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Measuring Firm Innovativeness: Cross Validation

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ABSTRACT

The primary purpose of this research was to test the validity of a structural model linking firm innovativeness and performance. A scale for innovativeness was recently developed for use with forest products companies. We conducted structural equation modeling analysis (SEM) to perform a tight cross-validation of the calibration sample (110 U.S. softwood sawmills) on two independent samples: 1) a validation sample composed of 117 primary forest products manufacturers; and 2) a validation sample composed of 101 secondary forest products manufacturers. The validation strategy allowed testing both for measurement invariance and structural invariance. SEM results validated the model at both levels and allowed merging all of the datasets and conducting a pooled analysis of the model. A positive relationship between innovativeness and performance was confirmed on both validation samples as well as on the merged sample. These results support the use of the new scale linking firm innovativeness and performance across the entire U.S. forest products industry, regardless of business type (e.g., primary or secondary manufacturing).

Keywords: firm innovativeness, financial performance, firm size, cross validation

Introduction

Innovation is the introduction of new products, processes, or business systems. The importance of innovativeness has been acknowledged by previous research, but many shortcomings have been identified with existing methods of measuring firm innovativeness. Deshpande and Farley (2004) point out several weaknesses of currently available scales and call for a universally valid and reliable measure of innovativeness. Crespell et al. (2006) also recognize the weakness of current scales for measuring innovativeness and call for the creation of a robust, reliable, and valid scale to measure the construct.

Innovativeness has been measured using several methods in previous research including current technology, self-evaluation, research and development funding, the number of new products introduced, and intellectual property. In addition to the multiple methods used to measure innovativeness, there have been numerous conceptualizations and definitions of innovativeness. This work serves to validate a new scale developed to assess firm innovativeness (Knowles et al. 2008) across several independent samples.

Theoretical Frame of Reference

Definition of Firm Innovativeness

Firm innovativeness has been defined in various ways in previous research. Several researchers have defined an innovative firm as one that adopts innovations (Utterback 1974, Daft 1982, Attewell 1992). Rogers (2003, pg. 22) defines innovativeness as “the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than any other member of the system.”

The definition often includes creativity, with innovativeness considered “the capacity of an organization to improve existing products and/or processes, and the capacity to utilize the creativity resources of the organization to the full[est]” (Gebert et al. 2003). Hurley and Hult (1998) broadened the concept further, defining innovativeness as “the notion of openness to new ideas as an aspect of a firm’s culture” implying that innovativeness is an integral part of the culture of the firm.

Recent work examined innovation in the forest products industry in Oregon and Alaska. Three aspects of innovativeness were identified – product, process, and business systems – showing that firms view not only new products and manufacturing processes as innovations, but also new business systems. Business systems innovation does not provide a new product or service, but consists of the development of new markets, the introduction of new management systems, marketing methods, administrative processes, or staff development programs (Hovgaard and Hansen 2004). These categories were identified also with larger companies across multiple countries (Hansen et al. 2007).

The definition of innovativeness used in this study is a more holistic definition adapted from the above definitions. Innovativeness here is: *the propensity of firms to create and/or adopt new products, manufacturing processes, and business systems.*

Innovativeness and Financial Performance

Innovativeness has historically been identified as an important factor impacting the performance of a business (Schumpeter 1934, Burns and Stalker 1961, Porter 1990). The link between firm innovativeness and financial performance has been thoroughly investigated across many industries (e.g., Damanpour et al. 1989, Narver and Slater 1990, Han et al. 1998, Hurley and Hult 1998, Desphande and Farley 2004). The broad consensus of this research is that more innovative firms perform better financially. Investigations of the forest products industry have also shown a positive relationship (Crespell et al. 2006, Knowles et al. 2008). Despite this evidence of a positive relationship between innovativeness and financial performance, the results of some previous work have shown the relationship to be inconclusive (Rogers 2003).

Innovativeness and Firm Size

Firm size has been found to have a positive association with innovation (Schumpeter 1942, Price and Mueller 1986). This positive association is especially true for incremental (process) innovation (Cohen and Klepper 1996). Past research in the forest products industry has found that process innovation is the most common (Crespell et al. 2006). Other research, however, indicates that different sized companies choose to concentrate on different types of innovation (Wagner and Hansen 2005). Small firms may be better suited to realize radical innovations (Rosen 1991). As such, size should be included as a covariate when studying the relationship between innovativeness and firm financial performance (Murphy et al. 1996).

