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Exploratory study of supply chain management trends in Indian Electrical Industry: A literature review

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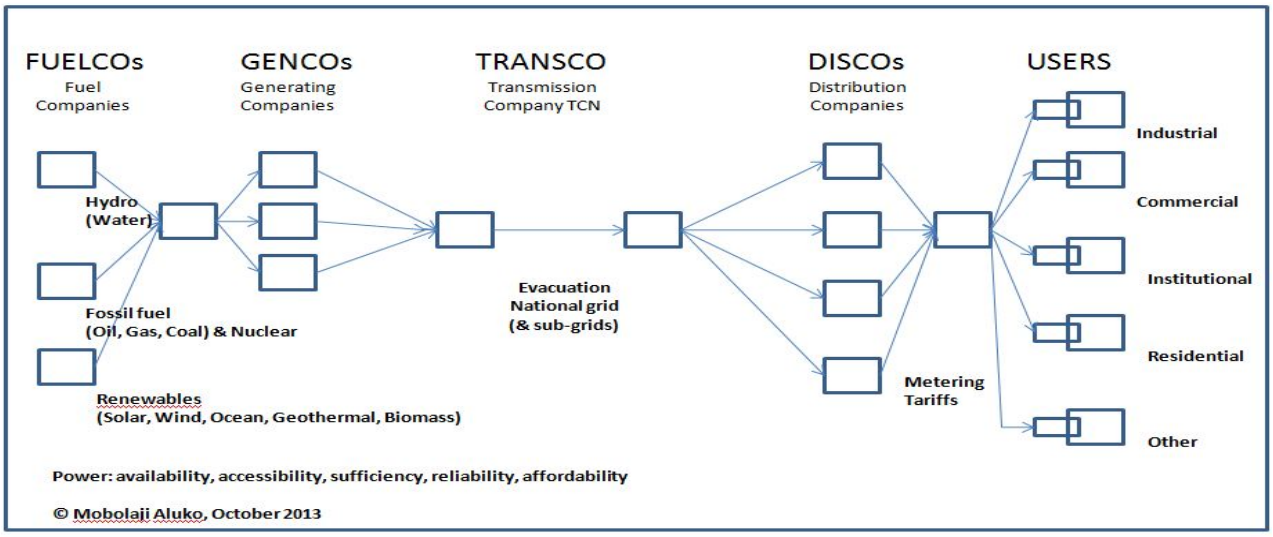
Abstract
Purpose: This paper focuses on need for studying supply chain management trends in Indian Electrical Industry and its preparedness to adopt lean supply chain management practices.
Design/Methodology/Approach: Electrical Industry has its root in engineering industry. The study is based on literature review pertaining to supply chain practices in engineering industry and its nature in electrical industry. It further aims at finding out the areas in which research is required.
Findings: Engineer to Order (ETO) products by nature are driven by specific industrial customer needs and have peculiarities of specific design. Electrical industry, subset of engineering industry, essentially serves power generation, transmission and distribution and hence is driven by economy and vision of the nation. A typical product in electrical industry e.g. generators, turbines, transformer, switchgear- protection equipment has a lead time of 16-18 months and involves lot of stakeholder in making final product. Hence it is interesting to study supply chain practices in this industry. The literature review done in this paper brings out the fact that not much knowledge base is available to understand the supply chain practices in the field of electrical industry particularly in Indian scenario. It also clearly brings out the fact that role of SME's in the value chain is entirely missing or not documented.
Research Limitations / implications: This paper explores the availability of literature in the area of supply chain practices of electrical industry. As a conclusion it gives further direction where research in Indian context should be focused. It is not a research to prove any hypothesis.
Practical implications: Although supply chain management is getting prime importance in today's business world, penetration of best practices is far away from reality. While the intent of SME's is always to adopt good practices, they are so much bogged down by their day to day activities and confined by limited resources that SCM participants at the far end of the value chain do not add much value thereby losing the rigor of value chain.

