Dealing with the Housing Crisis: A Study on Softwood Sawmills in the Southern United States

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Abstract

In this article we discuss the impact of the recent housing crisis and economic recession on the southern US softwood sawmill industry. We use the first difference model to quantify the impact of market conditions on the performance of independent sawmills including their adjustments and responses between 2006 and 2012. Our results show that lumber and log price change, adjustment in product mix and labor input, and export strategy were key factors influencing production and capacity utilization levels during and after the housing crisis. Furthermore, these factors contributed in different magnitudes in the housing crisis and recovery periods.

Softwood lumber is the single largest category of forest products in the United States. The production of softwood lumber is closely associated with the housing sector in North America as some 80 percent of softwood lumber in the United States ends up in housing construction projects (Spelter et al. 2007). Because the US housing sector experienced a severe crisis between 2007 and 2009, as evidenced by plummeting housing starts from 2.07 million units in 2005 to 0.55 million units in 2009, total softwood lumber consumption in the United States declined sharply from 64.3 billion board feet (bbf) to 31.3 bbf (Sasatani 2013), and lumber prices dropped almost 50 percent—from \$386 to \$198 per thousand board feet (mbf) in the same period (Random Lengths 2010).

The southern region of the United States contributes about half of the overall softwood lumber production in the country (Majumdar et al. 2011, Brandeis et al. 2012). Not surprisingly, the housing crisis had a big negative impact on forestry employment and timber product outputs in the region, and the forest sector's contribution to the regional economies was down by 24 percent between 2004 and 2009 (Hodges et al. 2011). However, it is unclear how individual sawmills adjusted strategically and coped with the crisis.

The purpose of this article is to discuss, in a quantitative fashion, how sawmills in the US South adjusted and coped with the severe housing crisis and to identify factors that contributed to the survival and success of these sawmills. In particular, we reveal responses, actions, and productivity changes during and after the housing crisis, such as employment levels, wood supplies and sources, product mix, and export strategies of independent sawmills, which typically are small or medium-sized firms. In response to economic shocks, firms that are able to carry out their critical activities exhibit a higher resilience than other firms (Berkes and Folke 1998). In 2009 and 2010, virtually every major western forest mill had curtailments and 30 large mills closed permanently (Keegan et al. 2011). While using sawmill-level data from Canada, Pinkerton and Benner (2013) found that the number of days in operation of value-added specialty sawmills is greater than commodity sawmills because the former have higher job requirements, greater production flexibility, more diverse products and markets, and more usable log species.

Most previous research on the US sawmill industry in the recent recession used macro-level aggregated data to gauge the industry-wide impact of the recession (e.g., Hodges et al. 2011, Keegan et al. 2011, Woodall et al. 2011). With the exception of Pinkerton and Benner (2013), who merely used descriptive statistics, there has not been any study that incorporates modeling to study how individual firms

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adjusted their production during the housing crisis and the recovery. In this article we try to fill in this gap. This article differs from other studies insofar as it focuses on independent sawmills and uses micro-level data obtained from a survey of sawmills in the southern United States. This study may help policy makers and sawmill owners better understand the competitive landscape of this industry after the recession.

Hypotheses and Methodology

The softwood lumber industry is a competitive industry, and softwood lumber is often regarded as a commodity (Murray 1995). As such, sawmills are competing on market segments (domestic vs. foreign markets) and product mixes on the output side and timber procurement, labor, and capital costs on the input side. In the long run, sawmills are also competing on technology and productivity. When there is a recession and lumber demand is down in the United States, sawmills would have to adjust their supply—including the segments of market they wanted to focus on as well as their inputs.

Thus, we hypothesize that when US lumber demand is down, softwood lumber producers would try to (1) ship more products overseas, (2) choose different product mixes, and (3) use more timber from their own timberland if they could not get timber from other sources. Of course, when lumber demand goes down, sawlog prices often fall as well. Our empirical constant time effects model (hereafter referred to as Model 1) is formulated as

$$Y_{it}^{j} = c + \beta^{j} X_{it} + \mu_{i}^{j} + \delta^{j} t + \varepsilon_{it}^{j} \tag{1}$$

where Y_{it}^{j} is the performance indicator j of sawmill i in year t. Performance indicator j represents a sawmill's annual lumber production volume or its capacity utilization, the ratio of actual production to annual production capacity. Furthermore, X_{it} is the vector of time-variant explanatory variables, μ_{i}^{j} is a sawmill-specific factor, δ^{j} is a vector of time-specific estimators, ε_{it}^{j} is residual error, and c and β are coefficients.

