DRAFT: NOT FOR QUOTATION

Innovation in the Pulp and Paper Manufacturing Industry: Insights from the 2005 Georgia Manufacturing Survey

by

Jan Youtie
Philip Shapira
John Slanina
Erin Lamos

Program on Science, Technology and Innovation Policy
Georgia Tech School of Public Policy
Georgia Tech Office of Economic Development and Technology Ventures
Georgia Institute of Technology
Atlanta, GA 30332-0640, USA
E-mail: jan.youtie@edi.gatech.edu

Prepared for the

Sloan Industry Studies Annual Meeting

December 15-16, 2005
Cambridge, Massachusetts USA

Acknowledgements. This paper draws on a study on the Adoption and Impacts of New Technologies and Techniques in the Paper Manufacturer Sector in Georgia, sponsored by the Georgia Tech Center for Paper and Business Industry Studies. Complementary sponsorship for the Georgia Manufacturing Survey was provided by the Georgia Manufacturing Extension Partnership at the Georgia Tech Office of Economic Development and Technology Ventures, the Georgia Tech School of Public Policy, the Georgia Department of Labor, and the QuickStart program of the Georgia Department of Technical and Adult Education. We greatly appreciate and acknowledge the time and consideration of manufacturers in Georgia in providing the information upon which our research is based.

1. Introduction

The ability of U.S. firms to compete in the global economy hinges on their capabilities and strategies to foster innovation in products, processes, services, organization, and other business aspects. This observation applies as much to the pulp and paper industry as to any other sector. Pulp and paper is a sector which is generally considered to be a mature industry. It is resource-intensive, which has led companies in the sector to focus their innovation efforts on such issues as how to minimize waste and byproducts harmful to the environment or how to reduce capital and operational costs to promote efficiency. But there are also important challenges and opportunities in the pulp and paper sector in other complementary areas of innovation, including how to acquire and use knowledge, how to better use new information technologies and upgrade workforce skills, and how to develop new product, process or service innovations that can be differentiated from the competition. This raises the question: what is the orientation towards innovation in the pulp and paper sector? Does innovation concentrate on traditional capital-intensive process technologies, or are there also efforts to develop and adopt innovative techniques and methods in other business areas?

This paper explores innovation in the pulp and paper industry in Georgia. We hypothesize that the pulp and paper industry will be more apt to use traditional business process approaches such as acquisition of capital equipment to engage in innovation and less apt to use knowledge-based approaches, including the development of patents and other forms of intellectual property. Drawing on the 2005 Georgia Manufacturing Survey, our results show that the pulp and paper industry leads other manufacturing sectors in the use of supply chain and business process innovation. However, other knowledge-based innovation methods are less common among pulp and paper firms than other types of manufacturers. Differences by size and

type of pulp and paper firm in use of knowledge-based innovation were not significant. We discuss the policy significance of knowledge-based innovation to the long-term prospects for the pulp and paper industry.

2. Innovation in Manufacturing

Innovation encompasses steps and activities involved in the introduction and deployment of new or improved techniques and methods within and between companies. Innovation has been viewed as the entire process through which knowledge is created and used to develop new or improved goods and services that are disseminated into the market. It contrasts with invention, where ideas are first developed but not yet transformed into practical and marketable use (Fagerberg 2004). The OECD's Oslo Manual distinguishes four types of innovation: (1) product innovation in goods or services that are technologically new products or existing products that are significantly improved; (2) process innovation concerning technologically new or significantly improved practices, technologies, or delivery; (3) organizational innovation involving new or significant changes in firm structure, management methods, or information exchange systems; and (4) marketing innovation of new or significant changes to packaging, sales methods, or distribution channels. These innovations can be supported by technological activities such as research on new products, and through non-technological innovations related to softer areas such as deriving new product concepts, engaging in marketing and customer relationships, monitoring competitors' capabilities, using consultants, purchasing information, buying engineering skills, investing in equipment or software systems, investing in new skills training, reorganizing production systems, and managing product quality. (OECD 1997; Jaramillo, Lugones and Salazar, 2001).

