INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

CAN SHIP RECYCLING INCREASE THE BRAZILIAN SCRAP CAPACITY?

Euler Sánchez
Universidade Federal Fluminense, Brazil
E-mail: eulersanchez@id.uff.br

Newton Narciso Pereira
Professor at Universidade Federal Fluminense, Brazil
E-mail: newtonaval@gmail.com

Submission: 2/11/2019
Accept: 2/27/2019

ABSTRACT

Ship recycling is commonly developed in Asian beaches due to labour cost and legal flexibility. The extraction of steel from ship recycling makes this activity economically viable and must accomplish with the labour and environmental requirements. In that way, local steel scrap market in Brazil presented a deficit of at least 3.0 million / tons in the last 8 years while not meeting the demand of the local steel and smelting industries. In this line, we considered the economic potential for developed ship recycling in Brazilian shipyards, finding an opportunity to meet local demand for steel scrap of 3.0 million/year - and international demand of 370,000 tons/year, both means between 2007 and 2017. Finally, we found that there is an opportunity of implement ship recycling activity in Brazilian shipyards for the extraction of steel scrap from local ship fleet with market value of US$ 587,51 million. After considering the premise of serve neighbouring Latin American ship fleets, the volume of steel scrap and market value increase to US$ 19,94. This scenario could promote an attractive business and the rotation of the assets for local shipyards.

Keywords: Ship recycling, Steel Scrap, Shipyards, Decommissioning, Sustainability

http://www.ijmp.jor.br _v. 10, n. 6, November - December 2019_
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

1. INTRODUCTION

The ship recycling practice consists in the dismantling of the constituent parts of the ship, so that, each of its parts must be classified, separated and withdrawn for later disposal (DINU; ILIE, 2015).

Shipbreaking in Asian countries lack safety and health standards (CHOUDHARY, 2011; HIREMATH; PANDEY; ASOLEKAR, 2015) most of the dismantling methods do not consider the challenges of sustainability and environmental practices (WORLD BANK, 2010). The last decade ship breaking industry started to adopt differential practices, being recognized with the term "ship recycling" (DEVAULT; BEILVERT; WINTERTON, 2016) because regulations required the handling of various materials, including toxic, flammable and fluid materials that require appropriate techniques for their management and disposal (KAISER; BYRD, 2005).

The ship recycling activity generates a considerable diversity of materials, mainly metals corresponding to 70% or 85% of ships total weight (JAIN; PRUYN; HOPMAN, 2016). The volume of non-metallic materials varies between 1% and 2% of the ship´s combined weight (ANDERSEN *et al.*, 2001; DEMARIA, 2010). Other gaseous and liquid pollutant arrive to Asian beaches in the interior of ships, representing a significant threat to the environment (DEVAULT; BEILVERT; WINTERTON, 2016). Most of these pollutants are unidentified in the ship's structure, which makes them difficult to track and manage (HOSSAIN; ISLAM, 2006)

To control environmental impacts from ship recycling industry, the international community and non-governmental organizations have created mechanisms as Basel Convention (BC) of 1989, the Hong Kong Convention (HKC) in 2009 for regulate the transboundary movement of hazardous materials between countries and the traceability of hazardous wastes on-board vessels (IMO, 2009B; SAHU, 2014). Subsequently, the European Parliament create the Ship Recycling Regulation or SRR - 1257/2013 applied for European vessels and including additional requirements in terms of safety and environmental management (YUJUICO, 2014).

The current requirements for developing ship recycling activity crated the need of standardized shipyards around the globe to enter in this market (MIKELIS, 2018a). Many countries from Asia as China, Turkey and India have applied to be approved by the EU commission for recycling European flagged vessels (MIKELIS, 2018b)

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

because they represent more than 30% of DWT scrapped every year in Asian beaches (NGO SHIPBREAKING PLATFORM, 2016). In America the Brazilian shipyards and various stakeholders (internal scrapping sector, steel mill and recycling industries) are assessing the opportunity to participate in ship recycling market as a potentially way for steel scrap extraction.

By the end of 2017, Brazilian ship building market presented an idle construction capacity due to the effects of the oil and gas crisis (PEREIRA, 2017; PEREIRA; TEIXEIRA, 2017). This idle capacity could be used in decommissioning and recycling of ships, so that we assessed the potential contribution of developing ship recycling activity in Brazilian shipyards. In that way, we considered the local and neighbouring South American ship fleets able to be recycled and estimated the Light Displacement Tons (LDT) recoverable from those ships and its market value.

2. THEORETICAL FRAMEWORK

2.1. Brazilian vessel construction and repairing industry

The Brazilian shipbuilding and repair industry have more than 81 years of evolution, since then it has faced different economic crises (BRANQUINHO; SALOMÃO; DUARTE, 2012). Those economic upsets made necessary to develop investment policies for boost large-scale modernization and expansion of the oil fleet, generating a current demand for the naval market (SINAVAL, 2015).

Since then, the shipbuilding industry concentrated on the construction of structures for exploration and transportation of oil and gas products (BNDES, 2012; SINAVAL, 2015a). Since then, the industry has been based on the offshore and oil sector (GUEDES, 2014). As of 2005, the number of jobs generated by the shipbuilding and repair sector starting increasing significantly reaching 82,472 direct and indirect jobs in 2014 (SINAVAL, 2015a). Because of the economic and political crisis related with the petroleum and gas sector that began in 2014, there was a fall in the sector's jobs, going from 82,472 in 2014 to 38,452 effective jobs in 2016 (SINAVAL, 2015b; D'AVILA; BRIDI, 2017)

Actually, in Brazil there are 19 shipyards dedicated to construction and repair, of which 11 are dedicated to vessels and specialized ships, six are dedicated to offshore structures, and two serve offshore structures and other kind of ships. The steel processing capacity to ship building in tonnes/year for these yards is approximately ± 900,000 (PORTAL NAVAL, 2017; SINAVAL, 2016). Those facilities count with

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

capacity to service various types of ships, from supply ships, Handymax, Panamax, Aframax and VLCC.

Although Brazil has focused on shipbuilding, maintenance and repair over the years, ship recycling shows a new perspective for Brazilian shipyards to increase their productivity, generating employment and incomes (PEREIRA, 2017; SINDAMAR, 2017). Up to 2017, most of the Brazilian shipyards were underutilized production capacity generated by the petroleum and gas sector crisis and could be used for ship recycling (SINDAMAR, 2017).

If these yards wish to participate in the ship recycling market, they would have to adjust their facilities and processes for the management and treatment of recyclable and non-recyclable materials, both of which are fundamental in this activity (OVERGAARD *et al.*, 2013; SINAVAL, 2015a; JAIN; PRUYN; HOPMAN, 2017). In addition, shipyards would have to evaluate their smaller and larger equipment, infrastructure and macrostructure, technical and engineering staff in order to adjust their processes (OVERGAARD *et al.*, 2013).

The **Erro! Fonte de referência não encontrada.** shows the information pertaining to the annual process capacities in tons/year of Brazilian shipyards.

Table 1: Brazilian shipbuilding and repairing shipyard´s capacity

Shipyard	Estate	Prod. Ktons. steel/year	Type of activity	Area (mil. m2)
Enseada do Paraguaçu	BA	60	Offshore	630
Jurong Aracruz	ES	48	Offshore	825
Atlantico Sul	PE	160	Vessels and Offshore	1.000
Vard Promar -STX	PE	20	Specialized vessels	800
Techint	PR	40	Offshore	NR
Rio Nave	RJ	10	Specialized vessels	95
Aliança	RJ	10	Specialized vessels	61
Aliança	RJ	10	Specialized vessels	61
São Miguel	RJ	5	Specialized vessels	21
BrasFels	RJ	50	Offshore	410
Estaleiro OSX	RJ	180	Vessels and Offshore	NR
QGI	RS	80	Offshore	70
Estaleiro Rio Grande (Ecovix)	RS	13	Specialized vessels	500
EBR - Estaleiros do Brasil	RS	110	Offshore	NR
Navship	SC	15	Specialized vessels	175
Detroit	SC	10	Specialized vessels	90
Keppel-Sigmarine	SC	10	Specialized vessels	77
Itajaí	SC	12	Specialized vessels	177
Estaleiro Oceana	SC	20	Specialized vessels	310
Wilson, Sons	SP	10	Specialized vessels	22

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Total	**883**

Source: adapted from SINAVAL (2015); Portal Naval (2017)

These volumes correspond to the total process capacity for shipbuilding and repairing activities. The ship recycling activity did not exist in Brazil and it is a limitation to determinate the ship recycling capacity of these shipyards.

2.2. Steel production industry and scrap generation in Brazil

In 2014, the Brazilian metallurgical sector accounted for 2.1% of world steel production and represented 52.3% of total Latin American continent production in the same period (CGEE - MDIC, 2014; INSTITUTO AÇO BRASIL, 2017).

In that way, the Brazilian steel mill is made up of 29 industrial units, 13 of them are integrated and 16 are equipped with electric furnaces. The total installed capacity is 47.8 million tons of crude steel in 2014 (CGEE - MDIC, 2014). These plants are managed by 11 business groups (Aperam, AcerlorMittal Brasil, CSN, Gerdau, Sinobras, ThyssenKrupp CSA, Usinminas, VBS Tubos, V&M do Brasil, Villares Metals e Votorantim (NOGUEIRA, 2013).

The mean of gross steel production mills from 2007 to 2014 varied between 28 and 34 million tons/year (CGEE - MDIC, 2014; Ministério de Minas e Energia (MME), 2015), and there is a projection for the total production between 35 and 49 million tons/year from 2017 to 2020 (CGEE - MDIC, 2014; MINISTÉRIO DE MINAS E ENERGIA (MME), 2015).

Both class steel mills and others steel transforming industries generate scrap by alternative ways, and it is reintroduced to the metallurgical industry. The share of scrap as material used by Brazilian steelmakers in the steel production process from 2005 to 2011, varied between 26% and 32% of total material balance consumed (CGEE - MDIC, 2014; INSTITUTO AÇO BRASIL, 2017). This balance allows the reduction of imply consumption in steel processing of at least 2/3 from the total energy employed to produce one steel ton (CGEE - MDIC, 2014).

