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Exploratory Assessment of e-Commerce Impacts on Processing Performance and Technology Changes in the Forest Products Industry

Bruce Lippke
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2005

Center for International Trade in Forest Products

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EXECUTIVE SUMMARY

Despite strong demand, the forest products sector has not generated even average financial returns on its invested capital. A PricewaterhouseCoopers survey found that while global forest products industry sales increased 11.8 percent in 2003-2004 to $340 billion, return on capital employed (ROCE) showed only modest growth. ROCE for the global industry averaged 5.5 percent in 2004, up slightly over 4.2 percent in 2003, but still far from the 10-12 percent industry target. New, efficient production facilities are emerging in the Southern hemisphere and higher-cost producers will be challenged to stay competitive.

Financial analysts have suggested that one of the reasons for the sector's poor performance is that, in general, firms are not responsive to customer demands, they have a poor understanding of inventories and internal business information, and they are inefficient.

Lean manufacturing methods have been used to remedy efficiency and productivity issues. During the past decade, information systems and e-commerce have been considered a component of lean manufacturing, capable of expediting sales processes, tracking orders, assisting with after-sales service, and inventory procurement and control. Given the history of lagging financial performance associated with the forest products industry, this research seeks, through a series of interviews with wood products manufacturers in the millwork, cabinet, and structural wood products segments, to determine to what degree e-commerce and information technologies positively or negatively impact production efficiency and profitability. The researchers recognize that assembling standardized performance data from companies producing different types of products is by itself a difficult task, therefore, this investigation is exploratory.

Clearly, the opportunity to improve productivity in the forest products industry exists, but are e-commerce and information technologies the solution? To answer this question, forest products companies need to better understand if e-commerce technologies and information technologies can improve production and sales productivity and profitability. Understanding how other forest products firms have used e-commerce to improve productivity may be all that it takes to promote change.

Millwork, precut home truss manufacturers, and large and small lumber mills were selected and interviewed to obtain an understanding of changes in the technologies used and their impacts. Findings revealed that while firms are adopting e-commerce technologies to improve production processes and inventory management, they place much less importance on the use of company managed websites for marketing and sales. While all firms interviewed use email and the Internet for communication and searching and/or purchasing non-wood goods such as e-technology equipment, few firms said they use websites for advertising, selling products, or to provide Internet-based customer order tracking functions. Companies who sold products on their own or third party websites found the medium relatively ineffective. The primary reason given is that their customers prefer to place orders directly with sales staff to ensure that they understand the products and that the order is placed correctly. This is especially true for small customers who are not reliant on e-commerce – a common profile in the forest products industry. With few exceptions, large home center retailers are the primary users of the technology for marketing activity.

Most manufacturers in the sample said that they are reluctant to purchase or sell products via the Internet because it removes their ability to develop and maintain relationships, a factor that is essential to conducting business in the commodities market. In lumber manufacturing, while sawmills try not to produce more lumber than they can sell, sales people rely on personal relationships developed over time to move excess inventory. None of the companies interviewed expressed and interest in purchasing raw materials over web-based exchanges, even though it is manufacturers' highest cost purchase.

While the use of Internet based technologies does not appear to be very prevalent, preliminary findings indicate that companies, regardless of size, are adopting *information technologies (IT)* to improve

processing productivity and internal information management, resulting in substantial productivity gains -- in most cases over 50 percent within a few years of introduction. Advances in computer-aided technology have come almost as a requirement for improved sawing technology and processing equipment. Bar codes are used almost universally.

Ultimately, firms have upgraded their IT systems to maintain or improve competitiveness in light of increasing competition from lower cost producers, declining availability of high quality raw materials, and a greater proportion of smaller orders coming from a greater number of customers. For more complex secondary manufacturers, the opportunity to provide a greater number of product designs using computer controlled production and assembly is replacing higher cost customization while satisfying a broader set of consumer requirements.

While companies in the sample collect information about their performance, they are rarely equivalent metrics, making a statistical analysis of cause and effect difficult. However, in all cases in this study performance improvements were credited to new applications of internal information technologies rather than Internet processes.

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1.0 INTRODUCTION

Internet, intranet, information systems, and e-based business transactions have become an integral part of global commerce. According to the Progressive Policy Institute (1998), the value of the US Internet economy doubled between 1996 and 1997 from $15.5 billion to $38.8 billion (Atkinson and Court 1998). By 2002 e-commerce shipments were valued at $752 billion. Business-to-business e-commerce accounted for the largest share with $186 billion (US Department of Commerce 2002).

The e-commerce bubble has since burst, yet proponents and vendors of e-commerce technologies continue to tout e-technologies and information systems as remedies to company inefficiencies. Vendors credit e-commerce and information systems with improving administrative and production efficiency while lowering costs for companies in the areas of sourcing, product customization, delivery, waste reduction, and inventory management, among others. Ernest & Young project that companies could reduce their inventories by $350 billion if they were to "use the Internet to share promotional plans, point-of-sale data and sales forecasts with partners" (Anonymous N.D.). Companies are also encouraged to use e-technologies to create closer linkages with customers and suppliers, thus reducing delivery time. Together, these changes can result in the substantial redesign of a production process to more efficiently meet customer preferences.

E-commerce extends beyond simply buying and selling goods. Much of the attention paid to e-commerce focuses on retail sales, yet in 1992 e-commerce transactions accounted for only 1.4 percent of total retail sales (US Department of Commerce 2004). Instead, according to a 2001 Census Bureau (2004) survey, manufacturers are the most likely to use e-commerce technologies. The survey found that in 2002, 93 percent of e-commerce transactions were conducted between businesses, predominately via Electronic Data Interchange (EDI).

During the late 1990s the number of e-marketplaces and e-commerce service providers with services tailored to the forest products industry boomed. All offered services to improve sales volume, productivity, and profitability. However, forest products firms had no way to determine if these services would truly improve firm productivity. While many of the e-marketplaces and service providers have gone out of business or retooled to provide a different service, a number of providers remain, which underscores the need for quantified metrics to help companies determine the effectiveness of e-commerce and information systems to improve company efficiency.

This exploratory research aims to determine if there are common factors that characterize companies that have achieved a significant degree of success as a result of adopting e-commerce technologies and those that have not. The intent is to provide companies with information about costs and efficiency gains associated with e-commerce technologies based on the experiences of companies who have used these tools. One hypothesis is that in order for e-commerce to have a significant impact on performance, the technology has to fundamentally change the way a company conducts business. This may be a technology that causes a substantial change in the production process, purchasing, marketing, customer service or inventory control that is reflected in related performance measures. Finally, we hypothesize that for e-commerce to contribute significantly to increased performance it needs to change management processes, characterized by the innovations that were first credited to Japanese Management (i.e. total quality control, continuous improvement, just in time processes, zero defects, etc.).

