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Shipbuilding Industry in Brazil, 100 Years (1960-2060)

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Summary

This work is the summary of an undergoing research effort as part of the "Blue Industry Collection", available at www.industrianaval.com.ar. It is structured into three parts: Industry, Policies and Future, in order to analyze the span of the century 1960-2060 (sixty past years and forty projected).
"Industry" chapter describes historical stages, analyses competitive factors and the evolution per market segment, using "Value and Employment generated" as uniform comparison criteria,
The "Policies" part discusses incentives in relation to customary international practices, carrying out the pertinent comparisons. In studying the roles of the State, the analyses focus on those of the Shipowner and Regulator with a critical view on protection, financing and local-content measures.
But it is in "Future" where the most significant contributions are made. The section opens with the presentation of a strategic vision, which moves on to a qualitative and quantitative projections for demand up to 2060 for the four sectors (offshore, military, merchant and export) in a new industrial phase named the "Exporting" stage, on the basis of the proposed strategic focus. Impacts are analyzed as regard capacity, employment, financing and sectorial risk.
It ends with a Numerical Summary of some key performing parameters and the list of the abundant Bibliographic References.

1. Introduction

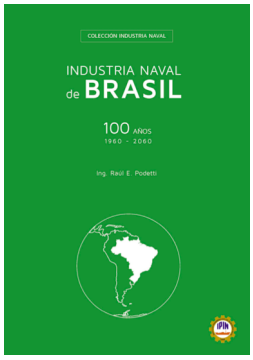
Shipbuilding is extensive and can be divided in three axes: according to service, into Construction or Repairs; according to size of vessel, into Heavy or Light; and according to position on the industry chain, into Shipyards or Parts Suppliers.
The focus of this work is on Heavy Construction from the Shipyards' point of view.
One hundred years is the span analyzed in this work. In order to make the most of the potency enfolded in historical experience, we go back sixty years, to 1960, when the measures included in the Goals Plan, which fostered the modern phase of the Brazilian shipbuilding industry, began to take shape. But in addition, and so as to cover the timeframe in which the sectorial policies proposed herein can consolidate and yield results, forty years are projected into the future, until 2060.
To conclude this introduction, I will share a personal anecdote that came to mind during this research. Years ago, during the Brazilian shipbuilding boom (and downsizing of argentine industry), I recall that an advanced naval architecture student in Buenos Aires asked me,

- "Professor, which matter of study will be most helpful in my professional future?"

To which I remember that I pragmatically replied,

- "Portuguese language."

As the President of SOBENA wrote in the Preface of the coming book on this subject, I have the benefit to be Argentinian and that permits me to have an impartial objective view of the evolution of this magnificent industry that I admire very much.



2. Industry

2.1. History of Shipbuilding in Brazil

As mentioned in (Barat, 2013 and CEMBRA/ SINAVAL 2017) the first records of ship construction activity in Brazil indicate that in 1531 a small shipyard existed on Guanabara Bay, were the Rio de Janeiro Yacht Club now stands. In 1662, the galleon *Padre Eterno* was built on *Ilha do Governador*, being sent to Portugal; it was regarded as one of the world's largest shipbuilding undertakings.
Five naval arsenals were built and the one featuring the greatest development was *Arsenal de*

Marinha do Rio de Janeiro (AMRJ), founded in 1763, which launched its first steam vessel in 1843 and which in 1867 employed 2,300 people; nevertheless, within a few years almost all Brazilian shipbuilding activity ceased.

Campos Neto (2013) and other references are used to develop the following historical stages.

A **Merchant Stage** started in the 50`s when *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES) and the *Fundo da Marinha Mercante* (FMM) were to finance merchant shipbuilding development. The industrialization process was launched by President Kubitscheck with his *Plano de Metas*.

The combination of protectionist policies (Cargo Preferences, 1969), available funds (- FMM) and the very powerful *Superintendência Nacional da Marinha Mercante* (SUNAMAN) enabled the setting up and development of the Emergency Plans (1969-70), PCN1 (1971-74) and PCN2 (1974-79), which established fleet increase goals. In order to boost financing, charges were raised and the *Adicional ao Frete para Renovação da Marinha Mercante* (AFRMM) created. All of this generated a great development up to 1979, albeit with excessive government intervention.

In 1980, in the midst of great inflation and economic problems, SUNAMAN fell into crisis because of management problems, financial difficulties and allegations of corruption due to the organization's excessive power and lack of adequate oversight. It was also charged that technical criteria had been replaced by political ones and that the only consideration was the shipyards' convenience, without the existence of competitiveness improvement goals. This combination generated great discredit for the shipbuilding sector.

The world economic crisis and large global transformations in the maritime transport business cut back demand for merchant ships in all countries, including Brazil. In 1990 President Collor de Melo instituted a policy of deregulation of the shipping sector, opening up traffic to foreign vessels without palliatives, which led the shipbuilding industry to virtually nil levels towards the end of the twentieth century.

An **Oil-Oriented Stage** started in 1997 when the Petroleum Law opened up the exploration and refining market, which accelerated offshore expansion. In 1999 Petrobras launched the plan for the construction of support vessels, POFERAM 1, followed by successive stages in 2003 and 2008. In November 2000, the *Navega Brasil* Program improved naval credit lines expanding the FMM's participation to 90%, from 85%, and expanding the term to 20 years, from 15.

Concurrently with the saturation of international shipyards, there was a major change in Petrobras' purchasing policy, reflected in two ways: On one hand, *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* (ANP) adopted criteria that demanded a higher percentage of Local Content (LC%) of 39% for exploration and 53% for production. On the other, *Programa de Mobilização da Indústria Nacional de Petróleo e Gás Natural* (PROMINP), launched in 2003, pursued the objective of using hydrocarbons production to generate employment and industrial growth.

The combination of the price of oil, the positive results of four decades of exploration, and the discovery of the pre-salt layer spurred Petrobras to order a series of offshore production systems, with deliveries between 2004 and 2019 and high LC% demands, which in the later years were gradually rendered more flexible.

In 2005, Transpetro, a Petrobras subsidiary, launched the *Programa de Modernização e Expansão da Frota da Transpetro* (PROMEF), with 65% to 70% LC, for the construction of oil and natural gas tankers.

In 2008, access to financing was facilitated by the creation of a Shipbuilding Industry Guarantee Fund (FGIN), and Petrobras launched the EBN program to promote the emergence of Brazilian ship operators, offering them long-term contracts.

The year 2011 saw the launching of a program for 29 drilling rigs (23 ships and 6 platforms) with 60%LC – carried out by Sete Brasil, with Petrobras shareholding – which never materialized.

Starting in 2015, a series of situations negatively affected shipbuilding development. Among them, the collapse in the price of oil, Petrobras' economic and financial crisis, the changes in economic policy, and the effect of the *Lava Jato* which implicated very high officials of Petrobras, Transpetro and Sete Brasil, the principal promoters of Brazilian shipbuilding demand, in cases of corruption.

The reduction in shipyard activity in the offshore area was minimally offset by demand by the military sector. In 2009 the Navy launched the ambitious *Programa de Desenvolvimento de Submarinos* (PROSUB) program consisting in the construction of a shipyard, a navy base and five submarines (4 conventional and one nuclear). In March 2020 a 2,200 MMUsd contract was signed for four Meko-class frigates to be delivered in 2025 - 2028, generating 2000 jobs and 30% to 40%LC.

2.2. Competitiveness of Shipbuilding in Brazil

In general terms, the competitiveness of a country's shipbuilding industry is defined as its capacity to produce at international levels of cost,

delivery times and quality. Some key aspects are discussed as follows (COPP/UFRJ, 2005 and Das Dores, 2013 and other references).

