A DECISION SUPPORT SYSTEM TO SHIPBUILDING BUDGETS APPRAISAL

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ABSTRACT

The Merchant Marine Fund – FMM is the main source of financing for the shipbuilding and shipping industries in Brazil. Since the interest rates are subsidized, the shipyards are required to present a detailed ship construction budget. The FMM Agency and the commissioned governmental banks in charge of the loans management are supposed to assess these budgets to prevent overpricing and production inefficiencies. This paper presents the main features of a Decision Support System oriented to management of a production cost database and to modelling and running the relevant statistical analysis.

INTRODUCTION

The Brazilian modern maritime industry was established in the 1950's, on the basis of a governmental National Development Programme. By that time, the Merchant Marine Fund – FMM was implemented, as an official system to provide financing to the shipbuilding and shipping industries in Brazil, under favoured and strictly regulated terms.

Most of FMM funds come from a tax levied on maritime import and cabotage freight payment. The system is operated through a complex process of collection and distribution. The FMM is under the jurisdiction of the Ministry of Transport, but the financing contracts are under the responsibility of three public banks, that are among the biggest financial institutions in Brazil.

By law, the FMM financing is related to production cost. Thus, there is in Brazil a kind of contract that is a unique combination of fixed price and cost plus.

As the interest rates are subsidized, the banks are required to analyse the budgets submitted by the shipyards (and the shipowners) in order to verify if the reported costs are compatible with the Brazilian industry standards, so trying to prevent overpricing and rebates.

Historically, the budget assessment process has been conducted without formal technical foundation, relying on subjective judgement of the analysts.

However, in the last years, the FMM-Agency and the commissioned banks have been endeavouring to improve the FMM system governance. One of these banks, herein referred as FMM-Bank, promoted the development of a shipbuilding cost database and procedures for systematic assessment not only of budgets, but also of schedule and general viability of each submitted project.

Every ship constructed in Brazil in the last 30 years has a standard datasheet with a detailed construction budget archived by FMM. This material is, of course, an invaluable repository of shipbuilding production cost data.

Besides the relevance as an analysis tool, in terms of the quality of the approved projects, the database will be a valuable instrument, for example, to monitoring maritime industry evolution, ship design and shipbuilding supply chain evaluation.

With these objectives a Decision Support System called SAPNAV was developed. SAPNAV aims at integrating the functions of data acquisition and validation; structured and non-structured queries; statistical analysis of the main cost drivers; and

assessment of the total cost of projects submitted by the builder and the owner.

The present article discusses the main features and economic impacts of the FMM system. Moreover, the article aims at discussing the structure and functionalities of the SAPNAV system, project acceptation criteria, methods of analysis, and computational architecture and interfaces.

1. BRAZILIAN MARITIME INDUSTRY AND SHIPBUILDING FINANCING SYSTEM

The modern Brazilian maritime industry, encompassing shipping and shipbuilding sectors, as well as marine equipment production and technical services and engineering, was established at the end of the1960's.

Previously, the shipbuilding industry consisted only of small shipyards capable of constructing small vessels and a few old facilities for ship repairing. The national merchant fleet was composed of small coastal vessels and a few obsolete ocean-going ships. A novel *Merchant Marine Policy* was introduced in that period, which included many incentive and protection mechanisms.

This policy was very successful. It promoted the development and consolidation of a shipbuilding industry on an international scale, and produced an impressive expansion of the merchant fleet. The shipbuilding industry's production rapidly increased and, ten years later, by the end of the 1970's, Brazil was one of the world's largest shipbuilders. The Brazilian flag total tonnage, considering bulk carriers, tankers and general cargo ships, increased from less than 2 million dwt in 1970 to more than 9 million dwt in 1984.

The protection and incentive policies included subsidies, tax incentives, cargo reservation laws, strict economic regulation of the main shipping markets, public direct investment, operation of large state-owned shipping companies and a peculiar financing system to shipyards and shipowners.
However, due to a conjunction of many internal and external factors, in the mid 1980´s, the Brazilian maritime industry entered in a long period of depression.

The late 1980's and early 1990's were characterized by a deep process of deregulation and privatization of Brazilian economy. These were also years of economic crisis, marked by very low growth and high inflation rates.

At the same time, deep changes in the world liner shipping industry led to the reduction of bilateral specialized trades, which were the main market niche for developing countries' flags.

