REVIEW AND ILLUSTRATION ON SOME AREAS OF THE SUPPLY CHAIN NETWORK IN INDIAN RAILWAYS

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ABSTRACT

This paper aims to highlight the importance of transport and logistics in the area of Supply Chain Management (SCM) in Indian Railways. SCM aims to provide finished goods, services and information to the ultimate customer smoothly and effectively. This paper identifies various developments of supply chain in the field of transportation especially in railways. In Indian Railway, coal transportation has been the major source of revenue earning as far as freight transport is concerned. This paper further presents a case study where coal loading statistics of two consecutive years in Dhanbad Railway Division of India has been used to calculate the process capability index. The paper concludes with the findings that the average target loading per day was 7.574 M.T, while average actual loading achieved per day was 7.437 M.T and the average actual C_{pk} achieved was 0.249.

Keywords: Supply Chain, Freight Service, Process Capability, Transport, Coal Loading.

INTRODUCTION

The aim of this paper is to discuss the Supply Chain in transportation sector in Indian Railways (IR). It's a well known fact that cost of a product or service includes the cost of logistics and transportation. In this era of globalization, it is the need of time that a particular product or service should reach the hands of end users at the cheapest possible rates. In order to ensure the efficient flow of variety of goods, services and information there is a need for an effective Supply Chain Management (SCM) system.

This paper presents a number of developments in the field of transport and logistics especially the field of railways. Railway in any part of the world is considered as the life line for its contribution in passenger and freight service. Thus, keeping in mind the Indian scenario, rail freight service is the major source of freight transfer for the industries. It is a major source of revenue for the IR. The revenue earning tonnage rose from 195.9 million tonnes in 1980-81 to 1,014.15 million tonnes in 2012-13, thus registering a sustained increase in revenue earned as compared to ₹.15,509 millions in 1980-81 to ₹.691,658 millions in 2012-13. In commodity wise loading Coal topped the chart with 496.42 millions tonnage causing a revenue earning of ₹.358,944 millions in the year 2012-13 [1].

1. Supply Chain Management

The SCM concept is relatively new which appeared in literature in early 1980s. The concept of SCM can be said to have evolved from overall improvement in the strategies of distribution over the past few years. These strategies combine all elements like material handling, storage and transportation into an integrated logistics concept. Table 1 illustrates some popular definitions of SCM and Table 2 defines the key elements in the SCM system.

1.1 Supply Chain Areas

Supply chain Management has numerous applications which can be implemented in any type of industry, whether you are producer, supplier or a service provider. It has been in widespread use in automotive, garment, logistics, manufacturing etc. In building, an efficient supply chain, requires a longer development period but with the rising pressures of competition, it can make the large customer firms follow a short-period strategy based on cost factors, without taking into account the relevant strategic factors such as technological capability, financial robustness, quality etc. This strategy undermines

Authors	Definition of SCM
Tan et al. (1998)	SCM encompasses materials/supply management from the supply of basic raw materials to final product. It focuses on how firms utilize their suppliers processes, technology and capability to enhance competitive advantage. It is a management philosophy that extends traditional intra-enterprise activities by bringing trading partners together with the common goal of optimization and efficiency [2].
Berry et al. (1994)	SCM aims at building trust, exchanging information on market needs, developing new products and reducing the supplier base to a particular OEM (original equipment manufacturer) so as to release management resources for developing meaningful, long term relationships [3].
Ellram (1991)	A network of firms interacting to deliver products or services to the end customer, linking flow from raw material supply to final delivery [4].
Kopczak (1997)	The set of entities, including suppliers, logistics service providers, manufacturers, distributors and retailers, through which materials, products and information flow [5].
Lee and Ng (1997)	A network of entities that starts with the suppliers and ends with the customers for the production and delivery of goods and services [6].

Table 1. Definition of SCM

S.No	Key elements	Purpose
1	Packaging	Unit size, protective packing, ease of material handling
2	Inventory	What to stock, where to stock and how much to stock
3	Warehousing	Size, capacity, location, cargo handling system and type
4	Information	Information system, tracking, control
5	Transportation	Modal transport, infrastructure, scheduling

Table 2. Key elements of supply chain

the development of a supply chain and its own long term competitiveness.

1.2 Supply Chain in Transportation

There are multiple options for transportation eg. roadway, railway, airway, ships and pipelines, amongst these road, rail and ship account for major freight transport. Trucks are characterized by limited capacity, flexibility and door to door service. Railways are known for handling large capacity, fast service and causes lower environmental impact, ships can carry heavy loads but speed is a constraint.