Model 1 assumes that the coefficients of factors affecting performance are constant over time. In reality, they could change, especially in different phases of a business cycle such as the housing crisis period from 2006 to 2009 and the recovery period from 2009 to 2012. To test if the β coefficients are substantially different across business cycle phases, we have modified Model 1 into a time-specific effects model (hereafter referred to as Model 2):

$$Y_{it}^{j} = c + \beta_{k}^{j} X_{it} + \mu_{i}^{j} + \delta^{j} t + \varepsilon_{it}^{j} \tag{2}$$

where β_k indicates the vector of coefficients β taking different values during and after the housing crisis.

Our selection of independent variables in both Model 1 and Model 2 is based on Hotelling's Lemma, which states that product supply is a function of output price and unit input costs. In our case, the output price is softwood lumber price, and the most important unit input costs include log price and labor cost. Thus, all the independent variables we used are these variables and factors affecting these variables, including

- market condition variables (lumber prices) as small and medium-sized enterprises (SMEs) are assumed to be price takers in a lumber market;
- production input variables such as log price and the number of direct workers for operation;
- forest ownership variables: softwood sawmills owning forests have some flexibility in their sources of timber supply; and,
- business strategy variables such as exports that could be measured by percentages of lumber sold to the export markets, and changing product mix, which helps firms respond to changes in market demand.

Finally, we could not ignore the possible omitted variable bias if the individual-specific, time-invariant heterogeneity component μ_i was not available. If μ_i is correlated with the regressors, fixed-effects models are preferred to random-effects models. The results of the Hausman test (Hausman 1978) showed that fixed-effects models are preferred rather than random-effects models in our estimation.[1]

Time-differencing Models 1 and 2 permit us to eliminate the influences of μ_i, resulting in

$$\Delta Y_{it}^{j} = \beta^{j} \Delta X_{it} + \delta^{j} + \vartheta_{it}^{j} \tag{3}$$

and

$$\Delta Y_{it}^{j} = \beta_{k}^{j} \Delta X_{it} + \delta^{j} + w_{it}^{j} \tag{4}$$

where Δ represents simple change between time periods t and $t-1$, and the last term in each of these two equations is the respective residual errors. First-difference variables are used for estimation. Coefficient δ^{j} measures the additive time effects.[2] Coefficients β_k would be estimated using an interaction between dummies for business cycle phases and first-differenced independent variables. A joint test of the interaction effects gives the preferred estimation between Equations 3 and 4 as to different performance indicators. As shown in the ''Results'' section below, Equation 4 (time-specific effects) is preferred for both the production and capacity utilization models.

Data

The population of this study includes softwood sawmills owned by SMEs[3] in the US South,[4] and the unit of observations in the study is a single sawmill establishment (i.e., each sawmill). Profile of softwood sawmills in the United States and Canada 2013 (Spelter et al. 2013) and Big Book 2013 (Random Lengths 2013) were used to identify the population of the study. We excluded sawmills owned

[1] The Hausman test was used to select an appropriate specification based on Model 1. The results for the production function are $\chi^2_7 = 223$ and Prob $> \chi^2 = 0.00$, indicating that our initial hypothesis that the individual-level effects are adequately modeled by a random-effects model is rejected. We also chose a fixed-effects specification for capacity utilization function for comparing the effects of independent variables on these two performance indicators.

[2] In the final estimation, we deleted this additive time-effects variable because δ^{j} is insignificant at the 10 percent level in both Equations 3 and 4.

[3] In this article, we adopted the definition by the US Small Business Administration Office of Advocacy: SMEs include all enterprises with fewer than 500 employees (US International Trade Commission 2010). SMEs usually do not include microenterprises.

[4] The US South includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Oklahoma, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

by large integrated forest products firms such as Georgia Pacific, Weyerhaeuser, West Fraser, and Canfor; microsawmills whose annual production capacity was less than 15 million board feet (mmbf); and lumber remanufacturers. This resulted in a population of 107 sawmills operating in 2013. We understand that these sawmills survived the housing crisis and that, therefore, our results are likely to have survival bias. There was no newly established sawmill located within the geographic area during this time span.

