Analysis of Wood Cross-Tie Price Sensitivities

James C. Gauntt
Railway Tie Association

Allan M. Zarembski, Ph.D., P.E.
ZETA-TECH Associates, Inc.

ABSTRACT

The price of wood cross-ties is dependent on the availability of timber, the competition with uses for other timber products cut from the same log, and railroad usage of cross-ties. This paper examines historical wood cross-tie price as a function of key timber tie industry factors such as monthly and annual timber tie production, monthly and annual tie inventories, and green 4/4 2A Red Oak board foot price. Using detailed data from a multi-year period, a statistical analysis was performed of the relationship between hardwood cross-tie prices and the above key timber industry parameters. The resulting sensitivity of the tie price to these factors and the associated "predictive" relationship is presented together with the potential impact on railroad tie purchasing practices and behavior. Finally, the effect of changes in railroad purchasing practices which may provide for more stable tie prices are examined in terms of the life cycle costs of alternate purchasing policies.

Introduction

The last 15 years of tie production and usage can be characterized as volatile from a historical norm perspective. Downsizing and mergers by Class I Railroads, their changing maintenance practices, other short-term cash flow considerations and the emerging purchasing influence of Short Line Railroads are all contributing factors to a vastly different marketplace.

Satisfying the annual demand for crossties is also dynamically different. Procurers of untreated ties experience the negative results that market volatility has caused, as do the sawmills that produce them. The effect of documented structural changes that occurred in sawmilling during the last decade, are felt more acutely during peak demand periods, than in previous times.

Thus, the changing "demand" side of the marketplace and the structurally altered "supply" side coexist within a framework where upside pricing pressures are quickly translated into significantly more expensive crossties. Because of this, it has become increasingly important for users and producers to seek increased stability in the marketplace.

Discussions that occur between railroad and tie supplier personnel also consistently point to the benefits that would accrue from greater marketplace stability. These include improved price stability and greater security in raw material supply. However, even though this seems to be intuitively understood, railroads have shown no ability to change the short-term nature of their fluctuating patterns of demand. Tie suppliers, on the other hand, may not have yet fully recognized, within their production/inventory schematics, the divergence between what used to be a Class I only driven marketplace and the reality of a more diverse Short Line Railroad influenced environment.

It may well be, in both cases, that the reason this volatile nature of the status quo continues to exist is because an economic case for changing the modus operandi has yet to be quantified. Therefore this paper attempts to identify:

A) The relative importance of the key indicators that are currently tracked by industry personnel to the price of ties.

B) Potential techniques for creating cost savings such as:
   1-Steady-state purchasing practices
   2-Accurate and effective predictive market models

C) The role that improved planning and communication could play in creating a less volatile environment in which to conduct business.

It can be stated at the outset that this is an initial attempt to scientifically answer the question raised by these issues. It will become clear that additional work is needed to further illuminate an improved path for these two interrelated industries.

Data Used

There are several key indicators used by the railroad and crosstie producing industries to evaluate the marketplace for wood crossties. These are:

- Monthly Tie Production: The number of green (untreated) wood ties bought and paid for by the members of the Railway Tie Association each month.

- Monthly Tie Inventories: The total number of untreated and treated ties on hand owned by RTA member companies[1].

- Green Tie Price Trends: A composite number that accurately represents an average price across three geographic hardwood producing regions [2].

- Benchmark Red Oak Price Trends: a similar composite number that represents an average price across three geographic hardwood producing regions.

---

[1] The Railway Tie Association represents producers and users of treated wood crossties. Producer companies that are members of RTA represent 92-95% of all wood crossties produced annually in North America and thus provide a comprehensive data base.

[2] Tie Price Definition: *Crossties* magazine reports a "tie price" that reflects a weighted average of the high and low prices reported in each of three geographic regions by the Hardwood Market Report. These are the "tie prices" used in this economic analysis. Therefore, "tie prices" as used herein, while representing very consistent and valid data, do not necessarily refer to a specific actual price of a green tie at any specific moment in time. The number is, however, a close approximation to what could be considered an average price across all three geographic regions (Southern, Northern, and Appalachian hardwood producing areas as defined by the Hardwood Market Report). Similarly, Benchmark Red Oak pricing is presented in the same weighted average manner.

While there may be other railway tie industry trends or data suitable for use, these statistics are used in the analysis because they are the ones for which the longest history exists and because they are the most commonly used.

Additional data used in this paper includes the past 40 years of Class I railroad tie installation and annual traffic density history as reported by the Association of American Railroads and normalized tie installations as modeled by *TieLife* software. "Normalized" tie installations account for changes in railroad operating trackage and tonnage from year-to-year.

Background

There is a distinct relationship between annual railroad tie installations, railroad purchasing practices and the wood crosstie industry's production and inventory patterns. Futhermore, these relationships exhibit a distinct cyclic nature. Industry personnel have historically used the data outlined in the preceding section to make certain business judgments. It is reported by RTA members that this data illustrates what part of the business cycle the tie industry is in and where it may be headed.

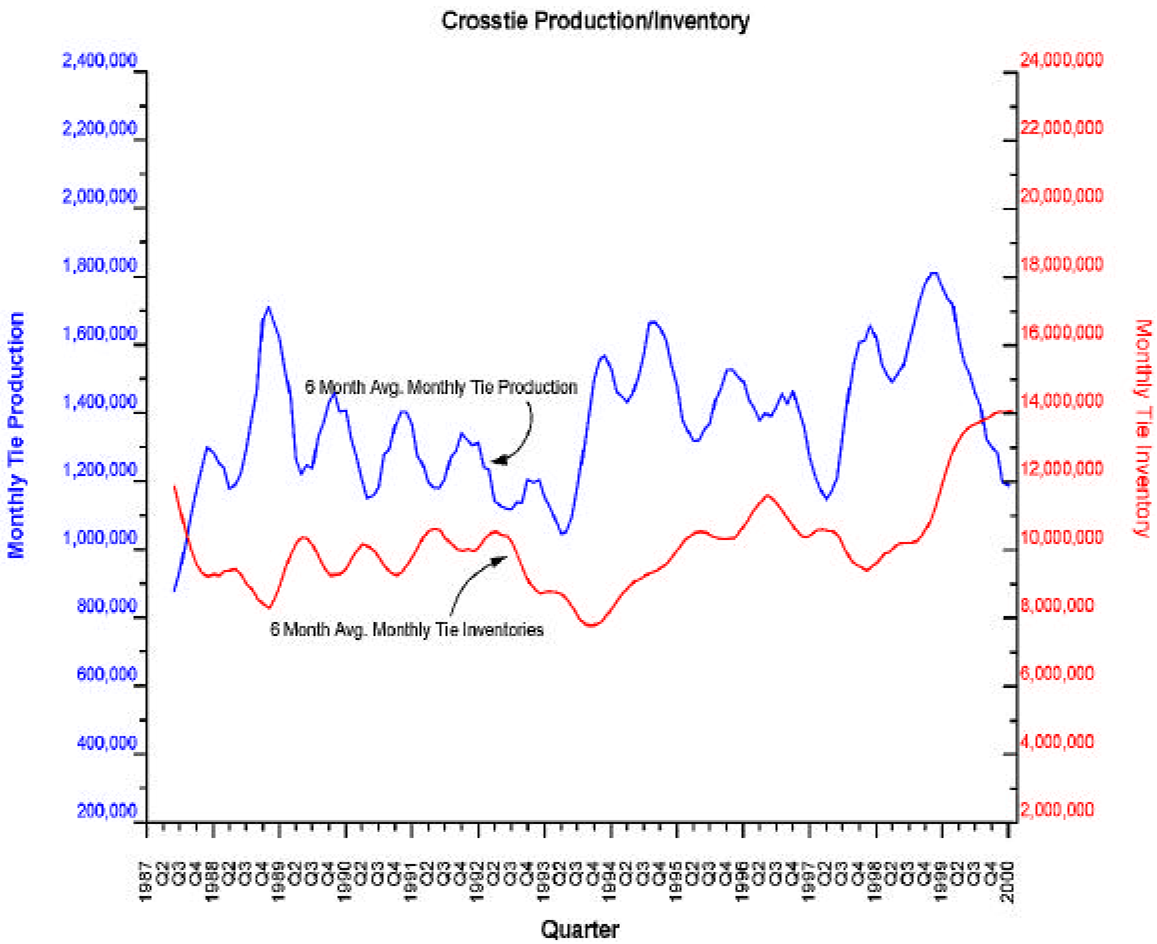
In Figure 1 the tie inventory and production data tracked is graphed in 6 month moving averages. Viewing the data in this way, two 6-year patterns are visible, 1987-1993 and 1993-1999. The annual seasonal up's and down's are easily seen along with the fact that the two 6-year patterns differ markedly from each other.

