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# TOWARDS GREATER SHIPBUILDING SUPPLY CHAIN SURPLUS IN INDIA – A REVIEW

**M. Jaison**

**Abstract**

*Indian shipbuilding industry has several advantages and a very large untapped potential. This article aims to identify the focus areas in Indian shipbuilding, where tangible improvements made now can substantially increase the supply chain surplus. Interventions recommended for greater shipbuilding supply chain surplus in India are presented and also discussed in the context of some important recent policy initiatives impacting the industry. This study applied a literature review approach to examine the Indian shipbuilding industry, in comparison to shipbuilding industries of US, UK, Japan, China and Korea, for the period after World War II, with a focus on underlying supply chain management strategies. Progress made by Japan, Korea and China towards world leadership in shipbuilding was found to fit the supply chain management approach. The main contribution of this study is in identifying the common factors in supply chain management of shipbuilding among Japan, Korea and China, which helped them accelerate towards world leadership in shipbuilding. Based on this and the study of current status of Indian shipbuilding, focus areas for policy initiatives for realising the industry's potential were identified. The study also helped evolve a conceptual model for analysis of supply chain management of shipbuilding. This study will help policy makers to frame suitable policies, in the identified focus areas, based on successful policies implemented in the automotive and pharmaceutical sectors in India. This study is among the first to provide theoretical contributions towards supply chain management of shipbuilding in India and is the first to examine the supply chain management of shipbuilding from the perspective that the drivers of supply chain management viz. the logistic drivers -facilities, inventory and transportation and the cross-functional drivers – sourcing, information and pricing, determine the performance of the shipbuilding supply chain, moderated by the supply chain management adaptations, to deliver shipbuilding supply chain surplus.*

***Keywords: Supply Chain Management (SCM), Shipyard, Craft administration techniques, Bureaucratic administration techniques, Drivers of SCM.***

## 1. INTRODUCTION

The Indian shipbuilding industry has distinct advantages; such as an abundant coastline, proximity to international sea routes and low manpower cost. India's shipbuilding capabilities, however, have not kept pace with its economic development, market demand and human resource potential, Government of India Report [1]. Although the industry has grown considerably in capacity and future outlook is positive, Indian shipbuilding still has several thresholds to cross to reach its full potential. To understand the Indian shipbuilding industry a peek into the world shipbuilding industry is necessary. Historically, shipbuilding industry played an important role in the economic development of maritime countries, Xie [2]. Shipbuilding is a highly cyclic industry shaped by world economic situations and major events. Fig. 1 shows the past cycles. The last peak was in 2011 and another peak could be expected in the next few years, Thangam & Kumar [3]. India has the potential to position itself suitably to derive maximum benefit from the next such peak in shipbuilding and gain a greater share of the evergreen ship repair industry, in the process, and achieve greater self-reliance and national prosperity.

**Fig. 1: Cyclic nature of World Shipbuilding Industry [Source: Clarkson Research services.]**

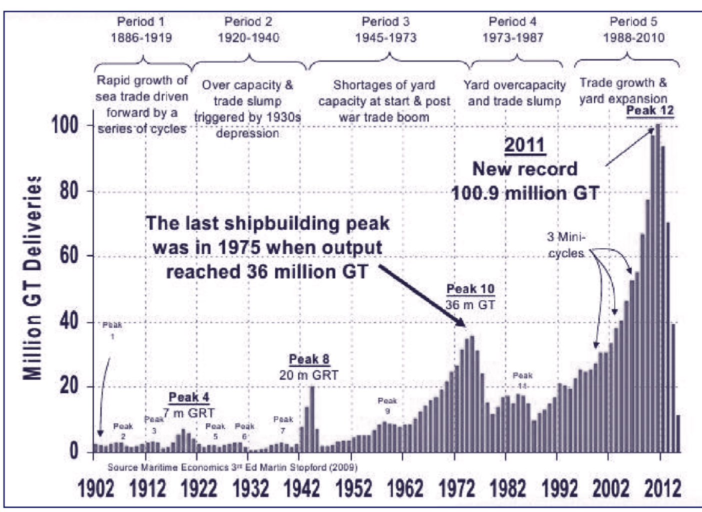
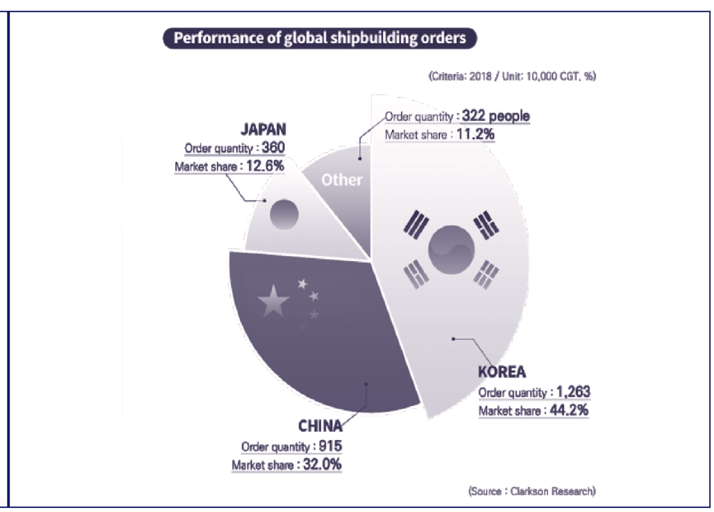



**Fig. 2: World Shipbuilding orders and market shares [Source: Clarkson Research services.]**



World shipbuilding orders in 2018 showed that Korea had 44.2% market share, followed by China with 32.0%, Japan with 12.6% and rest of the world accounting for 11.2%. See Fig.2.