Data and Sampling

Calibration Sample

The sample frame for the calibration sample consisted of every softwood sawmill in the United States and Canada (excluding Quebec) listed in the 2005 Big Book (463 sawmills). The target respondent for the questionnaire packet was the top manager at the sawmill. Each sawmill was mailed a study announcement letter, addressed to the top manager, providing a description of the study objectives, methodology, and expected outcomes. Approximately one week after mailing the announcement letter, the top manager at each of the selected sawmills was faxed a cover letter with an accompanying copy of the questionnaire. Respondents were encouraged to respond by fax; however, they were also given a mailing address where they could send their completed questionnaire. Approximately one week after the original questionnaire was faxed, a reminder postcard was mailed to all of the sawmills that had not responded. Approximately two weeks after the reminder postcard, a second questionnaire packet was faxed to all of the sawmills that had not responded. Due to a lower than expected response rate after faxing the questionnaires, a questionnaire packet was mailed to all of the sawmills that had not responded to the first two rounds of faxes approximately one week after the second questionnaire packet was faxed. The final response rate for the calibration sample was 25.1 percent.

Validation Samples

Model validation was performed using two validation samples drawn from the same population. Data in these samples was collected from forest industry mill managers between December 2006 and March 2007. Validation Sample I was composed of manufacturers from the primary wood processing industry (n = 571). Validation Sample II was composed of secondary manufacturers who rely on finished primary products as their production input (n = 882). The overall response rate for the validation samples was 15.2 percent (20.5% for primary manufacturers and 11.5% for secondary manufacturers). The industry sectors represented in the calibration sample and the two validation samples are shown in **Table 1**. Detailed methods for sampling can be found in Crespell and Hansen (2007).

Table 1. Industry sectors represented in the calibration sample and the two validation samples.

Calibration sample		Validation sample I		Validation sample II	
Primary manufacturers	**n**	**Primary manufacturers**	**n**	**Secondary manufacturers**	**n**
Softwood lumber	110	Softwood lumber	11	Moulding and millwork	38
		Hardwood lumber	19	Furniture	21
		Softwood plywood	4	Cabinets	29
		Hardwood plywood	19	Windows and doors	13
		Oriented strandboard (OSB)	1		
		Particleboard	1		

		Engineered wood products	17		
		Other primary[a]	45		
Total	110	Total	117	Total	101

[a] Includes pallet manufacturers and wood treating mills.

Geographic Representation of Samples

Geographically, the calibration sample represented all of the regions of the continental United States and Canada, with the exception of Quebec. Both validation samples were well represented in all regions of the continental United States, although there was a clear dominance of the East Coast, reflecting the higher density of forest products companies in that region.

Concept Measurement

Innovativeness

Innovativeness was assessed in this study using the propensity to create/adopt new product, process, and business systems scale developed by Knowles et al. (2008). This scale was composed of 15 items, assessed using a 7-point Likert scale where 1 = strongly disagree and 7 = strongly agree (**Table 2**).

Table 2. Fifteen items used to measure firm innovativeness.

Our company tends to be an early adopter of new products.
Our company actively seeks new business systems from outside this organization.
Our company actively develops in-house solutions to improve our manufacturing processes.
Our company actively develops new products in-house.
Our company tends to be an early adopter of new manufacturing processes.
Within our company, we are able to implement new business systems used by other organizations.
Our company actively seeks new products from outside this organization.
Our company sees creating new products as critical to our success.
Within our company, we are able to implement new products used by other organizations.
When it comes to creating new processes, our company is far better than the competition.
Our company tends to be an early adopter of new business systems.
Our company sees creating new business systems as critical to our success.
When it comes to creating new products, our company is far better than the competition.
Our company sees creating new manufacturing processes as critical to our success.
Our company actively develops in-house business systems solutions.

Descriptive Information

Descriptive information about respondents included the respondent's position at the mill and the number of years they have been with the company. Firm size was measured by the number of employees.

