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Abstract

The need to enhance innovation capacities has received growing attention in recent years. This paper aims to profile innovation methods within the pulp and paper industry based on a survey of Georgia manufacturing establishments and in-person interviews. Pulp and paper survey respondents are compared with those in other industries in terms of their introduction of new or significantly improved products, processes, and organizational approaches and differences in firm size and type of pulp and paper operation are noted. Three unobserved dimensions of innovation—intellectual property-based, supply-chain based, and business process based—are identified through exploratory factor analysis and differences by sector are highlighted. Pulp and paper firms are generally found to lead other sectors in supply chain and process innovation, but lag in intellectual property based innovation. Qualitative in-person interviews suggested that innovation through the supply chain may reduce firm distinctiveness and offered approaches such as migration to different product types and relocating R&D to university campuses as examples of efforts to shift from traditional innovation practices.

1. Introduction

There is increasing emphasis on the need for U.S. firms to enhance capabilities in 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 typically thought of a mature industry. It is resource-intensive, which has led companies in the sector to focus innovation efforts on issues such 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 exploit new information technologies and upgrade employee skills, and how to develop new product, process or service innovations that can be differentiated from the competition. This brings up 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 offerings, techniques, and methods in other areas?

This paper explores innovation in the pulp and paper industry in Georgia. Due to the nature and scale of production, pulp and paper manufacturers are expected to be more likely to engage in process innovation than product innovation than those in other industries. It is further anticipated that pulp and paper firms, relative to those in other industries, are 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, product and 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 these findings to the long-term prospects for the pulp and paper industry.

2. Innovation in Manufacturing

There is now a new understanding of innovation dynamics. Innovation was conceived traditionally as a linear process from research to development to manufacturing and finally to markets, but today it is viewed much more holistically. Innovation is currently defined as the steps and activities involved in the introduction and deployment of new or improved techniques and methods within and between companies (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 patentable R&D. They can also be supported through non-technological innovations related to softer areas such as engaging in marketing and customer relationships, investing in new skills training, reorganizing production systems, and managing product quality (OECD 1997; Jaramillo, Lugones and Salazar, 2001).

Sectoral differences in the characteristics of innovation and the propensity to develop and adopt innovations have been a primary subject of investigation (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 reckoned to be most influenced by suppliers of machinery, equipment, and other inputs. Scale intensive firms, found in bulk materials and automotive industries, used 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 utilized internal R&D and relationships with academic researchers to develop product innovations and the new processes to make these products.

Using Pavitt's scheme, the pulp and paper industry has conventionally been regarded as a supplier-dominated sector. 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 by purchasing major capital equipment from these equipment providers for example. There has also been an orientation toward process 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 in such areas as multi-layered, technology embedded smart paper) 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.

It is also suggested that proximity to customers, especially knowledgeable leading users, constitutes an important sources for innovation (von Hippel, 2005). Thus, we might expect that within the pulp and paper industry, non-mills engaged in more end-product activity such as development of product packaging might have higher adoption of knowledge-based innovation than mills that separate fibers from wood used in further downstream production.

Within an industry group, it is important to consider innovation differences by particular firm characteristics, since firms vary in their resources and capabilities (Shapira and Rehpann 1996; Cohen, Levin, and Mowery 1987; Acs and Audretsch, 1991; Rosenfeld 1992). However, findings here are mixed. 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. 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.

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 Georgia's pulp and paper manufacturers engaged in introduction of process innovations than in other industries. We conversely expect to find 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 (2005), 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. Although there has only been one Georgia closing in recent years (a facility in St. Mary's Georgia which was rather old and did not maintain appropriate capital investment levels), global competition has led to consolidation and loss of employment. 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 main 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 Enterprise Innovation Institute 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 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.

To examine innovation, this paper focuses on two approaches. We draw upon analogous innovation measurement concepts used by Community Innovation Surveys (CIS) in Europe and elsewhere (see, for example, European Commission, 2004). The identification of new or significantly improved products, processes, organizational, and marketing introductions was measured in the survey using comparable wording to what is employed in the CIS surveys. We engage in a more in-depth analysis of a range of 13 innovation-related activities based on items used in a recent survey-based knowledge content study in Malaysia (Shapira, et. al, 2006). The innovation dimensions underlying these items are further examined in an exploratory factor analysis, which is used to highlight industry differences in innovation practices.

In addition to survey based data, in-person interviews with a group of pulp and paper suppliers and mill representatives were conducted. These interviews were designed to supplement quantitative survey information with qualitative insights about the role of innovation in the pulp and paper industry.