The total volume of scrap consumed by the steel mills depends on the operational levels of both integrated and electric furnaces (NOGUEIRA, 2013; CGEE - MDIC, 2014). This because they can use three types of steel scrap, being internal, obsolescence and industrial scrap. In this manner, the internal scrap corresponds to residual product of the steel production processes. It basically depends on the degree

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

of integration of the steel mill downstream. In Brazilian case, a vast portion of output mills corresponds to semi-finished products (slabs and billets for export). The internal scrap generated by the Brazilian steel mill units is more than 10% of the crude steel production (data considered as a national average (CGEE - MDIC, 2014).

The obsolescence scrap results from another economic segment, but on a more limited scale. This is the capital consumption and large equipment segment like automobiles, appliances, silos, storage tanks, among others, that after lifecycle considered by economic or technical assumptions are transformed in scrap (NOGUEIRA, 2013).

Finally, the industrial scrap is generated from the steel processing of the industries that consume and transform this material, being result of losses in the transformation of steel into final goods or in the residuals of said operations (CONFEDERAÇÃO NACIONAL DA INDÚSTRIA - CNI, 2012).

2.3. Scrap recovery through ship recycling activity

Ship recycling activity is an old practice (OSHA, 2010), it is applied on end of life ships with ages typically between 25 and 30 years (UNEP, 2003; CHOUDHARY, 2011; DINU; ILIE, 2015; HIREMATH et al., 2015). Different key factors are considered for shipment vessels to recycling, like technical or financial obsolescence; principally when cost-effectiveness of keeping this asset still operational is not attractive (DEVAULT et al.,2016; KARLIS et al., 2016; JAIN et al., 2017). Therefore, this practice consists in decommissioning of the constituent parts of ships, because it´s an engineering superstructure and each of its parts could be removed and classified for later reuse and destination for respective recycling process (DINU; ILIE, 2015).

This industrial activity is heavily practiced in South Asia countries, but those shipyards have many deficiencies related to the pertinence of the infrastructures and low labour guarantees required to execute the industrial process by environmentally and socially sustainable way (CHOI et al., 2016; HOSSAIN; ISLAM, 2006; KNAPP et al., 2007). There are many negative environmental and social impacts from ship recycling in Asia (DEMARIA, 2010; FREY, 2013B; CHOI *et al.*, 2016)

This industry generates recyclable and non-recyclable materials, the first one is reused or recycled, and they justify the ship recycling practice (HIREMATH; TILWANKAR; ASOLEKAR, 2015). Most part of this kind of materials is metallic and

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

correspond between 70% and 85% of the overall weight of a ship, ranging from 50% to 70% (ANDERSEN *et al.*, 2001; DEMARIA, 2010; WORLD BANK, 2010). These metals correspond to rolled naval steel, which is reused by the steel mill industries as plates or common scrap in its steel processes (DEMARIA, 2010; JAIN; PRUYN; HOPMAN, 2016; JAIN; PRUYN; HOPMAN, 2017).

2.4. Ship recycling regulations

International regulations such as BC, HKC - 2009, SRR 1273/2013 stipulated the set of guidelines and parameters to be met by shipowners, shipyards and intermediaries involved in ship recycling activities and transboundary transportation of hazardous materials (EUROPEAN PARLAMIENT & EUROPEAN UNION COUNCIL, 2013; IMO, 2009B; SECRETARIAT OF THE BASEL CONVENTION, 1989). They should therefore use facilities that include docks (Dry or Floating), slipways, waterproofed floors, hazardous materials warehouses, among other equipment like cranes, cutting equipment, and the preventive measures required to ensure environmentally sound and safe recycling (OSHA, 2010).

The ship recycling process is constituted by stages similar to shipbuilding, but obeying to a reverse flow. It can be differentiated by the non-sustainable processes related with management and withdrawal of hazardous materials (ANDERSEN et al., 2001; KAISER, 2008; JAIN, 2017). According to (HIREMATH et al., 2015), there are more than ten stages typically adopted by shipyards in Asia in the ship recycling process.

In other way, (JAIN et al., 2016) assures that the standardization and processing capacity of the worldwide shipyards destined to shipbuilding and repairing activities, counts with higher capacity than substandard Asian shipyards, this due to technical preparation and infrastructure.

Studies related to mapping and treatment of the materials extracted from ship recycling activity, as evidenced in (HOSSAIN; ISLAM, 2006; HIREMATH et al., 2015a; HIREMATH et al., 2015; DEVAULT et al., 2016; JAIN et al., 2017), demonstrate the challenge of this activity corresponds to the reduction and mitigation of environmental impacts. It depends on the technical and operational shipyard capacities.

They replicated the most important factor related with the successful of ship recycling production is productivity, which depends directly of technical preparation

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

and structural shipyard´s capacity, which could be improved via simulation or modelling.

In this sense, Brazil counts with shipyards destined to shipbuilding and repair, the annual steel processing, many of these facilities have dry docks and docks, others rely on mooring berths supported by cranes (MINISTÉRIO DOS TRANSPORTES, 2017; PORTAL NAVAL, 2017). Thus, although Brazilian shipyards were designed for construction and repair, recycling would represent a process of less complexity in relation to construction and repair. Then, it is possible that the recycling capacity in LDT/year is even greater. In addition, these facilities count with an environmental operating license, an entire operational chain that consists of a network of service providers for the treatment of materials.

3. RESEARCH PROBLEM

The crisis in the Brazilian shipbuilding and repair sector attenuated since 2014 had created unproductiveness in local shipyards. Therefore, different stakeholders involved in this industry have been economically affected (PEREIRA; TEIXEIRA, 2017; SINDAMAR, 2017). The search for different productive activities has let these stakeholders to study ship recycling activity as a productive alternative for local shipyards, however, without substantial technical advances. international legislation as SRR and HKC has required ships to be recycled exclusively through sustainable methods on facilities with appropriated capacity and structures (IMO, 2009; EUROPEAN PARLAMIENT; COUNCIL OF THE EUROPEAN UNION., 2013).

Consequently, specialist ensure that ship recycling techniques are a less complex process compared to shipbuilding and repairing (JAIN, 2017). Hence, is possible to infer the possibility of Brazilian shipyards to take advantage of their structures and standardization for develop ship recycling activities.

Finally, the steel mill and smelting industry in Brazil shows itself as a potential consumer of scrap, there is a deficit in the local scrap supply demanded for the manufacture of steel products. Thus, the larger the proportion of scrap implemented in steel production, the greater economy in the manufacturing process (CONFEDERAÇÃO NACIONAL DA INDÚSTRIA - CNI, 2012; CGEE - MDIC, 2014; INSTITUTO AÇO BRASIL, 2017).

3.1. Hypotheses

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

The extraction of steel scrap thought ship recycling industry results in an economically viable alternative for the Brazilian shipbuilding industry and for the internal steel scrap market.

The following premises were considered with the purpose of evaluating the hypothesis:

a) Demand for steel scrap due to local production from the steel and foundry industry would leverage ship recycling as a new niche market for local shipyards;

b) The volume of steel scrap available in the Brazilian local market and its negotiation in international markets indicates a commercial possibility for the extraction of scrap from ship recycling;

c) The recycling of vessels belonging to the Brazilian fleet can serve as a supplier of steel scrap to the local steel and smelting industries;

In this way, the following variables were defined to helped the hypothesis corroboration:

I. Offer and demand of domestic steel scrap;

II. volume of steel scrap traded by Brazil in the international market;

III. the potential volume of steel scrap extractable from the recycling of Brazilian ships and other neighbouring ship fleets;

IV. market value (US $) of steel scrap extractable from Brazilian and other neighbouring ship fleets;

4. METHODOLOGY

We make a symmetrical relationship analysis between the information of variables (I), (II), (III), (IV) and (V) in order to identify their relationship and used them to make an inductive analysis. The methodological sequence is described above.

INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

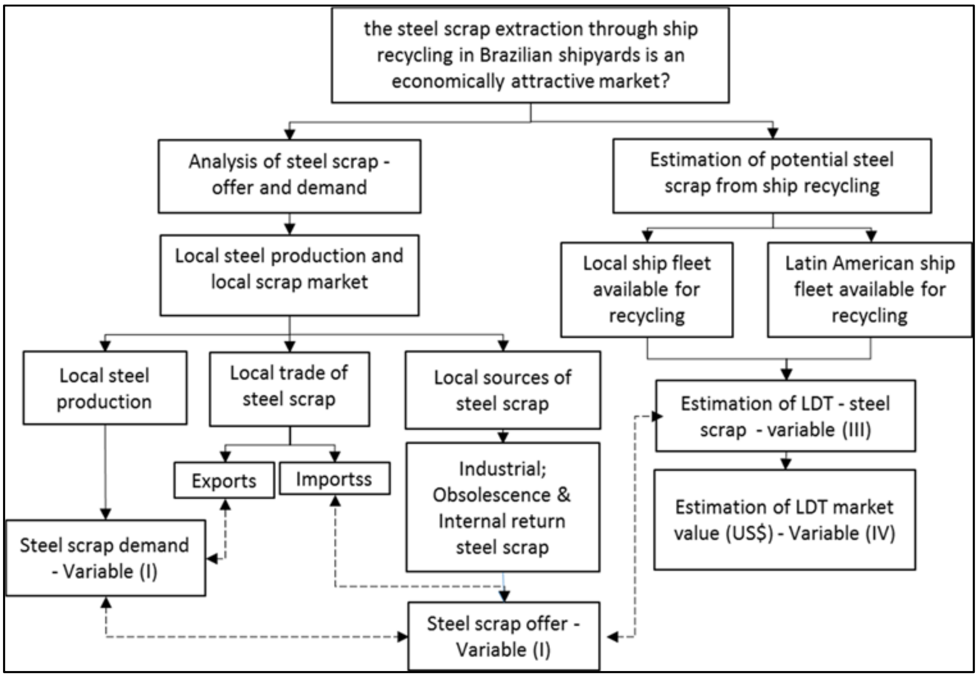

Figure 1: methodology flow process

The research was divided into two fronts, thus, they correspond to the analysis of the supply and demand of steel scrap (left of the flow) and the estimation of the steel scrap potentially withdrawn through the recycling of ships (flow right).

