Measuring supply chain performance of tyre manufacturers in India: an empirical investigation

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Abstract: Supply chain management is crucial for the successful business operations. Current businesses pose many challenges in terms of cost pressure, lesser profit margin and supply chain complexity in Indian set up. In such a situation, monitoring the performance of supply chain is necessary. Keeping this in mind, this paper tries to measure the performance of five tyre manufacturers in India based on the published financial statements. The empirical data is gathered for five Indian tyre manufacturing companies for the last four years. The financial data of these five companies are taken from the public domain of financial database, Capitaline Databases. The finding of this study demonstrated that there are two groups of tyre manufacturers. One group contains similar supply chain management practices. The other might have different practices leading to difference in supply chain performance. This study provides valuable insights not only for tyre manufacturers to improve their supply chain performance, but also for research scholars who want to conduct their further research in the same domain.

Keywords: supply chain; supply chain length; efficiency; working capital productivity; India.

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1 Introduction and review of literature

In the past literature, it has been observed that competitive advantage is one of the outcomes of well managed supply chain therefore in last two decades supply chain got immense importance in business operations.

With the purpose of managing the supply chain actions for realising improvement in enterprise performance, it is necessary to improve the planning and management of activities such as materials planning, inventory management, capacity planning, and logistics (Chandra and Kumar, 2000) with suppliers and clients.

> "Supply chain management (SCM) refers to corporate business processes integration from end users through suppliers that provide information, goods, and services that add value for customers." (Ellram et al., 2006)

Saiz et al. (2007) observed that the stake holders are currently focused on performance measurement related to the supply chain. Supply chain performance (SCP) and effective management of supply chains is getting importance in gaining competitive advantage for firms (Christopher, 1998; Simchi-Levi et al., 2008).

A good SCP measurement system requires for improvement in SCP (Charan et al., 2008). The ability to provide information connections across the supply chain allows supply chain partners to share knowledge about plans, requirements, and status resulting in improved SCP (Zhang et al., 2006). AMR Research (2010), a Boston-based research firm that conducts independent research on supply chains, has shown that organisations with superior SCP outperform their competitors in earnings per share, return on assets and profit margins (Caruso, 2004). SCP refers to the extent to which a supply chain meets end-customer requirements, and contains operational efficiencies which can deliver that performance (Hausman, 2005). Vokurka and Lummus (2000) told that the goal of SCM is to add value for customers at reduced overall costs. The added value should be reflected in the cost, quality, flexibility and delivery components of SCP (Ho et al., 2002). All the narrated citations show importance and need of SCP in carrying out business in concurrent time. These studies also convey that performance measurement will help the organisation to create value for customers, to reduce cost for end users and to gain competitive advantage over competitors in the industry. This builds rational for measuring the performance of supply chain.

The existing methods of measuring SCP are identified as an important field of research for both academicians and practitioners. However, the area, SCP measurement,

has not gained proper attention from researchers or practitioners (Beamon, 1999; Holmberg, 2000; Gunasekaran et al., 2001; Chan and Qi, 2003; Chan et al., 2003; Gunasekaran et al., 2004; Folan and Browne, 2005; Park et al., 2005; Shepherd and Gunter, 2006; Theeranuphattana and Tang, 2008).

There are several metrics in the literature to measure SCP (Gunasekaran et al., 2004; Gunasekaran and Ngai, 2005; Gunasekaran and Kobu, 2007; Folan and Browne, 2005; Fynes et al., 2005), yet an effective performance measurement method has always been under considerable debate, and requires further research exploration (Beamon, 1998, 1999; Gunasekaran et al., 2001; Hervani et al., 2005; Holmberg, 2000; Lummus and Vokurka, 1999; Quinn, 1997; van Hoek, 1998; Gunasekaran and Kobu, 2007).

Further, there is a lack of significant study of supply chain practices and its performance in developing countries, in general and India, in particular (Austin, 1990). In the Indian context, there have been many attempts to measure the performance at the organisational level, but very few attempts have been made to measure the performance at inter-organisational level (Saad and Patel, 2006).