Financial Performance

Financial performance was assessed using a four-item measure based on previous literature (Dess and Robinson 1984). The four items were: after tax return on sales; sales growth rate; after tax return on assets; and overall competitiveness. Respondents were asked to rank their facility into one of five categories based on how their facility compares with competitors in their industry (from bottom 20% to top 20%).

Analysis

Non-Response Bias

Non-response bias was tested using the method advocated by Armstrong and Overton (1977). Each sample was divided into 'early respondents' (first 25% approximately) and 'late respondents' (last 25% approximately). These two groups were compared based on innovativeness, firm performance, and firm size. The results of the independent samples t-tests showed no significant differences between these two groups for each sample with all *p*-values being above 0.05.

Model Validation

Structural equations modeling analysis was performed using EQS 6.1 (Bentler 2006). Estimation was done using the Maximum Likelihood algorithm and Robust methods. In the presence of deviations from the multivariate normal assumption, EQS allows the estimation of adjusted parameters through the use of Robust methods. Our datasets exhibited non-normality and hence robust estimators are reported. Additionally, the five records that caused the largest effect on the deviation from the normal distribution were detailed. Four of those records were primary manufacturers (Validation Sample I) and one was a secondary manufacturer (Validation Sample II). Multiple imputation was performed using the ME algorithm to account for missing values for the performance variables (Acock 2005). The approach to validation followed the seminal work by Jöreskog (1971), as described by Byrne (2006). In this 'invariance-testing strategy', a final model (that with the best fit for the *calibration* sample) is tested on a second (or more) independent *validation* sample from the same population. This strategy tests the replicability of both the measurement and structural models across groups. Covariation was allowed between 'return on assets' and 'return on sales.' This was based on the literature (Hansen et al. 2006) and Lagrange tests.

In the hypothetical model, *number of employees* acts as a covariate adjusting for differences in mill size. **Table 3** shows the size distribution in each sample.

Table 3. Distribution of mill size (n employees) by sample.

# of employees	Calibration	Primary	Secondary
1: 1 to 20	21	1	0
2: 21 to 50	13	22	22
3: 51 to 100	29	54	46
4: 101 to 200	36	28	24
5: 201 to 400	11	8	5

6: >400	0	2	3
Missing	0	2	1
Total	110	117	101

Results

The hypothesized model (**Figure 1**) was tested and modified based on data from the calibration sample of sawmills. The final best-fitting model for this sample yielded acceptable goodness of fit statistics (Calibration, **Table 4**). This model served as the baseline for further validation testing.

Figure 1. The hypothetical model evaluated in this paper.

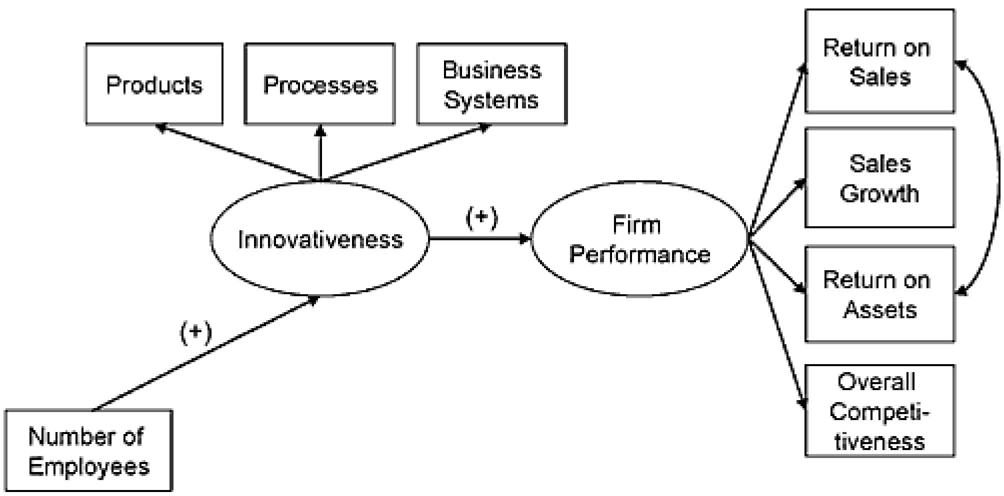


Table 4. Goodness of fit statistics. All samples.[a]