This study set out to examine the impacts of e-commerce impacts only. However, initial conversations with company representatives revealed that while some companies interviewed used Internet-based e-commerce tools, more companies used internal information systems. Therefore, the survey was expanded to determine the extent to which companies used e-commerce and information systems, and the effectiveness of both of these technologies to improve productivity and profitability.

We begin by characterizing how e-commerce can impact business performance and we present a case for how e-commerce might improve the efficiency for forest product manufacturers based upon experiences in other sectors. We then describe our survey methodology and performance models to aid the understanding of performance impacts. We discuss the impacts we observed for a range of companies in the survey and detail activities and technologies that were reported to have the biggest impact on performance. We also detail what appear to be significant obstacles to adoption. Finally, we compare what we observed with a model of modern management and offer some conclusions.

1.1. HOW E-COMMERCE CAN IMPACT BUSINESS PERFORMANCE

Information systems may be applied to only one segment of a firm's operation or they may be an integral part of the business. The types of technologies used may range from a single piece of equipment that monitors processing equipment to a series of networks that link each stage from raw material acquisition to product marketing, order taking, and delivery. Improved performance from these systems can be profound. Information systems and e-commerce have been credited with lowering distribution and transaction costs and improving efficiency in the manufacturing and service sectors with savings estimated to be in the billions of dollars (Pastore 1999). The adoption of e-commerce technologies is credited with producing $17.6 billion in savings for companies in industrialized nations and in 2002, $15.2 billion of which is attributed to US companies. Worldwide savings totaled $1.25 trillion (Pastore 1999).

Just-in-time delivery systems, near zero inventory systems, reduced set up time, zero defects, and many other modern management techniques (Schonberger 1982, Fukuda 1983, Shingo 1985, Hasegawa 1986, Nemoto 1987, Suzaki 1987) have been used for more than two decades but can be enhanced through effective use of e-commerce and information systems, resulting in processing and delivery performance improvements. Return on investment related to the adoption of e-commerce has been found to be substantial. According to Deloitte Consulting "ROI reported by more than 200 survey respondents averaged 300 percent over the first 2 to 3 years based on an average implementation cost of $2 to $3 million and an annual procurement savings of nearly 9 percent over the first 2 years" (Vlosky and Westbrook 2002).

1.1.1. An argument for the use of e-commerce in the forest products industry

Despite strong demand, the forest products sector as a whole has not generated even average financial returns on its invested capital. A PricewaterhouseCoopers survey found that, while total global forest products industry sales were up 11.8 percent in 2004 to $340 billion from $304 billion in 2003, return on capital employed (ROCE) showed only modest growth. ROCE for the global industry averaged 5.5 percent in 2004, up slightly over 4.2 percent in 2003, still far from the 10 -12 percent industry target. According to Craig Campbell of PricewaterhouseCoopers, "The earnings in the global forest and paper industry are slowly coming back to the levels seen five years ago, but overcapacity and production fragmentation are still limiting financial performance. New, efficient production facilities are coming on stream in the Southern hemisphere and higher-cost producers will be challenged to stay competitive" (PricewatershouseCoopers 2005).

Part of this inability to maximize ROCE may be due to the industry's reluctance to adopt new technologies. For example, a 2000 Census Bureau survey of e-commerce use in manufacturing sectors found use of e-commerce technologies in the forest products industry were consistently lower than most other manufacturing sectors (Table 1).

Toivonen's (1999) study of the use of information systems in marketing and sales in the Finnish forest products industry also found that companies did not exploit information systems to their fullest potential. She concluded that companies' strategies were not reflected in the information technology systems that they utilized. She hypothesized that producers of commodity grade forest products may increase the value of their products and offset some of the competition from substitute products by tailoring products to customer specifications through the use of information technologies. Toivonen said that information systems could be capable of improving the competitiveness of producers of value-added products by enabling them to customize products to meet customer specifications. The

study concluded that commodity and value-added producers could improve customer relations and lower costs by improving the efficiency of delivery and ordering processes, and by incorporating customer feedback into production systems.

Totev's (2000) in-depth survey of Washington wood products manufacturers (sample of manufacturers of cabinets, millwork, structural wood products, and fixtures and furniture) linked problems with productivity and efficiency problems in the forest products industry primarily to efficiency and information control. Totev found that wood products manufacturers tended to underutilize their employees and machinery, and they had insufficient inventory control and poor profitability even when market demand was strong. He also found that companies in the sample had higher than average rework and scrap rates. Totev concluded that forest products companies tend to look for solutions to their problems in capital investments without having a clear understanding that their existing resources are underutilized. Further, "a large portion of potential profits are consumed by external factors like excessive regional production capacity, severe competition, underbidding, etc., and by internal factors like overtime, long changeovers, rework, and scrap" (Totev 2000). Since this suggests wood products manufacturers have been slow to adopt modern management techniques to reduce waste and increase the return on capital one of our main interests in analyzing the performance of e-commerce adopters was to determine if adoption would foster fundamental changes in management techniques.

2.0 METHODOLOGY

Manufacturers representing a range of sectors in the forest products industry (lumber, millwork, and pre-cut home and truss manufacturers) were selected and interviewed to obtain a better understanding of the types of firms that facilitate e-commerce and its impacts on performance. Millwork, truss, and large and small lumber producers in Washington and Oregon were selected as a means of comparing impacts among similar firms. The selection process was not a random sampling since companies who did not use e-commerce typically declined to participate. An initial list of 30 companies was compiled with the help of Washington Manufacturing Services. Company managers were called and asked a set of preliminary questions to determine if they used e-commerce and/or information technologies. A large number of firms were removed from the sample set either because they did not use the technologies or because they refused to be interviewed. The final sample included nine companies that participated in a detailed survey – two each from the millwork and truss sectors and five lumber producers. E-commerce and information technology consultants were also interviewed. Questions were directed at representatives from many other firms probing for different experiences but we did not detect a need to extend our interviews. The survey was conducted in person and generally required two to three hours to complete.