Simatupang and Sridharan (2004a, 2004b) revealed that there was no aggregate measure of overall SCP from which a firm could compare performance with other industry members. Absence of such performance measurement system in SCM can be viewed as a major deficiency.

Brewer and Speh (2000) and Ittner and Larker (2003) advocated that financial indicators should be used in conjunction with non-financial indicators; otherwise performance of the firm suffers. This indicates that performance measurement system should have both types of performance indicators.

Although the supply chain operations reference (SCOR) model provides a common supply chain framework, standard terminology, common metrics associated benchmarks, and best practices, the approach on the utilisation of SCOR seems to be rather rigid (Samuel et al., 2004). Wong and Wong (2008) have clearly specified in the review of SCP benchmarking problems that:

- Past literatures on performance measurements had not viewed supply chain as a whole entity. Hence, it is difficult to evaluate performance when there are multiple inputs and multiple outputs to the system. The difficulties are further aggravated when the relationships between the inputs and the outputs are complex and involve unknown trade-offs.
- Past work had failed to address the collaborative relationships in the area involving joint decision making.
- Mathematical models are scarce.
- SCOR model needs a more dynamic platform to address the integration synchronisation when it involves collaboration in joint decision making in supply chain.

Above review of literature depicts that there is no complete matrix or model available in Indian context which measures the performance of supply chain operated in India. It is also highlighted that contemporary models are more rigid, complex, time consuming and therefore there is a need of new method of SCP measurement which provide a simple and appropriate methodology of data collection and data analysis for calculation of relevant parameters. Moreover as narrated by Shah (2009) unlike western countries majority of

Asian countries suffer from the problem of data availability and this to refer to the non-financial data. As narrated by Shah (2009), companies operated in India do not have sufficient data to apply other models for measurement of SCP. Due to this reason, it is important to have such measure of SCP which relies on published financial data. The Shah's model is fully dependent on financial data which can be taken from published financial statements. Above discussion proposes a research gap which needs to be addressed. To address above narrated gap, researchers have adopted model proposed by Shah (2009) for measuring the SCP. After adoption of measurement model, researchers have applied it in one industry which is tyre manufacturers. In other words, researchers want to analyse the performance of supply chain of selected tyre manufacturers based on the Shah's model. Researchers have given justification for adoption of tyre industry as mentioned below.

2 Selection of industry

To apply Shah's model researchers zero down on tyre manufacturers of India. Tyre manufacturing industry is neither too complicated nor too simple. It is evident that tyre manufacturing industry does not posses complication similar to automobile industry. At the same time, it is also evident that tyre manufacturing is not similar to simple paper manufacturing industry, wherein only one type of raw material is required. Researchers have adopted middle order approach. Too simple industry does not show full-fledged supply chain operations and therefore by selecting such industry gives inappropriate conclusion on supply chain study. At the same time too complicated industry involves nexus of suppliers which brings complexity of operations and coordination in the supply chain study. Based on studying above two approaches, researchers adopted moderate approach and therefore selected tyre manufacturing industry. Nevertheless, the analytical procedure performed in this study can be applied to any industry in order to understand the performance of supply chain.

3 Selection of companies

In tyre manufacturing industry, two criteria have been selected for choosing tyre manufacturers. First criterion is net sales of tyre manufacturers and second criterion is net profit of tyre manufactures. First criterion (net sales) is focusing on the magnitude of the business of tyre manufacturer. Higher sales show higher movement of material, money and information flow in supply chain. Similarly higher net profit shows lower cost and well managed supply chain activities.

All the tyre manufacturing companies are arranged in descending order of net sales for the last four years. Based on the sales data, first five tyre manufacturing companies are selected for analysing SCP (refer Table 1). Financial data of net sales and net profit are taken from the public domain database 'Capitaline database'. Some tyre manufacturing companies are to be selected for the supply chain analysis. The criteria adopted to select tyre manufacturing companies are net sales and net profit. Five tyre manufacturing companies' net sales and net profit are 85.56% and 76.64% of total sales and total profit respectively. So as a concluding justification, these five companies that are representative of entire tyre industry are taken forward for further analysis.

