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Change and innovation in Georgia manufacturing: A 10 year perspective

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Small and medium-sized manufacturers in the United States are experiencing increasing challenges in today's global economy. U.S. manufacturing employment declined by nearly 13 percent from 1998 to 2002. More than 2.25 million manufacturing jobs were lost during this time period. Ninety-eight percent of all manufacturers, or approximately 350,000 enterprises are small or mid-sized, having 500 or fewer employees. These enterprises account for over half of the value of U.S. industrial production, and employ about 10 million jobs or two-thirds of all U.S. manufacturing workers. These workers earn in excess of twice the wages of retail workers.

Studying the problems and needs of manufacturers is a logical first step in understanding their economic performance as a function of their business and investment decisions in a resource-constrained environment. Within this broad context, studies in the last decade have focused on investigating technology adoption needs and trends among manufacturers. Information and Communication Technologies (ICTs), Advanced Manufacturing Technologies (AMTs), and 'soft technologies' including industry practices like Just-In-Time, Continuous Improvement Programs, Quality Circles, other Quality systems and standards have been investigated for their adoption and impact on performance. Beaumont and Schroder (1997) note that evidence of positive effects of technology adoption on manufacturing success is "muted at best". However they do find that automated inspection techniques, TQM, LAN and EDI are all associated with positive effects on business. While some earlier studies do not report any strong correlation between investments in ICT and firm profits (Weill, 1990), it might very well be because such investments are associated with an accompanying and more significant change in the way firms operate and can take time to bear effect (Beaumont and Schroder, 1997).

Encouraging manufacturers, especially smaller established firms to focus on innovation is both a major challenge and an important opportunity for policy makers. Porter's (1990) identification of innovation as a key factor in competitive advantage has been highlighted in empirical studies of the extent to which a firms decision to develop and improve products and processes affect its profitability and growth. Innovative firms, that is, firms that invest on new product and process improvement or development are seen to perform better than their counterparts who adopt price-based strategies

(Smallbone, et al 2003; Roper and Hewitt-Dundas, 1998). Research also points to the benefits of a client specific or customization strategy (Christensen et al. 1987). On the other hand, product standardization and mass production enables cost advantages and economies of scale. Schumpeter (1950) suggests that large firms can be more innovative not only because of the natural economies of scale and scope inherent to R&D investments but also due to large firm benefits like superior access to financing and ability to spread risk in diverse portfolios (Holmstrom, 1989). Besides, other supporting functions both to develop and reap the economic benefits of innovation are more developed in the large firms (Cohen, Levin, & Mowery 1987). However, other empirical studies show that the number of innovations per dollar of R&D is inversely related to firm size, and that the contribution of smaller firms to innovations is often understated (Bound et al 1984; Acs & Audretsch, 1988, 1991a; Cohen & Klepper, 1996). Small firms have also been shown to be more efficient in their usage of capital and labor resources in producing innovation (Acs & Audretsch, 1991b). Firms, especially the Small and Medium sized Enterprises (SMEs) are hence faced with a quandary of choices on the right strategy to adopt. Smaller firms with limited resources are also particularly sensitive to short run demand fluctuations and are constrained by local input market conditions. Innovation and technology adoption theories that emphasize the demand side and spatial linkage aspects focus on the role of customers, (Braga and Willmore, 1991; MacPherson, 1992), urban agglomerations and locations where positive industrial information and technological externalities exist (Oakey and O'Farrell, 1992; Rosenfeld, 1992; Tödtling, 1992; Appold and Gant, 1993; Lundvall, 1995; Freel, 2003). These theories are gaining increased attention among policy makers for their implications in viewing the process of innovation from a broader setting, external to firms.

Over the last 10 years, policies and programs have been designed to address constraints to technology adoption and innovation. Among the most commonly cited constraints are the high investments of time, capital and labor associated with technology acquisition and use, lack of scientific and technical information, shortage of skills, training difficulties, organizational problems associated with difficulties in introducing changes, management attitude, worker resistance, institution-related problems associated with tax regimes and government regulations and standards (Baldwin and Lin, 2002).

System-level obstacles including System-level factors such as disorganized inter-firm relationships, inadequate financial resources, regulatory barriers, and deficient standardization magnify enterprise-level challenges to being innovative.

If policies are to address the challenges increasingly facing U.S. manufacturers, information tracking trends, needs, strategies, and performance is needed. This paper describes the methods, findings, and implications of an initiative in the state of Georgia, in the Southeast United States, to strengthen the evidence base for manufacturing improvement policies and programs. The paper highlights results from the recent (2002) Georgia Manufacturing Survey, which focused on measuring adoption trends in product and process development, e-commerce, and organizational methods, as well as relationships between business strategies, technology diffusion, and enterprise performance. Comparisons with earlier 1994, 1996, and 1999 surveys and a discussion of how this survey-based evidence is used in program implementation and policy development are presented. Our findings suggest that while ICT has achieved high penetration among Georgia manufacturers, human resources continue to be an area of concern. Product development is emerging as a leading need. Despite the diminishing returns to investments in cost and process based strategies, a huge proportion of firms still compete on price. We also notice a huge disparity between the top manufacturers and the rest on several operating indicators. While the Georgia Tech assistance programs appear to have achieved some success, we also offer suggestions for its reorientation to focus on emerging innovation needs. While the immediate end-users of the survey are program and policy managers in the state, we will see that the survey is also used for research, evaluation, enterprise benchmarking, and national and international comparisons.

Manufacturing in Georgia

Some 10,000 manufacturers do business in Georgia. Georgia's manufacturing base has traditionally been dominated by three industries: food processing, textiles, and pulp and paper. These three industries account for more 40 percent of manufacturing jobs in the state. In addition, transportation, electrical and electronics, wood products, chemicals, printing, plastics, and metals and machinery comprise much of the rest of the state's manufacturing employment. Georgia's manufacturing industries added employment in the 1990s. From 1993 to 1997, the net increase in manufacturing employment was more than 36,000. But by 2002, Georgia had lost more than 75,000 manufacturing jobs.