Keywords: OEM, ETO industry, SCM

1. Introduction
Energy literacy organization states that, generating clean energy is of prime importance and will need developing countries to adopt the technology from the developed nations. As per the world energy statistics for year 2008 (Garg, 2012) [1], India has lowest consumption of power in the world but the energy resources used for power generation is a growing concern. Ritica Sood (2014), in her report says that while 85% of villages are electrified, around 57% of rural household and 12% of Urban household do not have access to electricity. The findings says that, although figures look bright and prosperous as compared to last decade, the frequent load shadings, power cuts, breakdowns imply poor quality of power. Vision 2022 for Indian Electrical Industry is "To make India the country of choice for the production of electrical equipment and reach an output of US$ 100 billion by balancing exports and imports". Under this backdrop, it becomes important to study how the Supply Chain of this industry contributes to the vision of the nation. The role of supply chain partners especially on the supply side becomes a topic of study since real value to the end product is contributed by upward supply chain partners.

2. About Indian Electrical Industry
Electrical industry by its nature is Engineer to Order type barring utility items like fans, bulb, and switches etc. that are available off the shelf. Unlike the automotive industry and other repetitive type of industry where most of the activities relates to procurement, manufacturing and distribution, in Electrical Industry, Engineering is time consuming activity which decides the lead time of the product to the market. Most of the electrical industry goods are capital goods in nature and are required in electricity generation, distribution and transmission. Such goods are not readily available and are generally customized. The indigenization of components that goes into electrical goods is necessity today. Joint ventures, technical collaboration, value chain partnering, green channel vendors are some of the models that are adopted in electrical industry. A typical supply chain for electrical industry is depicted below.



The above picture talks about the stakeholders that are involved in vividly distinct areas of power generation, distribution and transmission. A typical electrical industry involves different companies like fuel companies, generating companies, transmission companies, distribution companies and end users like industrial, commercial, institutional, residential and others.

All these three areas until recently were governed by Ministry of Power. Privatization of Power sector attracted private players to enter into this market. The infrastructure needs for generation, transmission and distribution require huge capital goods like turbines, generators, furnaces, distribution grids, switchgear equipment, transformers, circuit breakers etc. apart from energy resources that is the finally converted into energy and supplied to various users.

The role of SME's in this area is very important since SME's are technically very sound and have the niche in value chain. The product range that is provided by electrical industry is

1. Overhead Electrical Conductors
2. Overhead Lines
3. Power Transformers
4. Switchgear and Control gear
5. Circuit Breakers
6. High Voltage Testing Machines
7. Winding Wires
8. Magnetic Alloys and steels
9. Coil products
10. Surge Arresters
11. Gas-insulated Switchgears
12. Capacitors
13. Disconnectors
14. Bushings
15. Switches
16. Metering cubicles
17. Smart Panels

The big players in electrical industry generally get orders from government bodies and also some private players. They enter into long term contracts with government electricity boards for power generation and power distribution needs. It is very interesting fact that ecology of these big players is greatly influenced by SME's which are tier 1, tier 2 and tier 3 suppliers of these giants. The role of SME's in economic growth of nation is always at the apex. In fact entrepreneurship is the backbone of all developing nations whether it is brick and mortar industry, or clicks and brick industry or clicks and clicks industry. The supply side of the value chain always have hard core manufacturing activities that needs electricity, water, land and machinery

