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Technology, Customization, and Time-Based Performance in the Apparel and Sewn Products Industry

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ABSTRACT

This study analyzed levels of technology and customization in relationship to time-based performance measures in 46 U.S. apparel and sewn products firms that produce domestically. Although large firms indicated higher overall technology use, small firms were just as likely as large firms to use a number of pre-production, production, information, and communication technologies and more likely to offer a high percentage of custom products or services. Two time-based performance measures, work-in-process and reorder delivery days, were significantly better for firms with high technology use. Future research is recommended to further investigate the promise of technology, customization, and time-based performance measures in advancing the competitiveness of the apparel and sewn products industry.

Key words: apparel industry, technology management, customization

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Introduction

Technology has been traditionally used in apparel manufacturing to increase efficiencies often by producing higher volumes of products in less time. With the diffusion of information technology and Internet applications for operations management including inventory and replenishment, financial transactions, and communication with vendors and customers, technology is available to enhance every aspect of the apparel manufacturing process. Mass customization, a business strategy that focuses on customizing individual orders using enabling technologies, is of special interest to manufacturing industries as a competitive strategy.

The apparel industry in general and small and medium sized apparel firms specifically have not adopted technology as quickly as firms in other industries. The labor-intensive sewing operation is certainly one reason for slower adoption. Cost, need for technical support, and workers' technical literacy have been identified as other factors in this non-adoption (Schroeder, Gopinath & Congden, 1989). Large firms have been identified as the early adopters of design and production technology such as computer assisted marker making, cutting, grading, and production planning systems (Sullivan & Kang, 2000; Kincade, 1995). Retailers have been described as the drivers of information technology adoption by apparel manufacturers, such as

electronic data interchange (EDI) (Abernathy, Dunlop, Hammond, & Weil, 1995b). Communication technology such as e-mail and the Internet are most likely to be used by management level personnel internally and externally for marketing or sales.

Kilduff (2000) described how new business strategies are being adopted in the textile and apparel industry to address changes in consumer demand for more variety and value, information technology that has increased production efficiency as well as communication with customers at every step, international competition, and retailers shifting inventory burdens to the manufacturing sector. He concludes that "rapid and flexible response to customer requirements and the provision of value-added services" (p.7) require information technology and management system investments for a competitive future for the U.S. apparel industry.

The performance of an apparel manufacturing firm has traditionally been evaluated by financial measures such as sales volume in dollars or pieces or profitability. However, size of firm influences these measures and disadvantages smaller firms. With the increased emphasis on time and flexibility especially with custom offerings, other performance measures (Jang, Dickerson & Hawley, 2002) such as days in inventory, work-in-process, and delivery time may provide valuable performance benchmarks, especially in the evaluation of more individualized products offered in smaller quantities as in mass customization. The purpose of this study was to analyze technology use, custom product or service offerings, and time-based performance of domestically-producing apparel and sewn products manufacturers.

Mass Customization and Technology

Mass customization has been identified as a business strategy dependent on technology that offers the apparel industry great potential for the future. Davis (1987) coined the phrase "mass customization" and Pine (1993) developed the concept more fully to describe a business strategy that achieved "mass production of individually produced goods" (p. 48). He illustrated mass customization strategies by describing companies engaged in it in many industries, including the apparel industry. Duray (1997, 2001) empirically tested some of Pine's tenets and found that customer involvement during the design, production, and delivery processes and the use of modularity in product design did in fact distinguish the levels of mass customization strategies being used by firms in the furniture, fabricated metal products, machinery, electric and electronic equipment, transportation equipment, and instruments industries.

Mass customization strategies require the use of technologies to deliver smaller quantities in shorter times so that the customer can have what they want when they want it (Davis, 1987). Technology use and custom offerings are tied together in mass customization to achieve personalized products and services. In contrast to traditional custom production that often uses manual operations and focuses on one-of-a-kind characteristics at any cost, mass customization uses technology to address customer-demanded characteristics at a comparatively low price. Although mass customization in the apparel and most other industries is still in its infancy, the connections between technology and efficient custom offerings may already be affecting performance variables based on time such as inventory planning, work-in-process, and delivery.