The first step of the research involved developing a survey made up of performance measures typical of those used in Japanese management theory and more recently adopted by those advocating lean management. Many of these measures are extensions to those developed in Totev's (2000) study of production performance of wood products manufacturers in Washington State. For each performance measure that appeared to have a potential link to a change related to adoption of e-commerce, we created a question linked to the performance measure and the process. The questions were ordered around stages of business operations or processing (marketing and market research, sales and order taking, design and production planning, procurement, inventory, labor training, quality control, shipping, management, and demographics control), as shown in Table 2. The first section of the survey was used to determine when technologies were first adopted specific to each stage of processing. Questions targeted each stage of processing: (expenses, employee management, percentage of sales that were Internet-based, changes resulting from e-technologies, processes that have been automated, parameters measured, set up time, inventory control, defect tracking and control, etc.). A copy of the survey is included as Appendix A.

The model of interest for this study was how e-commerce affects profitability and productivity. A long term profit maximizing model that has been used in Japanese management training to focus on areas of performance improvement relates the financial return on investment to increasing sales, minimizing

waste and assets, and increasing margins. Determining whether and how changes introduced by companies impact the key parameters of this model helps in understanding the degree to which performance will be impacted.

$$\text{Model: ROI} = \frac{\text{Sales(units)} * \text{Profits/unit (margin)}}{\text{Assets}} = \frac{\text{Return}}{\text{Assets}}$$

- maximize sales by serving the customer better
- maximize margin by working smarter
- minimize assets by driving out all waste and unnecessary assets

3.0 FINDINGS

It became apparent early in the interview process and questioning many company representatives not in the final sample that relatively few firms were using e-commerce technologies in any depth. We did find that companies, regardless of size, are adopting internal information systems, or networks, to improve processing productivity and information management. For many manufacturers, advances in computer aided technologies have come as a requirement for improved cutting and processing equipment. Other company managers have sought large, more comprehensive information systems as an approach to improve productivity and profitability. These systems were typically adopted with improved cutting and finishing equipment. Bar codes are used almost universally among lumber, millwork, and precut home and truss producers interviewed. Most firms interviewed also track inventory with computer aided technologies. In general, most of the performance improvement reported came from successful implementation of internal information systems integrated with processing equipment. There were a few exceptions and knowing what has and has not been successful can be important.

3.1 USE OF INTERNET MARKETING AND SALES

While all firms interviewed use email and the Internet for communication and searching and/or purchasing non-wood goods, fewer firms in the sample offer Internet-based customer order tracking or purchasing functions. Companies who advertise on company-owned or third-party websites found the medium to be an ineffective sales tool.

Almost all companies interviewed said that they had offered Internet-based ordering, but discontinued it because their customers strongly preferred to place orders via phone or fax and opposed ordering online. A number of respondents said that many of their customers are small companies, are not highly reliant on Internet-based systems and fear ordering errors. Likewise, manufacturers are reluctant to use the Internet to purchase or sell wood products because they said it removes the ability to develop and maintain relationships, a factor that is considered essential to conducting business in the commodities market. Particularly in lumber manufacturing, sales people can sell unexpected excess production based on personal relationships they have developed. Email and faxes are used to supplement communication, but sales people tend not to want to use a company-owned or third party online interface. Value-added producers also said that the ability to provide personal service plays a significant role in developing customer loyalty. The exception is the use of EDI, which is used to service big box retailers. Big boxes were noted by almost all sellers as the driver for their adoption of EDI and Internet based services including online ordering, invoicing, order tracking, and truckload and delivery schedule management.

Most firms in the sample that have websites have adopted them as a marketing or public relations tool, but most respondents considered their company websites secondary to activities to improve production efficiency and customer service. Only one truss/prefabricated house manufacturer in the survey used their company website extensively to relay information and downloadable forms and marketing information to its overseas sales staff. However, the company's marketing manager said that he created the website because the company would not provide funds for its development, an indication of the

lack of management support for Internet technology. This company also did not use any information technology computer systems.

3.2 USE OF INTERNET – CUSTOMER ORDER TRACKING

Several of the firms surveyed offer Internet-based customer order tracking systems that automatically notify customers via email when their orders are shipped and Internet-based scheduling reports to enable customers to check on the progress of their orders. However, those who offer the service reported that very few customers, with the exception of large home retailers, use the system. The majority of customers prefer to work directly with company representatives.

3.3 DRIVERS OF ADOPTION AND RESULTS – INFORMATION SYSTEMS

Companies who adopted information systems uniformly said they adopted information systems to improve production speed and efficiency, reduce waste, and to help maintain market share as competition from lower cost producers has increased and the number of customers has declined. Almost always related to improved machinery and information gathering, companies reported substantial improvements to productivity over a several year period with some increase in capacity, and reduced waste and downtime. The size of the company and degree of processing conducted had some impact on the use and complexity of the information systems employed. Manufacturers of commodity goods were more likely to use information systems that are strictly related to improving sawing machinery, such as systems to track waste rates and productivity, while value-added manufacturers tended to have more production stages and different types of equipment, and therefore, more complex information systems. Manufacturers of highly manufactured products such as millwork and trusses typically adopted the most complex information systems of all of the producers interviewed. These manufacturers were more likely to have systems that track components and integrate manufacturing systems, inventory control, order tracking and analysis functions, and systems to coordinate shipping with production lines. A matrix showing the types of functions companies from each of the sectors examined are included in Table 3.

Information systems are becoming an integral part of secondary processing. They can be configured to streamline and improve the efficiency of sales, production, shipping, inventory, and customer information management functions. Some of the more complete systems being used in the forest products industry include order receipt; automatic generation of building plans; inventory analysis and re-order notification; quality control and defect rate tracking; analysis of customer ordering history; analysis of employee hours, productivity rates, and payroll; and software capable of grouping orders by shipping date and destination to consolidate shipments. Multi-module information systems are also capable of generating vendor analyses to ensure that the surveyed manufacturers receive the correct dimension, grade, volume, moisture content and product ordered.

3.4 PRODUCTIVITY AND EFFICIENCY GAINS

Users of information system reported significant productivity gains. Several companies reported 50 percent gains in output per unit of labor within a few years of implementing new information systems that were integrated with sawing technology. One millwork company had a 50 percent decline in production volume over three years, yet by using information systems and advanced production equipment to produce more complex and therefore higher priced goods tailored to suit niche markets, it lost little revenue. However, in order to compete in the custom home and luxury building materials market, companies must typically be able to supply goods within two to three weeks of receipt of an order. According to a survey of Washington secondary wood manufacturers, average lead time in the state was 20 days, and even 60-70 days for some companies (Totev 2000).

In addition to being able to produce customized products, commodity and non-commodity producers are finding that fast, cost-efficient shipping is vital to sustaining profits. Faced with smaller and more complex orders from more customers, company's said they have used internal information systems to help them consolidate a number of orders into the same truck to reduce shipping costs and meet tight delivery deadlines.