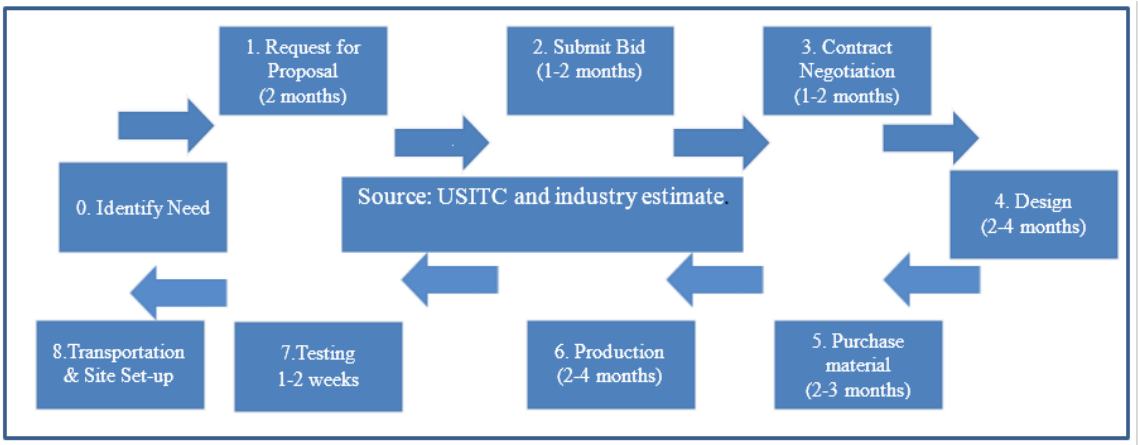
An electrical industry is typically characterized by roping in multiple subcontractors small or big in size to build a final product. This is due to the fact that large number of sub-assemblies, manufactured components and other products along with the intermittent jobs go into final assembly. They are different in nature when it comes to manufacturing any of them (R Nagraj, 1981). Over a period of time, subcontracting business in developed nations has matured to the extent that each partner in the business co-exists in the defined boundaries and adds value to the final product. Sub-contracting has emerged as separate line of business with defined meaning and scope. There exists a contractual relationship for a long duration between small firm and big player to conduct a commissioned work with big player acquiring dominant position (Kawasaki, 1998). The role of subcontracting and ancilliarisation is an important feature in modern manufacturing ecosystem. However, as per the reports and experts in India it has not acquired due attention in electrical industry resulting in supply chain becoming more sluggish and being at the mercy of big players. The need for subcontractors in electrical industry is evident from the fact that big players has to achieve the targets of numbers when it comes to manufacturing switchgear components like Current Transformers, Voltage Transformers, Switches, relays, motors, panels etc. Not much of literature review is available to gauge the effectiveness of subcontracting in the Indian context and issues like meaning of subcontracting, its distinguishing features, different forms and economic factors and institutional aspects of industrial development remains unexplored (R Nagraj, 1981).

2.1 About Transformer and Switchgear (ETO) Industry

Switchgear and Transformer industry is very old industry and have been in the business of subcontracting since long. In India, the small and medium enterprises have emerged due to the way this industry has created ecology of its own. In addition, there exists a policy framework laid down by the government to uplift the SME's and make them a part of

value chain by making it obligatory for large enterprises to subcontract their part of work, conferring a distinct identity to them as ancillary unit, to create supplier cluster, create subcontract exchanges. The overall focus of this framework is to have more cost effective and better quality products. The supply chain of Switchgear and Transformer involves large number of players especially on upstream side. There exists number of issues like increased work in progress, frequent schedule changes, increase in safety stocks, sub-optimised improvement efforts, decreased competitiveness (Karmarkar, 1983) that adds together to overall increase in lead time and waste. Practicing lean within the organization and across the value chain can be a solution to eliminate heavy waste in supply chain.

A Transformer is a device that is used in electrical industry to either step up or step down the voltage and current in electrical circuit. Switchgear is a combination of devices that are used to monitor, control and protect electrical installations throughout the grid. The various segments for both transformers and switchgears are characterized by low voltage, medium voltage and high voltage. These products are engineered to order construction products and supply chain activity "Design" determines the total lead time of these final products (Jan Elfving, 2002) [14]. The lead time of any supply chain determines the agility and flexibility of the business. Over the years lead time reduction has become primary focus of the organization (Forrester, 1961) and is looked as one of the lean practice. The lead time of any product is also determined by type of product being manufactured either as Make to Stock or Make to Order or Engineer to Order. While Make to Stock has less cycle time as far as customer delivery is concerned the Make to Order, Engineer to Order has high cycle time since it involves customization from customer point of view. A typical procurement process and estimated optimal lead time to execute large power transformer order is depicted as under