4.1. Local steel production and scrap market

We collected data from Brazilian gross steel production, using the statistical yearbook of the Steel Brazilian Institute (INSTITUTO AÇO BRASIL, 2017), the report of steel and the pig iron production levels for Brazilian steel industry, both projected up to 2020 (CGEE - MDIC, 2014). We also analysed the data of total steel scrap generated from the Brazilian steelmaking activities, for this we considered the three most common sources of scrap generation in the local market (obsolescence scrap, Industrial scrap, internal return scrap) (INSTITUTO AÇO BRASIL, 2017), so that we characterized the variable (I).

On the other hand, the international trade of steel and iron steel scrap in Brazil were analysed, using the records about volumes and prices of steel scrap trade balance (imports and exports) consolidated in the commerce combined nomenclature - CCN - 7204 registered by the Ministry of Industry, Foreign Trade and Services (ALICE WEB, 2017). So that, were possible to characterized the variable (II).

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

In order to perform the characterization of variable (II), we compared the scrap price practiced in local market within international scrap market price, especially with those prices practiced on Asian ship recycling market. This approach was assumed to compare the similarity between national and international steel scrap price traded.

4.2. Steel scrap from ship recycling

We consider two scenarios for estimating the potential of ship recycling scrap market for Brazilian shipyards. First, we estimated the extractable steel scrap (LDT) taking account the potential number of ships to being recycled from the Brazilian ship fleet. Secondly, we considered the potential number of ships to being recycled from Latin American ship fleets. Both scenarios considered the possibility of ship recycling process being developed in Brazilian shipyards.

To obtain the number of ships from the Brazilian ship fleet, we used the National Water Transport Agency (Agência Nacional do Transporte Aquaviário - ANTAQ) databases, which provides detailed characteristics of each ship, between them DWT, GT, Year of construction, etc. So that, were found approximately 2.259 ships pertaining to the Brazilian fleet.

To obtain the number of ships available from the Latin American fleets, we consulted the opened access UNCTADstat as describe in (Table 2), section 4.3. After that, we get the DWT, GT, year of construction among other structural parameters of each ship for the 10 fleets consulting the opened access Marine-Traffic database.

Finally, all ships where group and treated in four classifications: (1) Tanker, (2) Bulk Carrier, (3) General Cargo / Ro-Ro / Reefer and (4) Container / Others. For each classification was utilized a conversion factor to get either DWT from GT and LDT from DWT as describe in section 4.4, those factors were already used by (STOPFORD, 2003; ECORYS, 2005; CHOUDHARY, 2011). Through those estimations where possible to get the information for characterized the variable (III).

4.3. Latin American fleet criteria selection

To select the 10 Latin American ship fleets to being analysed, we consulted the maritime merchant profile registered on UNCTADstat till November 2017, so that the number of ships by country fleet were used as a criteria selection, getting the fleet profile summarized in Table 2.

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Table 2: Number of vessels consulted by country fleet

Country	# Marine Traffic records consulted	% Total records	DWT 1 - (records consulted)	DWT 2 - (UNCTADStat)	% DWT 1 vs DWT 2
Panama	3,697	70.02%	169,359,682	332,877,600	53%
Bahamas	1,062	20.11%	56,033,732	56,033,732	70%
Mexico	160	3.03%	1,281,599	1,281,599	75%
Chile	97	1.84%	1,324,921	1,324,921	100%
Ecuador	69	1.31%	452,259	452,259	100%
Argentina	49	0.93%	548,708	548,708	88%
Bermuda	43	0.81%	2,258,403	2,258,403	21%
Venezuela	42	0.80%	1,246,714	1,246,714	69%
Colombia	37	0.70%	83,344	83,344	81%
Uruguay	24	0.45%	58,961	58,961	100%
Total registers	5,280				

Source: Adapted from UNCTADStat (2017)

4.4. Estimating the scrap available for recycling

After quantifying the number of vessels available for recycling pertaining to both group of fleets (Brazilian and Latin American) we consider only ships larger than 500 DWT in the estimation, due to its steel scrap quantity contribution, this selection criteria was utilized by (JAIN, 2017) accordingly to the application of the HKC for ships.

After this classification, we estimate the potential tons of steel scrap (LDT) for both group of fleets. For this, a commercial ship lifespan of 25 years for all vessels since its manufacture´s year was adopted, like used in many maritime econometric analyses (ANDERSEN et al., 2001; KAISER; BYRD, 2005; FREY, 2013; DINU; ILIE, 2015; HIREMATH et al., 2015)

Subsequently, to carry out the LDT estimation, the conversion factors from (Table 3) were applied to the DWT and GT vessels parameters (CHOUDHARY, 2011; DINU; ILIE, 2015; FREY, 2013; HIREMATH et al., 2015).

The total LDT that can be extracted from each ship, excluding the non-constituent weights of its structure was estimated employing the method presented by (STOPFORD, 2003; ECORYS, 2005; CHOUDHARY, 2011). Then, we could characterize the analysis variable (IV).

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Table 3: Conversion factors for calculate LDT

Tonnage Factor	***Tanker***	***Bulk Carrier***	***General Cargo, Ro-Ro, Reefer***	***Container, Others***
DWT using GT	1.75	1.70	1.44	1.00
LDT using DWT	0.30	0.33	0.44	0.34

Source: Adapted from Stopford (2003), ECORYS (2005), and Choudhary (2011)

Considering that steel scrap prices in the local and international markets are similar, they were used to estimate the market value (US $) of recoverable scrap from Brazilian ship and neighbouring ship fleets through development of ship recycling activities in local shipyards. This estimation is developing in section (5.4 e 5.5) in this way was characterized the variable (III). The steeps describe in methodology process are summarized in the next flowchart:

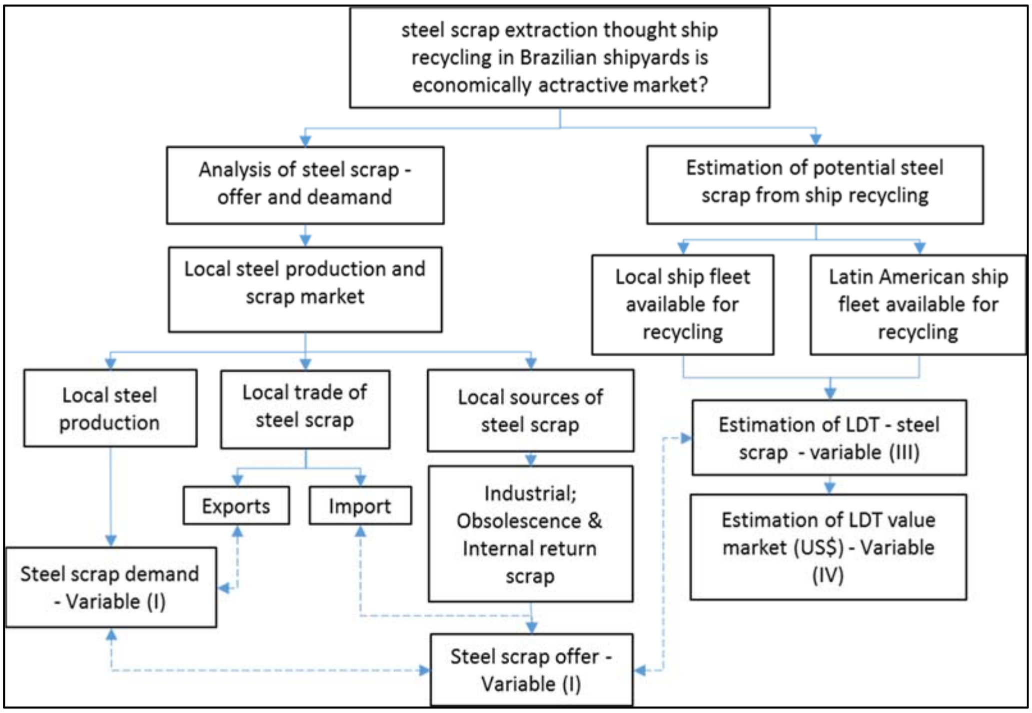

Figure 2: Methodology flowchart

5. RESULTS

5.1. 5.1 Steel production and scrap generation in Brazilian

In 2017, the total steel scrap generated in Brazil from steel foundry mill industries and other sectors which process and transform the steel was 15.2 Million tons /year (Mty), while the total scrap demanded was approximately 18.7 Mty. This situation shows that there is an unsatisfied scrap demand on the steel and foundry industry (CONFEDERAÇÃO NACIONAL DA INDÚSTRIA - CNI, 2012; CGEE - MDIC, 2014).

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

According to Alice-web databases from 2007 to 2016, Brazil exported an average of 2.8% of the total scrap available in the internal market (370,000 tons/year), while imports represented 0.4% of the domestic demand for steel scrap (49,000 tons/year) considering different types of steel scrap (ALICE WEB, 2017; OLIVEIRA, 2014).

The Table 4 shows the data of steel production in Brazil broken down by type of furnaces (integrated industry and electrical) from 2007 to 2014. These data were collected from the Centre for Management of Strategic Studies in Brazil – (Centro de Gerenciamento de Estudos Estratégicos do Brasil - CGEE), the industry and commerce development Ministery (Ministério do Desenvolvimento da Indústria e Comercio MDIC) and the Ministry of Mines and Energy (Ministério de Minas e Energia - MME).

Table 4: Gross steel production and return scrap generation – Mty

	Steel production			
Year	Electric Furnace	Integrated Industry	Total (mi-ton)	Return steel scrap generation
2007	8.1	25.7	33.8	3.4
2008	7.9	25.8	33.7	3.4
2009	6.3	20.2	26.5	2.7
2010	7.8	25.1	33.0	3.3
2011	8.2	27.0	35.2	3.5
2012	8.1	26.4	34.5	3.5
2013	8.6	25.6	34.2	3.4
2014	8.4	25.5	33.9	3.4
2015	7.2	26.0	33.3	3.3
2016	7.1	24.2	31.3	3.1

Source: Adapted from CGEE - MDIC (2013); MME (2015); Instituto Aço Brasil (2017)

The table clearly shows the predominance of the integrated steel industries, to the detriment of the electric arc power plants, thus, the greater participation in the generation of return scrap obeys the plants of the first type. Figure 3 summarizes data of total Brazilian steel production from both types of mills from 2007 to 2016. It is worth clarifying that the annual steel production corresponds to backward series.

INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

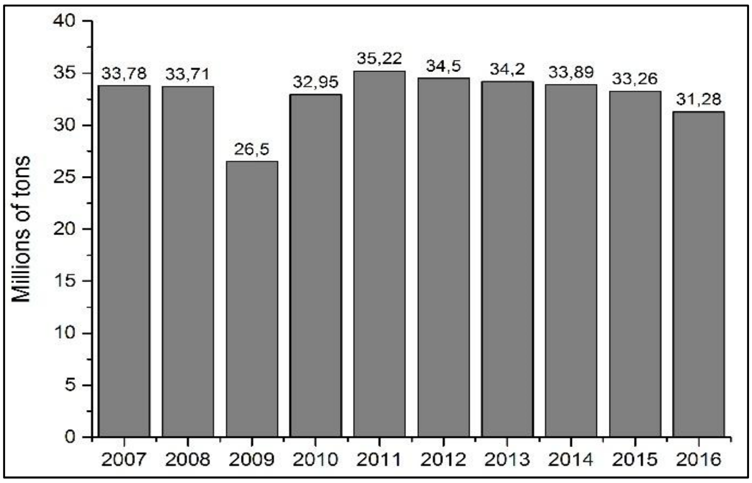

Figure 3: Brazilian steel production (2007 - 2016)
Source: Adapted from CGEE - MDIC (2014); Ministério de Minas e Energia - MME (2015); Instituto Aço Brasil (2017)

It is possible to observe that steel production showed few fluctuations in the previous years, except, 2009 which is probably linked to the international economic crisis. Thus, the demand for steel scrap can be considered as a demand with low variations and accompanying the trends of the local and international economy. Figure 4 shows a historical series from 2005 to 2017 of total steel scrap demand from steel mills and smelting plants in Brazil. This shows a deficit in the supply of scrap. When domestic and international scrap prices are unattractive to steel mills, especially integrated ones, they choose to use a more considerable proportion of pig iron (CNI, 2012).

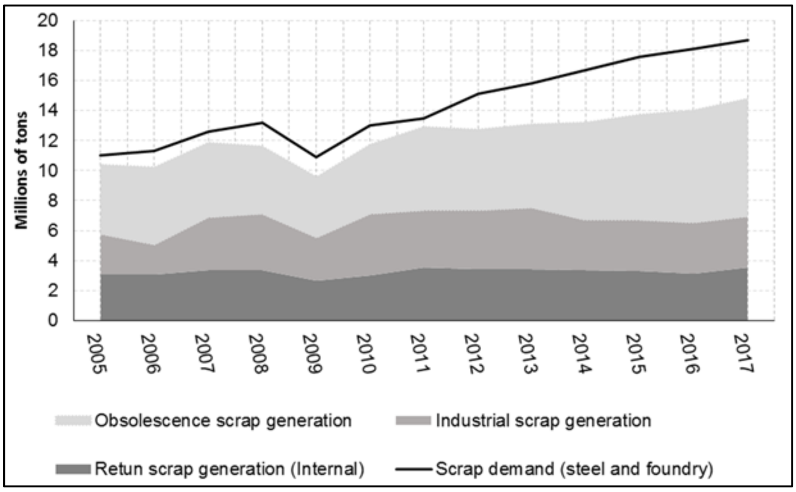

Figure 4: Scrap (demand and generation) in Brazil (2005 – 2017)
Source: Adapted from CNI (2012; CGEE - MDIC (2014); Ministério de Minas e Energia - MME (2015); Instituto aço Brasil (2017)

Figure 4 shows the difference between scrap demand and its sources of generation (internal, obsolescence and industrial) corresponds to the amount of pig

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

iron and other row materials used by steel mills to complement the balance in steel production. It is clear that there is an unsatisfied demand for scrap of at least 3.0 million of tons between 2011 and 2017.

Another relevant aspect to be considered in the Brazilian steel scrap supply and demand equation, corresponds to imports and exports of this material. Brazil negotiates in foreign markets scrap of cast iron and waste of iron or steel, them traded under the international combined trade code (CCN – 7204).

Figure 3 shows the dynamic of the steel scrap market trade, the supply and demand of the materials are summarized in the CCN - 7204 code between 2006 and 2017.

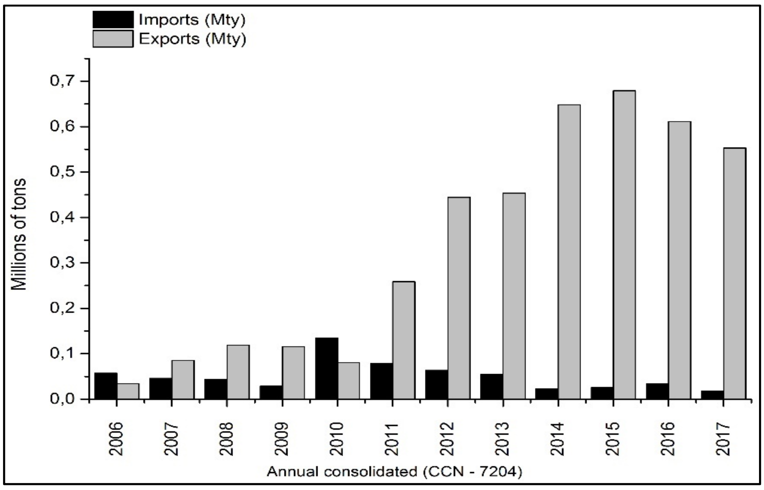

Figure 5: Trade of steel scrap and derivatives - Brazil (2006 - 2017)
Source: Adapted from CGEE - MDIC (2014); Alice-web (2017)

According to Figure 5, it is possible to observe in the Brazilian trade balance corresponding to CCN - 7204 that exportation of scrap, waste iron and steel have a more significant share compared to importations. Thus, the information in Figures 2 and 3 show a deficit scenario as the availability of steel scrap in Brazil, which implies probable difficulties in the steel and foundry industries before the possibility of expansion of production capacity.

5.2. The international Brazilian steel scrap market

Although there is even now a deficit in the quantity of steel scrap demanded in Brazil, the sale of Brazilian steel scrap to international markets is evident (Alice Web, 2017). Table 5 shows the comparison between scrap exportations and local scrap generation indexes, as well as the ratio between the local scrap demand and the imports of steel scrap.

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Table 5: Comparisons between generation, imports and exports of steel scrap

Year	Scrap demand (steel and foundry)	Scrap generation	Exports (Mty)	Imports (Mty)	(%) exports vs scrap generation	(%) imports vs total demand
2.007	12,60	11,88	0,09	0,05	0,7%	0,4%
2.008	13,20	11,61	0,12	0,04	1,0%	0,3%
2.009	10,90	9,61	0,12	0,03	1,2%	0,3%
2.010	13,00	11,78	0,08	0,13	0,7%	1,0%
2.011	13,50	12,94	0,26	0,08	2,0%	0,6%
2.012	15,10	12,73	0,44	0,06	3,5%	0,4%
2.013	15,80	13,09	0,45	0,05	3,5%	0,3%
2.014	16,70	13,19	0,65	0,02	4,9%	0,1%
2.015	17,60	14,20	0,68	0,03	4,8%	0,1%
2.016	18,10	13,68	0,61	0,03	4,5%	0,2%
2.017	18,70	15,20	0,55	0,02	3,6%	0,1%
			Average percent		**2,8%**	**0,4%**

Source: Adapted from CNI (2012); CGEE - MDIC (2014); Instituto Aço Brasil (2017); Alice-web (2017)

It is observed that in 2017 approximately 3,6% of scrap available in local market was exported (ratio between steel scrap generation and steel scrap exports). According to (MINISTÉRIO DA INDÚSTRIA COMERCIO EXTERIOR E SERVIÇOS - MDIC., 2016), in 2016 at least 78% of Brazil's scrap available was exported to Asian countries, including Bangladesh (22%), India (17%), Pakistan (15%), China (0.67%) and other Asian countries (24%).

These destinations correspond to the same headquarter of South Asian shipyards where the activity of ship recycling is practiced extensively, making evident that certain part of the demand of steel scrap of these countries, is being attended through import practices. One of the justifications for the export of local scrap steel is underpinned by the parity between steel scrap prices in the domestic and international markets as shown in table 6 (MINISTÉRIO DA INDÚSTRIA COMERCIO EXTERIOR E SERVIÇOS - MDIC., 2016; ALICE WEB, 2017).

5.3. Ship recycling market estimation through Brazilian fleet

We identified around 2.600 ships with several DWT sizes (100 DWT– 274.000 DWT) from the ANTAQ database. Moreover, after selecting the ships above 500 DWT, we got only 340 ships for analyse. Thus, a 25-year life span since the construction´s date of each ship was assumed to estimate the year of recycling, so that only 295 vessels were considered technically capable of recycling between 2018 and 2042 (Figure 6). Other 45 ships were already available for recycling before 2018 due to

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

being ships with more than three decades of age, so they were denominated as “ready to recycling”.

For calculating the LDT extractable from Brazilian ships fleet we applied the conversion factors mentioned in table 3 using the DWT and GT parameters of each ship. The number of vessels available to being recycled every year from 2018 to 2042 and its respectively LDT estimations are shown in Figure 4.

