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SOFTWOOD SUBSTITUTION IN THE US RESIDENTIAL CONSTRUCTION INDUSTRY

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September 1996

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EXECUTIVE SUMMARY

Material substitution in the residential construction industry is driven by a variety of factors including product availability, product performance, price, price stability, and in-place costs. As competition between softwood lumber and substitute products increases, managers need to understand end-users' changing perceptions of softwood lumber and the competitive position of softwood lumber *vis à vis* substitute products. Despite the relative availability of product literature describing substitute building materials, the extent of substitute product diffusion remains unclear. Perhaps more importantly, virtually no information exists regarding the diffusion process for substitute products in the residential construction industry, including the impact of specific product attributes and end-user characteristics in promoting the diffusion process. This exploratory study was developed to assess the competitive relationship between softwood lumber and substitute products in structural end-use applications in the US residential construction industry. In particular, the study was designed to identify those product attributes that are perceived by residential contractors to be important in influencing the substitution process.

Empirical data for this exploratory study was obtained from a cross-sectional mail survey of 1,500 residential contractors in the United States. The sample frame for the study was derived from the membership of the National Association of Home Builders (NAHB). In order to obtain a uniform geographical representation, equal numbers of participants were randomly selected from the northeast, southeast, southwest, and northwest regions of the US. 176 usable questionnaires were returned, providing an effective response rate of 11.7%.

Over 90% of the respondents indicated that they had used at least one substitute product for softwood lumber in a structural end-use application. The use of specific substitute products varied considerably, with 72.7% of respondents reporting that they had used glulam beams while none of the respondents reported using plastic lumber. Only two products (glulam beams and wooden I-beams) were used by more than half of the respondents. Adoption/trial curves for several substitute products show a rapid increase in their use, particularly over the past five years. Despite this, respondents indicated that their use of structural softwood lumber is changing only moderately.

Respondents were asked to rate the importance of various product attributes in influencing their purchase decision regarding structural building materials. The analysis of the data indicates that product strength and straightness were rated the most important factors. Price and price stability were also rated highly, while environmental factors generally received the lowest importance ratings. A principal components factor analysis of the twelve product attributes identified three underlying factors that influence the material substitution process: the physical characteristics of the product, the technical characteristics of the product, and economic/supply characteristics of the product.

When asked to rate their satisfaction with softwood lumber, respondents indicated that they were satisfied with only two product attributes: lumber strength and lumber availability. Of the remaining product attributes, respondents were neutral regarding three and were dissatisfied with the remaining five product attributes. Lumber attributes with which respondents expressed dissatisfaction included: lumber straightness, number of defects, overall lumber quality, price, and price stability.

To explore the impact of environmental issues on the substitution process, respondents were asked to compare the perceived environmental impact of substitute building materials with that of softwood lumber. Surprisingly, almost all of the substitute products were perceived to produce a lower environmental impact than softwood lumber. No product was perceived to have a greater environmental impact than softwood lumber and only two products, plastic lumber and plastic/fiber composite lumber, were perceived to have a similar environmental impact. Finally, a statistical analysis of the research data indicated little variation in the responses based on the geographic location of the firm or the size of the firm.

The residential construction industry is extremely fragmented and competitive and the results of this research indicate that residential contractors are quite willing to experiment with new substitute products. To counter the competitive threat posed by aggressively promoted substitutes, softwood lumber manufacturers must become

market-oriented. Only by adopting a strong market orientation can they hope to place themselves in a position to understand the needs of residential contractors and develop marketing strategies to meet those needs, thereby increasing customer satisfaction. It is only by thoroughly understanding and responding to residential contractors needs that the softwood lumber industry can effectively reduce market penetration by the wide range of substitute products currently being offered in the marketplace.

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INTRODUCTION

The forest resource in the Pacific Northwest (PNW) has evolved over time as old-growth stands have been replaced by natural second-growth and plantation grown trees (Powell *et al.* 1992). Over the past forty years this has resulted in a shift from large diameter old-growth trees towards smaller diameter second-growth trees (Powell *et al.* 1992; Haynes *et al.* 1995). Similarly, changes in the age structure and growth rates of the forest resource have influenced the ability of forests in the PNW to produce high quality softwood lumber (Haynes *et al.* 1995; Warren 1995).

The declining trend in softwood lumber quality has perhaps been most dramatic for coastal Douglas-fir and hem-fir, but is also occurring with the inland species such as ponderosa pine and lodgepole pine, where there has been a steady decline in the recovery of the higher quality lumber grades over the past twenty years. According to production and yield data, the recovery of higher grade lumber has declined while the production of medium and low quality lumber products has increased (Haynes *et al.* 1995; Warren 1995).

In addition, availability of timber from federal and state forests in the PNW has been adversely impacted by a shift in public opinion regarding the disposition of publicly-owned natural resources. While in the past the public has placed a high value on utilizing the natural resources found on public lands, today there appears to be an increased emphasis on reducing utilization and/or on preservation of those resources. The public is also beginning to attach economic and aesthetic value to the ancillary services provided by old-growth and second growth forests, such as biodiversity, watershed protection, recreation, and wildlife habitat.

Recent changes in natural resource legislation at the federal and state levels have adversely impacted the volume of timber harvested from publicly owned forests in the PNW. In Washington and Oregon, public ownership of timberlands represents 44.8% and 60.2% of the total resource, respectively (WWPA 1996). The impact of harvest restrictions on public forest lands from legislation and litigation is a significant factor behind the decline in lumber production in the PNW. For example, from 1987 to 1994, total lumber production in Washington and Oregon declined by 11.8% and 44%, respectively, while the ratio of timber harvested from public lands declined from 37.1% to 20% in Washington, and from 59% to 21.3% in Oregon (Warren 1996).

In addition to reducing harvest volumes, resource legislation has locked up the majority of the remaining old-growth and second growth resource on public lands, further reducing the quality of lumber produced in the PNW region. The primary timber species in the PNW are Douglas-fir, ponderosa pine and the hemlock-fir-spruce group collectively known as hem-fir. From 1972 to 1992, for example, recovery of higher quality lumber grades declined from 21.1% to 12% for Douglas-fir, from 15.1% to 9.2% for ponderosa pine, and from 11.3% to 6.5% for hem-fir (Warren 1995). Harvest restrictions have also contributed to price increases and price instability. For example, the price of No. 2 Douglas-fir sawlogs more than doubled between January 1989 and January 1993. Log prices remained high throughout 1994 before declining slightly in 1995 (Log Lines 1995). The events described above have contributed to a growing perception of uncertainty regarding the availability and price structure of forest products in the PNW.

Structural Changes in the Mix of Forest Products

Over the past five years, reductions in resource availability, resource quality, and price fluctuations have contributed to an increase in competition from substitute building materials in residential and non-residential construction markets. As a result of price and quality considerations, substitute products such as engineered wood products, steel lumber and plastic lumber, have registered substantial market gains at the expense of softwood lumber and are expected to continue this strong performance in the future. For example, the American Iron and Steel Institute (AISI) estimates that, while steel studs currently represent approximately 3-5% of the residential housing market, they expect to capture 25% of the market by 1998 (Random Lengths 1996). Although most experienced industry managers regard this claim to be unrealistic, it illustrates the new competitive environment in the residential construction industry.

Many industry analysts estimate that steel studs become price competitive with softwood lumber at a price of $425/mbf. During the course of 1994 the composite price for softwood framing lumber, for example, fluctuated between $350/mbf to $520/mbf (Random Lengths 1995). Recent research by CINTRAFOR suggests price stability and comparative price are equally important factors in influencing substitution between wood and steel studs. Future uncertainty regarding the supply of timber from public lands in the PNW will continue to contribute to price volatility, further increasing the competitiveness of price stable substitute products.

Perhaps more interesting than the steel-wood debate from a marketing perspective has been the remarkable success of engineered wood products in the marketplace. From such basic products as oriented strandboard (OSB) to more exotic, specialty products like Parallam® and Timberstrand® lumber, engineered wood products are increasingly gaining acceptance as substitutes for solid wood products in many structural end-uses and even in some appearance applications. As a result of increased market acceptance, production of these products has increased substantially (Table 1). One measure of the success of engineered wood products was reported in a recent nationwide survey of building material retailers, which found that while less than one-half of building material retailers stocked engineered wood products in 1990, but by 1994 87.3% reported stocking wood I-beams, 83.1% stocked glulam beams, 80% stocked laminated veneer lumber and 58.6% stocked parallel strand lumber (McDowell 1994).

Table 1. Production trends for panel products and engineered wood products in North America.

Product	1972	1994
Western plywood (mmsf, 3/8 inch basis)	13,005	6,425
Southern plywood (mmsf, 3/8 inch basis)	5,449	13,139
Canadian plywood (mmsf, 3/8 inch basis)	2,234	2,200
Particleboard	3,334	5,614
Medium density fiberboard	231	1,434
Oriented strandboard, US (mmsf, 3/8 inch basis)	100	7,986
Oriented strandboard, Can. (mmsf, 3/8 inch basis)	190	3,600
Laminated veneer lumber (million board feet)	0	440
Parallel strand lumber (Parallam) (million linear feet)	0	50
Wood I-beam (million linear feet)	180	385
Glue laminated lumber (million board feet)	140	308
Finger jointed lumber (million board feet)	0	133

Sources: APA; Statistics Canada; USDA FPL GTR 82; Widman World Wood Review 1994; Crows 1992.

Factors That Influence the Acceptance of New Products

A recent study of the building materials industry suggests that the market success of engineered wood products can be attributed largely to a strategy of push marketing (McDowell 1994). This is an impressive accomplishment given the fact that a more effective marketing strategy for introducing new products is a pull rather than a push strategy. In using a push strategy, a manufacturer tries to increase demand for a product by providing retailers with a variety of price and/or promotional incentives that encourage them to push the product to consumers. In contrast, a pull strategy creates demand for a new product by informing consumers of the benefits of the new product and, if successful, the resultant consumer demand for the product will encourage retailers to stock it, in essence "pulling" the product through the distribution channel. Naturally, the fundamental requirements for implementing an effective pull strategy requires that consumers are: a) made aware of the new product, b) educated regarding the potential benefits of the new product with respect to existing products, and c) convinced that the new product represents a better value than existing products.

In the same survey, builders and retailers indicated that three factors restricted the wider acceptance of engineered wood products in the US: high prices, limited availability (particularly with respect to the ability of retailers to order smaller lot sizes), and lack of product knowledge at the consumer level (McDowell 1994). In addition, geographic location appears to influence the adoption rate for engineered wood products in the US. The survey results indicated that, while 53% of building material retailers in the western US stocked engineered wood products, less than 25% of retailers in the east stocked the same products (McDowell 1994).

While there is some evidence to suggest that builders and contractors are increasingly using alternative materials as substitutes for softwood lumber in structural applications, much of this information is anecdotal or based on samples of limited size and scope. The purpose of this study is to determine the extent to which substitution between wood and non-wood structural products is occurring within the residential construction industry. The study was also designed to identify those factors that influence the decision to utilize substitute products in structural end-use applications in the residential construction industry.

LITERATURE REVIEW

The Softwood Lumber Market

Over the period 1980-1995, lumber consumption in the United States grew from 33.8 bbf to 47.6 bbf, an increase of almost 41% (WWPA 1996). Traditionally, the residential construction industry has been regarded as the driver for softwood lumber production and there has been a strong correlation between the number of residential housing starts and the volume of softwood lumber production (Figure 1). However, the relationship between housing starts and softwood lumber production began to change in the mid-1980's, largely in response to increased consumption in the repair and remodel (R&R) market segment (Figure 2). Not only has the R&R market for softwood lumber grown to rival that of residential construction, but consumption in the R&R market segment has exhibited a more stable trend over the past twenty-five years.

Despite overall growth in softwood lumber consumption, softwood lumber production in the US exhibits two dramatically different historical trends (Figure 3). Following the economic recession of the late 1970's and early 1980's, softwood lumber production increased rapidly from 1982-1988. During this period softwood lumber production increased by 60% to a volume of 50.3 bbf. In contrast, since 1988 softwood lumber production declined by 11% to a volume of 44.7 bbf (WWPA 1996). Softwood lumber production statistics reveal that the overall production decline has occurred despite a rise in softwood lumber production in the southern US to record levels. Virtually all of the decline in softwood lumber production has occurred in the PNW and can be largely attributed to federal timber harvest restrictions that have adversely affected harvest levels in public forests.

During this period of increasing domestic consumption and declining domestic production of softwood lumber, the role of foreign suppliers has become increasingly important. During the period 1988-1995, softwood lumber imports into the US increased by 26% to an all-time high of 17.3 bbf (WWPA 1996). Softwood log imports have increased at an even faster rate, although the volume of softwood log imports is only a small percentage of softwood lumber imports. While the vast majority of softwood lumber imports originate from Canada (over 90%), increasing volumes of lumber are arriving from New Zealand, Chile, and Mexico.

Obviously, timber harvest restrictions in the PNW have contributed to a restructuring of the global trade flows of softwood lumber and have fundamentally changed the competitive structure of the softwood lumber industry. For example, in recent years the market for softwood lumber has been characterized by steadily increasing prices punctuated by sudden price spikes (Figure 4). The combination of rising consumption, declining production, and price instability has contributed to a market environment where substitute products are more attractive to consumers.

Substitute Building Materials

The literature on building materials describes a wide variety of potential substitutes for softwood lumber in structural end-use applications (MIT 1991; McKeever and Anderson 1992; NAHB 1993). Some substitute products (*e.g.*, glulam beams) have been on the market for many years and enjoy wide acceptance within the residential construction industry. However, many of the substitute products currently available (*e.g.*, Timberstrand® lumber) are relatively new arrivals to the market (Gunderson and Gleisner 1994). When discussing substitute products, it is useful to differentiate between wood-based products and non-wood products.

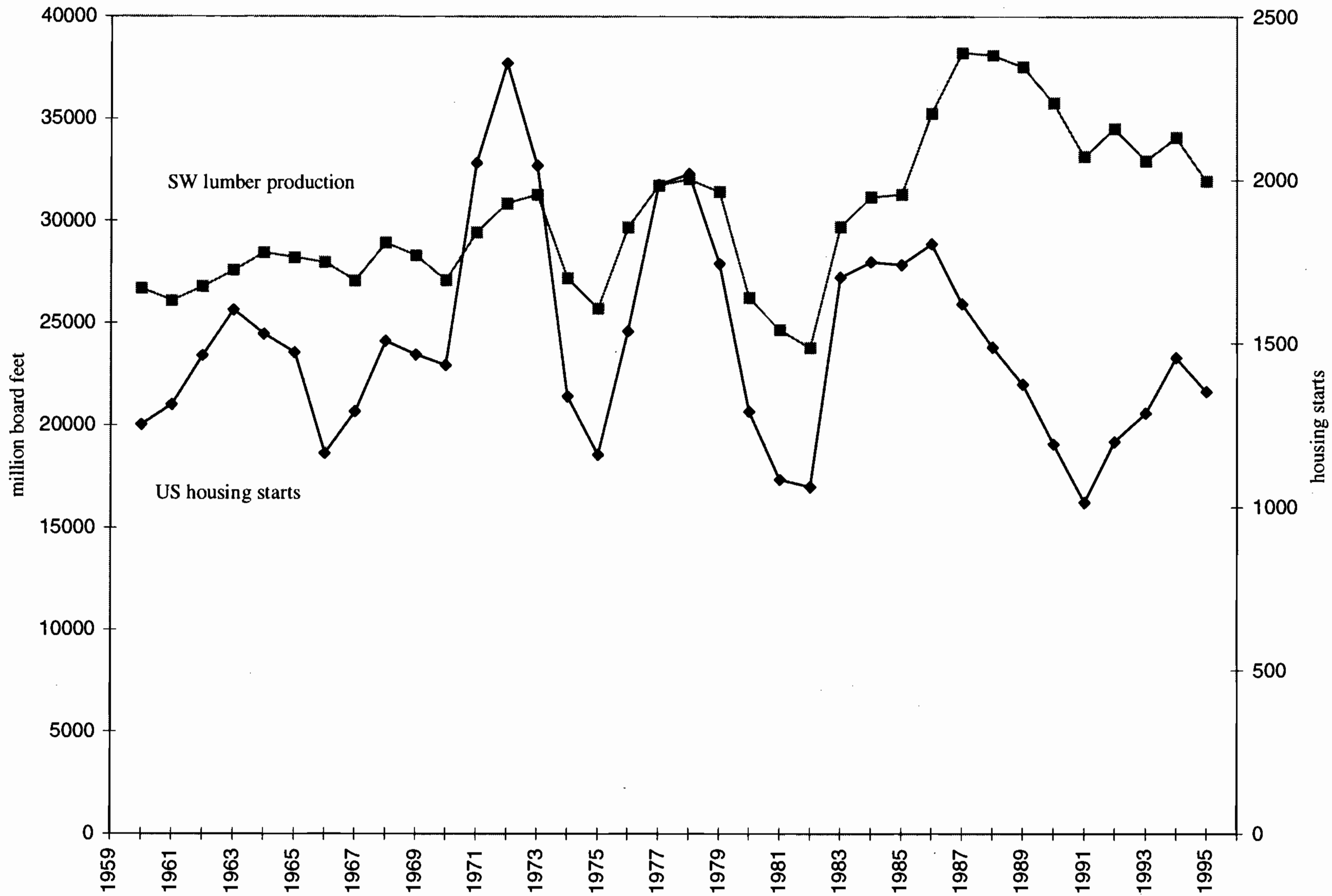


Figure 1. The relationship between housing starts and softwood lumber production in the US (US Bureau of the Census 1995).