The following support the view that India has considerable potential for further overall development. Goldman Sachs had predicted that India, China and Brazil would account for over half of the global business activity by 2050. India's competitiveness in exporting software and IT services, Business Process Outsourcing and manufacturing areas; such as automotive components and pharmaceuticals, have been acknowledged worldwide, Mathews [4].

As stated in the Manufacturing Plan [5], nearly 95% of India's foreign trade in terms of volume and more than 65% in terms of value, is through sea routes. Currently, about 10% of our trade is carried by ships with an Indian Flag, while the ships manufactured in India carry even less cargo. India's emergence as a major economic power would require greater integration in terms of trade with the rest of the world and corresponding increase in merchant shipping tonnage. This would require considerable increase in the share of Indian built and Indian Flag vessels also. Indian Shipbuilding and Ship Repair are listed amongst sectors of strategic importance, where greater focus is required to increase indigenization in production [5]. In order to obtain a greater insight into the Indian shipbuilding industry and to examine he strategies used by world leaders in the shipbuilding industry for accelerated progress in this sector, from a supply chain management (SCM) perspective, a literature based study was undertaken to compare the Indian merchant shipbuilding industry, with the shipbuilding industries of US, UK, Japan, Korea and China, during the period after World War II.

To achieve this, the available literature on SCM in shipbuilding was examined first. It was observed that, while scholarly articles addressing the area are few in numbers, efforts to benefit from application of SCM in shipbuilding is about two decades old and is still evolving. Fleischer et al. [6] in a 1999 report on 'Shipbuilding Supply Chain Integration Project', designed to improve the understanding of best practices in SCM in US shipbuilding concluded, inter alia, that SCM in shipbuilding lags other industries and most SCM approaches can work in shipbuilding. Sarder et al. [7] brought out that the shipbuilding supply chain is very complex, especially due to the length of time it takes to complete one finished product. Ref. [7] also states that as material and equipment (to be installed in the ship) make up over 50% of the cost of the delivered ship, efficient sourcing and material management, which is a part of the SCM, is crucial for its contributions towards the supply chain surplus. Mello and Strandhagen [8] say that SCM in shipbuilding depends essentially on improving the relationships with suppliers and adopting appropriate information and communication technology. Sundara [9] corroborates the observations in Ref. [7] to state that the cost of raw materials and equipment could go up to 70% of the total cost of the ship, which highlights the importance of material management as an important focus area, as a part of SCM, for potential savings in cost and time. Ref. [9] also brings out that the shipbuilding SCM strategies are not amenable to empirical generalisation and that there is further scope in identifying the underlying characteristics of the supply demand strategy and uncertainty in the supply network, citing the several cost and time overruns experienced in shipbuilding projects worldwide. Summarily, the literature on SCM on shipbuilding highlights the importance of material management, while there is no clear consensus on a generalised SCM strategy for shipbuilding. Scholarly articles on effect of costs and sourcing of inputs, including ship design, for shipbuilding on competitiveness of shipbuilding in India or on SCM of shipbuilding in India could not be found. The above gaps in literature provided the motivation to approach the study of SCM of shipbuilding, using a novel approach. An important finding of this study is that the progress made by the shipbuilding industries of Japan, Korea and China towards world leadership in shipbuilding, though initiated well before SCM as a strategy was well-known and adopted in any industry, fit the SCM paradigm. The main contribution of this study is in identifying the common factors in SCM of shipbuilding among Japan, Korea and China, under the novel approach of examining them under the drivers of SCM of Facilities, Inventory, Transportation, Sourcing, Information and Pricing, Chopra & Meindl [10], which helped them achieve accelerated progress and sustain positions of leadership in world shipbuilding. Based on the above common factors in SCM of shipbuilding among the world leaders in shipbuilding and an evaluation of the current status of shipbuilding in India, focus areas for greater shipbuilding supply chain surplus in India were identified. A novel conceptual model for analysis of supply chain management of shipbuilding has also been developed and presented here, based on supply chain management theory, the above common factors in SCM of shipbuilding and the common nature of the shipbuilding industry.

This study will be useful in formulating policy initiatives for development of shipbuilding, ship repair and ship recycling in India. The shipbuilding industry, in the context described here, includes the ship repair industry and the ship recycling industries, which are considered as subsectors of the shipbuilding industry. The author is of the opinion that time is ripe for a quantum jump in the contribution to the manufacturing sector from shipbuilding in India and recommends pursuit of suitable policy initiatives in the identified focus areas, in mission mode. The scope of discussions here excludes warship building and repair. The differences in forms of government and socio-economic indices between countries are also excluded from this study.

Colton & Huntzinger [11] highlight that several characteristics of ships and shipbuilding give continuing importance to past events. Because modern ships have an economic life of about 30 years, some of the factors affecting current markets are echoes from past events. And other factors that affect current markets are based on expectations about what is likely to happen in the next 30 years. Another reason for the past events to continue to have influence is that large numbers of skilled workers and costly facilities are required for ship construction, which requires concerted efforts in achieving competitiveness and sustenance of the competitiveness. Maintenance of the competitiveness is extremely dependent on sustained volume of business.

The salient aspects of post-World War II merchant shipbuilding industries in India, US, UK, Japan, Korea and China, which emerged from this study, are appended below in succeeding paragraphs.

## 2. INDIAN SHIPBUILDING

India was an early entrant into steel shipbuilding and some of the important areas for increasing the competitiveness of Indian shipbuilding were identified in the 1950s and actions initiated. Foundation stone for Scindia Shipyard, the first Indian shipyard for steel shipbuilding in India, was laid in June 1941. World War II caused interruptions in its construction and the shipyard was completed in 1946, Desai [12].