Assistance programs specifically targeted toward manufacturers have long been housed at the Georgia Institute of Technology (Georgia Tech). The national manufacturing extension partnership (MEP) program partners with Georgia Tech's Economic Development Institute (EDI) to deliver services as the Georgia MEP. This arrangement leverages Georgia Tech's long-standing state industrial extension program, which began in 1960 and now operates a 17-office statewide network.

The Georgia Manufacturing Survey: Development and Administration

The Georgia Manufacturing Survey is a set of four statewide cross-sectional surveys conducted in Georgia since 1994 and most recently in 2002.[1] Researchers from EDI and the School of Public Policy at Georgia Tech manage the survey. The survey aimed to identify innovation trends and needs in the manufacturing base, and to measure change in the performance of firms assisted by EDI's manufacturing extension service.[2] The survey was targeted to managers at manufacturing establishments with 10 or more employees in Georgia.[3] To identify these manufacturing facilities, we compiled a list of Georgia establishments from Dun & Bradstreet's Market Place database and EDI's internal activity and reporting system. We then called manufacturers by telephone to update contact information.

Themes addressed in the survey include manufacturers' problems and needs, technology adoption, manufacturing productivity and performance, and usage and results

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[1] Jan Youtie and Philip Shapira, "Manufacturing Needs, Practices and Performance in Georgia: 1994 Georgia Manufacturing Technology Survey," GMEA Evaluation Working Paper E9501, Revised, March 1995; Jan Youtie and Philip Shapira, "Manufacturing Needs, Practices and Performance in Georgia, 1994-1998," GMEA Evaluation Working Paper E9703, May 1997; Jan Youtie et al. , "Manufacturing Needs, Practices and Performance in Georgia, 1999-2001," GaMEP Evaluation Working Paper E9901, December 1999; Jan Youtie, et al., "Manufacturing Needs, Practices and Performance in Georgia, 2002," GaMEP Evaluation Working Paper E200201, December 2002.

[2] EDI's manufacturing extension service – the Georgia Manufacturing Extension Partnership – is an affiliate of the U.S. Manufacturing Extension Partnership (MEP).

[3] An establishment is defined by the U.S. Census Bureau as "a single physical location where business is conducted or where services or industrial operations are performed."

of technical assistance. Many questions are the same or similar across all four surveys. However, each survey had a distinctive emphasis. For example, the 1999 survey focused on diffusion of manufacturing technologies and techniques over time. The 2002 survey emphasized innovation by including a series of questions about product and process development practices and constraints.

Each of the four surveys used mail questionnaires. The 2002 survey is illustrative. The 2002 survey was conducted from April 2002 to October 2002 using four waves of mailings and follow-up. A packet containing a questionnaire, a cover letter from the Director of Georgia Institute of Technology's Economic Development Institute, and a self-addressed, postage-paid envelope was mailed to 4,437 manufacturing establishments. Shortly after the first mailing, about 1,000 survey packets were distributed at a Georgia Manufacturers Association meeting. This method did not yield any usable responses. A second follow-up mailing consisted only of a letter signed by the Director of the Georgia Department of Technical Education (DTAE). For the third mailing, the full survey packets were mailed; 500 of the packets included a calling card. Finally, a fourth wave of surveying was done with assistance from specialists from EDI and DTAE, who either personally visited or called randomly selected manufacturers. This entire process yielded a total response of 636 surveys, for a final response rate of 15.9%.[4] While this response rate was low, it is comparable to rates currently being achieved in similar mail surveys where response is voluntary. However, there has been a noticeable decline in the willingness of firms to respond to the survey: in 1999 a 13.7% response rate was achieved; in 1996, a 16.2% response rate was achieved; in 1994, the response rate was 28%.

To evaluate the representativeness of the survey responses, we compared the survey responses to statewide establishment data published by the Georgia Department of Labor. We have consistently found that smaller establishments with fewer than 20 employees have been underrepresented in survey returns. Over the years, metalworking, machinery and electronics related firms tend to consistently respond to the survey in

[4] The response rate was calculated by dividing the number of completed survey forms by the total number of manufacturing establishments, in business, in the target population (manufacturers with 10 or more employees).

higher disproportionate numbers to their representation amongst Georgia manufacturers. This may be due to the engineering and technical emphasis associated with Georgia Tech and the type of needs expressed by these industries. To correct for under- and over-representation, we stratified the sample by industry and establishment size and applied expansion weights.[5] The 2000 Georgia Department of Labor database of 5,445 establishments was used to calculate these weights. Some respondents preferred not to answer one or more of the items on the questionnaire. We thus conducted an item response analysis. For many questions, item response rates neared or exceeded 90 percent, but for a few questions, response rates were below 70 percent. Different reasons for item non-response are likely. For example, the 76 percent rate for return on sales may reflect a preference not to disclose this information, whereas the 74 percent rate for hours spent on training may mean that the company did not collect the information.

Another step in the analysis involved verification of the accuracy of responses to certain questions. The project team ran checks on answers to the performance measure questions. For items that fell outside generally accepted ranges (e.g., payroll per employee or average wages of more than $75,000), the team telephoned the respondents to verify and, as necessary, correct, the information on the survey.

Results from these four surveys do not constitute panel data. Name changes and high turnover of manufacturing establishments make it difficult to construct a consistent panel. Nevertheless, the similarities in questions and data frames enable a meta-analysis of findings to be presented. These findings are discussed below. This is followed by a discussion of the use of the survey and its policy and programmatic implications.