Table 1 Net sales of tyre manufacturing companies

Sr. no.	*Name of the company*	*Net sales (in Rs. Crore)*				
		2010–2011	*2011–2012*	*2012–2013*	*2013–2014*	*Total*
1	MRF Ltd.	9,743.17	11,870.18	12,131.16	13,197.58	46,942.09
2	Apollo Tyres Ltd.	5,490.49	8,157.88	8,511.73	8,711.74	30,871.84
3	JK Tyre & Industries Ltd.	4,830.13	5,479.58	5,430.83	5,951.08	21,691.62
4	CEAT Ltd.	3,498.77	4,475.74	4,881.44	5,354.81	18,210.76
5	Balkrishna Industries Ltd.	1,934.14	2,819.96	3,190.57	3,576.71	11,521.38

In addition, the second criterion considered for the selection of tyre manufacturing companies is net profit. Again all the tyre manufacturing companies are arranged in descending order of net profit for the last four year. Based on net profit, first five tyre manufacturing companies are selected for the SCP analysis (refer Table 2).

Table 2 Net profit of tyre manufacturing companies

Sr. no.	*Name of the company*	*Net profit (in Rs. Crore)*				
		2010–2011	*2011–2012*	*2012–2013*	*2013–2014*	*Total*
1	MRF Ltd.	619.42	572.36	802.21	897.89	2,891.88
2	Balkrishna Industries Ltd.	185.56	268.52	355.83	488.37	1,298.28
3	Apollo Tyres Ltd	198.25	181.33	312.53	442.62	1,134.73
4	CEAT Ltd.	22.28	7.54	106.35	253.78	389.95
5	JK Tyre & Industries Ltd.	61.32	11.00	105.54	134.68	312.54

Both these criteria (i.e., net sales and net profit) lead to different results for the five tyre manufacturing companies. Based on sales criteria, MRF Ltd. is leading one which is followed by other companies in order of its sales: Apollo Tyres Ltd., JK Tyre & Industries Ltd., CEAT Ltd. and Balkrishna Industries Ltd. whereas in terms of net profit criteria, MRF Ltd. is again performing well which is followed by other companies in order of its net profit: Balkrishna Industries Ltd., Apollo Tyres Ltd., CEAT Ltd. and JK Tyre & Industries Ltd.. After considering both the criteria together, the same five companies are screened for further analysis in the tyre industry.

4 Hypotheses development

4.1 Length of supply chain

Excess inventory conveys inability and less competence of the organisation in managing its supply chain processes. It also depicts absent of coordination and collaboration among supply chain partners, poor forecasting ability, and a lack of flexibility and agility to adjust to demand shifts. The inability to execute basic supply chain processes can negatively affect the firm's reputation. This reflects the importance of lower stock of

inventory in supply chain. It is also important to note here that fewer days of inventory means lower length of supply chain.

4.2 Supply chain inefficiency ratio

A high level of inventory creates significant cost of tied-up capital (Farris and Hutchinson, 2002). Due to this reason organisation has to reduce inventory related costs and thereby increasing efficiency ratio. Higher distribution cost and holding cost of inventory are contributing to supply chain inefficiency (SCI) ratio.

4.3 Supply chain working capital productivity

As Mehta (1974) proved that the working capital of the firm is affected by production plan, credit period and number of sundry debtors of the organisation. Better integration among intermediary results in increased cost efficiency (Jensen and Meckling, 1976). Smolen (1997) concluded that the organisation takes long to pay their bill be negotiated for supply chain overall performance. Higher inventory, higher account receivable and lower account payable leads to lower supply chain working capital productivity.

The objective of this paper is to measure the performance of supply chain of five tyre manufacturers through the model proposed by Shah (2009). As per the model of Shah, three criteria (i.e., length of supply chain, SCI ratio and supply chain working capital productivity) are used to measure the performance of supply chain for five tyre manufacturers. It is very important to test whether each criterion used to measure the performance of supply chain is significantly different across five tyre manufacturers. To study above objective it is necessary to develop hypothesis and to test it therefore following hypotheses are formulated:

H_1 Total length of supply chain of tyre manufacturing companies is significantly different.

H_2 SCI ratio of tyre manufacturing companies is significantly different.

H_3 Supply chain working capital productivity of tyre manufacturing companies is significantly different.