Several respondents whose companies use information systems that include several interconnected modules, similar to the system described above, reported that not only did information systems help them reduce lead time, increase production volumes, and lower overhead; the systems have also helped improve customer relations. Several respondents said that the information systems have improved their relationship with their customers because they enable the supplier to provide better customer service and ship products on time. These factors were rated by one company president as "the most important factor" in his business. Survey respondents also credited information systems with helping firms analyze customer histories in order to develop marketing strategies – something that was very difficult to do prior to adopting the software.

Information systems also improved production efficiency for a number of companies interviewed. One firm improved production efficiency by 46 percent, reduced overtime wages, and eliminated defect rates in its finished products just two years after adopting the company's information system The company also eliminated component defect rates on the production line and throughout most of the assembly department. After-sale claims were cut in half, although part of this reduction was due to the use of engineered wood products. A lumber mill that produces 165 million board feet annually and spent $100,000 for computerized sawing equipment said the new equipment and software improved the mill's quality control process. All lumber is scanned as it comes off the production line, which provides the mill managers with better information about inventory, faster than without the computerized equipment. Separately, a bar code system used for raw logs and lumber also provides more accurate inventory management.

One truss manufacturer reported a 170 percent increase in production after the company adopted a system that automatically downloads templates from the main office to the production line. Automation cut the time it takes the production line to do setups in half. The automated system can now do 2,300 setups per day at two to three seconds per setup, compared to manual setups which take five minutes each. Laser setups of truss designs and automatic nailing and routering also improved the accuracy of the company's wall systems. The company is exploring the use of lasers instead of jigs. While jigs reduce setup time from one hour to ten minutes, according to the company president, lasers can improve productivity even more.

All of the mills in the survey used some version of automation to track inventory. The technologies ranged from bar codes used by two of the lumber mills and one truss manufacturer to more complex systems linked to information systems. One large lumber mill that uses an information system to track inventory said that while the system hasn't changed the way the company manages inventory, the managers do have a better understanding of their inventory volume since adopting the system. The volume of inventory in stock is dictated by demand and kiln volume, and the in-house system is used to control raw material purchases.

Producers of more highly value-added products such as millwork and trusses naturally used more complex systems that generated reject rates and raw material purchase prices. Both of the millwork producers used information systems for this function and one of the truss plants used automated inventory control systems.

It is difficult to quantify the impact of information systems on productivity because these systems are usually a component of state of the art milling or processing technologies. While few respondents could pinpoint the degree to which information systems improved their production processes, many of the firms reported achieving 30 to 75 percent capacity and productivity gains in five to seven years. These gains are substantially above the industry average of four percent per year derived from production data (USDA) for Washington and Oregon. However, even the two-state average shows productivity growth increasing from one percent for the last two decades to four percent during the five year period leading up to our interviews. While there is a substantial increase in productivity in recent years it also suggests that many companies have not benefited from the impact of information systems and new processing technologies observed in our survey or the state-wide gains would have been even larger. Companies almost universally associated their production improvements to a combination of improved processing and information technology systems. The distinguishing feature is that email, the

Internet, online exchanges, and electronic documentation tracking were not considered the reason for performance improvement. However, information system technologies; mainly processing control, more automated production of parts, measurement and hence quality control, were almost always the principle agent of change identified. That is not to say that the more recent e-commerce technologies had no impact, but that the more traditional forms of computer processing and control have finally been recognized as having a major impact on manufacturing performance.

3.5 ADOPTION OF INTERNET E-COMMERCE TECHNOLOGIES

While the complexity of information systems used by the survey group varied widely, use of e-commerce was more consistent. Very few companies used e-commerce technologies as a sales or marketing tool. Most of the companies in the sample reported purchasing office equipment online, yet none purchase raw wood materials via the Internet or other external networks. While some firms had offered online ordering and order tracking services, they stopped due to lack of interest from their customers. With the exception of large home centers and wholesalers, customers refused to use online ordering, even when offered discounts as an incentive.

The exception is Electronic Data Interchange (EDI), which can be used in two ways: with an external network to communicate with and sell products to large retail home centers, and as a means of inputting order specifications into a company network.

As a tool required to service home centers, EDI standardizes product information following two standards, Global Trade Identification Numbers (GTIN), which are standardized numbers for products and their prices, sizes, colors, etc. and a Global Location Number (GLN). Manufactures make their product catalog available in "data pools" that are linked to a global registry. Retailers search the registry to identify the "data pools" where information is stored about the products they want to synchronize. Retailers then establish a link from these data pools to their own catalog via a synchronization engine. The information in their catalog is then automatically updated and synchronized on a continuous basis (Data Communication Solutions 2005). Big boxes also require electronic ordering, invoicing, shipping information, and delivery date and time notification. Firms report strict pre-scheduled delivery times and levy penalties for deliveries that are even hours late.

This type of EDI use among wood products producers is clearly driven by Big Box retailers. Home centers now constitute approximately 10-15 percent of larger suppliers' sales, which means they have the power to dictate their purchasing terms. Home center sales also take up less of a suppliers' sales department time than other customers since home centers typically sign yearly contracts that simply need to be re-supplied throughout the year. All of the firms in the survey that sell to home centers use EDI.

When used to receive and input orders, EDI can significantly improve efficiency and reduce errors. However, only one company in the survey used EDI in this capacity. The company did report significant results however. After implementing EDI software the company's sales staff was able to book 500 to 2,000 orders per day with virtually no billing mistakes and no errors in the bills of materials. Prior billing errors totaled $1,000 to $10,000 per day. Improved ordering efficiency also enabled the company to eliminate nine positions in the sales office. Improved ordering, processing, and labor management software also reduced overtime wages by five to ten percent.

3.6 INCREMENTAL ADOPTION

Companies in the sample ranged from those who had little automation to companies with multi-component information systems. Most firms said they make incremental improvements due to the high cost of implementing a complete system and to enable managers to evaluate the benefits of the technology implemented. This is not always possible when there is a substantial change in the way processing control is managed. Small companies can be extremely vulnerable during a processing change adoption. A single computer program and programmer can be critical to the entire process, and the impact of a changeover can be substantial with the entire operation.

According to companies in the survey, the investment in software, customization, and computer technicians required to customize a multi-mode system is approximately $700,000-$750,000 with and additional $40,000 for annual maintenance. This system would determine the components needed for assembled products, calculate the raw material needed, the raw cost and the final cost, deliver the plans to the production floor, manage inventory and employee hours, analyze customer histories, and monitor incoming raw material costs (with an EDI for order receipt). Companies using this type of system reported immediate efficiency improvements and cost savings even without substantial changes in processing equipment.