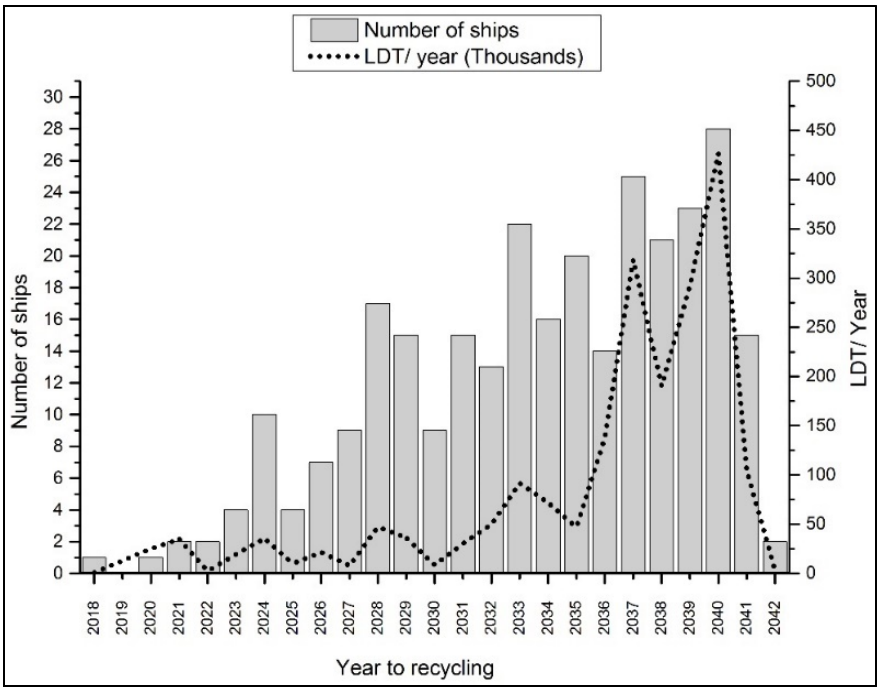

Figure 6: Number of ships and LDT per year available for recycling from Brazilian fleet (2018 - 2042)

Thus, the absolute amount of LDT - steel scrap for the 340 ships available for recycling were estimated in 2.35 million LDT. It is possible to note that the periods with the highest contributions in LDT are between 2033 and 2040 with a mean of 180.566 LDT in this time series. it is clear that between 2018 and 2042 the quantity of vessels exhibits semi-cyclical variations which may be linked to the technical and structural generations of each ship class.

The number of ships available to be recycled between 2018 and 2042 are shown in a multi-series graph by ship class (1), (2), (3) and (4) and its equivalent amount of LDT, as shown in Figure 6.

INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

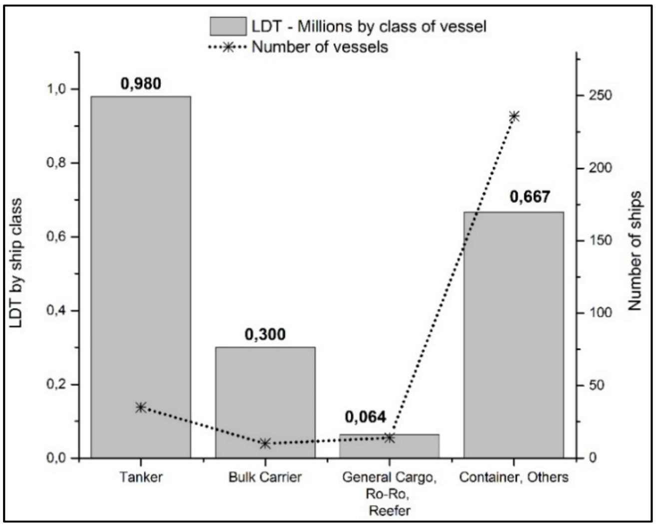

Figure 7: Estimation of LDT available for recycling from Brazilian fleet by ship´ class (2018 – 2042)

In order to calculate the market value of ships available for recycling from to Brazilian ship fleet, an average price for steel scrap quoted in the international market of $250/LDT was used (JAIN; PRUYN; HOPMAN, 2016; MIKELIS, 2018b). The price was considered due to its similarity with the export prices traded on Brazilian market (MDIC, 2016). As follows, the market value per year from 2018 to 2042 can be seen in the Figure 8.

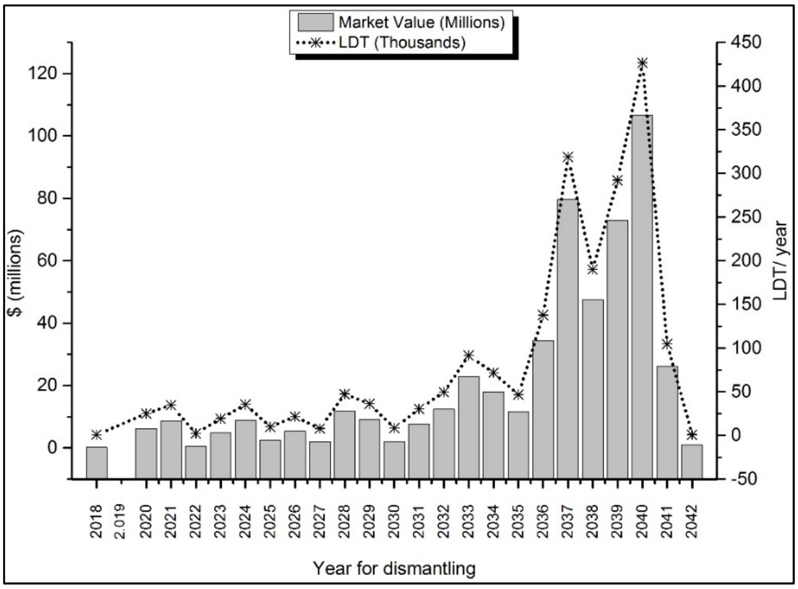

Figure 8: Estimation of market value of ship recycling market through Brazilian fleet

The total market value estimation corresponds to US$ 587.51 million taking account the 45 ships already available for recycling before 2018 and the other 295 ships overspread from 2018 to 2042.

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

When comparing the amount of steel scrap demanded by the domestic steel industries between 2014 and 2016 (Figure 8), and the potential steel scrap generation by implementation of ship recycling activity, is evident that the ship recycling yards will be obliged to look for foreign markets to export this material. This situation evidences the opportunity for Brazil to exploit scrap exports to Southeast Asian countries because they are currently in high demand for this type of material at competitive prices.

5.4. Ship recycling market estimation through Latin American fleet

In order to increase the representativeness of develop ship recycling activities in Brazilian shipyards, we extended the analysis to estimate the number of ships available for recycling to 10 neighbouring Latin American countries´ fleets. After applying the criterion selection descried in the methodology, we estimated an overall of 5,280 ships available for recycling. However, when considering the the 25-year life span since the construction´s date of each ship, we estimated ±4,303 vessels available to being recycled between 2018 to 2042. From total quantity, approximately 977 ships were already able to being recycled before 2018 due to their age. Figure 9 shows the number of ships available to being recycling from 2018 to 2042 and its equivalent in LDT/year.

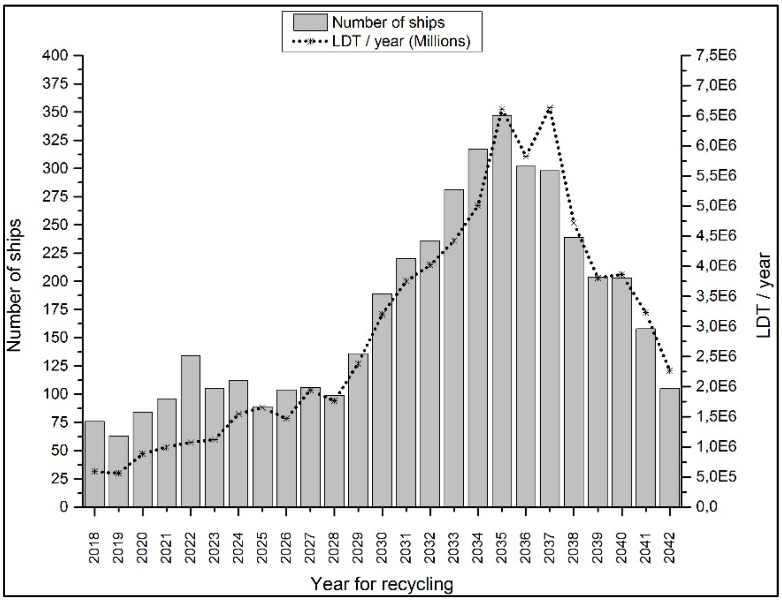

Figure 9 - Number of ships and LDT per year available for recycling from Latin American fleets (2018 – 2042)

Thus, the total amount of steel scrap available in LDT represented by the potential recycling market of Latin-American ship fleets, considering both series

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

mentioned above, is ±73,35 million LDT. A key consideration is that, these Latin American countries are closed of Brazilian shipyards and connected from Atlantic Ocean.

Figure 10 shows the volume of potentially retrievable steel scrap for each of the Latin American fleets that were selected for the analysis. The order of LDT contribution by country were: Panama (74.37%), Bahamas (22.9%) and Mexico (0.40%) and the others seven countries with (2.4%). Eventually, Panama, was the principal contributor (3,697 ships), follow by Bahamas (1,062 ships) and Mexico (160 ships) and other countries (361 ships), as shown in figure 8.

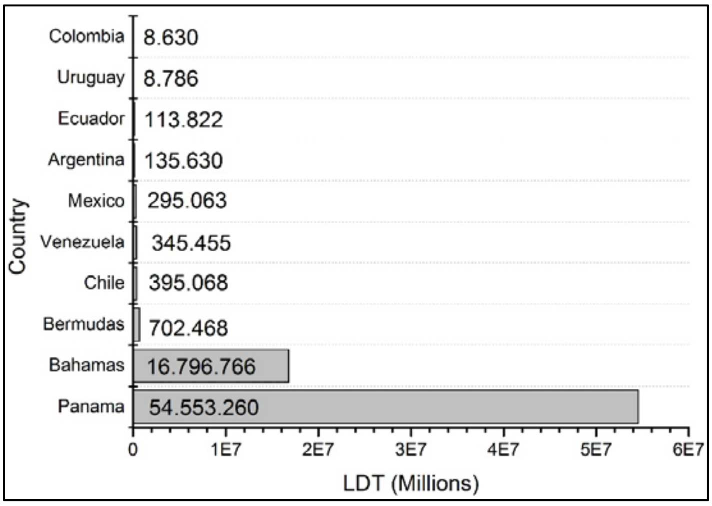

Figure 10: Estimation of LDT available to recycling through Latin American fleet by country

Figure 10 shows the number of ships available for recycling corresponding to the Latin American fleet between 2018 and 2042 grouped in the four ship classes.

