performance from low to high. The responses to these questions are confidential and will not be disclosed.

(Please *circle* the number that best corresponds to your company's performance.)

	Low Performance			High Performance		
Loss of domestic customers	1	2	3	4	5	Not Applicable
Stagnant/declining lumber prices	1	2	3	4	5	Not Applicable
Lack of skilled labor	1	2	3	4	5	Not Applicable
Increasing energy prices	1	2	3	4	5	Not Applicable
Shortage of loggers	1	2	3	4	5	Not Applicable
High raw material prices	1	2	3	4	5	Not Applicable
Increased operating costs	1	2	3	4	5	Not Applicable
Demand for certified lumber	1	2	3	4	5	Not Applicable
Decrease in lumber production	1	2	3	4	5	Not Applicable
Demands of international customers	1	2	3	4	5	Not Applicable
Changes in secondary manufacturing	1	2	3	4	5	Not Applicable
International competition	1	2	3	4	5	Not Applicable
Increased transportation costs	1	2	3	4	5	Not Applicable

23. What would you change to improve the performance of your company?

24. Comments and Suggestions. Please use the space below to let us know what else you think is important regarding performance of hardwood lumber manufacturers.

Thank you for completing the questionnaire. Please fold, tape, and return the questionnaire. Please indicate if you would like to receive a summary of the results.

☐ Yes, send results by email. My email address is _____

☐ Yes, send results by mail to same address as this questionnaire.

☐ Yes, send results by mail but send to this address: _____

☐ No thanks, don't send me the results.

Appendix F. Curriculum Vitae

Education

Doctorate in Philosophy in Forest Products, Virginia Tech, Blacksburg, VA. Area of Concentration: Business and Utilization. GPA: 3.77. May 2009.

Master in Science in Forest Products, Virginia Tech, Blacksburg, VA. Area of Concentration: Business and Utilization. GPA: 3.72. December 2006.

Bachelor in Science in Forestry, Wood Science, Processing Option. West Virginia University, Morgantown, WV. May 2001. GPA: 3.49.

Associate in Science in Forest Technology. Glenville State College, Glenville, WV. May 1997. GPA: 3.17.

Career

Graduate Research Assistant. Department of Wood Science & Forest Products. Virginia Tech, Blacksburg, VA.

Performed research on forest products business and utilization. Edited two newsletters: Center Focus (quarterly) & Research Update (biannual). Designed and maintained a website. Wrote and published scientific peer-reviewed articles and trade journal articles. (9 to date) Followed macroeconomic and global trends in numerous segments of the forest products industry such as hardwood lumber, wood furniture, cabinetry, millwork, flooring, softwood lumber, structural panels, and bioenergy. Made presentations at various conferences and attended industry meetings. Conducted phone, fax, mail and internet surveys as part of my research. Collected information and data on forest products companies. Analyzed data and trends using statistics. Developed and wrote proposals and reports. Participated and served on the Energy & Sustainability committee where I was able to communicate and interact with senior executives at Virginia Tech.

Workshop Manager. Westminster Woodworks, Winchester, VA.

Supervised seven shop employees and one draftsperson. Managed custom cabinetry projects from design to installation. Solved problems by communicating with all employees. Developed people management skills.

Outside Salesperson. Winchester Woodworking Corporation, Winchester, VA.

Sold windows, doors, trim, columns and custom millwork. Managed over one half million dollars in sales in 2002. Interacted with customers and suppliers to ensure satisfaction. Developed project management skills.

Process Control Technician. Georgia Pacific, Mt. Hope, WV.

Worked full-time during summers of 1998, 1999, & 2000. Performed quality control tests on oriented strand board. Monitored flake thickness, geometry and percent fines. Worked as a team to fix any quality problems.

Student Waiter & Manager. West Virginia University, Morgantown, WV.

Worked part-time during 4 years of WVU education. Trained and supervised student waiters. Worked with employees and customers to solve problems. Scheduled and audited student employment. Developed people and management skills during this time.

Forestry Aide, W.V. Division of Forestry, Beckley, WV.
Worked during summers of 1996 & 1997. Cruised timber and calculated volume of stands. Marked timber, boundaries and road layout. Assisted foresters and forest rangers.

Teaching

Teaching Assistant. Introduction to Natural Resources (NR 1114). Fall 2004.

Teaching Assistant. Forest Products Business Management (WOOD 4634). Fall 2007.

Publications

Perkins, Brian and Al Schuler. 2009. The Financial Crisis and the Wood Products Industry. Timberline. February. Volume 15. Number 2. P. 21-22.

Perkins, Brian and Al Schuler. 2009. Examining the Causes and Proper Responses to the Current Global Financial Crisis. Pallet Enterprise. February. Volume 29. Number 2. p. 24-27.

Perkins, Brian and Al Schuler. 2009. Financial Cobweb: The financial entities entangled themselves, the U.S. housing industry, and every mom and pop on main street. here's how it happened. Timber Processing. January/February. Volume 34 Number 1. p. 14-17.

Perkins, Brian and Brian Bond. 2008. Scragg Mill Low-Down. Southern Lumberman. September Vol. 126 No. 6. p. 22-23.