Productivity: The most customary index for measuring this (for sizable ships) is the amount of Compensated Gross Tonnage (CGT) produced in relation of the unit of Man-Hours (MH) worked. The best levels at Brazilian yards, prior to the crisis of the 1990s, were of the order of 65 MH/CGT and the average stood at 85, while Korean shipyards stood (1992) at 45.

Learning curve: This industry is characterized by a slow product innovation, so that advantages are achieved via continuous process improvements over the course of time, through learning. The concept of "continuity" needs to be stressed, for the positive effects of the learning to be really effective. In the cases of Korea and Japan, their current very high levels of productivity are mainly due to thirty years of continuous shipbuilding activity. In the case of Brazil, it has never managed to maintain continuity for more than 15 years.

The improvement depends on the position of shipyards on their learning curve. Brazil stood (2012) with a factor of 85%. This means that for every doubling of cumulative production, the improvement in productivity would be of 15% in terms of MH/CGT. For comparison purposes, the Asian countries that are most advanced on the curve stand at a factor of 70%.

Labor cost: This unit cost emerges from the combination of physical productivity (CGT/MH, for example) and the unit cost of the hours worked.

The labor cost at a Brazilian yard, working regularly in a continuous manner in the 1985-1996 period was of between 40% and 60% of the Japanese cost and between 50% and 70% of Korea's.

Total costs: An analysis dated 1999 shows that total costs in Brazil for local yards were 40% higher than the best international ones, but were only 5% above international ones as regards their export, by reason of the lower applicable taxes and lower demands for the use of local marine parts which were more expensive. Labor costs in Brazil were less than half but equipment more expensive.

Studies in 2013 show that the price of steel accounts for 20%/30% of the cost and that Brazil has been efficient as regards that output. Labor represents between 15% and 20% of the cost of ships, and equipment is 30% to 50% of cost.

Repetitive production/specialization: Shipyards achieve higher competitiveness when they carry out repetitive construction. However, that ideal circumstance is the least common one. A study of Japan, carried out by Society of Naval Architects and Marine Engineers (SNAME) in 2003, indicates that one third of construction in recent years was constituted by one-off projects, 76% were projects with fewer than 4 repetitions, and fewer than 15% topped 7 equal units. Brazilian yards have begun to specialize but without sufficient repetitions.

A case of succes (Botter, 2018) is the yard Wilson & Sons that expanded, investing in technology to specialize in the Offshore Support Vessels niche.

Delivery times: The average delivery times of Brazil's 5 largest shipyards between the years 1983 and 1996 was of 68 months, but that period was marked by several crises with production discontinuities. The case of Ishibras, between 1990 and 1994, is more realistic since it operated in a continuous manner on a series of eight Suezmax oil tankers for export with an average delivery time of 82 weeks, which can stand comparison with timeframes in Korea (27 weeks) and Europe (66 weeks). That was the Brazilian best performance.

2.3. Evolution. Value -Employment criteria.

Given the variety of shipyards, and types of ships produced by the Brazilian yards, it is necessary to find suitable variables that will allow an analysis of the evolution of the activity as a whole, independently of those great differences. This difficulty in the analysis was already broached in the literature when the attempt was made to update statistics as production began on offshore systems to which the GT measure cannot be applied, although it was indeed appropriate for the merchant ships previously produced. Therefore the statistical correlation with jobs generated had been lost, and the literature posed the need for a better unit of measure. This is evident by comparing these charts.

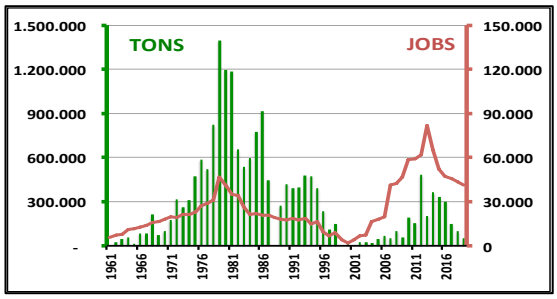


Figure 1 – Shipbuilding in Brazil: Jobs and Tonnage

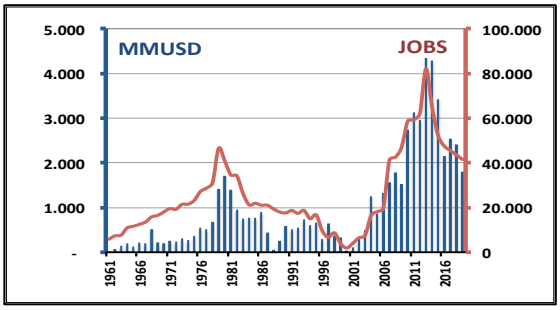


Figure 2 – Shipbuilding in Brazil: Jobs and Value

Figure 1 is the one customarily used in the bibliography to show the development of shipbuilding industry in Brazil, in which it is seen that during the Merchant Stage a good correlation exists between Employment and Tonnage, but that then, in the Oil-Oriented Stage (1997/2019), the relationship is lost.

In order to solve this difficulty, in Figure 2 Tonnage was replaced by Value produced, employing the criterion defined at Podetti (2018), and which in the case of the Argentine shipbuilding industry showed that a strong correlation existed.

It was therefore decided to employ the criteria of Value and Employment generated at shipyards in Brazil and to create the first full database of main Brazilian newbuildings. An archeological work was undertaken that identified the 1,250 largest vessels that built in Brazil over the last sixty years and that account for 98% of the total value produced.

The **Value** criterion employed doesn't seek to represent the real "price" of the commercial transaction between shipyard and shipowner, which not only is hard to locate and seldom trustworthy, but that in addition often depends on circumstantial factors. Nor does it seek to establish the "historical value" of the transaction in terms of prices at the time, which would require much adjustment. Lastly, neither does it attempt to identify the "added value" of the shipyard or of the country, subtracting the imported component from it. This Value criterion simply seeks to be representative of the "value of ship" received by the owner as if that delivery (or that of an similar current ship) were made in the last few years, disregarding the market's cyclic variations. It is thus attempted to prioritize ease of interpretation and the possibility of employing it in comparative analysis, beyond historical or commercial exactness, which aren't this work's goals.

The **Employment** criterion used seeks to represent the number of personnel working at the shipyards to produce the vessels considered. This includes both those employed directly (welders, mechanics, painters, etc.) and also those who carry out other naval tasks not related to the construction projects evaluated (ie, ship repairs). As with the above-mentioned criterion, priority is given here to ease of interpretation and possibility of comparisons, above exactness, in this case also taking advantage of the very good statistical information available.

Having made these necessary clarifications, the analysis is divided into five sectors of activities:

- Military vessels
- Cargo and port services ships
- Oil tankers
- Ships for offshore operations support
- Offshore production ships and systems

Military Vessels. This information is based on Câmara (2011) rounded out with additional data on later projects and author´s estimates.

It should be stressed that the State-owned shipyard AMRJ delivered only 38% of the units, and that those were of relatively smaller displacement, but of higher power and unit value.

Cargo and Port Services Ships. In this segment, a total of 852 units delivered between 1960 and 2019 were identified, which were valued at 23,429 million US dollars (27.4 million $/u), the immense majority of which (596 u, 22,478 million dollars, 37.7 million $/u) were merchant vessels and the remainder for port support operations (256 u, 951 million dollars, 3.7 million $/u).

To estimate the value of the merchant vessels, governmental data for the 1980s and 90s were used (GEIPOT, 1999, p.131) and for the oil tankers contracted as of 2005 under PROMEF. For these values, a regression analysis was performed ($/GT vs GT thousands), which leads to a sufficiently appropriate equation for these purposes (R^2= 0.805), one which was used for the individual evaluations. The data for the port services craft (PROFERAM) emerge from the information indicated by Campos Neto (2013).

Tankers (Oil-Oriented Stage – PROMEF). The production of oil tankers for Fronape and for export in the Oil-Oriented Stage has been included in the previous group; indicated here, therefore, is Transpetro's demand via PROMEF exclusively.