Encouraging manufacturers to focus on innovation is both a major challenge and an important opportunity for policy makers. Schumpeter (1934) argued that innovation was important to firm survival across business cycles. Christensen (1997) showed that the inability of firms to adopt disruptive innovations, even innovations developed within their own corporate family, can cause them to decline. Porter (1990) identified innovation as a key factor in competitive advantage in terms of profitability and growth. The Council on Competitiveness (2004) argues that innovation is of high importance in the national policy arena.

Differences in the adoption of innovation-related practices have been examined by firm size, spatial linkages, and sector. (Shapira and Rehpann 1996; Cohen, Levin, and Mowery 1987; Acs and Audretsch, 1991; Rosenfeld 1992) The findings across these dimensions are mixed with respect to innovation. For example in the case of firm size, several studies find that the patent yield from R&D expenditures is relatively greater for large firms than small firms (Acs and Audretsch, 1991, Bound et al, 1984, and Hausman et al, 1984). However, others have found that small firms, particularly small high tech firms, are more innovative than large firms. Kim, Lee, and Marshkee (2004) found that small firms in the semiconductor industry had higher numbers of patents per inventor than their large firm counterparts. Bardham and Jaffee (2005) found that smaller firms were more apt to conduct R&D in the U.S. and to produce more innovative technologies and ideas than were larger firms.

There are clearly sectoral differences in the characteristics of innovation and the propensity to develop and adopt innovations (OECD, 2000). Pavitt (1984) originally distinguished among four general industrial sectors based on the technological and innovation trajectories they adopted. Supplier dominated firms, in traditional agricultural and textiles industries, were deemed to be most affected by suppliers of machinery, equipment, and other

inputs. Scale intensive firms, found in bulk materials and automotive industries, employed product and process innovations in tandem through incremental changes informed by for example, internal engineering departments. Specialized suppliers were in high tech instruments, and machinery industries that focus on product innovation for use by other sectors. Science-based firms in chemical and pharmaceutical industries employed internal R&D and relationships with academic researchers to develop product innovations and the new processes to develop these products.

The pulp and paper industry has conventionally been considered a supplier-dominated sector (using Pavitt's scheme). As a large-volume, process industry, the pulp and paper industry has typically undertaken innovation through linked industries, including equipment providers, control and information systems manufacturers, chemical suppliers, and energy utilities (Autio, et. al, 1997). The pulp and paper sector adopts or otherwise benefits from these supplier innovations, for example through the acquisition of major capital equipment. There has also been an orientation on innovations that promote energy efficiency and address environmental concerns, including the reduction or remediation of the by-products of paper manufacturing (Estes, Porter, and Kongthon, 2004). However, technological advances, such as in coatings (and even nanotechnology-related research) have suggested that new science-based product innovations for pulp and paper industries are beginning to be more important. (Ragauskas 2005; Teague 2005). Additionally, the greatly increased attention paid to organizational, service, logistical, knowledge management, and other forms of "soft" innovation across business in general (Tushman and Moore, 1988; Stewart, 1997; Wengel and Shapira, 2004) indicates that there are likely to be opportunities in pulp and paper to benefit from non-technological innovation.

Our analysis explores the take-up of these varieties of innovations in pulp and paper and other industry groups in the context of manufacturing in the state of Georgia. Based on our assessment of the literature (as discussed above), we expect to find a relatively higher percentage of pulp and paper manufacturers engaged in introduction of process innovations than in other industries. We conversely expect to find that the rate of other knowledge-based innovations in pulp and paper to be relatively lower than other manufacturing sectors in the state. Within the pulp and paper sector, large firms are anticipated to have higher rates of other knowledge-based innovation than their small firm counterparts. In addition, we expect non-mills to have higher rates of other knowledge-based innovation than mills because non-mills are comprised of firms such as container manufacturers than tend to be closer to the end product.