Technology adoption in the apparel industry has been widely studied (Sullivan & Kang, 2000; Kincade & Cassill, 1993; Kincade, 1995) with emphasis on computer-assisted technology (CAD) to provide quick response. Kincade developed a set of quick response technologies that were related to the implementation of quick response management systems based on plant managers' perspectives. Panizzolo (1998) studied technology management from an organizational management perspective and identified human, organizational, and technical elements of technology management. Abernathy, Dunlop, Hammond and Weil (1995a) found that information technology along the supply chain in planning, production, and distribution was crucial for competitive apparel firms in the future. Daly and Bruce (2002) highlighted the

use of e-commerce in apparel firms using case studies. Yet, Rabolt and Stark's (1998) study of the San Francisco area apparel industry found little internal and external use of information technology among contractors and manufacturers, suggesting unrealized potential for technology use in small firms.

By adapting the sets of questions and scales used by Panizzolo, Kincade (1993), and Kincade and Cassill (1995) on technology management and by Duray on mass customization, the following research questions were addressed:

- What are the relationships between technology use and custom offerings in domestic-producing apparel and sewn products firms?
- Can time-based performance measures differentiate firms based on technology use and level of custom offerings?

Sample Selection

Over fifty apparel and sewn products manufacturing firms were identified for progressive use of technology, custom product or service offerings, and some domestic production by industry experts serving on the Sewn Products Resource Council of the American Apparel and Footwear Association (AAFA) and from our personal contacts. The purposive sample was developed to compare apparel and sewn products manufacturers with production facilities across the country, including the Northeast, Southeast, Midwest, and West. Firms in 18 states were represented; 22 New York State firms were included in the sample to allow for a comparison with firms in other geographical locations. The firms ranged in size from six employees to 20,000 in order to evaluate the effects of size on technology use, custom offerings, and domestic production. An executive level person from each firm was personally contacted by phone to request participation in the study.

Forty-nine firms agreed to participate and 46 completed interviews were analyzed. The preliminary interview was used to confirm that the firm used computer-assisted technology in design, production planning, or process planning; offered some custom products or services; and produced some products domestically. Baseline information about each firm and contact information for three to five company respondents for the main interview were collected from the initial contact. Multiple respondents from each firm were chosen to match their expertise to the questions posed. These included:

- A senior manager with knowledge of the company's vision,
- A production or plant manager with knowledge of the technology, customized offerings, and production processes, and
- One to three production employees who used a computerized pattern making, process planning system, or production planning system every day.

Methods

Four questionnaires were developed to use in the telephone interviews based on a variety of apparel industry studies, both reports of surveys of technology use and mass customization and three case studies of apparel and sewn products firms conducted as a preliminary part of our research (Loker, 2002). A list of 21 technologies used in the apparel and sewn products industries was developed based on other studies (Kincade & Cassill, 1993; Kincade, 1995, Duray, 1997; Panizzolo, 1998). Production, computer assisted design and manufacturing (CAD-CAM), and information technologies were included. The use of the Internet was addressed separately. Duray's (1997) survey instruments on levels of customization, customer involvement, and modularity were adapted to evaluate apparel and sewn products and services. Questions describing firm characteristics, basic performance measurements such as sales volume and inventory, and performance measures related to time such as work-in-process and delivery times were also included.

The questionnaires were evaluated by four industry experts for content and revised. Pilot interviews were conducted with a senior manager, production manager, and technology user employed by a single apparel firm not included in the final sample. Each employee responded to the questions and also indicated when clarification would be helpful to avoid

confusion or inaccurate responses. Their recommendations were incorporated into the final interview instrument.

The campus Computer Assisted Survey Research Team (CAST) conducted the phone interviews between May and September 2000. The total average length of the three to five interviews for each firm was one hour. Standard statistical methods were used to analyze the data including descriptive statistics, correlations, partial correlations, t-tests, chi square tests, and ANOVA.

