Product Life Cycle of the Manufactured Home Industry

Gavin Wherry,[a] and Urs Buehlmann [b,*]

Residential construction consumes an estimated 26 percent of the total U.S. wood harvest and thus plays an important role in the forest products value chain. While being a relatively small part of the U.S. residential construction market, the factory-built residential housing industry, originating from manufactured homes (*e.g.* mobile homes), is embracing emerging industry segments such as modular or panelized homes. Since indications exist that factory-built home production is slated to gain a more prominent role in the U.S. construction markets at the cost of traditional stick-built production, the factory-built home industry sub-segment is of considerable importance to the forest products industry. This research looks at manufactured home producers as a benchmark for analyzing the current economic state of the industry and discusses competitive strategies. The analysis concludes, through macroeconomic modeling, that manufactured homes are in the declining stage of their product life cycle due to changes to the U.S. residential construction sector and the factory-built home industry and by advancements of rival industry-segments. As market share continues to decline, firms operating in this industry-segment seek to either hedge their losses through product diversification strategies or remain focused on strategically repositioning the manufactured home segment.

Keywords: Forest products markets; Residential construction industry; Manufactured housing industry; Product-life-cycle (PLC); Strategic positioning

*Contact information: a: Plant Manager, Universal Forest Products, 2100 Avalon St., Riverside, CA 92509; b: Associate Professor, Department of Sustainable Biomaterials, Virginia Tech, 1650 Research Center Drive, Blacksburg, VA 24061, USA; *Corresponding author: buehlmann@gmail.com*

INTRODUCTION

Residential housing construction activity is critically important for the U.S. forest products industry. McKeever (2009) quantifies the amount of wood products used in U.S. residential housing at 110 million m^3 or 25 percent of all wood fiber supplied from U.S. forests (Wernick *et al.* 1998). In the same year, an additional 19 million m^3 was used by construction-related industries in furniture, cabinetry, flooring, and other value-added manufacturing activities (McKeever 2009). Forest resources used for value-added wood products typically contribute a higher share of income to forest owners than lower-end products such as paper or fuel wood. Thus, forest owners and managers are greatly impacted by the evolution of the U.S. residential housing market and industry. Of particular interest in this manuscript is the evolution of the factory-built housing industry, especially of the industry's most important product, manufactured housing. Also attention is paid to the traditional stick-built residential construction industry's interest in factory-built housing, as the outcome impacts the nation's forest products value chain greatly.

The U.S. residential construction sector is influenced by the cyclical nature of the U.S. economy and has exhibited expansion and contraction periods in relation to a multitude of economic variables (Sullivan and Sheffrin 2003). In the current century,

moderate years of residential construction were seen during the 2000 to 2002 economic cycle. These years saw new home construction maintain levels of 1.57, 1.6, and 1.7 million new home starts (U.S. Census Bureau 2009a). The steadiness of the U.S. home market during the early 2000's was broken by a frenzy of construction activity in 2005 and 2006, when new home starts exceeded 1.9 million units for two consecutive years (U.S. Census Bureau 2009a, 2009e). Such a boom had not been seen in the U.S. since 1971-73, when home starts topped a record high 2.0 million units (U.S. Census Bureau 2009a, 2009c, 2009d). However, after these two years of frenzied activities in 2005 and 2006, the economic depression that started in 2007 reduced the number of new home starts to levels not seen in modern times, hitting bottom in 2009 with 0.75 million units (U.S. Census Bureau 2011).

The U.S. residential single-family home construction sector consists of site-built and factory-built home producers. Site-built construction consists of residential structures erected on-site using mostly dimensional lumber and engineered building components (Gurney 1999). Factory-built construction is defined as residential structures constructed within a manufacturing facility followed by transporting the entire structure or segments of it to the final site (HUD 2007). The factory-built home industry is characterized by its four industry-segments of manufactured (*e.g.*, mobile homes), modular, panelized, and pre-cut homes (HUD 1998). However, the pre-cut home industry-segment is not part of the discourse in this manuscript, as it is a negligible niche of the factory-built home market and to this point has been sheltered from dramatic industry changes (Kochera 1998; U.S. Census Bureau 2009b).

In terms of economic importance, the site-built and the factory-built industries are non-equivalent, with new site-built construction accounting for approximately 1.25 of the 1.35 million new single-family residential home starts in 2007 (U.S. Census Bureau 2008a, 2009g; Manufactured Housing Institute 2008). Alternately, less than 96,000 new residential home shipments were produced by the factory-built home industry during the same year (U.S. Census Bureau 2008a), two-thirds of which were manufactured homes. Indeed, over the past decades, individual success within the sector by the site-built home industry has been at the expense of the factory-built home industry, which has seen market shares decline rapidly over the past decades from a record high of 28% in 1969 to single digits today (Agarwal 1997; Phillips and Kirchhoff 1989; U.S. Census Bureau 2008a).

However, while the factory-built construction sector is currently small compared to the site-built sector and has lost market share due to the demise of manufactured housing's decline, indications exist that factory-built housing will overtake site-built housing in the future (Woodbridge and Associates 2003). Reasons for this expected shift from site-built to factory-built residential housing construction include, among other things, a lack of skilled labor necessary for site-built construction, increasing expectations in quality and consistency of the product by consumers, and limits to efficiency improvements of site-built construction dealing with widely dispersed, often small construction sites that are subject to the elements year-round (Schuler and Adair 2003; HUD 2007). Thus, as the factory-built housing industry is slated to gain in importance, understanding the current state of the U.S. factory-built housing industry becomes critical. In particular, this manuscript provides evidence of the decline of manufactured home industry and discusses implications of the shifting relationship between the manufactured home and the factory-built home industry. This relationship is critically important as manufactured homes producers may possibly be a powerful

spawning ground for other forms of factory-built housing. However, such information is currently nonexistent, as earlier studies on supply, demand, and policy concerning manufactured housing focused on prescriptive recommendations for change, such as lending practices based on real estate titling and demand elasticity of consumer preferences towards manufactured homes within the factory-built home industry (Marshall and Marsh 2007).