The Brazilian merchant fleet steeply decreased, and the main national shipping companies disappeared or were privatized or acquired by foreign companies. The most important exception was the tanker fleet, which belongs to Petrobras, the state-owned Brazilian oil company.

Due to the collapse of domestic demand for shipbuilding, besides its own performance shortcomings, the Brazilian shipbuilding industry also collapsed. The main shipyards were almost completely inactive in the end of the 1990's and the subsidiary industry was dismantled.

The depression period lasted from the mid-1980's to the beginning of the 2000's. Then, a boom in the oil and gas market has promoted a strong recovery of shipbuilding and shipping industries.

Since the beginning of the 2000's, the oil and gas offshore exploration and production have expanded and became one of the main economic sectors in Brazil and the main driver of the maritime industry recovery and development. Huge reserves have been discovered in Brazilian ultra-deep waters, in the pre-salt layer, and, at same time, the international oil market became very favourable.

In this context, a new expansion cycle of shipbuilding industry has initiated. Most of existing shipyards were modernized or revitalized, and a number of modern facilities were developed, some of them with very large capacity.

There is a significant demand for offshore platforms, like production and drilling semi-submersible rigs, FPSO and drillships.

Moreover, in the sector of ship construction, there is also a significant orderbook, mainly related to oil and gas industry. This orderbook is composed mainly of oil and gas carriers (LPG, product tankers, Aframax and Suezmax), OSV – Offshore Support Vessels (PSV, AHTS, LH, etc.) and shuttle tankers. These ships belong to or are time chartered by Petrobras, which is the biggest Brazilian company.

In this period, the expansion of national economy as a whole has stimulated also the demand for cabotage container carriers, harbour tugs and river ships, leading to an expansion in all shipbuilding segments, including small vessels construction.

However, the strong dependence of the Brazilian maritime industry on the oil industry, and, mainly, on Petrobras, amplifies the uncertainty of both

shipbuilding and shipping markets, which are yet normally volatile.

In fact, in the last two years, the simultaneous collapse of petroleum, shipbuilding and shipping international markets, associated with a serious crisis in Petrobras, due to management and domestic political issues, the maritime industry is experiencing a very unstable period. Nevertheless, a complex industrial infrastructure is established, a number of technical and engineering education programmes are in operation, and there is a large orderbook already contracted.

Therefore, there are favourable prospects for recovering the growth trajectory, despite the short term turbulence.

To give an overview of the Brazilian shipbuilding industry scale, Figure 1 and Table 1 are presented. Figure 1 indicates the evolution of the global domestic shipbuilding output, in dwt, considering ocean cargo carriers, OSV, harbour tugs and river vessels. Table 1 indicates the estimated orderbook in the end of 2012.

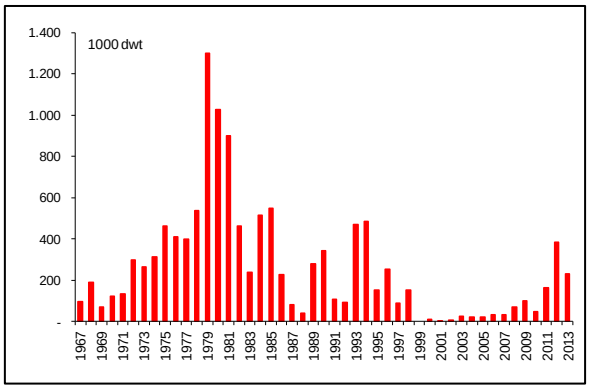

Figure 1 - Brazilian shipbuilding output

Table 1 - Brazilian shipyards orderbook - end of 2012

Ship Type	Orderbook	New Orders
Offshore Support Vessels	22	89
Tankers / Products	55	21
FPSO / Semi-Subs	16	-
Box	3	4
Bulk	1	2
River Barges/Tugs	37	72
Drillships	7	21
Chemical	4	5
Gas	8	-
Port Tugs	5	27
Total	**158**	**241**

Source: SINAVAL (2015)

As stated before, the expansion and consolidation of the Brazilian maritime industry was an achievement of governmental shipbuilding and shipping policies. The regulation and incentive instruments have been changed many times along this period of more than 50 years. However, the main industrial policy instrument, in force since the late 1960's, with small alterations, is the financing system.
The construction of practically every ocean ship built in Brazil and most river vessels and harbour tugs, as well as the construction, expansion and refurbishing of almost all shipyards, were financed by this system.