Description of the Sample Firms

Personnel from 46 firms completed the pre screen and three interview schedules and the firms are described in Table 1. Eighteen states were represented with 21 firms from New York State, eight others in the Northeast, three in the Southeast, five in the Midwest, and nine in the West. Ten firms employed 5-50, six firms employed 51-100, and ten firms 101-300. Eight firms employed between 550-1100, ten firms from 1700-9700, and two firms employed over 17,000. Twelve firms offered exclusively custom products and services, 13 offered 25-99% custom and 21 offered 0-25% custom. Custom products included men's suits, jeans, school uniforms, boat covers, and embroidered shirts and caps. About half of the sample, 23 firms, rated their level of emphasis on domestic production to be a great deal (5 on a 5-point scale) while five indicated a rating of 4, eight a neutral rating of 3, four a rating of 2 and five a rating of 1 (no emphasis).

Table 1. Description of Sample Firms

- 46 firms
- 18 states
- 22 firms in New York
- 5-20,000 employees, mean=245
- 0-21 production plants owned in U.S., mean=3
- 0-100% of total production in US owned factories
- 13 firms produced 100% in own U.S. factories
- 17 firms contracted no production,
- 2 firms contracted all production to U.S. firms
- 66% of total production in U.S. on average
- 68% made to order [not for stock] on average

Products

- 33 men's wear, 34 women's wear, 18 children's, 5 other products
- 50% produced tops, 54% bottoms
- 46% produced outerwear, 15% underwear, 15% suits, 76% other sewn products
- 91% sold own brand, 63% sold for private labels

Results and Discussion

Performance

Based on 38 responses from firm senior managers, annual sales volume in dollars ranged from $40,000 to $500 million with a mean of $88 million and a median of $16 million. Based on 36 firm responses, annual production volume in pieces ranged from 600 to 120 million pieces with a mean of 11 million pieces and a median of 900,000 pieces. These standard performance variables were significantly correlated to size of firm based on employees, i.e., the larger firms had higher sales and production volumes.

However, time-based performance measures (one, four-item scale for inventory and throughput times and a second, four-item scale for delivery times) were not significantly related to size of firm in this sample based on t-tests. Time-based performance variables might be more relevant measures than sales and production volumes of the successful integration of technology use and custom product and service offerings in all sizes of apparel and sewn products firms. In addition, these responses were from domestic factory managers rather than senior managers and represented single plant productivity measures rather than averages across the entire companies' domestic and off-shore production. Figures 1 and 2 display the mean days of inventory, throughput, and delivery for the 29-36 firms responding to these questions.

The mean days firms kept material in inventory was 65 and finished goods were kept an average of 47 days. Throughput times averaged 18 days and work-in-process 19 days. Mean days of delivery ranged from a preseason average of 60 days to 28 average delivery days for reorders, 26 delivery days for custom orders, and 12 days for expedited orders. Note the wide range of responses on all items (e.g., 9-60; 0-240), reflecting the variation in type of customization and services offered.

Figure 1. Mean Days of Inventory and Throughput

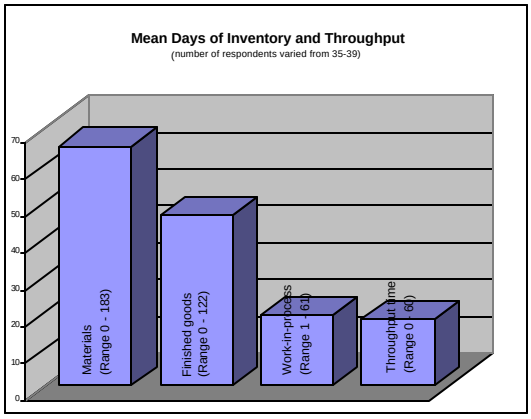
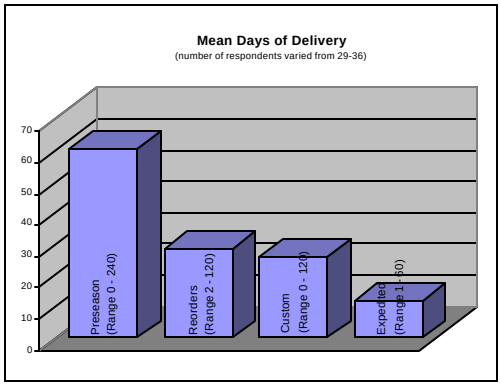


Figure 2. Mean Days of Delivery



*zero (0) means less than one day

Technology Management

Plant managers rated their use of 21 CAD, production, information, and communication technologies on a five-point scale, 1=not at all, 3=for about half of the orders, and 5=for all of the orders. A technology index was created with 19 technologies, an additive scale that measured the total technology use of each firm. Using Cronbach's alpha, a reliability coefficient of .88 was achieved by dropping two technologies, knowledge-based system and group technology due to low response rates. Then two analyses were conducted to evaluate the relationships among technologies—t-tests and correlations. Table 2 lists the 21 technologies with the mean scores of the sample for the 30-46 firms responding to these questions.