Perkins, Brian, Bob Smith and Philip Araman. 2008. Analyzing the Feasibility of Utilizing Small Diameter Hardwood Timber for Solid Wood Products and Residues. USDA Forest Service, Southern Research Station. General Technical Report. GTR-SRS-111. p. 6

Perkins, Brian. 2008. Managing Energy Costs, Opportunities. Pallet Profile Weekly. May 16.

Perkins, Brian, Robert Smith, and Brian Bond. 2008. Case Study of the Economic Feasibility of a Red Oak Small Diameter Timber Sawmill and Pallet Part Mill. Wood & Fiber Science. 40(2): 258-270.

Perkins, Brian, Robert L. Smith and Brian Bond. 2008. Solid Wood and Residue Yield Analysis of Small-Diameter Red Oak Logs. Forest Products Journal. 58(1/2): 97-100.

Perkins, Brian and Robert Smith, 2008. A Look at the Woodworking Industry's Response to Globalization. Wood & Wood Products. January.

Perkins, Brian and Robert Smith, 2007. Virginia Tech Survey Shows Companies Responding, Adapting to Globalization. Pallet Enterprise. November. Vol. 27 No. 11. p. 28-29.

Proposals Funded

Benchmarking Factors that Determine Marketing and Firms Performance of Eastern Hardwood Lumber Manufacturers
Investigator(s): Smith, Robert L. and Brian R. Perkins
Sponsor: Wood Education Resource Center of USDA Forest Service
Amount: $63,916
June 27, 2007 - June 1, 2008

Presentations

Perkins, Brian, Robert L. Smith, Gerry Jackson, and Susan LeVan-Green. 2005. Evaluating Markets for Small-Diameter Timber: A Case Analysis in Northern Mississippi. 59th Forest Products Society International Convention. Quebec City, Canada. June 19-22. FPS Poster

Perkins, Brian, Robert L. Smith, and Charlie Becker. 2006. A Business Model for a Small-Diameter Processing Facility in Southwest Virginia. Presented at the 60th Forest Products Society International Convention. Newport Beach, CA. June 25-28, 2006.

Perkins, Brian R. and Robert L. Smith. 2006. A Business Model for a Small Diameter Processing Facility in Southwest Virginia. Presented to the Research Review team from the U.S. Forest Service Southern Station out of Atlanta for the Virginia Department of Forestry Review held at Blacksburg on August 16.

Perkins, Brian R. and Robert L. Smith. 2007. Opportunities for Business Development Utilizing Small-Diameter Timber. Poster presentation at the 61st International Convention of the Forest Products Society, Knoxville, TN, June 10-13, 2007.

Perkins, Brian R. and Robert L. Smith. 2007. Globalizations Impact on the Marketing and Management of Forest Products Firms in the U.S. Presentation at the 61st International Convention of the Forest Products Society, Knoxville, TN, June 10-13, 2007.

Perkins, Brian R. and Robert L. Smith. 2008. Opportunities for Business Development Utilizing Small-Diameter Timber. Poster presentation at the Smallwood 2008 Conference, Madison, WI. May 13-15, 2008.

Perkins, Brian R. and Robert L. Smith. 2008. Factors that Influence Firm Performance of Eastern Hardwood Lumber Manufacturers. Poster presentation at the 62nd Forest Products Society International Convention at St. Louis, MO. June 22-24.

Perkins, Brian R. 2008. Overview of Hardwood Utilization in the United States by Market Segment. Presented at the 62nd Forest Products Society International Convention at St. Louis, MO. June 22-24.

Reports

Perkins, B., Casselman, C., Bonsi, R., and Leonard, T., 2005. Marketing Plan for Turman Log Homes. Final Report. 43 p. Department of Wood Science & Forest Products, Forest Products Marketing Class.

Perkins, B., Smith, B., and Jackson, G., 2005. Potential Utilization of Small Diameter Timber in Northern Mississippi. Final Report. 66 p. Department of Wood Science & Forest Products, Center for Forest Products Marketing & Management, Virginia Polytechnic Institute & State University Blacksburg, VA.

Perkins, Brian, Robert L. Smith, Brian Bond, A.L. Hammett, and Philip Araman, 2006. A Business Model for a Red Oak Small Diameter Timber Processing Facility in Southwest Virginia. M.S. Thesis. 149 p.

Newsletters

Perkins, Brian (Editor). *Center Focus*. March 2005 to present. Quarterly. Center for Forest Products Marketing & Management, Department of Wood Science & Forest Products, Virginia Polytechnic Institute & State University Blacksburg, VA.

Perkins, Brian (Editor). *Research Update*. March 2005 to present. Biannual. Center for Forest Products Marketing & Management, Department of Wood Science & Forest Products, Virginia Polytechnic Institute & State University Blacksburg, VA.

Service

Member of the University Energy & Sustainability Committee. Fall 2006 to current.
Delegate to the Graduate Student Assembly. Spring 2005 to Summer 2008.
Wood Magic volunteer. 2005, 2006, & 2007.

Awards

Member #271 of National Honor Society for Forest Technology.
Andersen Tully Management Scholarship recipient. 2005.
Appalachian Hardwood Manufacturer's, Inc. Scholarship recipient. 2006.
Steven Sinclair Forest Products Marketing Scholarship 2007.