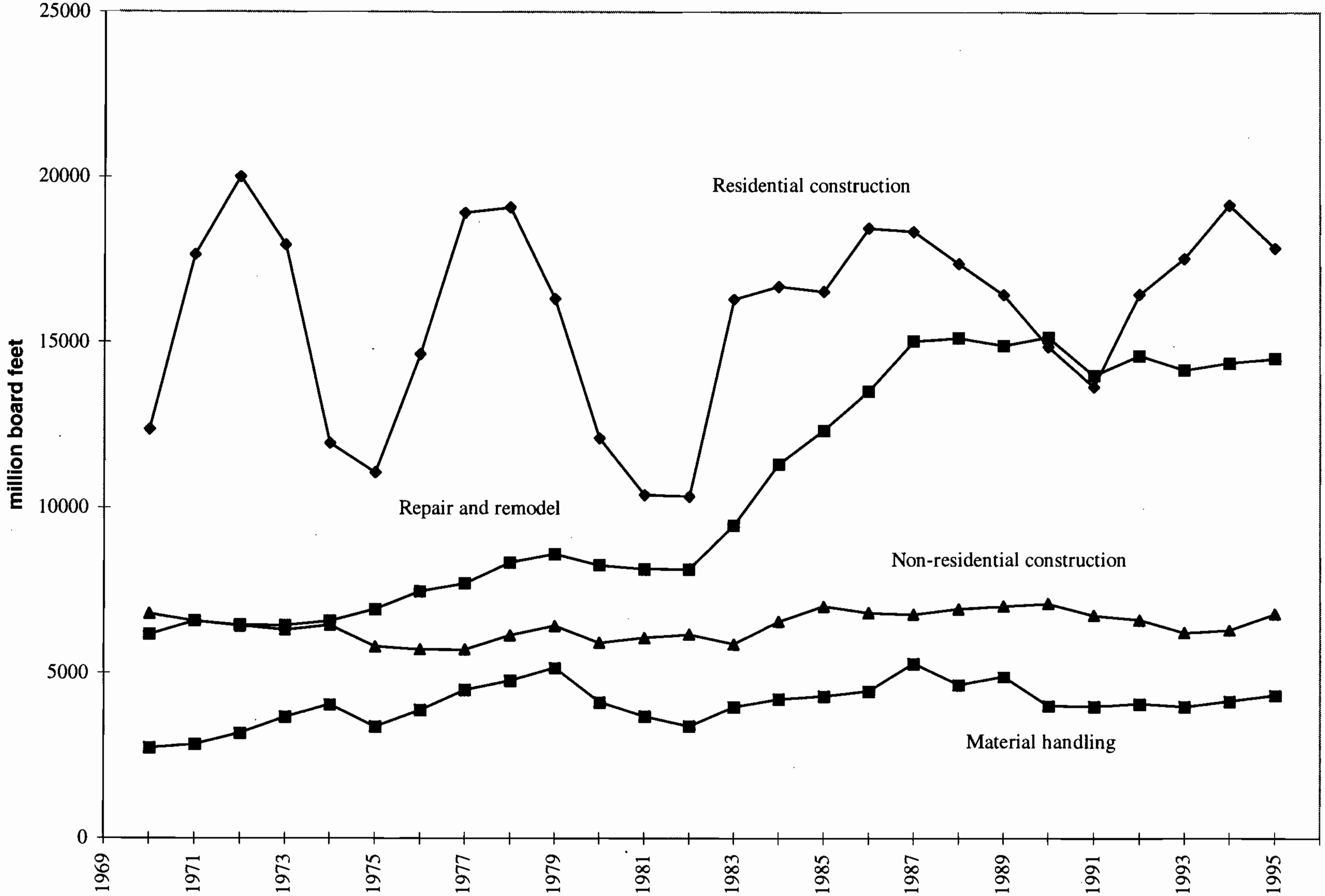


Figure 2. US consumption of softwood lumber, by end-use market (WWPA 1996).

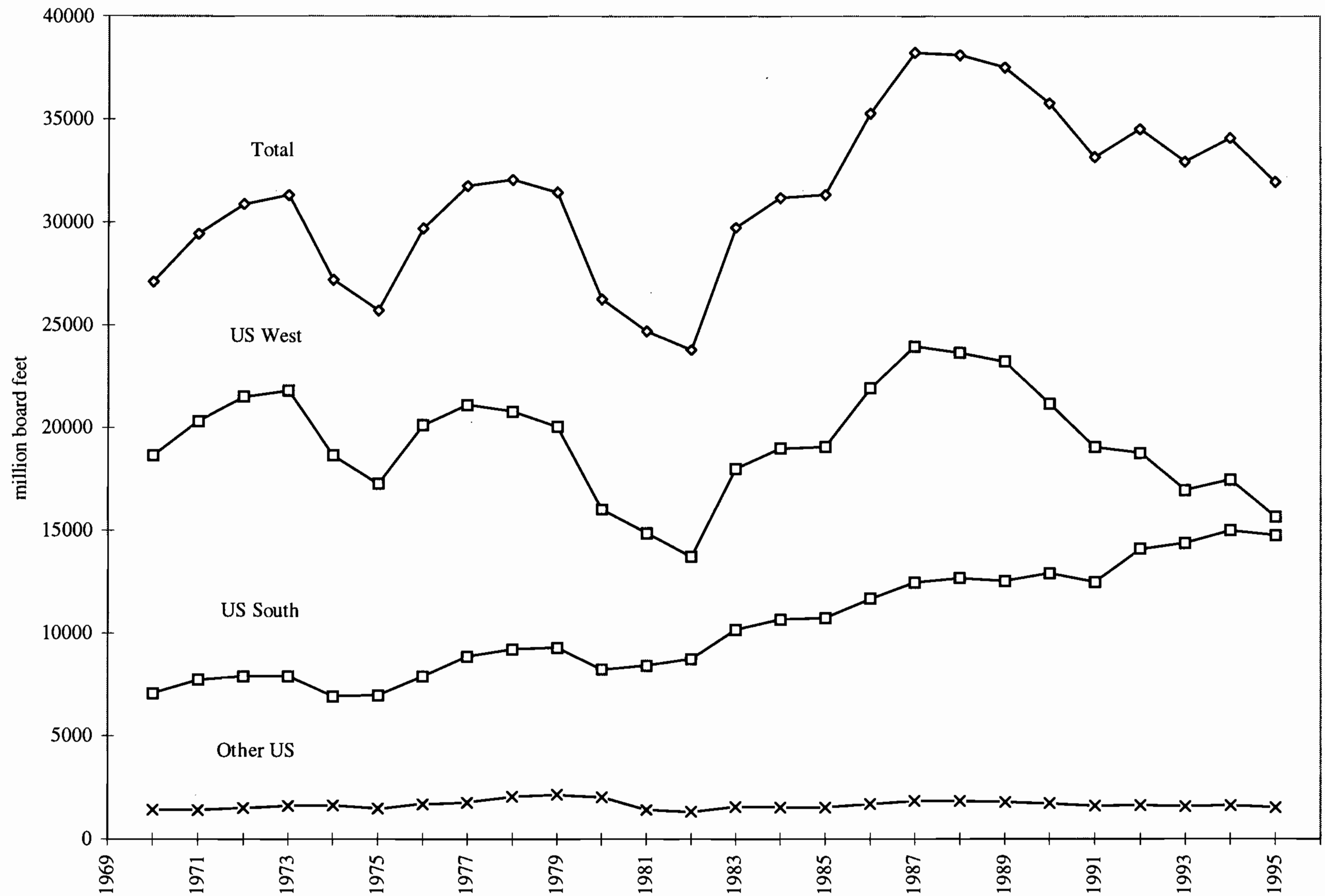


Figure 3. US softwood lumber production, by region (WWPA 1996).

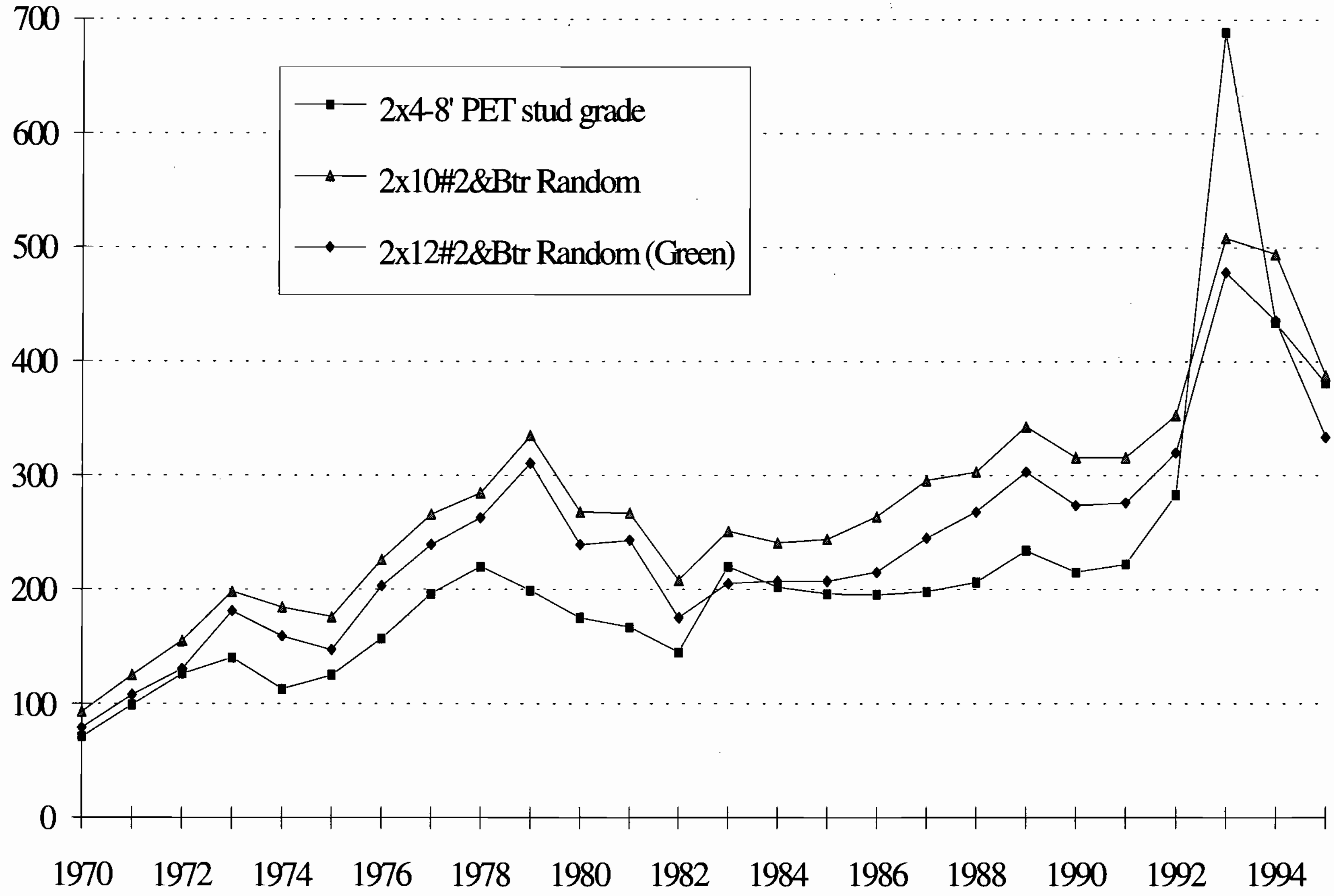


Figure 4. Prices for Douglas-fir lumber (Random Lengths 1995).

Wood-based building materials
As a generic product category, engineered wood products are not new to the market (Crowley 1990; Abbot 1993; Douglis 1993; Widman 1993; McDowell 1994). For example, plywood in one form or another has been in use for thousands of years (Baldwin 1995). Over the past twenty years, however, the engineered wood products industry has grown rapidly, partly in response to the changing nature of the timber resource. As the quality of the forest resource has declined, innovative firms have found ways to manufacture a high quality product from a low quality resource. In large part, the growth of the engineered wood products industry can be attributed to the advantages these products provide over softwood lumber (Koch 1992; Maloney 1992; Marshall 1994).

An engineered wood product can be described as a matrix of wood particles and adhesive that is formed and pressed into a panel or lumber product. Given the flexibility of the production process, the geometry of the wood particles can range from individual wood fibers to long, thin strands of wood. The design of engineered wood products allows for more efficient utilization of a low quality resource while providing a uniform product with superior technical performance characteristics. Engineered wood products can also be designed to provide increased architectural design freedom by allowing longer spans without the need for intermediate supports.

Substituting engineered wood products for softwood lumber is particularly important in structural end-use applications. Engineered wood products that substitute for softwood lumber in structural applications include laminated veneer lumber (LVL), wood I-beams, parallel strand lumber, Timberstrand® lumber, and finger-jointed material. Open web trusses, which are essentially I-beams made with wood flanges and metal webbing, are included as a wood-based substitute because the firms which make them are more closely tied to the forest products industry than to the metals industry.

Laminated veneer lumber is produced from softwood veneers that are glued together into panels with the grain of the veneer oriented parallel to the length of the panel. The panels are then pressed and cut into lumber. Whereas with solid lumber products the presence of knots can reduce structural strength, the design of LVL allows strength reducing defects to be dispersed throughout the product. As a result, there is no zone of weakness and the final product is structurally superior to softwood lumber. LVL has traditionally been used in niche markets because of its relatively high price but is gaining broader acceptance as a substitute for softwood lumber in specific structural end-use applications. LVL is most often used as a substitute for softwood lumber in the following structural framing applications: hip and valley rafters, stairwells, door and window headers, long span beams, and scaffolding. LVL is also widely used to manufacture the flange component of wooden I-beams. Recently, some manufacturers have expressed an interest in utilizing LVL for furniture components and it is currently being used as a substitute for lumber in the manufacture of door stiles (Eckelman 1993).

Between 1990 and 1992, the number of lumber retailers who stocked LVL products increased from 55% to 80% and use by residential contractors increased from 43.2% to 72.8% (Williamson 1994). In 1992, it was estimated that 275 million board feet of LVL was produced, representing approximately 0.5% of total lumber consumption. While LVL production was expected to increase to 520 million board feet by 1995, its high price relative to softwood lumber would likely have mean that it would continue to be used in specific structural end-use applications requiring superior strength characteristics (Widman 1995).

Wooden I-beams derive their name from the fact that the cross-section of the product resembles an "I." The upper and lower caps of the "I" are referred to as flanges while the center body portion is called the web. Wooden I-beams have been used since the 1920's when they were used in the production of wooden aircraft (Leichti et al. 1990). In recent years, wooden I-beams have become a growth industry in North America and production has increased from 153 million linear feet in 1990 to 385 million linear feet in 1994. Wooden I-beams are generally manufactured using either softwood lumber, low density hardwood (*e.g.*, tulip poplar) lumber, or LVL for the flanges, while oriented strandboard is usually used for the web (although plywood and hardboard are also used). Wooden I-beams offer many advantages over softwood lumber in floor and ceiling applications, including a high strength to weight ratio, longer lengths, and reduced construction labor costs.

Glue laminated beams (glulam) were first produced commercially in the 1950's. Manufactured by gluing together 1 to 2 inch thick softwood lumber, glulam beams can be produced in long lengths and large cross-sectional sizes. The laminating process allows strength-reducing defects located in individual lumber components to be dispersed throughout the beam, producing a beam with enhanced strength characteristics. Commonly used as structural beams, columns and arches, glulam beam production has more than doubled since 1990, increasing from 143 million linear feet in 1990 to 308 million linear feet in 1994. Glulam lumber is cost competitive with softwood lumber in structural end-use applications that require long spans and/or large cross-sections.

Parallel strand lumber (Parallam®) is manufactured from long pieces of clipped veneer that is mixed with phenolic resin and formed into billets. The billets are then extruded to produce a beam that meets specific cross-sectional and length requirements of end-users. Manufactured at only two facilities in North America, it is estimated that 50 million linear feet of parallel strand lumber was produced in 1994. Parallel strand lumber is generally used for beams, columns, and headers. Similarly to LVL and wooden I-beams, it allows architects to design longer unsupported spans thus providing increased design flexibility. Given its high cost and low level of production, parallel strand lumber will likely remain a specialty product for niche markets.

Timberstrand® lumber is a panel product manufactured from 6 to 12 inch long wood strands (in contrast to Parallam® which utilizes waste wood veneers as a raw material input). The wood strands are mixed with an isocyanate resin, are formed into a mat, and are pressed into a panel using a single-opening, steam injection hot press. The final panel can range in thickness up to 6 inches and is sawn into a broad range of lumber products. Timberstrand® is currently produced in a single facility but work has begun on a second manufacturing plant. End-uses for Timberstrand® lumber include window and furniture components.

Finger-jointed lumber is produced by removing the defects from softwood lumber and gluing together the small, clear pieces into longer lengths using finger-joints (Tonge 1992; Jones 1993). Finger-jointed lumber is considered to be a solid wood product and is a direct substitute for softwood lumber in residential construction (Cohen 1993). Production volumes of finger-jointed lumber in 1994 reached 130 million board feet, more than double the volume produced in 1990 (Widman 1993). The price of finger-jointed lumber is generally 10-15% higher than softwood lumber, a factor which has restricted its use in the residential construction industry. However, the advantages of this product (longer lengths, greater straightness, and minimal defects) often outweigh the higher price. One common misperception among contractors is that the finger joint represents an area of weakness in the lumber. In actuality, the finger joint is considerably stronger than the other areas of the lumber. While the overall market for this product is still relatively small, regional markets can be quite substantial. For example, approximately 80% of the residential contractors in Dallas, TX are reported to have used finger-jointed studs.

Prefabricated trusses are manufactured from solid wood components that are joined together using either metal or plywood connectors. Prefabricated trusses are used in roof systems to replace rafters and ceiling joists, or as an alternative to softwood floor joists (Wardell 1993). Prefab trusses reduce construction time because they arrive on the construction site pre-assembled and ready to be set in place. In addition, trusses provide cost savings because they reduce labor costs and virtually eliminate material waste on the construction site.