Between the two stages of the program, 41 craft were ordered, of which a total of 27 were delivered between the years 2011 and 2019, these units representing 2.5 million GT and being valued at 2,305 million US dollars (85.4 million $/u).

Maritime Support Ships. Foreseeing the needs of the offshore operations that were projected and underway, as of 1999 Petrobras launched a series of PROFERAM plans. In each of these, it defined the type and number of vessels it would contract under time charters (medium to long-term duration) from ship owners that in turn had to negotiate with the shipyards and BNDES. The first 19 units contracted in 1999 were already in operation by 2002. The 58 units contracted in 2004 were likewise delivered on time. The third plan included 148 additional vessels (64 AHTS, 64 PSV and 18 ORSV, among others) which had to have an LC higher than 75%. This plan was divided into seven successive sub plans between 2004 and 2014. Of 246u contracted under all the PROFERAM, 240 had been delivered by 2019 for a value of 8,587 million US dollars (35.8 million $/u).

Offshore Production Systems. Demand ensuing from the results of offshore exploration carried out since 1970, combined with domestic development

policies, led to a Brazilian shipbuilding industry of large magnitude. The discovery of the super-giant pre-salt reservoirs in 2007 generated even greater enthusiasm. Petrobras came to represent 22% of world offshore production in deep waters. All this generated great demand for offshore production systems at Brazilian shipyards, but owing to some lateness in deliveries, as of 2013 Petrobras had to shift some of these commissions (in part or in whole) to foreign shipyards. In many cases, Petrobras separated the manufacture of hulls from that of the modules and their integration, with the result that it is estimated that orders from local shipyards represented 58% of total investment in this gigantic equipment.

The 29 offshore production units delivered from 2004 to 2019 represented some 20,342 million dollars for Brazilian industry (701 million $/u).

Adding the information developed above for each of the sectors leads to the summary of Value produced that is presented in the following Table 1

Table 1 – Units and Value built in Brazil

	QUANTITY		VALUES		
	UNITS	%	MMusd	%	MMusd/u
MILITARY	101	8%	4.602	8%	46
CARGO AND PORT	852	68%	23.429	40%	27
TANKERS PROMEF	27	2%	2.305	4%	85
MARIT SUPPORT	240	19%	8.587	14%	36
OFFSHORE PROD.	29	2%	20.342	34%	701
TOTAL	1.249		59.265		47

Regarding the Value generated, this analysis concludes that merchant and port vessels accounted for the greater number of units (852 u, 68%) and the most value (23,429 million dollars, 40%). Nevertheless, offshore production systems, albeit accounting for only 2% of units (29), represent, by virtue of their high average unit value (701 million $/u), 34% of the value produced.

The Employment generated within the shipyards emerges from the information provided by *Sindicato Nacional da Indústria da Construção e Reparação Naval e Offshore* (SINAVAL) and the estimates made by the author.

Another estimate made by the author refers to the value of production and the employment generated at the new ICB submarines shipyard, which is to generate 9,000 jobs over 10 years for the 5 submarines, with a total value of 4.4 billion dollars (550 million dollars per conventional sub and 2.2 billion dollars for the nuclear vessel). It has been estimated that 33% of the jobs and 27% of the value have been generated, which in this analysis have been placed between the years 2018 and 2019, as if referring to deliveries (Rocha, 2011)

Previous Figure 2 shows the evolution of Employment and of Value generated annually, confirming the good correlation between these variables, and spotlighting the record for production in the year 2013, with a value of 4,681 million dollars and 82,000 jobs at the shipyards.

Seen in the chart (Figure 3) are the estimates for the values of the ships financed by FMM and the actual data on FMM disbursements for those ships in 1996-2016. Military and Offshore Production vessels, which aren't covered by that source are excluded. The ratio of FMM contributions to total Value is of 90.5%, almost coinciding with the percentage financed by the FMM, confirming the sufficient correctness of the method employed.

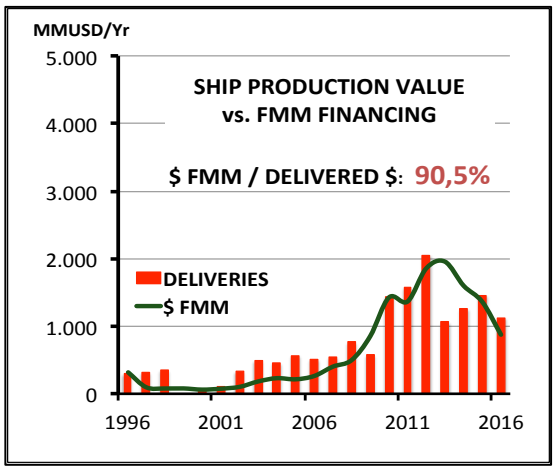


Figure 3 – Ships Value Delivered versus FMM Resources

Employment/Value Ratio. This ratio of jobs per million dollars (Figure 4) is an indicator of productivity, which went from an average value of 38, over the entire period, to one of 21 in the present century.

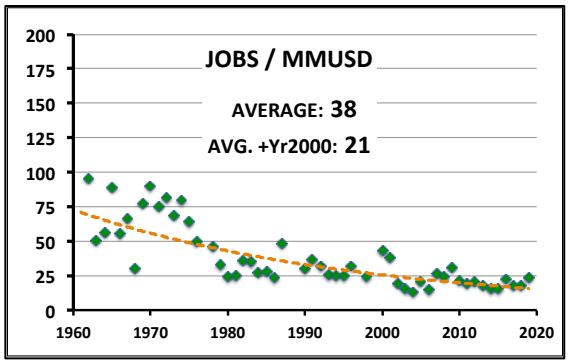


Figure 4 – Jobs/Value Relationship in Brazilian Shipyards

In other countries these ratios are of the same magnitude, as seen in diverse studies (GEIPOT, 1999, p.16) and it also agrees with the case of South America's principal Pacific shipyards

(Podetti, 2018, p.62). These numeric agreements provide confirmation not only of this ratio but also of the value estimates used, since the employment data originate in SINAVAL's annual statistics.

Values per segment The following charts (Figures 5 and 6) show the value of the deliveries, separated by segment. First one shows the Value of the Oil & Gas driven demand and next one shows the rest, mainly formed by military and merchant/port demand.

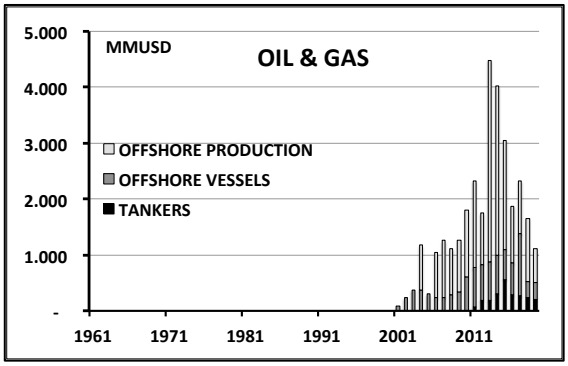


Figure 5 –Value of Ships built in Brazil - Oil & Gas

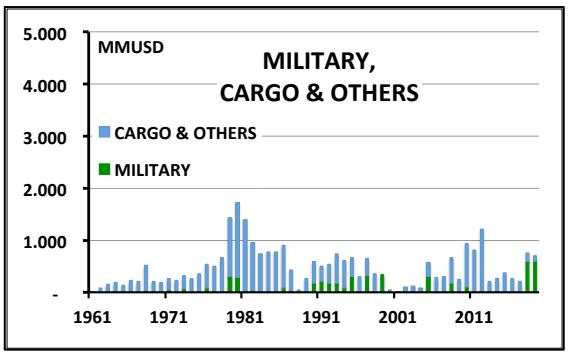


Figure 6 –Value of Ships built in Brazil - Navy, Cargo, etc.