The first 6-year pattern shows significant symmetry in the peaks and valleys of production and inventory. During this time period, there is very little time lag between low points in inventories and peaks in production. In the latter 6-year period, however, a more asymmetrical and erratic pattern develops.

It has been speculated by many in the industry that this is due to the structural charges that occurred in sawmilling in 1990-1992, as reported by Luppold[3]. The hypothesis is that after a long period of stagnant or declining markets for hardwood producers, consolidation and closure of small mills created a more flexible sawmill. As the resulting sawmill base became more flexible and the average size of mills increased, these mills became more capable of pursuing other more profitable markets for all hardwood products. In general, this has been proven by Luppold and others, but the effect on how these newly empowered mills view producing crossties has not been studied. The fact that

[3] **William Luppold**. 1995. *Structural Changes In The Central Appalachia Hardwood Sawmilling Industry*. USDA Forest Service.

Figure 1


Crosstie Production/Inventory
Monthly Tie Production
Monthly Tie Inventory
6 Month Avg. Monthly Tie Production
6 Month Avg. Monthly Tie Inventories
Quarter

these changes did occur in the sawmilling community, and that crossties are eighth on the list of largest markets for sawn hardwood products, gives ample credibility to the speculation that cutting ties is, now more than ever, a matter of choice rather than necessity for many existing mills.

During the development of this paper the same production and inventory data was graphed on a twelve-month moving average. This was done, in part, to test the validity of the conclusions drawn from viewing production and inventory in the 6-month format. Figure 2 shows tie production data in 12-month format vs. the same data in 6-month format. Interestingly, much of the erratic nature exhibited in the post 1993 period seems to melt away when viewing it in the 12-month format. This, and the fact that trends emerge without the clutter of seasonal variations, would suggest that industry analysts may wish to view tie production and inventory in the longer moving average format.

Even so, both rail and tie industry experts continue to report that something about the last 6 years is different in the way the marketplace responds to volatile demand. In fact, a look at Figure 3 (illustrating both inventory and production in a 12 month format) does suggest that something is different about 1994-1999 in the same way the 6 month format does. Upon additional investigation, the difference appears as a greater time lag between the low points in inventories and the peaks in production. This time lag is now extended by several months. Something has changed tie producers response time to peak demands.

To investigate this further, estimated Class I Railroad purchases (based on annual tie installation data) was graphed against reported Class I tie installations (Figure 4). Between 1993 and 1994 industry wide tie production begins to exceed Class I installations by increasing margins. This divergence leads to the inevitable conclusion that there must be other buyers for crossties affecting the market or that tie inventories are growing to unhealthy levels.

In fact, production of ties for Short Line railroad usage increased significantly during the last 6 years[4]. Also, particularly in the last 2 years, tie inventories have ballooned to historical highs. Both factors would seem to be in play.

The value in exploring this background data is that it illustrates that tie markets do indeed follow typical supply and demand market forces. Thus, it also indicates that this market can be measured in a way that will allow the activity in the marketplace to be predicted with a properly designed model. It further suggests that the effect of structural changes that occurred at the source of supply during ‘90-‘92, coupled with Class I Railroads behavior in purchasing ties and the influence of Short Line Railroads on the market, all contribute to the manner in which tie producers are able to respond to large demand peaks.

Therefore, determining the interrelationship between tie production and inventory, and railroad usage of ties, as it affects tie prices, becomes the first critical question to investigate.

[4] Based on annual RTA short line railroad industry surveys.

Figure 2

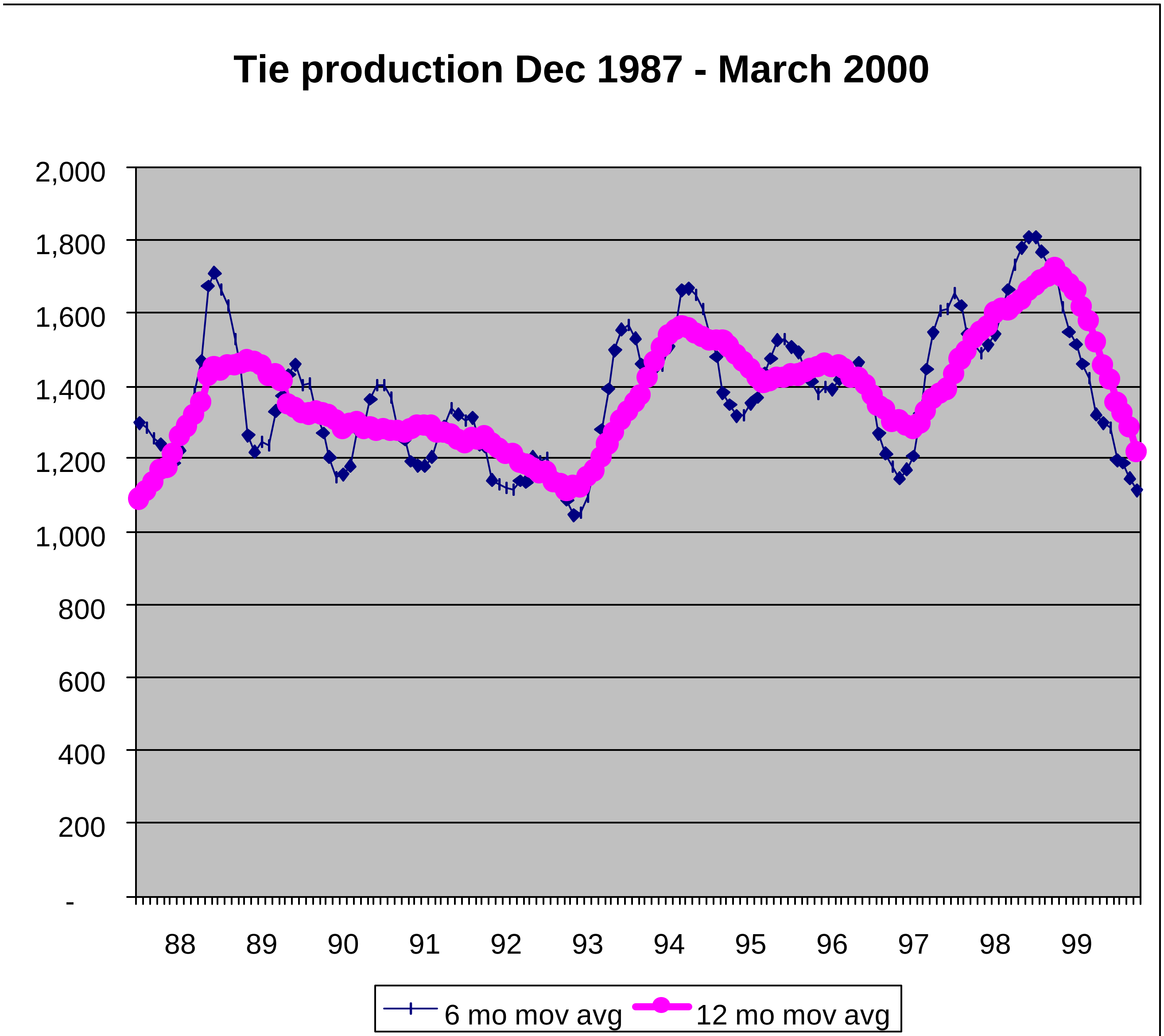

Tie production Dec 1987 - March 2000
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
88
89
90
91
92
93
94
95
96
97
98
99
6 mo mov avg
12 mo mov avg

