Segmentation of Ohio's Logging Industry Based on Productivity and Cost Variables

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Abstract

The objective of this research was to develop baseline information regarding the structure and performance of Ohio's logging industry. Questionnaires were distributed on-site at logger chapter meetings across the state. Multivariate clustering was used to group similar types of firms based on responses to 15 productivity and cost variables. Three clusters were identified: Local Mill Suppliers, Product Merchandisers, and Volume-Dependent Producers. The clusters were largely homogeneous as far as the overall makeup and administration of their companies. Clusters did differ regarding haul distance, pieces of equipment owned, and equipment age. Volume-Dependent Producers, while not significantly larger in size statistically, viewed the productivity, present, and future cost variables more pessimistically than the other clusters. The key variable of concern across clusters was the cost of consumables, primarily fuel, paralleling more recent findings in other states.

Commercial logging in Ohio directly employed 2,300 people and produced $238 million in output in 2010 (McConnell 2012). While employment has increased from 2,145 since 2001, industrial output has declined from $286 million (Letson et al. 2006). Loggers are constrained economically, requiring larger forested tracts to remain cost competitive (Egan 2011). However, woodlot size is shrinking as family property is divided, converted to alternative land uses, or sold, and this trend was expected to continue for the foreseeable future (Kittredge et al. 1996, Egan et al. 2007). Additionally, landowners are generally more nonconsumptive in nature than consumptive (Campbell and Kittredge 1992). Starr (2013) found little motivation present among Ohio tree farmers to obtain timber-based income from their land, and forest products production was an overall lowly rated objective of landownership. These issues are contributing to an ever-increasing limitation in production forestry, which is the viability of the logging community.

Production forestry depends on a capable logging sector to harvest and deliver timber in a cost-effective manner. Because these are the initial processes in wood utilization, the overall health of the forest products industry can be impacted by the functioning of its logging community. Moreover, the logger's dollars make valuable economic contributions to rural communities through daily business activities. However, the logging industry by and large is inadequately capitalized and bears an inordinate amount of financial risk (Stuart et al. 2003).

The consistent publishing of the Logging Cost Indices for the eastern United States began in 2003 (Stuart et al. 2003). Businesses were largely a standard C or special tax status S corporation with one operating crew, and labor was the number one cost in operations. Equipment (trucks, harvesters, skidders, loaders, etc.) tended to be older, with investments in equipment largely declining since the base year 1995. Consumables were also increasing annually since 1995, with spikes noted following the tropical storms of 2004 and 2005. The overall finding from this series has been that logging costs were outpacing inflation as measured by the Consumer Price Index (Stuart et al. 2008). Logging costs had risen 56 percent since 1995, 36 percent of that beginning in 2004, while inflation had risen only 32 percent. Small and midsized firms were seeing the largest rises in costs. Adjusted costs highly correlated with tons of production at a rate of $13.45 per ton produced.

The characteristics of the logging industry have been examined across the eastern United States in the South (Greene et al. 1998, Munn et al. 1998), central Appalachia (Luppold et al. 1998, Milauskas and Wang 2006), and

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Forest Prod. J. 63(5/6):174–181.
doi:10.13073/FPJ-D-13-00034

Northeast (Egan 2009, 2011). Recent studies in Ohio, though, have focused more on logging's economic contributions (Letson et al. 2006, McConnell 2012) than on the sector's structural attributes. These studies used the software system IMPLAN to conduct a series of input–output analyses. The IMPLAN system uses economic multipliers and trade coefficients to calculate the spillover effects of an industry, i.e., its indirect and induced impacts, from its direct contributions. Each impact is described by four measures: employment, labor income, value added, and total industrial output. Summing the direct, indirect, and induced impacts provides a description of the sector's total economic contributions (McConnell 2012).

While valuable, the economic impact assessments can provide only a snapshot of dollars generated. Further, defining the true impact of a rural industry such as logging can be problematic. First, the data utilized when constructing the input–output model in IMPLAN are based on government estimates of industrial sectors. Second, companies within the logging industry can be and often are classified into various other sectors, such as truck transport and support services for forestry (Greene et al. 1998, Santos et al. 2011). To resolve this recognized problem, it was proposed by industry stakeholders to develop a more precise description of the Ohio logging industry. Given the recent economic recession, part of this undertaking included defining its structure and performance and where shortcomings in its viability may exist.