5 Data analysis and major findings

Data has been analysed based on the financial statement published by five tyre manufacturing companies in their financial report taken from the public domain database ‘Capitaline database’.

5.1 Indicators of SCP

Keeping objective of this research study in mind, SCP of these five tyre manufacturing players for last four years are analysed by computing three important ratios viz. total length of supply chain, SCI ratio and supply chain working capital productivity.

5.1.1 Total length of supply chain

The duration of time taken by the material flow is captured by this measure. The total length of the chain is arrived at by adding up the days of inventory of raw materials, work in progress and finished goods. The lower the length of supply chain is better. The company that has the minimum total length of the chain is said to have the best performance. As per the formula of Shah (2009) shown below, total length of supply chain for the five selected tyre manufacturing companies are computed:

$$\begin{aligned}&"\textit{Total length of supply chain (in days)}\\&=\textit{Raw material holding period (in days)}\\&+\textit{Work in process (WIP) holding period (in days)}\\&+\textit{Finished goods holding period (in days)}"\end{aligned}$$

where

$$"\textit{Raw material holding period (in days)} = (\textit{Stock of raw material} * 365\ \textit{days})/\textit{Cost of raw material}"$$

$$"\textit{Work in process holding period (in days)} = (\textit{Stock of WIP} * 365\ \textit{days})/\textit{Cost of production}"$$

$$"\textit{Finished goods holding period (in days)} = (\textit{Stock of FG} * 365\ \textit{days})/\textit{Cost of sales}"$$

On the first performance criteria i.e., total length of supply chain (in days), CEAT Ltd. perform very well on this dimension due to low length of its supply chain in comparison of other selected companies as summarised in Table 3. However, other companies in ascending order of their supply chain length are JK Tyre & Industries Ltd., Apollo Tyres Ltd., MRF Ltd. and Balkrishna Industries Ltd.

Table 3 Total length of supply chain (in days)

Sr. no.	*Name of the company*	*2010–2011*	*2011–2012*	*2012–2013*	*2013–2014*	*Mean*
1	CEAT Ltd.	57.331	46.108	43.917	56.392	50.9370
2	JK Tyre & Industries Ltd.	57.990	50.302	61.566	55.409	56.3168
3	Apollo Tyres Ltd	81.970	55.500	50.546	57.046	61.2655
4	MRF Ltd.	64.058	60.119	66.842	60.938	62.9893
5	Balkrishna Industries Ltd.	111.258	87.424	70.318	84.943	88.4858

5.1.2 SCI ratio

This ratio measures the relative efficiency of internal SCM. This ratio is required to be as low as possible for the companies which want better performance on the efficiency front. To compute this ratio, total inventory carrying costs and distribution costs – components

of internal SCM costs are considered. As per the formula of Shah (2009) shown below, SCI ratio for the five selected tyre manufacturing companies are computed:

The formula for SCI ratio is shown as under:

$$\text{"}Supply\ chain\ inefficiency\ ratio = SCM\ costs / Net\ sales\text{"}$$

where

$$\text{"}SCM\ costs = Distribution\ costs + (Inventory * Inventory\ carrying\ cost\ in\ \%)\text{"}$$

The SCI ratio (the lower the better) provides an insight into the internal SCM efficiency of the company. This measure is termed the SCI ratio since the supply chain cost will be higher if there are inefficiencies in the system. The companies with efficient supply chain system will have relatively lower score in inefficiency ratio measure.

Table 4 SCI ratio

Sr. no.	*Name of the company*	*2010–2011*	*2011–2012*	*2012–2013*	*2013–2014*	*Mean*
1	MRF Ltd.	0.0525	0.0488	0.0518	0.0513	0.0511
2	Apollo Tyres Ltd	0.0612	0.046	0.0438	0.0597	0.0526
3	CEAT Ltd.	0.0498	0.0506	0.0524	0.0612	0.0535
4	JK Tyre & Industries Ltd.	0.0506	0.0466	0.0575	0.0601	0.0537
5	Balkrishna Industries Ltd.	0.0943	0.0735	0.0691	0.0671	0.0760

Based on the SCI ratio depicted in Table 4, it can be inferred that MRF Ltd. is found to have efficient supply chain system than that of other tyre manufacturing companies selected for analytical purpose. However, Apollo Tyres Ltd., CEAT Ltd. and JK Tyre & Industries Ltd. have shown good performance as compared to Balkrishna Industries Ltd. due to lower SCI ratio.