3. Pulp and Paper Industry in Georgia

The state of Georgia is one of the leading manufacturers of pulp and paper in the United States. Georgia manufacturers account for 10 percent of all pulp and paper shipments in the United States (Estes, Porter, and Kongthon, 2004). According to the Georgia Department of Labor, in 2003 there were approximately 48,000 people in Georgia employed in the pulp and paper industry, which is about 11 percent of the state's total manufacturing employment. Nationally, 7 percent of total manufacturing employment in the United States is in the pulp and paper industry, so Georgia's economy is more specialized in this sector. The U.S. Bureau of Economic Analysis reports that the pulp and paper industry's share of Georgia's Gross State Product (GSP) had fallen from 1.43 percent in 1997 to 1.02 percent in 2003. Compared to the United States as a whole, where the share had fallen from 0.96 percent in 1997 to 0.80 percent in

2003, Georgia's decline is more precipitous. This underlies the imperative to further examine the needs of the state's pulp and paper industry.

Facilities within Georgia's pulp and paper industry perform three distinct activities: the production of pulp, the production of paper, and the manufacturing of converted paper products. Pulp production encompasses separating cellulose fibers from wood or used paper products; paper manufacturing involves matting the cellulose fibers into a sheet; and the manufacturing of converted paper products entails shaping, cutting, and possibly coating paper into specific products.

4. Methods

Our study draws on the 2005 Georgia Manufacturing Survey – a statewide survey conducted every two to three years by Georgia Tech's Office of Economic Development and Technology Ventures and the Georgia Tech School of Public Policy to assess the business and technological conditions of Georgia's manufacturers (Youtie, et. al., 2005). The survey focuses on problems and needs; operational performance; trends in product, process, and organizational innovation; current and planned use of new technology; and the impact and effectiveness of Georgia's manufacturing assistance programs.

In early- to mid-2005, the Georgia Manufacturing Survey sent questionnaires to all manufacturing establishments in Georgia with 10 or more employees. The mailing list originated from data provided by two sources: Dun and Bradstreet's Zapdata business information database and the Fisher International Pulp and Paper database. Overall, 654 surveys were received, which represents 16.3 percent of the manufacturing facilities in Georgia. Of this amount, 32 of the surveys are associated with the pulp and paper industry, which accounts for 22

percent of the firms in our sampling frame. These results were then weighted to reflect industry and employment size breakdowns in the Georgia Department of Labor's ES-202 database.

To better understand the pulp and paper industry, comparisons were made between facilities that differed by employment size and facility type. Manufacturing facilities that have between 10 and 99 employees are labeled as "small" and facilities with 100 or more employees are considered "large." Additionally, comparisons were made between pulp and paper mills and non-mills. "Mills" are facilities that produce either pulp or paper at their facility. "Non-mills" include paper converters, package manufacturers, and other firms that do not actually produce paper products from raw or recycled materials. Facilities were designated as a mill if they were specified as such in the Fisher International Pulp and Paper database.

5. Analysis

We asked manufacturers to tell us whether or not they were engaged in 13 items that measure "innovation-related activities" during the period 2002 to 2004. See Table 1. Pulp and paper firms had higher proportions of respondents engaged in innovation through capital equipment purchases; planning, engineering, and design; training; and working with customers.

[TABLE 1 ABOUT HERE]

It can be interpreted that these items are indicators of underlying dimensions of innovation approaches. We employed principal components analysis in an exploratory manner to understand these underlying dimensions.[1] The total survey participant base of Georgia

[1] Performing factor analysis on dichotomous variables has some drawbacks regarding the assumption of use of interval or ratio data. We employ principal components analysis here rather than maximum likelihood estimates in

manufacturers was used in this analysis. Communalities captured from 26 percent to 66 percent of the variance in each of the items. Three factors, which explain 47 percent of the total variance, were extracted. These factors have been interpreted based on high loadings in the rotated matrix. (See Table 2.) We interpret the first factor as measuring innovation through intellectual property. Items such as purchase or license of patents, inventions, know-how; applied for a patent; and registered a trademark had high loadings on this factor. The second factor can be labeled "innovation through the supply chain". The items that loaded highest on this factor were work with customers to create or design a product, process or other innovation; and work with suppliers to create or design a product, process or other innovation. The third factor concerns business operations given high loadings on items associated with purchase of machinery, equipment, computers, or software to implement innovations; planning, engineering, design; and training. We saved the factor scores associated with these three dimensions as separate variables for further analysis.