An often-used method in the literature for defining the range of nonindustrial private forest landowners and their needs is multivariate clustering of similar demographics and attitudes. Salmon et al. (2006) suggested dividing landowners according to ''benefit-based audience segmentation,'' much like marketing links customer motives with purchasing behavior. Following this rationale, cluster analyses have been conducted based on various landowner characteristics to clarify the human dimensions of natural resource management (Kluender and Walkingstick 2000, Ross-Davis and Broussard 2007, Majumdar et al. 2008, Surendra et al. 2009, Kuipers et al. 2013).

Loggers too have been grouped in past studies for analysis of the industry (Luppold et al. 1998, Stuart et al. 2003, Rickenbach and Steele 2005, Egan 2011), but these works have used prior knowledge of companies' characteristics, such as location, annual production, or type of operation, to examine variables of interest within the industry. The objective of this study was to survey and describe Ohio's logging community using no a priori information of firms operating in the state. Here, multivariate clustering was used to segment loggers based on 15 productivity and cost factors identified by Luppold et al. (1998), Stuart et al. (2008), and Egan (2011) affecting logging firms in the eastern United States.

Methodology

A questionnaire was designed at The Ohio State University and divided into three sections: demographics, operations, and productivity and costs. The demographics section contained 10 questions, the operations section contained 8 questions, and the productivity and cost section contained 9 questions. Nominal, ordinal, and continuous data were obtained. The survey was pretested with Ohio State University Extension specialists and Ohio forest industry stakeholders in the summer of 2012, modified for clarity, and conducted in the fall and winter of 2012 to 2013.

The survey was administered on-site at each of the eight logger chapters in Ohio. This helped to maximize response rates and allowed for clearly explaining the need for the information being requested. Prior to distributing the survey, a brief presentation was given on the economic impacts of logging in both Ohio and the local chapter's area.

All of the logging firms present at each chapter's meeting participated in the survey ($n = 84$). This represented 58.3 percent of the 144 logging companies enrolled in local chapters in Ohio and 42.0 percent of the estimated 200 total businesses based in the state. For their participation, each company received 1 hour of continuing education credit in the Ohio Master Logger Program. This program is administered by the Ohio Forestry Association in conjunction with the State Implementation Committee, which is responsible for meeting the compliance goals set forth by the Sustainable Forestry Initiative. Participants, who were either the owner or production manager, were free to not answer a question if they chose not to do so. Surveys were collected and coded by chapter and number (1-1, 1-2, etc.). Survey data were entered into Excel and imported to SAS (SAS Institute Inc. 2008) for analysis.

Logger clusters were constructed based on productivity and cost components within their businesses (Table 1). Loggers were asked to rate 15 issues (9 production related and 6 business related) currently affecting the productivity and costs of their firm on a 1 to 7 Likert scale. A rating of 1 suggested the issue did not at all affect the company, and 7 meant it greatly affected the company, with a rating of 4 being neutral. Six surveys were not included in the segmentation due to incomplete responses; thus, analyses were performed on 78 completed surveys.

Multivariate classification often follows a series of steps (Majumdar et al. 2008; Omi et al. 1979, and references therein). The first step is data reduction by factor analysis, which diminishes the variables of interest to a smaller set of unrelated factors. Factor scores are then computed by weighting the survey responses for each variable by the corresponding correlation coefficient between a variable and factor. The second step is conducting a cluster analysis to group like individuals based upon their factor scores. Clusters are developed to minimize within- and maximize between-cluster variations. Cluster validation is then tested using discriminant analysis. As needed, one or more discriminant functions can be applied to refine the clusters to maximize an individual's probability of correct classification.