5.1.3 Supply chain working capital productivity

The supply chain working capital productivity is calculated using the following formula given by Shah (2009).

$$\text{"}Supply\ chain\ working\ capital\ productivity = Net\ sales / Supply\ chain\ working\ capital\text{"}$$

where

$$\text{"}Supply\ chain\ working\ capital = Inventory + Account\ receivable - Account\ payable\text{"}$$

Table 5 Supply chain working capital productivity

Sr. no.	*Name of the company*	*2010–2011*	*2011–2012*	*2012–2013*	*2013–2014*	*Mean*
1	Apollo Tyres Ltd	7.136	10.033	12.162	15.459	11.1975
2	JK Tyre & Industries Ltd.	7.638	11.732	5.828	5.951	7.7872
3	CEAT Ltd.	3.597	6.536	7.321	7.498	6.2380
4	MRF Ltd.	3.533	4.972	4.850	5.246	4.6502
5	Balkrishna Industries Ltd.	3.243	3.911	4.909	5.203	4.3165

With regard to supply chain working capital productivity, the performance of Apollo Tyres Ltd. is excellent than that of others players. Nevertheless, Balkrishna Industries Ltd. is having low supply chain working capital productivity as compared to other selected tyre manufacturing companies (refer Table 5). Hence, based on supply chain working capital productivity, the performance of other companies in descending order are as: JK Tyre & Industries Ltd., CEAT Ltd., MRF Ltd. and Balkrishna Industries Ltd..

5.2 Hypotheses testing

To apply one way ANOVA, one metric and one non-metric variable is required. In this case total length of supply chain, SCI ratio and supply chain working capital productivity are metric variables. Name of the company is non-metric categorical variable with five categories. As conditions of scale are satisfied, one way ANOVA is applied to test whether difference exist among five tyre manufacturers for three measured variables. After that, independent sample t test is applied for post hoc analysis, to test which pair of companies have significant difference.

- ANOVA 1: name of the company * total length of supply chain (in days)
- ANOVA 2: name of the company * SCI ratio
- ANOVA 3: name of the company * supply chain working capital productivity.

*5.2.1 ANOVA 1: name of the company * total length of supply chain (in days)*

H_1 Total length of supply chain of tyre manufacturing companies is significantly different.

One way ANOVA is performed to test the differences among five tyre manufacturers in terms of total length of supply chain. Table 6 shows that the assumption of homogeneity of variance ($p = 0.181 > 0.05$) is achieved among these five tyre manufacturers. Hence, one way ANOVA can be performed on it. Furthermore, the result of one way ANOVA is also found to be significant at 0.05 level ($F = 7.409$, $p = 0.002 < 0.05$), indicating that there is statistically significant differences in total length of supply chain among five tyre manufacturers (refer Table 7), thus, supporting H_1.

Table 6 Test of homogeneity of variances for Hypothesis 1

Levene statistic	*df1*	*df2*	*Sig. (p > 0.05)*	*Assumption*
1.800	4	15	0.181	Meet

Table 7 One way ANOVA for Hypothesis 1

	Sum of squares	*Df*	*Mean square*	*F*	*Sig. (p < 0.05)*
Between groups	3,350.901	4	837.725	7.409	0.002
Within groups	1,695.977	15	113.065		*(Significant)*
Total	5,046.879	19			

Moreover, in order to examine significant differences among each pair of five tyre manufacturer, Tukey HSD post hoc test is also performed (refer Table 8). The result of post hoc test highlighted that the significant differences in terms of total length of supply chain is found to be significant for all the pairs with Balkrishna Industries Ltd., while for other pairs, no significant differences are observed. Thus, based on total length of supply chain, four players viz. MRF Ltd., Apollo Tyres Ltd., JK Tyre & Industries Ltd. and CEAT Ltd. perform similarly in their supply chain practices and therefore, resulted into no significant differences in their total length of supply chain.