3.7 OBSTACLES TO ADOPTION

While companies that have adopted e-commerce technologies, either throughout the plant or in select areas, reported improvements to production efficiency, reduced overhead and better inventory control, most companies said that they experienced an adoption curve, either because the initial system was not a good fit, or because it took some time to incorporate the system into the production or sales process.

Several of the companies interviewed used off-the-shelf software customized by programmers to the companies' needs. Several of these companies reported initial problems with the software. One firm attempted to use a software program to help the firm purchase lumber. The system was intended to track dimensions, species, and grades in the firm's inventory. It ended up being very expensive and management of the system was beyond the firm's in-house technical capabilities. The firm was advised by an IT consultant to completely replace the system at a cost of $350,000. The company decided to purchase a new system that would better suit their needs because they felt that their old system was so ill suited to the company that the firm would never realize a return on their original investment.

Other firms also reported problems related to the software they adopted. Some of these problems were temporary and associated with the down time and learning curve while introducing a new system or customizing off the shelf information system software, yet others reported continuing problems such as improperly operating scanners.

3.8 OBSTACLES TO CONNECTING PERFORMANCE WITH TECHNOLOGY ADOPTION

While our survey did identify performance changes and process changes, the links were never that direct. Moreover, attempting to conduct a survey with a sufficient number of companies to establish statistical significance was hindered by little commonality in the metrics used. Each company, even those producing similar products, used significantly different language when describing their process. Primary manufacturers can fall back on lumber volume and man-hours as primary productivity measures but even here, modern processing attempts to emphasize dollar value so that volume productivity is less meaningful. Mills that used to cut for maximum volume may now simulate the value they can expect to get processing their log deck for different market niches. In effect, every mill is customizing their operation to their own niche in the market. The parameters of interest are not always the same. Secondary product manufacturers are replacing custom processing with Cad/Cam-like delivery (i.e. while the product may no longer be custom, the processing control system can produce so many different variants that the available options are close to custom ordering). If a mill does not develop this capability they will likely become too high cost and too slow to respond and lose market share. Many of the measures that we had hoped would link performance to e-commerce are not tracked by managers. While it might be possible to collect data needed to analyze the effect of e-commerce technologies on financial performance and productivity, the investment in e-commerce technologies is typically so limited compared to other capital equipment expenditures, that quantifying the effectiveness of new e-commerce tools is not a priority for company management.

4.0 CONCLUSIONS

We hypothesized that for e-commerce to significantly increase performance it would need to change the management process, which is characterized by innovations that were first credited to Japanese

management (i.e. total quality control, continuous improvement, just in time processes, zero defects, etc.). In *e-Commerce Operations Management* (2002), a guide to achieving efficiency improvements through the use of e-commerce, Schniederjans and Coa characterize eight critical success factors within operations management where e-commerce contributes to performance improvement. They emphasized the importance of operations management and not marketing. We observed efforts in many of these success factors in our survey and in the following paragraphs we draw a link between our findings and the eight factors. Noting those areas where forest products companies are or are not adopting new technology to improve performance provides a revealing summary of the sectors response and progress.

1. Supply Chain Management:

Some companies in the sample reported that they are moving toward supply chain management (i.e. taking over control of the supply and inventory management for some customers). Schniederjans and Coa (2002) reported that performance gains were largely related to increasing the inter-dependence and coordination between supplier and customer. We found that some of the mills in the survey succeeded in providing this service and they reported benefits. One important benefit has been the dependence on sole sourcing in the supply chain, which provides both reliability and increased stability in product flow. The supplier assumes some of the risk that the customer had previously but through improved coordination, the two parties collectively reduce costs with more timely delivery and more rapid response to changes.

2. Purchasing Management:

Almost all of the companies in the sample said they purchased computers and office supplies via the Internet but almost no other products. Wood raw materials make up a large part of their other purchases, yet mill managers said that personal relationships were important when ordering material that is not uniform. While wood may be considered a commodity, its characteristics can be highly variable, which can be better matched to the purchasers needs by reliable and personal supplier relationships.

3. Product and Process Design Management:

There were no cases found where companies work directly with customers to design products or processes. However, changes in the way companies use internal information systems were found to produce similar results. Improved processing equipment and the adoption of information systems has enabled producers of value-added product such as doors to move away from custom production processes to automated processes that can produce many more design alternatives, so many customers can find exactly what they want without placing a custom order specification. The ability to electronically and immediately communicate the product alternatives leverages the benefits of automated production processes. While there is some communication flow from customer to producer, the introduction of computer controlled production processes that can cut products that meet a number of different specifications has been the largest agent of change.

4. Forecasting & Scheduling:

As large home centers and luxury home builders, who demand on time deliveries, become a more prominent part of the distribution chain, ensuring on-time deliveries has become more important for suppliers than ever. Companies in the survey reported using internal information systems and e-commerce to schedule production and deliveries, although at this point, use is not widespread. Lumber mills, with less complex manufacturing methods use online train schedules to coordinate their shipments and delivery. Larger manufacturers with more complex manufacturing processes employ more complex internal information systems to coordinate the completion and loading of multiple orders destined for similar locations onto the same truck.

5. Inventory Management:

Regardless of firm size and processing complexity, inventory management was perhaps the most frequent use of internal information system and e-commerce technologies. Firms use bar codes to track raw material inventory as well as to track components used to assemble value-added products.

Electronic inventory control also enables firms to schedule and track re-orders or raw materials. More complex information systems permit firms to automatically reorder materials, yet no manufacturers in the survey used this function, preferring instead to manually reorder materials. Some systems also generate reports that detail reject rates and changes in material prices, which survey respondents said helps them maintain the price and quality of their raw material supply. While all of the companies surveyed reported using bar codes with or without internal information systems to track and analyze inventory, none of the sample used Internet-based e-commerce for this task.

6. Quality Management:

Many companies reported more frequent email communications with customers, which includes some quality feedback but none reported using a more formal or improvement oriented quality measurement system.

7. Human Resource Management:

In *e-Commerce Operations Management*, Sones stated that an e-commerce business must align itself with clear lines of action to be responsive to a different way of doing business (Schniederjans and Cao 2001). Most companies interviewed placed significant responsibility on a small information systems group to support process and management training. It was clear these groups were operating with the support of their top management. Since most of our companies were small, the interplay between management and the working teams is much more open and direct than we might expect to be the case in larger companies.