An extension of principal component analysis, factor analysis, was first used to reduce the data by grouping any correlated variables while still accounting for the maximum amount of variance. This uncovered any uncorrelated latent variables contained within the 15 productivity and cost components presented in the survey (Table 1). Varimax rotation was used to maximize the factor loading, or the individual variable-factor correlation coefficient, for each factor (Majumdar et al. 2008). Three factors were obtained from the original 15 variables, labeled as Operations, Administration, and Organization, and are presented in Table 2 with their factor loadings. Kaiser's measure of sampling adequacy for the factors was 0.83, which suggested the variables were suitably grouped, and 63 percent of the total variance between the responses was

Table 1.—Ratings for the productivity and cost variables surveyed.

Variable	Cluster[a]		
	Local Mill Suppliers	Product Merchandisers	Volume-Dependent Producers
Productivity			
Available timber supply	2.5 B (1.7)	4.1 A (1.8)	4.8 A (1.6)
Available business capital	1.8 C (1.2)	3.4 B (1.8)	5.4 A (1.3)
Available labor	1.9 C (1.4)	3.9 B (2.0)	5.2 A (1.6)
Equipment breakdowns	2.4 C (1.7)	3.7 B (1.6)	5.2 A (1.5)
Products sorts at deck	1.6 B (0.8)	2.9 B (1.7)	4.5 A (1.8)
Inconsistent haul weights	1.6 B (1.0)	3.3 A (1.9)	3.9 A (1.9)
Mill quotas	1.8 C (1.6)	3.8 B (2.3)	5.1 A (1.6)
Turnaround time	1.6 C (1.4)	3.0 B (1.6)	4.8 A (1.8)
Communication with mill	1.3 C (0.6)	2.8 B (1.5)	4.4 A (1.7)
Costs			
Equipment costs	2.0 C (1.3)	4.1 B (1.8)	5.8 A (1.1)
Labor costs	2.3 C (1.5)	4.2 B (1.5)	5.5 A (1.5)
Consumables costs	3.3 C (1.8)	5.2 B (1.3)	6.5 A (0.7)
Administrative costs	1.6 B (0.9)	2.6 B (1.4)	4.4 A (1.5)
Insurance costs	2.5 C (1.3)	4.6 B (1.7)	5.6 A (1.4)
Cost of contract services	1.7 B (1.1)	3.1 AB (1.8)	3.5 A (1.8)

[a] Values are means (standard deviations). Means with different letters across rows are significantly different at $\alpha = 0.05$.

explained by the three factors. A high degree of reliability was also obtained, with Cronbach's alpha ranging from 0.826 to 0.833 for each factor.

Factor 1, Operations, combined seven variables: the productivity components *available timber supply, available labor,* and *equipment malfunctions and breakdowns* and the business cost components *equipment, labor, consumables,* and *insurance*. Factor 2, Administration, combined four variables: the productivity components *mill quotas, turnaround time at the mill,* and *communication and planning with the mill* and the business cost component *administrative costs*. Factor 3, Organization, combined four variables: the productivity components *available business capital, product sorts at the log deck,* and *inconsistent haul weights* and the business cost component *contract services*.

Table 2.—Factor loadings representing the correlations between individual productivity and cost variables and factors.

Variable	Factor		
	Operations	Administration	Organization
Productivity			
Available timber supply	0.67		
Available business capital			0.54
Available labor	0.62		
Equipment breakdowns	0.53		
Products sorts at deck			0.53
Inconsistent haul weights			0.59
Mill quotas		0.78	
Turnaround time		0.81	
Communication with mill		0.82	
Costs			
Equipment costs	0.89		
Labor costs	0.80		
Consumables costs	0.74		
Administrative costs		0.49	
Insurance costs	0.67		
Cost of contract services			0.78

Ward's minimum variance clustering method was used to cluster similar logging firms based on the three factors obtained. This method, a hierarchical agglomerative procedure, starts with treating each object as its own cluster. Individuals are sequentially combined to produce a cluster with minimal within-group variation while simultaneously maintaining clusters of reasonable size (Johnson and Wichern 2007). Diagnostic checks, including the plotting of the cubic clustering criterion versus the number of clusters and T^2 clustering history, concluded the presence of three distinctly separate clusters.