The shipyard struggled to make ships at competitive prices, while incurring higher costs of steel, (as compared to UK then), importing propulsion & auxiliary machinery and other equipment and coping with inexperience of workers (as it was a new area of industrial manufacture in India). After building a few ships and incurring heavy losses, in spite of limited subsidies by the government, the shipyard was taken over by the Government of India and renamed Hindustan Shipyard Limited (HSL), in 1952 [12].

Several initiatives were pursued by the Government to develop shipbuilding in India, in the 1950s. These include [12]: -

- Signing of an agreement with a French Shipbuilding firm (La Societe Annonysme Des Ateliers et Chantiers de la hoire, (the ACL)) in 1952, for, inter alia, development of a full-fledged design and estimation office at HSL. The contract was extended till 1958.
- In 1955, the Estimates Committee, in their 14th report, recommended the setting up of ancillary industries for the manufacture of engines, standardized parts/ fittings and equipment for shipbuilding in India.
- A Ship Ancillary Industries Committee was appointed in 1957. The committee in its report had also stated that a phased programme of development of the ancillary industries would be necessary to make shipbuilding and ship repair in India competitive.
- A second shipyard was proposed in 1959, to be set up at Kochi, which eventually became the Cochin Shipyard Limited (CSL).

HSL delivered 31 ships with an aggregate of 258000 DWT (Dead Weight Tons) and 05 small vessels by 1961 [12]. Although these did not include large ships, it is interesting to note that India had considerable experience in steel shipbuilding before Korean shipbuilders entered the domain. At present, Indian shipbuilding is mainly based on 27 shipyards, comprising of 8 Public Sector shipyards and 19 Private Sector shipyards [1].

Indian shipbuilding industry, which had only about 0.1% share of the world shipbuilding in 2002, expanded over 10 fold to capture 1% share of the world shipbuilding in 2011. The Indian shipbuilding industry doubled its capacity from about 2.5 Lakh DWT in 2007 to 5.0 Lakh DWT in 2011, with a specific focus on offshore supply vessels and anchor handling tugs, for the export market [3].

Some of the identified areas requiring further growth in Indian shipbuilding, including its subsector of ship repairs, are [1]: -

- Speed of construction and repair. Infrastructure required for faster construction and expeditious repairs (high speed of steel renewal, speed of surface preparation for underwater hull painting etc.).
- Ancillary industry development. At present almost all machinery and equipment required for installation in a ship are imported.
- Ship design capability. At present most of the designs for commercial ships are imported from abroad.

## 3. US SHIPBUILDING

The US shipbuilding industry played a vital role of producing ships at an unprecedented rate during World War II, but surplus ships and lack of orders for ships after the war led to gradual decline of the industry. During the war the US shipbuilding industry expanded considerably. At the end of the war, the US had 8 naval shipyards and 64 private-sector shipyards that were actively building large naval and merchant ships. After the war the US was left with large surplus fleets, both naval and commercial. The US government sold large numbers of Liberty and Victory ships to other countries at relatively low prices [11]. Industrial engineering principles developed in the US wartime economy, with large-scale assembly-line construction of ships, using standard designs and with individual shipyards specializing in only one or two types of designs, was an important contribution of US shipbuilding industry [11]. The US shipyards were not damaged by the war. The huge surplus led to fewer new construction orders for ships, which led to gradual decline of the US shipbuilding industry, in spite of certain programs to control the trend by the US Maritime Administration in the early 50s [11]. The US shipbuilding capabilities slowly contracted to the minimum level required for their strategic purposes, with little international competitive presence in commercial shipbuilding.

## 4. UK SHIPBUILDING

The facilities at the UK shipyards turned obsolete as the newer shipyards established / rebuilt elsewhere after World War II, turned out to be more efficient. Inadequate technological upgradation of processes and manpower also caused gradual decline of competitiveness of UK shipbuilding industry in the 60s. The geographic concentration of large British shipyards in the north of England and in Scotland had protected their shipbuilding industry from worst of the bombing during World War II and so relatively little reconstruction was required, which also meant that the shipyards modelled on the labour-intensive practices of the 1920s and 1930s did not benefit from immediate modernization. The post war rebuilding of economies generated huge demand for ships in Europe, which could be capitalised by the functioning shipyards of UK, with the advantages of their location and UK shipyards prospered between 1946 and 1956, with little competition from other regions [11]. However, as other countries rebuilt their damaged facilities or built new shipyards, which were much more efficient than those of the past, the older shipyards of UK were suddenly at a competitive disadvantage, not only in terms of cost, but also delivery [11]. While the newer entrants and re-built facilities had the advantage of modernized facilities, the long prosperous UK shipbuilding industry, with considerable sunken costs of plant and machinery, now had obsolescent facilities, with neither the surrounding areas nor the available depth of water conducive to further expansion, Mc Wiggins [13]. The inability to expand also brought in manning constraints of skilled workers for British shipyards, which relied on Craft Administration Techniques for ship production. It generally took five years of shipyard work for an apprentice to become a journeyman. It took several more years, serving in positions of increasing responsibilities to become a Master Craftsman. Under craft administration techniques of production, the master craftsmen and foremen often informally served as design engineers at critical points in production. Craft unions controlled admission to their apprenticeship programs, which were not optimistic about British shipbuilding's future in the 60s, as were the shipyard owners, and restricted admissions to just replace anticipated number of people retiring or leaving the industry, which resulted in fewer qualified personnel. Both infrastructure and manpower constraints brought about decline of the UK shipbuilding industry [13]. The UK shipbuilding industry gradually contracted to the minimum level required for strategic purposes, with reducing international competitiveness in commercial shipbuilding.