We designed a survey questionnaire and pretested it with sawmill managers attending the Alabama Forestry Association's annual meeting in 2013. Because the population for this study was quite small, we utilized multiple methods to collect data. We first used a mail survey because it provided the most efficient and cost-effective means of gathering data from a large, geographically dispersed population (Dillman 1991). Before sending out the survey, we called the managers of all sawmills, informed them of the objectives of the research, and asked for their participation. Each mail survey contained a cover letter, a questionnaire, and a postage-paid return envelope. Follow-up surveys were sent out 2 months after the initial mailing. Additionally, we conducted structured interviews on the basis of the same questionnaire with sawmill managers who preferred to answer questions over the phone or face to face during industry meetings.

In total, 41 responses were received, which represents 38 percent of the target population. Among these, 22 were from the mail survey and 19 were from structured interviews. Nonresponse bias was evaluated comparing mean values of respondents from the initial mailing and from the second mailing (Armstrong and Overton 1977). We also evaluated potential bias introduced by the different data collection methods by comparing mean values of respondents. On the basis of the nonparametric Mann-Whitney *U* test, we could not find any evidence of systematic bias. Table 1 presents the definition and summary statistics of the variables used in the empirical model of the balanced sample of 123 sawmills (i.e., 41 sawmills in 2006, 2009, and 2012, respectively).

Annual production is defined as the annual volume of softwood lumber produced. Responding to the housing crisis, the average annual production decreased by about one-third, from 83 mmbf in 2006 to 56 mmbf in 2009 before rebounding to 77 mmbf in 2012. However, the annual production capacity remained relatively stable: 78 percent of respondents did not change their production capacity during the recession, and 80 percent of respondents did not adjust production capacity during the recovery period. The mean values of production capacity were 88, 87, and 92 mmbf in 2006, 2009, and 2012, respectively. As such, production capacity is treated as a time-invariant variable and omitted from our empirical model. Still, the production capacity utilization provides us with a measurement of sawmill performance. As shown in Table 1, the annual capacity utilization decreased from 92 percent in 2006 to 68 percent in 2009 before rebounding to 83 percent in 2012.

The mean number of direct workers (full-time operation workers from log yard to product shipping) was 102 in 2006 and 75 in 2009. The mean number of indirect workers (overhead, support, marketing, administration, forest procurement) remained stable from 2006 to 2012, varying from 17 to 18, which was treated as a time-invariant variable and omitted in the empirical model. The average number of direct workers per annual production was 1.24, 1.34, and 1.20 workers per mmbf in 2006, 2009, and 2012, respectively. This implies that sawmills were unwilling or unable to adjust their workers on the basis of the level of production during the crisis; some 29 percent of respondents did not even reduce the number of direct workers from 2006 to 2009. On the other hand, small and medium-sized sawmills in the US South had flexibility to operate below capacity and production efficiency during economic shocks, which is consistent with the finding of Pinkerton and Benner (2013).

The average sawlog price (respondents reported average price for purchased logs at the mill gate assuming same volume and quality) decreased 19 percent from 2006 to 2012. This decrease is much smaller than the reported average regional delivered softwood sawlog price in the same period (Timber Mart South 2014). There are two possible explanations for this discrepancy. One is that some sawmills used the revenues from their chip sales against their log costs and possibly excluded cost from wood harvested from timberlands that they owned. The other is possible bias in our study sample. Although not reported in Table 1, some 46 percent of the responding sawmills invested in improving their mills (including production efficiency, grade, product mix, and recovery rate) in the crisis period from 2006 to 2009, and this percentage increased to 61 percent in the recovery period from 2009 to 2012. Almost one-third of them invested in facilities during both periods.

On average, 62 and 12 percent of the softwood lumber of the responding sawmills were dimension lumber and timber

Table 1.—Summary statistics of participating sawmills.[a]

	Description	2006	2009	2012
Production	Annual volume of softwood lumber produced (mmbf/yr)[b]	82.53 (54.50)	56.17 (36.07)	76.88 (48.17)
Capacity utilization	Ratio of annual production to capacity (%)	91.67 (0.11)	67.91 (0.20)	82.78 (0.16)
Labor	No. of direct workers for operation	101.98 (60.74)	75.44 (45.23)	92.24 (51.94)
Log price[c]	Average price index for purchased logs at the mill gate (2006 = 100)	100.00 (0.00)	83.25 (12.90)	81.43 (15.12)
Own logs	Logs originated from own forest lands (%)	9.85 (21.56)	10.51 (21.49)	6.12 (13.84)
Dimension	Share of dimension lumber (%)	62.47 (35.13)	59.21 (37.01)	57.33 (38.38)
Timber	Share of timber volume (%)	11.65 (21.67)	13.61 (22.37)	16.95 (26.41)
Lumber price	Random Lengths framing lumber composite price ($)	327.00 (0.00)	222.00 (0.00)	322.00 (0.00)
Export	Lumber sold to the export markets (%)	8.33 (19.61)	11.13 (21.90)	12.26 (22.94)

[a] Values are means with standard deviations in parentheses.