Following cluster selection, discriminant analysis was used to test the validity of the clusters' compositions. Discriminant analysis judges the performance of the clustering process by calculating the probabilities of misclassification, given a defined set of known groupings (Johnson and Wichern 2007). A simultaneous calibration/validation procedure was applied to obtain a linear discriminant function with reduced bias in its error count estimates of misclassification for each cluster.

The demographics, operations, and productivity and cost components between the clusters were analyzed using analysis of variance. Means were compared using the Tukey-Kramer test for unbalanced data. Perceptions of present and future costs within clusters were examined using paired *t* tests. All testing was conducted at $\alpha = 0.05$ significance level with moderate differences reported up to $\alpha = 0.10$.

Clustering Results

The typical Ohio logging administrator surveyed was a 48.9-year-old high school graduate. His company was a 24.7-year-old sole proprietorship that employed 6.9 people, operated 1.3 crews, and was a grade hardwood sawtimber harvesting operation. Employees largely ranged from 30 to 50 years old with 10 to 20 years of service. Harvesting equipment was generally bought used and was 15 years old. Daily capacity was 6.7 loads, with production averaging 5.0 loads. Production efficiency averaged 70.7 percent and was

consistent going back to 2000. Haul distance was approximately 40 miles, with the company owning 1.8 trucks and 2 trailers.

Three distinct clusters of Ohio logging firms were identified based on the principal components defining their productivity and costs, which were the factors Operations, Administration, and Organization (Table 2). These clusters, labeled Local Mill Suppliers, Product Merchandisers, and Volume-Dependent Producers, explained 99 percent of the total variation between the factor scores.

Poststratification weights were created to obtain some measure of logging firms not identified in the survey (Table 3). Two weights were calculated using data obtained from recent regional studies on administrator age and years in logging/business (Milauskas and Wang 2006; Egan 2009, 2011). They were then applied individually to the responses for each of the 15 productivity and cost variables, with the factor and cluster analyses rerun. The cluster compositions between the original and weighted responses were compared, and no differences in individuals' assignments were obtained by using either set of weighted response. Still, generalizing these results to the Ohio logging industry as a whole should be done prudently.

Table 3.—Poststratification weights used to gain a measure of nonidentified Ohio loggers.

Variable	Literature values[a]	Ohio loggers	Weights
Avg. age (y)	47.1	48.9	0.96
Avg. years in logging/business	22.4	24.7	0.91

[a] Literature values were averaged from Milauskas and Wang (2006) and Egan (2009, 2011).

Cluster 1: Local Mill Suppliers

Local Mill Suppliers was the smallest cluster ($n = 17$). This cluster was largely unaffected by the productivity and cost variables presented (Table 1). Only 6 of 15 variables rated at least 2.0: available timber supply, equipment malfunctions and breakdowns, and the costs of equipment, labor, consumables, and insurance. The lone factor rating above 3.0 was the cost of consumables. Available timber supply rated as the (relatively) highest productivity issue, 2.5. This cluster significantly differed from Volume-Dependent Producers on all variables.

The average age of a Local Mill Supplier was 48.7 (standard deviation = 12.2) years old with a median education level of high school graduate. Businesses were structured as limited-liability companies (LLCs; 56.3%), sole proprietorships (37.5%), and C corporations (6.3%). These companies had been in business an average of 24.3 (15.8) years. The mean number of employees was 7.0 (11.8) and of crews was 1.12 (0.49).

Employees were 30 to 60 years of age with service time ranging from 3 to 20 years. More experienced employees tended to run the loader or drive a truck. Three companies owned a harvester (7 total machines for the cluster), 13 owned a skidder (17 total), 12 owned a loader (15 total), 14 owned a dozer (16 total), 9 owned a log truck (15 total), and 9 owned a trailer (15 total). These machines ranged in average age from 13.2 to 16.0 years. Seventy percent of all machines were purchased used, with their average ages ranging from 14.0 to 17.6 years. Bulldozers on average had been with their current owner the least amount of time (5.5 y), with all others being in the company's possession for at least 7 years.