## 5. JAPANESE SHIPBUILDING

The Japanese shipbuilding industry continued to build on its inherent strengths through World War II. After the war, with US collaboration, they further developed newer facilities and put policies in place to stay competitive. The reconstruction of the Japanese economy after the war led directly to the emergence of Japanese shipbuilding industry as a world power. The industry, with its potential proven before the war, effectively benefited from the contracting US shipbuilding industry. Leasing of the Japanese Kure shipyard, by the National Bulk Carriers (NBC) of US for construction of larger tankers for Japanese use, than their current standard sizes, (as Japan was independent of Suez Canal restrictions for its oil supply route), was a turning point in Japanese shipbuilding. The maximum size of tanker built then for passage through Suez Canal was 35000 Dead Weight Tons (DWT) (Also called Suezmax), whereas the tankers constructed in Japan at that time were of 85000 DWT. The NBC shipyard was the first Japanese shipyard to adapt the industrial engineering principles developed in the US wartime economy. The large Japanese trading companies immediately saw the potential for large-scale assembly-line construction of ships, using standard designs and with individual shipyards specializing in only one or two designs. These concepts were quickly copied and developed in other Japanese shipyards and by 1956; the Japanese industry overtook Britain to become the leading shipbuilding nation in terms of output [11]. The closure of the Suez Canal in 1956 had a stunning effect on the tanker market. Suddenly the flow of oil from the Persian Gulf to Western Europe had to be routed around the Cape of Good Hope. Economies of scale demanded larger tankers, without the constraints of the Suez Canal. Japanese shipyards, due to their earlier fortuitous experience with large tankers, were well placed to take full advantage of this sudden unexpected boom. The Japanese shipbuilding industry increased its output from 5 million Gross Tons (GT) in 1957 to 60 million GT in 1973 [11].

Japanese shipyards refined their production technologies during this period to the point that their productivity was more than double that of American Yards, while their wages remained low [11]. Japan's shipbuilders exist within a wider maritime cluster that provides crucial upstream and downstream products and services. For example, upstream from shipbuilding, steel and marine equipment are important input sectors. Japan is the world's largest producer of steel, after China, and produced 107.6 million tons of steel in 2011. Shipbuilding enterprises undertake a variety of activities alongside ship construction, such as ship design, ship conversion and ship repairs [14].

As tanker construction is simple, though labour intensive, the huge worldwide demand fuelled the development of shipbuilding in less developed countries of the time [11]. India also commenced actions towards setting up of a large tanker shipbuilding facility at Kochi during this period [12], which became the Cochin Shipyard Limited (CSL).

## 6. KOREAN SHIPBUILDING

South Korea entered the shipbuilding market in the late 70s, to create the biggest shipbuilding industry in the world, in just 20 years [1]. In 1965, South Korea, 12 years after the Korean War, was a poor agrarian country, deeply dependent on American support to defend itself. It effectively possessed no significant shipbuilding capability. Forty years later in 2005, South Korea was the world's leading shipbuilding nation [13].

If one does not delve into the governmental structure, the advantages in driving the export-oriented growth policies and other social parameters of the Korean society in the 60s, the following aspects stand out as important enablers of shipbuilding in Korea [13]: -

- Indigenous manufacture of steel was pursued with the motto that, "Steel is National Power". The Pohang Iron and Steel Company (POSCO), a state owned enterprise established with Japanese assistance, provided good quality steel at controlled prices to the shipbuilders, which helped them offer very competitive prices for ships built in Korea.

- Development of green field shipyards, with state of the art infrastructure, employing Bureaucratic Administration Technique of shipbuilding (Bureaucratic administration technique has the following features of work process planned in advance by personnel not on the work crew; the location of tasks, the movement of tools, materials and workmen to these locations; sometimes movements performed to complete tasks; the time allotted for tasks; and the inspection criteria for particular operations. Craft administration technique by comparison, mentioned earlier under UK shipbuilding is defined as having "these characteristics of the work process" governed in accordance with craft principles).

- Development of capability for manufacturing marine engines, castings (propellers, rudder horns etc.) and electrical equipment. By 1980, Hyundai was one of a handful of shipyards, in the entire world, that could make all of the major components of ship construction, in its own facilities.

Korean shipbuilding surpassed Japanese shipbuilding in 1999 and has managed to stay competitive, while facing increasing competition from China and Japan.

## 7. CHINESE SHIPBUILDING

China became competitive in the World shipbuilding in the late 80s to become a dominant player, in a shorter time frame, as compared to Korea [1]. After the establishment of the People's Republic of China in 1949, the government started rebuilding the economy. Many shipyards in China were re-built in the 1950s and they started learning shipbuilding technologies from other countries. At the beginning these shipyards could only build small passenger vessels, bulk carriers and tankers for domestic transport. By learning technologies from other countries in the 1960s, Chinese shipyards could build more advanced seagoing vessels. In the 1970s, China adopted the "Open Development Policy", which promoted the shipbuilding industries effectively. Chinese shipyards thereby got more opportunities to learn advanced shipbuilding technologies and developed towards exporting ships [2]. Shifting of the world's main shipbuilding centre to the Far East in the end of the 20th century also benefitted the Chinese shipbuilding industry. Labour cost in China in 2006 was only one-ninth of that in Korean shipyards and one-tenth of that in Japanese shipyards. Some world class shipbuilding companies, such as Samsung and Mitsubishi, established subsidiary companies in China to minimize building cost. These also provided the Chinese shipbuilding industry to learn from the best practices in shipbuilding technologies in Korea and Japan [2].