2. BRAZILIAN SHIP FINANCING SYSTEM

The shipbuilding financing in Brazil is provided almost exclusively by public funds sourced from the Merchant Marine Fund – FMM (Pires et al (2005)). The main source of FMM funds is a tax on import and cabotage freight, payable by the shippers. This tax is called the Additional Freight to Merchant Marine Recovery (AFRMM). Since the creation of the system, the rate was changed many times. Presently AFRMM rates are 25% of import freight and 10% of cabotage freight. However, there are a number of exemptions as, for example, cargoes having ports located in the northern region as origin or destination.
The FMM has two components: a common account (the FMM itself), and a group of owners' accounts. The common account is fed by the AFRMM from goods carried by foreign shipping companies and by foreign-chartered ships operated by Brazilian shipping companies. In the case of cabotage, the whole amount of AFRMM (10% of the total freight earnings) goes to the owner's account. It is important to point that this deposit is done even if the shipper is exempted. In such cases, the money comes from the FMM.
The balances of these owners' accounts can only be used for acquisition, conversion or repair of Brazilian ships or the repayment of FMM loans. The money of AFRMM owners' accounts must be used in three years, otherwise it is transferred back to the FMM. If the company orders a ship from a Brazilian shipyard, this benefit can be extended to a chartered foreign ship with similar characteristics. This means that the AFRMM generated by the chartered ship goes to the owner's account and can be used to pay for the ship under construction.
Besides this direct subsidy mechanism, the FMM grants very favourable financing conditions to shipowners ordering ships in domestic shipyards. The FMM financing system is one of the main mechanisms for tying the shipbuilding and shipping industries, and thereby, generating subsidy cross-transfers (Pires (2001)). Virtually all merchant ships built in Brazil in the last 40 years were financed by the FMM.

In the context of analysing the FMM system from the Brazilian economy's point of view, two issues are

particularly important. The first is the effect on the national transport system, on foreign commerce and on the national economy as a whole. The second is the effect on the formation of the shipowner's effective capital cost.

Pires et al (2005) have addressed the former issue, focusing in the general economic impacts of FMM system, more specifically the direct and indirect effect of imposing the AFRMM tax. To assess the impact of the AFRMM on the economy as a whole, as well as the distribution of burdens between shipowners and shippers, complex econometric models would be needed. Nevertheless, Pires et al (2005) managed to obtain a robust analysis by considering two limit market structures: perfect competition and pure monopoly. The general analysis derives from the hypothesis that the real markets have intermediate properties.

a) Perfect competition

Under perfect competition, because of the order of magnitude of the demand elasticity prevalent in Brazilian foreign commerce, one can summarize the results for Brazilian import trade as follows:
– the AFRMM does not significantly modify the freight rates charged by shipping companies;
– the tax burden is almost entirely borne by consumers;
– the effect on the economy as a whole corresponds to a simple monetary transfer from the Brazilian importer to the FMM.

b) Pure monopoly

In synthesis, the main conclusions of Pires (2005) for the pure monopoly case are:

– the profit-maximizing monopolist keeps the freight rate constant, regardless the AFRMM;
– the tax produces a non-significant reduction in the cargo volume and monopoly profit;
– the net loss for the economy as a whole is also not significant because the AFRMM effect corresponds in practice to a monetary transfer from the importer to the FMM.

Therefore, the conclusions for monopoly are essentially the same as those for perfect competition. For intermediate market structures, the conclusions are expected to be similar.

The second issue, which is the effect on the shipowner's effective capital cost, basically depends on the financing terms and the application of AFRMM owner's account, like previously described.

Table **2** presents examples of ship construction financing terms in the context of FMM system.

As indicated in

Table **2**, the financing terms depend on ship type and local content, which accounts for the percentage of the production cost corresponding to domestically provided items. The interest rates and periods of grace and amortization are determined by the FMM operator bank, based on shipyard or shipowner risk rating.

The investor effective capital cost is influenced yet by the application of funds from AFRMM owner's account, like previously discussed. For the more favoured sectors – like inland tanker shipping – a significant part of the national fleet has been totally funded by those accounts.

The impact of the financing terms on effective capital cost can be appraised by the comparison between the ship contract price and the present value of the total cash outflow including own capital disbursements and loan repayment.