Supply chain has in particular had a great impact on logistics and business. Railway is one of the major aspect of logistics, which cannot be overlooked. Indian railways freight business is the main concern which can be concentrated to build more efficient and responsive network. Transport network and transport infrastructure are the important elements in efficient logistic system, hence supply chain has particularly a great impact on logistics business and railways. Table 3 discusses the five year plans with respect to transport system in India.

2. Supply Chain and Railways

Jensen (1998) focused on competition in railway monopolies; a theoretical framework and a model were developed for evolution of impact of transformations on efficiency. The result indicates loss of scale advantage and it concluded that the competitive pressure was strong in most of the supply segments (Arne J, 1998). Geyer and Davis (2000) have analyzed the changing patterns of relationship between suppliers and railway operators in Europe. Based on two case studies it was suggested that the dynamic system integration and effective co-ordination capabilities are the most important for successful innovation in market based railway operations.

Reddy et al. (2000) have studied and focused on road and rail transport. They have suggested that the goal of the IR sector should be an efficient, capital-saving, non-import-intensive, affordable, serviceoriented and environmentally sound transport system, i.e., a sustainable transport system; further, both short-term and low-cost measures have been developed to attract political decision-makers with short timehorizons and long-term measures.

Black and Halatsis (2001) studied the demand driven freight transport system for supply chain. Artemis project was considered to improve integration between freight transport and other requirements of a supply chain. It was observed that the telematic applications in supply chain area can reap larger benefits.

Bhagwat and Sharma (2007) have developed a balanced scorecard for SCM. It provides a useful guidance for practical managers in evaluating and measuring SCM and further proposes a balanced performance measurement system to map and analyze supply chains.

Sectors/Units	Upto V Plan ^ 1950-78	VI Plan 1980-85	VII Plan 1985-90	VIII Plan 1992-97	IX Plan 1997-02	X Plan 2002-07	XI Plan 2007-2012	XII Plan 2012-2017
Railways (Rs in crore)	4,723	6.585	16,549	32,306	45,725	84,003	*1,89,838@	4,19,221@
Transport Sector (Rs in crore)	10,117	13,962	29,548	65,173	1,17,563	2,59,777	6,13,185	12,04,172
Transport Sector as % of Plan	16.9	12.8	13.5	13.4	14.4	17.0	16.7	15.7
Railways as % of Total Plan	7.9	6.0	7.6	6.7	5.6	5.5	5.2	5.5

Legend :- ^ Excludes inter-plan period 1966-69. # Original Outlay. * revised @ the outlay does not include funding from PPP or private source

Table 3. Five year plans and transport sector in India [7]

Esposito and Passaro (2009) have studied supply relationship evolution in railway and aircraft manufacturing industries and analyzed vertical relationships. Circulation of Information and Technology as a critical factor for supply chain efficiency has been shown [13].

Osleeb and Ratick (2010) have addressed transportation/trans-shipment issues associated with rail distribution of ethanol bio-fuel by extending Inter-period Network Storage Location Allocation (INSLA) model formulation into a Rail-INSLA model to evaluate rail transportation cost efficiencies that may be realized through the use of storage on the network to agglomerate unit train sized shipments [14].

Hanaoka and Regmi (2011) have studied and reviewed intermodal freight transport in Asia from an environmental prospective. A dry port development case study in Asia has been discussed; further, the policies and ways for promotion of freight transport options are discussed.

Haralambides and Gujar (2011) have studied Indian dry port sector, pricing policy and opportunities for Public-Private Partnership (PPPs) and favored greater devolution through PPPs. Recommendations for legal, regulatory and general economic policy have been made keeping the Indian specificities in the right perspective.

Armstrong and Pretson (2011) have discussed the role of railway over the next half century keeping in mind social and technological changes during this period. Based on the report of Intelligent Infrastructure, future issues of peak oil and climate changes have been studied for the possible role of rail transport in meeting our future needs.

Pittman (2011) has studied risk averse restructuring of freight railways in China. The railway, under capacity pressure acting as a constraint on economic growth has been discussed along with its failure in keeping up demands despite significant increase in network capacities.

Suzuki and Li (2012) have discussed the freight transport in disaster affected situations. Response of railway freight has been reviewed along with discussion on necessity of importance of intermodal freight transport for vital flow of freight in disasters.