The strategies used by the Chinese government for fostering shipbuilding were [2]: -

- Development of a series of industries, such as steel industries and services industries.

- Formation of three shipbuilding zones in Bohai Bay, Changjiang Delta and Zhujiang Delta to establish comprehensive infrastructure.

- Stimulation of shipping by developing national shipping business. In 2008 the National Development and Reform Commission (NDRC) promulgated a plan for making Chinese shipbuilding a world power by 2015. The policy package included tax breaks, open funding options and finance incentives to promote the industry's strategic structural re-adjustment. In 2009, the Chinese government unveiled the "Project for adjusting and enhancing the shipbuilding industry".

Problems faced by the Chinese shipbuilding industry were [2]: -

- Rising wages. Chinese shipyards continued to enhance the technological skills and productivity of workers.

- Chinese shipbuilding is still weak in advanced shipbuilding technologies.

- In 2006, 80% of ship components such as engines and electronic systems were still required to be imported, although 14 new co-operative marine associated manufacturers were established for ship components, such as engines and ship electronic systems, in the same year.

- The Chinese steel plates, as of 2007, could not completely meet the requirements of special vessels like LNG and required these plates to be imported from Japan and Korea.

- In comparison to Japan and Korea who could produce 20 new-designed ships annually, the Chinese shipbuilding industry still lacked the core technologies in designing ships, such as LNGs and drilling vessels.

## 8. COMMON FACTORS IN SCM OF SHIPBUILDING AMONG JAPAN, KOREA AND CHINA

To provide an insight into the aspects pertinent to SCM of shipbuilding in India, the common factors in SCM of shipbuilding among Japan, Korea and China were examined, to understand the underlying approach and philosophy used by them in achieving world leadership positions in shipbuilding and sustaining them. The strategy followed by Japan, Korea and China, in achieving international competitiveness in shipbuilding, though initiated well before SCM was a well-known strategy, is observed to have followed the classical supply chain management approach. Japan was the world leader in shipbuilding from 1956 to till 1999, when it was surpassed by Korea. As of 2018 Korea, China and Japan together owned nearly 89% of the world shipbuilding orders [Fig. 2]. According to the theory of SCM [10], the three logistical drivers, namely; facilities, inventory and transportation and the three cross-functional drivers, namely; sourcing, information and pricing, determine the performance of a supply chain, measured in terms of efficiency and responsiveness, which impinge on the supply chain surplus. The objective of a supply chain is to maximise the supply chain surplus, which is the difference between the value generated from customer and the overall cost across the supply chain. Using the above concepts, the following common factors in SCM of shipbuilding among Japan, Korea and China, were identified under the various drivers of SCM: -

**1.1 Facilities** All the countries invested in progressive upgrading of infrastructure for shipbuilding and now have state of the art facilities in shipbuilding. The countries also use state of the art shipbuilding technologies, acquired and fine-tuned in the process of growth, through the various methods, mentioned above, including the benefits acquired through subsidiary companies from more advanced countries. For example, Japan benefitted from NBC of US at Kure, Korean POSCO steel manufacturing facility was established with assistance from Japan and China benefitted from subsidiary shipbuilding companies of Japan and Korea. The scale of infrastructure held at present is commensurate with the requirements of world leadership and are therefore considerably large. South Korea, for instance, has 24 dry docks, with lengths above 500 metres [15]. The sufficiently large infrastructure available provided considerable flexibility in operations, leading to higher capacity for timely response to prospective owners (responsiveness). The high levels of automation and bureaucratic method of construction helped lower the cost of production, leading to higher efficiency of the supply chain.

**8.2 Inventory** All the countries followed a policy of sourcing steel indigenously as a source of competence and price advantage, and relentlessly pursued it with much success. The policy was also applied progressively and effectively to all mechanical, navigational and electrical equipment to reach near 100% in the case of Korea (overcoming some interim dependence on Japan), with the associated price advantage for international competitiveness. While in the process of achieving self-reliance, supply chain adaptations, such as import of steel/ equipment were also resorted to. Indigenous sourcing also provided the advantages of smaller inventories, as the inputs were under greater control with much lower uncertainties, as compared to imports, leading to lower costs and higher efficiency.

**1.2 Transportation** Transportation is examined here in the context of internal transportation only. The large infrastructure and associated internal transportation facilities provide definite advantages, for instance, the advantages of making large intermediate structures (mega blocks), which smaller shipyards with smaller capacities of such facilities cannot exploit. The capabilities for handling larger blocks also permitted more work in protected areas (faster work due to more congenial work environment), thereby also preventing the accumulation of assembly work in more critical and multi-purpose infrastructure, such as dry dock, contributing to lower cost of construction and higher efficiency. The greater availability of such multi-purpose infrastructure, such as dry dock, also provided higher responsiveness.

**1.3 Information** Information is examined here in the context of internal processes only. The bureaucratic method of administration adopted along with leveraging of group technology has been observed as a factor of competitiveness in shipbuilding in all the above cases, with impacts on efficiency and responsiveness.

**1.4 Sourcing** Sourcing is examined here only in the context of procurement of materials for shipbuilding, primarily steel, mechanical & electrical equipment for ships and design of ships. The indigenous sourcing of steel, mechanical & electrical equipment and ship designs was made a high priority area by all the three countries and is a fundamental source of their supply chain surpluses, as exemplified by their market shares [Fig. 2].