Problems and Needs

The extent to which innovation is perceived as a significant problem or need by Georgia manufacturers is likely to be an important factor in the adoption of innovative strategies and practices. We examine this by analyzing responses to the question: "*In which of the following areas does your facility have the most significant problems or*

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[5] See Terance Rephann and Philip Shapira, *Survey of Technology Use in West Virginia Manufacturing*, Morgantown, WV: West Virginia University Regional Research Institute, December 1, 1993, p. 8. Non-respondent surveys were not conducted. However, a few non-respondents told us that they did not understand, use, or feel that the technologies mentioned in the survey were applicable to their business. It is possible that the survey respondents are more advanced in technology use than the non-respondents.

needs?” The results show that traditional concerns about human resource skills have been most common among Georgia manufacturers but that innovation related issues such as product development have been growing in importance.

In 1994 and 1996, the human resource area was the most frequently mentioned problem area. The 2002 survey continued this trend, however, the percentage of manufacturers reporting human resources as a significant problem area declined from 53 percent in 1996 to 39 percent in 1999. Within the human resources area, technical and supervisory skills—problems specifically relevant to modern manufacturing technologies and techniques—were more commonly mentioned than problems with basic skills. Basic skills ranked below many other problem areas. (See Table 1.)

The biggest shift in priorities between 1999 and 2002 surveys involved marketing. More manufacturers have needs in marketing and product development in 2002 than in 1999. Manufacturing process difficulties also ranked high. Concerns about information technology hardware and software took a different trajectory. The percentage of manufacturers with problems or needs in this area rose from 13 percent in 1994 to 27 percent through 1999. Then in the 2002 survey, manufacturing needs in this area declined to 20 percent.

Large manufacturers with 500 or more employees were more likely to report concerns in the human resource areas. Small manufacturers expressed more concern about market development and planning. Medium-sized manufacturers indicated more problems with manufacturing process issues (see Figure 1). The emphasis given to specific problems differed by industry. The food processing and electronics industries were more likely to report problems or needs than were the other industries. Food processors indicated more concern with problems such as technical skills, plant layout, marketing, and environmental concerns such as energy costs and environmental compliance. Compared to other industries, the food processing industry was least likely to have quality assurance problems or needs. The electronics industry was most concerned with manufacturing process issues, technical and management skills, quality assurance, and marketing. The textile/apparel industry had greater marketing needs than needs in any other category. Resource industries cited manufacturing process and plant layout as problem areas. The machinery industry most often mentioned problems with manufacturing process, marketing, and technical skills.

Manufacturing Strategy

Do manufacturers adopt innovation strategies or do they compete on price? The Georgia Manufacturing Survey found that Georgia manufacturers use somewhat standard process-based strategies or low-cost strategies to compete in the market for customer sales. The 1999 survey asked manufacturers to rank six strategies from 1 (highest importance) to 6 (lowest importance): low price, high quality, innovation/new technology, quick delivery, adapting product to customer needs, value-added customer and product services. Nearly half of the manufacturers compete primarily through emphasizing quality. Only 5 percent of Georgia firms report competing primarily through innovation or new technology. Quality and low-cost strategies were more prominent among Georgia manufacturers in 2002 than in 1999. Particularly significant was the increase in the percentage of manufacturers competing on low price, which rose from 19 percent in 1999 to 27 percent in 2002. Fewer companies competed through quick delivery, customer adaptation, value-added service offerings, and innovation or new technology in 2002 than in 1999. (See Figure 2.) Although quality was the top strategy for all size and industry groups, medium-sized companies were most likely to compete on low price. Small and medium-sized companies also were more apt to say that quick delivery or innovation was a primary strategy for them than were establishments with 500 or more employees.

Even though innovative product or process development is not a main strategy for most Georgia firms, the 2002 survey found that more than 60 percent of Georgia manufacturers did some type of product development during the 2000 to 2002 time period. Twenty-two percent developed new-to-the-industry products and 37 percent offered support services that add value to their products. All but 5 percent of the respondents engaged in product development did it in-house. Many of these firms (45 percent) did product development on their own without any industry or customer collaboration. Thirty-seven percent developed their products in collaboration with their customers. And 14 percent of respondents developed their products in cooperation with other companies. Modifications to existing products and development of new-to-the-market products were most likely to be done in-house. Copies of competitor products most often tended to be done in collaboration with customers.

It is generally believed that branch plants are limited in their product development activity. However, we found that the majority of Georgia's branch plants were involved in product development. In fact, product development activities were at a higher percentage of out-of-area branch plants than at Georgia-headquartered and single-facility plants. Three-quarters of all branch plants with out-of-state headquarters conducted some type of product development activity at the plant compared to 56 percent of single-establishment facilities and 56 percent of facilities with Georgia head offices. Higher product development rates for branch plants with out-of-state headquarters persisted even after controlling for industry. Single-establishment electronics firms were the exception; a slightly higher percentage of them (57 percent) developed products than their branch plant counterparts (51 percent). This finding suggests that a portion of the product development and innovations in Georgia manufacturing come from linkages with innovative out-of-state companies.

Manufacturers engaged in product development activities companies faced constraints as well as benefits.

Manufacturing Technologies and Techniques

Many have argued that industrial competitiveness depends not just on innovative new products, but also on the diffusion, effective application, and further incremental improvement of known technologies (Beaumont and Schroder, 1997). We summarize what we've learned about technology adoption based on the results of the four surveys.

ICT, particularly Internet-related technologies, diffused at a much faster rate than other types of design or manufacturing technologies or management practices. It took just one year for Web site use to go from 5 percent to 25 percent penetration in the state, compared with 7 to 12 years for manufacturing technologies such as computer-aided design or computer numerical control. (See Table 2.) High rates of ICT adoption continued to be evident in the 2002 survey; more than 90 percent of manufacturers reported using email, 74 percent had a company Web site, 70 percent had shared databases, and 60 percent used high-speed Internet connections. At the same time, we found that most ICT adoption did not significantly involve e-commerce applications. For example, two-thirds of 2002 survey respondents' Web sites provided information about the company, products, and services, compared with only 26 percent that allow customers to place on-line orders. Only 6 percent of respondents to the 2002 survey got 10 percent or more of their 2001 sales through their Web site.