Sixteen of the 17 Local Mill Suppliers were deliverers of grade hardwood sawtimber in varying lengths. Eight businesses within this cluster used their own trucks for hauling, one had their trucking operation as a separate business, two used their trucks and contractors, while three were dependent on independent truckers for delivery. These firms had a production efficiency of 66.8 percent, with efficiency being the ratio of production to capacity. Production averaged 3.8 loads per day with an average capacity of 5.9 loads per day. Their average hauling distance was 33.0 miles, which was significantly less than for Volume-Dependent Producers.

Cluster 2: Product Merchandisers

Product Merchandisers made up the largest cluster of Ohio logging firms ($n = 33$). These loggers responded primarily in and around the median (4.0) regarding the effects the productivity and cost issues presented had on their company. The productivity factor affecting them the most was the available timber supply, although Volume-Dependent Producers were affected to a similar degree. Communication and planning with the mill(s) affected them the least. The costs of consumables concerned them the most, followed by insurance, labor, and equipment. Product Merchandisers placed significantly greater degrees of importance on all variables than did the Local Mill Suppliers, with the exceptions of product sorts at the deck, administrative costs, and the costs of contract services (Table 1).

The average age of the administrator was 44.8 (11.5) years. The median education attained was high school graduate. These companies had been harvesting and hauling timber for an average of 25.1 (16.5) years. A sole proprietorship was the primary company structure (53.1%), followed by LLC (32.3%), S corporation (12.9%), and C corporation (3.2%). The mean number of employees was 7.31 (8.55) and of crews was 1.34 (0.65).

Product Merchandisers were primarily providers of grade hardwood sawtimber (75.0%). Only three were strictly chipping or random-length pulpwood operations, while four firms provided a combination of sawtimber and chips or pulpwood products. Fourteen businesses used only their own trucks and trailers for hauling logs, two structured their trucking operations as separate businesses, eight used a combination of their own trucks and contract haulers, while four depended on other trucking businesses for hauling. Daily production efficiency was 75.9 percent, which was a consistent level dating back to 2000. Average production was 4.7 loads per day, while average daily capacity was 6.0 loads per day. Average hauling distance on a typical day was 36.8 miles.

Workers ranged in age from 30 to 60 years with 5 to 20 years of service. Those with the least service were more likely to run chainsaws, while the most experienced ran machines or drove trucks. Ten companies owned at least one harvester (18 total machines for the cluster), 26 owned a skidder (46 total), 4 owned a forwarder (5 total), 27 owned a loader (48 total), 2 owned a chipper (3 total), 24 owned a dozer (30 total), 25 owned a log truck (55 total), and 22 owned a trailer (58 total). The average age of all machines ranged from 9.2 to 13.4 years. Nearly two-thirds (63.6%) of

the total machines were purchased used, with an average age range of 11.9 to 15.3 years. They had been with the current owner for over half their lives.

Cluster 3: Volume-Dependent Producers

Twenty-eight logging firms made up the cluster of Volume-Dependent Producers. These were the main providers of weight-scaled and tree-length products. Six firms supplied either random-length pulpwood or chips exclusively, while eight additional firms provided these products in combination with grade hardwood sawtimber. Twelve businesses were also providers of grade hardwood sawtimber in varying lengths.

This cluster showed the greatest degree of concern regarding the productivity and cost variables presented. Only two issues rated below 4.0—inconsistent haul weights and the cost of contract services—yet this cluster still rated them higher than the other two logger types. Available business capital, available labor, equipment malfunctions, mill quotas, and the costs of equipment, labor, consumables, and insurance all rated at least 5.0. Turnaround time and coordination of their operations with the mill were also concerns. Available business capital hindered these producers' productivity the greatest, while consumables were the greatest cost.

Volume-Dependent Producers averaged 47.5 (11.6) years of age with a median education of high school graduate. The number of employees averaged 10.2 (15.3) and number of crews averaged 1.6 (1.0). Businesses had been operating an average of 29.9 (15.2) years and were sole proprietorships (48.1%), LLCs (25.9%), C corporations (22.2%), or S corporations (3.7%).