Group	n	X2	df	S-BX2	CFI	RMSEA	90% RMSEA CI	SRMR
Calibration	110	51.5	18	49.3	0.93	0.13	0.84, 0.168	0.10
Validation I	117	37.2	18	35.5	0.96	0.09	0.045, 0.135	0.08
Validation II	101	31.4	18	29.0	0.97	0.08	0.007, 0.013	0.08
Multigroup P[b]		99.7	44	92.9	0.94	0.10	0.072, 0.128	0.13
Multigroup S[c]		93.5	44	74.7	0.96	0.08	0.048, 0.112	0.10

[a] S-BX2 = Satorra-Bentler scaled statistic; CFI = robust comparative fit index; RMSEA = robust root mean square error of approximation; CI = confidence interval; and SRMR = standard root mean squared residual.
[b] Sawmills and primary manufacturers analyzed as multigroup.
[c] Sawmills and secondary manufacturers analyzed as multigroup.

Both multigroup models showed an acceptable fit, as evidenced by high values for robust comparative fix index (CFI) and robust root mean square error of approximation (RMSEA) less than or equal to 0.10 (Hu and Bentler 1999, Browne and Cudeck 1993). The ratio X2/df was close to 2.0, which indicates good fit. Standard root mean squared residual (SRMR) was slightly high for multigroup P, given a cutoff point of 0.10.

An inspection of the Lagrange multiplier test of equality constraints revealed support for all of the constraints, as indicated by a non-significant probability (**Table 5**).

Table 5. Lagrange multiplier test of equality constraints.

#	Constraint	Validation I Univariate Increment Probability	Validation II Univariate Increment Probability
1	(1, F2, Sales Growth (SG)) = (2, F2, SG)	0.20	0.43
2	(1, F2, Return on Assets (ROA)) = (2, F2, ROA)	0.83	0.89
3	(1, F2, Overall Competitiveness (OC)) = (2, F2, OC)	0.76	0.45
4	(1, F1, Process Innovativeness) = (2, F1, Process Innovativeness)	0.24	0.13
5	(1, F1, Business System Innovativeness) = (2, F1, Bus Sys Innovativeness)	0.47	0.74
6[a]	(1, F2, Return on Sales (ROS)) = (2, F2, ROS)	0.58	0.87
7	(1, Error ROS, Error ROA) = (2, Error ROS, Error ROA)	0.22	0.43
8[a]	(1, F1, Product Innovativeness) = (2, F1, Product Innovativeness)	0.22	0.11
9	(1, F1, N Employees) = (2, F1, N Employees)	0.08	0.59
10	(1, F2, F1) = (2, F2, F1)	0.98	0.90

[a] Obtained from an independent run where the loadings previously fixed to 1.0 were freed to allow testing invariance of all factor loadings (probabilities are not comparable). F1 = Innovativeness, F2 = Firm Performance

These results confirm that the hypothesized causal pattern of innovativeness on firm performance is equivalent across three independent samples of forest products manufacturers. Once model invariance was determined across samples, the data was pooled and a new analysis was conducted to estimate both the measurement model and the structural model. In presence of correlated errors, coefficient RHO is the best indicator of reliability. RHO for the measurement model took a value of 0.87, which indicates high reliability of the scales. **Table 6** shows the loading coefficients and errors from the measurement model. It also shows the values for composite reliability and variance extracted.