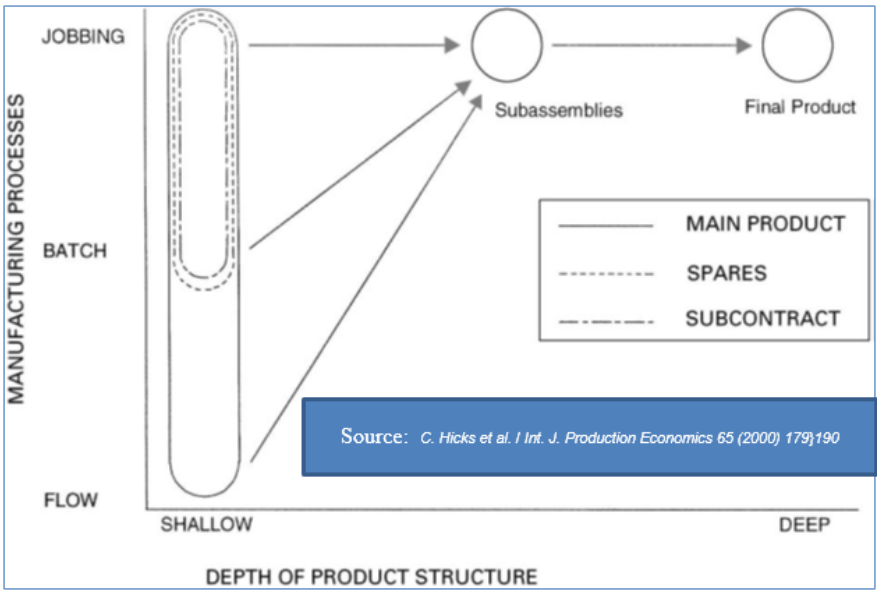


The activities 1, 2 and 3 are front end activities and involve heavy information flow. The activities 4, 5 & 6 involve Design, subcontracting, Material purchase. These are hard core processing activities and determine the lead time of entire supply chain. The upstream activities that are originated by OEM through information flow to subcontractors, tier1 supplier and tier 2 supplier needs to be studied carefully for ETO products. Although industry standards for lead time of processes like procurement, subcontracting are available, how to make these processes more efficient and effective depends on how market sensitive the local industry is and how the business growth is perceived by these OEM giants. Typically in India an average lead time of 4-6 weeks in automobile industry is a general norm (Meyr, H. 2004). In case of power transformer the lead time is in the range of 18 to 24 months. The high volume industry like automobile is able to adapt to lean and agile way of managing their supply chains which is not the case with low volume ETO products. This is due the nature of this ETO industry (C. Hicks *et al*, 2000) [16].

In case of Engineer to Order (ETO) product, the product specifications, design and procurement time are added in overall cycle time (Jan Elfving, 2002) [14]. The OEM's play major role in partnering with government agencies for long term contract, partnering with subcontractors for technology sharing, partnering with green channel vendors and partnering for ancilliarisation. Compared to manufacturing activity of ETO products, the engineering activity consumes much more time and affects the end delivery. Long lead times in case of ETO products leads to work in progress, changes to schedules, and increase in safety stock, increased variability, sub optimized work efforts (Karmarkar, 1983). The contracting activity of ETO products generally mandates long term contract with supplier and involves many design decisions that originates from initial vague idea (Koskela 1999).

Supply chain integration in ETO is unique in its way and hence supply chain practices of MTS, like reducing supplier base and having long term relationship may put some constraints on established practices of ETO supply chain methods (Hicks *et al*. 2000) [16]. The Upstream supply chain of an OEM is characterized by large number of supply chain partners and significant outsourcing making it difficult to attain the effectiveness of supply chain integration (Dainty 2005). As a known fact, the demand regularity and OEM power regime dictates the supply chain management techniques and may vary from region to region (Ireland 2004).

A Typical vertical integration between various stakeholders in upstream supply chain for ETO industry can be portrayed as under



Fragmentation of product and processes plays very important role when it comes to manufacturing strategy of ETO products. During the year 1994-2006 in India, subcontracting by formal enterprises gained importance and brought momentum to the informal industry (Ana I. Moreno-Monroy *et al*, 2012). The formal enterprises started subcontracting the most labor intensive jobs to the traditional informal enterprises in order to minimize the labor cost, creating a strong relationship between the two.