[TABLE 2 ABOUT HERE]

Table 3 presents an analysis of these innovation dimensions which compares pulp and paper firms to those in other industries. The data show that pulp and paper firms have higher scores on supply chain oriented innovation methods than other Georgia industry sectors. The mean score for pulp and paper firms in this dimension that involves innovation through working with customers and suppliers is .41, which is higher than mature industries such as other food and textiles (.10), other materials-based manufacturing (-.15), or metals and machinery (-.02). It

obtaining this solution because of the level of measurement of our items. See K. Kubinger, On artificial results due to using factor analysis for dichotomous variables, Psychology Science, Volume 45, 2003 (1), p. 106-110.

is also higher than science-based (.08) and electronics/electrical/transportation (.16) manufacturers. Pulp and paper firms also have relatively high use of business operations methods to engage in innovation such as acquiring capital. On the other hand, pulp and paper firms have very low scores in terms of their use of knowledge-based methods for undertaking innovation, such as patents and trademarks. Scores on the intellectual property innovation dimension are -.39, which is below all other industry sectors. It is significantly lower than these scores for metals and machinery (.02), electronics/electrical/transportation (.52), and science-based firms (.97).

[TABLE 3 ABOUT HERE]

It is highly informative to track innovation by employment size and type of pulp and paper firm. We expected large pulp and paper manufacturers to be more engaged in innovation than small ones. Table 4 showed, however, that large firms had similar low intellectual property innovation scores and low supply chain innovation scores as their small firm counterparts. Only on business operations innovations did large pulp and paper firms perform, with innovation scores of .65 compared to .11 for small firms, although these differences were not significant. We also compared innovation scores of mills and non-mills and found no difference between the two in their scores on knowledge-based innovation and supply chain innovation. Mills, however, had significantly higher scores on business operations-based innovation (1.26) than non-mills (-.10).

[TABLE 4 ABOUT HERE]

6. Conclusions

This paper focuses on innovation in pulp and paper manufacturing through an examination of the results of the Georgia Manufacturing Survey. Despite the increasing importance of knowledge-based innovation, our hypothesis that pulp and paper firms would be less apt to engage in this type of innovation received some support. The pulp and paper industry had significantly lower intellectual property-based innovation scores than other manufacturing sectors in the state. This does not mean that the pulp and paper industry fails to engage in innovation. The industry was a leader relative to other manufacturing sectors in the state in its use of supply chain innovation such as working with customers. It also scored rather high in its use of business process innovation practices such as the purchase of machinery and equipment.

We also find that few significant differences existed between pulp and paper firms of various sizes and types, although mills and non-mills did differ in their use of business process innovation activities. There are several possible explanations for these intra-industry similarities. Anecdotal information suggests that more and more mills are adding conversion of paper and packaging to their product offerings to maintain their competitiveness, thereby making distinction between mills and non-mills is less clear. And regarding facility employment size, all but five of the pulp and paper respondents were affiliates of a parent group of holding company. As such the practices of both small and large manufacturing facilities may have been influenced by the larger parent group. Traditionally, it was believed that branch plants were less innovative because they could make no local decisions, but this survey suggested that perceptions about branch plants are not always true. For example, in the sample as a whole we found that branch plants were significantly more likely to have introduced to-to-the market products than were single establishment enterprises by a margin of 38 percent to 27 percent. Branch plants also had higher mean intellectual property-based innovation scores than single facilities (.10 vs. -.08) and

significantly higher mean business process innovation scores (.14 vs. -.10). Supply chain-innovation scores were relatively equal between the two (-.01 for branch facilities vs. .01 for single establishment firms).