Open web trusses are becoming a popular substitute for softwood lumber joists in floor and ceiling end-use applications. Made with 2x4's or a combination of 2x4's and steel tube webbing, they offer many of the same advantages of LVL and wooden I-beams in that they provide longer spans and utilize smaller sizes of wood to replace large dimension lumber. Production of open web trusses totaled 199 million linear feet in 1990.

Non-wood building materials

As the price of wood products has increased, substitution of non-wood-based materials such as steel, plastic, and concrete have become more attractive to residential contractors (McKillop *et al.* 1980). While steel and concrete have long been used as substitutes to softwood lumber in non-residential construction, recently they have begun to be promoted more aggressively in the residential construction market (McLeister 1992; McHatton 1993).

The American Iron and Steel Institute (AISI) has vigorously promoted ***steel lumber*** in both residential and commercial construction projects, and it appears that their efforts have begun to pay off. For example, in 1993 12,000 homes were built using steel studs, up from 500 homes in 1992. AISI hopes to capture 25% of the residential market, approximately 300,000 homes, by 1997 (Barnard 1993; Daniels and Grogan 1994; Haws 1994). In 1993, 750,000 tons of steel dimensional products were produced, and it is expected to increase to between 800,000 to 850,000 tons in 1994. Currently, the total production capacity for steel lumber products is approximately 1,000,000 tons. To compare the volume of wood and steel consumption in a residential home, AISI estimates that a typical 2,000 square foot house requires 6 tons of steel lumber in comparison to 13,000 board feet of softwood dimension lumber (Haws 1994).

Wood industry analysts feel that steel lumber will only substitute for softwood lumber in an all-or-nothing way because the cost of using steel lumber and softwood lumber in combination is too high (McLeister 1993a; McLeister 1993b; Duff 1994; Irland 1994; Wardell 1994). Limited acceptance of steel lumber by both residential contractors and home buyers is one of the major issues confronting the steel industry. AISI has worked hard to promote the steel framing system to contractors hoping to gain increased acceptance by this traditionally conservative group. Currently, the National Association of Home Builders (NAHB) is evaluating steel lumber as a residential construction material in a number of demonstration houses to see how it functions as a substitute for softwood lumber (McLeister 1993b).

The steel industry must still overcome the perceptions of builders that steel is an expensive method of construction. While steel lumber is more expensive than softwood lumber, construction costs for an entire house designed and built with steel lumber can be 10-15% lower than a similar project using softwood lumber. However, this is not universally true and most residential contractors still find wood construction to be the more economical construction technique (McLeister 1993).

Plastic/fiber composite lumber is produced from a combination of recycled plastic and wood fibers and is manufactured by over one hundred companies. Recycled materials such as plastic grocery bags, industrial stretch film, sawdust and wood pallets provide the raw materials for this product (Leaversuch 1993; Chapdelaine 1994). Plastic lumber possesses workability characteristics similar to lumber although its strength is reported to be only about 60% of that of southern yellow pine and Douglas-fir lumber (Sonvig 1992). As a result, plastic/fiber composite lumber is primarily used in non-structural exterior end-use applications (*e.g.*: decking surfaces and fences). Plastic/fiber composite lumber is a growing industry and the acceptance of this product by consumers and contractors is increasing. However, the product is not endorsed by all environmental groups for fear that increasing popularity could eventually lead to increased demand for primary plastic products (Tomsho 1991; Meil 1994). Current research efforts are being focused on increasing the strength of plastic/fiber composite lumber so that it can be used in structural end-use applications.

Concrete is the most widely used substitute to wood framing in residential construction. For example, between 30 and 40% of the single family homes in Florida and Georgia are built with concrete walls (McLeister 1993). A number of different types of concrete systems and products are available for use in wall systems and foundations. In addition, pre-cast reinforced concrete components (floor joists and span blocks), can be used in residential floor systems while lightweight composite concrete/wood fiber panels are used as floor underlayment and exterior siding (Miller and Moslemi 1991; Lee and Chung 1993). However, given concrete's poor insulating characteristics its use in wall systems has generally been restricted to the southern regions of the US.

The Adoption of New Industrial Products

The decision to purchase a new product is a complex process that is influenced by a variety of factors. Product cost, type of end-use market (consumer vs. industrial), managerial attitude to risk, availability of product information, availability of product support, and familiarity of product form are just a few factors that influence the adoption of new products (Goldberg and Shepard 1989).

The type of end-use market for a new product strongly influences the adoption process. In part, the level of complexity associated with adopting a new industrial products is related to the magnitude of the impact that the product will have on both the manufacturing process and the profitability of the firm. Interrelated with this is the consideration that, on a personal level, the decision to utilize a new product represents a risk that could have an adverse impact on the career of the manager involved. As a result, it is important that marketers recognize the complexity of the adoption process and take steps to identify and evaluate the factors that most strongly influence the adoption process.

To illustrate the complexity of the adoption process it is useful to analyze the process at both the macro and micro levels. At the macro level the adoption process can be conceptualized as being comprised of four components. The first three components (adoption model, adopter classifications, and the rate of new product diffusion) form the basis for the fourth component, the synthesis of a marketing strategy for the new industrial product.

At the micro level, each of the first three process components can be further analyzed. There are several theoretical models that have been proposed to describe the new product adoption process (Lavidge and Steiner 1961; Baker 1975). The simplest model is usually referred to by its acronym, AIDA. The AIDA model suggests that the new product adoption process is comprised of four stages: Attention, Interest, Desire, and Action. A more refined model of the adoption process was provided by Lavidge and Steiner (1961). In this model it is suggested that the process of adopting a new product begins with awareness followed by knowledge, liking, preference, conviction, and purchase. However, perhaps the most accepted model of the new product adoption process is that proposed by Rogers (Baker 1975). In his model, initial awareness of the product is followed by interest, evaluation, and trial. Assuming a favorable trial outcome, the fifth and final stage of the process would be adoption of the new product.

The key to achieving a positive outcome during the adoption process is the effective design and implementation of a marketing strategy that makes potential customers aware of the new product and persuades them to try the product. However, perhaps more important is the ability of the marketer to identify the appropriate segment of potential customers toward whom to focus the promotional message. Baker (1975) suggests that marketing strategies could be made more effective with the help of a model that identifies a consumers' likelihood of adopting a new product, assuming that all potential adopters become aware of the product at the same time. In his adoption curve model, potential customers are categorized into one of five adopter groups: innovators, early adopters, early majority, late majority, and laggards. Those consumers most likely to purchase a new product are called innovators and represent about 5% of all consumers. Early adopters, who represent about 10% of consumers, are more likely to purchase a new product than is the average consumer, although they require more time and information to reach a decision than do innovators. The early majority (35% of consumers) are willing to purchase a new product only after it has been proven to perform well. A product will have been well accepted by consumers by the time that members of the late majority decide to purchase it. Finally, Baker suggests that there is a group of consumers, referred to as laggards, who are unwilling to purchase a new product no matter how well it may have been accepted by the market.

Each of these adopter categories is a conceptual effort to represent the propensity of a consumer to purchase a new product. While Baker's model is theoretical and not based on empirical data, it has important implications for marketing new industrial products. Perhaps most importantly, it asserts that the initial market for a new product is likely to be limited to a small segment of potential customers. This suggests that marketers focus their efforts on developing a demographic profile of innovators to facilitate the development of an efficient and effective marketing strategy.

Equally important, the model suggests that the marketer can identify which information sources and outlets innovators rely on for information about new products. For example, while early adopters might rely on sales people to provide them with comparative product information, innovators are much more likely to undertake an active information search and rely on professional publications, scientific journals, and special interest magazines for information to help them make a purchasing decision.

The third component of the adoption process implies that not all new products achieve the same rate of diffusion (market acceptance) into the market. In Mansfields' (1968) research on the diffusion of industrial innovations, he concludes that several factors strongly influence the adoption of new industrial products. First, he suggests that the diffusion process for new industrial products is considerably slower than new product adoption in consumer markets. Second, it appears that there is a bandwagon effect for new industrial products. This suggests a differential diffusion rate, with diffusion occurring relatively slowly during the introductory phase until a critical mass of consumers has adopted the product, when the diffusion rate for the new product increases substantially. Third, new products that can be shown to increase the profitability of the firm are more likely to be initially adopted by firms earning lower than average returns on investment (ROI). Finally, the attitude of managers towards accepting the risk associated with adopting a new product is perhaps the single most important factor influencing the rate of diffusion of a new industrial product.

Residential construction can be thought of as an industrial process that incorporates a broad range of diverse building materials into the final product. The attitude of residential contractors towards new building materials strongly influences their willingness to evaluate and adopt a new product. While little research has been done to identify those factors that influence the new product purchase decision, a recent survey looked at residential contractors' attitudes towards new products (Building Products 1992). The results of this non-scientific survey indicated that 77% of respondents had changed or added product brands over the past year. In addition, 73% of the respondents indicated that they had evaluated products that were new to the firm, while 60% had evaluated products that were new to the market. While the participants in the survey may not be representative of the industry as a whole, these results appear to indicate that residential contractors as a group are willing to try new products.

The survey further asked respondents to evaluate their satisfaction with a broad range of building materials. Of the materials listed, structural lumber received the third lowest satisfaction rating. Over 23% of survey respondents indicated that they had changed, or considered changing, their brand of structural softwood lumber because of their dissatisfaction with its performance and/or quality. This level of dissatisfaction indicates that there is an opportunity for alternative building materials to be substituted for structural softwood lumber, particularly if residential contractors have a high propensity to experiment with new products, as implied by the survey results reported by *Building Products* magazine.

RESEARCH OBJECTIVES

While a wealth of information exists on substitute building materials, the extent to which these products are used in residential construction is unclear. This study was designed to clarify this issue by assessing the current status of substitution between softwood lumber and alternative wood and non-wood building materials in the residential construction industry. Structural building materials were chosen as the focus of this study because of the importance of the residential construction industry to the softwood lumber industry. To assess the current status of substitution in the residential construction industry, this study identified the substitute building materials currently available and the extent to which each is being used by residential contractors. Primary data was collected to identify those firms using substitute materials and determine those factors that appear to influence the material substitution process in the residential construction industry.

A better understanding of building material use in structural applications (*i.e.*, wall systems, floor joists, ceiling joists, and roof trusses) is necessary for forest products managers to be in a position to confront the challenges of the rapidly changing marketplace. A popular catch phrase in customer-oriented marketing is that consumers buy solutions, not products. This is important for forest products managers to keep in mind as they respond to increasing competition from substitute building materials. For example, when considering substitutes to softwood lumber, an innovative contractor might look beyond those products that are direct substitutes (*e.g.*, steel lumber or finger-jointed studs) and expand his search to include products such as wall panel systems that may or may not include softwood lumber in their manufacture.

In order to assess material substitution in the residential construction industry appropriately, we need to identify the range of alternative products available and assess contractors' knowledge about and attitudes towards these substitute materials. A more complete understanding of the competition between softwood lumber and alternative building materials requires more than a list of the substitute products available, however. More specific information is needed to determine who is using these products and why they are being used. While rising production volumes for substitute products provides empirical evidence that their use is increasing, it provides little insight into the factors driving the substitution process. In an economic sense, price is generally credited with driving the substitution process. However, other factors might be perceived as being more important than price by innovative residential contractors. For example, increased product quality, reduced on-site labor costs, increased service life, and reduced in-service maintenance can all reduce the long-term costs of adopting a substitute product, thus increasing the value of a high priced product relative to a lower priced product. The manufacturers of substitute building materials have recognized the importance of non-price factors in encouraging the substitution process, and their advertisements in construction trade journals often emphasize the importance of these non-price factors.

In order to provide information on the substitution between softwood lumber and alternative building materials within the US residential construction industry, four objectives were developed for this project:

- Compile a summary of the major wood and non-wood building materials used to substitute for softwood lumber in structural end-use applications within the residential construction industry.
- Assess end-user satisfaction with softwood lumber.
- Quantify the extent to which substitute products are being used in the residential construction industry.
- Identify those factors that are perceived to influence the substitution process.

SURVEY DESIGN AND METHODOLOGY

The primary data for this project was obtained using a cross-sectional mail survey of residential contractors throughout the US. Residential contractors were chosen as the sample frame because they not only work with building materials but are often involved in the material selection process as well. A 1992 survey of residential contractors reported that 95% of respondents indicated they were very involved in the material selection process (Hanley-Wood, Inc. 1992).

The sample frame was purchased from the National Association of Home Builders (NAHB). The NAHB provided a mailing list of residential contractors chosen randomly from their membership of general contractors. The mailing list consisted of 1,500 residential contractors and was specifically constructed to provide equal representation of contractors throughout the four regions of the US: northwest, southwest, southeast, northeast.

Following an extensive review of the literature and interviews with industry experts, a preliminary questionnaire was developed. The questionnaire was pre-tested by five residential contractors located in the Seattle area, a market researcher at NAHB, and two marketing faculty members at the University of Washington. The pretest comments were used to guide the development of the final questionnaire (Appendix A). The final questionnaire consisted of four pages and was mailed to the study participants at the beginning of February, 1995. The initial mailing included a cover letter describing the purpose of the study, a copy of the questionnaire, and a stamped, return envelope. A follow-up letter encouraging participation was mailed two weeks after the initial mailing (Appendix B). Each completed questionnaire was dated upon receipt in order to facilitate testing for non-response bias. The cut-off date for receipt of completed questionnaires was the last day of April, 1995.

The research questionnaire was designed to solicit three types of information from respondents. First, nominal scales and open-ended questions were used to evaluate respondents use of substitute building materials in specific end-uses and identify those factors that were perceived to influence the material substitution process. Second, Likert scales were used to evaluate respondents overall satisfaction with a variety of softwood lumber attributes; to evaluate the importance of different product attributes in influencing the material purchase decision; and to assess respondents' perception of the environmental impact of using softwood lumber with respect to substitute products. Finally, basic demographic data relating to respondents' age, length of time with firm, education, position, firm type, annual sales revenue, and firm location was collected.

The preliminary number of responses totaled 196, of which 192 were fully completed. The four respondents who did not complete the questionnaire indicated that they were no longer involved in residential construction and their questionnaires were removed from consideration. A qualifier question was employed to screen out those firms that generated a majority of their sales revenue from non-residential construction projects. Following the screening process, the initial response rate of 13% (based on 196 responses) was reduced to an effective response rate of 11.7% (based on 176 usable responses).

The data obtained from the study was statistically analyzed using the SPSS statistical software package. To test for the presence of non-response bias, the Armstrong and Overton method (1977) for analyzing time trend responses across early and late respondents was used. Non-response bias is a concern in the interpretation of survey data because of the possibility that respondents may differ in some way from non-respondents. Non-response bias, if found, indicates that the survey results are not representative of the population being studied. In the Armstrong and Overton analysis, late respondents are used as a proxy for non-respondents on the assumption that late respondents will be more representative of non-respondents than would be early respondents. Early and late respondents were tested across a number of survey questions and no significant differences were detected, an indication that non-response bias was not a factor in the survey.

RESULTS AND DISCUSSION

Profile of Respondents

Respondents were asked to estimate the percentage of their firm's 1994 sales revenue generated from each of the following business activities: single family residential construction, multi-family residential construction, home improvement/remodeling, non-residential (commercial) construction, and patio/deck construction. Nearly 87% of the sales revenue generated by the responding firms resulted from one of the three industry segments associated with single family residential construction (Table 2). New single family residential construction represented the single largest source of revenue for respondents, providing almost three quarters of the total sales revenue reported. Home improvement/remodeling represented the second largest industry segment with almost 13% of total sales revenue. Interestingly, the non-single family market segments (*i.e.*, multi- family and non-residential construction) together accounted for 12.6% of total sales revenue and, despite the importance of the single family construction industry, more than half of the respondents were involved to some degree in multi-family and commercial construction projects.

Respondents were also asked to provide information regarding the geographic location of their business activities. Their responses were used to classify them into one of four geographic regions: northwest, southwest, northeast, and southeast. Although the sampling methodology was designed to provide for an equal distribution across the four regions, the response rate obtained from each region differed substantially. Respondents from the northeast region of the US provided 40% of the survey responses obtained, while the northwest region accounted for just 15%. The southeast and southwest regions represented 23 and 22% of the survey respondents, respectively.

Table 2. Percent of survey respondents 1994 sales revenue generated from various lines of construction.[a]

Line of Construction	1994 Sales Revenue (%)	Cumulative Percent
Single family residential construction	72.7	72.7
Home improvement/remodeling	12.9	85.6
Multi-family residential construction	9.4	95.0
Nonresidential construction	3.2	98.2
Patio/deck construction	1.2	99.4
Other	0.6	100.0

[a] Effective sample size = 173.

Survey respondents were asked to provide information regarding the total sales revenue of their firm in 1994. The information obtained from this question was used to segment the responding firms based on firm size, which was operationalized as the total sales revenue of the firm (Table 3). The survey results indicate that over 50% of the responding firms had sales revenues below $2.5 million in 1994, with an additional 26.6% of the firms reporting sales revenues in excess of $20 million. To facilitate the statistical analysis of the data, respondents were categorized into one of three industry segments based on firm size. Small firms were defined as those firms with annual sales revenues of one million dollars or less, medium-sized firms had sales revenues ranging from one to ten million dollars, and large firms had annual sales revenues in excess of ten million dollars. As a result of the segmentation process, small firms were found to comprise 33.5% of the respondents (58 firms), medium-sized firms represented 39.9% of the sample (69 firms), and large firms provided the remaining 26.6% of the respondents (46 firms).