In order to give a general idea of the order of magnitude of the potential impact of the Brazilian ship construction financing system in the effective capital cost, some typical situations were selected and are indicated in Table 3.

Table 3 refers to three vessel types (OSV, tug and cargo ship). The local content, for each one, was considered as 65%, which is the minimum level required by Petrobras in tanker contracts. The interest rates were taken as the medians of the relevant intervals. The periods of grace and amortization were taken as the maximum allowed (4 and 20 years, respectively), and a building time of two years was supposed.

Discount rates of 6% and 8% were considered, allowing for different scenarios for long term capital cost.

Table 3 shows the present value of capital outflow – VPK, as a percentage of ship price, as well as the respective *Implicit Subsidy*:

$$IS = 1 - \frac{VPK}{ShipPrice}$$

Table 2 – Brazilian ship construction financing terms

	Local Content	Maximum Loan		Interest Rate (annual)		Maximum Grace Period* (years)	Maximum Amortization Period (years)
		Domestic Items	Imported items	Domestic Items	Imported Items		
OSV	≥ 60%	90%	70%	2% to 4.5%	3% to 6%	4	20
	< 60%	90%	60%	2% to 4.5%	4% to 7%	4	20
Tug/Pusher	≥ 50%	90%	75%	2% to 4.5%	3% to 6%	4	20
	< 50%	90%	60%	2% to 4.5%	4% to 7%	4	20
Cargo Vessel	≥ 65%	90%	90%	2% to 4.5%	3% to 6%	4	20
	< 65%	90%	70%	2% to 4.5%	4% to 7%	4	20

*Period between the beginning of project and the start of loan repayment.

Table 3 – Brazilian shipbuilding financing system – *Implicit Subsidy*

	Discount Rate 6%		Discount Rate 8%	
	VPK	IS	VPK	IS
OSV	80,04	20%	67,79	32%
Tug	79,77	20%	67,23	33%
Cargoship	78,95	21%	65,56	34%

The figures are based on just indicative data, and the model is simplified. Nevertheless, they bring a robust indication of the order of magnitude of the extremely significant subsidy implicit in the FMM system.

In Brazil, ship construction contracts are normally established accordingly to the fixed price paradigm. Thus, the price is freely negotiated between the shipyard and the buyer. On the other hand, the FMM financing is referred to the production cost.

In fact, the FMM system becomes a unique combination of fixed cost and cost plus contract paradigms.

The project budget is required to be open to the buyer and the bank.

The need for thorough analysis of production cost reported by shipyards comes from two issues.

Firstly, there is a significant subsidy, depending on the reported production cost, as evidenced in the above discussion. Hence, consequently, there is a clear risk of arbitrage, as well as risk of collusion between the private agents, through illegal rebate agreements.

Secondly, one of the objectives of the shipbuilding policy is to induce the improvement of productive efficiency. Thus, it is important that the cost structures of the favoured shipyards do not carry excessive inefficiencies.

Therefore, the development of tools and criteria to appraise judiciously the submitted budgets should be a strategic objective of the FMM Agency and commissioned banks.

3. SHIP CONSTRUCTION COST DATABASE

The general governance of the Merchant Marine Fund – FMM is a responsibility of the Ministry of Transportation. However, the management of financing contracts is a responsibility of specifically commissioned governmental banks.

Until 2005, only one bank – BNDES – Economic Development Bank, participated of the system. On that occasion, other two (Banco do Brasil and Caixa Economica Federal) started operating in shipping and shipbuilding financing.

The decision on loan granting as well as interest rates and periods of grace and amortization is up to the bank. The bank managerial duties include risk rating assignment, project supervision and control and assessment of warranties. On the other hand, the banks bear all the financer's risks.

As previously discussed, the banks are supposed to analyse the budgets submitted by the shipyards (and the shipowners) in order to verify if the reported costs are compatible with the Brazilian industry standards, since the interest rates are subsidized.

Historically, the budget assessment process has been conducted without formal technical foundation, relying on subjective judgement of analysts. However, due to the entrance of new banks, and evolution of compliance requirements in governmental institutions and projects, the need for technical improvement of FMM project management has become evident.

The Decision Support System discussed in this article was developed in this context. This system will be herein referred to as ***SAPNAV***.