Innovation can still occur in a sector, even if its formal R&D activities are weak. Indeed, this has been found to be the case in an earlier study of innovation in the European pulp and paper sector (Autio, et. al, 1997). The Georgia pulp and paper industry has done a good job of focusing on process innovation. Nonetheless, our paper suggests that it may be appropriate to encourage more knowledge-based innovation practices in the industry. This orientation will surely require more investment in research and development. That will be a challenge in an industry that has a long history of making large investments in capital equipment and facilities. For example, the median pulp and paper firm spent less than $200 per employee on in-house R&D compared to the median manufacturer as a whole which spent the still low figure of $250. Acquisition of external R&D was even less common, with only two pulp and paper respondents indicating investments in this area. An additional issue has to do with human capital. Knowledge-based innovation will require more investment in skilled workers with strong technological capability. However, pulp and paper firms in Georgia are particularly prominent in their reporting of difficulties in finding workers with basic skills such as reading, writing, basic math, and English speaking. Thirty-six percent of the pulp and paper firms reported that their more significant problems or needs had to do with basic skills compared to only 25 percent of all Georgia manufacturers.

Assistance sources can serve a critical role in helping pulp and paper firms overcome risks and support the adoption of innovation-oriented practices. Georgia has several state programs that encourage innovation in manufacturing. The Institute of Paper Science and

Technology (IPST) is a membership-based organization on the campus of Georgia Tech that conducts pulp and paper research and provides graduate education based on a multidisciplinary approach that involves faculty from forest biology, chemistry, engineering, and materials science. IPST supports several nanotechnology laboratories that conduct research in filler-in-fiber engineering: nanolayer coated clay fillers using self-assembling nanotechnology, hydrogel nanoparticles for barrier coatings, nanomaterial/polymer interaction, bonding-type filler materials, nanocellulose products, and nanomaterials analysis and characterization. The Center for Paper Business and Industry Services at Georgia Tech is a Sloan Foundation Industry Center that fosters industry-academia connections to "gain an improved understanding of strategically important managerial, economic and organizational challenges facing the Industry."[2] The Herty Foundation is a private nonprofit contract research and development organization located in Savannah Georgia which conducts lab tests and pilot scale investigations of paper, board, and advanced materials. The state of Georgia established the Traditional Industries Program (TIP) in 1994 to link industry and university researchers who can work on critical competitiveness problems in the pulp and paper industry (as well as the food processing, and textiles and carpet industries). TIP uses a board of industry advisors to identify problems that are put forth in the form of RFPs to university researchers in the state.

Our study demonstrates that pulp and paper firms are engaged in process based innovations which are enabling them to compete in the short term. We believe that in the long-term these firms, as well as others in the state of Georgia, will have to adopt other knowledge-based practices to maintain their position and flourish in today's global economy. In Georgia, manufacturing as a whole has relatively weaker innovation performance than that of many other states, with smaller and traditional industries contributing to this weakness. In this context,

[2] http://www.cpbis.gatech.edu/

assistance sources should continue to place emphasis on stimulating manufacturers to be more aware of the importance of long-term investments in innovation.

References

Acs, Z. and Audretsch D. (1991). "R&D, Firm Size, and Innovative Activity" in Z. Acs and D. Audretsch, eds., Innovation and Technological Change: An International Comparison, New York, NY: Harvester Wheatsheaf.

Autio, E., Deitrichs, E., Führer, K, and Smithy, K. (1997), Innovation Activities in Pulp, Paper, and Paper Products in Europe. STEP, Oslo, Norway.

Bardham A. and Jaffee D. (2005). Innovation, R&D, and Outsourcing. Fisher Center for Real Estate and Urban Economics. University of California, Berkeley.