[b] mmbf = million board feet.

[c] In the survey, we asked the approximate percentage of change (either increase or decrease) in the average price for purchased logs (assume same volume and quality) at the mill gate in 2009 and 2012 relative to 2006.

(for framing), respectively, and the remaining was other lumber products that included 1-inch lumber in 2006. By 2012, the percentage of dimension lumber decreased to 57 percent, whereas the percentage of framing timber increased to 17 percent. None of the responding sawmills produced studs during the research period. A couple of sawmills significantly shifted their production toward timber because of changing market demand. For example, one sawmill primarily producing dimension lumber in 2006 stopped operation and reinvested in its facility during the housing crisis and became a timber mill by 2012.

About 61 percent of the respondents owned forest land. The mean value of forest land owned by each sawmill was 27,680 acres, and forest ownership did not change from 2006 to 2012. Holding timberland enhances a forest products company's profitability and lowers its systematic risk (Li and Zhang 2014). The mean percentage of sawlogs from owned forest lands increased slightly from 2006 to 2009 and then declined from 2009 to 2012. This is because sawtimber stumpage prices are lagging a couple of quarters to southern lumber production (Fig. 1), which means that sawmills relied on their own timber when stumpage prices were high. Furthermore, as stumpage prices fell in the crisis period, nonindustrial private landowners were reluctant to sell their timber, possibly forcing sawmills to rely more on their own timber. On the other hand, many sawmills relied on logs from external sources after the housing crisis because log prices remained low and nonindustrial forest landowners either accepted the reality of low stumpage price or could not postpone timber harvesting anymore. Surprisingly, some sawmills decided to use more logs from their own forests in the middle of the crisis. One sawmill owner even increased the share of logs from his own forest land from 5 percent in 2006 to 90 percent in 2009 because he wanted to keep his sawmill running.

Sawmills adopted different international business strategies during 2006 to 2012. Overall, about 92 percent of lumber was sold to the domestic market in 2006, and this percentage dropped to 88 percent with a higher deviation in 2012. About 76 percent of sawmills sold more than 95 percent of their lumber to the domestic market in 2006. In 2012, only 66 percent of sawmills sold more than 95 percent of their lumber to the domestic market. About one-fifth of these sawmills generated all their profits in the domestic market during the entire research period.

Results

Table 2 presents the correlation coefficients between variables. Labor and log price had a correlation coefficient of 0.45. Equations 3 and 4 were estimated using Stata 13.0 with robust standard errors clustering on individual sawmills. Results indicate good fits with adjusted R^2 values above 0.7 and 0.6 for the production and capacity utilization models, respectively. A Tobit model and a fractional panel model were also estimated for the capacity utilization equation. The results are nearly identical to the ones reported here, probably because none of the responding sawmills reached their full capacity in the three survey years.

Possibly owing to the substantial demand change before and after 2009, factors influencing sawmill performance indeed changed over time. The F test value of 2.21 for the capacity utilization model indicated that the coefficients of the two periods were jointly different at the 5 percent significance level. Similarly, the F test value was 1.99 for the production volume model, indicating that they were jointly different at the 10 percent significance level. Therefore, we mainly focus on the results based on the time-specific effects model in Table 3.

The marginal effects of individual variables differ between the crisis and recovery periods as well. During the housing crisis, export, log price, and the number of direct workers had significant effects on production and capacity utilization. After the housing crisis, lumber price, owned logs, and number of direct workers had significant effects on both performance indicators.

Market conditions and performance

We used Random Lengths framing lumber composite price as a proxy for lumber prices at individual sawmills. To