Figure 3

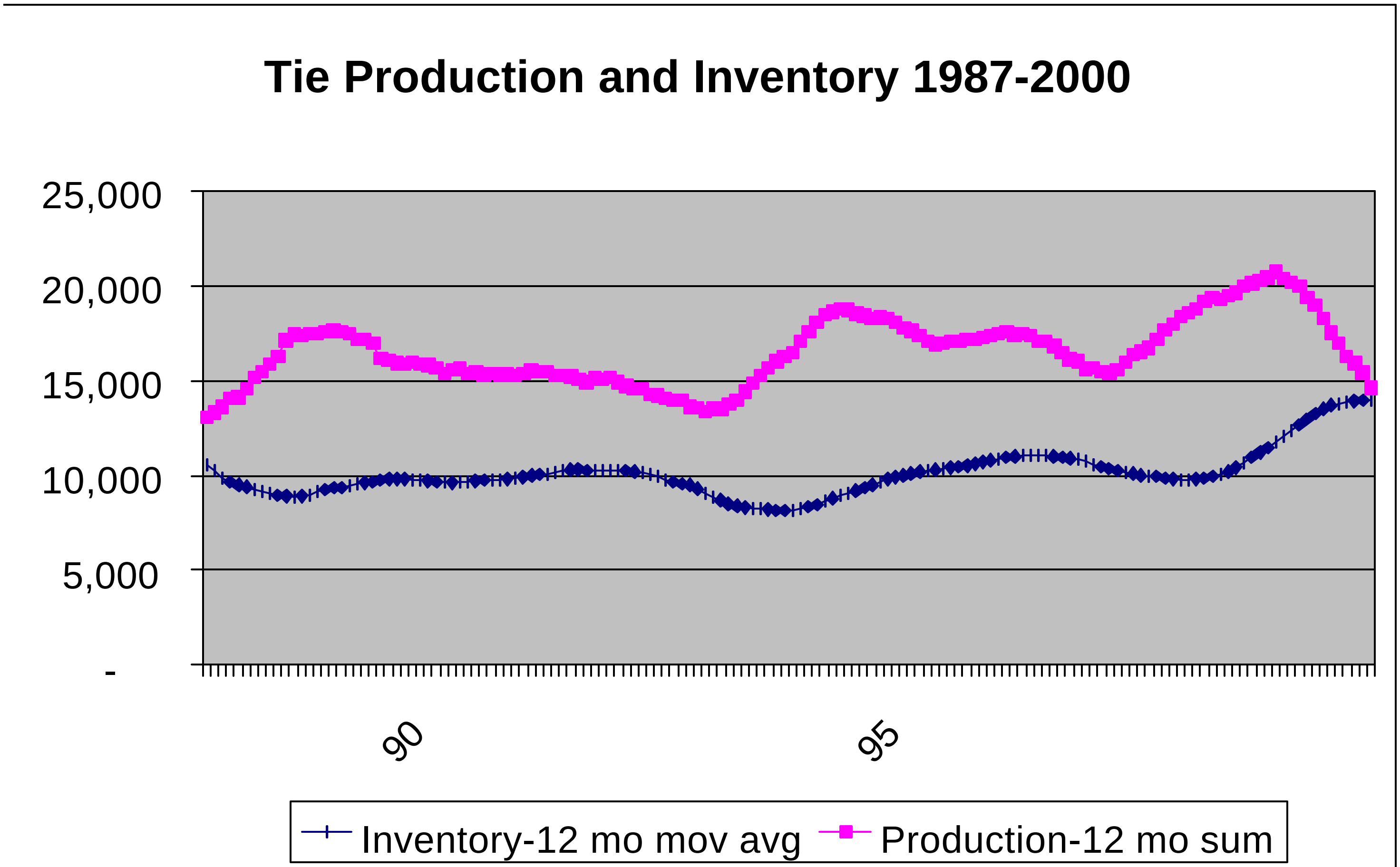
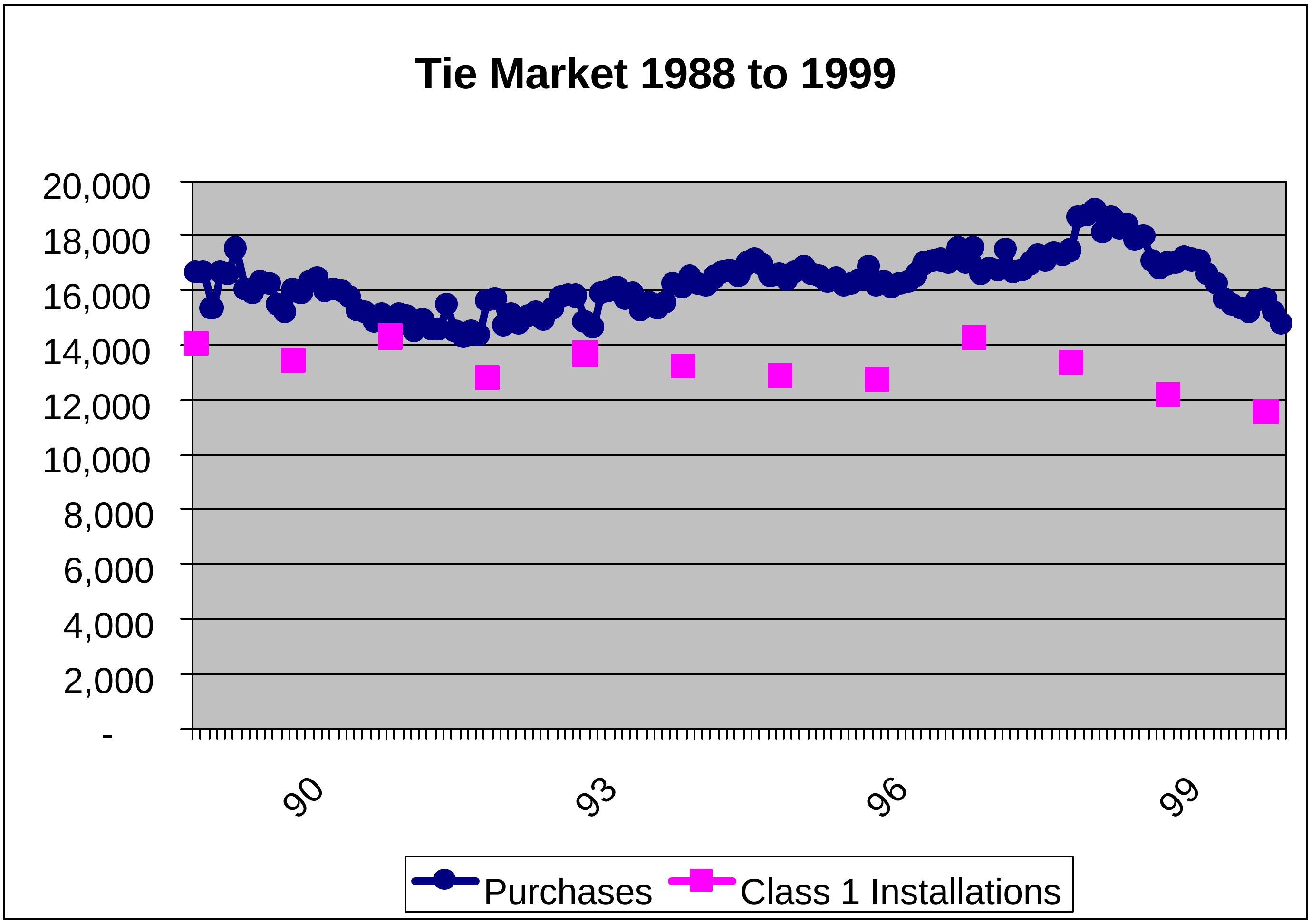

Tie Production and Inventory 1987-2000
25,000
20,000
15,000
10,000
5,000
-
90
95
Inventory-12 mo mov avg
Production-12 mo sum

Figure 4


Tie Market 1988 to 1999
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
90
93
96
99
Purchases
Class 1 Installations

Interrelationship Model of Production/Inventory/Usage

The prediction of cross-tie prices is of keen interest to all sectors of the railroad community to include both railroad buyers and tie producers. Among the factors that have been identified as being factors in the fluctuations in tie prices are:

- Production; the number of ties produced in a given (reported) time period
- Inventory; the number of ties in inventory, either at the producer or at the railroad
- Green wood price, such as the Green 4/4 2A Red Oak price

All three of the above factors are monitored on a monthly basis by the industry and reported in Crossties Magazine, a bi-monthly industry publication. In order to see if it possible to use this commonly used data to "forecast" the price of green hardwood cross-ties, an analysis of approximately 5 ½ years work of data (65 month from January 1994 through December 1999- see Table 1) was performed. This analysis took the form of a multi-variable linear regression analysis, with the dependent variable being the green tie price and three independent variables, the three factors noted above: cross-tie production, cross-tie inventory and Green 4/4 2A Red Oak price.

The results of this analysis was the following equation for the calculation of green cross-tie prices:

$$GCTP = 0.00076*TP + 0.00023*INV + 0.01833*G2AB + 3.9045$$

Where:

GCTP = Green cross-tie price (in dollars)
TP = monthly tie production (in thousands of ties)
INV= monthly cross-tie inventory (in thousands of ties)
G2AB = Green 4/4 2A Red Oak price (in dollars)

Table 2 presents a summary of the analysis statistics. As can be seen from this summary, the regression analysis generated an excellent statistical correlation with an R^2 of 96%.

Figure 5 presents a comparison of the predicted tie price with the actual tie price for the entire analysis period (January 1994 through January 2000). Table 3 compares the predicted and actual prices for the period January 1995 through May 1994 and presents the difference in percent. On average (for the entire 65 month analysis period) the difference between the actual and predicted price was 2.0%.