Bound, J., Cummings, C., Griliches, Z., Hall, Bronwyn H., and Jaffe A. (1984) "Who Does R & D and Who Patents?" in R&D, Patents, and Productivity, ed. Z. Griliches, Cambridge, MA: NBER.

Cohen W., Levin R., and Mowery D. (1987). "Firm Size and R&D Intensity: A Re-Examination" Journal of Industrial Economics, 35, 543-63.

Council on Competitiveness. (2004, December). Innovate America. Washington, D.C.: Council on Competitiveness.

Christensen, C. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston, MA: Harvard University Press.

Estes, C. Porter, A., Kongthon, A. (2004). Futures for Traditional Industries: Strategic Issues in the Pulp and Paper Industry in Georgia. Atlanta, GA: Georgia Institute of Technology.

Georgia Department of Labor (2005). Covered Employment and Wages, May 2003. Atlanta, GA: Georgia Department of Labor.

Fagerberg, J. (2004), "Innovation: A Guide to the Literature," in J. Fagerburg, D.C. Mowery, and R. Nelson (eds), The Oxford Handbook of Innovation, Oxford, UK: Oxford University Press.

Hausman, J., Hall, B. and Griliches, Z. "Econometric Models for Count Data with an Application to the Patents R and D Relationship," Econometrica 52, 1984.

Jaramillo H., Lugones G., and Salazar M. (2001). Bogota Manual: Standardisation of Indicators of Technological Innovation in Latin American and Caribbean Countries, 2001.

National Academy of Public Administration, (2004, May). The Manufacturing Extension Partnership Program. Washington, DC: National Academy of Public Administration.

OECD (1995). The Measurement of Scientific and Technological Activities. Proposed Guidelines for Collecting and Interpreting Technological Innovation Data. Oslo Manual. 2nd edition, DSTI, OECD / European Commission Eurostat, Paris 31 Dec 1995.

OECD (1997). Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, Manual Oslo, Eurostat.

OECD (2000). Final Report: Measuring and Reporting Intellectual Capital: Experience, Issues, and Prospects, OECD, Paris.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. Research Policy 13 (1984), pp. 343–373

Porter, M. (1990). The Competitive Advantage of Nations London: Macmillan.

Ragauskas A. (2005). Nanotechnology Innovation Directed to the Forest Products Industry. Proceedings of the TechnoBusiness 2005 Forum, Atlanta, Georgia.

Roper S and Hewitt-Dundas N (1998). “Innovation networks and the diffusion of manufacturing practice: a comparison of Northern Ireland and the Republic of Ireland", NIERC Report, Series No 14, Northern Ireland Economic Research Centre, Queen's University Belfast, Belfast

Rosenfeld S, (1992). Competitive manufacturing: New strategies for regional development, Center for Urban Policy Research, New Brunswick, NJ

Schumpeter J. (1934). The Theory of Economic Development. Cambridge, MA: Harvard University Press.

Shapira, P. and Rephann, T. (1996), “The Adoption of New Technology in West Virginia: Implications for Manufacturing Modernization Policies,” Environment and Planning C: Government and Policy, vol. 14, pp. 431-450.

Smallbone D., North D., Roper S., Vickers I. (2003). “Innovation and the use of technology in manufacturing plants and SMEs: an interregional comparison” Environment and Planning C: Government and Policy 2003, volume 21(1) February, pages 37 – 52

Stewart, Thomas A. (1997), Intellectual Capital, Currency/Doubleday.

Teague, C. (2005). Development and Promise of Nanotechnology: Examples for the Forest and Paper Products Industry. Proceedings of the TechnoBusiness 2005 Forum, Atlanta, Georgia.

Tushman, ML, and Moore WL. (1998). (Eds.) Readings in the Management of Technological Innovation, New York: Harper Collins.

Wengel, J., and Shapira, P. (2004). Machine Tools: The Remaking of a Traditional Sectoral Innovation System, in Sectoral Systems, Innovation and Growth in Europe (F. Malerba, et. al., Eds.), Cambridge University Press, pp. 243-286.