Product life cycle (PLC) analysis has widely been used as a tool to reassess and reformulate company strategy. The PLC is an inherent concept pertaining to a market's demand of a specific good over time and can be measured by its sales over a given period (Polli and Cook 1969). A start of a period is defined by the introduction of a product to market, and the period continues throughout the growth, maturity, and declining stages of a product's evolution (Cox 1967). Lackluster industry growth in the maturation stage of the product life cycle is shadowed by an impending turndown throughout industry declination (Harrigan 1980, 1983). Fundamentally, the trend and timeline of the product life cycle are not fixed measures and can be thwarted through efforts geared towards market penetration, development, diversification, and/or application of products to new markets (Day 1981; Covin and Miles 1999; Dess *et al.* 2003; Bouquet and Morrison 2006; Swatch Group 2009). Industries fear the fate of decline, as it is the eulogy to industrial demise and vanishing profitability (Harrigan 1980; Porter 2008). However, as Harrigan (1980) notes, market potential for firms in a declining industry still exists where end game strategies of competitive advantage hedge on market positioning and the sophisticated navigation of barriers to exit (Porter 2008).

While the ongoing changes in the residential construction industry, and the factory-built home industry in particular, is being discussed, no conclusive proof of the status of the product life cycle of the industry has been provided, yet. This study, using an index of U.S. manufactured home shipments to U.S. residential home starts, establishes the slope parameters of the manufactured home industry-segment's (NAICS code 321991; U.S. Census Bureau 2009g, 2009h) product life cycle across three economic periods. This information is essential for industry participants, government employees, and researchers to allow for the formulation of well-founded strategic discourse and decision-making. The exploitation of these shifting forces of competition can spawn industry transition towards new ways of competing (Porter 2008), while competitive strategy can be seen as the means by which long-run firm profitability is attained (Mason 1939; Porter 1980). Although, a strategic path must be chosen concisely, this path must be intermittently reassessed, as industry structure and therefore, competitive forces, fluctuate across the cycles of introduction, growth, maturity, and decline (Harrigan 1980).

To date, no study has established scientifically the product life cycle (PLC) of the U.S. manufactured home industry using secondary data (U.S. Census Bureau 2008a, 2009a) and segmented regression analysis (Hudson 1966; Kimeldorf and Wahba 1970; Sall *et al.* 2005). This study, for the first time, provides numerical evidence of the decline of the manufactured home industry as measured by market share and discusses the opportunities of manufactured home producers in the factory-built home market. The manuscript starts out by providing background information on the U.S. construction industry and the PLC concept. Then, the data and methods used are explained, including a review of generalized linear regression and segmented regression analysis. Results are next presented in the form of a segmented regression curve and the product life curve (PLC). A discussion of the findings from this study concludes the manuscript.

DATA AND METHODS

Producers in the factory-built home industry now face the dual assessment of product life cycle positioning and diversification within a transitioning macroeconomic climate (Woodbridge and Associates 2003; Ligaya 2014). Factory-built homebuilders, to construct a market evaluation, need a diagnostic scope. This scope was created through a focused range of sector data using statistical strength of regression-based analysis on available data of the U.S. residential construction sector (Ott and Longnecker 2001). Alternative methods of analysis, such as expert forecasting or industry surveys, do not capture the desired quantitative foundation that regression based analysis is able to provide (Montgomery *et al.* 2001; Bryman and Bell 2011).

The focal point of this manuscript is the current economic era, coined The New Economy (French 1997). This era encompassed the U.S economy from 1993 through 2008 and is the backdrop for analysis of the manufactured housing industry-segment. In addition to the New Economy, two preceding economic eras are referenced in this manuscript. These two eras, as is the New Economy, are marked by macroeconomic changes in government policy, particularly the government laden Keynesian period known as Post War Prosperity from 1959 to 1973, and the contrasting, laissez-faire period of Deregulation, from 1974 to 1992 (Carson 1980; French 1997; Snowdon and Vane 2005).

The population for this study is the manufactured home industry-segment, NAICS code 321991 (manufactured home manufacturers; U.S. Census Bureau 2009g, 2009h). Shipment data for the manufactured home industry-segment and home start data for the U.S. residential construction industry was obtained through the U.S. Census Bureau and entails economic data collected between 1959 and 2008. Auxiliary supporting data on manufactured home manufacturers was obtained from the Manufactured Housing Institute (2008).

Data

Data collected from the U.S. Census Bureau provides a high level economic view of the fluctuating nature of the U.S. residential construction sector. An index, or proportional ratio, of U.S. manufactured home shipments to U.S. residential home starts was constructed using U.S. Census Bureau data. This proportional measure depicts an annual market share percentage of the U.S. manufactured housing segment compared to the U.S. residential construction sector and is represented by Eq. 1, in which new manufactured home shipments is X_i, new site-built residential home starts is Y_i, market share percentage is P_i, and i represents the year (1959 to 2008; Harrigan 1983).

$$P_i = [\, X / (Y_i\, X_i)] \bullet 100\% \quad (1)$$

Attention was paid to the conflicting data comparisons found by the ratio of manufactured home shipments and residential home starts. However, tested methodological similarities have validated the use of this ratio (HUD 2007). Methodology provided by the U.S Census Bureau (U.S. Census Bureau 2008b) indicates that manufactured home shipments are completed home units, sold directly to consumers or indirectly through dealers to end users, whereas new site-built residential starts are owned home units held by private investors (U.S. Census Bureau 2008c). Theoretically, these definitions provide a supply side perspective of the finished goods produced by the

site-built residential construction industry, therefore providing a framework for parallel comparison. Nonetheless, readers should be aware that differences between the measures obtained for manufactured home shipments and site-built residential home starts exist.

A continuous market share data table was constructed using Eq. 1 populated with U.S. Census Bureau data from 1959 through 2008 (U.S. Census Bureau 2008a, 2009a). Market share data were found to be normally distributed when tested for normality using a Shapiro-Wilk W Test ($p = 0.0537$).

A two-step method of data manipulation was performed on the continuous market share data set constructed by means of Eq. 1. The previously discussed economic periods of Post War Prosperity (1959-1973), Deregulation (1974-1992), and The New Economy (1993-2008) were allocated to the market share data set. This allocation process created three distinct economic data sets ranging from 15 years to 19 years in length. Secondly, a chronological year based time-series, ranging from 1 to 19, and titled "*Year of Economic Period*" was overlaid with the economic data sets (Ostrom 1990; Ott and Longnecker 2001). Results of the economic period allocation and year based time-series manipulation created a pivot-table that measures on the vertical axis the year of the economic period, wherein there was a horizontal display of each of the three economic periods.