A further perspective on technology adoption involves an analysis of manufacturer plans compared with actual adoption two years later. We found that for some technologies, manufacturers had difficulties meeting planned usage. Preventive maintenance was exemplary; in 1994, 59 percent of manufacturers reported adopting preventive maintenance practices and 28 percent planned to do so. By 1996, however, the percentage who actually used preventive maintenance practices was not any higher than 1994 levels.

There were differences in technology adoption based on size, industry, and location. Small and medium-sized manufacturers with fewer than 500 employees were less likely than large manufacturers to ICT technologies, CAD, software for production and control, teamwork and continuous improvement/problem-solving teams, ISO 9000/QS-9000 certification, and automated bills of materials via CAD-MRP. However, three technologies showed little difference in usage between small and large manufacturers—rapid prototyping, current or simultaneous engineering, and ISO 14000 certification—in part because their low usage levels. By industry, electronics firms were the most frequent users of modern technologies and business practices. Urban-rural differences were also noted. Shared databases, enterprise resource planning systems, high-speed Internet access, and company Web sites were less common among rural than urban manufacturers. However, e-mail, because it has such a high adoption rate, was almost equally prevalent among rural and urban manufacturers. In some cases, controlling for industry mix made a difference. Electronics firms in rural areas have similar if not higher rates of company Web site and high-speed Internet adoption than in their urban counterparts.

Manufacturing Performance

Traditionally, performance has been better among larger manufacturers than smaller ones. The 1994 Georgia Manufacturing Survey confirmed this for several operating characteristics: percentage of workers using computers, manufacturing lead time, customer reject rates, and training expenditures per employee. Large companies generally had significantly better starting values and better two-year changes in these values than did their smaller counterparts. However, the top 5 percent of facilities in all size categories had similar values on these operating characteristics. This finding suggests that small and medium-sized manufacturers can narrow the operating performance gap with large companies.

In the 1999 survey, discrepancies between the top 10 percent of companies and the rest of the pack were revealed. For example, the top 10 percent of manufacturers have almost all their workers using computers or programmable controllers on a weekly basis, whereas the lowest percent have virtually no computer usage. Likewise, in training, the top 10 have most of their workers exposed to at least 2 years of industrial-related training, whereas the lowest 10 percent have no workers with industrial-related training. In performance measures, the top 10 percent of manufacturers in Georgia had more than three times the sales growth rates of the typical manufacture, more than seven times the employment growth rates, more than four times the rate of increase in average wages, and more than six times the rate of increase in value-added per employee from 1996 to 1998. The worst performing firms had declines in all these measures.

The 2002 survey further explored attributes of the top 10 percent of manufacturers by examining whether manufacturers that rank highly on one measure rank highly in others. We found that few manufacturers ranked in the top 10 percent across all measures. For example, less than 2 percent of survey respondents fell into the top 10 based on their percentage change in sales (a measure of growth), average annual return on sales (a measure of profitability), and change in value-added per employee (a measure of productivity). Another example: only 4 percent of survey respondents are both ISO certified and have export sales of more than 15 percent (which was the top 10 percent of the export sales distribution). This suggests that manufacturers that rank highly on one measure do not necessarily rank highly in others.

The 2002 survey also explored the relationship between various innovation measures and performance indicators. Manufacturers that compete on low price (or quick delivery) had lower average return on sales and paid lower average wages than those competing on innovation. On average, annual wages were $10,000 higher at innovative manufacturing firms and returns on sales were almost a full percentage point higher than at firms competing on low price. Manufacturers with higher values on various innovation measures—new-to-the-industry products, value-added service offerings, and substantial employee use of computers—had significantly higher growth, profitability, and productivity than those not engaged in these practices. Companies with new-to-the-industry products on average had nearly 5 percent higher sales growth, 1.6 percent higher profitability, and more than 30 percent better productivity than those not having developed new-to-the-industry products. Manufacturers that offer value-added services had 2.5 percent higher sales growth, 1.5 percent higher profitability, and nearly 20 percent higher productivity on average. Facilities in which at least 20 percent of employees regularly utilize computers (no less than weekly) had 2.5 percent higher sales growth, nearly 1 percent greater profitability, and nearly 25 percent more productivity.

In addition, product development efforts that include modifications, extension, and copies were positively linked to sales growth and return on sales. Manufacturers submitting patent applications during 1999 to 2001 had significantly higher return on sales as well. Significantly higher return on sales and growth in value-added per employee also accrued to companies that introduced new processes. Firms with Web-based customer/supplier linkages or ordering capabilities had significantly higher returns on sales than those without these capabilities. Significantly higher average return on sales and increased value-added per employee was found in companies with training dollars per employee above median levels, and with more than one employee with a bachelor's or higher degree. On the other hand, export sales were not significantly related to any of the three performance indicators, but had higher mean averages for at least one of these measures.

Use of Assistance Services

In the 2002 survey, 24 percent of the manufacturers responding had received assistance from Georgia Tech. This number is comparable with estimates in the three earlier surveys in which approximately 25 percent of those firms surveyed received Georgia Tech assistance. (See Table 3.)

Facility employment size is a major determinant of using outside assistance. In general, the larger the firm, the more apt it is to use outside assistance sources. Private-sector consulting firms, technical colleges, and federal laboratories are especially more likely to be used by the largest firms with 500 or more employees. Georgia Tech uniquely penetrates medium-sized firms with 50 to 499 employees (although it has fairly substantial penetration of large firms as well). More than 35 percent of medium-sized firms, (or about half of all medium-sized manufacturers that use outside assistance), use Georgia Tech. The biggest challenge is with the smallest companies having 10 to 49 employees because they are least likely to use any outside assistance source.