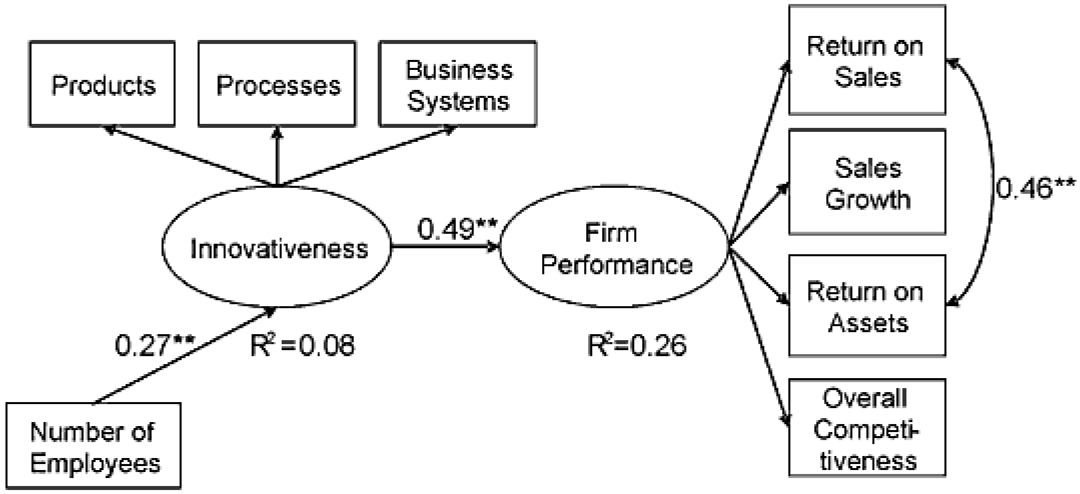
Table 6. Standardized loading coefficients and errors for the measurement model. Pooled analysis.

Indicator	Standardized loading	Error	Composite reliability	Variance extracted
Return on sales	0.75	0.66	0.80	0.50
Sales growth	0.68	0.74		
Return on assets	0.84	0.55		
Overall competitiveness	0.86	0.50		
Product innovativeness	0.90	0.43	0.83	0.62
Processes innovativeness	0.91	0.42		
Business systems innovativeness	0.83	0.56		

The values for composite reliability and variance extracted are equal or above the cutoff points of 0.7 and 0.50, respectively, which supports construct validity (Fornell and Larcker 1981, Anderson and Gerbing 1988). The structural model showed good fit, with the following statistics: CFI = 0.97, SB-X^2_{18}:

46.3, RMSEA = 0.070 [0.045, 0.095], SRMR = 0.07. **Figure 2** shows the model and its estimated parameters.

Figure 2. The model and its parameters. Pooled analysis (factor loadings not shown).



Discussion and Conclusions

This work provides support for the validity of the newly developed scale for measuring firm innovativeness, with the scale showing acceptable validity when used with three independent samples. The results of this work provide further support for the results of a previous assessment of this scale (Knowles et al. 2008). The results of this study suggest that the newly developed scale for innovativeness can be used on both primary and secondary forest products manufacturers. It is possible that this scale is also suitable for use in industries other than forest products because the items in the scale are not specific to the forest products industry.

The results confirm previous work, showing a positive and significant relationship between firm innovativeness and financial performance (Damanpour et al. 1989, Narver and Slater 1990, Han et al. 1998, Hurley and Hult 1998, Desphande and Farley 2004, Crespell et al. 2006, Knowles et al. 2008). This is an important result because both firm innovativeness and financial performance were measured using self-rated, subjective scales. Consistent with previous findings, product and process innovativeness were found to be stronger indicators than business systems (Crespell et al. 2006). The forest products industry has focused mostly on these two types of innovations, leaving room for future progress on business systems innovations.

Firm size, measured by number of employees, was found to be a significant covariate, suggesting a positive association with innovativeness. This is also consistent with previous findings and could be a proxy for availability of resources and higher levels of networking within companies (Wagner and Hansen 2005). In other words, the more resources available, the more innovative a firm can be. A large size may also facilitate higher levels of influence over competitors, channels of distribution, regulating agencies and customers. This in turn may allow for a more proactive market orientation and higher levels of innovation.

Limitations and Further Research

The cross-sectional nature of this study prevents any claims of causality or predictive validity. The absence of an independent rating of innovativeness prevents the assessment of concurrent validity. Therefore, it is expected that more complex longitudinal studies are needed. Future work should follow a multi-trait multi-method approach, executed over a period of time, allowing for test–retest correlations and the assessment of predictive validity.

An additional limitation of this work is the use of subjective measures of firm performance. While previous research has shown a strong relationship between subjective and objective measures of firm performance (i.e., Dess and Robinson 1984), future work should focus on validating this scale with objective performance measures.

Churchill (1979) identifies the creation of a measurement instrument as an iterative process, requiring multiple stages of data collection and scale refinement. The scale validated in this manuscript was developed using a two-stage process. Further work is required to complete the refinement of this measure.

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