Generalized Linear Regression

Linear regression analysis is a common analytical technique that uses mathematical modeling to approximate a response based on factors and parameters across a given range of data (Sall *et al*. 2005). This study looks at the factor, year of the economic period, and its relationship to the response, market share of the manufactured home segment. This relationship between the factor and response is expressed through the slope parameter (Ott and Longnecker 2001). The slope parameter directly indicates the change in market share occurring across the specified economic era (Kent 2001). This study deals with three distinct ranges of data, also known as segments, the Post War Prosperity (1959-1973), Deregulation (1974-1992), and The New Economy (1993-2008). Market share data for the manufactured home segment was modeled by generalized linear regression analysis to establish the slope parameter for each of the economic eras. Overall, the objective of this analysis is to provide a comparison of slope parameters across the three economic periods that recount to the changes seen across a product's life cycle.

Additionally, the three established market share slope parameters of the manufactured home segment data will be used in conjunction with a theoretical PLC curve. Correlative assessment of the slope parameters to the PLC will be evaluated by overlaying graphical representations of each (Huang and Tzeng 2008). Correlative relations between the slope parameters of the regression models and the PLC curve will be discussed as a foundation for strategic market actions of the manufactured home segment and the factory-built home industry.

Segmented Regression Analysis

The objective of comparing regression models across multiple ranges of data is not uncommon. These models have a broad historical background in applied functionality ranging from shipbuilding to advanced medicine (Muggeo 2003). Appropriate terminology for this analytical technique has been coined as segmented regression analysis, or knotted spline theory (Hudson 1966; Kimeldorf and Wahba 1970). Objectively, this analysis seeks to define break points, or joints, in continuous data sets,

thus rendering the series segmented (Hudson 1966). Application of these joint locations to a linear model provides insight into the non-constant relationship of the data series (Muggeo 2003). Advanced practices in segmented regression analysis typically look beyond these independent models in an attempt to integrate a generalized theory (Hudson 1966; Farley and Hinich 1970; Kimeldorf and Wahba 1970; Feder 1975). However, this analysis is mathematically complex and partially ill-suited for direct application to the overall needs of this research (Feder 1975). Therefore, this study will utilize a straightforward application of segmented regression analysis, where predetermined series joints are located at the intersection of economic segments and the independent regression models remain autonomous for comparison purposes (Huang and Tzeng 2008).

Secondly, contrary to fully quantitative techniques used in marketing research analysis (Hudson 1966; Feder 1975; Muggeo 2003), this study looks to apply qualitative models, based on a quantitative framework, to a segmented PLC curve, a methodology previously explored by Huang and Tzeng (2008) in the context of forecasting shipment levels of high-technology products throughout their PLCs. A modified approach to the methods of Huang and Tzeng (2008) will be used in this study as the methodology will not incorporate a full quantitative model but rather a mixed model, similar to that of Solomon *et al.* (2000). The quantitative model for this study is the previously outlined market share composition, and the qualitative model is the theoretical PLC curve. The quantitative regression models will be analyzed for their slope orientations and applied to the qualitative PLC curve (Solomon *et al.* 2000). Overall, this mixed model analysis provides a comparative application of segmented linear regression parameters to an equally segmented PLC curve (Anderson and Zeithaml 1984). Once the hypothesized correlation between slope orientation and the PLC is obtained, further discussion on the manufactured housing segment's PLC position and future market strategy will be presented.

Data Preparation

Economic dissection of the continuous time series data provides the opportunity for era introspection using segmented generalized linear regression analysis comparative to that used by Huang and Tzeng (2008), Solomon *et al.* (2000), and Sood *et al.* (2009). The generalized linear regression model is expressed by Eq. 2, where $\hat{y}$ is the predicted response, β_o is the intercept, β_1 is the slope, x is the independent variable (e.g., P_i from equation (1)), and ε is the random error term (Ott and Longnecker 2001).

$$\hat{y} = \beta_o + \beta_1 x \quad (2)$$

All three segmented data sets were tested for the formal assumptions of regression analysis, *e.g.* linearity, homoscedasticity, independence, and normality (Ott and Longnecker 2001). Figure 1 displays graphically the linear relationship of the dependent ($\hat{y}$) and independent (x) variables across the three data segments. All eras displayed linearity in respect to predicted and actual responses. Figure 2 graphically depicts residual plots to check for residual homoscedasticity for the three economic segments through plots of predicted responses paired against response residuals.

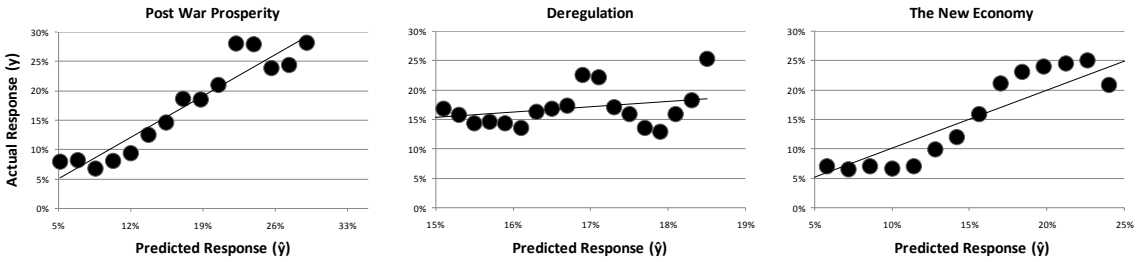

Fig. 1. Linear relationship between predicted and actual response for post war prosperity, deregulation, and the new economy

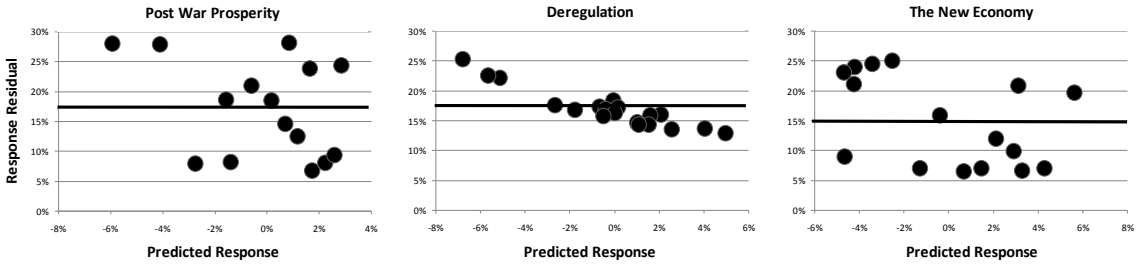

Fig. 2. Residual plots for post war prosperity, deregulation, and the new economy

Table 1 provides the results of assumption testing for normality and data independence. Normality testing was conducted using the Shapiro-Wilk W Test and resulted in non-normal distributions for the economic data segments of Deregulation ($p = 0.02$), and The New Economy ($p = 0.01$), whereas Post War Prosperity revealed normality ($p = 0.06$; Ott and Longnecker 2001).