Nine Volume-Dependent Producers used only their own trucks and trailers for hauling logs, two structured their trucking operations as separate businesses, nine used a combination of their own trucks and contract haulers, while six depended on other trucking businesses for hauling. Daily production efficiency was 72.4 percent. Loads per day averaged 5.9 at an average capacity of 7.9 loads per day, which was a consistent dating back to 2000. Average hauling distance was 48.2 miles.

Employees ranged in age from 30 to 50 years with 5 to 20 years of service. Those with the most service time ran the harvester or loader. Ten companies owned at least one harvester (19 total machines for the cluster), 26 owned a skidder (61 total), 21 owned a loader (39 total), 9 owned a chipper (14 total), 25 owned a dozer (42 total), 19 owned a truck (69 total), and 21 owned a trailer (81 total). The average age of all machines ranged from 9.0 to 12.4 years. Just over half (54.4%) of all machines were purchased used, with an average age range of 13.0 to 22.8 years. They had been with the current owner for over half their lives, except for the chippers, which had been in the company's possession for just under 30.0 percent of the machine's average life.

Cluster Comparisons and Discussion

While multiple clusters were formed due to the variance in loggers' perceptions of productivity and cost issues, Ohio logging firms, like those of other states (Egan 2011), were found to be quite homogeneous in regard to the overall makeup and administration of their companies. Demographically, Ohio loggers were also similar to logging contractors in other states (Greene et al. 1998; Luppold et al. 1998; Munn et al. 1998; Egan 2009, 2011).

Local Mill Suppliers were significantly less efficient than Product Merchandisers and Volume-Dependent Producers from 2000 to 2010 ($P < 0.01$); however, current production efficiency ($P = 0.47$) did not differ between clusters (Table 4). Haul distance significantly differed between clusters ($P = 0.05$) with Volume-Dependent Producers having the greatest distance and Local Mill Suppliers the shortest. Moderate differences were found between the clusters regarding business structure ($P = 0.06$), as Product Merchandisers were more likely to be sole proprietors, whereas Volume-Dependent Producers were a near equal mix of protected and unprotected business structures. Local Mill Suppliers tended to seek protection as either an LLC or a C corporation.

Fully mechanized harvest and haul systems are highly capitalized (Keegan et al. 1995), which was also the case for Ohio's logging industry. Significant differences were found in regard to equipment ownership, as more pieces of large equipment were owned by the average Volume-Dependent Producer ($P = 0.01$; Table 4) than by the Local Mill Supplier; Product Merchandisers were not different from either of the two other clusters. Local Mill Suppliers tended to own older pieces of equipment than did the other clusters, but the significance of these differences varied between types of equipment (bulldozer, $P = 0.03$; harvester, $P = 0.05$; loader, $P = 0.51$; skidder, $P = 0.83$; Table 4). Older chippers ($P = 0.08$) tended to be owned by Volume-Dependent Producers rather than by Product Merchandisers.

Cluster compositions cut across geographical boundaries, as classification of individuals was not dependent on logger chapter ($P = 0.35$). It is logical, though, that some link to proximity of markets was present, as the state's two pulp mills were significant consumers of Volume-Dependent Producers' roundwood. Likewise, it appeared that Product Merchandisers tended to operate in the supply zones of the state's two pulp mills and/or its largest sawmills (annual production $\geq$ 10 MMBF).

Local Mill Suppliers' lower ratings of the productivity and cost variables may have been linked to the nature of their operations, a lower level of mechanization present in their firms, and a lower haul radius for their businesses. As a consequence of nearly all of them being harvesters of grade hardwood sawtimber, their businesses were more quality-based operations than were the businesses of Volume-Dependent Producers. While their efficiency was initially low, their goal of extracting high-grade hardwood logs may have offset the lack of overall productivity from a pure volume standpoint. Product Merchandisers perhaps also benefited to a degree from the same philosophy. Additionally, they were the only cluster using forwarders, which carry a higher payload than a skidder. This may have contributed to their ratings as well.