Table 2. Mean Use of Technology related to Firm Size by Number of Employees

Technology	Mean Usage[a]	T-tests: Small=300 or fewer employees Large=500+	Correlations: As Firm Size increases, use of technology significantly increases
Computer Aided Marker Making	3.98	2.28*	
Computer Aided Grading	3.98	2.27*	
Computer Aided Pattern Making	3.76		
Material Requirement Planning	3.69		
Computer Aided Design	3.52		.306*
Customer Tracking	3.50		
Computer Aided Process Planning	3.28		
Bar Coding - SKU level	3.09	3.07*	
Point of Purchase/Sale data	2.81		
Computerized Sewing Equipment	2.72	3.36*	.320*
Bar Coding –order level	2.72	3.58*	
Decision Support Systems	2.68		
Computer Aided Automatic Cutter	2.60	3.61*	.317*
Bar Coding - article level	2.52		
Electronic Data Interchange	2.54	2.09*	
Knowledge-based System	2.27		
Flexible Manufacturing System	2.40	2.41*	
Unit Production System	2.39	3.46*	.409**
Group Technology	2.08		
Computer Aided Single Ply, Automatic Cutter	1.60		
Robotics	1.33		

[a]1=never, 3=for half of the orders, 5=for all orders
p=.05, ** p=.01;
Number of respondents varied from 30 - 46

The means ranged from 3.98 to 1.33 on a five-point scale where 5=use for all order, 3= use for about half of the orders, and 1= use for no orders. The computer-aided (CAD) marker making, grading, and pattern making equipment received the highest mean scores indicating that the sample firms were most likely to use these technologies on most of their orders. Material requirement planning, customer tracking, and computer-aided design, computer-aided process planning, and bar codes at the SKU level were the other technologies receiving means above 3.

Not surprising, the CAD single ply automatic cutter and robotics were used on fewer of the orders by these sample firms, probably a combination of the specialization of these technologies as well as their low industry-wide use.

The technology index scores ranged from 19 (no use of any technology) to 83 (average of 4.4 on 19 technologies) with a mean of 52. The technology index scores, or overall use of technology, were significantly and positively correlated to firm size based on number of employees (r^2=.438*) and sales volume in dollars (r^2=.420*). The technology index was significantly and negatively correlated to use of domestic production and was not significantly correlated to percent of custom product and service offerings. As in previous studies (Sullivan & Kang, 2000; Kincade & Cassill, 1993; Kincade, 1995), larger firms used more technology overall than smaller firms. These firms were more likely to be able to afford to purchase extensive technology. However, even though smaller companies used less technology overall, selective use based on their needs or competitive advantage was clear from the analyses below related to use of individual technologies.

After dividing the sample into two groups based on employees (over and under 500 employees), t-tests were run to determine significant differences between large and small firms on levels of technology use (see Table 1). Large firms were significantly more likely than small firms to have higher levels of use on nine of the 21 technologies. Perhaps more interesting, are the technologies where there were no significant differences. For example, the preproduction technologies of material requirement planning, CAD patternmaking, CAD design, customer tracking, and process planning were rated quite high in use (means ranged from 3.28-3.98) yet were not significantly different based on firm size. This suggests that these technologies were first to be adopted and provided competitive advantage to small and large firms for specialized services and volume production. Use of point-of-purchase (POS) sales data (2.81) was also not significantly different between firm sizes and was used, on average, on less than half of the orders. Technologies that had lower means (1.33-2.68) and non-significant differences between firm sizes indicated a lower overall use of these technologies in the industry. These might be potential competitive advantages but might also be less useful technologies for this industry. Examples included robotics, computer-assisted single ply automatic cutter, and group technology.