Quantities and Unit Values. The following bar charts (Figure 7) show the number of units delivered for each segment and their corresponding unit values, it being noticed that cargo ships represent a large number of units of lesser value while the opposite is the case with offshore production systems.

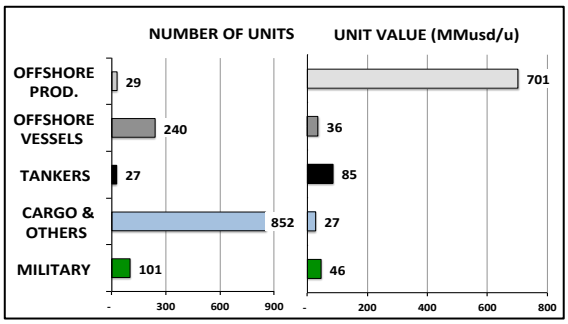


Figure 7 – Quantity and Unit value of Ships built in Brazil

Exports. The Brazilian model was one that did not promote exports or participation in international trade. Nevertheless, a significant share of output during the Merchant Stage was exported. Between 1974/1996 70 ships were contracted for export, representing 5.5 million GT, and 4,662 million dollars. Verolme and Ishibras were the main exporters with 92% of the total (GEIPOT, 1999)

3. Policy

3.1. Global Context

In the first decade of the new century Brazil had an average of 1% of world orders, reaching 2% in 2012 (in number of units) while more than 60% was retained by the three Asian leaders.

In addition, countries specialized ever further in order to gain in competitiveness. Large cargo vessels are concentrated in China, Korea and Japan while Singapore leads the Offshore market.

With regard to the participation of Brazilian-flagged ships at global level the SCH Report indicated that Brazil possessed 290 units (0.5% worldwide) which represented 0.2% of worldwide tonnage.

Relative Importance of Shipbuilding in GDP. The comparison (Podetti, 2018, p.172) of the relative importance of shipbuilding industries in the economies of several countries, updated for this case, shows (Figure 8) that during the Merchant Stage, Brazil's shipbuilding industry had a major relative importance with an average of 0.4% of the GDP and, at its peak of production, in 1980, reached a surprising historical maximum of 0.73%. In the Oil-Oriented Stage, it remained at an average of 0.15% with peaks of close to 0.2% which is very significant given the extremely high increase in the Brazilian GDP in those years.

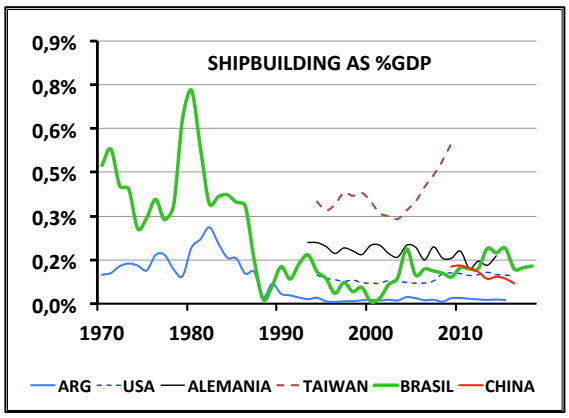


Figure 8 - Shipbuilding as % GDP

Employment/Value Ratio in the Global Context. This ratio provides a first approximation of productivity and allows us to make an initial

comparison of competitiveness among shipyards and countries (Figure 9).
One reason for the curves to tend downwards is the trend to external subcontracting, only the most essential tasks being concentrated in shipyards, like assembly, coordination and site management.

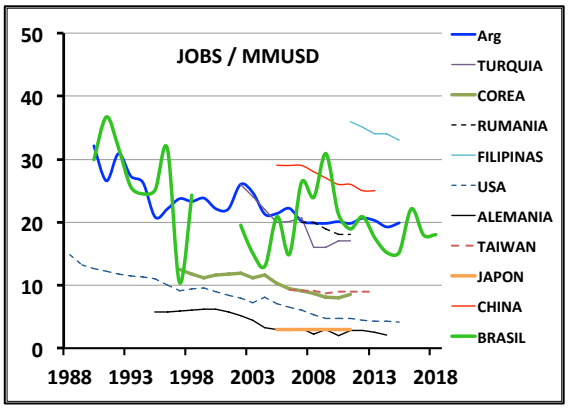


Figure 9 - Jobs/Value Relationship in Shipbuilding

This chart (Podetti, 2018) shows the cases of more than 95% of world production on three continents. Brazil and Argentina (private shipyards) exhibit similar ratios, which in this century are of the order of 21 total jobs per million dollars of production, as do those of Latin America's principal Pacific shipyards. There is still room for improvement.

Government Policies. Many countries consider the maritime industry as strategic, for which reason they generate protection mechanisms that guarantee its existence. A 2001 study by UNCTAD (ABDI, 2008) identifies 17 types of maritime subsidies, and the countries that apply them. These policies are mainly in support of shipping lines and several are also, indirectly, an incentive to shipyards.

Making clear that not all countries participated, among those that apply the most policies of maritime support are Italy, US, Germany, Denmark and Norway (more than 60% of policies) and those that apply the fewest are Switzerland, Kuwait, Saudi Arabia and Singapore (fewer than 20%).

Brazil is located in an intermediate position, applying 41% of the policies in 2001, in the following years increasing this both in number and in magnitude of application.

At the same time, more than 60% of countries with a maritime industry apply the following policies: Coastal Traffic Reservation, Bilateral Agreements, Tax Reductions, Financing Programs and Subsidies.

Experience indicates that promoting the supplying of the domestic market is a good way of achieving sectorial development. But it is also markedly important to seek technological development, increases in productivity and the development of suppliers, since only those that are internationally competitive will thrive when, for some reason, the protections are reduced.

Korea and Japan are recent successful examples of industries that were strongly protected and promoted over a period of time and that gradually generated such competitiveness that it allowed them to continue to compete after the subsidies were reduced. In any event their governments follow developments attentively and act in their defense in crisis situations.

Nevertheless, competitiveness must not be sought at any price. Policies must, whenever possible, be created without cross subsidization such that other industries finance the shipyards. An example of the latter is the case of steelmakers selling steel for shipbuilding below market rates, or shipping activity applying policies that cause its freight to rise. Although subsidies are frequently necessary at moments in which an industry is recovering, they must be transitory and be gradually reduced.

Errors in Brazilian Policies. Domino Effect.

In the Merchant Stage, the program for the promotion of the maritime industry was umbilically linked to the merchant marine and to shipyards. The former enjoyed its own policies for protection (Reserve of Cargo) and accessibility (financing and subsidies) while shipyards were allowed to operate within a virtual monopoly. The crisis in the shipping industry in the 1980s was mainly due to the drop in demand for the Brazilian merchant marine, impacted by global changes in the shipping business beyond the sway of local policies. When that market fell, the shipyards fell. Excessively focused policies run these risks; when there is a crisis in one sector, instead of the crisis remaining encapsulated there, it drags down other activities that are highly dependent on it, in a domino effect.

It must be made clear that the same crisis of the 1980s was suffered by all of the world's maritime industries, which led to interventions by governments such as those of Japan and several European countries to preserve industrial capacity until the crisis passed, something that was not done in Brazil nor in Argentina.

In the face of crisis situations, such as that of 2016, the main shipbuilding countries react in similar fashion to preserve the industry for the future.

China, with the majority of its shipyards under State control, defined a list of shipyards that merited financial support to ride out the crisis and continue operating. The least competitive ones had to disappear. Additionally, in 2019, the two biggest shipyard groups, CSSC and CSIC, initiated their merger to gain competing power, generating the giant China Shipbuilding Group.