Although there exists four types of ETO (Amaro *et al*, 1999) i.e. vertically integrated, design and assembly, design and contract and pure project management, each of them involves fragmentation depending on the decoupling point decided by degree of customization. This clearly distinguishes the attributes of ETO Supply chain that defines the customer involvement, purchasing decisions, design activities and production activities. This type of production needs large scale inputs to be co-ordinated in order to achieve customer's requirement. Irrespective of degree of customization, where each ETO order is treated as new order or modified from existing order, decoupling point is located at design stage and decides design and production dimension (Wikner *et al*, 2005) [11]. This also means shifting the de-coupling point towards the customer (Dennis Towell, 1996). Hicks (2000) [16] in his article mention that although lot of research work is done in the area of operations and supply chain management, the ETO supply chain is neglected. Hence objective of the paper is

- To study the existing work done in establishing the best practices in supply chain management of ETO industry.
- To study the supply chain management scenario in Electrical Industry
- To study the supply chain management research work done in Indian Context
- To indicate direction for future research to develop supply chain practices in Indian Electrical Industry

3. Methodology

Scopus database is referred to identify the work done in the area of supply chain of electrical industry. Following selection was made

- Period 2005 to 2016.
- Sector
- Electrical industry
- Subject Area
- Supply chain
- Lean Supply Chain
- Lean Production
- Lean Manufacturing
- Type of work
- Article

In order to understand the latest trend in the area of ETO supply chain, the literature review for last 10 years is done. Only research articles were selected for reviewing the literature. The data from the search was taken to excel worksheet and various analyses were obtained.

4. Literature Review

4.1 Journal wise paper publication

Table 1.0: Source: Scopus Database

Sr No	Name of the journal	Total	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	International Journal of Production Research	15	1	0	1	1	1	3	2	2	1	2	1	
2	Journal of Manufacturing Technology Management	9					3		1			1	3	1
3	International Journal of Production Economics	8		3			1	1	1			2		
4	Journal of Cleaner Production	6									3	2	1	

5	Production Planning and Control	6			1	1				1		1	2	
6	Industrial Engineer	4				1			3					
7	Industrial Management and Data Systems	4	1	1	2									
8	ZWF Zeitschrift Fuer Wirtschaftlichen Fabrikbetrieb	4					2	1			1			
9	World Academy of Science Engineering and Technology	4						3	1					
10	Expert Systems with Applications	3							1		1	1		
11	Automotive Industries AI	3	2	1										
12	Journal of Japan Industrial Management Association	3						1			1	1		
13	International Journal of Services and Operations Management	2					1				1			
14	International Journal of Industrial Engineering and Management	2									1	1		
15	International Journal of Industrial and Systems Engineering	2		1									1	
16	Proceedings of the Institution of Mechanical Engineers Part B Journal of Engineering Manufacture	2			1	1								
17	IEEE Transactions on Engineering Management	2			1					1				
18	Journal of Operations Management	2	1				1							
19	Producao	2											2	
20	EMJ Engineering Management Journal	1						1						
21	Engineering Economics	1											1	
22	Engineering Technology	1	1											
23	Computers and Industrial Engineering	1				1								
24	Flexible Services and Manufacturing Journal	1								1				
25	IEEE Latin America Transactions	1											1	
26	IEEE Transactions on Semiconductor Manufacturing	1			1									
27	International Journal of Manufacturing Research	1							1					
28	International Journal of Services Technology and Management	1					1							
29	Advanced Science Letters	1											1	
30	International Journal of Six Sigma and Competitive Advantage	1						1						
31	International Journal of Technology Policy and Management	1				1								
32	Jisuanji Jicheng Zhizao Xitong Computer Integrated Manufacturing Systems CIMS	1											1	
33	Journal of Civil Engineering and Management	1										1		
34	Advances in Natural and Applied Sciences	1								1				
35	Journal of Industrial Engineering and Management	1										1		
36	Arpn Journal of Engineering and Applied Sciences	1												1
37	Assembly Automation	1						1						
38	Automation in Construction	1												1
39	Journal of Scientific and Industrial Research	1	1											
40	Building Engineer	1					1							