By industry, Georgia Tech's highest penetration is among electronics firms. Food processors tend to use a combination of Georgia Tech, other universities, and private consultants. Textile/apparel and resource-based industries are least likely to use any outside assistance. By region, a slightly higher percentage of firms in the south used Georgia Tech/EDI assistance than was the case in the north or Atlanta regions. This regional difference reflects the longer and more consistent history that Georgia Tech/EDI has had in the southern part of the state.

Georgia Tech/EDI-assisted firms also used other assistance sources. For example, 35 percent of Georgia Tech/EDI assisted firms also used private-sector assistance sources, such as private consultants, vendors, customers, and industry associations. In the 1999 survey, 51 percent of the firms assisted by Georgia Tech/EDI also used private-sector assistance sources. In the 1996 survey, this figure was 67 percent. These findings demonstrates that manufacturing firms using Georgia Tech/EDI assistance either (1) have needs that have changed in the past two years and can be met by Georgia Tech/EDI alone or (2) that Georgia Tech/EDI has diversified its services offered to the extent that firms no longer are forced to rely on assistance from sources other than Georgia Tech/EDI. In addition, 35 percent of Georgia Tech/EDI-assisted firms also used public or non-profit sources such as the Small Business Development Center/Business Outreach Services, technical institutes, the Georgia Power Company, and federal laboratories or other federal technology programs.

Manufacturers in 2002 reported being most concerned about human resource, manufacturing process, and marketing areas. In a subsequent question, the survey specifically asked about areas manufacturers would like to receive technical assistance. More than half the companies responding to the Georgia Manufacturing Survey 2002 were interested in receiving training or technical assistance. The most frequently mentioned areas of interest were lean manufacturing and marketing, followed by safety and health and set-up reduction/preventive maintenance. Interest in technical assistance was generally below 1999 levels, particularly in human resource, manufacturing process areas such as constraint management or quality, and enterprise resource planning/manufacturing resource planning ERP/MRP software. More manufacturers were interested in product development assistance and, to a lesser extent energy management, in 2002 than in 1999.

Manufacturers are somewhat interested in receiving information about Georgia Tech's services. The survey form asked manufacturers if they would like to receive information about Georgia Tech's services, seminars, and workshops. Twenty-eight percent of the respondents said they would like to receive such information. This is much lower than the 38 percent figure reported in the 1999 survey. Mid-sized manufacturers employing 50 to 499 workers were most apt to request information. Thirty-seven percent of them requested information about Georgia Tech's services compared with less than 24 percent of respondents employing either less than 50 or 500 or more workers. However, when firms are delineated by industry, the percentages asking for information are very similar, ranging from 26 to 29 percent.

Nine out of 10 survey respondents served by Georgia Tech/EDI report benefits from this assistance. Almost half of these manufacturers said that management skills and know-how were improved. The next most frequently mentioned benefits were improved an existing process (39 percent), increased productivity (39 percent), and improved employee skills (37 percent). Some of these benefits were more pervasive in the 2002 survey than in the 1999 survey. A higher percentage of Georgia Tech customers in 2002 reported that they experienced quantitative outcomes such as productivity increases and profitability increases than was reported in 1999. In addition, existing product/service improvement, adoption of new technologies, and greater use of computers were more prevalent benefits among Georgia Tech customers in 2002 than in 1999, even as softer employee-related benefits (e.g., skill improvements, team orientation) were cited less often.

Twenty percent of Georgia Tech customers in the survey provided estimates of returns and investments from Georgia Tech/EDI. Over the survey period, total impacts experienced by Georgia Tech/EDI customers included more than $17 million in increased sales and $4.3 million in cost savings. Nearly 220 new jobs were created, and more than 510 existing jobs were saved.

A few Georgia Tech assisted customers gained substantial benefits. Seven Georgia Tech clients added sales of more than $1 million. One customer reported cost savings of $1 million. Two Georgia Tech customers invested more than $1 million into their projects. Although Georgia Tech-assisted manufacturers report benefits, this does not necessarily prove that the results are attributable to Georgia Tech services. Unassisted firms could also have experienced these same benefits during the 1999-2001 time period. Benefits or lack thereof may have arisen from the general economic conditions of the time rather than the assistance received from Georgia Tech. Georgia Tech-assisted manufacturers may also have been influenced by other companies (for example, vendors and consultants, other manufacturers) or by other public assistance sources (for example, federal laboratories, other state-funded educational or assistance institutions). To account for these influences, we have developed a model to estimate the impact of Georgia Tech project-related extension services on client productivity. Productivity is measured by value added per employee, which is calculated as sales less the cost of materials, parts, services, and other purchased inputs divided by the number of employees. Drawing on Jarmin[6], we examined the growth rate in the standard value-added production function

[6]Ronald S. Jarmin, 1999. "Evaluating the Impact of Manufacturing Extension on Productivity Growth," *Journal of Policy Analysis and Management* 18 (1): 99-119. We employ a similar model which estimates the logged change in value-added per employee as a function of changes in labor and capital (logged), along with control variables

from 1999 to 2001 (logged), as a function of receiving Georgia Tech services. We controlled for an array of facility characteristics, including:

- facility employment growth rate 1999-2001 (logged)
- change in the capital/labor ratio 1999-2001 (logged)
- whether this is the only facility in the company (dummy variable)
- industry classification (dummy variables)
- whether the facility is located in a metropolitan statistical area (dummy variable)
- whether the facility is located in a county with a Georgia Tech extension office (dummy variable)
- whether the survey respondent reported using a private consultant (dummy variable)
- whether the survey respondent reported using a non-Georgia Tech public service
- provider (dummy variable)
- whether the survey respondent reported participating in a cooperative activity with other firms involving product or process development (dummy variable).

