Sustainable operations in reverse supply chain of shipbuilding business

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Abstract
Sustainable operations have become vital for survival of present day shipbuilding business wherein triple bottom-line criteria needs to be satisfied. This paper discusses about recapturing value at the end-of-life of a ship and reintroducing it to the value chain through reverse supply chain channel, thereby also benefitting humans and ecology.

Keywords: Sustainable Operations, Reverse Supply Chain, Shipbreaking.

Introduction
Shipbuilding today, is a multibillion dollar business with the major share of shipbuilding activity occurring in China, South Korea and Japan (Barry Rogliano Salles – Annual Review 2012). As the number of new ships introduced to the existing fleet of ships increase year-on-year, to meet the increasing freight of international trade, older ships are phased out from the fleet. The ships taken out of service are sent to the scrap yards for demolition and possible recovery of materials. However, lately there have been concerns on the environmental and human safety aspects, at places where demolition of ships take place. Almost 92 per cent of the ship scrapping in 2011 took place in developing Asian countries such as India, Bangladesh, China and Pakistan (UNCTAD 2012). Although there are economic implications of shipbreaking business as it provides jobs to thousands of people, there are legal and ecological safety issues as well. According to Basel Convention prevention, minimization, recycling, recovery and disposal of hazardous and other wastes subject to the Basel Convention must be undertaken, taking into account social, technological and economic concerns. This is where sustainable operations have an important role to play. In order to balance the economic and environmental aspects of business, the supply chain may be extended to incorporate reverse logistics thereby recapturing value at the end of the value chain and reintroducing it back into supply chain. This will enable
us achieve success in the form of the triple bottle line – profit, people, planet, all of which are vital in today’s balance sheets, for businesses to survive (Kleindorfer et al. 2005). This paper also discusses on minimizing the carbon footprint in the business processes in the shipbuilding supply chain thereby making the processes more efficient and environment friendly.

**Literature review**
There are mainly three areas where the extant literature has been studied. They are: reverse and closed loop supply chains, ship-breaking business, and sustainable operations. A brief of the literature that has been reviewed is elaborated, as follows.

*Reverse and closed loop supply chains*
Strategic issues in product recovery management (PRM) have been studied (Thierry et al. 1995), and the information required for making accurate analysis on PRM has been enlisted as: composition of manufactured product, magnitude and uncertainty of return flows, markets for reprocessed products and materials, actual product recovery and waste management operations, product recovery options, repair, refurbishing, remanufacturing, cannibalization, and recycling. Quantitative models for reverse logistics have been developed (Fleischmann et al. 1997) including MRP system for product recovery. Product returns for remanufacturing may be managed by a mix of activities termed as product acquisition management (Guide and Wassenhove 2000) which includes value creation, profit maximization by product returns management, operations streamlining and creating new markets for reused goods and products. The options for collecting used products for remanufacturing in a closed loop supply chain has been analyzed (Savaskan et al. 2004). Among three options dealt within the study i.e. – direct collection from customer, collection by retailer and collection by third party, it has been concluded that maximum supply chain profits (as same as centrally coordinated supply chain) are attained when the retailer collects the used product. The case of competing retailers in the reverse channel design has been studied (Savaskan and Wassenhove 2006) wherein there is interaction between manufacturer’s reverse channel choice to collect used goods and the forward channel pricing decision. When the buy-back payments are transferred to the retailers for postconsumer goods, as against direct collection, a wholesale pricing is achieved that can be used to price discriminate between retailers of different profitability.

*Shipbreaking business*
Much has been discussed in literature about shipbreaking in recent times due to the controversies regarding dumping of toxic waste materials associated with the shipbreaking process. This has renewed interests in developing methods by which scrapping of ships may take place without adversely affecting the environment. Reddy et al. (2003) have discussed about the quantification and classification of ship scrapping waste at Alang-Sosiya (India), one of the biggest ship-breaking yards in the world. This industry generates a huge quantity of solid waste in the form of broken wood, rubber, insulation materials, paper, metals, glass and ceramics, plastics, leather,
textiles, food waste, chemicals, paints, thermocol, sponge, ash, oil mixed sponges, miscellaneous combustible and non-combustible substances. The sampling experiment revealed that 96.71 metric tons of wastes per day are deposited on the shore due to the scrapping activity. Hossain and Islam (2006) conducted a study on the ship breaking activities and its impact on the coastal zone of Chittagong (Bangladesh). They have come up with a fourteen point recommendation for incorporating sustainable practices in ship breaking industry. European Commission Directorate General (July 2007) in its report has prescribed the guidelines for ship dismantling and pre-cleaning of ships, including exploring different options for developing strategies for ship dismantling in European Union. A statistical overview of ship recycling was carried out in order to quantify some aspects of recycling such as size of operating fleet, lightship, age of ship etc. (Mikelis 2007). The work provided some interesting insights such as: there is a direct correlation between the freight markets and recycling prices. Price differentials that exist are not only due to shipping market but also due to differences in labor and environmental costs in recycling at different locations, and due to the internal ship steel demand in different economies. The activities at Alang ship-breaking yard, including conditions of workers, impact of shipbreaking on ecology, and recent controversies on asbestos dumping has been treated in detail (Thomas 2007). The case of scrapping of asbestos laden Blue Lady (cruise liner) at Alang, and the legal, environmental and human hazard related problems associated with it has been elaborated (Pelsy 2008). Sonak et al. (2008) discusses the case of French aircraft carrier ‘‘Le Clemenceau’’, which was sent to Alang, India, for disposal. They further assessed the implications of shipping hazardous waste to developing countries and emphasized the need for promoting research to plug the gaps and for implementing stringent measures to check the trade in environmental pollutants. In order to ascertain quantitatively, a methodology to model the environmental impacts of ship dismantling has been suggested (Carvalho et al. 2009). They have also elaborated on the impact on the ecology with respect to the type of ship that is being dismantled.