**1.5 Pricing** The competence in producing steel at internationally competitive prices, while also importing iron ore from India (Press Trust of India [16]), is a common factor among the three countries and is a very important factor in internationally competitive prices of their ships. Efficient facilities, lower cost of inventory, transportation, bureaucratic administration technique based on information and indigenous sourcing (of mechanical & electrical equipments and ship designs) also contributed to pricing advantages. Summative advantages in pricing emerged from the combined strengths of all the other drivers, associated SCM adaptations and their contributions to efficiency and responsiveness, with the result of greater shipbuilding supply chain surplus, in each of the above countries.

## 9. INTERVENTIONS FOR GREATER SHIPBUILDING SUPPLY CHAIN SURPLUS IN INDIA

An SCM approach of strengthening all the drivers, as necessary, and using appropriate SCM adaptations to achieve maximum efficiency and responsiveness, using current strengths of drivers, emerges as the rational way ahead, for greater supply chain surplus of shipbuilding in India. In the light of the common factors among the leading shipbuilding nations of the world, the recommended interventions which could deliver greater shipbuilding supply chain surplus in India have been identified. These are presented under the various drivers of SCM (Related aspects are brought out in more detail under discussion in this article): -

**1.1 Facilities** There is a need for progressively upgrading the infrastructure for shipbuilding and ship repairs in India.

India also needs to further modernize and use state of the art shipbuilding technologies, in shipbuilding and ship repair. India also needs to adopt Enabling Technologies for Industry 4.0 (I 4.0 ET) in the manufacturing and SCM context in shipbuilding, by overcoming the challenges that need to be addressed, including those of high primary investment cost and lack of research in the area, to move from the current nascent stage of adoption to accelerated adoption, for greater efficiency and competitive advantage [17].

**1.2 Inventory** Achieving self-reliance in being able to provide indigenous steel and all mechanical, navigational and electrical equipment for shipbuilding and ship repair in India, so as to be able to achieve greater control over inventory and maintain lesser inventory, is recommended to be pursued vigorously.

**1.3 Transportation** The internal transportation facilities also need to be progressively enhanced in capabilities for shipbuilding and ship repairs in India.

**1.4 Information** The bureaucratic administration technique needs to be fully adopted for greater leveraging of group technology in shipbuilding and ship repairs in India, such that information flow for internal processes are state of the art.

**1.5 Sourcing** Indigenous sourcing of materials for shipbuilding, primarily steel, mechanical & electrical equipment for ships and design of ships, need to be pursued on mission mode to achieve competitiveness in these areas progressively for commercial ships. The advantages of considerable recent progress in India in the automotive sector [4] can be effectively leveraged for indigenous manufacture of such equipment.

**1.6 Pricing** Certain fiscal incentives need to be explored to enhance the price advantages, which would arise only progressively from indigenous sourcing of major inputs required for shipbuilding and ship repair, to support the industries in the supply chain, through the incubation phase. The nature of these measures would depend on policies adopted for encouraging indigenization of the inputs.

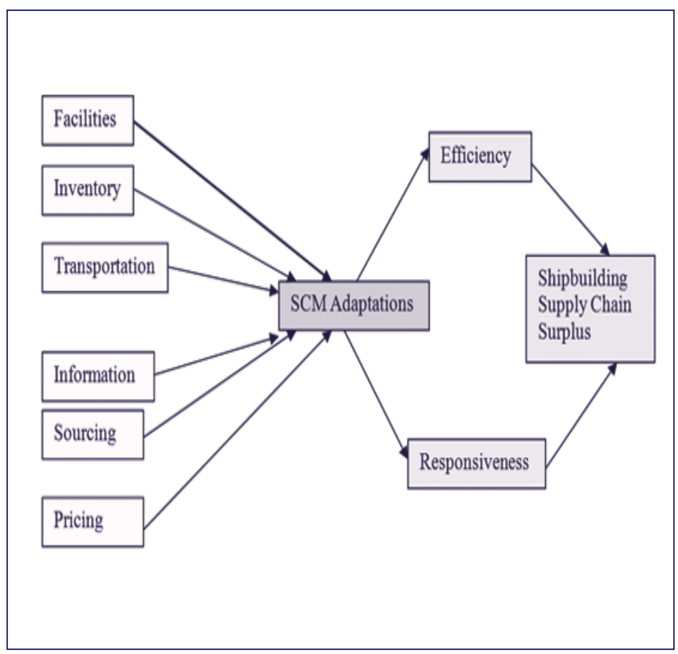
## 10. CONCEPTUAL MODEL FOR ANALYSIS OF SCM OF SHIPBUILDING

Scholarly articles on analysis of SCM of shipbuilding, from the perspective of drivers of SCM and SCM adaptations, could not be found. Such a model, however, would be necessary for analysis of SCM of shipbuilding, taking into account the nature of the industry. Based on the above observations and the theory of SCM, a conceptual model for analysis of SCM of shipbuilding, linking the drivers of SCM viz. facilities, inventory, transportation, sourcing, information and pricing, through SCM adaptations to efficiency and responsiveness, which in turn influence the shipbuilding supply chain surplus, has been proposed, as shown in Fig. 3.

The study of the post World War II shipbuilding industries of Japan, Korea and China show that consistent improvements were progressively achieved across all drivers of SCM of the shipbuilding industry, although these were initiated well before SCM became a buzz word in any industry. As briefly mentioned under subsection 8.6 of this article, pricing benefitted from the strengths across all the drivers of the SCM of shipbuilding in the countries. SCM adaptations were observed to have been chosen dynamically (for instance imports of steel for LNG ships by China, from Korea and Japan) in tune with the status of the strengths of the drivers of SCM. The approach followed and results achieved by the countries fit the SCM paradigm, thus validating the conceptual model. Some explanation on the conceptual model is provided in succeeding paragraphs.