Use of Substitute Structural Materials

An objective of the project was to quantify the use of substitute structural building materials within the US residential construction industry (Table 4). To evaluate the use of substitute building materials, respondents were asked a series of questions regarding their use of specific substitute products. Respondents were asked to specify the year they first used each substitute product and whether anyone currently employed by their firm had ever received training in the use of a substitute structural product. In addition, respondents were asked to approximate the volume of each structural building material used in the four structural ends-use applications being investigated, stud walls, floor systems, ceiling systems, and roof truss systems.

Table 3. Breakdown of survey respondents total 1994 sales revenue.[a]

1994 Sales Revenue	Number of Respondents	Percent of Respondents	Cumulative % Respondents
0 - $500,000	28	16.2	16.2
$500,001 to $1,000,000	30	17.3	33.5
$1,000,001 to $2,500,000	33	19.1	52.6
$2,500,001 to $5,000,000	21	12.1	64.7
$5,000,001 to $10,000,000	15	8.7	73.4
$10,000,001 to $20,000,000	22	12.7	86.1
Over $20,000,000	24	13.9	100.0

[a] Effective sample size = 173.

During the course of the literature review, very little information was found regarding the volume or proportion of substitute building materials being used in structural end-use applications by residential contractors. As a result of this research project, we found that almost 92% of the respondents had used at least one substitute product in a structural end-use application (Figure 5). While the vast majority of firms had used at least one substitute product, the number and type of substitutes used varied considerably among the respondents. For example, while almost three-quarters (73%) of the respondents indicated that they have used glulam beams, less than 10% reported using fiber/plastic composite lumber, while no respondents indicated using plastic lumber in a structural end-use application.

Despite an increase in media coverage of and industry promotional activities for steel framed homes, only 27% of respondents reported ever using steel lumber and less than 5% used steel lumber in 1994. In fact, only glulam beams and wooden I-beams were used by more than one-half of the respondents, while a total of five products were used by more than one-third of the respondents.

Table 4. Product substitutes for softwood lumber in structural end-use applications.

Wood-based Substitutes[a]	Non-wood Substitutes
Fiber/plastic lumber composites	Plastic studs
Finger-jointed lumber	Reinforced concrete
Glulam beams	Steel studs
Laminated veneer lumber	
Parallel strand lumber	
Wood I-beams	
Wood/steel floor trusses	
Wall panel systems	

[a] Category includes partially wood-based materials.

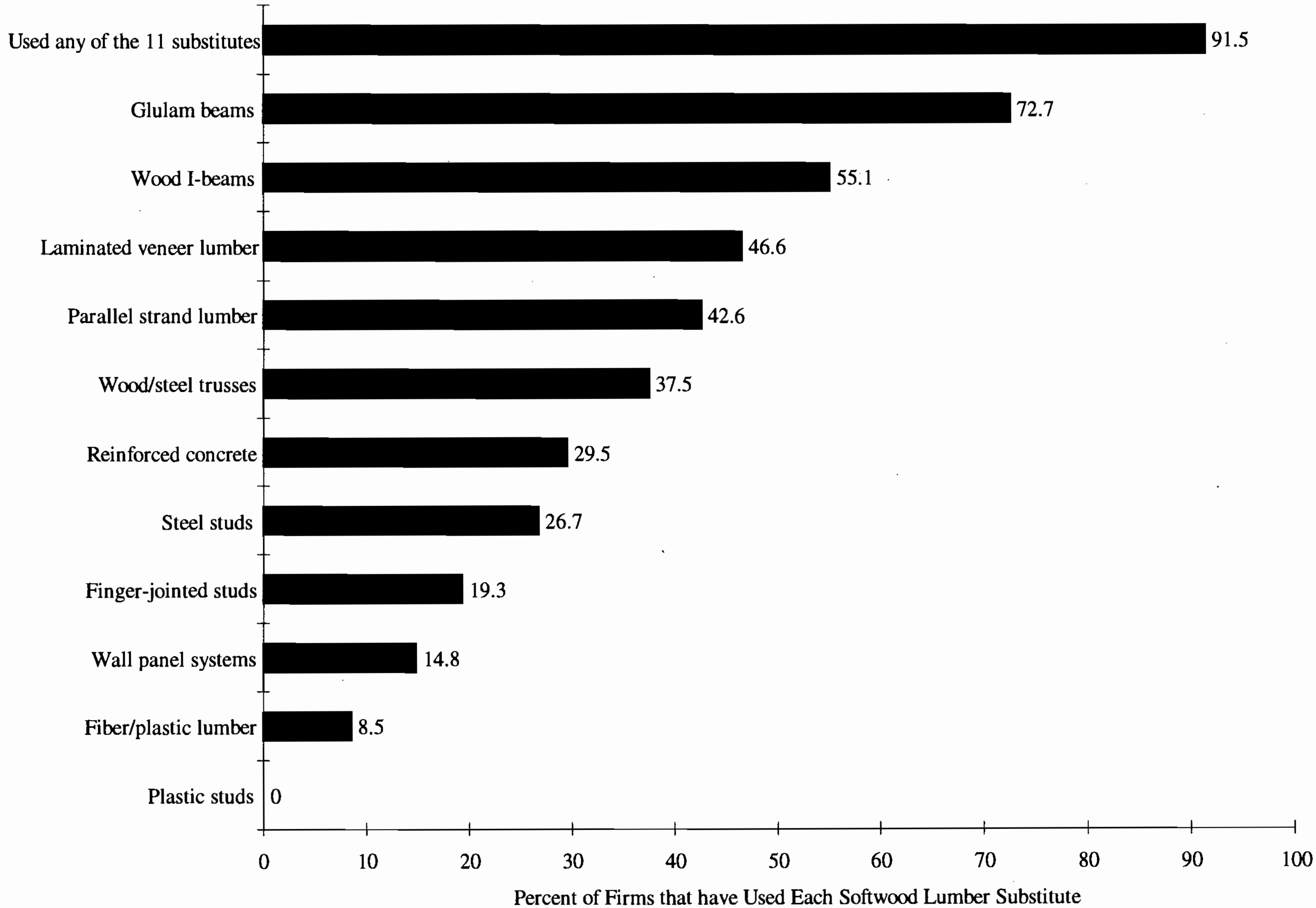


Figure 5. Percent of responding firms indicating use of various softwood lumber substitutes (n=176).

Respondents were asked to specify the number of substitute products they have ever used. The survey results indicate that respondent firms have used an average of 3.5 substitute products while the median number of products used was found to be 4 (Table 5). The distribution of the number of substitute products used by respondent firms appears to be normally distributed. Slightly over 66% of the respondents indicated that their firm had used between two and five substitute materials, while almost 20% reported using six or more substitute products. Just 8.1% of respondents indicated that they have never used a substitute for softwood lumber in structural applications. Based on these results, it appears that single family residential contractors are willing to try substitute products in structural end-use applications.

For each substitute product, respondents were asked to indicate the year that the substitute product was first used in their firm, if ever. This information was used to construct adoption/trial curves for the substitute products. The adoption/trial curves for wooden I-beams, laminated veneer lumber (LVL), steel studs, and finger-jointed studs are presented in Figure 6. Caution should be taken in interpreting the adoption/trial curves because no effort was made to determine if respondents had adopted each of the products and were still using them or if they had merely used the product as part of a trial evaluation and had since discontinued its use. In this sense, it might be better to think of the adoption curves more as trial curves than actual adoption curves.

The adoption/trial curves reveal several interesting patterns. First, the curves for wooden I-beams and LVL are quite similar to each other but distinct from the curves for steel lumber and finger-jointed studs. Second, both wooden I-beams and LVL appear to have acquired more than twice the market acceptance of steel lumber and finger-jointed studs. Finally, the adoption/trial of the wood-based products appears to be slowing while steel lumber exhibits an increasing rate of adoption/trial.

Table 5. Total number of substitute materials used by respondents.[a]

Total Number of Substitute Materials Used	Number of Respondents	Percent of Respondents	Cumulative Percent of Respondents
0	14	8.1	8.1
1	16	9.1	17.2
2	24	13.6	30.8
3	30	17.0	47.8
4	41	23.3	71.1
5	22	12.5	83.6
6	15	8.5	92.1
7	8	4.5	96.6
8	6	3.4	100.0

[a] Effective sample size = 176.

The similarity observed between the adoption curves for wooden I-beams and LVL can be partly attributed to the fact that both products are used as substitutes for wide width (8-12") structural lumber in joist and header applications. Given the similar end-use applications, it may be that many residential contractors are opting to replace solid wood joists and headers with substitute products in response to increasing product prices and the perceived decline in softwood lumber quality (see page 27). In addition, several manufacturers of wooden I-beams and LVL have been promoting their products as components of an engineered framing system, in effect encouraging contractors to switch from softwood lumber to engineered wood products in all joist, header and roofing applications.

The greater market share displayed by wooden I-beams and LVL with respect to steel lumber and finger-jointed lumber might be attributable to several factors. First, wooden I-beams and LVL are engineered wood products that are perceived by many contractors as being manufactured to consistently high quality

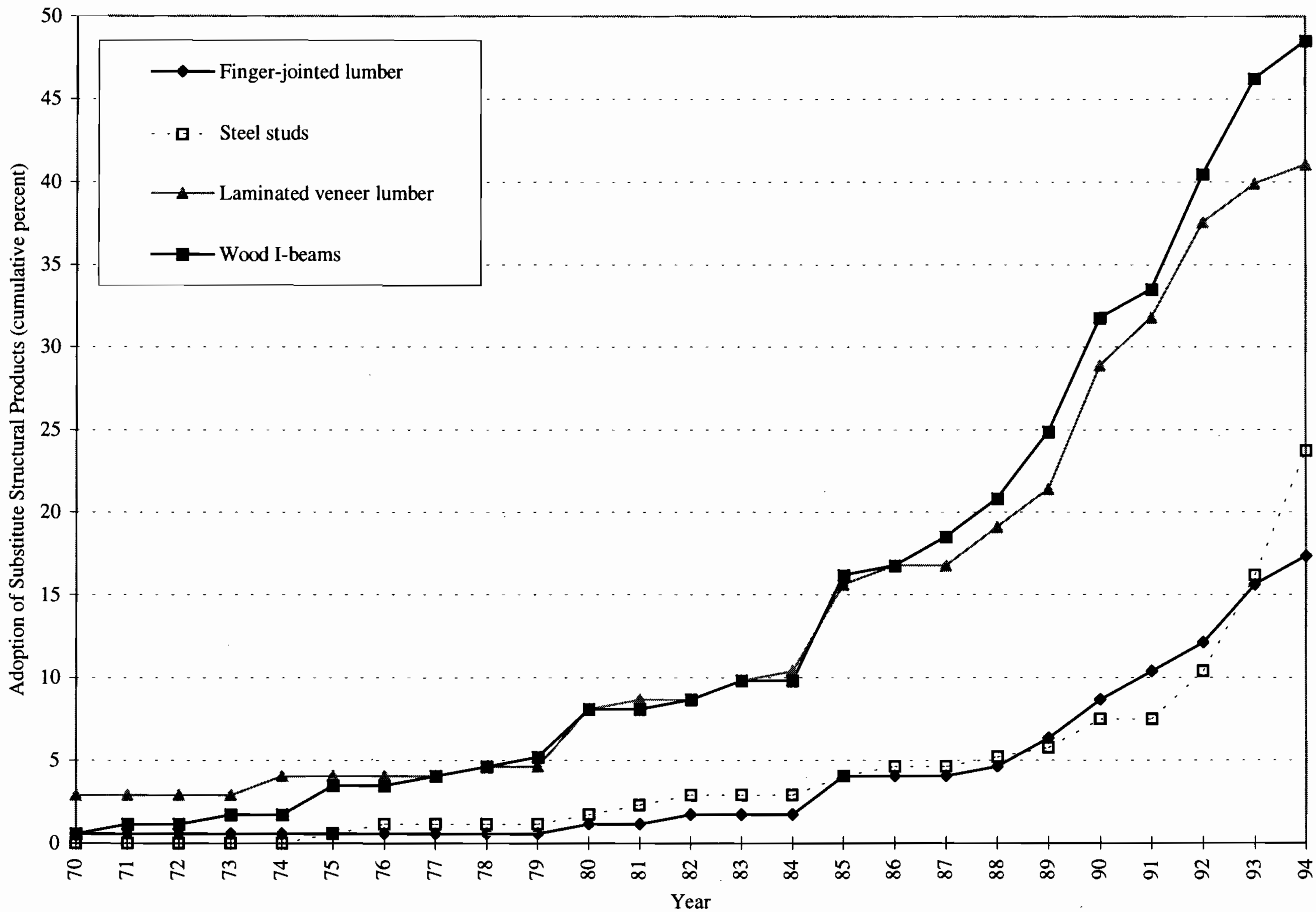


Figure 6. Adoption/trial curves for four substitute structural products.

standards. In addition, these engineered wood products are promoted as having superior strength characteristics and lower installation costs than softwood lumber. In contrast, finger-jointed lumber is perceived by many contractors as being a poor-quality product with low strength characteristics. While these perceptions are actually contrary to the fact, they nonetheless are widely held beliefs and appear to have effectively restricted the marketability of finger-jointed studs. In the case of steel lumber, contractor perceptions of product quality and strength are less of a concern. Rather, many builders are reluctant to use steel lumber for one of two reasons. Either they are concerned about the higher cost of building homes from steel or they perceive switching to the steel framing technology will require large expenditures of time and money to purchase new tools and retrain their employees. There is also some concern that steel building materials provide less flexibility for customization on the job site.

Finally, the disparity between the declining adoption rates for wood-based substitutes versus the increasing adoption rate exhibited by steel lumber is most likely influenced by the dramatic price increases and price fluctuations of softwood lumber in early 1993. It is also influenced by the aggressive promotional campaign undertaken by the American Iron and Steel Institute (AISI). It would appear that the AISI promotional campaign has been somewhat effective in lowering builders resistance to using steel framing by providing them with abundant technical and economic information regarding a steel building system. In addition, the recent price increases and fluctuations of softwood framing may have provided some builders with the necessary incentive to experiment with steel lumber because of the relative price stability of steel products. Given the prevailing practice of pricing a home prior to its construction, most residential contractors consider the price stability of building materials to be an important factor in the product purchase decision. As a result, it is hardly surprising that some residential contractors appear to be more willing to consider steel as a building material in the aftermath of the 1993 lumber price run-up. Price instability is probably the single biggest factor contributing to residential contractors willingness to evaluate the steel building technology, followed closely by their perceptions of the declining quality of softwood lumber.

To assess the level of market acceptance and end-use application of each of the substitute products, respondents were asked to estimate their products usage (by volume) for each of the four structural end-use applications being considered (Table 6). Not surprisingly, respondents indicated that softwood lumber was the dominant material used in stud wall applications, comprising 93% of the material used by respondents. The only other products used to any degree in stud walls were finger-jointed lumber and steel framing which accounted for just 4% and 3% of the volume used, respectively.

The use of softwood lumber in the other three end-use applications was not as dominant as observed in the case of stud walls. For example, there were three products used in floor systems, softwood lumber, wooden I-beams, and wood trusses, which accounted for 59, 23, and 16% of the volume used, respectively. The predominant materials used in ceiling systems were softwood lumber and wood trusses, with 64% and 28% of the volume used, respectively. Similarly, softwood lumber and wood trusses represented 97% of the volume used in roof truss applications, with material use being split almost equally between these products.

Table 6. Percent of building materials utilized by survey respondents in structural end-use applications in 1994, by volume.

	Percent of Material Being Utilized in the Following End Uses			
Structural Building Material	**Wall Studs**	**Floor Joists**	**Ceiling Joists**	**Roof Trusses**
Softwood Lumber	93	59	64	51
Wood trusses	--	16	28	46
Wood I-beams	--	23	7	2
Finger-jointed lumber	4	--	--	--
Steel studs	3	--	--	--
Other material	--	2	1	1

It is interesting to note that while Figure 6 suggests that 24% of residential contractors have used steel framing at least once, the market share data presented in Table 6 suggests that steel framing is not as widely used as might be thought. According to the data contained in Table 6, steel framing captured just 3% of the stud wall market in 1994 while negligible volumes of steel framing were used in the other structural end-use applications. This would seem to imply that perhaps residential contractors have opted not to switch to steel after having had the opportunity to evaluate the product in an on-site application. In contrast, it may also indicate that a substantial number of contractors have decided to learn the steel framing technology as an alternative strategy in the event that softwood lumber prices exhibit the same type of price instability that occurred in early 1993.

A similar disparity between the adoption curve data and material usage data was observed for finger-jointed lumber although this may be explained by residential contractors preference for solid lumber, assuming relative price parity between the two products. It may also be influenced by residential contractors' perceptions of the relative product quality and strength characteristics associated with each product. Given the current relationship between the price of Douglas-fir precision end-trimmed (PET) stud grade lumber ($398/mbf) and PET finger-jointed studs ($390/mbf), there appears to be little incentive for contractors to switch from solid lumber (Random Lengths 1996).

During the development of this project, the geographic location of the respondent firm was thought to have an influence on the use of substitute structural products. To evaluate this hypothesis, respondents were segmented by geographic location and their use of the different substitute products in each of the four structural end-use applications was evaluated (Table 7). A statistical analysis of the geographic location data using the Scheffé

Table 7. 1994 market shares for various building materials in structural end-use applications, by region.