Table 8 Tukey HSD post hoc test (multiple comparisons) for Hypothesis 1

(I) company	*(J) company*	*t value*	*Sig. (p < 0.05)*	*Sig. diff.*
Apollo Tyres Ltd.	CEAT Ltd.	1.37	0.652	No
	MRF Ltd.	–0.23	0.999	No
	JK Tyre & Industries Ltd.	0.66	0.962	No
	Balkrishna Industries Ltd.	*–3.62	0.018	Yes
CEAT Ltd.	MRF Ltd.	–1.60	0.518	No
	JK Tyre & Industries Ltd.	–0.72	0.950	No
	Balkrishna Industries Ltd.	*–4.99	0.001	Yes
MRF Ltd.	JK Tyre & Industries Ltd.	0.89	0.897	No
	Balkrishna Industries Ltd.	*–3.39	0.028	Yes
JK Tyre & Industries Ltd.	Balkrishna Industries Ltd.	*–4.28	0.005	Yes

Note: *The mean difference is significant at the 0.05 level.

*5.2.2 ANOVA 2: name of the company * SCI ratio*

H_2 SCI ratio of tyre manufacturing companies is significantly different.

For testing differences among five tyre manufacturers in terms of SCI ratio, one way ANOVA is run. Table 9 summarises that the assumption of homogeneity of variance is violated (Levene test: $p = 0.034 < 0.05$) and hence, as shown in Table 10, robust tests of equality of means (i.e., Welch test) is applied which meet the assumption of equality of means (Welch test: $p = 0.093 > 0.05$). So, one way ANOVA is performed on it. In addition, the result of one way ANOVA is also found to be significant at 0.05 level ($F = 7.130$, $p = 0.002 < 0.05$), showing that there is statistically significant differences in

SCI ratios for five tyre manufacturers (refer Table 11), thus evidencing the statistical support to H_2.

Table 9 Test of homogeneity of variances for Hypothesis 2

Levene statistic	*df1*	*df2*	*Sig. (p > 0.05)*	*Assumption*
3.475	4	15	0.034	Violated[#]

Note: [#]Welch ANOVA is suggestive for testing group differences.

Table 10 Robust tests of equality of means

Welch statistic[a]	*df1*	*df2*	*Sig. (p > 0.05)*	*Assumption*
3.174	4	6.499	0.093	Meet

Note: [a]Asymptotically F distributed.

Table 11 One way ANOVA for Hypothesis 2

	Sum of squares	*Df*	*Mean square*	*F*	*Sig. (p< 0.05)*
Between groups	17.475	4	4.369	7.130	0.002
Within groups	9.191	15	0.613		*(Significant)*
Total	26.666	19			

Furthermore, to examine which pair of tyre manufacturers is significantly different with each other in terms of SCI ratio, independent sample t test is performed. Table 12 clearly highlights that pair of all tyre manufacturers with Balkrishna Industries Ltd. is found to be significantly different for SCI ratio; however all the other pairs are statistically insignificant as far as their SCI ratio are concerned.

Table 12 Independent sample T test (for pairwise comparison)

(I) company	*(J) company*	*t value*	*Sig. (p < 0.05)*	*Sig. diff.*
Apollo Tyres Ltd.	CEAT Ltd.	–0.127	0.903	No
	MRF Ltd.	0.145	0.890	No
	JK Tyre & Industries Ltd.	0.842	0.451	No
	Balkrishna Industries Ltd.	–3.370	0.028*	Yes
CEAT Ltd.	MRF Ltd.	0.231	0.826	No
	JK Tyre & Industries Ltd.	0.874	0.438	No
	Balkrishna Industries Ltd.	–3.198	0.029*	Yes
MRF Ltd.	JK Tyre & Industries Ltd.	0.328	0.763	No
	Balkrishna Industries Ltd.	–3.043	0.025*	Yes
JK Tyre & Industries Ltd.	Balkrishna Industries Ltd.	–3.968	0.027*	Yes

Note: *Pairwise difference is significant at the 0.05 level.