This model was estimated using ordinary least squares. Table 4 presents the results. Georgia Tech assistance is positively and significantly linked to productivity growth. Over the study period, Georgia Tech clients experienced a 0.3 percent logged growth rate in value-added per employee over non-clients. This is equivalent to a value-added increase of $353,000 to $443,000 for the average client facility (or $3,000 on a per employee basis), adjusting for what value-added per worker would have been if the company had not been a client.[7] A similar analysis was conducted from 1996 survey data, which yielded virtually the same results--.3 percent logged percent logged growth rate in value-added per employee for Georgia Tech clients over non-clients, or $366,000 to $440,000 for the average client plant.

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representing manufacturing characteristics (e.g., employment size, industry, location, and status as a branch plant).

[7] Ronald S. Jarmin, Memo: Estimated Impact of Manufacturing Extension, February 12, 1997. The range is based on 90 percent confidence intervals.

Conclusions

In this paper, we drew on our experience of over a decade in evaluating the strategies and performance of Georgia SMEs. We found some consistency in the self reported needs of local industry over time, especially in the area of human resources. This has been mostly driven by employers' needs for technical and supervisory skills. Other needs have been more transient. The perception of ICT adoption as a problem area peaked in the year 1999 and is showing a declining trend. Marketing and product development have emerged as the leading concern among Georgia manufacturers in 2002.

While low response rates to our surveys have always been a problem, the declining willingness of firms to respond over time adds to our concern. An important factor driving the declining response rates might be the high turnover among manufacturers. However, given the absence of national census surveys or similar efforts targeted at manufacturing practices, our survey provides a detailed view of the requirements and trends of manufacturers at the state level.

Our analysis of survey results also provides important insights to help explain the growth of manufacturing in Georgia in the 1990's and its subsequent decline in recent years. We speculate that the growth was mainly spurred by the adoption of basic process and information technologies by local manufacturers. This enabled the firms to compete on low cost and price-based strategies. However, the recent economic downturn and the increasing focus on innovation, has contributed to the decline in manufacturing in Georgia. This is evidenced by the emphasis placed by respondents on innovation and product development needs in our latest survey.

Finally, we investigated the impact of Georgia Tech assistance on local manufacturers. We found that medium and larger sized firms benefit the most from Georgia Tech services. Despite the possibility of bias in our results due to selection effects, (whereby firms that have benefited from Georgia Tech services are more likely to have responded to our questionnaire), assistance from Georgia Tech appeared to be a significant predictor of increased productivity measured by manufacturing value added compared with firms not assisted by Georgia Tech. Georgia Tech customers indicated that they benefited from enhancement of management and technical skills.

Policy and Programmatic Implications

Traditionally, Georgia has not been viewed as an innovative, technology-intensive business location. The state's modern transition away from its agrarian roots has been dominated by strategies of industrial attraction: the recruitment of often routine facilities from elsewhere in the U.S. and increasingly from overseas attracted by the state's relatively low costs and good access to markets. Industrial research and development (R&D) spending in Georgia is low, the state ranks in the bottom half of states in patent generation, and federal R&D spending in the state has been traditionally dominated by defense procurement.

Nevertheless, changes are occurring and a growing technology sector has emerged in and around Atlanta. The state has invested in science and technology research, and three research universities, (Georgia Tech and Emory in Atlanta and the University of Georgia in Athens, about 70 miles outside Atlanta) are ranked among the top 50 in total R&D expenditures in the U.S. More public and private technology-based incubator programs and services support an expanding number of start-ups (mostly in the Atlanta area). Efforts to attract venture capital appear to be paying off. The American Electronics Association ranks Georgia among the five fastest growing states in high-tech employment growth. A PricewaterhouseCoopers MoneyTree Survey placed Georgia among the top five states in terms of venture-backed investments. The rising complex of technology-oriented resources and companies in metro Atlanta is remarkable: the city is emerging as an innovative, high technology location. However, Georgia's second-tier cities have fared less well, and rural Georgia is generally left out

The findings from the Georgia Manufacturing Survey confirm these trends. In particular, while a small group of innovative manufacturing enterprises has developed, most manufacturers in the state focus on lean but routine manufacturing strategies. These firms emphasize quality and low prices, but do not emphasize innovations in their products. They do take up process and organizational innovations, but especially for small and mid-sized firms there is a lag in deployment.

These findings lead to policy insights both for policy and for program practice. At the level of state policy, a major new technology infusion thrust would help to bridge the gap between Georgia's strong public- and weak private-sector R&D. Mechanisms to do this include greater use of public-private industrial partnerships, industrial cluster initiatives, incentives for private R&D and product development, and support for technology deployment and modernization strategies. In general, Georgia's efforts here are under-funded relative to their counterparts in states such as Pennsylvania and Ohio.[8] This gap may widen as states begin implementation of tobacco settlement funded technology transfer initiatives.

In terms of implications for program practice, the challenge to get more Georgia companies to be more innovative probably requires that technology transfer professionals spend more time with a concentrated number of companies undertaking strategic and customized projects. Examples of such work would include:

- Providing assistance to help existing companies develop capacity to manufacture tooling and dies or produce subassemblies and final products (in addition to, or instead of, routine components)
- Assisting companies to employ new materials in existing products
- Providing customized engineering assistance
- Helping companies design and produce new proprietary products for identified or emerging markets
- Providing support for efforts to spin out new technology-based companies
- Regional collaboration and network initiatives to strengthen innovation capabilities in local industrial clusters.

Services to address these needs could include more direct provision of product development, marketing, materials and other product-related engineering assistance by Georgia Tech's manufacturing extension professionals. In addition to direct service provision, these efforts could require additional technology transfer professionals or "brokers" knowledgeable about specialized capabilities such as technology design and testing, venture financing, management sources, legal issues, and other capabilities.