	Volume of Materials Used for Specific Building Applications						
End Use Application	**Softwood Lumber**	**Wood Trusses**	**Finger-jointed Studs**	**Wooden I-Beams**	**Laminated Veneer Lumber**	**Steel Lumber**	**Other Material**
Northwest Region (n=26)							
Wall studs	90.4	--	8.0	--	--	1.5	--
Floor joists	51.3	8.8	--	40.0a[a]	0.1	--	--
Ceiling joists	59.3	22.2	--	20.1a	--	--	--
Roof trusses	49.4	44.0	4.2	2.4	0.1	--	--
Southwest Region (n=39)							
Wall studs	89.9	0.3	5.5	0.3	0.1	2.7	--
Floor joists	43.6	20.2	--	31.7a	1.3	--	--
Ceiling joists	59.3	30.9	--	6.8b	0.5	0.1	--
Roof trusses	45.2	51.8	--	2.7	0.3	0.1	--
Southeast Region (n=41)							
Wall studs	89.1	--	4.2	--	--	2.8	1.4
Floor joists	62.6	20.6	0	14.9b	1.4	0.4	--
Ceiling joists	61.8	32.8	0.6	2.9b	1.1	0.8	--
Roof trusses	59.1	39.2	--	0.6	--	1.1	--
Northeast Region (n=70)							
Wall studs	94.8	1.3	0.1	--	--	3.7	--
Floor joists	63.2	11.8	--	16.2b	1.2	2.3	--
Ceiling joists	68.4	25.2	--	5.2b	0.7	0.5	--
Roof trusses	51.4	44.0	--	2.2	1.0	--	--

[a] Corresponding cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Corresponding cells displaying no letters were statistically equivalent.

multiple comparison of means test indicated that the volume of substitute products used in each of the four regions in the various end-use applications did not differ significantly. In other words, it does not appear that the geographic location of the firm influences the use of substitute building materials. The only exception to this was observed with wooden I-beams, where the data analysis indicated that firms located in the western US used a significantly higher volume of wooden I-beams in floor systems than did firms in the eastern US. Similarly, firms located in the northwestern US used a significantly higher volume of wooden I-beams than firms located in the other regions.

Although the volume of finger-jointed studs used in stud wall applications varied considerably between the regions, these differences were not found to be statistically significant. However, it is interesting to note that while the volume of finger-jointed studs used by residential contractors in the northwest, southwest, and southeast ranged from 4.8% to 8%, virtually no finger-jointed lumber was used by residential contractors in the northeastern US. In addition, the use of LVL and steel lumber was much lower in the northwest than in the other regions.

A statistical analysis of the material use data segmented by firm size indicates relatively few differences in material usage (Table 8). The only statistically significant differences found indicate that large firms utilize greater volumes of wood trusses in floor, ceiling and roof systems than either medium-sized or small firms, while small and medium-sized firms use significantly greater volumes of softwood lumber in ceiling and roof systems than large firms. Although not significant, the data indicate that small firms are less likely to use finger-jointed lumber in stud wall applications than medium-sized and large firms. Perhaps a more interesting observation is that small firms used almost twice the volume of steel in stud wall applications than medium-sized and large firms. Finally, small and medium-sized firms use a significantly higher volume of softwood lumber in ceiling and roof systems than large firms.

Table 8. 1994 market shares for various building materials in structural end-use applications, by firm size.

	Volume of Materials Used for Specific Building Applications						
End Use Application	**Softwood Lumber**	**Wood Trusses**	**Finger Jointed Studs**	**Wooden I-Beams**	**Laminated Veneer Lumber**	**Steel Lumber**	**Other Material**
Small Firms (n=61)							
Wall studs	92.6	0.2	0.4	0.2	--	4.1	0.9
Floor joists	62.2	11.5a	--	21.3	1.3	0.6	--
Ceiling joists	68.1a[a]	23.2a	--	7.5	0.8	0.4	--
Roof trusses	59.1a	35.4a	1.8	0.7	1.2	--	--
Medium Firms (n=78)							
Wall studs	89.9	1.7	5.7	--	--	2.7	--
Floor joists	61.3	10.9a	--	23.1	1.4	1.8	--
Ceiling joists	72.9a	20.1a	--	4.8	0.9	0.4	--
Roof trusses	58.9a	38.5a	0.3	2.4	0.2	--	--
Large Firms (n=49)							
Wall studs	92.0	--	5.6	--	0.1	2.2	--
Floor joists	45.3	24.7b	--	24.4	0.3	0.4	--
Ceiling joists	40.8b	46.0b	--	11.3	--	0.9	--
Roof trusses	27.2b	69.0b	--	2.8	--	1.0	--

[a] Corresponding cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Corresponding cells displaying no letters were statistically equivalent.

A statistical analysis of substitute building material use by geographic region was performed to determine if there was a significant difference in the general use of substitutes in residential construction, irrespective of end-use application (Table 9). Plastic lumber was not included in this analysis because respondents indicated that they did not use this product in structural end-uses. Little variation was detected in the data, although the analysis did indicate that significantly more firms in the southwest region reported using finger-jointed lumber than firms located in the northeast.

Although not statistically significant, the results of the analysis suggest that some differences in material use exist between geographic regions. For example, residential contractors in the northwest appear to be less likely to use wood/steel trusses, reinforced concrete, panelized wall systems, and steel studs than are contractors in the other regions. In addition, residential contractors in the south seem to be less likely to use wooden I-beams while residential contractors in the southeast are less likely to use glulam beams than contractors in the other regions.

Table 9. Percent of survey respondents indicating that their firm had used a substitute for softwood lumber in structural end-use applications, by geographic region.

	Substitute Material Usage by Geographic Location (percent)			
Substitute Material	**Northwest**	**Southwest**	**Southeast**	**Northeast**
Use of any substitute	92	97	87	91
Glulam beams	80	85	58	71
Wooden I-beams	68	41	47	63
Laminated veneer lumber	48	51	37	47
Parallel Strand lumber	64	38	37	41
Wood/steel trusses	24	38	45	40
Reinforced concrete	16	33	29	31
Steel lumber	16	28	24	32
Finger-jointed studs	24	33a[a]	18	7b
Wall panel systems	8	13	18	18
Fiber/plastic lumber	12	10	5	7

[a] Cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Cells displaying no letters were statistically equivalent.

A breakdown of respondents' use of substitute building materials was performed to determine if the size of the firm significantly impacted the general use of substitute products in residential construction, in all end-use applications (Table 10). The results of the statistical analysis indicated that the only significant difference in substitute use occurred in the use of wood/steel trusses, where large firms were more likely to use these products than were small firms.

Several other differences in substitute product use were noted which, while not statistically significant, are worth mentioning. The data indicate that large firms are less likely to use wooden I-beams and LVL in structural applications than either small or medium-sized firms. In contrast, large firms are more likely to utilize wall panel systems than the other firms. Finally, small firms used less finger-jointed lumber than the other industry segments, while medium-sized firms appear to be using more fiber/plastic lumber composites than the other groups.

Approximately one-third of the respondents indicated that someone in their firm had attended at least one training program focused on utilizing a substitute product for softwood lumber, while 15% of respondents indicated that someone in their firm had received training in the use of two or more substitute products (Table 11). The only products for which more than 10% of the respondents indicated receiving training were wooden I-beams (22.5%) and steel lumber (12.4%). A statistical analysis of the data did not support the theory that a firm with an employee trained in the use of a substitute product would be more likely to adopt that particular product.

One interesting point concerns the finding that while only about 3% of residential contractors reported using steel lumber in 1994, over 12% of the respondents reported that they employed someone with training in the steel framing system. This of course raises the question that if these carpenters have received training in steel construction, why is there such a large discrepancy between the actual use of steel and the potential use level.

Table 10. Percent of survey respondents indicating that their firm had used a substitute for softwood lumber in structural end-use applications, by firm size.

Substitute Material	Substitute Material Usage by Firm Size (percent)		
	Small	Medium	Large
Use any substitute materials	84	96	96
Glulam beams	66	83	70
Wooden I-beams	59	62	43
Laminated veneer lumber	52	49	37
Parallel strand lumber	40	48	41
Wood/steel trusses	24a[a]	39	50b
Reinforced concrete	36	30	22
Steel lumber	31	22	30
Finger-jointed studs	12	23	22
Wall panel systems	10	10	26
Fiber/plastic lumber	22	35	21

[a] Cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Cells displaying no letters were statistically equivalent.

While the answer may be as simple as a loss of interest in the system once contractors have become more familiar with it, there are most likely other factors contributing to the low use of steel lumber. For example, residential contractors may have acquired training in the steel construction technology as a hedge against future softwood lumber price increases and/or price instability. Softwood lumber manufacturers would be wise to take note that a growing segment of residential contractors are acquiring the capability to switch to the steel construction system should they perceive lumber prices as representing a threat to their profitability or survival.

Table 11. Number of firms where at least one employee had received training in the installation and use of a particular substitute building material.[a]

Type of Building Material	Number of Respondents with Trained Employees	Percent of Respondents
Any of 11 substitutes surveyed	55	32.6
Wooden I-beams	38	22.5
Steel lumber	21	12.4
Glulam beams	12	7.1
Parallel strand lumber	10	5.9
Laminated veneer lumber	9	5.3
Wall panel systems	6	3.6
Other substitute product(s)	22	13

[a] Effective sample size = 169.

The results of the previous discussion indicates that there is a substantial amount of material substitution occurring in structural end-use applications within the residential construction industry. While there may be only a minimal amount of substitution occurring in stud wall end-uses (approximately 7%), in other end-use applications the use of substitute materials is much more prevalent (41% in floor systems and 49% in roof systems). The survey data also suggest that all residential construction firms do not use substitute building materials to the same extent.

Given this differential rate of substitute use, respondents were asked to evaluate how the use of structural softwood lumber was changing within their own firms using a Likert scale ranging from 1 (unchanging) to 10 (changing rapidly) (Figure 7). The mean response obtained from the survey data was 4.5 as compared to the scale center of 5.5 (where the scale center indicated that the use of softwood lumber was changing only moderately).

The Hotelling's T^2 statistical test was used to determine if the mean response obtained from the survey differed significantly from the scale center. The results of the statistical analysis indicate that the difference between the mean value and scale center was not statistically significant, suggesting that residential contractors as a group perceive that their use of softwood lumber in structural applications is changing only moderately.

Further analysis of the data indicated that, despite the perception of residential contractors as a group, not all segments of the industry have a similar perception on how the use of softwood lumber is changing. For example, it is interesting to note that the percentage of responses located below the scale center is more than double those located above the scale center (69.7% versus 30.3%). Perhaps of more interest is the fact that fully one-third of respondents perceive that their use of softwood lumber is not changing at all or is changing only slowly (those responses with a score of 3 or less). In contrast, and of interest to marketers of new building materials, almost 10% of respondents recorded a score of 8 or higher, indicating that they perceive their use of softwood lumber is changing relatively quickly.

Satisfaction with Softwood Lumber

One factor that has a direct impact on the use of softwood lumber is residential contractors satisfaction with softwood lumber used in structural end-use applications. Recognizing that products are comprised of more than just the physical product, respondents were asked to rate their satisfaction with a series of softwood lumber product attributes (Table 12). A summary of respondents' mean satisfaction ratings for softwood lumber indicate that they were satisfied with only two of ten product attributes (Figure 8). More importantly, they indicated that they were unsatisfied with five product attributes and neither satisfied nor unsatisfied with an additional three product attributes. These results were supported by a statistical analysis using the Hotelling's T^2 test statistic to determine if the mean satisfaction rating for each product attribute was significantly different from the scale center of four. Further analysis indicated that firm size and firm geographic location had little impact on a contractors' satisfaction rating for softwood lumber (Table 12).

Table 12. Survey respondents mean satisfaction ratings for different softwood lumber attributes, by geographic region and firm size.

	Mean Satisfaction Rating[a]						
	by Geographic Location				by Firm Size[b]		
Product Attribute	**Northwest**	**Southwest**	**Southeast**	**Northeast**	**Small**	**Medium**	**Large**
Strength	5.0	4.6a	5.4a	4.9	4.9	4.9	5.1
Availability	5.0	4.7	5.1	5.1	5.0	5.0	4.9
Energy efficiency	4.2	3.8	4.2	4.2	4.3	4.0	4.1
Longer lengths	4.1	3.9	4.4	3.9	4.1	3.9	4.2
Reduced environmental impact	3.9	4.1	4.1	4.2	3.9	4.1	4.3
Straightness	3.6	3.5	3.8	3.8	3.4b[c]	3.6	4.2b
Price	3.5	3.2	3.2	3.3	3.2	3.1	3.6
Lack of defects	3.5	3.3	3.7	3.4	3.2	3.4	3.7
Lumber quality	3.5	3.1	3.4	3.3	3.3	3.2	3.5
Price stability	3.0	2.4	2.7	2.8	2.9	2.4	2.9

[a] Survey respondents rated their level of satisfaction for each of ten attributes when making their solid wood structural material purchases on a Likert scale ranging from 1 (not satisfied) to 7 (very satisfied) and possessing a neutral value of 4.

[b] Classification of firm size operationalized by firm's 1994 sales revenue.

[c] Cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Cells displaying no letters were statistically equivalent.

The results of this analysis indicate that residential contractors are satisfied with just two softwood lumber attributes: lumber strength and lumber availability. In contrast, they are unsatisfied with one-half of the product attributes they were asked to rate. For the sake of simplifying the following discussion, the five softwood lumber attributes with which residential contractors indicated they were dissatisfied will be classified into two groups: (1)

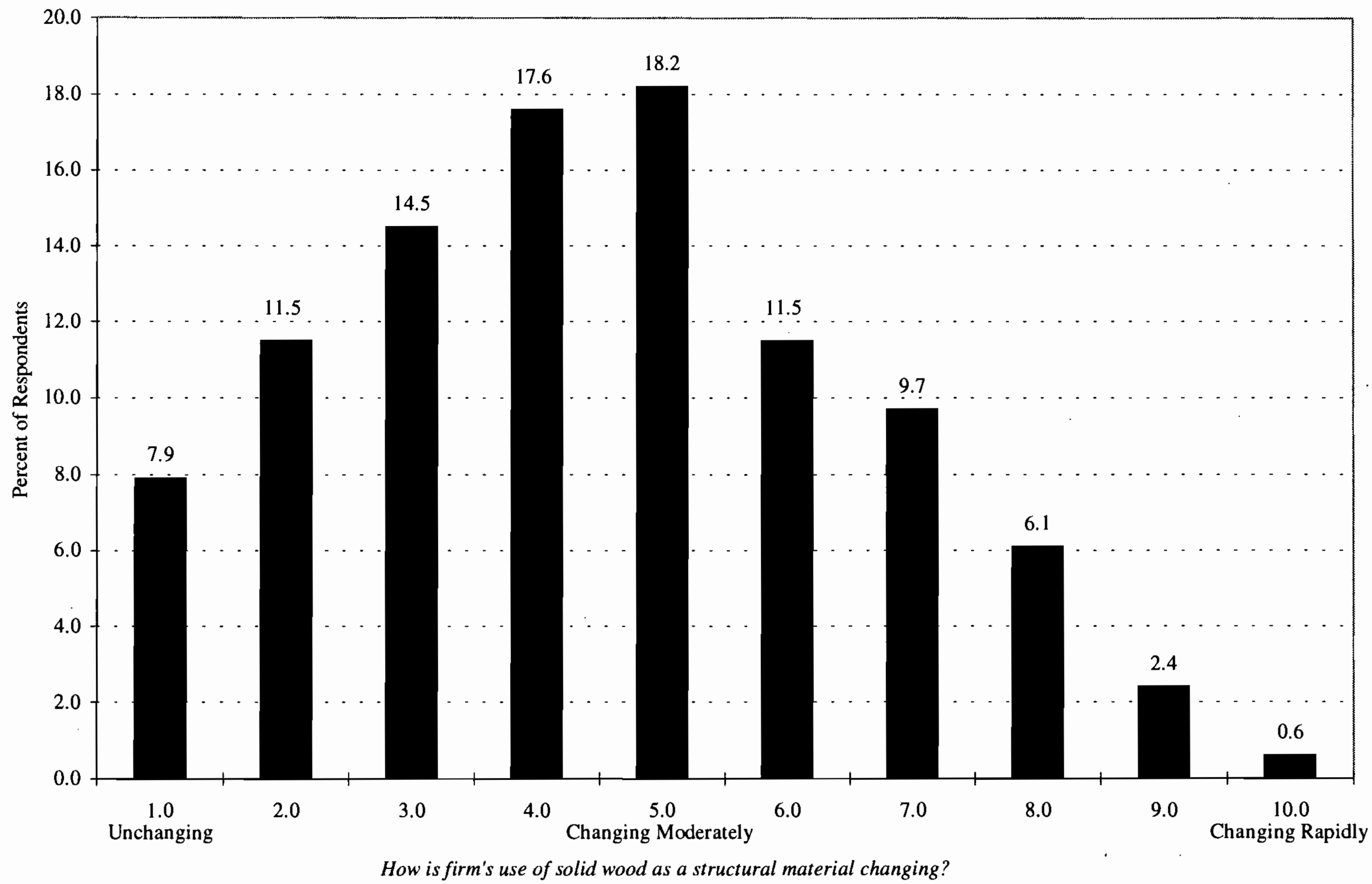


Figure 7. Distribution of survey respondents perception of change in their firm's use of softwood lumber as a structural material (n=165).