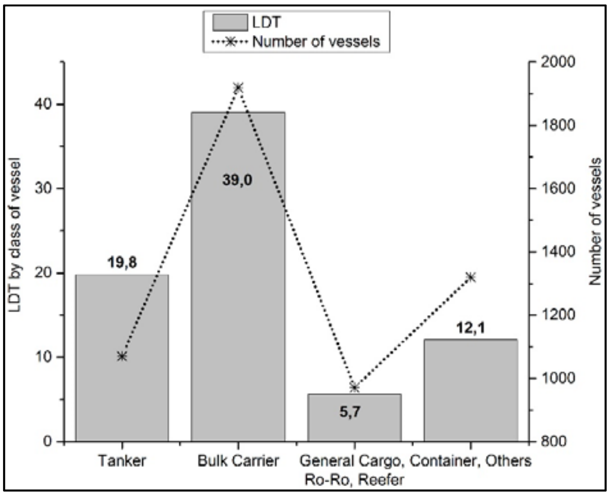

Figure 11: Estimation of LDT available for recycling from Latin American fleet by ship´ class (2018 – 2042)

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Figure 11 evidences the large participation of Bulk Carriers in LDT generation. In that way, Panamanian fleet represents more than 70% of the total number of ships available tor recycling with at least 55% of its ships between 10,000 and 50,000 DWT essentially corresponding to Bulk Carrier and General Cargo ships.

To calculate the market value of the ships available for recycling belonging to Latin-American fleets, we used the same price criteria for the LDT quotation in the international ship recycling market (±$250/LDT) (Jain, 2017; Mikelis, 2018b); so that, were possible to obtained a market value of US$19.94 billion. The following two figures show the market value per year from 2018 to 2042, figure 10 represents the market value for the two biggest fleets (Panama and Bahamas) and Figure 12 show the market value for the remaining fleets.

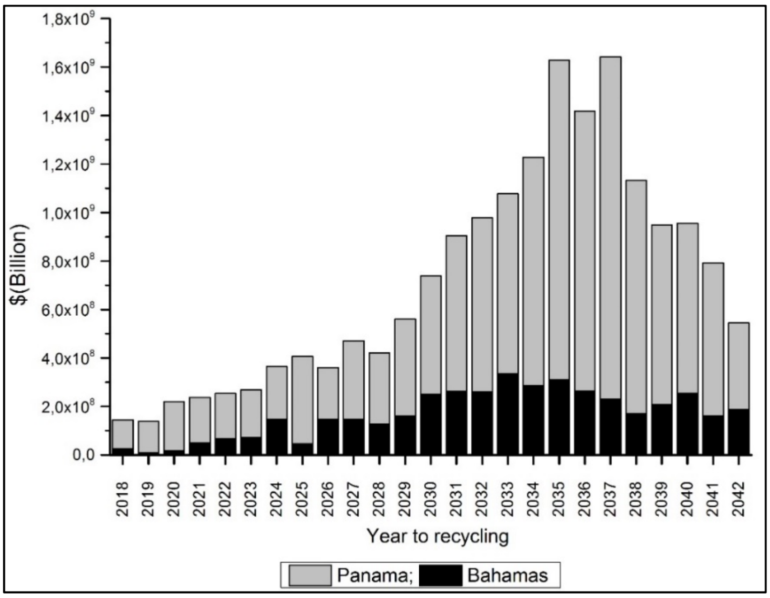

Figure 12: Estimation of market value of ship recycling through Panama and Bahamas ships´ fleet

Both Panama and Bahamas represent the largest demands of ship recycling in the series from 2018 to 2042. Their maximum values are between 2033 and 2040, representing annually more than $ 1 billion/year. The Figure 13 represents a general vision considering the other 8 countries selected from Latin America ship fleets for the analysis.

INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

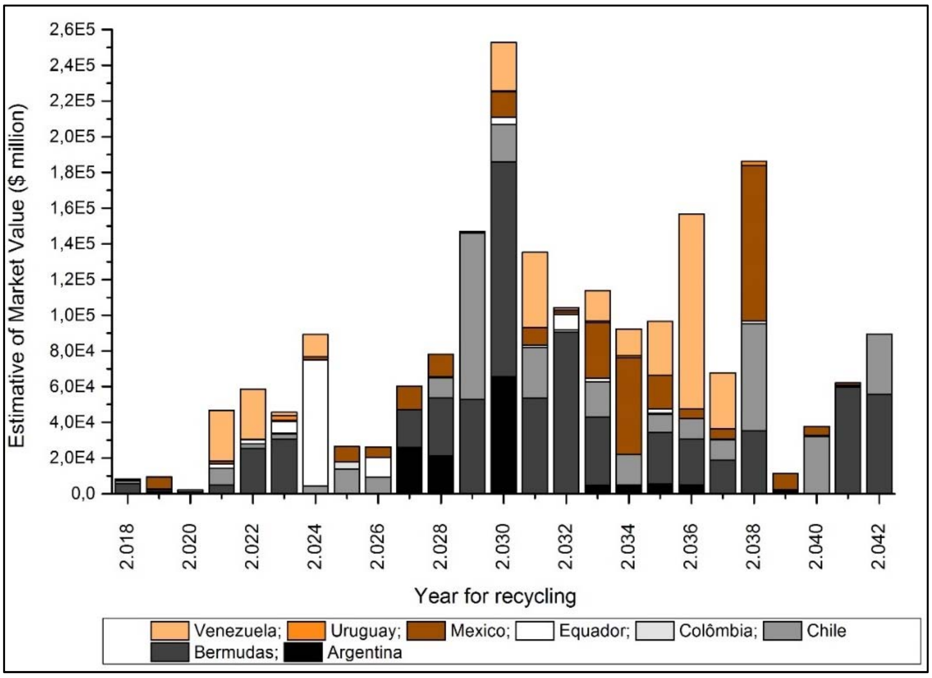

Figure 13: Estimation of market value of ship recycling through 8 Latin American ships´ fleet

Figure 13 shows that the market values do not represent a uniform series with tendency or seasonality, being notoriously scattered throughout the 25 years. Between 2027 and 2038 It showed a period with the greatest financial representativeness with its maximum in 2030. The disparity between the number of ships available for recycling each year and the elevated concentration in small and big portions are due to differences in size and contemporaneity of the ship fleets.

6. DISCUSSIONS

When analysing the variables (I) and (II) defined in the study problem, which are relate with the volume of steel production and the volume of steel scrap available in the domestic market cited in (4.1). The supply of steel scrap in Brazil does not serve the internal demand of this material as evidenced in Figure 3.

Figures 3 and 4 showed a deficit of steel scrap which is being demanded by the national steel and smelting industries. In the same order, Brazil exports steel scrap to different international destinations using similar prices, as practiced in the Asian and international market.

The Brazilian shipbuilding industry can articulate sectoral strategic plans with the council and the industry ministry to promote national steel scrap negotiations. This is to meet domestic and international demand for scrap involving all the commercial

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

groups participating in the local scrap supply chain. Many scrap industries in Brazil can participate of ship recycling activities and obtained a return in this operation. On the other hand, is necessary to clarify that the majority of the scrap to be extracted from ship recycling can be exported as laminated steel which is extensively used in the civil construction in the centre and southern Asia.

Another justification for the extraction of steel from ship recycling, relates to the quality of steel scrap to be used in the steel mills production process for the generation of high-quality products. According to (JANKE et al., 2000; PEREIRA et al., 2003) good quality scrap is free from undesirable materials that affect the characteristics of steel like a coatings and other mixed metals and that according to the type of blended metal can directly influence the ductility and deformability of the final steel (HAUPT et al., 2017).

After considering the total steel scrap available in Brazil in 2016, was observed that 54% corresponded to obsolete steel scrap, considered as the material with the highest impurities index (CGEE - MDIC, 2014; ALICE WEB, 2017; INSTITUTO AÇO BRASIL, 2017). In contrast, the steel processing industries of South Asia use ship´s steel scrap extensively in the re-laminating process due to its high purity and quality (SAHU, 2014; CHOI et al., 2016; DEVAULT et al., 2016).

This scenario described above allows us to infer that naval steel can guarantee the intrinsic characteristics of products to be manufactured and processed by the Brazilian steel and smelting industry. Then, there is a significant possibility of promoting the use of industrial steel scrap (Naval steel scrap from ship recycling) in the production process of the steelmakers, guaranteeing higher-quality steel and the reduction of operational costs related to yield, separation-classification and scrap purification.

When analysing the behaviour of the international trade balance of scrap between Brazil and other countries, as shown through variable (III). From 2007 to 2017, there was an average of 0.37 million tons/year of steel scrap exported, compared to 0.05 million tons/year imported in the same period. Therefore, Brazil is currently engaged in scrap exports, supported by the similarity of steel prices in the domestic and international markets.

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

In 2017 the index that compares the volume of steel scrap imports versus the internal scrap demand showed increments that allow inferring in the opening of export markets of steel scrap to other countries outside Brazil. Additionally, the index that compares the amount of steel scrap generated in Brazil compared with Brazilian scrap exports was 3.7%. Those indexes showed that even the local scrap market presented a deficit in steel scrap supply for local steel industries, several amounts of this material are exported to the international market.

On the other hand, when analysing the variable (IV) related to the volume of potentially recoverable steel scrap from ship fleets through the ship recycling activity, it was possible to identify that the implementation of ship recycling could provide significant volumes of steel scrap, especially leveraged by Latin American vessel fleets, as shown in Figures 7 and 8 respectively. The extraction of materials from the recycling activities of ships allows a high index of naval exploitation of steel (KNAPP et al., 2008; CHOI et al., 2016; JAIN, 2017; JAIN et al., 2017). Thus, the activity represents a market opportunity to be harnessed for the supply of scrap to the local steel and foundry industry, which can be leveraged by local shipyards.