Notwithstanding the lack of formal technical assessment protocol, every ship constructed in Brazil in the last 30 years with FMM financing has a standard datasheet with a detailed construction budget archived by the Ministry of Transportation. This material is, of course, an invaluable repository of shipbuilding production cost data.

This standard datasheet, which is known as ***OS-5***, was introduced in 1985, with the objective of defining the level of detail to be required and making feasible the comparison between different projects and shipyards' standards. Since then the standard datasheet OS-5 has suffered some minor alterations, but continues essentially the same.

Since then, hundreds of vessels were built in Brazilian shipyards, most of them with FMM financing support.

Unfortunately, until recently there was no computer system to support the management of this valuable data collection, hence much of this material was lost.

Due to the lack of systematic approaches to data management and budget analysis, many existing records contain errors and inconsistencies. Many problems are due to lack of standardizing of measurement units and of material or equipment naming.

Notwithstanding, even these existing datasheets, after a cleaning process, can be useful for a number of different analysis, albeit having severe limitations.

Of course, the first concern in SAPNAV development is to keep under control the quality and consistency of the new records to be incorporated.

A large and reliable shipbuilding production cost database is an invaluable instrument to ship design, production planning and policy-making. There are many relevant applications, like, for example:

– Assessment of cost structure of shipyards and benchmarking;
– Performance assessment at regional, sector or national industry level;
– Development of cost estimators for ship design, production planning, marketing or budgeting;
– Productivity assessment;
– Comparison between domestic and international ship prices;
– Analysis of individual budgets aiming at identification of distortions or overpricing, trough comparison with similar projects, or the market benchmarks.

In fact, the latter is the main reason to the FMM commissioned banks and FMM Agency itself to require the improvement of the whole process management. The SAPNAV system has been developed to meet this desideratum.

SAPNAV is composed of two modules. The first is a ship production cost database manager and the second is a support tool for budget analysis.

The system is a web-based application. The database is located at the FMM-Bank server machine, queries and analysis may run in FMM-Bank client machines, and the OS-5 data input and preliminary checking are performed at shipyards client machines.

The system is composed of a Microsoft Visual Studio© program, an ACCESS© data file, and EXCEL© applications with VBA© macros.

Figure **2** illustrates the SAPNAV general processing flow.

The input of a new OS-5 register starts with the shipyard downloading an empty OS-5 datasheet from the FMM-Bank server. The datasheet is an EXCEL© application containing the standard OS-5 fields and having a friendly interface. The shipyard-client application performs a preliminary validation, preventing a number of common mistakes, like differences in spelling of equipment names or unit inconsistencies.

After the datasheet is completed and validated, the shipyard client sends the file to FMM-Bank server. The file is recorded as a provisional register until the

appraisal and final approval by the Bank analyst, when the file is incorporated to the databank.

Figure 3 shows the opening screen of the application for creating and editing OS-5 registers, indicating the main components of the datasheet and system functionalities.

Figure 4 shows an example of the *Equipment* datasheets, for the group *Machines*, subgroups *Propulsion* and *Energy Generation*, aiming at illustrating the data structure and format. Figure 5 indicates the production cost composition according the FMM System standard.