41	Leadership and Management in Engineering	1							1					
42	Lecture Notes in Business Information Processing	1											1	
43	Manufacturing Engineer	1			1									
44	Manufacturing Engineering	1			1									
45	Metalurgija	1										1		
46	Paper Film and Foil Converter	1			1									
47	International Journal of Advanced Manufacturing Technology	1									1			
48	Construction Innovation	1								1				
49	Construction Management and Economics	1		1										
50	Reliability Engineering and System Safety	1										1		
51	Shenyang Gongye Daxue Xuebao Journal of Shenyang University of Technology	1					1							
52	Dyna Colombia	1										1		
53	Journal of the Institution of Engineers India Part PR Production Engineering Division	1							1					
	Total	117	7	7	10	6	12	12	12	7	10	16	15	3

Table 1.0 indicates that most of the work in the selection criteria is published in International Journal of production research followed by Journal of Manufacturing Technology Management and then by International Journal of Production Economics covering almost 30% of research work. It also states that there is an increasing trend in the research work done year on year barring few exceptions.

4.2 The year-wise publication for the same criteria is depicted as under

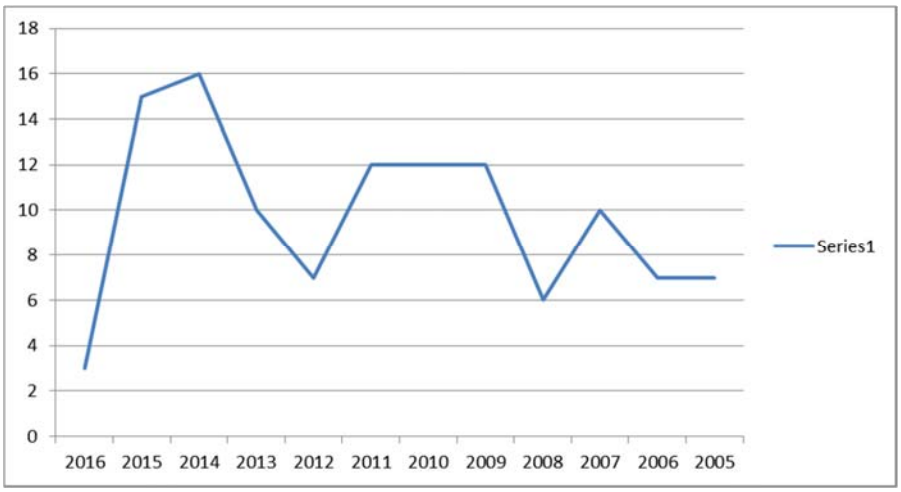


Fig 2: Source: Scopus Database

Year	No of documents
2016	3
2015	15
2014	16
2013	10
2012	7
2011	12
2010	12
2009	12
2008	6
2007	10
2006	7
2005	7

The graph shows that there is an increasing trend in publishing research work in this area. The publications for year 2016 should not be considered for comparison since the data is as of date.

4.3 The country-wise publication for the same work is depicted as under

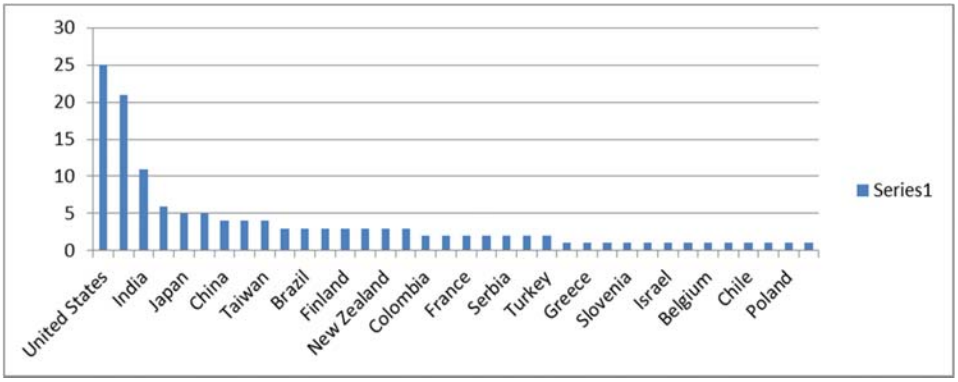


Fig 3: Source: Scopus Database

The graph shows that significant research work in this area is done by United States (21%) followed by UK (18%) and then India. It is interesting to know that best supply chain practices across automobile industry have been adopted from Japan. However contribution of research work in supply chain of electrical industry of Japan is at fifth position.