Table 1: Monthly Reported Statistics
January 1994 through January 2000

Date	Monthly Tie Price	Production	Inventory	2A Board Price
01/18/94	$16.30	1215	8901	$478.33
02/15/94	$16.30	1230	9072	$471.67
03/15/94	$16.30	1621	9317	$471.67
04/16/94	$16.31	1592	9197	$471.67
05/17/94	$16.34	1601	9178	$465.00
06/14/94	$16.23	1783	9202	$461.67
07/16/94	$16.13	1607	9599	$455.00
08/16/94	$16.09	1775	9469	$441.67
09/13/94	$15.97	1643	9688	$441.67
10/15/94	$15.90	1490	9834	$440.00
11/15/94	$15.90	1372	10112	$436.67
12/17/94	$15.90	1351	10409	$436.67
01/17/95	$15.83	1250	10839	$436.67
02/14/95	$15.65	1178	10708	$436.67
03/14/95	$15.62	1445	10559	$436.67
04/15/95	$15.59	1309	10446	$436.67
05/16/95	$15.43	1383	10281	$436.67
06/13/95	$15.39	1546	10231	$435.00
07/15/95	$15.36	1340	10289	$431.67
08/15/95	$15.27	1601	10200	$426.67
09/16/95	$15.24	1680	10433	$423.33
10/17/95	$15.04	1600	10511	$421.67
11/14/95	$14.99	1393	10314	$420.00
12/16/95	$14.99	1432	11435	$420.00
01/16/96	$14.98	1250	11722	$420.00
02/13/96	$14.97	1267	11863	$420.00
03/16/96	$14.90	1544	11710	$420.00
04/16/96	$14.86	1385	11572	$420.00
05/14/96	$14.79	1514	11293	$420.00
06/15/96	$14.79	1383	10655	$420.00
07/16/96	$14.79	1418	10682	$420.00
08/17/96	$14.79	1493	10463	$423.33
09/17/96	$14.79	1360	10468	$428.33
10/15/96	$14.90	1610	10058	$431.67
11/16/96	$14.96	1186	10168	$436.67
12/17/96	$15.13	1080	10386	$446.67
01/14/97	$15.15	885	11281	$456.67
02/11/97	$15.48	1164	11134	$471.67
03/15/97	$16.01	1140	10598	$485.00
04/15/97	$16.06	1424	9733	$500.00
05/17/97	$16.06	1330	10107	$515.00

06/17/97	$16.32	1309	9340	$528.33
07/15/97	$16.51	1577	9274	$533.33
08/16/97	$16.89	1901	9154	$541.67
09/16/97	$17.13	1738	9762	$551.67
10/14/97	$17.16	1787	9245	$561.67
11/15/97	$17.38	1358	9562	$568.33
12/16/97	$17.94	1575	10135	$575.00
01/17/98	$17.98	1363	10283	$578.33
02/17/98	$18.30	1438	10340	$588.33
03/17/98	$18.30	1556	10018	$588.33
04/14/98	$18.30	1653	10220	$588.33
05/16/98	$18.30	1487	10182	$588.33
06/16/98	$18.30	1746	10244	$586.67
07/14/98	$18.37	1752	10273	$581.67
08/11/98	$18.43	1799	10568	$578.33
09/16/98	$18.43	1954	11264	$575.00
10/14/98	$18.43	1938	11798	$568.33
11/11/98	$18.43	1664	12715	$558.33
12/17/98	$18.20	1749	13284	$546.67
01/14/99	$18.47	1507	13549	$541.67
02/11/99	$18.36	1597	13519	$523.33
03/11/99	$17.94	1854	13633	$511.67
04/15/99	$17.71	1320	13511	$501.67
05/17/99	$17.67	1267	13750	$495.00
06/17/99	$17.13	1539	13981	$491.67
07/15/99	$17.00	1189	13972	$490.00
08/16/99	$16.40	1363	14009	$490.00
09/16/99	$16.37	1251	14178	$491.67
10/14/99	$16.37	1187	14089	$501.67
11/15/99	$16.37	1175	14086	$508.33
12/16/99	$16.37	1007	13900	$515.00

TABLE 2: SUMMARY REGRESSION STATISTICS

R Squared	0.96
No. of Observations	73.00
Standard Error	0.39

ANOVA

	df	SS	MS	F	Significance F
Regression	3.00	98.40	32.80	215.37	0.00
Residual	61.00	9.29	0.15		
Total	64.00	107.69			

	Coefficients	Std Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	3.9045	0.60	6.49	0.00	2.70	5.11
X Variable 1	0.000763	0.00	3.15	0.00	0.00	0.00
X Variable 2	0.000231	0.00	5.74	0.00	0.00	0.00
X Variable 3	0.018329	0.00	20.72	0.00	0.02	0.02

Figure 5

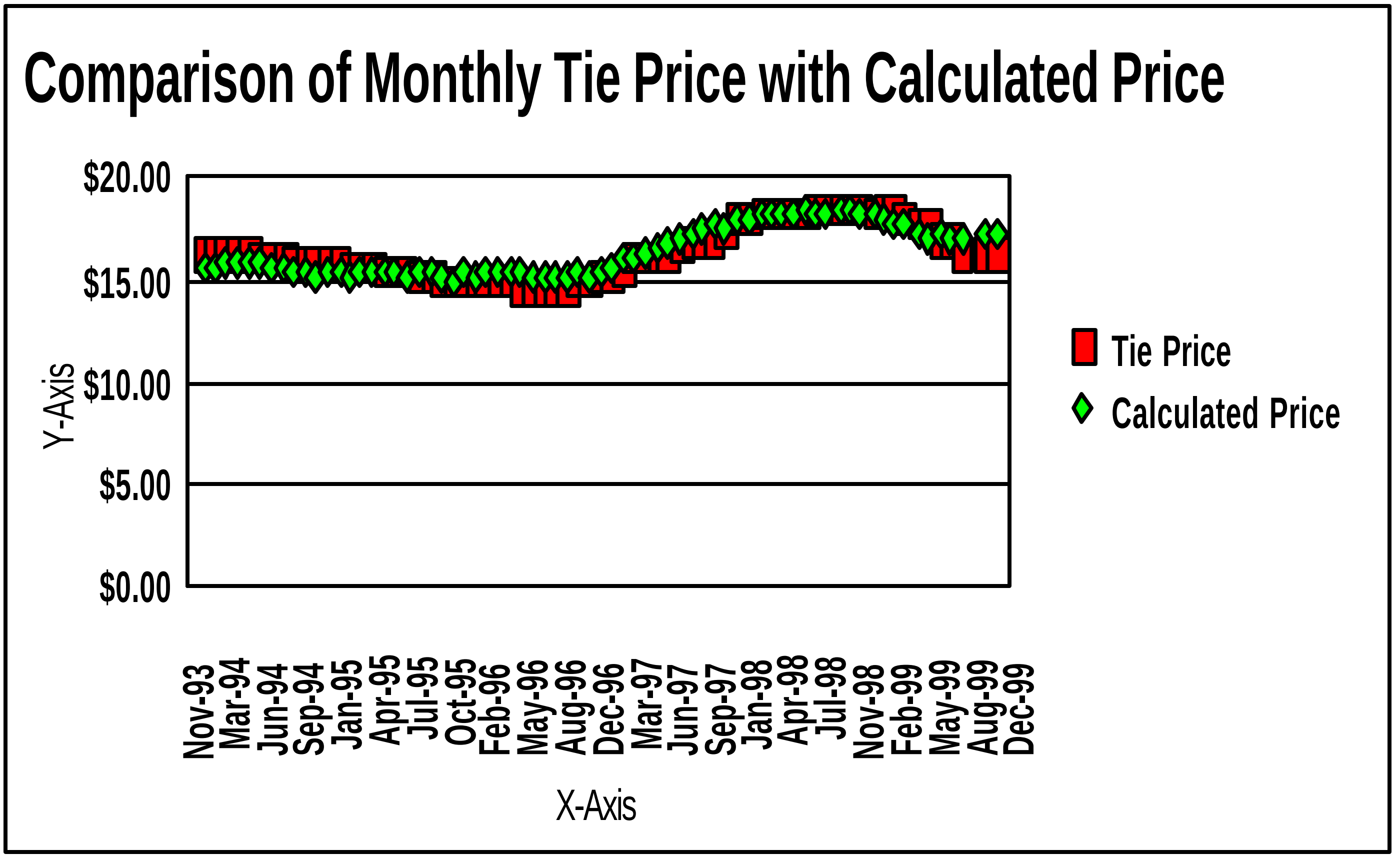

Comparison of Monthly Tie Price with Calculated Price
$20.00
$15.00
$10.00
$5.00
$0.00
Y-Axis
Nov-93
Mar-94
Jun-94
Sep-94
Jan-95
Apr-95
Jul-95
Oct-95
Feb-96
May-96
Aug-96
Dec-96
Mar-97
Jun-97
Sep-97
Jan-98
Apr-98
Jul-98
Nov-98
Feb-99
May-99
Aug-99
Dec-99
X-Axis
Tie Price
Calculated Price