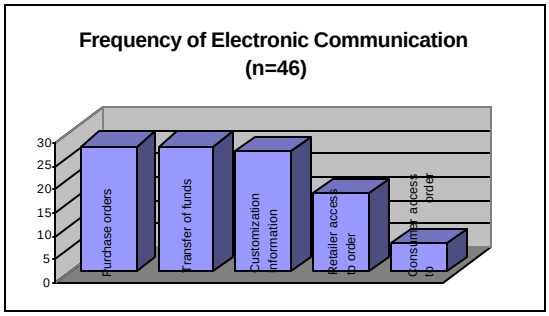
In contrast to the t-tests that tested for significant differences between large and small firms, correlations were run to determine whether when technology use increased, firm size, custom offerings, and emphasis on domestic production also increased. These results indicated only four significant relationships and suggested that smaller firms may be using technology to develop specific competitive advantages. For example, as the firm size increased, computer aided design, computerized sewing equipment, computer aided automatic cutters, and unit production systems also increased in use. These technologies are typically used in mass production operations where technology investment enhances economies of scale and, therefore, as firm sizes increased, technology use also increased. Non-significant correlations between technology use and firm size, on the other hand, suggested that technologies such as CAD pattern making and design, material requirement planning and customer tracking, and computer-aided process planning may be adopted to differentiate the firm's offerings for competitiveness even within smaller apparel and sewn products firms.

Significant correlations were found with level of custom offerings and domestic production: 1) as custom offerings decreased, the use of computer aided marker making and grading significantly increased and, 2) as emphasis on domestic production decreased, the use of bar coding at the SKU, order, and article level as well as electronic data interchange (EDI) increased. These significant correlations were to be expected based on mass production needs for grading and markers that are not necessary for custom production and on communication needs for off-shore production facilitated by bar coding and EDI.

Electronic communication and Internet Use

Questions relating to electronic communication covered both EDI and the Internet. Figure 3 indicates that over half of this sample of apparel and sewn products manufacturers used electronic communication for purchase orders (27), transferring funds (27), and entering customization information (26). Fewer used it for providing retailers (17) or consumers (6) access to their orders.

Figure 3. Frequency of Electronic

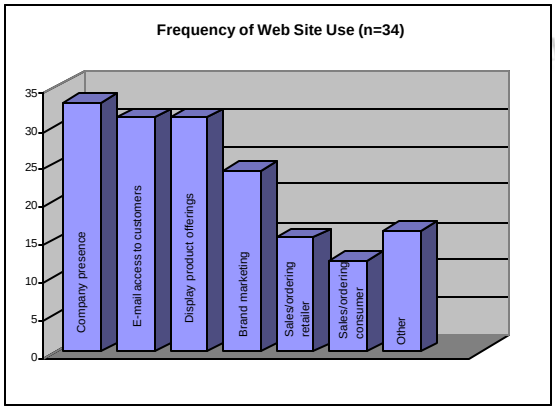


Communication Use

Thirty-four of the 46 companies (75%) hosted web sites, predominantly for establishing a company presence (33), e-mail access to customers (31), and to display product offerings (31) (see Figure 4). Using chi-square analyses, we compared those with and without web sites and found that firms most likely to have web sites had significantly

- more employees,
- more employees that used electronically controlled equipment or computers
- less emphasis on domestic production.

Figure 4. Frequency of Web Site Use



Other chi-square analyses found that firms offering 25-100% custom products or services were significantly more likely to display product offerings on their web sites. Of the companies that offered sales and ordering, more small companies (under 300 employees) offered it to consumers and more large (over 500 employees) companies offered it to retailers, but not at significantly different levels. The relatively limited uses made of electronic communication and web sites in this sample of apparel and sewn products manufacturing firms suggests that there is great room for growth and diversification for advantage in communication and transactions using the Internet.