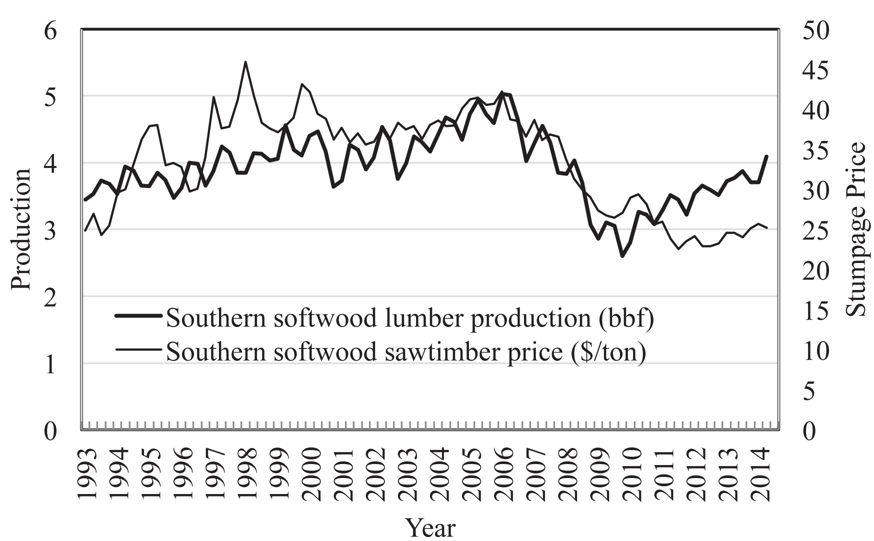

Figure 1.—Quarterly southern softwood lumber production and southern softwood sawtimber stumpage prices: 1993 to 2014. Data sources: Timber Mart South (2014) and Western Wood Products Association (US Monthly Softwood Lumber Production by Region, personal communication, 2014).

Table 2.—Pearson correlation coefficient matrix.[a]

	Labor	Log price	Owned logs	Dimension	Timber	Lumber price	Export
Labor	1						
Log price	0.4473	1					
Owned logs	−0.0864	−0.2524	1				
Dimension	0.0326	−0.1020	−0.0162	1			
Timber	0.0644	0.0590	−0.0668	−0.7745	1		
Lumber price	0.6046	0.5306	−0.1541	−0.1144	0.1394	1	
Export	0.0495	−0.1777	0.0077	0.2183	−0.1128	−0.1263	1

[a] Correlation coefficients are calculated using the annual change value of variable.

the extent that this variable excluded the price of timbers and nonframing lumber, our results may be biased. As shown in Table 3, lumber price had a significant positive effect on production during the recovery period. To be specific, for a given sawmill, one additional dollar increase in lumber price increases production by 106 mbf/yr, ceteris paribus. The effect of lumber price on capacity utilization was significantly positive during both the crisis and recovery periods. This is consistent with our expectation that higher lumber prices lead to more production. As the housing crisis deepened and lumber prices decreased by $105/mbf from 2006 to 2009, the capacity utilization of responding sawmills decreased by 9.5 percent of the 2006 level. Between 2009 and 2012, lumber prices increased about $100/mbf, which helped the responding sawmills to recover by 12.7 percent of the 2006 level, with a higher marginal effect in the recovery period (0.12) compared with in the housing crisis period (0.08).

Export strategy had a positive effect on sawmill performance during the housing crisis period (Table 3). A 1 percent additional lumber sold to the export markets increased the production by 653 mbf/yr and capacity utilization by 1 percent. Responding sawmills' exports increased 4 percent on average from 2006 to 2009, which helped them maintain their production and capacity utilization levels during the crisis.

A 1 percent increase in the share of framing timber volume increased capacity utilization by 1.8 percent during the housing crisis period, which is consistent with anecdotal evidence that some sawmills shifted their production toward timber because of changing market demand. Moreover, shifts to timber production had a significant positive effect on production during the recovery period, with 1 percent additional share of timber volume increasing production by 353 mbf/yr.

Table 3.—Estimation results of time-specific effects models.

		Production		Capacity utilization	
Period	Variables	Coefficient	SE[a]	Coefficient	SE
2006–2009	Labor	0.5048***[b]	0.1492	0.2236*	0.1147
	Log price	0.9315***	0.2425	0.7491***	0.2287
	Owned logs	0.0792	0.2103	0.0473	0.1437
	Dimension	0.2943	0.7406	0.9274*	0.5429
	Timber	0.1909	0.7174	1.8191***	0.6471
	Lumber price	−0.0150	0.0516	0.0825*	0.0478
	Export	0.6531*	0.3500	1.0174***	0.3299
2009–2012	Labor	0.5684***	0.1127	0.2172*	0.1303
	Log price	−0.2207	0.3053	0.2738	0.3333
	Owned logs	0.1789**	0.0872	0.2368**	0.1155
	Dimension	0.1438	0.2061	−0.0393	0.2254
	Timber	0.3531***	0.1306	0.1029	0.1243
	Lumber price	0.1057***	0.0337	0.1166***	0.0398
	Export	−0.3994	0.4442	−0.1007	0.4240
Degrees of freedom		14		14	
Adjusted R^2		0.7356		0.6586	

[a] SE, robust standard errors are clustering on individual sawmills.
[b] * = $P < 0.10$; ** = $P < 0.05$; *** = $P < 0.01$.