5. Analysis

The survey asked manufacturers to report on the introduction in their facility of product, process, organizational, or marketing approaches in the 2002 to 2004 time period. These

introductions were defined to be new or significantly improved from the perspective of the facility but not necessarily the sector or market. This relatively broader definition parallels definitions found in OECD innovation guidelines and CIS surveys. As Table 1 indicates, just over half of the pulp and paper respondents report that they introduced a new or significantly improved product or service. However, this percentage is somewhat lower than the average industry, even as it is significantly behind the levels exhibited by more technology-intensive electronics and science-based firms. Such is not the case for large pulp and paper manufacturers with 100 or more employees; their level of introduction of new product innovation is comparable to that of these technology-intensive sectors. In addition, non-mills are also found to have higher levels of new product introduction than mills.

To further explore the extent of introduction of new products and services, we examined the role these offerings played in generating sales. The percentage of total sales from new-to-the-market goods and services was the subject of analysis. For only 13 percent of pulp and paper firms did new-to-the-market goods and services account for more than 10 percent of their sales during the period 2002 to 2004. The one caveat is that this percentage is from a small base (n=11). In contrast, approximately half of all other industries indicated new-to-the-market goods and services accounted for more than 10 percent of their sales. (See Table 2.)

[TABLES 1 AND 2 ABOUT HERE]

However, the reverse is true when considering introduction of new or improved processes and organizational methods. The pulp and paper industry leads other sectors in their rate of introduction of new or significantly improved production processes or organizational methods.

Approximately two-thirds of respondents report that they introduced a new or significantly improved process, manufacturing technology, logistics, delivery or other type of process. Likewise, nearly 80 percent of pulp and paper respondents reported introducing new or significant changes to management systems, work structure, or relationships with other firms. There was not much size difference in these rates. However, non-mills were found to have higher levels of introduction of new or significantly improved processes and organizational methods.

One critique of these measures is that they seem somewhat general and qualitative in nature (Salazar and Holbrook, 2003) Hence, we added a series of questions about whether or not respondent facilities engaged in 13 more specific items that measure innovation-related activities during the period 2002 to 2004. These items were used in previous surveys of knowledge content. See Table 3. Pulp and paper firms had higher proportion of respondents engaged in innovation through capital equipment purchases; planning, engineering, and design; training; and working with customers.

[TABLE 3 ABOUT HERE]

These items can be interpreted as indicators of underlying dimensions of innovation. We employed principal components analysis in an exploratory manner to understand these underlying dimensions. The total survey participant base of Georgia 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 4.) 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 4 ABOUT HERE]

Table 5 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 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 5 ABOUT HERE]

Within the pulp and paper industry, differences in engagement along these dimensions of innovation were explored by size and type of pulp and paper manufacturer. We expected large pulp and paper manufacturers to be more engaged in innovation than small ones. Table 6 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 better, 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 6 ABOUT HERE]

6. Qualitative Observations

In-person interviews with seven executives from mill manufacturing companies and pulp and paper suppliers yielded an important complement to the quantitative survey information. For example, one manufacturer suggested that the quantitative data in the survey may have understated the extent of innovation in the industry, because general and plant managers are not often aware of R&D activities in affiliated enterprise units. There were several innovation

centers within his company, but he was unsure whether production managers would be aware of these centers and their R&D efforts. In addition, various industry activities such as the Agenda 2020 Technology Alliance of the American Forest and Paper Association was were lauded as an important roadmap for bringing major new products to market in the future. (American Forest and Paper Association, 2005)

On the other hand, several interviewees suggested that there may be attributes of the pulp and paper industry that challenge engagement in innovation. For example, several participants described how the capital intensity and strong productivity orientation of pulp and paper manufacturing made it difficult for them to introduce innovative ideas and to set up trial production runs for new products. In addition, respondents shared that production floor employees did not always have the type of knowledge and training necessary to implement new ideas outside of current practices.

Various approaches for innovating in this environment surfaced in respondent comments. One executive mentioned that his firm had changed its focus from mill working to developing products beyond paper. Another approach stressed the movement of the R&D function out of the industrial operation and onto a university campus to encourage more innovative activities near to where the research was being conducted.

Equipment and chemical suppliers to the pulp and paper industry raised multifaceted approaches used by their firms to stimulate innovation. These approaches included brainstorming, participation in research consortia, and other competitors and suppliers. It was lamented that intellectual property issues restricted open sharing of information between these types of organizations. However, particular note was made that innovating through the supply chain may not necessarily lead to innovation. Because suppliers present the same or similar

offerings to a range of customers, reliance on suppliers for innovation can result in the advantage of distinctiveness being lost.