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[8] Youtie, Y., Shapira, P., and Mohapatra, S., Technology Infusion: Assessing Current and Best Practice Programs. Report prepared for the Georgia Department of Industry, Trade, and Tourism. Center for Economic Development Services and School of Public Policy, Georgia Institute of Technology, Atlanta, GA., 2000.

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Table 1
Manufacturing Problems and Needs: 2001, 1999, 1996, 1994

	2002	1999	1996	1994	Difference 2001-1999
Human resources problems	44%	39%	53%	44%	5%
Technical skills	27%	25%	31%	n/a	2%
Supervisory, team skills	26%	21%	33%	n/a	5%
Basic skills	11%	13%	16%	n/a	-2%
Market development, exporting	37%	25%	17%	15%	12%
Manufacturing process	34%	29%	27%	37%	5%
Plant layout, expansion	24%	22%	22%	25%	2%
Computer applications	20%	27%	17%	13%	-7%
Computer software/packages	16%	19%	23%	26%	-3%
Computer hardware/systems	10%	16%			-6%
Automation			15%	8%	n/a
Product development, design	19%	13%	13%	12%	6%
Environmental, health & safety	18%	15%	17%	29%	3%
Quality assurance	17%	17%	19%	22%	n/a
General business analysis/finance	16%	11%	12%	12%	5%
Waste management	16%	11%			5%
Energy costs, conservation	15%	10%	13%	16%	5%
Material-related	9%	5%	5%	10%	4%
Financial planning/fundraising	6%	n/a	n/a	n/a	n/a

Source: Georgia Manufacturing Survey 2002, weighted responses of 710 surveys; Georgia Manufacturing Survey 1999, weighted responses of 727 manufacturers; Georgia Manufacturing Survey 1996, weighted responses of 1,002 manufacturers; Georgia Manufacturing Technology Survey 1994, weighted responses of 1,180.

Figure 1
Manufacturing Needs and Problems by Facility Employment Size

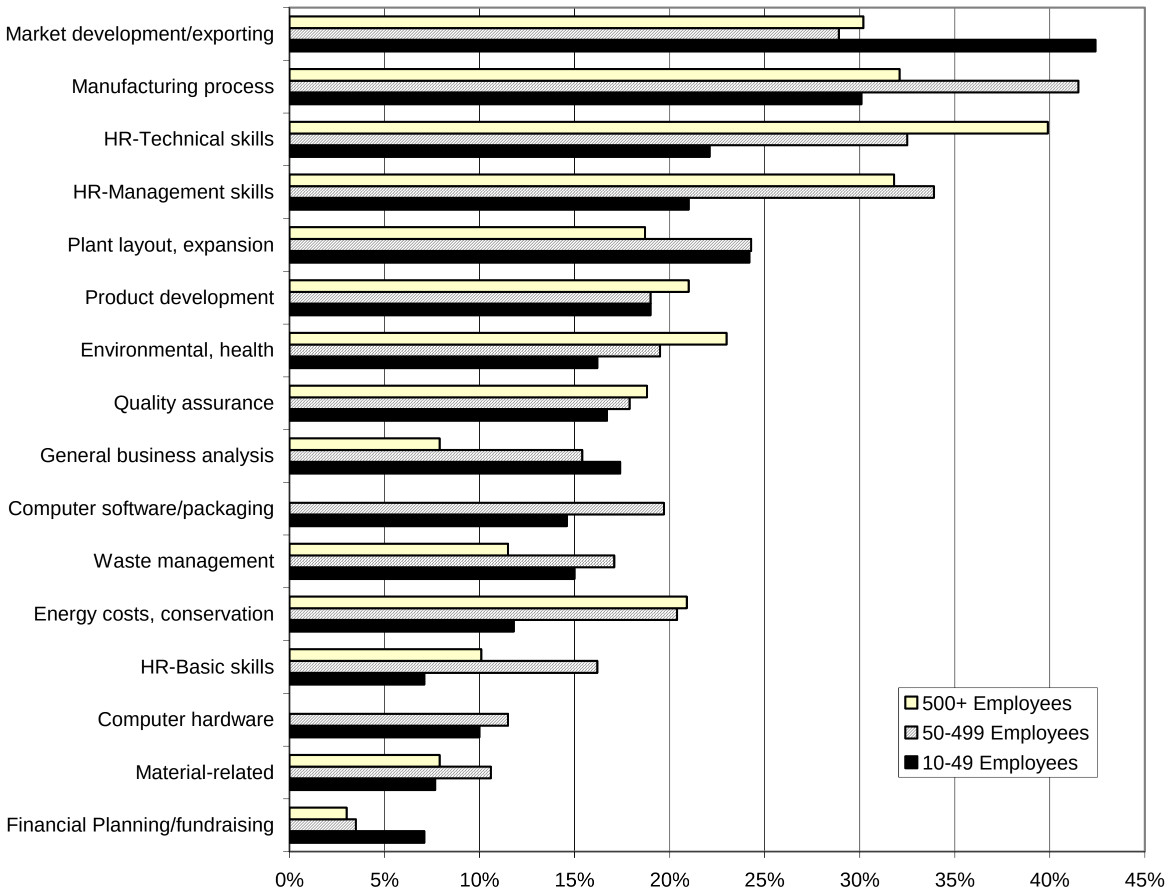

Table 2.
Dissemination of Technologies and Techniques

	% Currently Use Use (1999)	Use 2.5 Years Ago (1996)	Years from 5% to 25% Penetration
Design, Manufacturing			
MRP, ERP	51%	36%	8
CAD	48%	36%	7
CAD-MRP	24%	15%	10
CNC	22%	16%	12
Management Methods			
Teamwork--planning, production	57%	44%	12
Problem solving teams	47%	35%	9
JIT to customers	41%	32%	13
Information Technologies			
E-mail	68%	25%	4
Web site	59%	13%	1
Electronic exchange--CAD data	27%	4%	4

Source: Georgia Manufacturing Survey 2002, weighted responses of 636 manufacturers and Georgia Manufacturing Survey 1999, weighted responses of 727 manufacturers.