4.4 The role of Indian authors in paper publication for engineering industry is as under

Table 4: Source: Scopus Database

Sr No	Title	Author	Journal	Year
1	An experimental investigation of lean management in aviation Avoiding unforced errors for better supply chain	Kumar, R.B.R., Sharma, M.K.,Agarwal, A.	Journal of Manufacturing Technology Management	2015
2	Leagility index in supply chain - part-II: Case applications, benchmarking and comparative analysis	Banerjee, A., Mukhopadhyay, S.K.	International Journal of Industrial and Systems Engineering	2015
3	Impact of lean practices on performance measures in context to Indian machine tool industry	Sharma, V., Dixit, A.R., Qadri, M.A.	Journal of Manufacturing Technology Management	2015
4	Effect of supply chain management practices on supply chain profitability: An empirical investigation using structural equation modelling in Indian retail sector	Gawankar, S., Kamble, S.S., Verma, R.	International Journal of Services and Operations Management	2013
5	Evaluating reliability and validity of lean, agile and leagile supply chain constructs in Indian manufacturing industry	Soni, G., Kodali, R.	Production Planning and Control	2012
6	Need for integrated implementation of Lean manufacturing and Six Sigma for small and medium scale industries: A detailed survey	Fursule, N.V., Bansod, S.V.	Journal of the Institution of Engineers (India), Part PR: Production Engineering Division	2011
7	Effects of information transparency and cooperation on supply chain performance: A simulation study	Wadhwa, S., Mishra, M., Chan, F.T.S., Ducq, Y.	International Journal of Production Research	2010
8	Supply chain flexibility: A state-of-the-art survey	More, D., Babu, A.S.	International Journal of Services and Operations Management	2009
9	What's the buzz about moving from 'lean' to 'agile' integrated supply chains? A fuzzy intelligent agent-based approach	Jain, V., Benyoucef, L., Deshmukh, S.G.	International Journal of Production Research	2008
10	Mapping supply chains on risk and customer sensitivity dimensions	Faisal, M.N., Banwet, D.K., Shankar, R.	Industrial Management and Data Systems	2006
11	Performance evaluation of existing vendors using Analytic Hierarchy Process	Chakraborty, P.S., Majumder, G.,Sarkar, B.	Journal of Scientific and Industrial Research	2005

4.5 The paper published by Indian authors in electrical industry

Table 5: Source: Scopus Database

Sr N	Title of Paper	Author	Journal Name	Year
1	Structural Similarities and Differences between Smart Grids and Process Industry Supply Chains:	Patel, N., Abhinav, R., Srinivasan, B., Srinivasan, R.	Computer Aided Chemical Engineering	2015

	India Case Study			
2	Sustainable value creation through E-waste management: The role of marketing-retailers-operations interface	Mane, P., Niranjan, T.T.	Global Business Review	2014
3	Analysing green supply chain management practices in Brazil's electrical/electronics industry using interpretive structural modelling	Govindan, K., Kannan, D., Mathiyazhagan, K., Jabbour, A.B.L.S., Jabbour, C.J.C.	International Journal of environmental studies	2013
4	Flexible strategic framework for KM factors with the perspective of continuity and change: Study of supply chain of MNCs in electrical and lighting industry	Gupta, V.K.	Source of the DocumentInternational Journal of Value Chain Management	2012
5	The strategic fit between "competitive strategy" and "supply chain strategy" in Indian manufacturing industry: An empirical approach	Soni, G., Kodali, R.	Measuring Business Excellence	2011

5. Direction for future research

The research work in supply chain management practices of electrical industry is not very much evident from the literature review. Scattered work done in this area is available but cannot be taken as an industry practice. However the practices followed in ETO industry can be adapted to electrical industry. The supply chain trends in ETO industry can be can be summarized in following manner:

• Supply chain partners collaboration framework
• Supplier Management Tools and Techniques
• Supply Chain Management Best Practices
• Use of Information and Communication Technology (ICT) as an Enabler
• Subcontracting / Anciliarisation Practices
• Government policies and framework to boost the SME's on supply Chain

Since electrical industry is a subset of ETO industry, further research can be done in following area

- The ETO practices that are already followed in electrical industry,
- The new ICT tools that can be used to make the supply chain more responsive,
- The new practices that can be introduced considering the fact that developing countries like India import and export lot of sub-assemblies, equipment to other countries.
- Supply chain practices for smart power grid concept

6. References

1. Garg P. Energy scenario and vision 2020 in india. journal of sustainable energy & environment. 2012; 3:7-17.
2. Indian switchgear and controlgear industry- waiting to takeoff.
3. El afia abdellatif, et-tolba el hassan, A global modeling of electrical energy supply chain.
4. Jan A, Elfving iris D. Tommelein, glenn ballard, An international comparison of the delivery process of power distribution equipment.
5. Mikko punakivi, marianna herold. Analysing the electrical power network construction supply chain.
6. Yogesh M, Dr. Chandra Mohan G, Rajesh Arrakal. Application of Lean in a Small and Medium Enterprise (SME) Segment- A Case Study of Electronics and Electrical Manufacturing Industry in India. International Journal of Scientific & Engineering Research. 2012; 3(8):1. ISSN 2229-5518
7. Report - Growth of Electricity Sector in India from, 1947-2012.
8. Martha C, Cooper Lisa M, Ellram. Characteristics of Supply Chain Management and the Implications for Purchasing and Logistics Strategy. The International Journal of Logistics Management. 1993; 4(2):13-24.
9. Jonathan Gosling, Mohamed Naim M. Engineer-to-order supply chain management: A literature review and research agenda, International Journal of production economics, 2009.
10. Bala MH, Subrahmanya. External technology acquisition of SMEs in the engineering industry, 2014.
11. Joakim Wikner, Martin Rudberg. Integrating production and engineering perspectives on the customer order decoupling point. International Journal of Operations & Production Management. 2005; 25(7):623-641.
12. Yamagar C, Ravanan PM. Material management by using lean manufacturing principles a case study, proceedings of the 2nd international conference on manufacturing engineering, quality and production systems.
13. Wladimir andreff. Outsourcing in the new strategy of Multinational companies: foreign investment, International subcontracting and production Relocation, conference on international outsourcing and the europeanunion: impact on the domestic market, scenarios and strategies, madrid, 2008, 28-29.
14. Jan Elfving, Iris D, Tommelein, Glenn Ballard. Reducing lead time for electrical switchgear", Proceedings IGLC-Gramado, Brazil, 2002.
15. Yogesh M, Dr. Chandramohan G, Gilroy Thomas. Lean Manufacturing in Electronics & Electrical Manufacturing Industry in India. International Journal of Scientific & Engineering Research. 2014; 5(12):101. ISSN 2229-5518
16. Hicks T, McGovern CF, Earl. Supply chain management: A strategic issue in engineer to order manufacturing, Int. J Production Economics. 1999, 2000; 65:179-190.
17. Masoud Rahiminezhad Galankashi, Anoosh Moazzami, Najmeh Madadi, Arousha Haghighian Roudsari, Syed Ahmad Helmi. Supplier Selection for Electrical Manufacturing Companies Based on Different Supply Chain Strategies, Int. J of Technology Innovations and Research (IJTIR) Special Edition on Advanced Technique of Estimation Applications in Electrical Engineering, 2013.
18. Christos Tsinopoulos Keith Bell. Supply chain integration systems by small engineering to order

companies. Journal of Manufacturing Technology Management. 2009; 21(1):50-62.
19. Togar M, Simatupang Alan C, Wright Ramaswami Sridharan. The knowledge of coordination for supply chain integration. Business Process Management Journal. 2002; 8(3):289-308.
20. Rachel Mason-Jones Denis, Towill R. Using the Information Decoupling Point to Improve Supply Chain Performance. The International Journal of Logistics Management. 1999; 10(2):13-26.