Yang and Zhang (2012) have highlighted the effects of competition between air transport and High Speed Rail (HSR). It was found that ticket price of air transport and HSR decrease for given schedule frequencies.

Behrends (2012) has examined the relationship between urban transport and Intermodal Rail-Road Transport (IRRT). A framework for sustainable urban freight transport has been developed and applied on IRRT. The results show that the urban context is a threat for further growth of the rail freight [21].

Reis et al. (2013) have studied rail and multi-modal transport. They analyzed the advantages and disadvantages of combining rail transport with the other transport modes. The effective intermodal transport along with the transshipment technology for freight service and energy use for sustainable rail performance were discussed.

Islam et al. (2013) have discussed principles and methods used in logistics and supply chain. Mathematical formulation of transport and logistics related problems have been presented along with the discussion on the concept of sustainability. The Table 4 discusses the critical summary and major findings of the conducted literature review in the specific field of SCM in IR.

3. Practical illustration through a case study

Following is a case study on coal loading by Coal India

Sr.no.	Study area	Major findings	Author and year
1	Competition in rail monopoly	Developed a model for loss of scale	Jensen (1988)
2	Supplier and railway operator relationship	Dynamic system integration and coordination capabilities were defined as critical ones	Geyer and Davis (2000)
3	Rail and road transport	Goal of Indian transport must be sustainable	Reddy et al. (2000)
4	Demand driven freight transport system	Telematic applications in supply chain can reap larger benefits	Black and Halatsis (2001)
5	Supply chain management	Developed a balanced performance system to analyze supply chains	Bhagwat and Sharma (2007)
6	Network rail and financial analysis	Issues of distribution that were missing from policy debate	Robert Jupe (2009)
7	Supply relationship evolution in railway and aircraft industries	Information and technology circulation was defined as a critical factor for the supply chains	Esposito and Passaro (2009)
8	Transportation issues in rail distribution of ethanol biodiesel	Evaluation of rail transportation cost efficiencies was highlighted	Osleeb and Ratick (2010)
9	Intermodal freight transport	Dry port development and ways for promotion of freight transfer was discussed	Hanaoka and Regmi (2011)
10	Role of railway over next half century	Issues on peak oil and climate change were studied w.r.t. the railway.	Armstrong and Pretson (2011)
11	Risk averse restructuring of railway freight	Railway under capacity pressure was defined as a constraint on growth	Pittman (2011)
12	Freight transport in disaster situation	Railway response was reviewed along with necessity of intermodal transport systems	Suzuki and Li (2012)
13	Competition between air transport and High Speed Rail	Ticket price decreases in weight of welfare with homogeneous passengers and schedule frequencies were discussed	Yang and Zhang (2012)
14	Intermodal rail road transport	Urban context as a threat for future growth of freight was emphasized	Behrends (2012)
15	Rail and multimodal transport	Analysis of combining rail and other modes of transport along with energy use for sustainable performance was discussed	Reis et al. (2013)
16	Logistics and supply chain	Concepts of sustainability along with mathematical formulation of logistic problems were illustrated	Islam et al. (2013)

Table 4. Summary of the reviewed papers

Limited (CIL) in the Dhanbad division of IR.

The domestic coal-supply chain entails local coal consumption for power generation and petrochemical production in the metallurgical and general industries. The export coal-supply chain is entirely dedicated to the coal export to other countries. In India percentage contribution of nuclear energy and other non conventional energy sources to power generation is very less when compared to coal. As the major source of power generation in India is coal, the fact makes the supply chain of coal very critical. The plants use wagons of Indian Railways to transport coal from the coal mines (in case of domestic coal) or from the ports (in case of imported coal) to the plants. Once these loaded railway wagons have reached the power plant, they need to be unloaded and released within a stipulated time frame. The Dhanbad railway division is the leading coal transportation unit out of the five divisions (Danapur, Mughalsarai, Sonepur, Samastipur and Dhanbad) in ECR due to its geographical location. In this case study, targeted and actual loading per day data of coal (in M.T.) of two consecutive years 2012-13 and 2013-14 of CIL in Dhanbad division have been examined to inspect the trends, find percentage variation, C_{pk} value and its utility. Table 5 illustrates the handling capacity of colliery sidings in ECR, while Table 6 shows the coal loading data (in M.T) for the year 2012-14.