TABLE 3: Comparison of Actual and Model Calculated Tie Prices

Date	Monthly Tie Price	Calculated Price	% Difference
01/18/94	$16.30	$15.65	4.0%
02/15/94	$16.30	$15.58	4.4%
03/15/94	$16.30	$15.94	2.2%
04/16/94	$16.31	$15.89	2.6%
05/17/94	$16.34	$15.77	3.5%
06/14/94	$16.23	$15.85	2.3%
07/16/94	$16.13	$15.69	2.8%
08/16/94	$16.09	$15.54	3.4%
09/13/94	$15.97	$15.49	3.0%
10/15/94	$15.90	$15.38	3.3%
11/15/94	$15.90	$15.29	3.8%
12/17/94	$15.90	$15.34	3.5%
01/17/95	$15.83	$15.36	2.9%
02/14/95	$15.65	$15.28	2.4%
03/14/95	$15.62	$15.45	1.1%
04/15/95	$15.59	$15.32	1.7%
05/16/95	$15.43	$15.34	0.6%
06/13/95	$15.39	$15.42	0.2%
07/15/95	$15.36	$15.21	1.0%
08/15/95	$15.27	$15.30	0.2%
09/16/95	$15.24	$15.35	0.7%
10/17/95	$15.04	$15.28	1.6%
11/14/95	$14.99	$15.05	0.4%
12/16/95	$14.99	$15.33	2.3%
01/16/96	$14.98	$15.26	1.9%
02/13/96	$14.97	$15.31	2.3%
03/16/96	$14.90	$15.48	3.9%
04/16/96	$14.86	$15.33	3.2%
05/14/96	$14.79	$15.36	3.9%
06/15/96	$14.79	$15.12	2.2%
07/16/96	$14.79	$15.15	2.4%
08/17/96	$14.79	$15.22	2.9%
09/17/96	$14.79	$15.21	2.8%
10/15/96	$14.90	$15.37	3.1%
11/16/96	$14.96	$15.16	1.3%
12/17/96	$15.13	$15.31	1.2%
01/14/97	$15.15	$15.55	2.7%
02/11/97	$15.48	$16.01	3.4%
03/15/97	$16.01	$16.11	0.6%
04/15/97	$16.06	$16.40	2.1%
05/17/97	$16.06	$16.69	3.9%
06/17/97	$16.32	$16.74	2.6%

07/15/97	$16.51	$17.02	3.1%
08/16/97	$16.89	$17.40	3.0%
09/16/97	$17.13	$17.59	2.7%
10/14/97	$17.16	$17.70	3.1%
11/15/97	$17.38	$17.56	1.1%
12/16/97	$17.94	$17.98	0.2%
01/17/98	$17.98	$17.92	0.3%
02/17/98	$18.30	$18.17	0.7%
03/17/98	$18.30	$18.19	0.6%
04/14/98	$18.30	$18.31	0.0%
05/16/98	$18.30	$18.17	0.7%
06/16/98	$18.30	$18.35	0.3%
07/14/98	$18.37	$18.27	0.5%
08/11/98	$18.43	$18.32	0.6%
09/16/98	$18.43	$18.53	0.6%
10/14/98	$18.43	$18.52	0.5%
11/11/98	$18.43	$18.34	0.5%
12/17/98	$18.20	$18.32	0.7%
01/14/99	$18.47	$18.11	2.0%
02/11/99	$18.36	$17.84	2.9%
03/11/99	$17.94	$17.84	0.5%
04/15/99	$17.71	$17.23	2.7%
05/17/99	$17.67	$17.12	3.1%
06/17/99	$17.13	$17.32	1.1%
07/15/99	$17.00	$17.02	0.1%
08/16/99	$16.40	$17.16	4.6%
09/16/99	$16.37	$17.14	4.7%
10/14/99	$16.37	$17.26	5.4%
11/15/99	$16.37	$17.37	6.1%
12/16/99	$16.37	$17.32	5.8%

Intuitive Case for Market Stability

The interrelationship between the statistics tracked by rail and tie industry personnel exhibits significant correlation to the tie prices. Additional auto-correlation studies (prepared during the review process, but not presented here), intended to investigate the importance of the time lag within the analysis, proved to exhibit even greater significance with R^2 in the .98 range. There can be no doubt that the data utilized in this study is important to understanding the dynamics of the marketplace.

The second question that is natural to pose is: Are there other data that is also important to understand the market dynamics? If for no other reason than the short line railroad industry is 25 - 30% of tie usage in the marketplace, one would have to answer yes. Indeed, there may be several factors that should be included in any final predictive model.

The next sections will discuss why intensive efforts to develop or fine-tune such a model are economically important to railroads and the suppliers. Before such discussion, though, it is instructive to review the intuitive benefits that greater market stability can bring to railway tie users and producers.

The railroad business is a business that *thinks* long term when the engineering and equipment departments plan life-cycle parameters for major assets. Locomotives, for example, often provide service for many decades. Track components such as railway ties average 35-40 years in the North American rail system. Newly signed agreements reported by General Electric's locomotive manufacturing division (1999 fiscal year annual report), that take a long-term view of purchasing and servicing, are further evidence of this "long term" aspect of the railroad industry.

The wood tie producing industry also is an industry with several "long-term" aspects. Trees that are utilized for tie producing logs require many decades to reach "size maturity" for cutting ties. Then, once cut, ties must normally air-dry for an average of 6-10 months before they are ready to treat and be installed in track.

It is this second long-term aspect that *causes* the greatest difficulty in the marketplace. Tie producers and railroad purchasing departments have to make a "guess" at inventory needs 8-12 months ahead of actual installation *requirements* or *"allowments"*. This "guess" is made easier when engineering departments make precise plans for "requirements". The "guess" is made inaccurately when railroad finance departments alter the "allowments" based on short-term cash management objectives.

The reality in the early 21st century is that small sawmillers when forced to reduce or quit cutting ties, if they stay in business at all, find other markets for the products that can be cut from a tie log. Those mills that still remain at the conclusion of a "down" tie market must be coaxed away from the new product customers they have cultivated to stay in business. Coaxing these mills back into cutting ties takes mainly one thing - money. And the money normally required must not only exceed the price the sawmill now gets for the products it produces for new customers, it must exceed it by a significant premium. That is what happens at the sawmill that *survives* a "down" tie market.

For the sawmill that doesn't survive there is another cost component that gets "driven" into the market. The loss in capital invested for equipment that is not recovered, is at least one example of system wide costs that could potentially be minimized. This is particularly understandable when one investigates where a large portion of this financing originates.

Tie treating and contracting companies provide the most significant portion of this small sawmill financing and have an additional "driven-in" cost component that could also be minimized with steadier supply/demand scenarios. These larger entities have an overhead cost that consists, in part, of a capital fund used to provide "financing" to sawmillers. This capital cost is quantifiable. It can also be reduced in a marketplace that behaves with regularity rather than in a swift and dramatic cyclic nature.

Additionally, inventory carrying costs likewise influence the cost of producing ties and the producers cost of capital (relevant interest rates and cost of equity financing). Figure 6 shows inventory value estimated by using the purchase price of ties and prime interest rate. Estimated in this way, monthly inventory carrying costs were about $1.1 million during 1994-1997; during 1998 they rose to $1.4 million; during the past 15 months average monthly cost is $1.54 million--- 40% higher than normal. Inventory carrying costs are normally 5% of sales revenue, but are now over 7%. Higher interest rates will intensify this inventory cost problem.

All of these cost components are known by railroad purchasing staff, sawmills, tie contracting and tie treating companies. Yet, over the past 15 years, neither producer nor user has identified workable solutions to the dilemma. Furthermore, it would seem that finding new ways to induce the positive benefits (i.e., cost efficiencies) of steadier market supply/demand is critical to the health of both industries.

Therefore, determining if is there a potential realizable economic benefit for greater market stability and if it can be measured are important to the debate. If these questions are answered positively, then the next question is: Will the economic case create enough impetus for those who in a position to chart a new course, to actually do so? The following initial look at an economic case for increased stability in the demand provides one answer to these questions.