As summarised in Table 12, it can be inferred that Balkrishna Industries Ltd. is the worst performer on SCI ratio. This indicates that CEAT Ltd., MRF Ltd., JK Tyre & Industries Ltd. and Apollo Tyres Ltd. follows somewhat similar supply chain practices and therefore, resulted into non-significant differences in their SCI ratio. Moreover, as per Table 4, it is also apparent that SCI ratio of Balkrishna Industries Ltd. is the worst but at

the same time it is also noticeable that the inefficiency ratio of Balkrishna Industries Ltd. declining year on year, which indicates a good signal about an improvement in their SCP.

*5.2.3 ANOVA 3: name of the company * supply chain working capital productivity*

H_3 Supply chain working capital productivity of tyre manufacturing companies is significantly different.

In order to examine the differences among five tyre manufacturers in terms of supply chain working capital productivity, one way ANOVA is executed. Table 13 depicts that the assumption of homogeneity of variance is achieved and hence, one way ANOVA is performed on it. Furthermore, the result of one way ANOVA is found to be significant at 0.05 level ($F = 6.388$, $p = 0.003 < 0.05$), indicates that there is statistically significant differences in supply chain working capital productivity among five tyre manufacturers (refer Table 14), thus, statistically supporting H_3.

Table 13 Test of homogeneity of variances for Hypothesis 3

Levene statistic	*df1*	*df2*	*Sig. (p > 0.05)*	*Assumption*
2.154	4	15	0.124	Meet

Table 14 One way ANOVA for Hypothesis 3

	Sum of squares	*Df*	*Mean square*	*F*	*Sig. (p < 0.05)*
Between groups	125.642	4	31.411	6.388	0.003
Within groups	73.761	15	4.917		*(Significant)*
Total	199.403	19			

Table 15 Tukey HSD post hoc test (multiple comparisons) for Hypothesis 3

(I) company	*(J) company*	*Mean diff. (I-J)*	*Std. error*	*Sig. (p < 0.05)*	*95% confidence interval*	
					Lower bound	*Upper bound*
CEAT Ltd.	JK Tyre & Industries Ltd.	–1.549	1.568	0.857	–6.391	3.293
	Apollo Tyres Ltd.	–4.960*	1.568	0.043	–9.801	–0.118
	MRF Ltd.	1.588	1.568	0.846	–3.254	6.430
	Balkrishna Industries Ltd.	1.922	1.568	0.737	–2.920	6.763
JK Tyre & Industries Ltd.	CEAT Ltd.	1.549	1.568	0.857	–3.293	6.391
	Apollo Tyres Ltd.	–3.410	1.568	0.241	–8.252	1.432
	MRF Ltd.	3.137	1.568	0.312	–1.705	7.979

Note: *The mean difference is significant at the 0.05 level.

Table 15 Tukey HSD post hoc test (multiple comparisons) for Hypothesis 3 (continued)

(I) company	*(J) company*	*Mean diff. (I-J)*	*Std. error*	*Sig. ($p < 0.05$)*	*95% confidence interval*	
					Lower bound	*Upper bound*
CEAT Ltd.	Balkrishna Industries Ltd.	1.922	1.568	0.737	–2.920	6.763
JK Tyre & Industries Ltd.	CEAT Ltd.	1.549	1.568	0.857	–3.293	6.391
	Apollo Tyres Ltd.	–3.410	1.568	0.241	–8.252	1.432
	MRF Ltd.	3.137	1.568	0.312	–1.705	7.979
	Balkrishna Industries Ltd.	3.471	1.568	0.227	–1.371	8.313
Apollo Tyres Ltd.	CEAT Ltd.	4.960*	1.568	0.043	0.118	9.801
	JK Tyre & Industries Ltd.	3.410	1.568	0.241	–1.432	8.252
	MRF Ltd.	6.547*	1.568	0.006	1.705	11.389
	Balkrishna Industries Ltd.	6.881*	1.568	0.004	2.039	11.723
MRF Ltd.	CEAT Ltd.	–1.588	1.568	0.846	–6.430	3.254
	JK Tyre & Industries Ltd.	–3.137	1.568	0.312	–7.979	1.705
	Apollo Tyres Ltd.	–6.547*	1.568	0.006	–11.389	–1.705
	Balkrishna Industries Ltd.	0.334	1.568	0.999	–4.508	5.176
Balkrishna Industries Ltd.	CEAT Ltd.	–1.922	1.568	0.737	–6.763	2.920
	JK Tyre & Industries Ltd.	–3.471	1.568	0.227	–8.313	1.371
	Apollo Tyres Ltd.	–6.881*	1.568	0.004	–11.723	–2.039
	MRF Ltd.	–0.334	1.568	0.999	–5.176	4.508

Note: *The mean difference is significant at the 0.05 level.