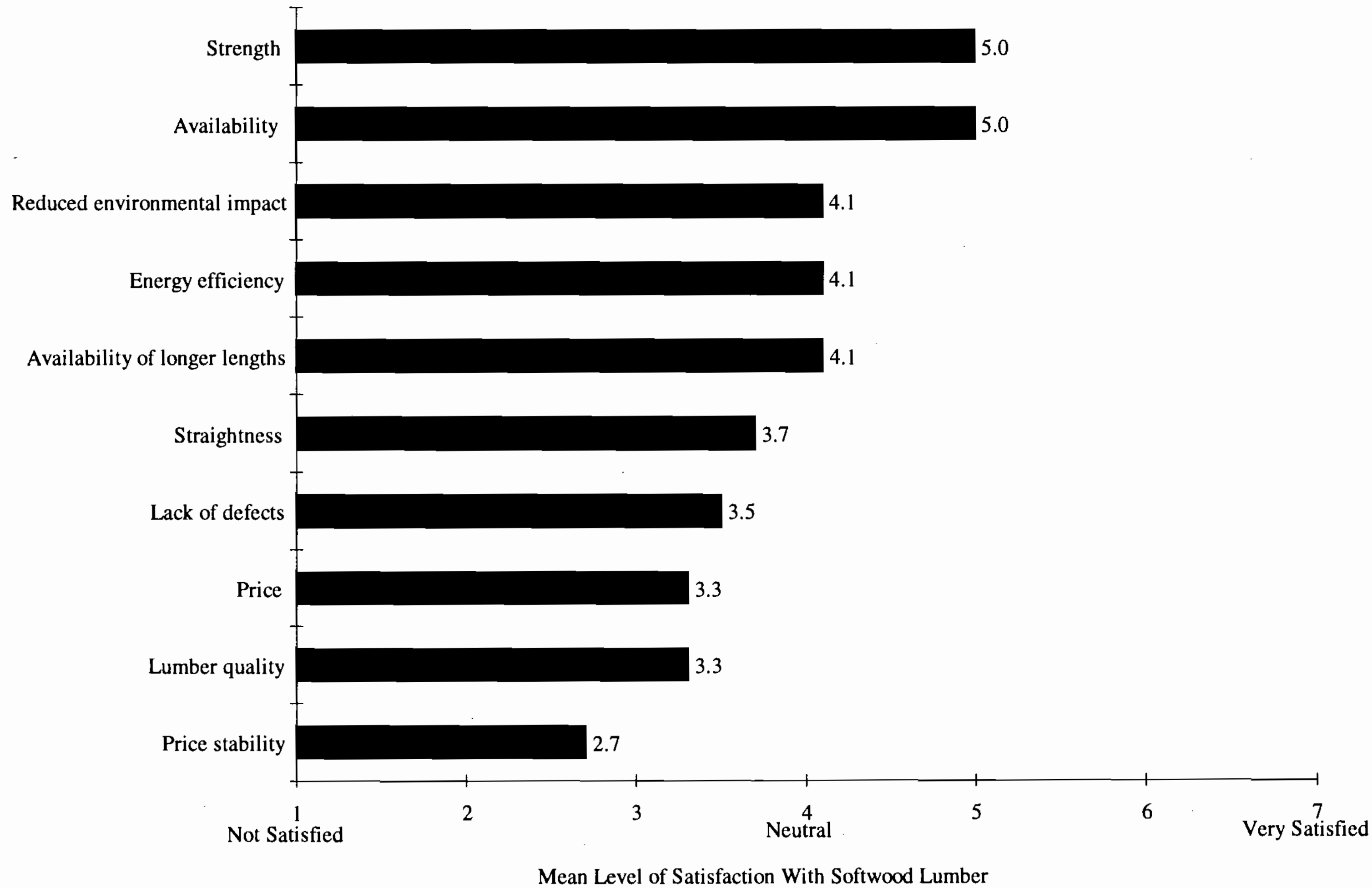


Figure 8. Survey respondents' mean satisfaction ratings for different softwood lumber attributes.

lumber price (consisting of lumber price and lumber price stability) and (2) lumber quality (consisting of lumber straightness, lack of defects, and lumber quality).

It is hardly surprising that residential contractors expressed dissatisfaction with softwood lumber prices given the increasing price trends for lumber and the extreme price fluctuations experienced over the past two years. In a competitive industry where projects are bid prior to the start of the project and profit margins are generally quite low, price stability is an important consideration for contractors, particularly small residential contractors. Once a project is contracted, material price increases are generally absorbed by the contractor, thereby reducing the firm's overall profitability for the project. Softwood lumber manufacturers should be concerned about lumber price trends and fluctuations because they can provide contractors with an incentive to switch to more price-stable substitute products or to other construction technologies.

Perhaps more important to the long-term competitiveness of softwood lumber is the perception among residential contractors that softwood lumber quality is declining. The survey results clearly indicate that respondents are dissatisfied with lumber straightness, the number of defects found in softwood lumber, and overall softwood lumber quality. Of the ten lumber attributes considered, overall lumber quality was rated the second lowest in terms of contractor satisfaction, exceeded only by softwood lumber price fluctuations. From a competitive perspective, softwood lumber manufacturers need to recognize and address contractors' concerns regarding declining product quality because they can provide contractors with an incentive to switch to other building materials or construction systems.

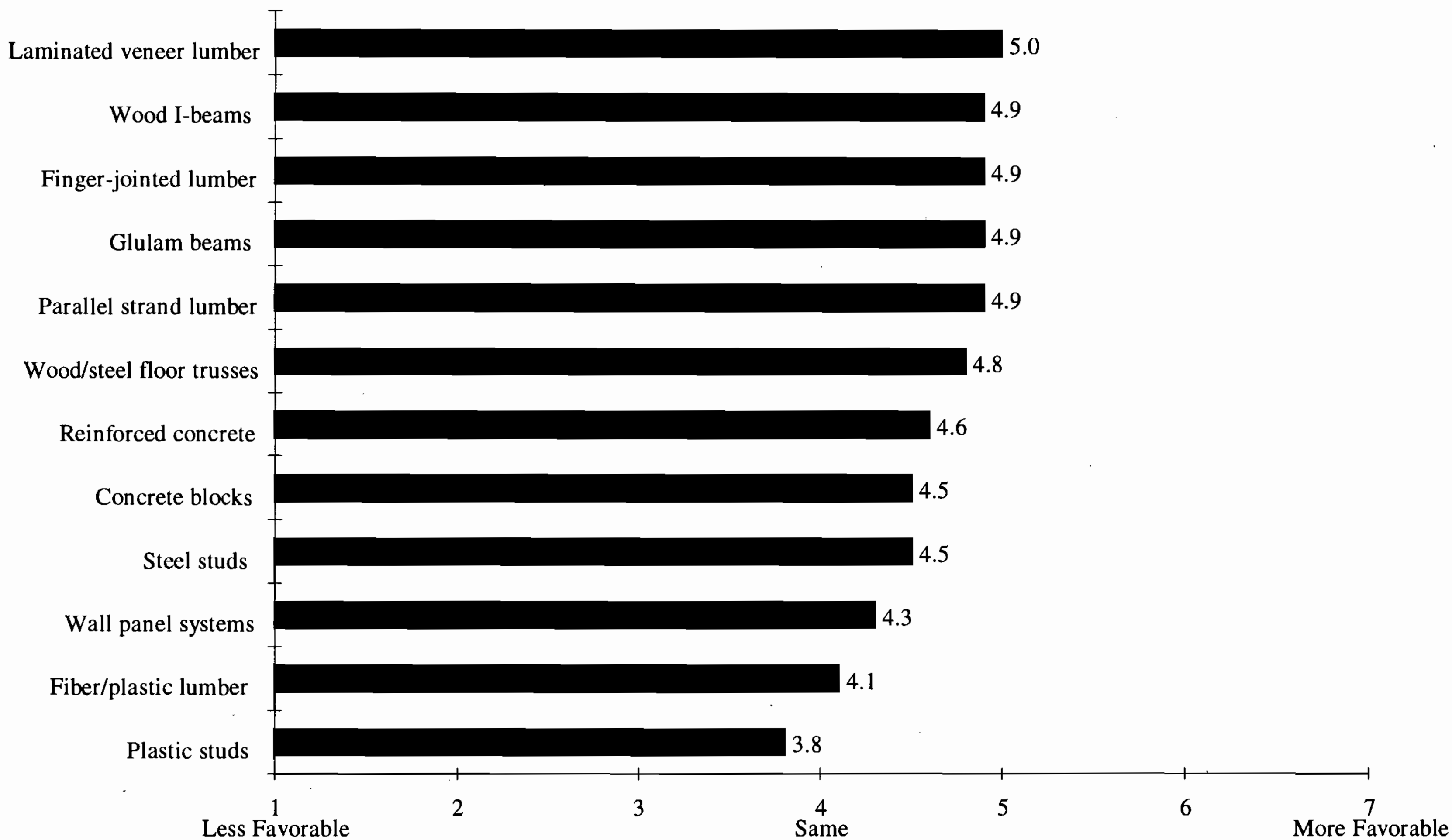
Perceptions of the Environmental Impact of Structural Building Materials

While still a relatively new phenomenon, a growing number of architects and contractors are beginning to design and build houses that produce a reduced impact on the environment. Through innovative designs and careful material selection, the environmental impact of a house can be minimized during all phases of its life cycle. Softwood lumber producers have long touted wood as a renewable resource and an environmentally friendly material. In an effort to see how well this message has been received and accepted, respondents were asked to compare the overall environmental impact of using softwood lumber with a variety of substitute products (Figure 9).

Respondents were asked to compare the environmental impact of the twelve substitute products to softwood lumber using a Likert scale ranging from a score of 1 (less favorable environmental impact) to 7 (more favorable environmental impact). An environmental impact rating of 4 indicated that the substitute material was perceived by the respondent to produce the same impact on the environment as softwood lumber. To determine if the environmental impact ratings obtained for each of the substitute materials differed from the neutral value of 4, Hotelling's T^2 test statistic was employed.

The results of the test indicated that, while plastic lumber and plastic/fiber composite lumber were rated as having the same environmental impact as softwood lumber, all of the other substitute products were perceived to have a significantly lower impact on the environment (*i.e.*, they were perceived to be better for the environment than softwood lumber) (Figure 9). A subsequent analysis of the data found that neither firm size nor firm location significantly influenced contractors' perceptions of the relative environmental impact of the substitute products being considered (Table 13). In addition, a cluster analysis of the data (using environmental impact as the dependent variable and geographic location and firm size as the independent variables) failed to detect statistically significant clusters, providing further evidence of the homogeneity across geographic regions and size of firm with regard to respondents perceptions of the relative environmental impact of the different products.

The analysis of the respondents' environmental ratings for the various materials produced some surprising results. Whereas the softwood lumber industry promotes wood as a renewable resource and an environmentally friendly material, residential contractors have obviously developed a different perception. It is encouraging to note that the engineered wood products were rated as generating the least environmental impact of all the building materials being considered. This result would be expected given the fact that engineered wood products utilize a lower-quality resource that often is not well suited to the production of solid lumber products, thereby providing more efficient utilization of the existing forest resource. However, the favorable environmental impact ratings



In your opinion, how do each of the listed materials compare to softwood lumber with respect to their impact on the environment.

Figure 9. Respondents perception of the environmental impacts associated with using different building materials relative to softwood lumber.

Table 13. Respondents perception of the environmental impacts associated with using different building materials relative to softwood lumber, by geographic region and firm size.

	Mean Perception of Environmental Impact[a]						
	by Geographic Location				by Firm Size		
Substitute Product	**Northwest**	**Southwest**	**Southeast**	**Northeast**	**Small**	**Medium**	**Large**
Wooden I-beams	5.6	4.7	5.0	4.8	5.1	4.9	4.8
Laminated veneer lumber	5.4	4.8	4.9	4.9	5.0	5.1	4.8
Parallel strand lumber	5.3	4.7	4.8	4.8	4.8	5.0	4.7
Glulam beams	5.1	4.7	4.7	4.9	4.8	4.9	4.8
Wood/steel trusses	5.0	4.8	4.4	4.9	4.8	4.8	4.7
Finger-jointed studs	5.0	5.0	4.8	4.8	4.7	5.1	5.0
Steel lumber	4.6	4.6	4.4	4.5	4.7	4.4	4.3
Reinforced concrete	4.6	4.6	4.8	4.4	4.6	4.7	4.5
Fiber/plastic lumber	4.5	4.1	3.9	4.1	4.2	4.2	4.1
Wall panel systems	4.4	4.2	4.4	4.3	4.2	4.2	4.5
Plastic lumber	4.3	4.2	3.5	3.6	3.9	3.7	3.9
Concrete blocks	4.3	4.4	5.2	4.2	4.9	4.3	4.8

[a] Survey respondents rated the environmental impact of each of twelve structural material substitutes as compared to solid wood structural materials on a Likert scale ranging from 1 (less favorable) to 7 (more favorable) and possessing a center value of 4 (the same).

obtained by the non-wood materials (*i.e.*, reinforced concrete, concrete blocks, and steel lumber) are difficult to explain. From a strategic perspective it is important that the forest products industry more fully explore contractors perceptions of softwood lumber and its impact on the environment, particularly with respect to substitute products.

The Influence of Product Attributes on Substitution

Price, although an important factor, is only one of many factors that can influence the material substitution process. In fact, price may not be the determinant factor in the substitution process and is perhaps subordinate to other factors such as the technical characteristics of the material, ease of use, or product quality. In order to develop a better understanding of the material substitution process in the residential construction industry, respondents were asked to identify those factors that influenced their decision to use a substitute product.

An analysis of the survey data indicated that the two most frequently cited factors for using a substitute product were the strength characteristics of the product and the straightness of the product (Figure 10). In contrast, the price related factors (lower price, price fluctuations of lumber, and the price stability of the substitute product) were each identified by only one-third or fewer of the respondents. Two of the product attributes, the availability of longer lengths and the lack of defects in the substitute product, were mentioned by 59.5% and 43% of the respondents, respectively. Finally, three of the product attributes (consumer interest in the product, familiarity of use with the product, and the energy efficiency of the product) were mentioned by less than 10% of the respondents.

The attribute ratings for each substitution factor were analyzed statistically to identify differences based on the geographic region of the firm or the size of the firm (Table 14). The results of the analysis indicate that neither firm size nor firm location appear to influence how often a substitution factor was cited as influencing the substitution process. The only major statistically significant exception was that small and medium-sized firms were more likely to consider the availability of longer product lengths as influencing their substitution decision than were large firms.

Several other differences were noted that, while not statistically significant, might be of interest. Large residential contracting firms were more likely to identify price stability and reliability of supply as being influential in the product substitution process than were contractors with small and medium-sized firms. In addition, contractors in

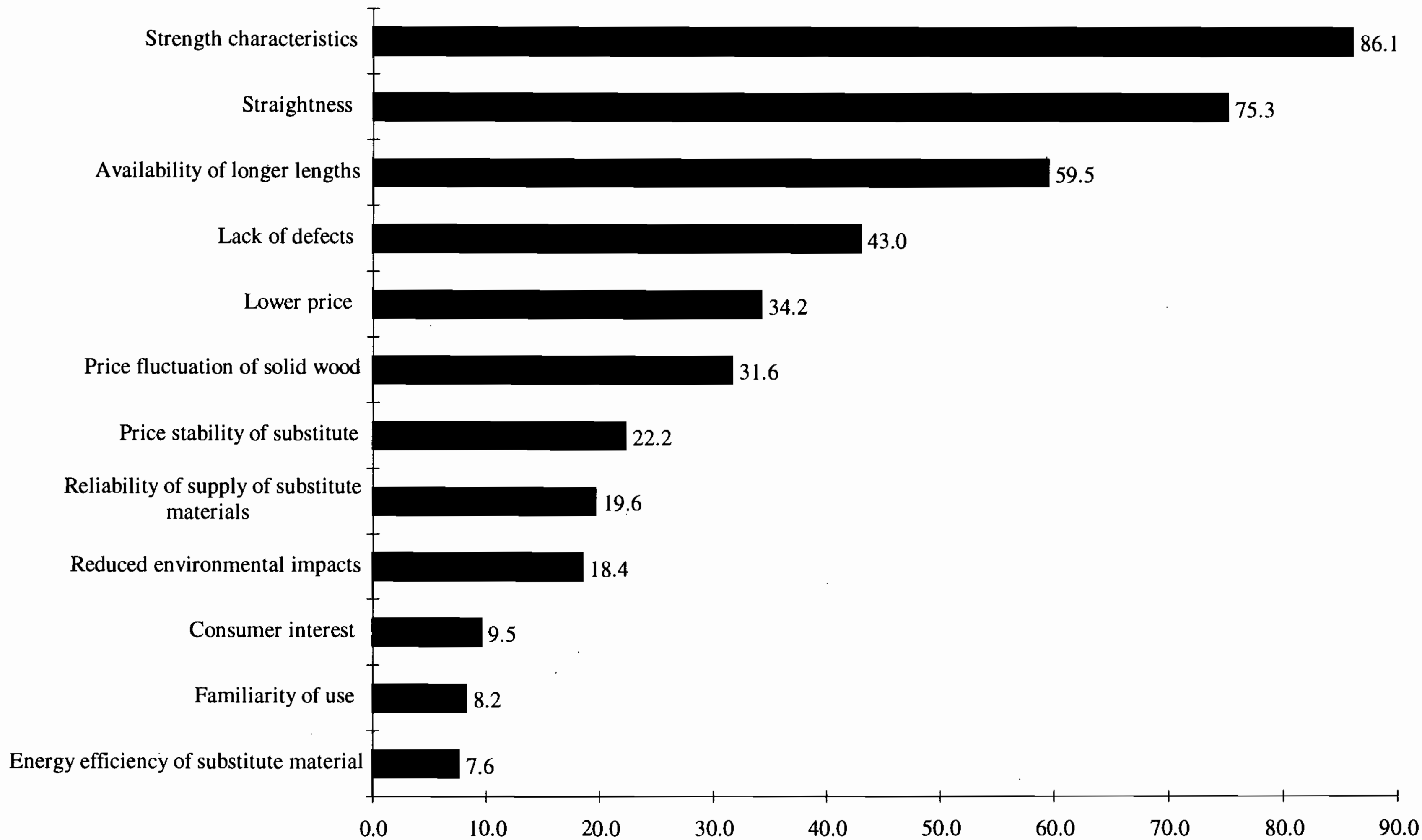


Figure 10. Product attributes indicated by respondents as influencing their decision to use a substitute building material (percent).