In South Korea, the Financial Services Commission (FSC) demanded a collective solution with corporate mergers among the three largest shipyards groups (Samsung, Hyundai and DSME).
In Japan, the Infrastructure Ministry is promoting the merger of 15 shipyards so as to be able to weather the crisis and compete with China and Korea, forming the All Japan Shipbuilding super-group, continuing the already advanced merger among the two largest shipbuilding groups.

3.2. The Roles of the State

Analyzed below are the major roles of the Brazilian State with regard to the maritime industry: as Shipowner and Regulator. Only two roles are considered because, unlike the case of other industries in the region, in Brazil the State has barely dipped into this industrial role, save, minimally, in the case of AMRJ.

3.2.1. Shipowning State

The role of Shipowner was very sizable through the Brazilian Navy, Petrobras, and the three State-owned shipping companies in the Merchant Stage.
Marinha do Brasil (Brazilian Navy, MB). As of the 1960s, MB demanded some 101 ships with an average unit value of 46 million dollars, contributing a total of 4.6 billion dollars which is equivalent to 8% of the total value constructed.
The combination of current construction plans and the policy signs that new constructions will for the most part be carried out locally, allow MB to be projected as having a very important shipowning role in the scenario for the future.
Petrobras. Created in 1953 had a monopoly on hydrocarbons exploration / extraction / transport until 1997. As an outcome of its keenness in exploration, it discovered offshore oil (1968) and ordered its first platform, *Petrobras I*, from the Mauá shipyard, to operate at a depth of 20m. This marked the beginning of its expansion and, in 1980, it discovered new marine oilfields like Campos Bacia, which by itself accounted for 85% of Brazil's oil. This led Petrobras to buy and rent offshore platforms abroad and, in 1975, to order *Petrobras V* from Verolme.
The biggest display of this role was during the Oil-Oriented Stage via programs such as PROMEF, PROFERAM and the Offshore Production Systems construction, placing a huge demand with yards.
Petrobras wasn't always the direct owner of the vessels ordered from the shipyards, instead guaranteeing long-term contracts to the private shipowners that ordered them, thus exercising a role as "indirect shipowner". On the other hand, in the case of the demand for oil tankers, Petrobras did indeed play a direct role, since Transpetro, the owner of these vessels, is a subsidiary.
State-Owned Merchant Shipping Lines. Those that played a crucial role during the Merchant Stage were three: FRONAPE, Lloyd Brasileiro and DOCENAVE. These companies generated 55% of tonnage demand during the Merchant Stage. It is also noteworthy (Table 2) that 79% of their ships (71% of their tonnage) were built in Brazil, hewing to a policy of only building abroad when local capacity was saturated. The two largest shipyards (Verolme e Ishibras) received the largest number of orders (80%), under the contracting of oil supertankers by Fronape, while Lloyd Brasileiro, for its part, contracted cargo ships and bulk carriers from the Mauá and EMAQ. As shown by the table, 71% of the of these three State-owned shipping firms, in that period, were made in Brazil.

Table 2 – Source of Ships to State Shipping Co. in Brazil

	Imported		Brazil		% Brazil	
Decade	Qty	ThDWT	Qty	ThDWT	Qty	ThDWT
1960	2	233	23	223	92%	49%
1970	20	1.739	55	3.117	73%	64%
1980	14	445	57	3.907	80%	90%
1990	6	950	22	1.076	79%	53%
Total	**42**	**3.368**	**157**	**8.324**	**79%**	**71%**

Following graph (Figure 10) shows the relative importance of State shipping companies during the Merchant Stage, with 55% of demand from shipyards, followed by exports with 36% of the total tonnage produced.

	ThDWT		
	SHIPOWNERS		
Decade	State	Priv.	Ext.
1960	222	378	-
1970	3.100	600	1.300
1980	3.894	396	2.310
1990	1.080	60	1.860
TOTAL	**8.296**	**1.434**	**5.470**
	55%	**9%**	**36%**

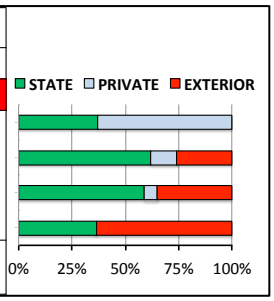


Figure 10 - Clients of Brazilian Shipyards by Tonnage

3.2.2. Regulatory State

In this role, the State decides "what it wants to happen," which is translated into concrete measures that taken as a whole constitute the State's sectorial policies.
Since these setups frequently include subsidy and protection systems which it isn't convenient to maintain *in eternum*, it is advantageous, from the outset, to plan the reduction of the benefits as a function of attainment of the goals pursued with

regard, for example, to an increase in the sector's intrinsic competitiveness.

Another important aspect is to try, over the course of the different governments and of changes in the worldwide environment, to have the outlines of the policies for the sector be maintained insofar as possible, adapting the measures to circumstances, to avoid the loss of the investment made and the development achieved in the previous process.

As can be seen over the course of this research, Brazil has been a real champion as regards the posing of public policies pertaining to the shipbuilding industry. But it is likewise clear that it failed with respect to controlling abuses of these systems, and lacked planning for the virtuous reduction of sectorial support in order to promote competitiveness. Lastly, another difficulty that it did not overcome was that of excessive concentration in areas of demand that might disappear, with the generation of a domino effect.

Main actions taken by the Regulatory State are:

Protection of Flag. In Brazil, overseas shipping is open to international companies, but coastal shipping and maritime/port support are restricted to Brazilian vessels, which favors the maritime industry in the following ways:

– The shipowners that build in the country can rent more foreign vessels.

– The shipowners that operate under the nation's flag benefit from AFRMM which can be spent at local shipyards, and benefit from FMM credits.

Market protection systems have been around since the beginning of the republic and began to be perfected in 1969 with the Cargoes Reservation Law, which, over the course of time, experienced variations as regards flexibilization.

Tariff Barriers. A shipowner may import a vessel to operate in the protected coastal market, or in port or maritime support services, but to this end must pay a series of taxes which render it highly inconvenient compared to the many incentives and convenient terms for local construction. The import taxes in question reach 60% (ABDI, 2008).

Tax Exemption. As of 1992, this activity was exempted from federal taxes such as IPI (tax on industrialized products). Exemption from ICMS depends on each state and varies between 18% and 12%. In the case of Rio de Janeiro, the shipbuilding industry was exempted in 1999, with great impact on the development of the sector.

Promotion of Exports. In the Merchant Stage, in addition to the financing system via FMM, exports enjoyed the PROEX system which offered a subsidy with regard to the cost of financing.

Local Content (LC%). This policy establishes a minimum % of domestic participation in the total value. The goal is to generate employment independently of the origin of the capital, encouraging multinational corporations to establish themselves in Brazil, contributing capital and technology.

At end of Cardoso's second mandate, the rate was of only 15% LC, and with Lula it was taken to 65%.

World leaders have high LC%. For example, Japan has 98%, Korea 90% and China 60%, while Brazil on average only reaches 40%.

Around 75% of developing countries and 30% of developed countries exercise minimum local content policies, according to a study by the US Trade Representative: Saudi Arabia, OPEC's largest oil producer, established a minimum of 70%. Countries like Venezuela, Angola, Bolivia, Libya and Argentina, which, on the contrary, didn't adopt LC policies to exploit their natural resources, face rising social economic problems.

Multiplier Effect (ME) on Employment. An aspect related to LC% is the employment generated in the ship parts industries that provide shipyards with equipment and materials. Although there are few studies of the ME in the Merchant Stage, it may be estimated at 2.42; i.e., for each job at a shipyard, 1.42 jobs were generated in auxiliary activities (GEIPOT, 1999, p. 95).