Figure 1 illustrates the trend analysis in the year 2012-13 & 2013-14 of coal loading of CIL in Dhanbad railway division. Figure 2 illustrates the C_{pk} values per month for target and actual loading. Figure 3 shows the comparison of percentage variation in coal loading for the year 2012-13 and 2013-14.

Where,

Load variation (%) = [(Actual loading – Target loading)*100] / Target loading.

The analysis indicated through Figures 2- 3 illustrates that the overall average per day target was 7.574 M.T while the achieved actual per day loading was 7.437 M.T. The average actual C_{pk}, calculated from the data was 0.263.

S.N.	Name of colliery sliding	Name of serving station	Rake capacity	S.N.	Name of colliery sliding	Name of serving station	Rake capacity
1	JGB No. 9 (S.Tisra Sdg	Pathardih	Full	28	K.D. Sdg (New Dakra)	Khalari	Full
2	JGB No. 6	Pathardih	Full	29	Tori Sdg	Tori	Full
3	Chasnalla (T.B.. Sdg)	Pathardih	Full	30	Dudhicha	Shaktinagar	Full
4	C.K. West	Pathardih	Full	31	Wharf wall	Shaktinagar	Full
5	C.K. East	Pathardih	Half	32	Jayant	Shaktinagar	Full
6	KDS II	Kusunda	Full	33	Bina	Krishnashilla	Full
7	Gareria	Kusunda	Full	34	Bina Wharfwall	Krishnashilla	Full
8	Bansjora	Bansjora	Full	35	Jhingurda	Singrauli	Full
9	Sijua	Bansjora	Full	36	Bachra (O)	Ray	Full
10	N. Govindpur	Katrasgarh	Full	37	Bachra (N)	Ray	Full
11	Barora	Katrasgarh	Full	38	Rajhara	Rajhura	Half
12	Barora	Katrasgarh	Full	39	Spur	Singrauli	Full
13	Kessurgarh	Katrasgarh	Full	40	South Govindpur	Katrasgarh	Full
14	Tarmi	Bhandaridah	Full	41	Sayal	Patratu	Full
15	Jarangdih LNo.1	Jarangdih	Full	42	Central Saunda	Patratu	Full
16	Jarangdih LNo.2	Jarangdih	Full	43	Sounda B	Patratu	Full
17	Angarpathra	Katrasgarh	Half	44	Giddi A (Raw)	Patratu	Full
18	Maheshpur	Katrasgarh	Half	45	Giddi A Washery	Patratu	Full
19	Phularitand	Katrasgarh	Half	46	Patherdih	Patherdih	Full
20	N.S. Dhori-I	Phusro	Half	47	Dugda Washery	Chandrapura	Full
21	West Bokaro	Chainpur	Full	48	Dhori (Line No. 1 and 2)	Phusro	Full
22	NorthRamgarh	Chainpur	Full	49	Kargali	Bermo	Full
23	Sarubera	Chainpur	Full	50	Swang	Gomia	Full
24	West Sirka	Ranchi Road	Full	51	Kathra	Jarandih	Full
25	Bhurkunda	Bhurkunda	Full	52	Jogta coal siding	Sijua	Full
26	RCM	Ray	Full	53	Kargali washery sdg PF II	Phusro	Full
27	K.D.H Sd (Old and New)	Khalari	Full	54	Kusanda siding	Kusunda	Full

Table 5. Colliery siding having full rake/ half rake handling capacity in East Central Railway

Coal loading (per day)	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Target 2012-13	6.93	7.14	6.96	7.07	6.94	6.78	7.69	7.69	7.69	7.75	7.51	7.75
Actual 2012-13	7.07	7.33	6.73	6.75	6.22	6.3	7.5	7.27	7.88	8.25	7.31	8.83
Target 2013-14	7.6	8.09	7.38	7.32	7.24	7.19	7.85	7.6	8.06	8.47	7.52	9.56
Actual 2013-14	7.28	7.61	7.32	7.73	7.16	6.89	6.58	7.59	8.4	8.39	7.81	8.29

Table 6. CIL coal loading for year 2012-14 (in M.T.) (East Central Railway, 2014)