In this line, the values presented in the Figure 7 (ship recycling market value for Brazilian ships´ fleets), and Figures 10 and 11 (ship recycling market value for Latin Americans´ fleets) showed a market with significant potential to exploring, in this manner, the high representativeness of other fleets of neighbouring ships was evident. Therefore, were estimated approximately 5,620 ships available for recycling from both Brazilian and Latin American ship fleet. This number of vessels corresponds to 78.912 million of LDT with a market value of US$ 20.52 billion.

The activities and operational flows commonly practiced in ship recycling process follow the reverse sequence of the shipbuilding process (ANDERSEN et al., 2001; KAISER, 2008; JAIN, 2017). However, the same author asserts that Asian shipyards use porticos and cranes with less capacity than those of other construction sites. In this line, (JAIN, 2017) argues that the average load capacity of cranes belonging to recycling yards in India is lower than others foreign shipyards. The crane represents the key mechanical structure limiting the displacement capacity daily from steel from the ship´s hull (pre-cut area) to the (post-cut) or sizing areas.

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Authors like (OVERGAARD et al., 2013) points out that the success of ship recycling activities is the technique applied to guarantee the decommissioning productivity. In this sense, the ship recycling yard is responsible for the appropriate design of the areas distribution of cutting and post-cutting phases allowing the best manoeuvres of the segments of the mega-structure, cutting and classification of the smaller parts (OVERGAARD, S. et al., 2013; HIREMATH et al., 2015; JAIN, 2017).

Yet, these aspects are recognized as elements that guarantee the productivity and success of recycling activities in Asia. Authors such as (HIREMATH et al., 2015) highlight that all operational aspects already mentioned, and highlight different variables that can be taken advantage of by the Brazilian shipyards as a key factor for the consolidation of productive and sustainable ship recycling activities.

Occasionally, Brazilian shipyards counts with steel processing capacity of ±900,000 tons - construction capacity - of which on average at least 91% are rendered useless. Those shipyards are highly mechanized and environmentally approved to develop ship recycling processes (BRASIL - MINISTÉRIO DO TRABALHO, 2013; OCAMPO, 2018). So that, we can infer that only serving the local fleet is not productively and economically viable to justify the implementation of ship recycling in local shipyards.

Therefore, it is necessary to consider the demand for recycling of other neighbouring fleets to carry out the activity of recycling of ships locally. On the other hand, Brazilian shipyards have appropriate facilities, consolidated process management and environmental licensing. Considering these points, we assumed the scenario in which the 19 Brazilian shipyards could participate in ship recycling activities. The technical capacity of the construction process is 100% usable and compatible with the recycling capacity of ships.

7. CONCLUSIONS

We conclude that less technical demands for ship recycling makes possible for the Brazilian shipyards to participate of this industry, because they count with infrastructural capacity to adapt their current processes of construction and repair to ship recycling activities. For this, they need to accomplish environmental and international ship recycling requirements.

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

While analysing the productivity scenario of steel mill and foundry industry in Brazil compared with the internal steel scrap demand, we identified the existence of an unsatisfied demand of steel scrap for the steel industry and local steel mills. However, it is necessary to specify that Brazil exports steel scrap to countries in South Asia. This market dynamic is supported by the common steel scrap prices practiced by Brazil and the Asian market besides the great demand of steel of the last countries.

It was evidenced that the obsolescence scrap is responsible for at least 50% of the total material supply for the Brazilian steel and smelting industry. It should be remembered that obsolescence scrap presents a series of secondary materials, alloys and impurities which influence its material quality and which demands a purification processes, representing an additional cost for the packaging of the material. Thus, naval steel has fewer treatments and secondary materials, in addition, most of its geometries are flat, presents itself as a promising scrap that would help to supply the presented scrap deficits.

The analysis of the economic value for the extractable steel scrap from both scenarios (Brazilian and Latin American fleets), showed an activity with significant potential market to be explored both together represents US$ 20,52 billion. Latin American fleets represents a business opportunity for Brazilian shipyards. Those fleets could contribute to the generation of revenues for the local shipyards thought ship recycling as an alternative activity. Therefore, a greater number of ships on the market year after year would increase the chances of shipyards ensure high occupancy and productivity of their assets.

The aspects already mentioned enables the articulation of plans for exportation of steel scrap from Brazil to foreign markets, thought the extraction of steel scrap locally by non-traditional ways, and meeting the local and foreign demand taking advantage from the price parity of this metal in the local and international market.

REFERENCES

ALICE WEB (2017) **Consultas**: Dados de importação e exportação por NBM - Brasil, Secretaria de Comerio Exterior; Ministério de Industria e Comercio. Available at: http://aliceweb.mdic.gov.br//index/home. (Accessed: September 11, 2017).

ANDERSEN, A. B. et al. (2001) **Technological and Economic Feasibility Study of Ship Scrapping in Europe**. Hovic, Norway. Available at: http://ec.europa.eu/environment/waste/ships/pdf/ship_scrapping_study_21feb01_1272.pdf.

BRANQUINHO, P.; SALOMÃO, E.; DUARTE, L. (2012) **A retomada da indústria naval brasileira**, BNDES - Biblioteca digital. Brasília. Available at: https://web.bndes.gov.br/bib/jspui/bitstream/1408/962/4/A retomada da indústria naval brasileira_final_P.pdf (Accessed: November 10, 2017).

BRASIL - Ministério do trabalho (2013) NR 34 - **Condições e meio ambiente de trabalho na indústria da construção e reparação naval**." RIo de Janeiro: Ministério do trabalho. Available at: http://trabalho.gov.br/images/Documentos/SST/NR/NR34/NR-34-2016.pdf.

CGEE - MDIC (2014) **Levantamento dos níveis de produção de aço e ferro-gusa, cenário em 2020, Modernização da produção de Carvão Vegetal**: Subsídios 2014 ao Plano de Siderurgia do MDIC, p. 1–63. Available at: http://www.cgee.org.br/eventos/arquivos/CarvaoVegetal-CGEE_NT-Producao_de_aco_e_gusa1.pdf.

CHOI, J. K. et al. (2016) Economic and environmental perspectives of end-of-life ship management, Resources, Conservation and Recycling. **Elsevier B.V.**, n. 107, p. 82–91. doi: 10.1016/j.resconrec.2015.12.007.

CHOUDHARY, G. K. (2011) **An analysis of the creation of a global ship recycling fund in the framework of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships**, 2009. World Maritime University. Available at: http://commons.wmu.se/all_dissertations Recommended.

CONFEDERAÇÃO NACIONAL DA INDÚSTRIA - CNI (2012) **A indústria do aço no Brasil**. Rio de Janeiro. Available at: http://www.acobrasil.org.br/site2015/downloads/livro_cni.pdf.

D'AVILA, A. P. F.; BRIDI, M. A. (2017) Indústria naval brasileira e a crise recente: o caso do Polo Naval e Offshore de Rio Grande (RS), **Cadernos Metrópole**, v. 19, n. 38, p. 249–268. doi: 10.1590/2236-9996.2017-3810.

DEMARIA, F. (2010) Shipbreaking at Alang-Sosiya (India): An ecological distribution conflict, Ecological Economics. **Elsevier B.V.**, v. 70, n. 2, p. 250–260. doi: 10.1016/j.ecolecon.2010.09.006.

DEVAULT, D. A.; BEILVERT, B.; WINTERTON, P. (2016) Ship breaking or scuttling? A review of environmental, economic and forensic issues for decision support, Environmental Science and Pollution Research. **Environmental Science and Pollution Research**, p. 1–34. doi: 10.1007/s11356-016-6925-5.

DINU, O.; ILIE, A. M. (2015) Maritime vessel obsolescence, life cycle cost and design service life, IOP Conference Series: **Materials Science and Engineering**, v. 95, n. 1. doi: 10.1088/1757-899X/95/1/012067.

ECORYS (2005) **The ship Recycling Found** - Financing environmentally sound scrapping and recycling of sea-going ships, Greenpeace.

EUROPEAN PARLAMIENT; EUROPEAN UNION COUNCIL (2013) **Regulation (EU) No 1257/2013 of the european parlamient and of the council of 20 November 2013**. European Parlamient & European Union Council (330/1). Available at: http://data.europa.eu/eli/reg/2013/1257/oj.

FREY, R. S. (2013a) **Breaking Ships in the World-System**: An Analysis of Two Ship Breaking Capitals , Alang India and Chittagong , Bangladesh, (May).

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

FREY, R. S. (2013b) Breaking Ships in the World-System: An Analysis of Two Ship Breaking Capitals, Alang- Sosiya, India and Chittagong, Bangladesh R. Scott Frey.” **Knoxville (13-01)**, v. 21, n. 1, p. 25–49. Available at: http://trace.tennessee.ed/utk_cssjpapers/2/.

Guedes, C. (2014) **Notas sobre a desconcentração regional da indústria de construção naval brasileira no princípio do século** XXI, Revista de Desenvolvimento Econômico – RDE, August, pp. 685–703.

HAUPT, M. et al. (2017) Influence of Input-Scrap Quality on the Environmental Impact of Secondary Steel Production, **Journal of Industrial Ecology**, v. 21, n. 2, p. 391–401. doi: 10.1111/jiec.12439.

HIREMATH, A. M.; PANDEY, S. K.; ASOLEKAR, S. R. (2015) Development of ship-specific recycling plan to improve health safety and environment in ship recycling yards, **Journal of Cleaner Production**. Elsevier Ltd, 116(February), p. 279–298. doi: 10.1016/j.jclepro.2016.01.006.

HIREMATH, A. M.; TILWANKAR, A. K.; ASOLEKAR, S. R. (2015) Significant steps in ship recycling vis-a-vis wastes generated in a cluster of yards in Alang : a case study, **Journal of Cleaner Production**. Elsevier Ltd, 87, p. 520–532. doi: 10.1016/j.jclepro.2014.09.031.