Table 1. Results of Assumption Testing for Normality and Data Independence

ASSUMPTION TESTING

Economic Period	Post War Prosperity *1959-1973*	Deregulation *1974-1992*	The New Economy *1993-2008*
NORMALITY TESTING			
Shapiro-Wilk W Test			
W	0.89	0.87	0.84
Prob < W	0.06	0.02	0.01
Parameter Estimates			
Location (μ)	0.17	0.17	0.15
Dispersion (σ)	0.08	0.03	0.07
INDEPENDENCE TESTING			
Durbin-Watson			
DW	0.13	0.70	0.10
Prob < DW	< 0.0001	0.0004	< 0.0001

Data transformations were not used to normalize data sets, as it was critical that the data remained constant across the segmented series for data comparison purposes (Harrigan 1983). Durbin-Watson testing for independence revealed serial correlation

amongst data in all three economic segments. However, testing an autoregressive model using the Yule-Walker estimates model parameters across the three economic periods revealed that model parameters did not change with the introduction of an autoregressive lag-1 testing error component (Sall *et al.* 2005). Thus, no significant effects were contributed to the slope parameter estimate or data trend due to this correlative component, and only a minor divergence from the originally stated generalized linear models' slope parameters was detected. Hence, in line with other research (Solomon *et al.* 2000; Ryan and Porth 2007), it was concluded that the regression models provided proper estimation of the slope parameters for this study's theoretical comparison between econometric and product life cycle models.

RESULTS

Table 2 illustrates regression analysis results through goodness of fit statistics, and ANOVA testing output. Regressions statistics yielded goodness of fit measures for periods 1 and 3 (Post War Prosperity and The New Economy) of R^2 = 0.90 and 0.77, respectively. These values indicate that there is a slight amount of residual variance around the linear regression models for periods 1 and 3. However, resulting F-test values prove model significance for both Post War Prosperity ($p < 0.001$) and The New Economy ($p < 0.001$; Ott and Longnecker 2001; Sall *et al*. 2005). Alternatively, period 2 (Deregulation), returned a poor goodness of fit measure (R^2 =0.098) and thus an ANOVA F-test result of non-significance ($p = 0.192$). Detailed introspection into the sum of squared regression and residuals values, for the period of Deregulation, concluded that residual variance was a major component of total model variance. Therefore, the horizontal mean line of the data range provides a more accurate estimate of manufactured housing market share than that of the estimated linear model (Ott and Longnecker 2001). Post hoc analysis of the three economic periods uses the prior ANOVA results in conjunction with the regression model parameter estimates, found at the bottom of Table 2 to further develop a conclusion for the manuscript hypothesis. Figure 3, the segmented economic regression model and the product life cycle curve, developed as a spline, will be used throughout post hoc analysis to illustrate the relationship between the segmented regression models and the theoretical PLC curve.

The Post War Prosperity linear model shows a positive, significant ($p = < 0.001$) slope parameter estimate of 0.017. This parameter result, when converted to a percentage, indicates a 1.7% positive increase in market share of the U.S. residential construction sector for each successive year of the period Post War Prosperity. Figure 3 shows the Post War Prosperity linear model in comparison to the growth stage of the PLC curve. Secondly, the linear model for the period of Deregulation displays non-significance ($p = 0.192$). Non-significance was expected for this economic time period, as it further substantiates the slope coefficient relationship between the market share data and the PLC curve. Overall, due to the non-significant ANOVA and slope parameter tests, it is concluded that market share data from the Deregulation period has a slope of zero and is therefore comparative to the maturity stage of the PLC curve (Peter and Donnelly 2001). Lastly, the linear model for The New Economy was tested for slope significance. Parameter estimates return a negative, significant ($p = <0.001$) slope parameter of -0.014, signifying a -1.4% market share loss of the U.S. residential construction sector for each additional year of The New Economy period. Figure 3 illustrates the relationship

between the linear model of The New Economy and the declination stage of the PLC curve.

Table 2. Generalized Linear Regression Results for Post War Prosperity, Deregulation, and the New Economy

GENERALIZED LINEAR REGRESSION RESULTS									
	Post War Prosperity			**Deregulation**			**The New Economy**		
Regression Statistics	*1959 - 1973*			*1974 - 1992*			*1993 - 2008*		
Observations	15			19			16		
R^2	0.900			0.098			0.778		
Standard Error	0.027			0.032			0.036		
ANOVA	*Regression*	*Residual*	*Total*	*Regression*	*Residual*	*Total*	*Regression*	*Residual*	*Total*
Sum of Squares	0.083	0.009	0.092	0.002	0.017	0.019	0.065	0.019	0.084
Mean Square	0.083	0.001		0.002	0.001		0.065	0.001	
F		116.765			1.843			49.183	
P-value		< 0.001			0.192			< 0.001	
Regression Model	*Intercept (β_0)*		*Slope (β_1)*	*Intercept (β_0)*		*Slope (β_1)*	*Intercept (β_0)*		*Slope (β_1)*
Coefficient	0.035		0.017	0.187		-0.002	0.268		-0.014
Standard Error	0.144		0.002	0.015		0.001	0.019		0.002
P-value	0.030		< 0.001	< 0.001		0.192	< 0.001		< 0.001
t Stat	2.434		10.806	12.290		-1.358	14.024		-7.013
Lower 95%	0.004		0.014	0.155		-0.005	0.227		-0.018
Upper 95%	0.066		0.021	0.220		0.001	0.309		-0.010
Slope Comparison									
Slope coefficient	positive			neutral			negative		
PLC coefficient	positive			neutral			negative		
PLC period	Growth			Maturity			Decline		