The three clusters did not differ with respect to capacity or production. However, mean productivity and cost concerns as a whole did positively correlate with mean production ($r = 0.87$, $P < 0.01$). The increasing magnitude of the average concerns with production paralleled the findings of Stuart et al. (2008) that logging costs rise with production.

Given their need to move wood to market, Volume-Dependent Producers indicated the cost issues presented would continue to be a concern into the future (Table 5).

Table 4.—Business, production, and equipment variables describing Ohio logging firms.

Variable[a]	Cluster[b]			*P* value
	Local Mill Suppliers	Product Merchandisers	Volume-Dependent Producers	
Business structure, % of total				
SP	37.5	53.1	48.1	0.06
LLC	56.3	32.3	25.9	
C	6.3	3.2	22.2	
S	0	12.9	3.7	
Production efficiency, avg. %				
2012–2013	66.8 (19.0)	75.9 (18.9)	72.4 (23.3)	0.47
2000–2010	55.0 B (23.4)	69.1 A (26.3)	77.6 A (12.2)	<0.01
Haul distance, avg. miles	33.0 B (19.9)	36.8 AB (13.3)	48.2 A (20.9)	0.05
Equipment, avg. no. of pieces owned	3.4 B (1.8)	4.8 AB (2.4)	6.5 A (3.7)	0.01
Equipment, avg. age (y)				
Bulldozer	15.4 A (8.3)	10.8 AB (3.6)	8.8 B (5.7)	0.03
Harvester	16.0 A (10.1)	9.2 AB (5.6)	9.0 B (6.5)	0.05
Chipper	—	8.0 (2.0)	19.9 (9.8)	0.08
Loader	14.9 (8.3)	13.4 (10.0)	11.8 (7.8)	0.51
Skidder	13.5 (6.5)	12.1 (8.7)	12.4 (8.7)	0.83

[a] SP = sole proprietorship; LLC = limited-liability corporation; C = C corporation; S = S corporation.
[b] Means (standard deviations) with different letters across rows are significantly different at $\alpha = 0.05$.

This cluster rated all of the variables significantly higher than the Local Mill Suppliers. Product Merchandisers also significantly differed with Volume-Dependent Producers on all future cost variables except contract services. Within the clusters, Volume-Dependent Producers saw contract services becoming a greater future cost concern ($P = 0.05$), with administrative costs ($P = 0.09$) perhaps becoming more important in time as well (Table 6). This cluster appeared to be the one that would benefit from receiving technical support on financial and banking matters.

Product Merchandisers felt that labor costs ($P = 0.01$) would be of much greater concern in the future (Table 6), with consumables ($P = 0.10$) and administrative costs ($P = 0.09$) possibly playing an increasing role. Local Mill Suppliers did not foresee any of the costs ($P > 0.20$ for all variables) in Table 6 having a greater effect on their companies in the future than they were currently. However, equipment costs did rate 69 percent higher than the current average concern. This should be continually tracked due to the overall older age of Local Mill Suppliers' equipment.

Validation of the clusters' partitioning using discriminant analysis was successful (Table 7). Only two firms were believed to be misclassified as Volume-Dependent Producers rather than Product Merchandisers, with one having a near 50/50 probability of residing in either cluster. These two businesses appeared to have a possible combination of shorter haul distances, lower production, or older equipment. Confirmation of the makeup of these clusters is critical as a measure of the performance of the analysis, particularly for further studies of Ohio's logging industry, where participation of additional individuals is of interest (Johnson and Wichern 2007, Majumdar et al. 2008).

Production forestry's well-being is tied to a logging industry that is competitive in the marketplace. Rickenbach and Steele (2005) and Milauskas and Wang (2006) discussed the evolving environmental, economic, and social challenges facing logging firms, which included shifts in species distributions, timber markets, technology adoption by the industry, and rural population demographics. Policy development in geographic regions where production forestry plays an important economic role has relied on these and other studies to clarify the structure, performance, and needs of this key sector (Egan 2009). Overall business management and financial issues were the primary concerns for Minnesota loggers (Smidt and Blinn 1994). West Virginia firms cited workers' compensation insurance as their overriding cost factor (Luppold et al. 1998), while Georgia suggested indirect benefits of labor costs (Greene et al. 1998). The industry as a whole in the eastern United States cited labor as the number one cost (Stuart et al. 2008).