The "Economic Case" for Steady State

The history of tie installation in the US is one of significant variation in numbers of ties installed. This variation is due, only in part, to changes in cross-tie prices or actual ties required for maintenance. Financial return and "cash flow" considerations often resulted in large-scale changes in ties installed. Table 4 presents the actual number of ties installed from 1960 through 1999. Part of the reason for the changes in ties installed over the years was the shrinking number of track miles and increasing level of traffic (as presented in Table 4 as Track Miles and Annual MGT respectively). However, normalizing for these two operating factors, as presented in Table 4, still results in large scale fluctuation in ties installed, from a normalized low of just under 11 million ties to a normalized high of almost 23 million ties. This type of large-scale variation in purchasing quantity must have an impact on the economic health of the tie producing industry and on the prices paid for the ties.

In order to see if there is an economic benefit in having a more consistent tie purchasing policy, an economic analysis of alternate tie purchase "streams" was performed. The RTA *TieLife* software package was used to predict future tie requirements, based on the historical data of Table 4. This data, together with actual tie prices for the last six years (Table 5) was used to perform an economic cost stream analysis for green cross-ties.

Figure 6

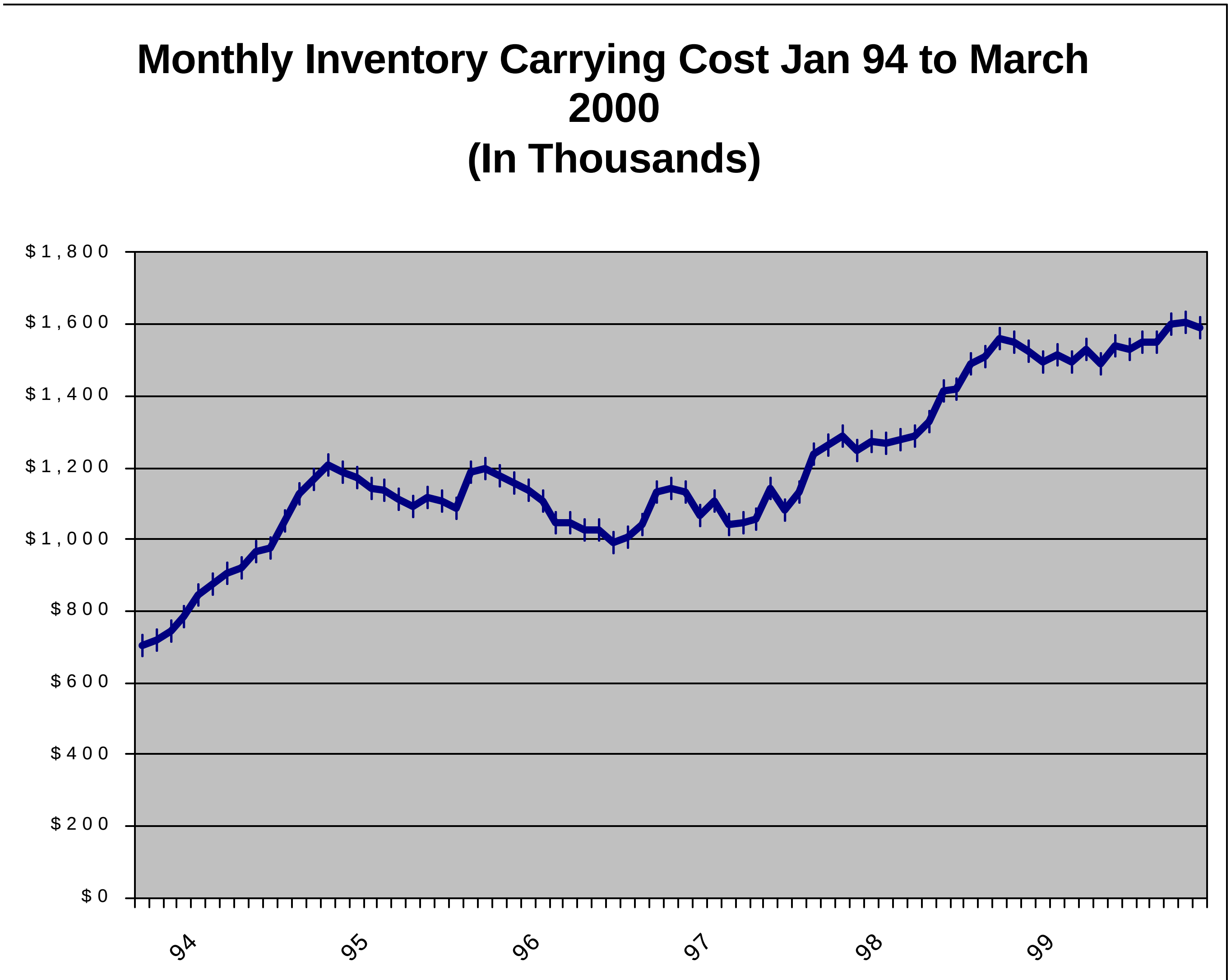

Monthly Inventory Carrying Cost Jan 94 to March 2000
(In Thousands)
$1,800
$1,600
$1,400
$1,200
$1,000
$800
$600
$400
$200
$0
94
95
96
97
98
99

Table 4: US Industry Tie Installations and Industry Performance Statistics

Year	No. Ties Installed	Track Miles	Annual MGT	Normalized Ties Installed
1960	16417000	358520	1.6	13579280
1961	13426466	338416	1.77	10918318
1962	15206006	335055	1.86	12039393
1963	15120230	332971	1.95	11632458
1964	16546000	347107	1.94	11255754
1965	16982000	345422	2.02	11266710
1966	17699000	344001	2.15	11723202
1967	17458000	341499	2.11	11811301
1968	19006000	339781	2.19	13858314
1969	20088000	338795	2.27	14305005
1970	19611000	336332	2.27	13981941
1971	22777000	334932	2.21	16633538
1972	22251000	331129	2.35	16025611
1973	19893000	328625	2.59	13434155
1974	21175000	327285	2.6	15883134
1975	20548000	310941	2.43	17055405
1976	27002000	312770	2.54	22964140
1977	27270000	310800	2.66	22555267
1978	27228000	309700	2.77	22660092
1979	26667000	300000	3.05	21335026
1980	25984000	270623	3.4	22226987
1981	26529000	267589	3.4	22950487
1982	20726000	263330	3.03	20209822
1983	20086000	258703	3.2	19146785
1984	23581000	252748	3.65	21741405
1985	20736000	242320	3.62	20063248
1986	18104000	233205	3.72	18656413
1987	14768000	220518	4.28	14507831
1988	14046000	213669	4.66	14341146
1989	13458000	208322	4.87	13641189
1990	14309000	200074	5.17	15577325
1991	12844000	196081	5.3	14007411
1992	13690000	190591	5.6	15906759
1993	13233000	186288	5.95	15040790
1994	12896000	183685	6.54	13604341
1995	12784000	180419	7.24	12735080
1996	14269000	176978	8.02	13725397
1997	13363372	172564	7.82	13431748
1998	12185000	171098	8.05	12586714
1999	11574711	169766	8.5	11574711

Table 5: Recent Cross-Tie Prices

Year	Normalized Ties	Cost/green tie	Cost/treated Tie
1994	13604341	$16.14	$24.90
1995	12735080	$15.37	$25.60
1996	13725397	$14.89	$25.70
1997	13431748	$16.51	$25.50
1998	12586714	$18.31	$28.70
1999	11574711	17.14	$27.80
average	12942998	$16.39**	$26.37**

** 6 year average

The *TieLife* generated forecast tie requirements for a twenty year time horizon (2000 through 2019) is presented in Table 6 and in Figure 7. Note that the forecast annual tie requirements fluctuate from 12.5 Million to over 16 Million, a variation of almost 30%. The mean or average of these annual forecasts is 14.45 Million ties as shown in Figure 2.

In order to calculate an economic cost stream for the future tie purchases, it is necessary to define the variation in tie cost with quantity of ties. In order to accomplish this, the actual tie price for the last six years was averaged (Table 5) to give a tie purchase price (for green ties) of $16.39[5]. During that same time period the average treated tie price was $26.37. This tie price was then normalized by the six year average of the ties installed (12.9 Million) to give an average tie price/million installed ties. Neglecting inflation (i.e. setting inflation to zero), it is then possible to calculate the annual tie purchase cost (using the quantity adjusted tie price noted above) for the 20 year forecast period as shown in Table 7. The Present Worth (PW) of this cost was also calculated based on an interest rate of 5% and is likewise presented in Table 7. As can be seen in this Table, the Present Worth of this 20 year tie purchase stream is $3.3 Billion.