Technology and Performance

We divided the 29 firms responding to all of the technology questions into three groups based on the technology index scores, low=19-46, medium=47-59, and high 60-83, and analyzed differences between groups on time-based performance measures using ANOVA. Two performance measures differentiated the high and low groups at significant levels, days of work-in-process and days for delivery of reorders. Custom days to delivery was tending toward a significant difference (p=.059) between the high and medium groups. The mean days to delivery for custom products was 7.0 for the high technology use group, 36.9 for the medium group, and 24.4 for the low technology group. Further study of the differences technology can play in offering quick delivery of custom products is needed to determine its competitive advantage. Time-based performance measures were also used to compare those firms with and without web sites with significant differences between the groups on work-in-process and throughput. Interestingly, the group means were exactly the same for days for custom delivery and material inventory.

Customized Offerings

Senior managers at each firm were asked to describe the percentage of their company's or division's sales volume in dollars that could be attributed to customized product and service offerings. A broad definition of "custom" was

presented to the respondents asking them to include any options offered exclusively to a customer that would make the order unique, including size, color, fabric, or style features and design, ordering, or delivery services. The level of custom offerings ranged from one to 100%--12 firms (26%) indicated 100% customized product or service offerings, 13 firms (28%) indicated 26-90%, 21 firms (46%) indicated 25% or less custom offerings, and ten firms (22%) indicated five percent or less custom offerings.

Senior managers described custom product offerings such as options in sizing, fabrics, colors, and styles (see Table 3). Custom service offerings included design, embroidery and screen printing, forecasting, and delivery options (i.e., direct drop ship to customer, overnight, pick and pack, expedited, and automatic replenishment.

Table 3. Frequency of Product and Service Customization (n=46)

Products		Services	
Style Options	30	Delivery Options	13
Fabric Options	29	Replenishment	14
Size Options	20	Screen Printing	4
Exclusives/Custom/ Made-to-Measure/Full Package/Private Label	9	Demand Planning/Forecasting	3
Embroidery	7	Embroidery	4
Color Options	3	Design Services/Full Package	3
Odd Sizes	3	Dropship to Customer	2
Length	2	Small Lot/Singles	2
Screen Printing	2	Special Packaging/Bar codes	2
		Pick & Pack Orders	1

Customization described by firms in this study was not all mass customization, but rather formed a continuum from mass produced to mass customized to less technology-dependent custom products. Producers interacted with business customers or consumers at the time of the order to address specific customer needs. Plant managers answered questions about custom manufacturing strategies. When asked to which customers they sold the highest percentage of custom offerings, 29 (63%) responded "to retailers," 10 (22%) responded "to wholesalers," three (6.5%) "to consumers," three (6.5%) "to business and corporate accounts," and one (2%) "to other customers." Of the twelve firms that indicated 100% custom offerings, three were contractors producing exclusively for retailers or wholesalers and five produced custom products for consumers either directly or through retail partners, using varying levels of enabling technologies. We knew that most apparel firms were not fully engaged in mass customization, but we were interested in the ways customization was being introduced—as the only offering or totally custom operations, as a special offering in addition to a mass production operation, or as an incremental step

toward mass customization based on current mass production operations.

Firms were divided into two groups by percent custom offerings, high (25-100% custom, n=27) and low (1-20%,n=19). Table 4 presents the cross-tab findings by product types. Small firms were significantly more likely to produce higher levels of custom products and services than large firms. This finding highlights the potential of mass customization strategies, and requisite enabling technologies, for both small and large firms. The level of technology adoption may not be as important as the strategic selection of technology for market niche.

Using chi-square analyses, we found no significant differences between level of custom offerings by product classifications. Men's wear, women's wear, and children's wear manufacturers were equally likely to produce low or high levels of custom products, though noticeably fewer children's wear manufacturers did. This suggests that production approaches that integrate custom offerings into mass production or produce a majority of custom goods hold potential within any product classifications.

Table 4. Description of Firms by Custom Levels

	0-20% Custom (n=18)	25-100% Custom (n=28)	Chi-Square
# Employees			3.74*
1-300	7	19	
500+	11	9	
Men's wear			.47
Yes	14	19	
No	4	9	
Women's wear			3.44
Yes	16	18	
No	2	10	
Children's wear			1.47
Yes	9	9	
No	9	19	

There were few differences found between these high and low custom groups beyond the firm size effect (X^2=3.74*). Firms with high and low custom offerings were not significantly different in sales volume, emphasis on domestic production, overall technology use based on the technology index, or time-based performance measures. Three individual technologies did indicate a significantly more likely use of computer assisted grading (t=3.98**), marker making (t=4.40**), and automatic cutter (t=2.15*) by firms with low levels of custom. This was expected as these technologies were developed for use with volume production. Companies with larger custom offerings were significantly more likely (at the .08 level) to provide after-sales services (t=2.00, p=.08), indicating a competitive strategies that complements a customization niche. Companies with higher percentage of custom offerings were significantly more likely than others to process both large and small orders together (t=2.09*). This might be a result of the large number of sample firms that served business customers and presumably customized large orders as well as small.