The ME on employment in the shipbuilding industry isn't an easy ratio to estimate. This is due to the fact that ship parts suppliers, which are those that contribute greater employment to activities "auxiliary" to that of the shipyards, also work for other industries, which makes it difficult to discriminate the number of jobs really generated by the shipyards. Nevertheless, taking several studies into consideration, it was estimated that in the Oil-Oriented Stage the ME was close to 3. This means that for every job at a shipyard, two others are generated beyond it (Rominger, 2013)

Additionally, since a large ME by the shipbuilding industry is a good political argument, some rather unrealistic effects are mentioned in speeches, like ME of 4 or 5, while serious research such as that of US Maritime Administration (MARAD) in 2014 have indicated that in the US the ME is only 2.6 (Podetti, 2018, p.182).

Maritime Financing. The Merchant Marine Fund (FMM) was created in 1959 to finance long-term new buildings or improvements of ships and shipyards and likewise to support maritime research and development. As well as financing, up to 1990 non-repayable grants were awarded to subsidize the difference in price between a ship's local value and the international value.

The BNDS, the principal FMM agent, assists corporations in preparing the projects, verifies contractual matters and bears the legal responsibility before the FMM for the operation's

risks. One of the main difficulties for greater development of the industry is the shipyards' high indebtedness with the BNDS, which makes new disbursements difficult.

On comparing Brazil's financing conditions with international ones in the late twentieth and current centuries, a great similarity is perceived. In 2008 they were: repayment term of 20 years, 4 years' grace, 90% coverage at rate of 3% to 5%.

Looking at the evolution of FMM resources in the Merchant Stage, a strong policy of awarding subsidies is observed in the first years (Figure 11), which disappeared in the 1980s. The "Other" heading refers to administrative expenses, debt servicing, project studies, etc.

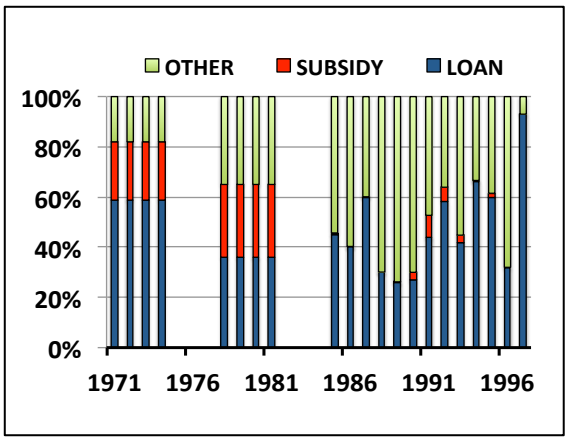


Figure 11 - FMM Resources % Application

The FMM's principal source of income, created in 1958, was the percentage-based duty on freight (coastal and overseas), initially known as TRMM, which as of 1970 came to be designated AFRMM. Of the funds generated for the FMM, 90% originate in overseas freight .

YEAR	IMPO	EXPO	CABOT	FLUVIAL
1958	5%	5%	15%	15%
1966	10%		15%	15%
1968	15%		20%	20%
1970	20%		20%	20%
1980	30%		20%	20%
1983	50%		20%	20%
1990	25%		10%	5%
1997	25%		10%	20%

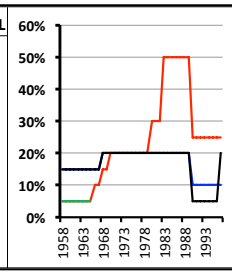


Figure 12 – Duties as Source of FMM Resources

Figure 12 shows the percentage evolution of revenue from the duty to generate funds for the FMM. In the 1984-1988 high-duties period, revenue was of the order of 500 million US dollars per year, while in 1990 it dropped to 200 million $/yr. In 1994 it was of 243 million dollars; in 1994 it rose to 450 million dollars, similar to the years that followed through 1996 (410 million $/yr).

In 1997, the total volume of resources available at the FMM was of 706 million dollars.

In total, the FMM financed 42% of the value produced up to 2019, oil companies 34%, and the rest was split in equal shares between the Navy, private funds and foreign funds for exports.

In the face of risk of non-compliance by the shipyard, the shipowner or financial agent demands an appropriate guarantee, and it is often the case that the shipyard cannot meet it since the shipyard's assets are normally lower than the value of the work. For that reason, shipbuilding leaders solve this with systems of subsidized guarantees.

In Brazil this is a delicate subject because of the bad experiences of the early 1980s. For that reason, in 2004 the FMM was allowed to guarantee up to 10% of the value of the contract, and in the case of exports, up to 20%.

But BNDS demands that the shipyard's assets be of 130% of the credit and that one of the principal guarantees available and acceptable under law is the ship under construction itself, but the BNDS is reluctant to accept it.

4. Future

4.1 S.W.O.T. Strategic Analysis

From (Pompermayer, 2014) it can be summarized:

Strengths. The capacity to develop its own marine projects is undoubtedly notable in Brazil, as successfully demonstrated in the past. In addition, there exists a solid ship parts industry which is gradually responding to the greater demands of the sector, exhibiting a growing competitiveness.

Another asset is the strengthening of the political and administrative system for maritime financing, showing it has learned from past errors in the FMM's original handling, with excessive power concentrated in one sole organization.

Weaknesses. The share of local engineering and domestic ship parts is still low.

The tax load is very high (double) in the Brazilian yards in relation to that borne by yards in Korea and Japan. This is so in relation to indirect taxes (not applicable in the case of exports).

The cost of labor per ton produced is very high.

Brazil is quite far behind on the learning curve in comparison to the leaders, which is seen in the values of the principal productivity indicator (MH/CGT), which in Brazil is two times worse than in China and eight times worse than in Korea.

Opportunities. Clearly, the potential demand to be generated by hydrocarbons development, in ultra-deep and pre-salt waters, generates opportunities on a colossal scale. The opportunity also exists to meet a similar demand for pre-salt exploration on the west coast of Africa, which is still in an initial

phase but which, given the geological similarities, is very promising.

Threats. The most evident threat is that of foreign competition on the local market and foreign potential (Africa). Another threat is the lack of planning of protectionist policies and subsidized financing without a demand for a counterpart nor foreseeability of an end to the protection.

A New Frontier: Pre-Salt

The discovery of pre-salt poses a new frontier that Brazil's shipbuilding industry is in optimum condition to conquer. It is a great opportunity that in addition extends its application to the west coast of Africa, so that two positive circumstances come together: similar technological requirements in which Brazil already has the advantage of its experience, and their application to a foreign market thus expanding the scale. The key here would involve accelerating this specific area of technological development since leadership in this market niche will only be sustainable on the basis of innovation and increase in productivity.

Domestic naval architecture will have a crucial role in this process by leading development and articulating among owners, shipyards, ship spare parts suppliers, consultancies and universities.

4.2. Projection 2060

If future public policies are positive, the following developments could be achieved.

Projection for Offshore Demand. Oil output projection is taken into account to estimate the demand for a greater volume of maritime equipment, to be added to the renovations.

RIDEX/SINAVAL (2018) presents the Petrobras estimation: for a level of 5 million barrels/day, the number of new offshore drilling systems would be of 39 units, with an investment of 70 billion US dollars; some 195 additional maritime support vessels would be required with an investment of 13.4 billion dollars. In 2018 it was estimated that this level of output would be reached in 2027.

With this information, the history of Brazil's offshore oil production and the projection for the price of oil, the following graph (Figure 13) was created with two curves that project oil and shipbuilding output.

In the upper part of the graph, with a continuous line, oil production is seen (Thous. barrels/day), indicating the different estimated paces of growth. The lower part of the graph shows, with a dotted line, the projection for the value of shipyards' cumulative production to provide the required equipment. Logically, theses curves are parallel.

It is considered that of the 70 billion dollar investment in offshore production systems, 56% will be made in Brazil, similarly to what occurred in the recent past. To this are added the 13.4 billion dollars for the necessary maritime support ships, thus totaling 52,920 million dollars, which, over the course of the fourteen years (2019-2033, until 5 million barrels/day are reached), averages some 3,780 million dollars annually in demand for the maritime industry (red dotted line).