7. Conclusions

This paper focuses on innovation in pulp and paper manufacturing through an examination of the results of the Georgia Manufacturing Survey and through qualitative in-person interviews. Our hypothesis that pulp and paper firms would be less apt to engage in product innovation received some support. In the survey data, large pulp and paper manufacturers and non-mills had relatively higher rates of new or improved product introductions, comparable to those of more technology-intensive industries. Qualitative interviews further confirmed that at least some mills are de-emphasizing traditional products and moving toward new offerings. But for most traditional pulp and paper manufacturers that introduced new products, new-to-the-market goods or services accounted for a smaller percentage of pulp and paper sales than sales in other industries. On the other hand, we found that the pulp and paper industry was substantially ahead of other industries in its level of introduction of new or significantly improved production processes and softer organizational innovations. And these higher rates of introduction did not vary much by facility employment size.

In terms of the more specific measures of innovation, 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. One caveat to these findings: we cannot measure the extent to which knowledge-based measures were designed to foster product or process innovations. Thus, it could be argued that the intellectual property score may reflect process or product innovations. However, when testing the difference in these scores between firms that introduced product or process innovations, it was found that those introducing product innovations had significantly higher intellectual property scores (.20) than those introducing new processes (.08). This suggests the existence of a product innovation-intellectual property link.

With the exception of the distinctions noted above, we found surprisingly fewer differences existed between pulp and paper firms of various sizes and types than expected. There are several possible explanations for these intra-industry similarities. Qualitative interviews suggest that more and more mills are moving their product offerings toward conversion of paper and packaging to maintain competitive advantage. This transformation could result in the distinction between mills and non-mills being 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). As well, qualitative interviews confirmed that pulp and paper manufacturers still rely on equipment and chemical suppliers for innovation. 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 and 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. In addition, pulp and paper firms were more likely than respondents in other industries to say that lack of qualified personnel was a barrier of high importance constraining their decision of whether or not to

innovate. (See Table 7.) Qualitative interviews substantiated that limitations on the knowledge of shop floor employees made the introduction of new ideas into their enterprise more difficult.

[TABLE 7 ABOUT HERE]

Our study demonstrates that pulp and paper firms are engaged in process and organizational 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, emphasis should be placed on stimulating manufacturers, including pulp and paper producers, to be more aware of the importance of long-term investments in innovation.

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Table 1. Percentage of Firms that Introduced Product, Process, and Organizational Introductions during the 2002 to 2004 Time Frame

	Introduced New or Significantly Improved			
	Product	**Process**	**Organizational Methods**	**Marketing Methods**
Pulp and Paper	51.5%	65.9%	78.7%	31.9%
Other materials	55.1%	48.4%	50.6%	26.3%
Food/Text.	51.7%	39.1%	41.8%	32.4%
Metals/Mach	51.7%	47.2%	52.1%	27.9%
Elec./Trans	63.8%	53.2%	60.6%	29.1%
Science	80.4%	60.8%	58.8%	39.2%
Total	56.5%	48.3%	51.6%	29.5%
Pulp and Paper Employment size				
10-99	40.0%	66.7%	80.0%	33.3%
100+	70.6%	64.7%	76.5%	29.4%
Mills, Nonmills				
Mills	48.8%	57.5%	78.6%	27.0%
Nonmills	57.8%	85.3%	78.9%	43.1%

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

Table 2. Percentage of Sales from New-to-the-Market Goods and Services by Industry

	Pulp and Paper	Other Materials	Food, Textiles	Metals, Machinery	Elect, Trans.	Science	Total
<5%	37.1%	24.9%	28.7%	28.4%	29.1%	28.5%	27.8%
5-10%	50.0%	27.7%	20.8%	16.5%	10.6%	28.5%	23.2%
More than 10%	12.9%	47.4%	50.5%	55.1%	60.3%	43.0%	49.0%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Number of Observations	11	61	38	59	28	28	225

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

Table 3. Descriptive Statistics: Proportion of Respondents Engaged in Innovation Activities in 2002 to 2004

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

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

Table 4. 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

Factor loadings over 0.50 are highlighted.
Source: Georgia Manufacturing Survey 2005, weighted responses of 654 manufacturers.

Table 5. 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
Source: Georgia Manufacturing Survey 2005, weighted responses of 654 manufacturers.

Table 6. 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
Source: Georgia Manufacturing Survey 2005, weighted responses of 654 manufacturers.

Table 7. Percentage of Respondent Firms Rating Limiting Factor of High Importance in Whether or Not to Undertake Innovative Activities

Limiting Factor	Pulp and Paper	Other Industries
Lack of qualified personnel	20.5%	12.3%
Lack of funds, costs too high	20.3%	13.6%
Market dominated by established companies	13.5%	16.4%
Uncertain demand for innovative goods or services	6.7%	16.4%
No demand for innovations	6.7%	5.2%
Lack of info on markets	5.9%	10.1%
Lack of information on technology	5.2%	2.5%
Difficulty finding partners	4.1%	2.7%
No need due to prior innovations	3.5%	8.9%

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