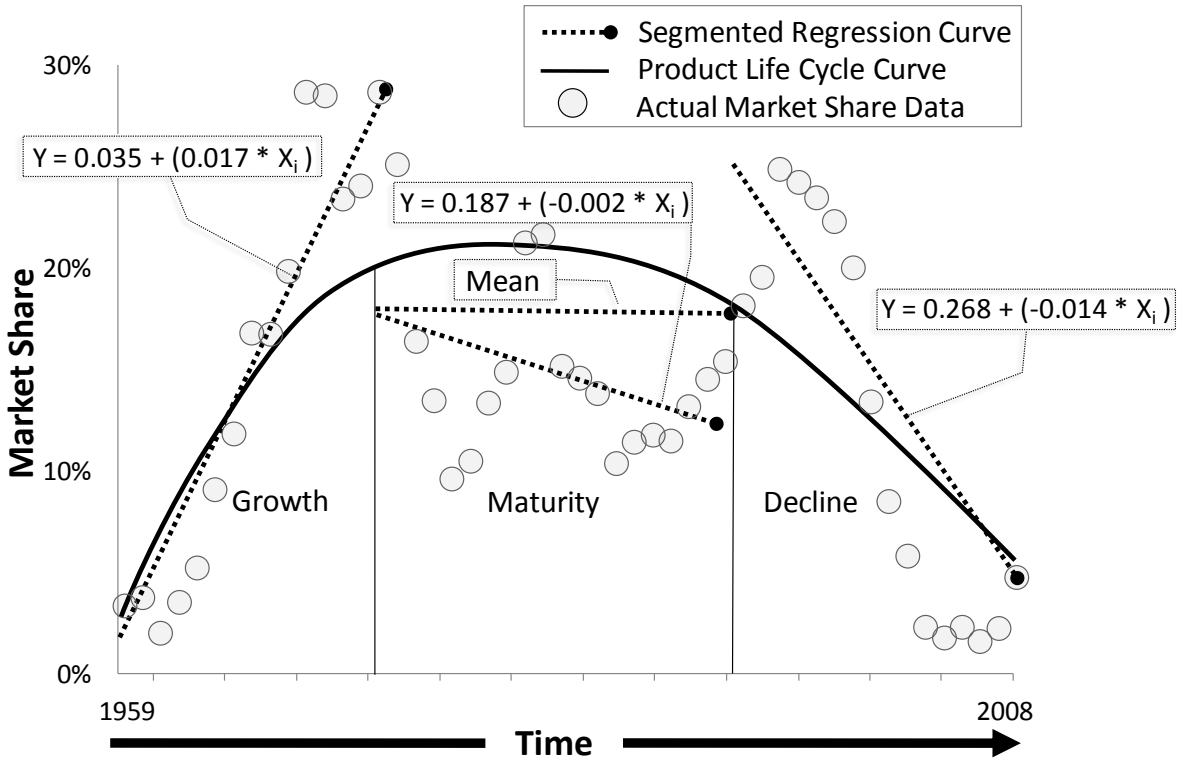

Fig. 3. Segmented economic regression model and the product life cycle (PLC) curve

DISCUSSION

Comparing results presented in this manuscript with previous studies by PATH (2003) and HUD (1998, 2006a, 2007) produces evidence that the manufactured housing industry-segment has lost market share effectiveness in the U.S. residential construction sector over the past decade and is currently enduring its forlorn song of decline. These results are counter to industry sentiment, which as of the late 1990's, resonated with conceit as manufactured home producers' believe that they had "… *Locked up*…" the affordable housing market (HUD 1998, p.116). Indeed, existing research (Hood 1998; HUD 1998, 2006a, 2007; Apgar *et al*. 2002) has dauntingly highlighted the capacity of manufactured housing to boost homeownership levels in the U.S. However, as homeownership levels rose from 2000 through 2005 (U.S. Census Bureau 2009f), the manufactured home industry-segment lost roughly 10 percent market share in the U.S. residential home sector (U.S. Census Bureau 2008a, 2009a), bringing to an end the manufactured home industry's belief that the affordable housing market is theirs to take without a fight.

With the state of the U.S. residential construction sector in flux, many homebuilders are readdressing their strategies. Strategy, "*... The match an organization makes between its internal resources and skills ... and the opportunities and risks created by its external environment*… (Hofer and Schendel 1978 p. 12)" is the essential planning tool to position firms favorably for future prosperity. Industry structure and business strategy determine how economic value is dispersed amongst industry participants (Porter 2008). To prosper, each industry participant must understand and leverage present and future forces of competition to gain and solidify their competitive strategies (Porter 1980, 2008; Harrigan 1983). Porter's (1980) original model of competitive strategy stipulates that industry participants operate based on competitive forces that interact with their suppliers, buyers, new entrants, rivalry, and substitute products (Porter 1980, 1985, 2008; Harrigan 1983) bound by geographic region and product scope (Porter 2008). The resource-based (Grant 1991) and the core competence theory (Prahlad and Hamel 1990) of strategic formulation have added to the scope of strategic consideration for industries and firms.

The recent market share losses of the manufactured home industry are a sign that the segment has lost its strategic edge in the U.S. residential construction sector as the provider of affordable housing solutions (Porter 2008; Harrigan 1988). This shift in what constitutes "*affordable*" housing today was driven by the boom of U.S. residential construction in the early 21st century, which inevitably led to lax credit standards and sub-prime lending (Center for Responsible Lending 2006) allowing what were once prospective manufactured home owners to purchase "*affordable*" site-built homes (Woodbridge and Associates, 2003). This shift today is being helped by the U.S. credit crisis that started in 2007 (Center for Responsible Lending 2006; RealtyTrac 2009), which has driven foreclosures of homes to record levels (RealtyTrac 2009). As this ample supply of foreclosed homes enters the market, new home prices are driven down due to oversupply (Center for Responsible Lending 2006). The manufactured home industry-segment thus suffers even deeper market share losses as market prices of foreclosed homes equalize with those of the niche market of affordable manufactured homes (Apgar *et al.* 2002). Existing literature asserts that this loss of market share will either force survival through economies of scale by means of consolidation (Harrigan

1980; HUD 1998) or drive producers of manufactured homes out of this industry-segment towards alternative forms of factory-built homes (Harrigan 1980, 1983).