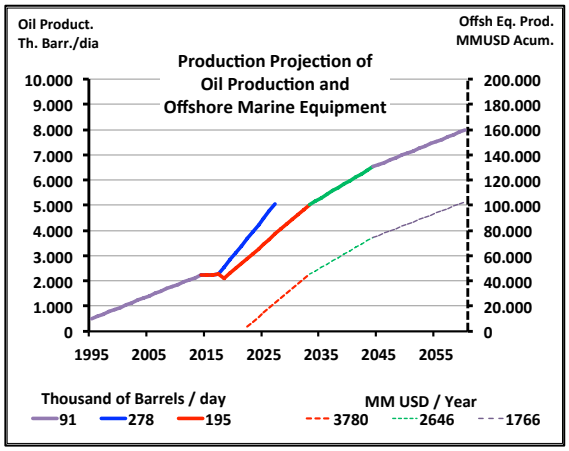


Figure 13 – Projected Oil and Offshore Equip. Production

Tied to the 30% deceleration in growth, this demand shrinks to 2,646 million $/yr (green dotted line), to then again pick up a pace paralleling that of the growth in oil output, maintaining a demand of 1,766 million $/yr until 2060 (violet dotted line).

It is additionally considered that the replacement of the units built in Brazil in the past is carried out 25 years after delivery.

Consolidating both demands, then, it can be concluded that the projected demand for the Brazilian shipbuilding industry by this sector would be of the order of 4,787 million $/yr, on average, until 2060, and that it would mainly (57%) originate in the demand generated by the higher output of hydrocarbons. In the second place (32%), the demand will be generated by the replacement of offshore production systems after 25 years of service, and lastly (11%) by the replacement of the support vessels with more than 25 years of service. Figure 14 shows the Projected Offshore Demand.

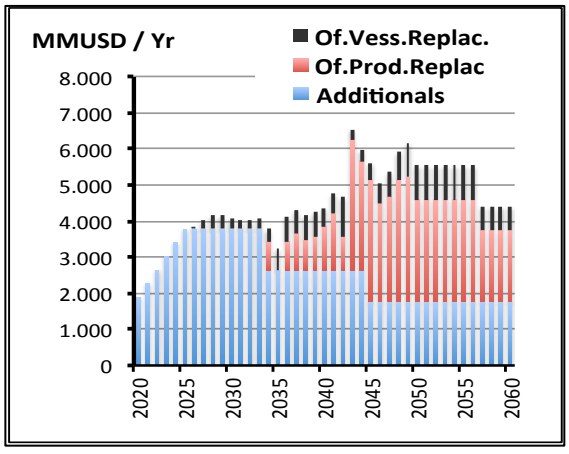


Figure 14 – 2060 Projected Value: Offshore

Projection for Merchant Demand. For a conservative projection of demand for port support and cargo vessels it is assumed that ships will only be built to replace the fleet built in previous years, when they reach 30 years after being put into service. Thus, no new constructions derived from market growth are contemplated.
In this way the average annual demand for the thirty-year period considered up to 2050 would be of 395 million dollars, for a total of 555 units, i.e. some 18.5 vessels per year (Figure 15).

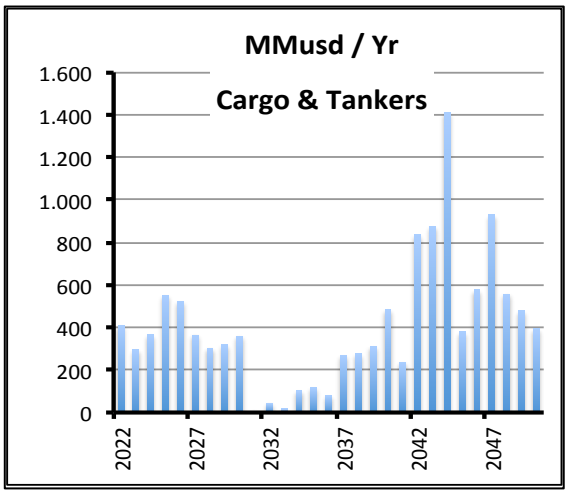


Figure 15 – 2060 Projected Value: Cargo and Tankers

Projection for Military Demand. The Brazilian military industry experienced a rebound as of 2009, with the launching of the PROSUB submarine project, which has ambitious expansion plans.

Table 3 – Brazilian Navy Newbuildings Estimate

UNIT TYPE	UNIT VALUE	NUMBER OF UNITS TO BE BUILT					
		PROSUB 1(B)		TAMAN-DARE	PAT.V. 500T	OTHER	TOTAL
	MMUSD/u	PS 1 (B)	PS 2				
CONVEN. SUB.	550	2	11				13
NUCLEAR SUB	2.200	1	5				6
CORVET. 3500 T	500			4			4
PATROL V. 500 T	35				40		40
OTHERS							
OPV 1800T, 27KN	100					12	12
FRIGATES 6000T	650					18	18
LOGISTIC 12000T	300					5	5
VARIOUS	156					170	170
TOTAL	241	3	16	4	40	205	268
MMUSD		3.300	17.050	2.000	1.400	40.865	64.615
		5%	26%	3%	2%	63%	

Another fact is the recent contract for the building of four *Tamandare*-class corvettes, and there is a projected construction plan of a large series of 500Tons patrol boats and some 170 units of varied kinds (Correa de Sá, 2012).
These military projects are summarized in Table 3 and are developed in greater detail in the Figure 16.

Up the year 2060, a demand for 268 units is projected, with an average unit value of 241 million dollars, which represents a total investment of 64,615 million dollars, i.e. some 1,615 million $/yr. This totals some 64,615 million dollars up to the year 2060.

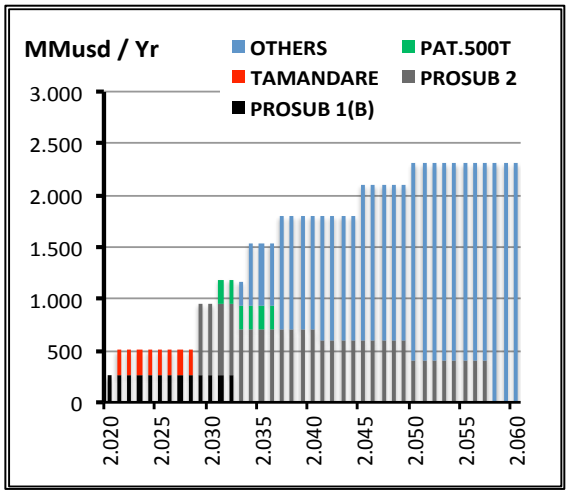


Figure 16 – 2060 Projected Value: Brazilian Navy

Projection for Exports. It is considered that, if the appropriate incentives are in place, Brazilian shipyards will have an important exporting presence, at least in the offshore and military areas. For these both, a continuously growing projection is proposed as of 2025, starting with 1% of total Brazilian offshore and military demand to reach a maximum of 40% by 2060.

Total 2060 Projection. Adding projections for demand in the Offshore, Merchant and Military segments, a Consolidated National Demand is obtained. The average annual national demand is of 6,613 million dollars, which represents 34% more than the historical maximum (2013). The distribution of this national demand would be: 70% Offshore, 24% Military and 6% Merchant.