**Sustainable operations**

The idea of sustainable operations has gained much ground especially in the last decade, due to concerns about the ecological and human impact of day-to-day operations. The evolution of sustainable operations management has been thoroughly elaborated (Kleindorfer et al.2005) detailing the three major areas of integration of sustainable operations i.e. green product & process development, lean & green operations management and remanufacturing & closed-loop supply chains. Demaria (2010) explained about the ecological distribution conflict emanating out of dumping toxic wastes associated with ship breaking, at the cost of environment, local workers, farmers and fishers. In his doctoral dissertation, Sivaprasad (2010) has elaborated on formulating a set of best practices for sustainable development in ship-breaking industry and implementing the 4E principles i.e. eco-friendliness, engineering efficiency, energy conservation and ergonomics in core operations. Technologies for reduced environmental impact from ships - ship building, maintenance and dismantling aspects have been discussed (Hayman et al. 2010) at length.
Reverse supply chain model in shipbuilding business

In the classical business supply chain of manufacturing industries, the finished product passes on from manufacturer to wholesaler, then from the wholesaler to retailer, then from the retailer to the customer who is the end-user of the product. After the service life of the product, the customer ‘throws away’ or disposes the product. This was the case till a few decades ago. However, in recent times, the producer or manufacturer of the product has been trying to retrieve the product from the customer after its use. This is done by providing incentives to the customer, for example, by buying back the product (of course, at a reduced price) at collection points (for instance, authorized retailers, 3rd party collectors etc.) near the location of customers. Collection of disposed products and remanufacturing helps the manufacturer to achieve the 3 Ps. Increase in ‘profits’ due to reduction in cost of manufacturing from raw materials, as disposed products can be collected and refurbished, recycled or remanufactured. ‘Planet’ friendly – lesser damage to the environment as disposed products are not released into the environment, but rather collected back. ‘People’ friendly – better health for humans, as they are saved from toxicity that emanate from products that are dumped in the environment. An illustration of the reverse supply chain is shown in figure 1.

Similarly, for shipbuilding business as well, there is an extension of the classical supply chain, to make it a closed loop supply chain. The difference of shipbuilding closed loop supply chain from that of normal products such as FMCG goods or automobiles is that the collection point of decommissioned ships (ships out of service) is clustered. This is an advantage as the collection effort required is lesser than for other products. Over the last decade, over 80% of the
world ship breaking took place in two ship breaking yards, one at Alang (India) and two at Chittagong (Bangladesh). These shipbreaking yards are a dominant source of cheap ship steel which constitutes almost 95 per cent of the ship (Abdi 2003). The 6,000 metric tons of steel that come out of Alang every day, on average, account for about 15 per cent of the country’s total steel output. It is not just steel that come out of these mammoth shipbreaking yards. A plethora of machinery and outfit components are also sold cheap at second hand rates. These include air compressors, chilling units, lathe machines, drilling machines, welding generators, oil purifiers, oil pumps, water pumps, heat exchangers, condensers, diesel generators, alternators, marine engines, incinerators, turbochargers, and many more equipment. Various outfit items and household equipment such as ladders, kitchen appliances, kitchen machinery, office and home furniture, handrails, fittings, mirrors, cupboards and sideboards, crockery and cutlery, flower pots and holders, used cables, steel pipes, nuts and bolts, screws, electric motors, bulbs and light fittings, wood, partition sheets etc. are also sold at considerable discount rates.

The sustainability part of the business chain comes into play with the accrual of profit that emanates out of shortening of the supply chain. The steel procured for ship construction previously was imported predominantly from abroad, which is now available as recycled steel at reduced prices. The lead time for procurement and transportation costs also reduce by purchasing from steel from nearby mills that produce recycled steel. This is as shown in figure 2.

![Figure 2 - Reverse Supply Chain in Gujarat](image-url)
The distance of transporting steel from East Asian countries like Japan and South Korea is about 50,000 km. This got reduced to less than 250 km when scrap steel from Alan was sent for recycling at mills in Gujarat at nearby districts of Rajkot an Ahmedabad. The re-rolled steel is sent as raw material to shipyards in Bhavnagar and Hazira which are at close proximity, as can be seen in the figure.