8. Reengineering and Consulting Management:

Most of the critical success factors required some reengineering. Institutionalizing such a process is the key to continuous improvement. The interviews found that reengineering exposed smaller companies to high risk for some time before they achieved success. For small companies, the re-engineering process is dependent upon a few key people, which leaves the company dependent on these peoples' knowledge and reliability. The risks associated with re-engineering in a company with only one production line is much higher than for larger companies with multiple production lines to rely on. Our research obviously only included survivors, but we know of many failures. The role of good consultants with relevant experience can reduce the risks associated with re-engineering, but they cannot substitute for employees who customize the change and support the implementation.

While many of the companies in the survey successfully engineered changes in these critical success factor areas, most of the change was related to companies adopting new ways to use information systems, many of which were integrated with automated processing equipment and independent of e-commerce technology. For this to occur, the success of the information system adopted was dependent upon management's support and commitment. The process of adopting an information system in the companies surveyed, whether simple or complex, was neither inexpensive or without downtime, and the need to adapt the system to the companies' specific functions and requirements. It has taken almost 20 years for forest products manufacturers to realize the potential of information systems technology to improve company performance. Since our sample reported much higher productivity gains than the industry average, there may be many improvements from late adopters yet to come.

Forest products companies are making substantial performance gains with new and better information system applications. We can expect the trend to continue as late adopters either catch up or drop out. In a few cases, such as supply chain management with automated product design, there is evidence that links between internal information systems and e-commerce technologies positively affect company performance. E-commerce technologies are used much less than information systems and appear to have less significant effects on company performance. Furthermore, there is room for growth in the number of companies using e-technologies and the complexity of the systems employed. Value-added companies that can substitute automated production control for product customization, and increase their market share in the process, might represent the most advanced adoption of both information systems and e-commerce technology. Wood products companies have generally been reluctant to replace personal selling by a seasoned sales force with any electronic media, yet they purchase

electronic equipment from the Internet. Avoiding errors is the usual justification. Wood may not be such a simple commodity after all if it requires confidence in the person to provide the product that works best for the customer.

There may be irony in this observation since forest products companies are largely commodity driven, with marketing generally considered the industry's weakness. Successful adoption of e-commerce links will almost certainly increase the information flow on products, enhancing the importance of marketing distinctive products.

5.0 FUTURE RESEARCH

While our survey found the use of e-commerce among forest products manufacturers in the Pacific Northwest for transactional and support functions to be limited, large homebuilders and wholesalers are beginning to require suppliers to make products available for sale through online interfaces (ProDealer Conference 2005). At the Home Channel News ProDealer Conference (2005) Valerie Hansen, President of Big Buck Building Centers, Inc. said she prefers working with suppliers that can help reduce administrative time spent reviewing price quotes. The purchasing manager for a large builder went as far as to say that his company will not purchase products from companies with "one or two computers". New systems have emerged that offer software applications as opposed to online exchanges, and these systems are being readily adopted by large customers and retailers. One system, BuyMetrics, an Internet hosted application solution provider that helps customers collect and compare price quotes from many suppliers is now used by five of the US's largest lumber producers and represents eight percent of the non-industrial lumber volume sold annually. This observation prompts the question: will all wood products manufacturers be required to adapt to these technology changes just as they were forced to adopt EDI to supply big box retailers? A second stage in this research could focus on customers and their requirements of suppliers which may reveal the direction the forest products industry will be forced to follow.

Table 1. Percentage of companies using e-commerce technologies, by industry.

		Average Sector Use of Various Types of Computer Networks (Percent of Total Respondents)				
Description	**Number of Responding Companies**	**Internet**	**Intranet**	**Local Area Network**	**EDI Network**	**Extranet**
Plant Count Totals	**38,593**	**75%**	**40%**	**69%**	**23%**	**6%**
Food products	3,390	70%	45%	67%	20%	4%
Beverage and tobacco	406	74%	51%	71%	18%	6%
Textile mills	762	73%	39%	70%	30%	7%
Textile product mills	484	68%	27%	55%	26%	3%
Apparel	892	61%	21%	50%	32%	4%
Leather & allied products	178	63%	24%	62%	21%	4%
Wood products	2,111	59%	29%	53%	9%	3%
Paper	1,616	80%	56%	78%	32%	5%
Printing & related support activities	2,108	80%	35%	68%	15%	6%
Petroleum & coal products	568	59%	43%	54%	15%	4%
Chemicals	2,619	80%	61%	79%	21%	7%
Plastics & rubber products	2,697	76%	41%	72%	29%	5%
Nonmetallic mineral products	2,074	60%	32%	54%	10%	3%
Primary metals	1,257	81%	44%	77%	33%	7%
Fabricated metal products	5,710	73%	29%	64%	23%	4%
Machinery	3,784	82%	40%	75%	19%	8%
Computer & electronic products	1,910	89%	59%	86%	27%	15%
Electrical equipment, appliances, & components	1,106	85%	56%	81%	30%	11%
Transportation equipment	1,759	85%	57%	82%	42%	12%
Furniture & related products	1,329	64%	24%	57%	17%	5%
Miscellaneous	1,833	73%	29%	62%	20%	5%
Average	**3,676**	**77%**	**42%**	**71%**	**24%**	**6%**

Source: US Department of Commerce 2002.

Table 2. Stages of Processing.

Stage of Processing	Measures
Market Research	Market Research Cost/Sales Revenue
Marketing	Marketing Cost/Sales
E-commerce equipment for marketing & sales	E-commerce costs for marketing & sales
Sales and order taking	Sales revenue/marketing costs & Sales Costs/FTE
Customer information for producer	Order file Delivery time
Production Planning	Value added/Total FTE VA/Machine (cost) Planned changeovers
Production information for customer Material purchases Material in inventory	 Material cost Material inventory Assets employed
E-commerce equipment for purchasing	Cost of e-commerce purchasing equipment
Machine set-up (& machine selection)	Change-over time Number of changeovers
Labor training	Cost of training Overtime
Production	Output per FTE Output per sales or cost
Recycle	Percent of waste
Quality Control Assurance	Defect rate (zero defect goal) Percent of rework
Product Inventory	Inventory turn rate
Scrap	Scrap/waste
Delivery	Delivery time (Just-in-Time)
Service	Returns and rejections
Overhead	Profit Operating margin

Table 3. Cross-industry use of information systems and e-commerce technologies*.