Input responses/choices and performance

Consistent with the findings by Nautiyal and Singh (1985), we found that labor inputs significantly affected performance. One additional direct worker increased production by 505 to 568 mbf/yr before and after the housing crisis at the 1 percent significance level. Similarly, labor inputs also had significant positive effects on capacity utilization during the housing crisis and recovery periods. The average reduction of 27 direct workers caused 13.6 mmbf less lumber being produced and a reduction of 6 percent in capacity utilization from 2006 to 2009. The increase of labor input from 2009 to 2012 helped production to rebound. The marginal effects of logs originating from owned forest land on performance were significantly positive at the 5 percent level during the postcrisis recovery period.

Surprisingly, log prices had a significant positive effect on performance during the housing crisis period.[5] This is contrary to our expectation and may be related to the fact that the level of lumber production and log price were both high at the beginning of the crisis period. Moreover, because the responding sawmills only reported an average of 17 percent log price decline between 2006 and 2009 and 19 percent between 2006 and 2012, which were much less than the log price decline seen in the southern United States, we suspect that there was a bias in our responding sawmill sample or in the reported log price data. This indicates that there may be a lack of construct validity or internal validity in the relevant questions in the survey, or that the questions are not measuring what we presumed they would be measuring. Perhaps there was a misinterpretation error by

[5] Because log price could be endogenous, we tried to instrument the log price variable with the strategy (cost reduction vs. quality improvement) and investment of responding sawmills in our survey. The former is a dummy variable. The latter is the total investment between 2006 and 2012. We used an instrumental variable regression and Wooldridge's (1995) score test to check the endogeneity of log price based on Equation 3. The results show that the exogeneity of log price cannot be rejected in the production model (H_0: exogenous, $P = 0.1861$) and the capacity utilization model ($P = 0.1004$). Therefore, we decided to keep log prices in Table 3.

the participants that led to the results. Alternatively and more likely, participants might provide inaccurate data when completing the survey. Finally, a normative explanation is that this result may be an artifact of speculative behavior (Bucklin 1965). Although we consider that this scenario is not likely in this study, it is well established that lumber wholesalers will take on considerable additional inventory if they believe that prices will continue to increase. As the majority of lumber production is sold through wholesalers, perhaps mill managers were reacting to the speculation behavior at the wholesale purchasing side of their business and increasing production despite increased raw material prices.

Discussion and Conclusions

In this article, we report on the market-induced input and output adjustments of independent southern US softwood sawmills during and after the housing crisis by modeling sawmill production and capacity utilization. We use the first-difference model to eliminate the influence of time-invariant variables and capture the time-specific effects of all other variables. Our results show that the lumber price and log price change, product mix, and sawmill adjustments on labor inputs and export strategies were key factors influencing the performance level from 2006 to 2012. Furthermore, the results from our time-specific effect model show that different factors had different impacts during the crisis and recovery periods.

Our results may have several implications. First, small and medium-sized sawmills benefited from export markets in their production and capacity utilization during the housing crisis. This is consistent with Zhang (2012), who found that efforts made by some sawmills in seeking export opportunities helped their survival and businesses. As the total number of direct workers did not vary in proportion to their level of production during the crisis, it seems that these sawmills tended to keep their employees during the economic downturn in fear that they would not be able to hire them back.

Second, factors influencing sawmill performance had varying effects during different phases of a business cycle. Labor input was a crucial factor in both business downturn and recovery. However, during the economic downturn induced by domestic demand decline, log prices and export markets played significant roles in the performance of sawmills. As demand began to increase, lumber price and timber supply from owned timberland had positive effects. All these indicate that sawmills had different focuses in different phases of the business cycle: cost reduction and searching for export markets in the downturn and ramp up of production in recovery.

Third, forest ownership plays a role in the survival and success of independent softwood sawmills in the southern United States. Although small and medium-sized sawmills rely mostly on outside timber supply, owning some timberland allows them to keep their raw material costs down and to get the timber needed during periods of low external supply caused by an economic crisis or bad weather. Even though many integrated forest products companies have sold their timberlands to institutional owners, we do not see sawmills selling their timberland any time soon.

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