Apart from this, use of recycled steel reduces the usage of virgin natural resources such as iron ore. The installation of steel recycling mills also provides employment opportunities to thousands of workers in the region. However, there is concern about the environmental and human hazard problems associated with the shipbreaking industry. Part of the extra profits accrued from the closed loop supply chain can be allocated to resolve this problem. This is treated in detail in the next section.

Environment and human friendly ship-recycling

Much of the environmental damage occurs due to breaking of the ship by the beaching method, which is practiced in the Indian subcontinent, without pre-cleaning of ships. The old ships contain toxic substances like mercury, asbestos, oil sludge, bilge, ballast water, zinc and other heavy metals which if released freely poses a danger to the environment, as it adversely affects agricultural produce, fishing catchment, human safety etc. Thus it is imperative for the ship-owners to decontaminate the ship, and remove all the hazardous wastes prior to export to its graveyard destination. The other alternative would be to remove the environmentally toxic materials once the ship has arrived at the site of shipbreaking. This option is recommended by International Maritime Organization (IMO). Till now, the ship-owners have been reluctant to bear the extra costs of pre-cleaning the olds ships, which the BASEL convention requires them to do so for disposing ships out of service. However, with the changing equation, instilled by sustainable operations practices, it becomes possible for ship owners to scrap ships without spending too much money or damaging the environment. The classical equation for ship scrapping without sustainable operations practices is as shown below:

\[
\sum X_i = P_i + W_i + A_i + E_i + H_i
\]

(1)

Where,
- \(\sum X_i\) = Total cost for scrapping \(i^{th}\) ship
- \(P_i\) = Pre-cleaning cost before scrapping \(i^{th}\) ship
- \(W_i\) = Labour and equipment cost for scrapping \(i^{th}\) ship
- \(A_i\) = Administration and licensing cost for scrapping \(i^{th}\) ship
- \(E_i\) = Environmental cost (damage to environment) due to scrapping \(i^{th}\) ship
- \(H_i\) = Human hazard cost related to scrapping \(i^{th}\) ship

As the \(W_i\) and \(A_i\) components cannot be done away with, as it is integral to the part of ship-breaking, most players in the business try to do away with the \(P_i\) component (pre-cleaning cost). This is at the expense of environmental and human hazard related cost \((E_i + H_i)\). The
inclusion of sustainable operations practices and usage of recycled steel for ship-building purposes in yards located in close proximity, tweaks the equation in the following beneficial form.

\[ \sum X_i = P_i + W_i + A_i + E_i + H_i - M_i - T_i \]  

(2)

Where the new terms are,

- \( M_i \) = Price of steel sold for recycling from \( i^{th} \) ship
- \( P_i \) = Reduction in transportation cost due to steel procured from scrapping of \( i^{th} \) ship

The introduction of the new terms \( M_i \) and \( T_i \), partly bears to provide for the pre-cleaning costs of ships to be scrapped. The pre-cleaning and effective decontamination of ships will decrease the environmental and human hazard related costs associated with shipbreaking. Sustainable operations in shipbreaking also involve reducing the carbon footprint associated with the shipbuilding supply-chain. The carbon dioxide emissions in freight transport in grams carbon per ton freight carried per kilometer by different modes of transport are as shown in figure 3.

![Figure 3 - Comparison of CO\textsubscript{2} emissions in freight transport by mode of transport (Source: UNCTAD, 2012)](image)

Needless to say that there is significant reduction in carbon dioxide emissions by local sourcing of steel than importing from abroad. For instance, procuring steel from a recycling mill located 250 km from the yard instead of a steel manufacturer (located in East Asia) 50,000 km away (even by a bulk carrier which has the lowest carbon footprint by maritime route) saves CO\textsubscript{2} emissions of the order of 50 kg CO\textsubscript{2} per ton of freight carried. To put this in real life perspective, for building an average general cargo ship of 20,000 Lightweight Tons, the savings accrued to procurement from local recycling yard is of the order of 1000 Tons of CO\textsubscript{2} emission. Therefore,
the ship-owners have an incentive to trade carbon credits to the local shipbuilders as an incentive to buy from the local steel recycling mills. Similar to steel sourcing, machinery and outfit components may also be sourced locally if refurbishment of old equipment to ‘new equipment quality’ is viable and technologically feasible.

Conclusion
The reverse supply chain in shipbreaking helps the shipping industry gain financial value out of zero-value vessels. It also enables the ship owner do away with the operational burden of maintaining vessel which has higher operating costs than its revenue. The reverse supply chain of large Built-to-order (BTO) products, like ships, provide huge amount of re-rollable steel without exploiting natural resources. The western geography of India does not have steel producing units. The shipbreaking industry provides balance to the steel sector by providing used steel to rerolling mills in Rajkot, Kutch, Hariza and Surat (Gujarat). Therefore, the ship recycling industry saves a lot of time and logistics cost for the steel sector industries. In addition to this, the reverse supply chain also gives a heads up to sustainable business practices as it reduces the CO₂ emissions and reduces damage to the environment.

References