Table 14. Product attributes indicated by respondents as influencing their decision to use a substitute building material, by geographic region and firm size.

	Percent of Firms Indicating Product Attribute						
Product Attribute	**Northwest**	**Southwest**	**Southeast**	**Northeast**	**Small**	**Medium**	**Large**
Strength characteristics	83	86	77	90	80	92	84
Straightness	75	83	71	73	75	77	73
Availability of long lengths	58	57	58	60	69a[a]	66a	39b
Lack of defects	58	37	29	44	51	34	45
Lower price	38	31	39	33	33	26	45
Price fluctuations of SW lumber	25	37	45	27	24	33	39
Price stability of substitute	25	29	16	21	18	15	39
Reduced environmental impact	8	17	26	21	16	20	20
Reliability of supply	25	17	26	13	18a	11a	30
Consumer interest	13	14	6	5	8	11	9
Energy efficiency of substitute	21a	0b	6b	8b	8	11	2
Familiarity of use	17	6	10	5	10	5	9

[a] Cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Cells displaying no letters were statistically equivalent.

the southeast US were less influenced by the lack of defects in a substitute product than were contractors in the other regions.

Having identified the product attributes that were influential in the substitution process, respondents were asked to rate the importance of each product attribute during the substitution process. The importance of each product attribute was determined using a seven point Likert scale where a rating of 1 indicated that the attribute was not important while a rating of 7 indicated that the attribute was a very important consideration during the purchase process.

An analysis of the survey data indicated that each of the product attributes received a mean importance rating that exceeded 4, indicating that all of the attributes listed were considered to have an important influence on the decision to purchase a structural building material (Figure 11). In addition, six product attributes received a mean importance rating of 6 or higher, suggesting that residential contractors considered these product attributes to have a very important influence on their decision to purchase a structural building material (Table 15).

The six most highly rated product attributes can be combined into a product quality group (composed of product straightness, product strength, and lack of defects) and a price group (including product price, price stability, and product availability). It is illustrative to compare respondents' satisfaction ratings for softwood lumber attributes (Figure 8) with their importance ratings of product attributes that influence the purchase decision of structural building materials in general (Figure 11). With the exception of product strength and availability, those softwood lumber attributes with which respondents reported being dissatisfied were the same product attributes they identified as having the most important influence on the purchase of building materials for structural end-uses.

Based on these results, it would appear that residential contractors are looking for a specific set of product attributes when selecting a building material for use in structural end-uses. The responses obtained from these same contractors indicate that they are dissatisfied with the ability of softwood lumber to provide the product attributes they perceive to be important. It is interesting to note that other product attributes were also identified as being important and that product price and quality, while being important factors, may not be sufficient to justify product substitution in the residential construction industry. For example, residential contractors need to be clearly informed about the benefits associated with using a substitute product as well as being provided with appropriate technical product information and product support services (*i.e.*, the availability of technical/engineering support). In addition, a number of product attributes that can be classified as product benefits (*i.e.*, ease of use, availability of long lengths, product appearance, and the energy efficiency of the product) were also rated as being important factors during the purchase process.

The product attributes were further analyzed to determine if the importance ratings differed by geographic region or size of firm. The results of the statistical analysis indicate that, regardless of the geographic location of their operations, residential contractors tend to attach similar levels of importance to each of the product attributes being investigated (Table 15). One interesting trend in the data suggests that residential contractors in the southeastern US place lower importance on all of the product attributes (with the exception of price) than do contractors in the other regions, although the differences in importance ratings were not statistically significant.

With respect to firm size, the data indicates that respondents from small firms appear to attach more importance to the various product attributes than do respondents from medium-sized and large firms. In fact, the mean importance ratings reported by small firms for several product attributes were significantly higher than those obtained from medium-sized and large firms. Those product attributes that were rated significantly more important by small firms include: lack of defects, availability of longer lengths, ease of use, and energy efficiency. While not statistically significant, the data also indicates that large firms rated price, price stability, and product availability as being more important than did small and medium-sized firms. This result is consistent with the fact that a higher proportion of large firms identified low price, price fluctuations of softwood lumber, price stability of substitutes, and reliability of supply as influential product attributes when considering the use of a substitute product (Table 14).

Principal Components Factor Analyses

A principal components factor analysis was performed on the attribute importance data summarized in Figure 11. The factor analysis was used to condense the information contained in the original set of twelve product attributes. The basic premise of the factor analysis is that there may be an underlying, undetected, subset of uncorrelated factors that can be used to simplify and explain the complex relationships contained in the original set of often correlated product attributes. This smaller set of uncorrelated factors is then used to define the fundamental constructs that underlie the original set of factors.

Table 15. Survey respondents mean importance rating for product attributes in influencing their purchase decision, by geographic region and firm size.

	Mean Importance Rating of Product Attributes[a]						
	by Geographic Location				by Firm Size		
Product Attribute	**Northwest**	**Southwest**	**Southeast**	**Northeast**	**Small**	**Medium**	**Large**
Strength	6.7a[b]	6.0b	6.5	6.5	6.7	6.3	6.3
Straightness	6.4	6.2	6.6	6.5	6.6	6.3	6.4
Product availability	6.3	6.1	6.3	6.3	6.2	6.2	6.3
Price	6.3	6.2	6.4	6.1	6.1	6.1	6.5
Lack of defects	6.3	5.9	6.0	6.1	6.4a	5.8b	6.0
Price stability	6.1	5.8	6.4	6.0	6.1	6.0	6.2
Availability of longer lengths	6.0	5.3	5.8	5.7	6.1a	5.6b	5.2b
Ease of use	6.0	5.5	5.7	5.8	6.0a	5.5b	5.8
Technical/engineering support	5.7	5.5	5.7	5.6	5.9	5.5	5.5
Energy efficiency	5.4	4.5	5.1	4.9	5.3a	5.0	4.5b
Appearance	5.4	4.7	5.4	4.9	5.1	5.8	5.3
Reduced environmental impact	4.4	4.4	4.6	4.5	4.5	4.6	4.3

[a] Survey respondents rated the importance of each of twelve attributes on their purchase decision on a Likert scale ranging from 1 (not important) to 7 (very important) and a neutral value of 4.

[b] Cells that do not share the same letter were significantly different from one another as indicated by Scheffé's multiple comparison of means test with an α set at 5%. Cells displaying no letters were statistically equivalent.

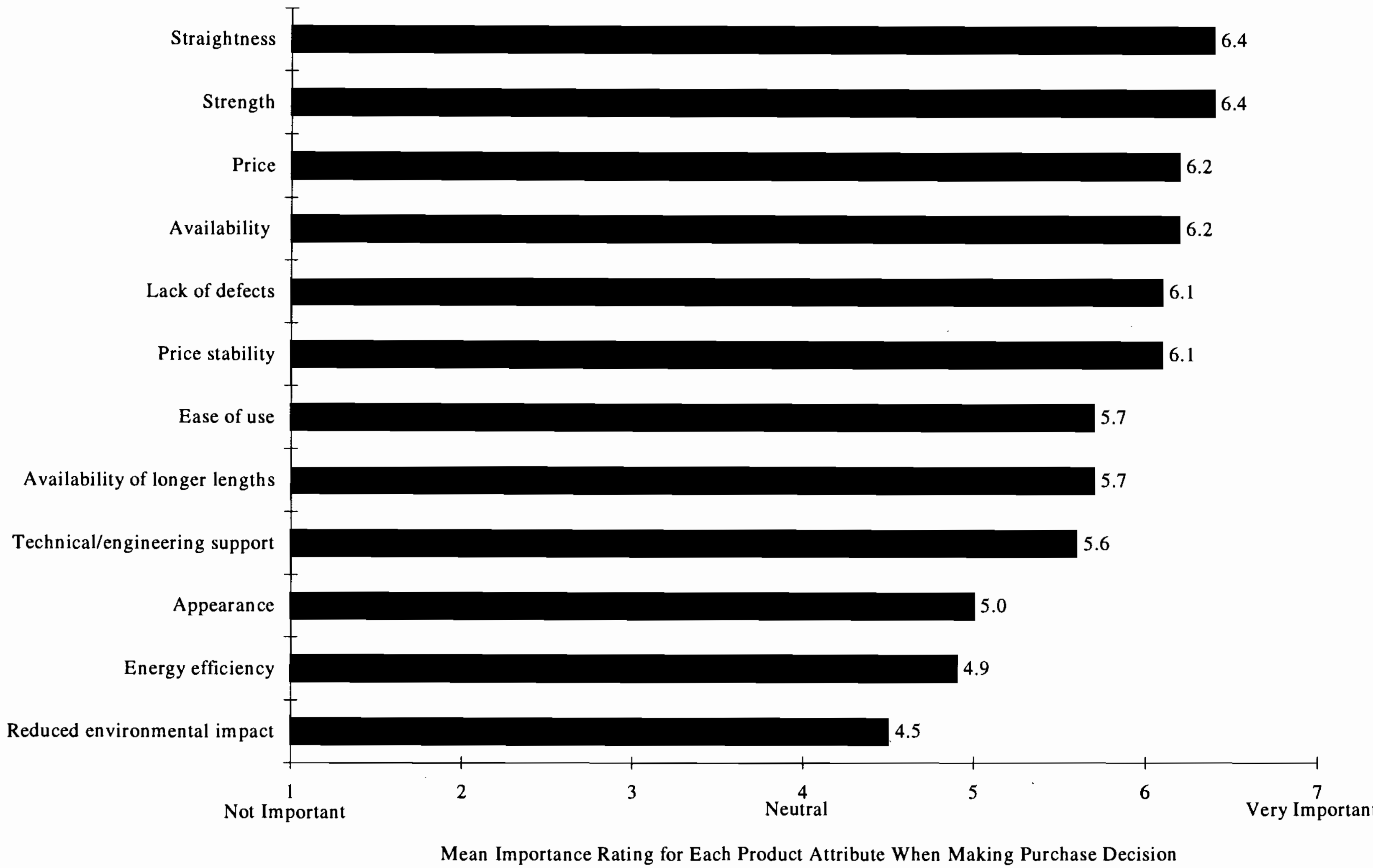


Figure 11. Mean importance rating for product attributes in influencing their purchase decision.

The data for this analysis was derived from the survey question that asked respondents to rate the importance of twelve product attributes in influencing their purchase of structural building materials. The factor analysis reduced the original twelve product attributes down to three uncorrelated factors that accounted for approximately 59% of the total variance in the original data set (Table 16).

The first factor accounted for one-third of the total variance in the original data set and was comprised of the following product attributes: straightness, strength, availability of long lengths, and lack of defects. The second factor, which accounted for approximately 14% of total variance, included the following product attributes: energy efficiency, reduced environmental impact, ease of use, appearance, and technical/engineering support services. The third factor accounted for almost 12% of the total variance in the data and incorporated three product attributes: price, price stability, and product availability.

Following completion of the factor analysis the task remains to analyze the subset of product attributes contained in each of the factors. The objective of this analysis is to try to identify some underlying commonality or construct that the group of product attributes collectively describes, an admittedly subjective process. Following a review of the factor analysis results, the following labels were assigned to each of the factors: Factor I: Physical Characteristics, Factor II: Technical Characteristics, and Factor III: Economic/Supply Characteristics. It is important to mention that the three factors are not listed in any order of importance, rather they are listed by their ability to explain a proportion of the total variation contained in the original data set. Also, it should be pointed out that there is a trade-off that occurs by reducing the twelve original product attributes to just three product

Table 16. Results of a principal components factor analysis of importance ratings for product attributes.[a,b]

	Factor I: Physical Characteristics	**Factor II: Technical Characteristics**	**Factor III: Economic/Supply Characteristics**
***Factor 1 Attributes*:**			
Straightness	***.83211***	-.07693	.15981
Strength	***.80510***	.05492	.09123
Availability of longer lengths	***.66265***	.30265	.01120
Lack of defects	***.61035***	.36090	.30718
***Factor 2 Attributes*:**			
Energy efficiency	.07665	***.83799***	.00301
Reduced environmental impacts	.03575	***.64397***	-.09444
Ease of use	.21153	***.63007***	.26000
Appearance	-.01737	***.59506***	.28758
Technical/engineering support	.34831	***.56740***	.15571
***Factor 3 Attributes*:**			
Price	.04049	.02599	***.88159***
Price stability	.11664	.18339	***.79067***
Availability	.39468	.09234	***.62020***

Variation Explained by Components	**Eigenvalue**	**Percent of Variation**	**Cumulative Percent of Variation**
Factor 1	4.00108	33.3	33.3
Factor 2	1.65776	13.8	47.2
Factor 3	1.40029	11.7	58.8

[a] Effective sample size = 156.

[b] Survey respondents rated their satisfaction with each of ten solid wood structural building product attributes on a Likert scale ranging from 1 (not satisfied) to 7 (very satisfied) and possessing a neutral value of 4.

factors. While the interpretation of the survey results is simplified by the reduced number of factors, the explanatory power of the analysis is reduced since the three factors only incorporate 58.8% of the total variation contained in the data.

The results of the factor analysis indicate that when purchasing structural building materials, residential contractors make their decision based on a combination of physical product characteristics, technical product characteristics and economic/supply characteristics. It is possible to rank the three factors in order of perceived importance by combining the factor analysis results with the importance ratings presented in Figure 11. A comparison of the information presented in Table 16 and Figure 11 indicates that the six most important product attributes are evenly distributed between Factors I and III, while five of the six least important product attributes are included in Factor II. As a result, it appears that a product's physical characteristics and price/supply characteristics provide a more important influence on the overall purchase decision while the technical characteristics of the product appear to be less important.

A second factor analysis was performed on the satisfaction ratings reported by respondents regarding softwood lumber. The factor analysis was used to determine if there might be some smaller subset of factors that could simplify the evaluation of residential contractors perceptions of softwood lumber. The results of the factor analysis indicate that the original ten product attributes can be reduced to two factors which account for 61.8% of the total variance in the original data (Table 17).

The first factor, which accounted for almost one-half of the total variance, included six softwood lumber attributes: strength, availability, reduced environmental impact, energy efficiency, availability of long lengths, and straightness. Based on the diversity of product attributes included in Factor I, it was assigned the label of "Product Performance/Availability." Factor II accounted for 13.6% of the total variance in the original data and was comprised of the remaining four product attributes: price, price stability, lumber quality, lack of defects. Since Factor II includes product price and quality attributes, a combination of attributes that is often used to represent the concept of value, it was labeled "Product Value."

In discussing the results of the second factor analysis it is useful to refer to Figure 8 and Table 17. In comparing the two sets of data it is evident that the six softwood lumber attributes included in Factor I received the highest satisfaction ratings from the respondents while the four softwood lumber attributes that comprise Factor II received the lowest satisfaction ratings. The factor analysis appears to have been relatively effective in discriminating between those softwood lumber attributes that respondents were satisfied with, or neutral towards, versus those lumber attributes with which they were dissatisfied.

The results of this analysis suggest that residential contractors have a favorable/neutral opinion toward the product attributes contained in Factor I. However, when all of the product attributes are considered together, it is fairly clear that residential contractors are dissatisfied with the value that softwood lumber provides them. This negative perception of softwood lumber value should be of particular concern to softwood lumber manufacturers. It is always possible to attribute the price increases and fluctuations experienced by softwood lumber in recent years to exogenous market forces and public policy decisions over which the softwood lumber industry has little or no control. Unfortunately, this argument cannot be used to explain why residential contractors perceive softwood lumber quality to be low, and therefore, the product represents a poor value when all of the product attributes are considered together.

Many in the softwood lumber industry would argue that product quality has not declined over time and this may very well be the case. In this study, we did not analyze softwood lumber quality and we make no assertions about the quality of softwood lumber. Rather, the results of this research indicate that residential contractors ***perceive*** that softwood lumber quality is poor as evidenced by the low satisfaction ratings for the various lumber attributes. This negative perception can only work against the softwood lumber industry and, if not properly addressed, will invariably provide residential contractors with an incentive to switch to substitute building materials and alternative construction technologies.

Table 17. Results of a principal components factor analysis of satisfaction ratings for softwood lumber product attributes.[a,b]

	Factor 1: Product Performance/Availability	Factor 2: Product Value
***Factor 1 Attributes*:**		
Strength	***.76646***	.17164
Energy efficiency	***.73398***	.04466
Reduced environmental impacts	***.71654***	.12918
Straightness	***.68200***	.45189
Availability of longer lengths	***.53948***	.35572
Availability	***.52740***	.12993
***Factor 2 Attributes*:**		
Price stability	.11962	***.90965***
Price	.06864	***.87156***
Lumber quality	.49478	***.72833***
Lack of defects	.59729	***.60962***

Variation Explained by Components	Eigenvalue	Percent of Variation	Cumulative Percent of Variation
Factor 1	4.82052	48.2	48.2
Factor 2	1.35895	13.6	61.8

[a] Effective sample size = 165.
[b] Survey respondents rated their satisfaction with each of ten solid wood structural building product attributes on a Likert scale ranging from 1 (not satisfied) to 7 (very satisfied) and possessing a neutral value of 4.

CONCLUSIONS

Overall, the use of substitute products among the survey respondents was found to be quite high, with 92% indicating that they had used at least one substitute product. Similarly, almost 85% of respondents have used more than one substitute product as a replacement for softwood lumber in a structural end-use application. These results suggest that many residential contractors have experience with evaluating and adopting substitute structural materials. The use of specific substitute products in structural end-use applications was found to vary considerably, however. For example, while more than one-half of the respondents have used glulam beams and wooden I-beams, less than 10% have used plastic/fiber composite lumber and none reported using plastic lumber.