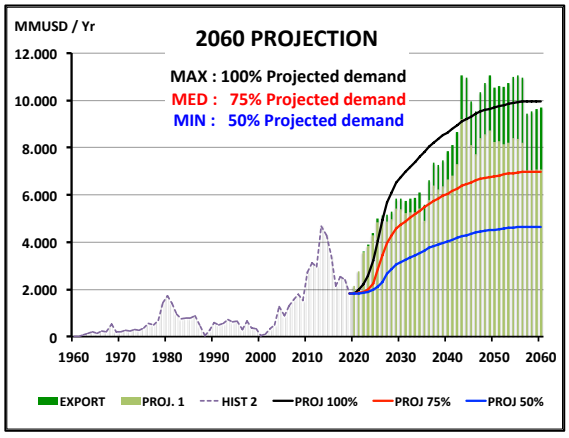


Figure 17 – Scenarios of 2060 Projection (Total Value)

To this is added the gradual increase in Exports as a rising percentage of production for the Offshore + Military market, and demand normalizes to form an "S-shaped" curve (Figure 17). Thus, the figure shows the Projected MAXIMUM Demand (black line), from which, applying factors of 75% and 50% to it, the Projected MEDIUM (red) and MINIMUM Demand (blue) are obtained. In all cases the projection curves take off slowly, which is followed by a period of strong growth which gradually decelerates to reach the final years of consolidation at the maximum projected level.

In order to assist in making comparisons between projections and history, the previous sixty years were added in the chart.

Considering these periods, it is found that:

-The projected median is between 2 and 5 times higher than that of an equivalent historical period.

-The best value projected (2060) is between one and two times that of the best historical (2013).

With regard to the Rate of Growth it is found that:

-The projected average is between 2.3 and 0.8 times the average median.

-The projection for the best decade is between 32% and 120% of the best historical decade.

These comparisons indicate that the projected scenarios stand at reasonable magnitudes in relation to the prior performance of the Brazilian shipbuilding industry.

4.3 Impact of 2060 Projection

Analyzed here are the impacts of these projections on Industrial Capacity, Employment, Financing and Risk in the sector.

Impact on Industrial Capacity. Depending on the future scenario the industry may face, it will or will not be necessary to expand installed capacity; it appears that expansion would only be necessary under the higher scenarios for demand. But under any of the scenarios, what will always be necessary is the modernization of the equipment and processes at the facilities, to allow improvements in productivity.

Good long-term planning is a key to all this; from it may arise strategies for mergers and specializations that would orient future efforts more efficiently. Such might be the case of new plants (or sectors) for a military maritime industry with an important future role.

Impact on Employment. The basis taken for the evolution of Direct Employment is the projection for value produced, applying to it the ratio of 17 jobs per million dollar of 2019 and adding to this the indirect employment generated at ship parts vendors, assuming an initial multiplying factor of 2.8 which increases to reach 3.7 in the 2060.

It is possible to attain levels of between 620,000 and 310,000 Total Jobs, higher than the historical maximum of 220,000 (2013). In the same way, levels of between 170 and 85 thousand direct jobs would be reached at shipyards, higher than the historical maximum of 82,000 (2013).

Impact on Financing. The next analysis focuses on the financial resources that would be required under Max demand. The diverse market segments are assigned their customary financing sources. In Table 4, the FMM is assigned the financing of 90% of merchant, maritime support and export vessels, and the remainder (10%) to owners. Oil companies can finance offshore systems (Cardoso, 2015) and military demand is financed as follows: 60% by participating foreign shipyards, and 40% by MB.

Table 4 – Sources of Financing of Projected Newbuidlngs

VESSEL TYPE	MAX. SCENARIO			FINANCIAL SOURCES				
	MMUSD	MMUSD/Yr	%	FMM	SHIP OWNER	OIL CO.	FOR. YARD	NAVY
CARGO	15.705	393	5%	90%	10%			
EXPORT	54.279	1.357	17%	90%	10%			
OFFSH. - OSV	47.403	1.185	15%	90%	10%			
OFFSH. - PROD	136.790	3.420	43%			100%		
MILITARY	64.615	1.615	20%				60%	40%
	318.792	**7.970**						

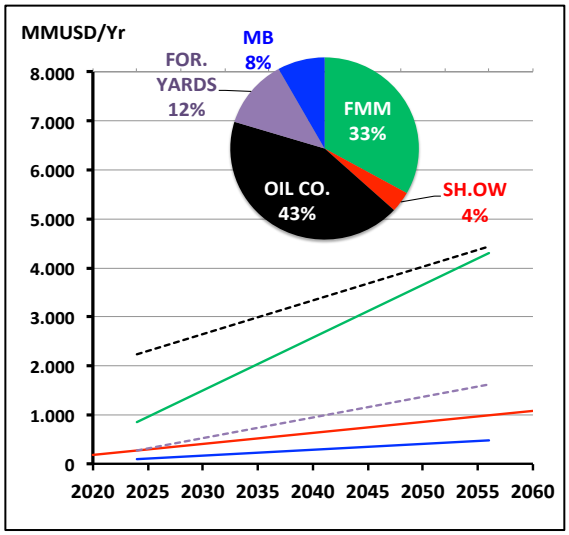


Figure 18 – New buildings Financing Evolution

No major problems are perceived (Figure 18) with regard to the financial demands made to the oil companies and ship owners, which have access, through their investors, to copious capital markets. Foreign military shipyards, for their part, have plentiful credits from their own countries at their disposal. The Brazilian Navy can turn to the sources of its own budget, to specific contributions from the State, a greater demand placed on the foreign shipyards and, lastly and eventually, to the FMM for certain applications.

Finally, the major financial demand placed with the FMM does not appear to constitute a problem either, when one compares the projected demand with the projection for the availability of resources to be applied to this type of financing. The figure shows that the projection for the FMM's net availabilities (dotted line) would always be positive, as drawn after the reduction according to the median projection for usage (full line).

Impact on the Sector's Risk. In this new stage of the industry which is being projected, the question may be posed: what risks should be feared?
The answer lies with the circumstances that have triggered negative situations, such as excessive concentration on markets and domestic approach.
One of the problems in previous stages was, precisely, the high concentration on specific sectors of demand which, when being reducing for external reasons, generated a domino effect.
Many of the 14 yards built in this century had only one client - Petrobras - and most of them are inactive and some did not even started operation (Botter, 2018).
Historically there was a heavy concentration, which should be reduced. In the Merchant Stage, there were only three markets; and just one of them, that of Cargo Transport, concentrated more than 63% of the total. In the Oil-Oriented Stage, there were again only three markets and the concentration on just one of them, Offshore, was even greater, of 71%.
The Exporting Stage projects diversification, with at least 4 markets and a lesser share by the largest (Offshore), reducing it to 57%.
In the previous stages, strong public policy measures headed the industry almost exclusively towards the domestic market, and additionally did so with a demand in which the State played a preponderant role. This led to the foreign market not being sufficiently attended to, with the exception of the end of the Merchant Stage when large yards successfully sold large ships abroad.
One problem caused by that excessively local-minded approach was the low incentive to increase industrial competitiveness, which is only acquired when facing the international market.
To avoid these risks, the projection adds the necessary rising participation of the shipyards in the foreign market, which in addition allows the raising of the ceiling of demand.

5. Numerical Summary

1250 Ships built since 1960 (larger ones, excluding river and fishing craft, light vessels, etc.): 70% Merchant, 22% Offshore, 8% Military.

60 Billion dollars of maritime value produced by Brazilian shipyards (1960-2019**):** 43% Merchant, 49% Offshore, 8% Military.

48 Million dollars per unit in average unit maritime value produced**:** 29 million $/u Merchant, 108 million $/u Offshore, 46 million $/u Military.

92% Built at Private Shipyards. The State's 8% was contributed by AMRJ.

88% State driven demand (Fronape, Lloyd, Docenave, Transpetro, Petrobras + contractors). Other: 9% Exports and 3% Private Shipowners.

42% FMM resources. The remainder: 34% Oil Companies; 8% each of Navy, Private and Foreign.

220,000 Max. Total Employment (2012) – Direct at Shipyards: 82,000 – Multiplier Effect: 2.7.

740,000 T/yr of Steel Processing Capacity by the entire industry in 2014.

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