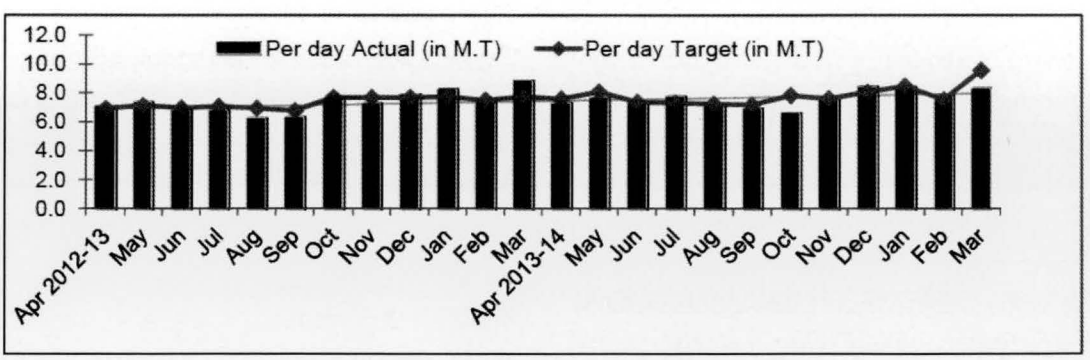

Figure 1. Coal loading Target vs Actual (in M.T.)

The most likely reasons for the lower performance could be shortage of workers and shortage of wagons. Shortage of open hopper wagons causes excess loading and unloading time. Seasonal variation also affects the coal loading as percentage variation in loading can be seen to be on the downward side in the months of August and September for both the years. This is so because the above stated two months receive heavy rainfall in this part

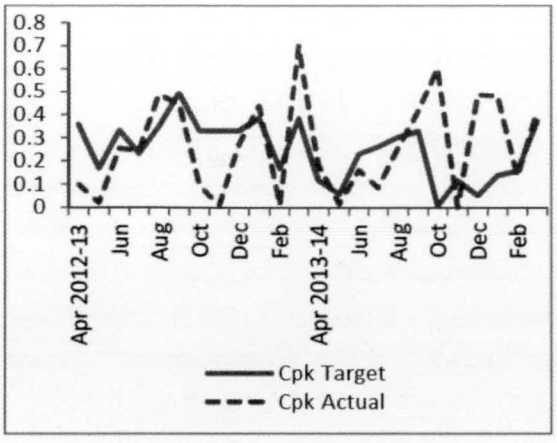

Figure 2. Calculated C_{pk} values for target

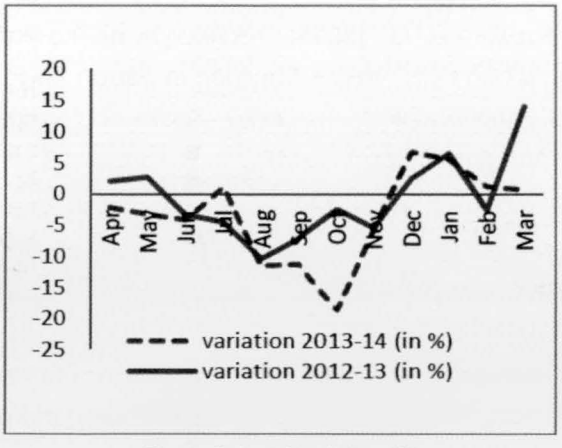

Figure 3. Load variation (%)

of India. Coal when exposed to moisture becomes a little sticky which causes delay in loading and unloading time. In December and January percentage variation in loading can be seen on the upward side in both the years, which indicates better working conditions for the workers in this season.

The main difficulties and challenges were improving the performance in coal transportation through other means like increasing and improving the rolling stock, upgrading and modernizing infrastructure at coal loading and unloading points viz. lighting facility to enable loading round the clock, better connectivity of roads to the loading points, providing better facilities to the loading men which could be some of the steps to be taken for achieving better loading performance. Time and motion study of workers action can also optimize the loading/unloading time.

Conclusion

SCM is a vital network which has the capacity to transform any industry/segment into an effective and economical one. Railways have tremendous potential in transport sector but Indian Railway is losing its freight share to roadways and other modes of transport which is a threat for the growth and survival of railway in India, as major portion of the income comes only from freight service. Apart from safe and punctual service aspects Indian Railway must also focus on satisfaction aspects like ease of booking, material handling, loss compensations, door to door service etc. Railway should follow a blend of efficient supply chain (service at minimum cost) and responsive supply chain (focused towards quick delivery).

The case study on coal loading by Coal India Limited (CIL) in the Dhanbad division of IR illustrates that average actual loading was less than the average target loading per day for the year 2012-14. There is a scope of further improvement in this area. The likely reasons and difficulties were further analyzed and presented along with some recommendations.

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