Youtie, J., Shapira, P., Slanina, J., Wang, J., and Zhang, J. (2005). Innovation in Manufacturing: Needs, Practices, and Performance in Georgia, 2002-2005. Georgia Tech Economic Development and Technology Ventures, Atlanta, GA.

Table 1. Descriptive Statistics: Proportion of Respondents Engaged in Innovation Activities in 2002 to 2004

Innovation Activities	Pulp and Paper	All Georgia Manufacturing
	0.38	0.42
In-house R&D	0.00	0.07
Purchased R&D	0.70	0.58
Purchased capital equipment	0.51	0.31
Planning, engineering, design	0.02	0.07
Purchase, license patents	0.32	0.21
Training	0.13	0.16
Market research	0.85	0.62
Work with customers	0.49	0.44
Work with suppliers	0.06	0.13
Applied for patent	0.02	0.10
Registered trademark	0.44	0.38
Signed confidentiality agreement	0.11	0.07
Published paper	0.38	0.42

Source: Georgia Manufacturing Survey 2005, weighted responses of 654 manufacturers.

Table 2. Principal Components Analysis of Innovation Activities: Rotated Component Matrix

Innovation Activities	Components		
	Intellectual Property	**Supply Chain**	**Business Operations**
In-house R&D	0.35	0.41	0.38
Purchased R&D	0.50	0.04	0.18
Purchased capital equipment	0.05	0.01	***0.69***
Planning, engineering, design	0.22	0.31	***0.60***
Purchase, license patents	***0.76***	-0.01	0.07
Training	0.06	0.09	***0.75***
Market research	0.40	0.16	0.32
Work with customers	0.04	***0.81***	0.04
Work with suppliers	0.12	***0.71***	0.22
Applied for patent	***0.75***	0.18	0.09
Registered trademark	***0.71***	0.09	0.05
Signed confidentiality agreement	0.43	0.48	0.07
Published paper	0.47	0.18	0.04

Source: Georgia Manufacturing Survey 2005, weighted responses of 654 manufacturers.

Table 3. Industry Group Differences Within Innovation Components

		Intellectual Property	Supply Chain	Business Operations
Pulp and Paper (n=32)	Mean	-0.39	0.41	0.31
	Std. Dev.	0.53	0.83	0.97
Other Materials (e.g., non-metallic metals, plastic and rubber, furniture) (n=212)	Mean	-0.22	-0.15	-0.02
	Std. Dev.	0.65	0.98	1.05
Food/Text. (e.g., food, beverage, feed, apparel, leather, textile, textile mills) (n=128)	Mean	-0.17	0.10	-0.03
	Std. Dev.	0.73	1.00	0.94
Metals/Mach (e.g., primary metals, secondary metals, machinery) (n=170)	Mean	0.02	-0.02	-0.11
	Std. Dev.	1.02	1.01	0.86
Elec./Trans (e.g., computer, electronics, electrical, household appliances, transportation) (n=61)	Mean	0.52	0.16	-0.01
	Std. Dev.	1.23	1.01	1.01
Science (petroleum, chemicals, medical devices) (n=51)	Mean	0.97	0.08	0.29
	Std. Dev.	1.67	1.01	1.14
Significance		*	*	

*Mean differences significant at p<.05

Table 4. Type of Pulp and Paper Firms and Innovation Component

		Intellectual Property	Supply Chain	Business Operations
Facility Employment Size				
10-99 employees	Mean	-0.40	0.49	0.11
	Std. Dev.	0.51	0.82	0.89
100 or more employees	Mean	-0.36	0.28	0.65
	Std. Dev.	0.58	0.82	1.02
				*
Type of Pulp and Paper firm				
Mills	Mean	-0.46	0.58	1.26
	Std. Dev.	0.58	0.75	0.79
Non-mills	Mean	-0.35	0.34	-0.10
	Std. Dev.	0.51	0.85	0.73

*Mean differences significant at p<.05