While efforts at improving efficiency would focus on reduction in cost, responsiveness would focus on the ability to meet the owner's expectations with respect to time of delivery of newly constructed ships/ time for completion of ship repairs, so as to enable the shipyard to bag the order. The shipbuilding industry and the ship repair industry are extremely sensitive to both cost and time. Prospective owners would expect fast and timely delivery new ships at competitive prices and existing owners, in the context of ship repairs, would expect a minimum of downtime of ships in service and competitive cost of repairs. It is therefore necessary to be responsive as well as efficient, with responsiveness often having a higher influence on the placement of the order, even at a higher price. The ship repair industry is even more tilted in favour of responsiveness, as compared to efficiency, as downtimes of ships in service are also extremely costly. Therefore, the market would favour that shipbuilder or ship repair service provider, with a SCM that would meet the required responsiveness with efficiency. Each shipyard would, therefore, adapt to the strengths and weaknesses of its drivers of SCM, by means of specific SCM adaptations, in order to maximise the responsiveness and efficiency, and strive to improve both, in contributing towards the shipbuilding supply chain surplus.

**Fig 3. Conceptual Model for Analysis of SCM of Shipbuilding**



## 11. DISCUSSION

Several measures to incentivize shipbuilding in India have been put in place over the years with good effect. Some of the recent examples are Implementation of Shipbuilding Financial Assistance Policy (2016-26) [18] and Union Cabinet approval of proposal for enactment of Recycling of ships bill on 20 Nov 19 [19]. Certain additional fiscal incentives may be necessary to promote the shipbuilding sector in India to self-reliance and prosperity, without eroding competence.

The discussion here is limited to the interventions recommended for greater shipbuilding supply chain surplus in India.

Considerable scaling up of infrastructure has been taken up by both Public and Private sector shipyards in India. For instance CSL is building a new large dry dock (310mX75/60mX13m, Draft – 9.5m), expected to be commissioned in 2021, which will enable the shipyard to build large merchant ships, such as LNG Carriers, Large Dredgers and Jack-up platforms, and considerably enhance the repair capability of the yard, especially for these types of ships. A new International Ship Repair Facility, with a Ship Lift of 6000 tons capacity (135mX25m), which could repair up to 85 ships in a year, is also expected to be commissioned soon by CSL, Anandan [20]. The Manufacturing Plan [5] had recommended the targets of achieving 5% of the global shipbuilding market by 2020 and 10% of the global ship repair market by 2020, for the Indian shipbuilding industry. The industry was also expected to meet the target of generating additional employment for 2.5 million persons (0.5 million direct and 2.0 million indirect) by 2020 in the core shipbuilding as well as the ancillary and supporting industry sector, which is indicative of the industry's perceived potential [5]. To meet these targets, at least by 2025, incentives to spur efficient utilization of available infrastructure, by means of suitable fiscal incentives to create momentum, are also considered necessary. A calibrated expansion, based on results achieved, could be followed for further development of infrastructure for new construction.

As stated in the Ref. [1], considerable improvement in the repair turnover can be achieved by diversification and optimum utilization of existing facilities. This is possible by modernization of blasting and cleaning procedures, painting, steel replacement etc., which are presently done by much slower manual processes, so that the ships under repairs can be turned around faster, thus allowing the yard to take on more ships and achieve greater turn over. The Yiu Lian Dockyard Ltd., which is reputed to be the biggest repair yard in China, has a steel renewal capacity of 250 tons/ day, as against 5 tons/ day at best in India, and a Sand/ Grit Blasting capacity of over 15000 square metres/ day, as against around 1000 square metres/ day in India. Thus, while it would take 6-7 days to blast the outer hull of a 30-40000 DWT ship in India, it can be done in a day in China. The same is true of steel renewal (and speed in this activity, which is one of the major activities in ship repairs, is more crucial for competitiveness in ship repair). While it would take 50 days to replace 250 tons of steel in India, the same can be done in a day in the Chinese shipyard.

Therefore increasing the speeds of steel renewal and surface preparation (Sand/Grit Blasting) are crucial for India's competitiveness in ship repair. Corresponding infrastructure augmentations are, therefore, recommended to be pursued on priority.

The National Steel Policy 2017 [21] is an effort to enhance steel production, with focus on high value- and value-added steels, while being competitive. It is being implemented through the Steel Research and Technology Mission of India (SRTMI) and recognizes the output multiplier effect of steel of 1.4X on GDP and employment multiplier factor of 6.8X. Availability of this indigenous steel would have considerable impact on the shipbuilding industry in India.

Indigenous sourcing of materials for shipbuilding, primarily steel, mechanical & electrical equipment for ships and design of ships, needs to be pursued on mission mode, using initiatives used in the automotive and pharmaceutical sectors as models, to achieve competitiveness in these areas steadily and progressively.

## 12. CONCLUSION

Steel shipbuilding industry in India has been in existence since the late 40s and several problems which limit its competitiveness were identified, as early as the 1950s and actions initiated for addressing them. However, the results achieved over the last seven decades have not been commensurate with true potential or comparable with appreciable results achieved in the automotive or pharmaceutical sectors in India. Japan, Korea and China could achieve substantial shares of the world shipbuilding markets by steadfastly following a policy, fitting the method of strengthening each of the drivers of SCM (facilities, inventory, transportation, sourcing, information and pricing) to international competitiveness, while following suitable SCM adaptations while on the route to such competitiveness.

Based on the analysis of the Indian shipbuilding industry by the novel approach of examining the strengths of each of the drivers of SCM of shipbuilding in India, the following focus areas are identified for policy initiatives, for overall growth, building the national capability to its true potential and its continued sustenance in shipbuilding, ship repair and ship recycling to meet the set and achievable targets for the industry [5]: -

- Increased speed of steel construction & renewal and surface preparation (Sand/ Grit Blasting) for shipbuilding and ship repairs.