Bernard *et al.* (2006) illustrate the urge for firms to extend their competitive advantages beyond their intrinsic industry-segment when market share is readily attainable. The competitive advantages of a firm are carried surreptitiously into an adjacent industry-segment, giving the firm a direct competitive advantage (Harrigan 1980; Bernard *et al.* 2006). And indeed, the demise of manufactured housing has helped spur bourgeoning growth within the factory-built home industry in modular and panelized home construction. With predictions slating annual factory-built modular or panelized home production to exceed nearly 500,000 units by 2020 (Woodbridge and Associates 2003), the industry is putting their considerable internal resources and capabilities (Grant 1991) acquired from designing, producing, and selling manufactured homes for decades (De Haan *et al.* 2002) to good use.

Interestingly, the manufactured home producers seem to be more attracted to modular home production as opposed to panelized home production. Market share for the modular home industry in the factory-built housing market rose from just over 30% in 1992, to 46% in 2002 (U.S. Census Bureau 2009b). The primary entrants to the modular home industry-segment have been manufactured home producers who are diversifying or switching production away from their native manufactured home industry-segment (Bady 1996; HUD 1998; Woodbridge and Associates 2003). Supporting this trend of selective diversification, Reed Construction Media (2009) reported that 21 of the top 25 U.S. manufactured home producers have now converted at least 15 percent of their production capacity to modular home production. This strategic diversification guides researchers to believe that the barriers of entry between manufactured and modular home production are limited and therefore easily exploitable (Bain 1956; Harrigan 1983, 1980).

While the panelized home industry-segment has also expanded market share over the past decade, the growth in this industry-segment has mainly been driven by the site-built home industry striving to overcome a lack of skilled labor, unsatisfactory quality and consistency of their product, and mediocre gains in efficiency (Schuler and Adair 2003; HUD 2007). Site-built homebuilders carry the market share potential needed to advance the panelized home industry-segment market helped by increased acceptance of panelized building systems by homebuyers. The limited interest of the manufactured home producers in diversifying into panelized home construction may rest on the larger dissimilarities between manufactured and panelized home building as opposed to manufactured and modular. However, depending on market preferences, which are continually evolving, manufactured homebuilders should be able to diversify into panelized home production should the modular market loose its attractiveness.

Today, with housing markets remaining at depressed levels and demand for manufactured homes continuing to decline, factory-built industry participants are forced to adapt their strategies to assure survival. While some chose to consolidate, others have started to diversify into adjoining industry segments such as modular or panelized homes, where existing internal resources and capabilities promise the highest rent. However, numerous challenges remain for the industry and further research is needed. One of the most critical issues for future industry prosperity is the long-standing bias of consumers against factory-built housing, as negative social perceptions are the main force preventing increased market success of factory-built homes (Beamish *et al.* 2001; HUD 2007, 2006b). Furthermore, the effort of the site-built housing industry to take advantage of the benefits of factory-built housing warrants attention. Given time and sufficient resources,

the site-built housing industry could build sufficient internal resources and capabilities in factory-built construction to become a powerful competitor to the incumbent industry. However, the increasing use of factory-built housing practices by the site-built housing construction industry could also potentially create a powerful ally in promoting the value and quality of factory-built homes to prospective customers.

This research has demonstrated that manufactured housing is in the declining stage of its product life cycle (PLC). Little indications exist that manufactured housing will regain its prominence in the future. However, the manufactured housing industry is in a formidable position to overcome the demise of the manufactured home by benefiting from ongoing changes in the residential construction industry of the U.S., in particular by the increasing interest in modular and panelized home construction. Time will tell if the industry is able to benefit from the growing market for factory-built housing and if the industry can use and protect its internal resources and capabilities (Grant 1991; De Haan *et al.* 2002) from other competitors.

CONCLUSIONS

1. Through macroeconomic analysis of the manufactured home industry-segments' market share of the residential construction sector this study concluded that manufactured homes are currently in the period of declination as described by the product life cycle (PLC) curve's decline stage. The PLC curve acts as a theoretical guide to product based life cycle commonalities that include the introduction, growth, maturity, and the eventual decline of a product's demand in a market.
2. The current state of decline in the manufactured home industry-segment has come not only as the result of changes to both the U.S. residential construction sector and the factory-built home industry, but also through major strategic advancements by rival industry-segments. As a direct result, manufactured home producers have been strained to cope with market share decline that is forcing drastic industry consolidation to survive economies-of-scale based competition as barriers to exit force participants to stay in business. Thus, producers of manufactured homes will seek diversification into surrounding industry-segments of the factory-built home industry, such as modular and panelized home construction, or they will remain focused on strategically repositioning the manufactured home segment.
3. Additional strain has been placed on the manufactured home industry-segment through recent advancements by site-built homebuilders into the factory-built home industry. These new entrants to the factory-built home market have targeted panelized home systems as means of increasing their competitive business edge in the production home market. As these site-built homebuilders develop market share in the panelized market, further market share problems will impact the manufactured home industry.
4. Overall, the manufactured home industry-segment is faced with a series of daunting tasks that start with the realization that market demand for manufactured homes is declining and that further growth in the factory-built home market is not easily captured by the segment.

ACKNOWLEDGMENTS

The work upon which this publication is based was funded in part through a grant awarded by the Wood Education and Resource Center, Northeastern Area State and Private Forestry, U.S. Forest Service, by the Virginia Cooperative Extension and by Virginia Tech. The authors also want to thank two anonymous reviewers for their helpful reviews.

REFERENCES CITED

Agarwal, R. (1997). "Survival of firms over the product life cycle," *Southern Economic Journal* 63(3), 571-584.

Anderson, C. R., and Zeithaml, C. P. (1984). "Stage of the product life cycle, business strategy, and business performance," *The Academy of Management Journal* 24(1), 5-24.

Apgar, W., Calder, A., Collins, M., and Duda, M. (2002). *An Examination of Manufactured Housing as a Community and Asset-Building Strategy*, Report to the Ford Foundation. Washington, D.C: Neighborhood Reinvestment Corporation. Cambridge, MA: Harvard University Joint Center for Housing Studies.

Bady, S. (1996). "Builders grow business the modular way," *Professional Builder* 61(13), 62-63.

Bain, J. S. (1956). *Barriers to New Competition, Their Character and Consequences in Manufacturing Industries*, Harvard University Press, Cambridge, MA, USA.

Beamish, J. O., Goss, R. C., Atiles, J. H., and Kim, Y. (2001). "Not a trailer anymore: Perceptions of manufactured housing," *Housing Policy Debate* (pp. 373-392), Fannie Mae Foundation, Washington, D.C.