HOSSAIN, M.; ISLAM, M. (2006) **Ship Breaking Activities and its Impact on the Coastal Zone of Chittagong, Bangladesh**: Towards Sustainable Management, Ship breaking-towards sustainable development. Chittagong. Available at: http://www.shipbreakingbd.info/report/Ship Breaking Activities and its Impact on the.pdf.

IMO (2009a) **Convenção internacional de Hong Kong para a reciclagem segura e ambientalmente adequada de navios**, 2009, p. 1–41. Available at: http://observatorio.antaq.gov.br/wordpress/wp-content/uploads/2016/12/conv_internacional_sr-2009-hong-kong.pdf.

IMO (2009b) **Hong Kong International Convention for the safe and Environmentally Sound Recycling of Ships**, 2009. Available at: http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/Default.aspx.

INSTITUTO AÇO BRASIL (2017) **Anuário estatístico - setor siderurgico 2017**. RIo de Janeiro - RJ. Available at: www.acobrasil.org.br.

JAIN, K. P. (2017) **Improving the Competitiveness of Green Ship Recycling, Delft University of Technology**. Delft University of Technology. doi: ISBN 978-94-6299-657-1.

JAIN, K. P.; PRUYN, J. F. J.; HOPMAN, J. J. (2016) Quantitative assessment of material composition of end-of-life ships using onboard documentation, Resources, **Conservation and Recycling. Elsevier B.V.**, n. 107, p. 1–9. doi: 10.1016/j.resconrec.2015.11.017.

JAIN, K. P.; PRUYN, J. F. J.; HOPMAN, J. J. (2017) Material flow analysis (MFA) as a tool to improve ship recycling, **Ocean Engineering. Elsevier**, n. 130 (October 2015), p. 674–683. doi: 10.1016/j.oceaneng.2016.11.036.

JANKE, D. et al. (2000) Scrap-Based Steel Production and Recycling of Steel, **Materiali in Tehnologije**, v. 34, n. 6, p. 387–399.

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

KAISER, M. J. (2008) **A Review of Ship Breaking and Rig Scrapping in the Gulf of Mexico**, p. 178–199. doi: 10.1080/00908320802013701.

KAISER, M. J.; BYRD, R. C. (2005) The non-explosive removal market in the Gulf of Mexico, **Ocean & Coastal Management**, n. 48, p. 525–570. doi: 10.1016/j.ocecoaman.2005.03.012.

KARLIS, T.; POLEMIS, D.; GEORGAKIS, A. (2016) Ship demolition activity . An evaluation of the effect of currency exchange rates on ship scrap values., **Journal of Economics and Business**, v. 66, n. 3, p. 53–70.

KNAPP, S.; KUMAR, S. N.; REMIJN, A. B. (2008) Econometric analysis of the ship demolition market, **Marine Policy**, v. 32, n. 6, p. 1023–1036. doi: 10.1016/j.marpol.2008.02.004.

KNAPP, S.; KUMAR, S.; REMIJN, B. (2007) **The Ship Recycling Conundrum : An Econometric Analysis of Market Dynamics and Industry Trends**, Econometric Institute Report, 2007–52, p. 1–22.

MIKELIS, N. (2018a) **What Will 2018 Bring to the Ship Recycling Industry?**, The Maritie Executive. Available at: https://www.maritime-executive.com/editorials/what-will-2018-bring-to-the-ship-recycling-industry#gs.QCuEqGI (Accessed: August 4, 2018).

MIKELIS, N. (2018b) **What Will 2018 Bring to the Ship Recycling Industry?** Available at: https://www.maritime-executive.com/editorials/what-will-2018-bring-to-the-ship-recycling-industry#gs.QCuEqGI (Accessed: January 6, 2018).

MINISTÉRIO DA INDÚSTRIA COMERCIO EXTERIOR E SERVIÇOS - MDIC. (2016) **Principais Produtos Exportados**: Desperdícios e resíduos de ferro ou aço, COMEX VIS: Visualizações de comércio exterior. Available at: http://www.mdic.gov.br/comercio-exterior/estatisticas-de-comercio-exterior/comex-vis/frame-ppe?ppe=1139 (Accessed: December 20, 2017).

MINISTÉRIO DE MINAS E ENERGIA (MME) (2015) **Anuário Estatístico do Setor Metalúrgico - 2015**. Available at: http://www.mme.gov.br/documents/1138775/1732813/Annuário+Estatístico+do+Setor+Metalúrgico+2015.pdf/3cd2fe18-4daa-4e51-8899-53f0cba47573.

MINISTÉRIO DOS TRANSPORTES, P. E A. – A. DE C. (2017) **Fundo de Marinha Mercante disponibilizará R$ 1,6 bilhão para indústria naval**, 28/08/2017. Available at: http://sinaval.org.br/2017/08/fundo-de-marinha-mercante-disponibilizara-r-16-bilhao-para-industria-naval/ (Accessed: July 1, 2018).

NGO SHIPBREAKING PLATFORM (2016) **Annual Lists of Scrapped Ships, List of all ships dismantled worldwide in 2015** (February 2016). Available at: http://www.shipbreakingplatform.org/annual-lists-of-scrapped-ships/ (Accessed: September 10, 2016).

NOGUEIRA T, J. C. (2013) **Obtenção, mercado e reciclagem de sucatas na indústria siderúrgica brasileira**. Rio de Janeiro, 2013. Available at: http://monografias.poli.ufrj.br/monografias/monopoli10010007.pdf.

OCAMPO, E. S. (2018) **Análise quali - quantitativa do mercado de reciclagem de navios**. Universidade Federal Fluminense.

OLIVEIRA, G. (2014) **Painel de indicadores setoriais para o comércio atacadista**

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

de sucata ferrosa. São Paulo, 2014. Available at: http://www.inesfa.org.br/.

OSHA, O. SAFETY AND HEALTH ADMINISTRATION (2010) **Safe Work Practices for Shipbreaking - OSHA 3375-03**. (Occupational Safety andHealthAct). Available at: https://www.osha.gov/Publications/3375shipbreaking.pdf.

OVERGAARD, S. et al. (2013) **Feasibility Study for Environmentally Sound Ship Dismantling**. Available at: www.basel.int/Portals/4/do%0Awnload.aspx?d=UNEP-CHWSHIPS-WHITEP2013ShipDismantlingStudy.%0AEnglish.pdf.

PEREIRA MACHADO, M. L.; MARQUES SOBRINHO, V. P.; ARRIVABENE, L. F. (2003) **Siderurgia Para Não Siderurgistas**. I. Vitoria -ES: Centro Federal de Educaçao Tecnológica do Estado do Espírito Santo.

PEREIRA, N. (2017) **Negócio para estaleiros brasileiros ?**” RIo de Janeiro - RJ: Marinetec South America, pp. 30–32.

PEREIRA, R.; TEIXEIRA, D. (2017) **Em colapso, indústria naval já demitiu quase 50 mil e tem dívida bilionária**, Estadão - Economia & negócios. Available at: http://economia.estadao.com.br/noticias/geral,em-colapso-industria-naval-ja-demitiu-quase-50-mil-e-tem-divida-bilionaria,70001817157 (Accessed: March 8, 2018).

PORTAL NAVAL (2017) **Principais Estaleiros do brasil - informações técnicas**. Available at: http://www.portalnaval.com.br/estaleiros/estaleiros-brasil/ (Accessed: April 14, 2018).

PRIYA J.; K.; PRUYN, J. F. J.; HOPMAN, J. J. (2016) Improving ship design process to enhance ship recycling, in **The 3rd International Conference on Maritime Technology and Engineering**, p. 663–671. doi: 10.1201/b21890-86.

SAHU, G. (2014) **Workers of Alang-Sosiya A Survey of Working Conditions in a Ship-Breaking Yard, 1983-2013**, Economic & Political Weekly, xIIX(50), pp. 52–59. Available at: http://www.epw.in/system/files/pdf/2014_49/50/Workers_of_AlangSosiya.pdf.

SECRETARIAT OF THE BASEL CONVENTION (1989) **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal Adopted by the Conference of the Plenipotentiaries on 22 March 1989**. Basel.

SINAVAL (2015a) **Cenário da Construção Naval - Balanço de 2015**. Rio de Janeiro - RJ. Available at: http://sinaval.org.br/wp-content/uploads/Cenário-da-Construção-naval-Balanço-de-2015-17-12.pdf.

SINAVAL (2015b) **Cenário da Construção Naval Brasileira - Balanço**, perspectivas e defesa do setor (Reunião com a Bancada Federal), Balanço perspectivas e defesa do setor - Reunião com a Bancada Federal. Edited by A. Rocha. Brasília: SINAVAL, pp. 1–67.

SINAVAL - SINDICATO NACIONAL DA IINDÚSTRIA DA CONSTRUÇÃO E REPARAÇÃO NAVAL E OFFSHORE (2016) **Cenário da construção naval – 1º Semestre de 2016**. Rio de Janeiro – RJ. Available at: http://sinaval.org.br/wp-content/uploads/Sinaval-Cenário-da-Construção-naval-1-Semestre-2016-27-7-16.pdf.

SINDAMAR (2017) **Unificar - Revista do Sindicato Nacional dos Ociciais da Marinha Mercante**, Desafios e oportunidades para a reciclagem de embarcações -

http://www.ijmp.jor.br v. 10, n. 6, November - December 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i6.1004

Junho 2017, pp. 59, 60, 61.

STOPFORD, M. (2003) **Maritime Economics** - second edition. Second. Edited by Taylor & Francis e-Library. New york: Routledg.

UNEP (2003) **Technical Guidelines for the Environmentally Sound Management of the Full and Partial Dismantling of Ships**. Suecia.

WORLD BANK (2010) **The ship breaking and recycling industry in Bangladesh and Pakistan (English)**. Washington DC. Available at: http://documents.worldbank.org/curated/en/872281468114238957/The-ship-breaking-and-recycling-industry-in-Bangladesh-and-Pakistan.

YUJUICO, E. (2014) **Demandeur pays**: The EU and funding improvements in South Asian ship recycling practices, Transportation Research Part A: Policy and Practice. Elsevier Ltd, 67, p. 340–351. doi: 10.1016/j.tra.2014.07.015.