- Availability of indigenous steel for shipbuilding in India.

• Self-reliance in manufacture of mechanical & electrical equipment for ships.

• Research and Development for infusion of advanced shipbuilding technologies in India.

• Research and Development for Innovative Indigenous Ship Designs.

The above would deliver impressive multiplier effects across other industries and create employment generation in shipbuilding and allied sectors. The policies evolved are recommended to be implemented by a suitably empowered body (similar to SRTMI), on mission mode. This study does not include warship building or repair. A study based on primary data pertaining to current practices in supply chain management of commercial shipbuilding in India, for an analysis of SCM of shipbuilding in India, is an area of recommended future research.

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**REFERENCES**

[1] *Government of India, Ministry of Shipping Road Transport and Highways Report (2007). Report of Working Group for Shipbuilding and Ship repair Industry for the Eleventh Five Year Plan (2007 – 2012), pp 4-65.*

[2] *Xie, Y. (2012), A phenomenological research in the relation between shipbuilding industry and national economy development: A major investigation of China, PhD thesis. University of Newcastle upon Tyne, UK.*

[3] *Thangam, K.M. and Kumar D.S. (2015), 'Competitiveness of Indian Shipbuilding Industry', International Journal of Innovative Research and Development, vol. 4, Issue 7 (Special Issue), pp. 18-25.*

[4] *Mathews, J. (2009), 'China, India and Brazil: Tiger Technologies, Dragon Multinationals and the Building of National Systems of Economic Learning', Asian Business and Management, vol.8,1, pp. 5-32.*

[5] *Government of India, Planning Commission (2011). The National Manufacturing Plan: Strategies for accelerating growth of manufacturing in India in the 12th Five Year Plan and beyond, pp 126-140*

[6] *Fleischer, M., Kohler, R., Lamb, T., Bongiorni, H.B., and Tupper, N. (1999). Shipbuilding Supply Chain Integration Project. Environmental Research Institute of Michigan, pp 2-52.*

[7] *Sarder, M.D.B., Ali, A., Ferreira, S., Rahman, M.A., (2010) 'Managing Material Flow at the US Shipbuilding Industry', International Conference on Industrial Engineering and Operations Management, Dhaka, Bangladesh, January 9-10, 2010*

[8] *Mello, M.H. and Strandhagen, J.O. (2011), 'Supply Chain Management in the Shipbuilding Industry', Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, IMechE Vol.225.*

[9] *Sundara, M.S.S., (2017) 'Understanding Shipbuilding Supply Network', Asian Journal of Research in Business Economics and Management, vol.7, 3, pp 107-113.*

[10] *Chopra, S. and Meindl, P. (2007), Supply Chain Management – Strategy, Planning & Operation, 3rd edn, Dorling Kindersley (India) Private Limited, New Delhi, pp. 60-82.*

[11] *Colton, T. and Huntzinger, L.V. (2002) A Brief History of Shipbuilding in Recent Times, Centre for Naval Analyzes, 4825 Mark Centre Drive, Alexandria, Virginia, 22311-1850, Report No: CRM D0006988.A1.*

[12] *Desai, H.B. (1964), The Indian Shipping Industry with Special Reference to its Post-War Developments. PhD thesis. Maharaja Satyajirao University of Baroda, Baroda.*

[13] *Mc Wiggins, D.P. (2013), Sunrise in the East, Sunset in the West: How the Korean and British Shipbuilding Industries changed places in the 20th Century. PhD thesis. University of Texas at Austin.*

[14] *OECD: Council Working Party on Shipbuilding (WP6) (2016). Peer Review of the Japanese Shipbuilding Industry. Viewed on 02 April 2020. <https://www.oecd.org/sti/shipbuilding>*

[15] *Clarksons Research, World Shipyard Monitor (2017), vol 24, No 12, p. 22.*

[16] *Press Trust of India (2019), 'India's iron imports rise 157% during April-December 2018, says report'. Business Standard, 14 March. Viewed on 02 April 2020. <https://www.business-standard.com/article/economy-policy/india-s-iron-ore-imports-rise-157-during-april-december-2018-says-report-119031400702-1.html>*

[17] *Raut, R.D., Gotmare, A., Narkhede, B.E., Govindarajan, U.H., Bokade, S.U., (2020) 'Enabling Technologies for Industry 4.0 manufacturing and supply chain: concepts, current status and adoption challenges', IEEE Transactions on Engineering Management (EMR), DOI 10.1109/EMR 2020.2897884, IEEE*

*[18] Government of India, Ministry of Shipping (2016). Guidelines for implementation of shipbuilding financial assistance policy (2016-26).*

*[19] Shipbuilding industry news (2019). Viewed on 22 April 20. <https://www. currentaffairs.gktoday.in/tags/shipbuilding industry>*

*[20] Anandan, S (2018). 'Work Afoot to Turn Kochi into a Maritime Hub'. The Hindu, 29 October, p. 2.*

*[21] Gazette of India: Extraordinary – Ministry of Steel (Establishment Division) Notification, New Delhi, 8th May 2017, National Steel Policy 2017 (GSR 452 (E)).*

## AUTHOR

**M. Jaison**, B. Tech (Naval Architecture & Shipbuilding), DIIT (NC), MBA (OR) Research Scholar, School of Management & Entrepreneurship, KUFOS, Panangad PO, Kochi – 682 506 (Kerala).

Email: jaisonsaya@yahoo.com, Mobile - 8447880180