In order to examine the effect of a steady state purchasing policy, this cost stream was compared to the case where the same number of ties were purchased over the 20 year period, but were distributed uniformly over the time period. This results in an annual purchase of 14.45 Million ties (the mean value presented in Figure 7). If it assumed that the cost per tie would stay fixed, based on this constant (steady state) stream of ties, then using the six year average price of $16.39, the Present Worth of the future (20 year) purchase stream is $2.95 Billion as shown in Table 8. Noting that the non-steady state Present Worth stream was $3.3 Billion, then the total savings (present worth) over the 20 year period would be $350 Million, a savings of over 10%. The corresponding average annual savings[6] would be $30 Million or 11% (based on an average annual cost of $267 Million for the non-steady state case presented in Table 7 and $237 Million for the steady state case presented in Table 8).

Thus it can be seen, that the potential for significant savings exists, if tie purchase fluctuations could be reduced or eliminated, with a corresponding reduction in the fluctuation in tie purchase price.

[5] During that same time period, the average treated tie price was $26.37.
[6] Net present worth.

Table 6: Forecast Tie Requirements and Tie Costs

Forecast Year	Forecast Ties	
2000	12486012	
2001	13592918	
2002	14071826	
2003	14061921	
2004	13248380	
2005	14393321	
2006	14891094	
2007	15495658	
2008	15746341	
2009	16190789	
2010	15001919	
2011	15412917	
2012	14934195	
2013	15107557	
2014	14080581	
2015	15303870	
2016	14245605	
2017	14459756	
2018	13550238	
2019	12724183	
	mean=	14449954
	std	972766

Figure 7

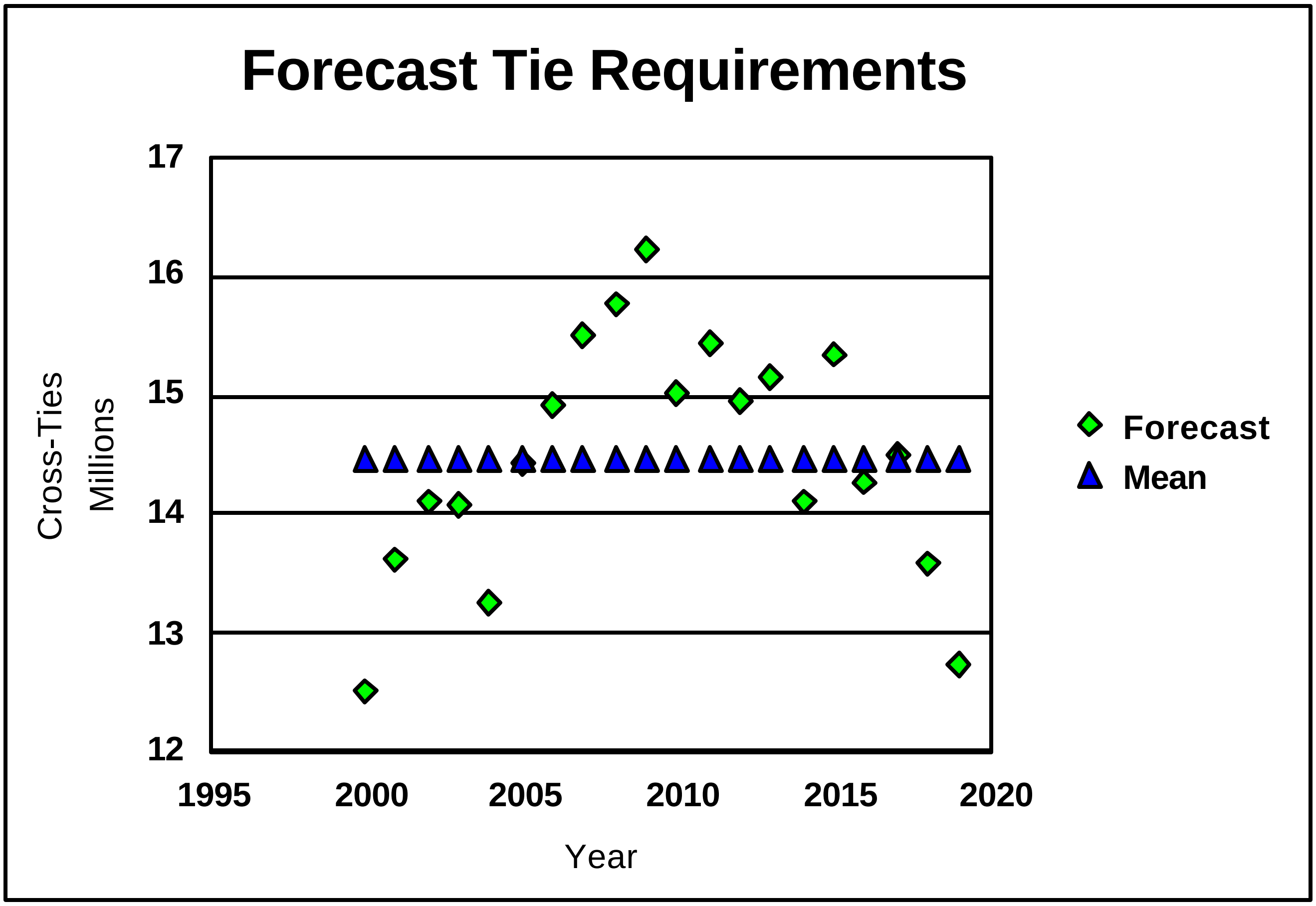

Forecast Tie Requirements
17
16
15
14
13
12
1995
2000
2005
2010
2015
2020
Year
Cross-Ties
Millions
Forecast
Mean

TABLE 7: Forecast Tie Requirements and Tie Costs

	Forecast Ties	Cost/tie purchased	Annual cost (in 000s)	PW (in 000s)
2000	12486012	$15.90	$198,587	$189,131
2001	13592918	$17.31	$235,358	$213,477
2002	14071826	$17.92	$252,234	$217,890
2003	14061921	$17.91	$251,879	$207,222
2004	13248380	$16.88	$223,578	$175,179
2005	14393321	$18.33	$263,892	$196,920
2006	14891094	$18.97	$282,460	$200,739
2007	15495658	$19.74	$305,861	$207,018
2008	15746341	$20.06	$315,837	$203,591
2009	16190789	$20.62	$333,918	$204,997
2010	15001919	$19.11	$286,680	$167,616
2011	15412917	$19.63	$302,603	$168,501
2012	14934195	$19.02	$284,097	$150,663
2013	15107557	$19.24	$290,731	$146,839
2014	14080581	$17.94	$252,548	$121,480
2015	15303870	$19.49	$298,336	$136,671
2016	14245605	$18.15	$258,503	$112,784
2017	14459756	$18.42	$266,333	$110,667
2018	13550238	$17.26	$233,882	$92,555
2019	12724183	$16.21	$206,235	$77,728
	14449954	TOTALS	$5,343,553	$3,301,667
	972766	average	$267,178	

Table 8 : Effect of More Consistent Installation (mean)

	Ties	Cost/tie	Annual cost	PW
		purchased	(in 000s)	(in 000s)
2000	14449954	$16.39	$236,883	$225,603
2001	14449954	$16.39	$236,883	$214,860
2002	14449954	$16.39	$236,883	$204,628
2003	14449954	$16.39	$236,883	$194,884
2004	14449954	$16.39	$236,883	$185,604
2005	14449954	$16.39	$236,883	$176,766
2006	14449954	$16.39	$236,883	$168,348
2007	14449954	$16.39	$236,883	$160,332
2008	14449954	$16.39	$236,883	$152,697
2009	14449954	$16.39	$236,883	$145,426
2010	14449954	$16.39	$236,883	$138,501
2011	14449954	$16.39	$236,883	$131,905
2012	14449954	$16.39	$236,883	$125,624
2013	14449954	$16.39	$236,883	$119,642
2014	14449954	$16.39	$236,883	$113,945
2015	14449954	$16.39	$236,883	$108,519
2016	14449954	$16.39	$236,883	$103,351
2017	14449954	$16.39	$236,883	$ 98,430
2018	14449954	$16.39	$236,883	$93,743
2019	14449954	$16.39	$236,883	$89,279
			$4,737,658	$2,952,085
		Savings	$605,895	$349,582
			11.34%	10.59%

Additional Benefits

The initial analytical work illustrates potential significant savings for railroads in a steadier market place. Furthermore, the intuitive case also suggests that benefits that could accrue from greater stability. Are there other benefits available in stable market supply/demand scenarios?

Efforts to improving operational efficiency are a constant part of daily work for anyone in the sawmill business. How to handle the material more efficiently, how to minimize waste, and other questions require consistent attention. Because this is such an integral part of their work, owners and operators of these mills often can accurately estimate the cost efficiencies that will occur as the result of a potential change in operating practices. Discussion with sawmillers have yielded estimates, that under ideal market conditions (i.e., steady market demand for products), a minimum level of 3% cost efficiencies could be induced into the system. If one were to speculate that steady demand would induce similar savings at the treating plant, the net result could be as much as 4-6% production related cost efficiencies system-wide in ideal markets. Would such efficiencies translate into net selling price reductions? History and market competition would almost certainly argue that it would.