Measure	Trusses/Prefabricator	Doors/Millwork	Large Lumber Company	Small Lumber Company
Cost	$0-$600,000	$700-$750,000	$300,000-$900,000	$100,000
Annual Maintenance	1-4 IT employees	$40,000	3-6 IT employees	0
E-commerce Mode	• Online ordering • Delivery notification • Customer order tracking • Website	• Electronic data interchange ordering • Automated product scheduling, plan download, scheduling, coordinated shipping, inventory management. • Vendor managed ordering • Delivery notification • Website for PR and product catalog	• Basic improvements related to upgraded milling equipment • Vendor managed ordering • Website for PR and product catalog	• Basic improvements related to upgraded milling equipment • Bar coded lumber • Evaluate defect rates • Purchase office equipment • No website
Decision to Adopt E-commerce Technologies	• Required to supply big boxes	• Required to supply big boxes	• Required to supply big boxes	• No e-commerce used • IS used in sawmill equipment
Impact of Adoption or E-commerce Technologies	• Negative reaction or refusal to use from all customers but big box retailers	• Negative reaction or refusal to use from all customers but big box retailers	• Negative reaction or refusal to use from all customers but big box retailers	NA
Decision to Adopt Information Systems	• Desire to improve efficiency, production speed, and lower costs	• Desire to improve efficiency, production speed, and lower costs	• Required with improved sawing equipment	• Required with improved sawing equipment

Table 3 continued on next page

Table 3. continued from previous page

Measure	Trusses/Prefabricator	Doors/Millwork	Large Lumber Company	Small Lumber Company
Production Impacts Related to Adopting Information Systems	• Increase in productivity • Employee setup time reduced by 50% • Improved ability to analyze profit margins. • Profit margins rapidly improved. • Improved customer satisfaction	• 50% production decline but no impact on revenue • Eliminated $1,000-10,000 in daily billing errors • Eliminated 9 sales staff • Reduced overtime wages by 5-10% • Rework rate on components eliminated • Faster and more efficient delivery time • Improved understanding of mill operations • Improved inventory control & lower in-house inventory • Improved customer satisfaction • Better plant integration • Up to date inventory and shipping info • Better analysis of customer preference, buying history • Automatic report generation • Information from central system directly transmitted to production	• Doubled production with half the staff in two years. • Improved understanding of inventory • Capacity increased 15-50% in 7 yrs (may not be all e- Related). • Improved plant integration • More vendor management • Lower inventories • Improved ability to analyze product mix • Automatic report generation • Information from central system directly transmitted to production line • Delivery timeliness • Improved customer satisfaction • Reduced invoicing staff by half • Production speed and volume sales have increased • Order and shipment errors has declined.	• Improved quality control • Improved inventory accuracy
Future Plans for E-commerce	• Starting to track rejection rates • Deliveries – paperwork exchange is faster and they have electronic schedules	• Already a significant user	• The lack of immediate feedback of e-commerce is a negative. • Belief that e-technology lends itself to forest products. • Future plans will only include IS to improve production capabilities.	• Little interest

* results from all interview respondents in each sector are shown in aggregate.

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APPENDIX A. MANUFACTURERS' SURVEY

Please indicate which of the following e-technologies your plant has tried.

Technology:	Year First Used		Adopted		Not Adopted
	Email	**Internet**	**Email**	**Internet**	
E-mail and or internet use:					
communication			□	□	□
general advertising			□	□	□
offering products for sale			□	□	□
receiving product inquiries			□	□	□
taking orders			□	□	□
searching for items to purchase			□	□	□
purchasing			□	□	□
shipment & delivery notification			□	□	□
employee training			□	□	□
	Year First Used		**Document communication via:**		
			EDI/ Email	**Internet**	**Not Adopted**
Electronic processing:			□	□	□
Sales order tracking			□	□	□
Order Acknowledgement			□	□	□
Know where inventory is located			□	□	□
Know what is already purchased and what is available for sale			□	□	□
Status of purchase			□	□	□
Assemble bills of materials			□	□	□
Manage truck load allocations for delivery			□	□	□
Automate Purchase Orders for electronic transfer			□	□	□
Electronic invoicing			□	□	□
Automated purchased inventory tracking			□	□	□
Automated inventory reorder			□	□	□
Automated product inventory tracking			□	□	□
Tracking defects			□	□	□
Tracking waste and or recycling			□	□	□
Tracking customer return rates			□	□	□
Automated bill paying			□	□	□
Quality control			□	□	□
Other (please specify			□	□	□

What were your plant's specific goals for adopting e-technologies?

Have these goals been achieved? Why or why not? In what specific areas have these goals been achieved and where have e-technologies failed to deliver desired results?

Some businesses choose not to use e-commerce methods in all of their stages of processing and service for a variety of reasons. Can you identify segments where you have not adopted e-technologies and explain why you have not?

Does your firm plan on adding any new e-commerce technologies in the next year? If so, what technologies?

What were your firm's initial start up expenditures on e-commerce or information automation technologies? $_____

In what year were these technologies implemented/installed? _____

What were your annual expenditures on the maintenance of these e-commerce technologies?

In 2000 $ _____
In 2001 $ _____
In 2002 $ _____

Do you contract an outside firm to manage your plant's e-technologies? □ Yes □ No

How many full time equivalent employees (FTE) do you have on staff to manage e-technology?____

How do you evaluate which service provider to select for managing your e-technology implementation and management?

- □ Provider's longevity/staying power
- □ Knowledge provider has of my business
- □ How the provider's e-technology will help my business
- □ Other: _____
- □ How much the technology costs

MARKETING AND MARKET RESEARCH

What were your annual **marketing & market research** expenses in 2001/2002? _____

What was your firm's full time employee time spent on **marketing & market research** in 2001/2002? _____

If your firm uses e-technologies for marketing:

What percent (estimated) of your **marketing & market research activities** are conducted via the Internet? _____%

Have your market research and/or marketing expenses changed as a result of introducing e-technologies? If so, by how much (%)? _____%

Has the amount of employee time spent on market research and/or marketing changed as a result of introducing e-technologies? If so, by how much (FTE)? _____%

How do you measure if e-technologies have improved market research and/or marketing functions?

_____

_____

SALES & ORDER TAKING

What is your firm's FTE time spent on sales? _____

What is the average salary and bonus cost per sales staff person? $ _____

What is your firm's average time spent per purchase order? _____

How are your purchase orders entered, reviewed and approved between parties?

_____

_____

Do you use e-technologies to customize production to fit a customer's preferences? If so, how?

_____

_____

Do you measure if e-technologies have improved product customization and/or customer satisfaction? If so, how?