Bernard, A. B., Redding, S. J., and Schott, P. K. (2006). *Multi-product Firms and Product Switching*, National Bureau of Economic Research (NBER), Washington, D.C.: Bureau of the Census.

Bouquet, C., and Morrison, A. (2006). "Swatch and the global watch industry," In D. W. Conklin, *Cases in The Environment of Business* (pp. 50-69), SAGE Publications, Inc., Thousand Oaks, CA.

Bryman, A., and Bell, E. (2011). "*Business Research Methods*," 3 Edition, Oxford University Press, Oxford, United Kingdom.

Carson, R. B. (1980). *Macroeconomic Issues Today: Alternative Approaches*, St. Martin's Press, Inc., New York, NY.

Center for Responsible Lending. (2006). *Losing Ground: Foreclosures in the Subprime Market and their Cost to Homeowners*, Center for Responsible Lending, Washington, DC.

Covin, J. G., and Miles, M. P. (1999). "Corporate entrepreneurship and the pursuit of competitive advantage," *Entrepreneurship Theory and Practice* 23(3), 47-63.

Cox, W. J. (1967). "Product life cycles as marketing models," *The Journal of Business* 40(4), 375-384.

Day, G. S. (1981). "The product life cycle: Analysis and applications issues," *Journal of Marketing* 45(4), 60-67.

De Haan, J., Voordijk, H., and Joosten, G.-J. (2002). "Market strategies and core capabilities in the building industry," *Construction Management and Economics* 20, 109-118.

Dess, G. G., Ireland, R. D., Zahra, S. A., Floyd, S. W. Janney, J. J., and Lane, P. J. (2003). "Emerging issues in corporate entrepreneurship," *Journal of Management* 29(3), 351-378.

Farley, J. U., and Hinich, M. J. (1970). "A test for a shifting slope coefficient in a linear model," *Journal of the American Statistical Association* 65 (331), 1320-1329.

Feder, P. I. (1975). "The log likelihood ratio in segmented regression," *The Annals of Statistics* 3(1), 84-97.

French, M. (1997). *U.S. Economic History since 1945*, Manchester University Press, New York, NY.

Grant, R. M. (1991). "The resource-based theory of competitive advantage: Implications for strategy formulation," *California Management Review*, Spring, 114-135.

Gurney, S. J. (1999). "Identifying opportunities for engineered lumber products in the modular housing industry," Thesis, Virginia Polytechnic Institute and State University, Wood Science and Forest Products, Blacksburg, VA.

Harrigan, K. R. (1980). *Strategies for Declining Businesses*, Lexington, MA: Lexington Books.

Harrigan, K. R. (1983). "Entry barriers in mature manufacturing industries," in: *Advances in Strategic Management*, R. Lamb (ed.), JAI Press Inc., Greenwich, CT, Vol. 2, pp. 67-97.

Harrigan, K. R. (1988). *Managing Maturing Businesses: Restructuring Declining Industries and Revitalizing Troubled Operations*, Lexington Books, Lexington, MA.

Hofer, C. W., and Schendel, D. (1978). *Strategy Formulation: Analytic Concepts*, West, St. Paul, MN.

Hood, J. (1998). "Factory-built housing: The path to ownership?" *Consumers' Research Magazine* 81(8), 15-18.

Huang, C.-Y., and Tzeng, G.-H. (2008). "Multiple generation product life cycle predictions using a novel two-stage fuzzy piecewise regression analysis method," *Technological Forecasting and Social Change* 75(1), 12-31.

HUD. (1998). *Factory and Site-built Housing, a Comparison for the 21st Century*, U.S. Department of Housing and Urban Development, National Association of Home Builders Research Center, Washington, DC.

HUD. (2006a). "Factory built housing roadmap: Including recommendations for energy research," Affordable Housing Research and Technology Division, U.S. Department of Housing and Urban Development. Washington, DC: Manufactured Housing Research Alliance.

HUD. (2006b). "Housing impact analysis," U.S. Department of Housing and Urban Development, Office of Policy Development and Research. Washington, D.C: Newport Partners L.L.C.

HUD. (2007). "Factory-built construction and the American homebuyer: Perceptions and opportunities," U.S. Department of Housing and Urban Development, Office of Policy Development and Research. Washington, DC: Optimal Solutions Group L.L.C.

Hudson, D. J. (1966). "Fitting segmented curves whose joint points have to be established," *Journal of the American Statistical Association* 61(316), 1097-1129.

Kent, R. A. (2001). *Data Construction and Data Analysis for Survey Research*, Palgrave, Hampshire, UK.

Kimeldorf, G. S. and Wahba, G. (1970). "A correspondence between Bayesian estimation on stochastic processes and smoothing by splines," *The Annals of Mathematical Statistics* 41(2), 495-502.

Kochera, A. (1998). "Modular, panelized, and precut homes," *Housing Economics* 46(5), 10.

Ligaya, A. (2014). "How factory-built homes are shedding their 'cheap' label and exploding in popularity," Retrieved August 9, 2014, from Financial Post: http://business.financialpost.com/2014/01/20/how-factory-built-homes-are-shedding-their-cheap-label-and-exploding-in-popularity/

Manufactured Housing Institute. (2008). "Manufactured home shipments and site built single-family housing starts and homes sold 1980-2007," Retrieved December 18, 2008, from Manufactured Housing Institute: http://www.manufacturedhousing.org/admin/template/subbrochures/390temp.pdf

Mason, E. S. (1939). "Price and production policies of large-scale enterprise," *The American Economic Review* 29(1), 61-74.

Marshall, M. I., and Marsh, T. L. (2007). "Consumer and investment demand for manufactured housing units," *Journal of Housing Economics* 16, 59-71.

McKeever, D. B. (2009). "Estimated annual timber products consumption in major end uses in the United States, 1950 – 2006," *General Technical Report FPL-GTR-181*. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI.

Montgomery, D. C., Peck, E. A., and Vining, G. G. (2001). *Introduction to Linear Regression Analysis*," 3rd Ed., Vol. xvi, Wiley, New York, NY.

Muggeo, V. M. (2003). "Estimating regression models with unknown break-points," *Statistics in Medicine* 22(19), 3055-3071.

Ostrom, J. C. (1990). *Time Series Analysis: Regression Techniques* (2nd Edition), SAGE Publications, Inc., Thousand Oaks, CA.

Ott, R. L., and Longnecker, M. (2001). *An Introduction to Statistical Methods and Data Analysis*, Dubury, Australia.