One of the key questions unanswered, though, is could such efficiencies occur under market conditions that vary, as long as that variance is minimal and predictable?

Identifying the range of variance in market demand for ties that is acceptable (i.e., manageable) in the market place, thus becomes an important question to answer.

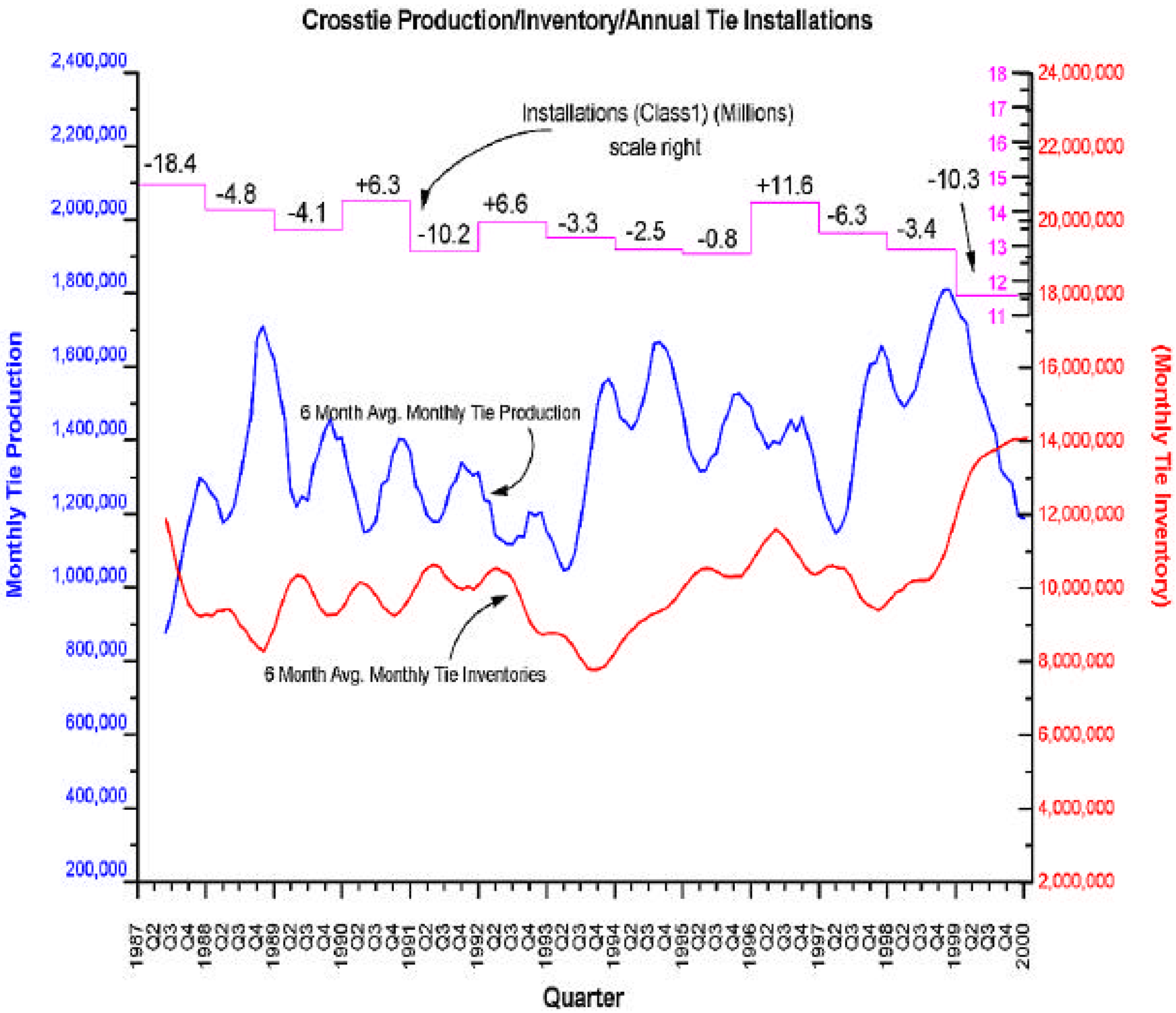
The data presented in Figure 8 illustrates the same production and inventory data mapped now with Class I railroad installations (the percentages given refer to the variance between each successive year and the year in which the percentage is given.) In the last 15 years there have been three spikes in demand from Class I railroads. Each of these spikes is followed, comparatively, by a significant curtailment in installations in the following year(s).

During these spikes in demand, cross-tie inventory is severely impacted downward. This is followed by an aggressive attempt not only to serve the railroad's needs but also to replenish inventories. Add to this, what appears in RTA surveys as increasing crosstie demand from short line railroads as well, and the tie producers feel enormous pressure to hasten a ramp up in production. From the data it can be seen, though, that this surge in railroad activity in each the peak periods is temporary. In other words, an extra measure of vigilance by producers, seems to be called for in managing inventories during these temporary market surges.

The behavior of railroads and producers can't be faulted during these times however. Railroads that need more ties for maintenance and construction do not want to be caught short. Producers, in what is obviously a volatile market, perceive a need to be most productive when market conditions are optimal.

What seems to be apparent from the data is that if the modulation between peaks and valleys in demand could be softened or smoothed out all parties would prosper from the results.

Figure 8


Crosstie Production/Inventory/Annual Tie Installations
Installations (Class1) (Millions)
scale right
-18.4
-4.8
-4.1
+6.3
-10.2
+6.6
-3.3
-2.5
-0.8
+11.6
-6.3
-3.4
-10.3
6 Month Avg. Monthly Tie Production
6 Month Avg. Monthly Tie Inventories
Monthly Tie Production
(Monthly Tie Inventory)
Quarter

The historical data presented in Figure 7 and the predictive price model would indicate that for producers demand variances, in the range of 2.5 – 3.0% annually, are manageable. However that same data shows that increases or decreases in the demand curve is significantly stressful to all parties when the variance exceeds 5-6%

While these percentages seem small, a 6% increase or decrease in tie production, based on current markets (all railroad activity included [class I, short line, etc.]), translates into 1,000,000 or more ties annually. Based on current RTA membership this would be the equivalent of the entire production of 80-100 average sawmills. So even though the percentage is a small number, the impact on the tie-producing network is significant.

Summary and Conclusions

During the first six months of 1992, the fundamentals in the patterns of tie production and inventory changed. Preceding that time, inventory low points were matched by peaks in production almost simultaneously. But, starting with the peak in demand in 1992, the pattern shifts to a low in inventory followed by a peak in production fully one year later. This pattern is repeated between 1997 and 1999.

This suggests that structural changes that occurred in sawmilling during 1990-1992 altered something in the response time of the wood tie industry. It is for this reason alone that more consistency between maintenance planning and purchasing would be beneficial. Furthermore, from this information it could be argued that, should additional structural changes in sawmilling occur because of continued erratic markets, future response times, pricing, and even the ability to provide stable supply could be impacted in dramatic ways.

On the economics side, the forest products industry would never contend that prices for any end-product, including crossties, will remain constant forever. First there is inflation to contend with, but since this would occur with any end product used by railroads and it has been discounted in this study. Second, it is clear that some of the price increases over the study period are induced by other demands for hardwood lumber and timbers.

However, it is certain from the analytical efforts undertaken, and the intuitive cases presented, that a significant minimum savings could occur annually for railroads. These savings could accrue from either a steadier approach to tie installations by railroads, or a method of accurately predicting actual tie installations/purchases. Either method, alone or in combination with each other, would be important new inventory management tools.

In other words, it is critical to both industries for tie producers to be able to plan inventory requirements at maximum efficiency. To create savings, the actual system-wide installations in a period 12-24 months into the future must be acted upon in inventory management schemes in the 0-12 month preceding period. It appears that this planning can be done effectively as long as system wide fluctuations in inventory requirements remains below 3%. Accomplishing this feat first requires an understanding of the key factors outlined in this paper. Second, it requires applying this understanding in the marketplace. Application could take the form of either behavioral changes within the railroads, creation of a global railroad/tie industry business communication strategy, or developing a reliable and accurate predictive supply/demand model that would have the same impact. In fact, for producers to operate at their optimum efficiencies, it will likely require thoughtful application of components of each of these options.

These options for achieving significant payback to railroads and tie producers, are worthy of additional economic research. This suggests that now is the time for representatives of these industries to gather together to discuss formation and implementation of one or more of these approaches.