Additionally, to check significant differences among each pair of five tyre manufacturers, Tukey HSD post hoc test is also performed. The result of post hoc tests (refer Table 15) reveals that the significant differences in terms of supply chain working capital productivity is found significant for three pairs namely, Apollo Tyres Ltd. with CEAT Ltd. ($p = 0.043 < 0.05$), Apollo Tyres Ltd. with MRF Ltd. ($p = 0.006 < 0.05$) and Apollo Tyres Ltd. with Balkrishna Industries Ltd. ($p = 0.004 < 0.05$). Thus, this indicates that supply chain working capital productivity of Apollo Tyres Ltd. is significantly different

from other three tyre manufacturers. Based on mean analysis, it can be seen that the performance of Apollo Tyres Ltd. is better than the rest of the tyre manufacturers.

6 Discussion and conclusions

The findings of the paper help various tyre manufacturing organisations to focus on factors which are important for the performance on supply chain. Based on the above analysis, it is concluded that the SCP of four tyre manufacturers falls in one group and the performance of Balkrishna Industries Ltd. falls in another group. It is also concluded that SCM practices might be similar as far as first group of four tyre manufacturers are concerned. However, SCM practices of Balkrishna Industries Ltd. are different from rest of the four tyre manufactures. This helps the tyre manufacturers to understand their position among the industry.

It is also evident from the result of hypothesis testing that the performance of four tyre manufacturers is not significantly different from each other. Nevertheless, based on the data analysis of four years of tyre manufacturers on three performance criteria, ranking within four manufacturers is done with the help of a simple mean analysis. Considering all the three criteria together and overall mean analysis, it is found that CEAT Ltd. performs the best. Companies in their descending order of performance are JK Tyre & Industries Ltd., MRF Ltd., Apollo Tyres Ltd. and Balkrishna Industries Ltd. respectively. Four tyre manufactures may also get insight for each individual criterion based on mean analysis. Within industry benchmarking for the performance on each criterion can be established based on mean analysis. For the first criterion length of supply chain, the performance of CEAT Ltd. is the best hence it becomes benchmark for rest of all the players to achieve. Similarly best performers in criteria two and three (SCI ratio and supply chain working capital productivity) are MRF Ltd. and Apollo Tyres Ltd. respectively to be followed by rest of the all the tyre manufactures. All the manufacturers should follow this benchmarking for their better performance in supply chain.

Above discussion shares the contribution of present study in the field of SCP measurement. Earlier studies did not show the benchmarking value to be pursued by tyre manufacturers to improve SCP based on said three criteria. Practitioners can get more insight with benchmarking value. They can also identify the variables to be observed and optimised to achieve said benchmarking value for their supply chains.

7 Future research direction

Present study is developed based on financial data of tyre manufacturers from published financial statements. Non-financial measures also contributes to performance of supply chain. Non-financial data can also be gathered for couple of years (with concentrated special efforts) which can be utilised in performance analysis along with financial data. By considering financial and non-financial data simultaneously, further study can be done which contributes even better than the existing study. Another scope of research is to identify variables which are responsible for benchmarking value for said three criteria. Present study helps tyre manufacturers to achieve the benchmarked value. But to achieve this benchmarked value which variables to be controlled or optimised can be studied in future.

8 Limitations

One of the limitations of the study is that it is based on published financial data of tyre manufacturers. This study does not include non-financial data related to supply chain of tyre manufacturers. This study is based on the financial data of last four years. The result of study may differ if the number of years is different from the existing study. One of the companies has not published their financial year data when the data was collected on Capitaline database therefore researchers could not include the financial data of latest year (2014–2015).

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