PATH. (2003). *Technology Road Mapping for Manufactured Housing*, Manufactured Housing Research Alliance, U.S Department of Housing and Urban Development, Washington, DC.

Peter, P. J., and Donnelly, J. H. (2001). *A Preface to Marketing Management*, McGraw-Hill, New York, NY.

Phillips, B. D., and Kirchhoff, B. A. (1989). "Formation, growth and survival; small firm dynamics in the U.S. economy," *Small Business Economics* 1(1), 65-74.

Porter, M. E. (1980). *Competitive Strategy*, Free Press, New York, NY; Collier Macmillan, London, UK.

Porter, M. E. (1985). *Competitive Advantage*, Free Press, New York, NY; Collier Macmillan, London, UK.

Porter, M. E. (2008). "The five competitive forces that shape strategy," *Harvard Business Review* 86(1), 78-93.

Polli, R., and Cook, V. (1969). "Validity of the product life cycle," *The Journal of Business* 42(4), 385-400.

Prahlad, C. K. and Hamel, G. (1990). "The core competence of the corporation," *Harvard Business Review* May/June, 97-91.

RealtyTrac. (2009). *Press Releases,* Retrieved September 18, 2009, from RealtyTrac: http://www.realtytrac.com/contentmanagement/pressrelease.aspx?channelid=9 and accnt=0 and itemid=6802

Reed Construction Media. (2009). "Factory built results," Retrieved October 18, 2009, from Housing Zone.com: http://www.housingzone.com/factory.html

Ryan, S. E., and Porth, L. S. (2007). "A tutorial on the piecewise regression approach applied to bed load transport data," Fort Collins, CO: U.S. Department of Agriculture, Forest Service: Rocky Mountain Research Station.

Sall, J., Creighton, L., and Lehman, A. (2005). *JMP Start Statistics: A Guide to Statistics and Data Analysis Using JMP and JMP IN Software*, Thomson, Belmont, CA.

Schuler, A., and Adair, C. (2003). "Demographics, the housing market, and demand for building materials," *Forest Products Journal* 53(5), 8-17.

Snowdon, B., and Vane, H. R. (2005). *Modern Macroeconomics: Its Origins, Development and Current State*, E. Elgar, Cheltenham, UK.

Solomon, R., Sandborn, P. A., and Pecht, M. (2000). "Electronic part life cycle concepts and obsolescence forecasting," *IEEE Transactions on IEEE tTransactions on Components and Packaging Technologies* 23(4), 707-717.

Sood, A., Gareth, J. M., and Tellis, G. J. (2009). "Functional regression: A new model for predicting market penetration of new products," *Marketing Science* 28(1), 36-51.

Sullivan, A. and Sheffrin, S. M. (2003). *Economics: Principles in Action*, Pearson Prentice Hall, Upper Saddle River, NJ.

Swatch Group. (2009). "The swatch history," Retrieved September 19, 2009, from Swatch.com: http://www.swatch.com/zz_en/about/history.html

U.S. Census Bureau. (2008a). *Shipments of New Manufactured Homes 1959 – 2007,* Retrieved February 19, 2009, from U.S. Census Bureau: http://www.census.gov/const/mhs/shiphist.pdf

U.S. Census Bureau. (2008b). *Manufactured Homes Survey Description, Reliability of the Data, and Seasonal Adjustment*, Retrieved September 15, 2009, from Manufactured Housing Survey: http://www.census.gov/const/mhs/method2005.html#meth

U.S. Census Bureau. (2008c). "Relationship between permits, starts and completions," Retrieved September 15, 2009, from New Residential Construction: http://www.census.gov/const/www/nrcdatarelationships.html

U.S. Census Bureau. (2009a). *Quarterly Starts and Completions by Purpose and Design*, Retrieved September 14, 2009, from New Residential Construction: http://www.census.gov/const/compann.pdf

U.S. Census Bureau. (2009b). "Characteristics of new one-family houses completed," Retrieved September 23, 2009, from U.S. Census Bureau: http://www.census.gov/const/www/charindex.html#singlecomplete

U.S. Census Bureau. (2009c). *American Housing Survey (AHS),* Retrieved August 26, 2009, from U.S. Census Bureau: http://www.census.gov/prod/2008pubs/h150-07.pdf

U.S. Census Bureau. (2009d). *Average Sales Price of New Manufactured Homes by Region and Size of Home,* Retrieved August 25, 2009, from U.S. Census Bureau: http://www.census.gov/const/mhs/mhstabavgsls.pdf

U.S. Census Bureau. (2009e). *Historic Tables*, Retrieved August 21, 2009, from New Residential Construction: http://www.census.gov/const/www/newresconstindex_excel.html

U.S. Census Bureau. (2009f). *Housing Vacancies and Homeownership (CPS/HVS)*, Retrieved August 26, 2009, from U.S. Census Bureau: http://www.census.gov/hhes/www/housing/hvs/annual08/ann08ind.html

U.S. Census Bureau. (2009g). *Physical Housing Characteristics for Occupied Housing Units 2005-2007*, Retrieved August 21, 2009, from American Community Survey: http://factfinder.census.gov/servlet/STTable?_bm=y and -qr_name=ACS_2007_3YR_G00_S2504 and -geo_id=01000US and -ds_name=ACS_2007_3YR_G00_ and -_lang=en and -format= and -CONTEXT=st

U.S. Census Bureau. (2009h). *Industry Statistic Sampler: NAICS 321991*, Retrieved September 15, 2009, from Economic Census 2002: http://www.census.gov/econ/census02/data/industry/E32199.HTM

U.S. Census Bureau. (2011). "New privately owned housing units completed - seasonally adjusted annual rate," Retrieved February 5, 2011, from New Residential Construction: http://www.census.gov/const/compsa.pdf

Wernick, I. K., Waggoner, P. E., and Ausubel, J. H. (1998). "Searching leverage to conserve forests: The industrial ecology of wood products in the United States," *Journal of Industrial Ecology* 1(3), 125-145.

Woodbridge, P., and Associates. (2003). "Market opportunities in factory-built housing, Group C - Ontario's value added wood products market potential in the U.S. great lakes states," Living Legacy Trust, 95-116.

Article submitted: March 3, 2014; Peer review completed: April 14, 2014; Revised version received and accepted: September 12, 2014; Published: September 17, 2014.