The plant managers described their firm's use level of customization strategies on a five-

point scale, 1=strongly disagree and 5= strongly agree. The questions addressed mass customization strategies such as using customer specification or offering product feature options, small lot and repeat order accommodation, modularity, delivery options, and use of point-of-sale for forecasting and replenishment programs. The responses to the 17 questions were added to form a custom index with possible scores from 17-85 and a reliability coefficient of .75. Only 29 companies responded to all 17 questions and could be used in this analysis. Firm scores ranged from 37 to 77. There were no significant relationships found between the custom index and

- sales volume
- firm size based on number of employees
- emphasis on domestic production
- per cent of customized products or services offered.

When the custom index scores were analyzed for significant differences based on time-based performance measures, there were no significant differences between high (37-56) and low groups (58-77) on the custom index for mean days of material inventory, finished goods inventory, work-in process, throughput, and preseason, reorders, custom, and expedited delivery.

Implications

The purpose of this study was to analyze technology use, custom product or service offerings, and time-based performance of domestically-producing apparel and sewn products manufacturers. Since complete implementation of mass customization strategies in the apparel and sewn products industry were rare, a broad definition of customization was used to identify 46 firms offering custom products and services either as the major offering or as a complement to offerings being mass produced. The small and non-random sample, mix of technology-driven customization and more labor-intensive customization, and broad range of product categories were major limitations of the study. These data and analyses provide a snapshot view of technology and customization in the apparel and sewn products industry that became quickly dated due to the fast-changing business environment of the early 2000's. Yet the patterns found in the results did provide some useful directions for industry and research.

The use of pre-production, production, information, and communication technology in the industry was limited to portions of firm operations. Although large firms had higher overall technology use scores, small firms were just as likely as large firms to use some technologies, particularly pre-production customer tracking, and process planning. Small firms were also significantly more likely to produce a high percentage of custom products or services. Production was exclusively custom for some, often smaller firms, while other firms combined mass and custom production for their business strategy. Custom offerings were for both business and consumer customers. These results indicate the potential for technology-based and customization-based competitive advantage in all sizes of firms.

Even with a small sample size, several time-based performance measures were found to be significantly better for firms with high technology use but not for firms with a high percentage of custom offerings. Days for work-in-process and delivery days for reorders differentiated high and low technology use groups but not medium use companies. Firms with web sites had significantly lower days of work-in-process and throughput than firms without sites. There were no significant differences on time-based performance measures between firms with two levels of custom offerings. These results suggest that time-based performance measures are promising evaluation tools for internal and external business strategies. The relationship between standard performance measures, such as sales and production volume, and time-based performance measures also deserves study.

Several future research possibilities can be proposed as a result of this study:

- Analyze the particular competitive niches of a sample of *small* apparel and sewn products firms that have high technology use and customization to clarify the relationships among technology, custom offerings, and

performance, both volume and time-based.

- For a larger sample of apparel and sewn products firms, compare levels of custom offerings and custom strategies with use levels of CAD pattern making, design, product planning, and material requirement planning—all technologies in this sample with high use and no significant differences in use level between large and small firms. This analysis may lead to a better understanding of particular customization opportunities and approaches.
- Explore the relationships between dollar-based sales volume and time-based performance measures to develop new strategies to evaluate performance, especially related to overall and selective technology use.
- The use of web sites for business-to-business and business-to-consumer communication and transactions should be considered for small firms, firms with high custom offerings, and domestically-producing firms.
- As more firms adopt mass customization strategies, the competitiveness of these firms should be analyzed based on use of preproduction, production, and information technologies, domestic production, and business and consumer customers.

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