_____

_____

Has customer satisfaction changed due to the adoption of e-technologies in the following areas?

	Large Decrease		Large Increase
Price	1	2	3
Quality	1	2	3
Product Performance	1	2	3
Delivery time	1	2	3
Service	1	2	3
Customer Relations	1	2	3
Other _____	1	2	3

Has the number customer rejections due to the following reasons declined since adopting e-technologies?

	Large Decrease		Large Increase
Quality Problems	1	2	3
Late Delivery	1	2	3
Incorrect Item Received	1	2	3
Prices	1	2	3
Lead-Time	1	2	3
Other _____	1	2	3

What is the percentage of on-time deliveries of your total deliveries? _____%

Has the use of e-technologies increased the rate of on time deliveries? □ Yes □ No
If so, by how much (%)? _____%

What are your sales distribution channels?

Sales Channel	Percent of Total Sales	Percent of sales that are sold via Internet/Intranet	What e-technology do you use to sell to this end-user?
1. Sell Direct To US Home Centers (As opposed to other retailers)	%	%	
2. Sell Direct To US Manufacturers	%	%	
3. Sell Direct To US Building Contractors	%	%	
4. Sell Direct To Other US Retail Outlet	%	%	
5 Sell To US Stocking Wholesaler Or Distributor	%	%	
6. Sell To US Non-Stocking Wholesaler Or Distributor	%	%	
7. Sell To Foreign Customers	%	%	
8. Other (please specify)	%	%	
	Total = 100%	Total = 100%	

How has the use of e-technologies affected your distribution sales channels?

_____

_____

How does your plant determine if the adoption of e-technologies have improved sales and delivery of your products?

_____

_____

DESIGN & PRODUCTION PLANNING

Has your plant incorporated e-technologies into the production process? □ Yes □ No
If so, in what ways?

_____

_____

What is your plant's average capacity utilization rate? _____%

Has the adoption of e-technologies helped increase your plant's capacity utilization rate?
If so, by how much? _____%

How do you measure if e-technologies have improved production rates?

_____

_____

How have you measured if e-technologies have been beneficial to the design and production process?

Do you plan on adding e-technologies to your design and production process? If so, what technologies will you add?

If so, what is your time frame for adding these technologies?

Do you have a method for tracking the progress of a product from the beginning of manufacturing to product completion? If so, what is it?

	Disagree		Agree
There are opportunities for more continuous flow or automation.	1	2	3

If so, what are they?

Do you have a method for monitoring and identifying points in the production process where there are product imperfections? (bar code system etc.) If so, what is it?

RAW MATERIAL PROCUREMENT

How has the adoption of e-technologies changed the way you purchase supplies?

Ex: Electronic inquiries
Product screening
Electronic tracking of purchases

How do you locate/procure the raw materials your plant purchases? Check all that apply.

Source	Percent of Volume Used
B2B Internet Auction Site (forestexpress.com, etc.)	%
Broker	%
Wholesaler	%
Self-supply (own forest lands)	%
Contract Forest Lands (DNR)	%
Other (please specify) _____	%
	Total = 100%

How does your plant source the following wood raw materials? (check one)

	Internally Supplied	Purchased	Volume Purchased 2001	Expenditures 2001	Sales Revenue 2001/2002
Timber	□	□			
Logs	□	□			
Cants/flitches	□	□			
Lumber	□	□			
Veneer	□	□			
Panels	□	□			
Moulding & Millwork	□	□			
Other (specify):	□	□			
Total					

Has utilizing e-technologies to procure raw materials reduced or increased the time spent on locating raw materials?
If so, by how much? _____%

Do you plan on adding e-technologies to your plant's raw material procuring functions? If so, what technologies will you add?

_____

_____

How have you measured if e-technologies have been beneficial to procuring raw materials? If they have or have not been beneficial, please explain why.

_____

_____

INVENTORY

What is your firm's average turn rate (i.e. production value divided by purchased inventory)?____%

What was the volume of products produced in 2000? _____

What was the volume of products produced in 2001? _____

What was the volume of products produced in 2002? _____

What was the total dollar value of sales from your plant in 2000? 2001? 2002? Sales means F.O.B. (freight on board) at the plant.

2000: $_____ 2001: $_____ 2002: $_____

Has the adoption of e-technologies changed the way you manage inventory? If so, how?

_____

_____

Do you plan on adding e-technologies to your plant's inventory control process? If so, what technologies will you add?

_____

_____

Has e-technology reduced the number of inventory buildups or bottlenecks in the production process? If so, to what degree?

Minimal Impact Great Impact
1 2 3

How have you measured if e-technologies have been beneficial in managing inventories? If they have or have not been beneficial, please explain why. Do you measure the deals per person-day, cost per material unit, level of service and time spent ?

_____

_____

LABOR TRAINING

Have e-technologies affected the amount of time spent on training?
If so, by how much _____% increase
_____ % decrease

Do you plan on adding e-technologies to the labor training processes? If so, what technologies will you add?

_____

_____

What measures does your plant use to determine if adoption of e-technologies has improved the labor training process?

_____

_____

QUALITY CONTROL & MANAGEMENT

Do you have e-technologies in place to address quality control? If so, what are they?

_____

_____

How has the adoption of e-technologies changed the way you manage quality control?

_____

_____

Has there been a decline in defect rates following adoption of e-technologies?

_____% defect rate before adoption
_____ % defect rate after adoption

What is the percentage of finished goods rejected at the final production quality check? _____%

What is your rework rate as a percentage of total manufacturing costs or annual sales? _____%

What is your scrap rate as a percentage of total manufacturing costs or annual sales? _____%

What are your priority areas for improvement?	Low Priority				High Priority
Quality Assurance	1	2	3	4	5
Marketing / Sales	1	2	3	4	5
Customer customization	1	2	3	4	5
Scheduling	1	2	3	4	5
Cost Accounting	1	2	3	4	5
Manufacturing	1	2	3	4	5
Maintenance	1	2	3	4	5
Inventory Control	1	2	3	4	5
Worker Skills / Training	1	2	3	4	5
Flexibility	1	2	3	4	5
Document Control	1	2	3	4	5
Safety	1	2	3	4	5
Other _____	1	2	3	4	5

Do you plan to add new e-technologies to your quality control process? If so, what you will add?

_____

_____

How do you measure if e-technologies have improved quality control rates?

_____

_____

DEMOGRAPHICS

How many full-time equivalent employees did your plant have in 2000? _____

How many full-time equivalent employees did your plant have in 2001? _____

How many production shifts run per day? _____