Figure 2 Most Important Manufacturing Strategies: 1999 vs. 2002
(Percentage of Respondents Ranking Strategy Highest)

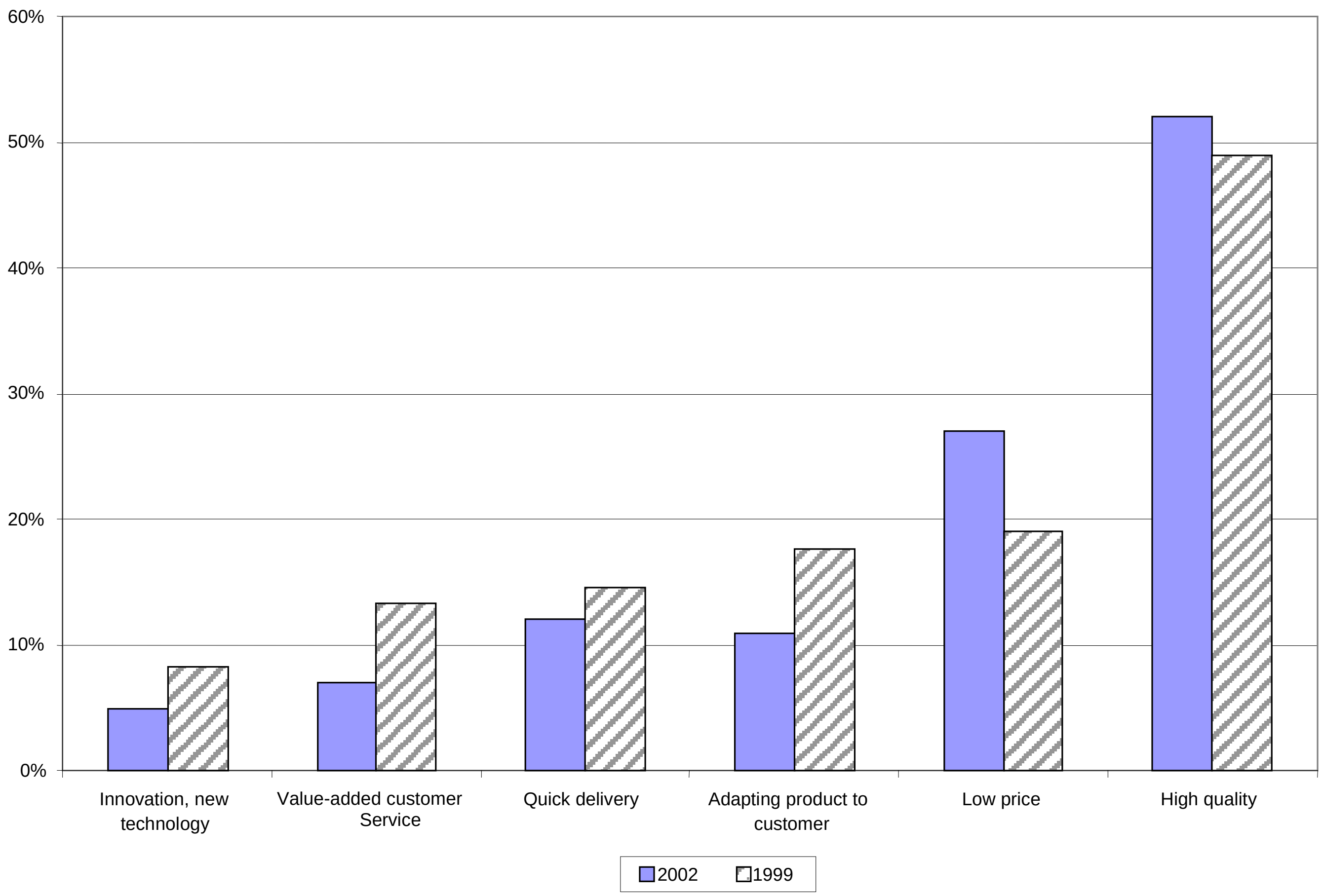

Table 3.
Percentage of Manufacturers Reporting That They Received Assistance from Georgia Tech and Other Assistance Sources: 1994 to 2002

	2002*	1999	1996	1994
Percent unassisted	30.9%	41.0%	40.3%	42.4%
Percent assisted by Georgia Tech	24.2%	27.0%	25.0%	25.3%
Percent public assistance	20.8%	19.0%	37.9%	27.0%
Percent private assistance	24.0%	41.0%	50.7%	47.0%

*53% of respondents did not answer this question in 2002, which limited comparability with previous years.

Table 4: Productivity is Significantly Higher for Georgia Tech Clients Than for Non-clients
Ordinary Least Squares – Value-Added per Employee Growth Rate 1999-2001

Variables	
% Change in labor inputs (employees)	-0.0924 ***
% Change in capital/labor	0.0391 ***
Georgia Tech client	0.0028 *
Located in an urban county	0.0036 **
Located in a county with a Georgia Tech regional office	0.0010
Used a private consultant	0.0012
Used a public service provider	-0.0018
Participates in inter-firm collaboration	-0.0003
The only facility in the company	0.0006
Food	0.0106***
Textile	-0.0009
Resource	0.0059 ***
Machinery	-0.0021
Electronics	0.0044
Constant	0.9998***

R-squared 0.086 ***

N 317

NOTE: The dependent variable is percent change in value-added per employee 1999-2001 logged. All growth rates denote logged values for period. Preliminary analysis, subject to revision.

***Clients vs. Non-Clients: differences significant at less than the 1%; **Clients vs. Non-Clients: differences significant at the 5%; *Clients vs. Non-Clients: differences significant at the 10%

Source: Georgia Manufacturing Survey, weighted responses of 636 manufacturers.