Fuel costs have risen substantially since those studies. The prevailing issue among this study of Ohio loggers was

Table 5.—Ratings for the future concern loggers had for the cost variables surveyed.

Variable	Cluster[a]		
	Local Mill Suppliers	Product Merchandisers	Volume-Dependent Producers
Equipment costs	3.4 B (2.1)	4.3 B (1.8)	5.9 A (1.1)
Labor costs	2.6 C (1.4)	4.8 B (1.7)	5.9 A (1.1)
Consumables costs	3.5 C (1.8)	5.5 B (1.2)	6.4 A (0.6)
Administrative costs	1.7 B (1.0)	2.9 B (1.6)	4.8 A (1.6)
Insurance costs	2.6 C (1.3)	4.6 B (1.9)	5.7 A (1.3)
Cost of contract services	2.3 B (1.3)	3.4 AB (1.9)	4.0 A (1.8)

[a] Values are means (standard deviations). Means with different letters across rows are significantly different at $\alpha = 0.05$.

Table 6.—Within-cluster mean ratings comparing loggers' current and future perceptions for the cost variables surveyed.

	Cluster					
	Local Mill Suppliers		Product Merchandisers		Volume-Dependent Producers	
Variable	Current	Future	Current	Future[a]	Current	Future[a]
Equipment costs	2.0	3.4	4.1	4.3	5.8	5.9
Labor costs	2.3	2.6	4.2	4.8*	5.5	5.9
Consumables costs	3.3	3.5	5.2	5.5**	6.5	6.4
Administrative costs	1.6	1.7	2.6	2.9**	4.4	4.8**
Insurance costs	2.5	2.6	4.6	4.6	5.6	5.7
Cost of contract services	1.7	2.3	3.1	3.4	3.5	4.0*

[a] * Significantly different at $\alpha = 0.05$; ** moderately different at $\alpha = 0.10$.

Table 7.—Discriminant analysis summary of misclassification results.

	No. of individuals in each cluster			Misclassification of future individuals (%)
Cluster	Local Mill Suppliers	Product Merchandisers	Volume-Dependent Producers	
Local Mill Suppliers	17	0	0	0
Product Merchandisers	0	33	0	0
Volume-Dependent Producers	0	2	26	7.1
Total	17	35	26	2.4

the cost of consumables, primarily fuel, which was similar to more recent studies in New York (Egan 2009) and southern New England (Egan 2011). This variable rated the highest among the 15 current productivity and cost variables. It was also the highest-rated variable of future cost concern. To help alleviate these costs, a fuel cooperative was established for both forest and agricultural producers, with the first station opened in south-central Ohio in 2012. Expanding the number of fueling stations offered through the cooperative may provide the greatest immediate benefit to Ohio's logging industry.

Conclusions

Ohio logging firms segmented into three clusters: Local Mill Suppliers, Product Merchandisers, and Volume-Dependent Producers. The clusters were similar in regard to the running of their businesses, but significantly differed concerning selected productivity and cost issues. Volume-Dependent Producers had the greater concerns, followed by Product Merchandisers and Local Mill Suppliers. Volume-Dependent Producers owned more pieces of large equipment per company than the other clusters. While no cluster was larger in terms of production, cost concerns did move with production. Volume-Dependent Producers would likely be the primary benefactors of small-business technical assistance and outreach. Providing contractors with fuel-savings opportunities could deliver immediate benefits to the industry as a whole.

Acknowledgments

This research was funded by the OSU Cares Innovative Grant Program. Megan Barnes, Kelly O'Bryant, and Ryan Mapes, The Ohio State University; John Dorka, Ohio Forestry Association; and Eric Roush, Glatfelter, kindly assisted with survey development. Dr. Nathan Little offered valuable suggestions to improve an earlier version of this manuscript. The constructive comments of the anonymous reviewers were greatly appreciated.

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