Substitute building materials were used in all of the structural end-use applications evaluated in the study, although the extent of substitution varied considerably by end-use. Stud walls were dominated by softwood lumber with small volumes of steel lumber and finger-jointed lumber being used. An interesting result pertains to the use of steel lumber. While steel lumber represented just 3% of the volume used in stud wall applications, it was not used to any great extent in the other structural end-use applications investigated. This runs counter to the perception that it is not cost effective to integrate steel framing into a traditional wood framed home. Indeed, many construction experts have indicated that steel construction is only cost efficient when the technology is adopted for an entire project. Based on this observation, it would appear that perhaps residential contractors are using steel framing for specific end-use applications or specific projects as a strategy to experiment with, and gain familiarity with, steel construction technology without committing to using steel framing in the more complex structural systems such as floor, ceiling and roof systems.

The results of the study also indicate that engineered wood products (EWPs) are the primary products being used to substitute for structural softwood lumber. The acceptance of engineered wood products in specific end-use applications can probably be attributed to several factors: the familiarity of contractors with the basic product forms; the working characteristics of EWPs which allow contractors to use traditional tools; and labor cost savings many EPWs provide during the construction process. The survey results also indicate that the level of substitution has increased in floor, ceiling, and roof systems where engineered wood products such as wooden I-beams and wood trusses have a comparative advantage over softwood lumber. Wooden I-beams are primarily used in floor joist systems and, to a lesser extent, in ceiling joist systems. Prefabricated wood trusses, the most commonly used substitute product, are used extensively in floor, ceiling and roof systems. With the exception of wood trusses, no single substitute product demonstrated the widespread acceptance of structural softwood lumber as a structural material in the four primary structural systems of a residential construction project.

The results of a statistical analysis indicate that few differences exist in the use of substitute products based on the geographic location of the firms or firm size. The only exception to this observation is that firms in the western US reported using significantly greater volumes of wooden I-beams in floor and ceiling systems while large firms reported using significantly greater volumes of prefabricated wood trusses in floor, ceiling, and roof systems. This result implies that the use of substitute building materials is relatively homogenous within the US residential construction industry. It should be noted that, while other researchers have reported a positive correlation between firm size and the use of substitute products in the residential construction industry (Goldberg and Shepard 1989), no such relationship was observed in this study.

Although the use of substitute building materials in the residential construction industry was found to be increasing over time, less than one-third of the survey respondents currently employ individuals who have received training in the installation and use of substitute products. For the most part, employee training seems to be focused on those substitute products that have already achieved a high degree of market acceptance, such as wooden I-beams. A statistical analysis of the survey data did not indicate a correlation between the use of a substitute product and employee training in the installation of the product, indicating that employee training does not necessarily influence the adoption and continued use of a substitute product.

While the use of substitute product in the residential construction industry has increased over the past decade, many industry analysts have speculated that this increased use may be attributable to the recent price increases and price fluctuations that have occurred in the softwood lumber market. Our results indicate that price-related factors, while important, are not necessarily the primary factors driving material substitution in the residential construction industry. For example, survey respondents indicated that product attributes such as strength and straightness are more important considerations in their purchase decision than lower prices and price fluctuations.

The competition between softwood lumber and substitute products, particularly steel framing, has received substantial coverage in trade publications and the popular press. In general this coverage has implied that the substitution process in the residential construction industry is driven primarily by economic factors. A factor analysis of twelve product attributes (including both price and non-price attributes) indicated that the substitution decision is dependent upon three underlying factors: the physical characteristics of the product, the technical characteristics of the product, and the economic/supply characteristics of the product. In comparing the results of the factor analysis with the mean importance ratings data it was determined that the physical characteristics of the product (Factor I) are at least as important as the economic/supply characteristics in influencing the substitution process (Factor II). In contrast, the technical characteristics of the product (Factor II) were perceived to be less important in influencing the substitution process.

Unfortunately, survey respondents clearly indicated that they were dissatisfied with half of the softwood lumber attributes evaluated, including: lumber straightness, the number of lumber defects, overall lumber quality, lumber prices, and the price stability of lumber. Survey respondents indicated that they were satisfied with just two of ten softwood lumber attributes (lumber strength and availability), while they were neutral regarding the three remaining lumber attributes (increased energy efficiency, reduced environmental impact, and the availability of longer product lengths).

Finally, survey respondents perceived that softwood lumber produced a greater adverse impact on the environment than almost all of the substitute products evaluated. Only plastic lumber was rated lower than softwood lumber, although the difference was not statistically significant. These results indicate that residential contractors may have a poor understanding of the environmental impacts associated with the production, use, and disposal of the different types of building materials used in residential construction. On a more positive note, survey respondents perceived wood-based building materials to be more environmentally friendly than non-wood building materials.

Clearly, residential contractors have developed some misconceptions about softwood lumber as a structural material, despite their almost daily use of the product. Promotional campaigns by the manufacturers of substitute products, including engineered wood products, have most likely had a substantial impact in shaping the perceptions (and misperceptions) of residential contractors regarding the benefits of softwood lumber. With the use of substitute building materials increasing, the softwood lumber industry must develop a competitive strategy to maintain its traditional dominance in this critical industry. Few would disagree that softwood lumber is the best all-around product for structural end-use applications in residential construction and its versatility as a construction material is unmatched by any other product. However, the results of this exploratory research indicate that softwood manufacturers must take note of the changing business environment within which they compete and develop competitive strategies based on the challenge being posed by substitute products. The alternative to this, business as usual, is unacceptable and will eventually lead to the continued substitution of softwood lumber by a broad range of alternative products, forcing softwood lumber to accept a secondary role in the residential construction industry.

Obviously, the softwood lumber industry is at a crossroads where changing end-user perceptions, aggressive marketing strategies by the producers of substitute materials, and adverse public policy decisions and economic trends have contributed to a rapidly changing competitive environment. The results of this exploratory research indicate that residential contractors perceive that softwood lumber quality is declining, softwood lumber prices are increasing and becoming unstable, and the use of substitute products (including steel and concrete) produces less of an impact on the environment than does softwood lumber. If this trend continues, substitute products may gain an even larger share of the building materials market. Members of the softwood industry need to recognize and respond to the changing competitive landscape in the residential construction industry or risk losing further market share to substitute products in their single most important market.

The residential construction industry is extremely competitive, and this research has shown that residential contractors are quite willing to try new products in order to increase their profitability and/or product quality. To counter the threat from aggressively promoted substitute products, manufacturers in the softwood lumber industry must become more market-oriented. Only by adopting a strong market orientation can they place themselves in a position to determine the needs of residential contractors and develop a marketing strategy that will allow them to meet those needs and increase customer satisfaction. Only by thoroughly understanding and addressing end-user needs and perception can the softwood lumber industry effectively compete against the myriad of substitute products in the marketplace.

RESEARCH LIMITATIONS

This research project was exploratory in nature and designed to identify current trends in the use of substitute products in the residential construction industry. Given the exploratory nature of the study, care should be taken in extrapolating our results to the entire population of residential contractors in the United States. For example, our sample frame was derived from the membership lists of the National Association of Home Builders rather than from a complete census of residential contractors in the US. This sampling methodology meant that small firms were most likely under-represented in our study, thereby biasing the results somewhat. In addition, NAHB provided just two sets of mailing labels with which to contact survey participants and, as a result, we were unable to contact the survey participants following the second mailing. This meant that we had no opportunity to use follow-up contacts in order to increase the response rate, particularly in those industry segments which were found to be under-represented (*i.e.*, small firms and firms located in the northwest). Finally, it is important to emphasize that this study focused on the substitution between softwood lumber and alternative products in structural end-use applications only.

FUTURE RESEARCH

It was not our intention to investigate the nature of softwood lumber quality as perceived by residential contractors and we make no assertions regarding the changing quality of softwood lumber. Our research does suggest that residential contractors consider a broad range of product attributes when defining product quality. Our future research will focus on identifying those product attributes that are perceived by residential contractors to be important components of softwood lumber quality. In addition, our future research will attempt to develop a methodology to rank the relative importance of the various product attributes in terms of their contribution to overall softwood lumber quality.

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APPENDIX A

SURVEY INSTRUMENT

****

This survey inquires about your company's use of non-wood structural materials (i.e. wall studs, floor joists, roof joists/trusses, and floor, roof, and wall systems). It is designed to gather information that will help in understanding the trends that are occurring within residential construction. When the survey refers to substitute products, we mean any material that is not solid wood lumber (i.e. steel, plastic, engineered wood).

****

1) Approximately what percentage of your company's revenue is generated from the following lines of work?

Single-Family Housing	______%
Multi-Family Housing	______%
Home Improvement /Remodeling	______%
Patio/Deck Building	______%
Non-Residential Construction	______%
Other Please Specify:	
____________________	______%
	100 %

2) Is the area in which the majority of your business conducted URBAN, SUBURBAN, SMALL TOWN or RURAL?
Please check ONLY ONE.

( ) URBAN (CENTRAL CITY): A city or group of contiguous communities with a population over 100,000.
( ) SUBURBAN (URBAN FRINGE): Similar to urban but with a population of 100,000 or less.
( ) SMALL TOWN: Isolated from a major urban area with a population of 100,000 or less.
( ) RURAL: Population scattered over a wide area, sparsely populated as compared to urban.

3) In what state do you conduct the majority of your business? ***Please name ONLY ONE state.***

____

4) Please indicate which substitute products you have used for structural applications in residential construction.
Please check ALL that apply.

	Year First Used:
( ) Finger Jointed Studs	________
( ) Steel Studs	________
( ) Plastic Studs	________
( ) Reinforced Concrete	________
( ) Fiber/Plastic Lumber Composites	________
( ) Wall Panel Systems	________
( ) Wood I-Beams	________
( ) Wood/Steel Floor Trusses	________
( ) Laminated Veneer Lumber	________
( ) Parallam Lumber	________
( ) Glue Laminated Beams	________
( ) Other, Please Specify:	
______________	________
______________	________
( ) Have not used any substitute products.	

5) If you have ever used any substitute building materials, what factors influenced your decision to use these products?
Please check ALL that apply.

( ) Strength Characteristics
( ) Straightness
( ) Reduced Environmental Impacts
( ) Reliability of Supply of Substitute Materials
( ) Lower Priced
( ) Price Fluctuations of Solid Wood
( ) Price Stability of Substitute
( ) Availability of Longer Lengths
( ) Energy Efficiency of Substitute Materials
( ) Familiarity of Use
( ) Consumer Interest
( ) Lack of Defects
( ) Other, Please Specify: ______________
____

6) How is the use of solid wood as a structural material in your company changing?
Please circle one number on the scale.

UNCHANGING			CHANGING MODERATELY					CHANGING RAPIDLY	
1	2	3	4	5	6	7	8	9	10

7) For each of the building components listed below, please estimate the percentage of each type of structural material used in the past year by your company. ***Write the approximate PERCENTAGE in the appropriate category for each building component.***

Building Components	Solid Wood Lumber	Wood Truss	Finger-Jointed Stud	Wood I-Beam	Laminated Veneer Lumber	Steel	Other, Please Specify	TOTAL
Wall Studs								100%
Floor Joists								100%
Ceiling Joists								100%
Roof Trusses								100%

8) Have you or any member of your company had training in the use of any products or new building systems mentioned in question four?

( ) YES
( ) NO

If yes, for which products?
1.) ____________________
2.) ____________________
3.) ____________________

9) In your opinion, how do each of the following materials compare to solid wood with respect to their impact on the environment? *Please rate each product on a scale of **1 = LESS FAVORABLE** to **7 = MORE FAVORABLE** by circling the appropriate number.*

PRODUCTS	LESS FAVORABLE			SAME			MORE FAVORABLE
Steel Studs	1	2	3	4	5	6	7
Plastic Studs	1	2	3	4	5	6	7
Finger Jointed Studs	1	2	3	4	5	6	7
Reinforced Concrete	1	2	3	4	5	6	7
Concrete Blocks	1	2	3	4	5	6	7
Wall Panel Systems	1	2	3	4	5	6	7
Wood I-Beams	1	2	3	4	5	6	7
Wood/Steel Floor Trusses	1	2	3	4	5	6	7
Laminated Veneer Lumber	1	2	3	4	5	6	7
Parallam Lumber	1	2	3	4	5	6	7
Glue Laminated Beams	1	2	3	4	5	6	7
Fiber Reinforced Plastic Lumber	1	2	3	4	5	6	7

10) When purchasing structural materials (either wood or non-wood), how important are the following product attributes? *Please rate each attribute on a scale of **1 = NOT IMPORTANT** to **7 = VERY IMPORTANT** by circling the appropriate number.*

ATTRIBUTES	NOT IMPORTANT			NEUTRAL			VERY IMPORTANT
Strength	1	2	3	4	5	6	7
Straightness	1	2	3	4	5	6	7
Reduced Environmental Impact	1	2	3	4	5	6	7
Availability	1	2	3	4	5	6	7
Price	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Availability of Longer Lengths	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Ease of Use	1	2	3	4	5	6	7
Technical/Engineering Support	1	2	3	4	5	6	7
Lack of Defects	1	2	3	4	5	6	7
Appearance	1	2	3	4	5	6	7
Other, Please Specify __________	1	2	3	4	5	6	7
__________	1	2	3	4	5	6	7

11) When purchasing solid wood structural building products, how satisfied are you with the following attributes. *Please rate each statement on a scale of* ***1 = NOT SATISFIED*** *to* ***7 = VERY SATISFIED*** *by circling the appropriate number.*

ATTRIBUTES	NOT SATISFIED			NEUTRAL			VERY SATISFIED
Strength	1	2	3	4	5	6	7
Straightness	1	2	3	4	5	6	7
Reduced Environmental Impact	1	2	3	4	5	6	7
Availability	1	2	3	4	5	6	7
Price	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Availability of Longer Lengths	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Lack of Defects	1	2	3	4	5	6	7
Lumber Quality	1	2	3	4	5	6	7
Other, Please Specify ____________	1	2	3	4	5	6	7
____________	1	2	3	4	5	6	7

****

Finally, we would like some information about you for statistical purposes.
Please remember, all information is strictly confidential.

****

12) What is your position/title?
____

13) How long have you been with the company?
_______________ YEARS

14) Your company is a (***select one***):
- ( ) Corporation
- ( ) Partnership
- ( ) Sole Proprietorship

15) What is your age?
- ( ) UNDER 21
- ( ) 21 TO 30
- ( ) 31 TO 40
- ( ) 41 TO 50
- ( ) 51 TO 60
- ( ) OVER 60

16) What is your level of education?
Please check ONE.
- ( ) Some High School or Less
- ( ) High School Graduate
- ( ) Some College
- ( ) Technical School Graduate
- ( ) Community College Graduate
- ( ) College Graduate\Bachelors Degree
- ( ) College Graduate\Advanced Degree

17) Approximately what was your firm's total sales in 1994. ***Please check ONE only.***
- ( ) 0 - $500,000
- ( ) $500,001 to $1,000,000
- ( ) $1,000,001 to $2,500,000
- ( ) $2,500,001 to $5,000,000
- ( ) $5,000,001 to $10,000,000
- ( ) $10,000,001 to $20,000,000
- ( ) Over $20,000,000

18) Approximately how many years have you been a builder? ___________________ YEARS.

****

Thank you for your time and cooperation in completing this questionnaire. Please return the questionnaire in the pre-stamped envelope provided. If you would like a copy of the final report please include your name and address.

Name: ______________________________
Address: ______________________________
____

****

Additional comments are encouraged and welcomed.

APPENDIX B

COVER LETTERS

^ ^ ^ ^ ^
^ ^ ^ ^ ^
^ ^ ^ ^ ^
^ ^ ^ ^ ^

C I N T R A F O R

January 27, 1995

Dear Participant;

The Center for International Trade in Forest Products at the University of Washington is conducting a research project focused on the process of substitution between wood and non-wood structural building materials in the residential housing industry. In particular, we are interested in identifying what types of products are being used as substitutes for wood, obtaining an estimate of the amount of substitution occurring, identifying those contractors and builders who are using substitute materials, determining those factors that are contributing to the substitution process, and providing a long-term outlook for both wood and non-wood structural building materials.

Your company was randomly selected to participate in this study, and we would like you to spend a few minutes completing the enclosed questionnaire. We understand that your time is very important, thus we have tried to minimize the length of the questionnaire. Because the number of participants in this study is small, your participation is very important, and I urge you to complete the questionnaire and make your opinions known. Upon completion of the questionnaire, please return it to me in the enclosed return envelope at your earliest convenience. The results of this study will be used to help producers of structural building materials gain a better understanding of the changes occurring in the residential housing industry and help them to better serve the needs of their construction customers.

I would like to emphasize that your responses to the survey are confidential. All information acquired from your responses will be aggregated in such a way as to maintain confidentiality. Thank you very much for you participation and prompt response. If you would like to make any additional comments regarding this study, please feel free to write them at the end of the questionnaire. And, if you are interested in obtaining a summary of the research results, include your mailing address at the end of the questionnaire.

Sincerely,

Dr. Ivan Eastin
Assistant Professor
Forest Products Marketing

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C I N T R A F O R

March 8, 1995

CINTRAFOR Survey on Material Substitution in the U.S. Residential Housing Market

Dear Participant;

I recently sent your company a questionnaire regarding the substitution between wood and non-wood structural building materials in the residential housing industry. I have received many excellent replies from companies across the country. If you have returned the survey, please accept my sincere thanks for your cooperation.

If you haven't returned the survey yet, I urge you to do so as soon as possible. Because the number of participants in this study is small your participation is very important to the success and accuracy of this project. Only through your participation can the results of this research be representative of the residential housing industry. Finally, because the research results will be made available to the suppliers of the residential housing industry, it is essential that the results be based on as broad an industry sample as possible.

Once again, thank you for your cooperation and prompt response! If you have any questions or comments related to this project, please feel free to contact me.

Sincerely,

Dr. Ivan Eastin
Assistant Professor, Marketing
University of Washington
(206) 543-1918

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