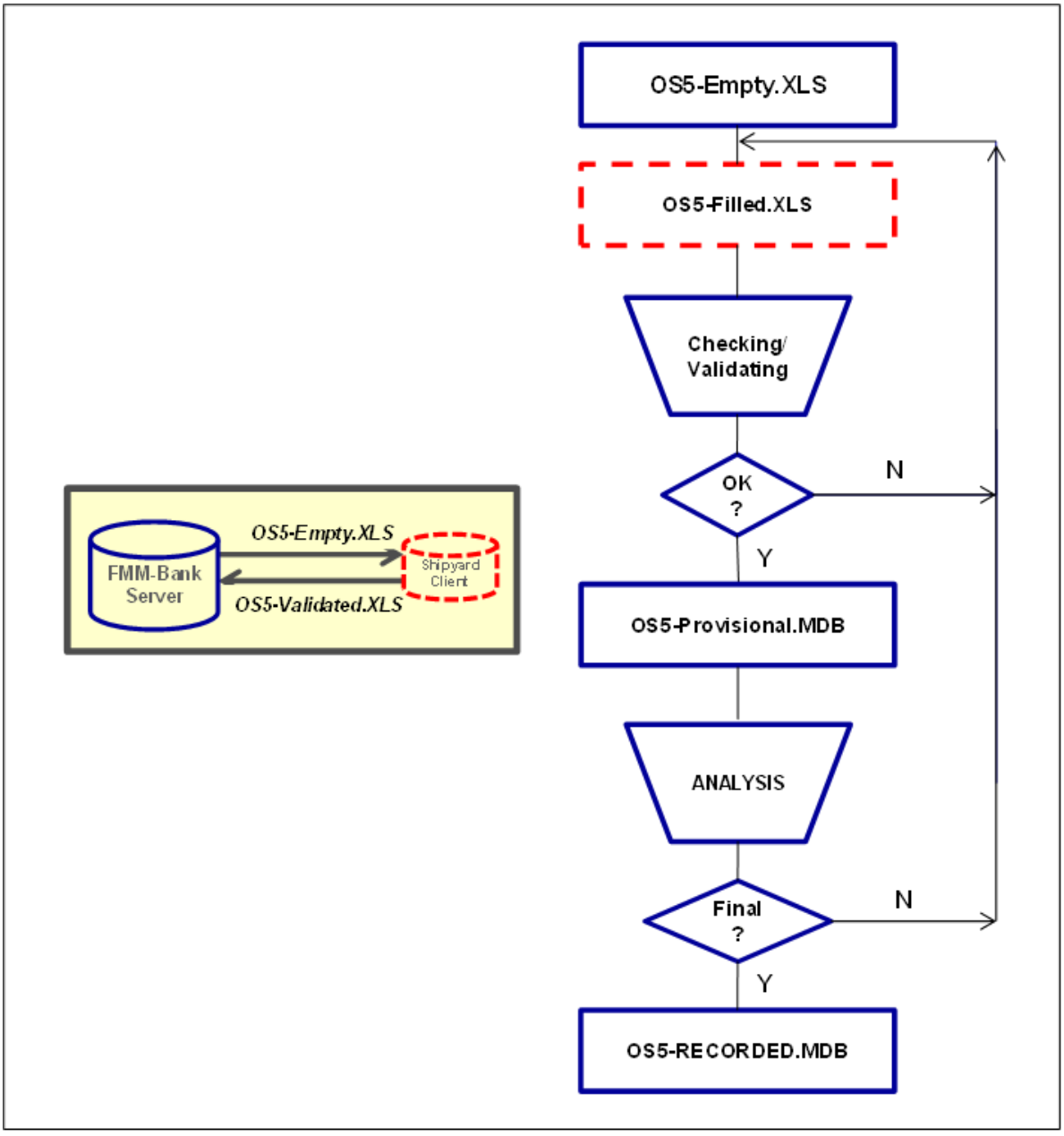

Figure 2 – SAPNAV – General Flow

Sapnav

COPPETEC FUNDACAO

PROJECT DETAILS

Recommendations	Basic Informations	Table I - General Information	Composition of Direct Labor	Man-hour Cost
Table III A - Group A Hull	Table III A - Group B Machines	Table III A - Group C Piping	Table III A - Group D Electricity	Table III A - Group E Hull Accessories
Table III A - Group F Finishing	Table III A - Group G Treatment and Painting	Table IV Other Production Expenses	Current Expenditure	Table V Uses and Sources
Tables III B and III C Sumary	Table II - Sale Price Composition	Checking	Main Equipment	Save
		Exit		

Figure 3 - Components of OS-5 Datasheet

Sapnav

COPPETEC FUNDACAO

Menu | Insert | Verify

TABLE III A - DIRECT COSTS
GROUP B - MACHINES

Shipowner : OCEANA NAVEGACAO S.A.
Shipyard : OCEANA ESTALEIRO S.A.
Vessel : PSV
Hull : OC 426

Data Base
06/09/2011

Currency: REAL

DESCRIPTION PROPULSION	QUANTITY	UNIT.	TOTAL COST P. NATIONAL	TOTAL COST P. IMPORTED
MCP + GENERATORS	4,0	CJ		5.307.071,00
ELECTRIC MOTORS (+ CONVERTERS AND TRANSFORMERS)	2,0	UNIT.	414.375,00	
PARTS AND ACCESSORIES	1,0	CJ	397.800,00	912.100,65
BOW TRUSTER	1,0	CJ		796.060,65
AZIMUTH TRUSTER	1,0	CJ	240.000,00	5.210.578,80
CONSOLES	2,0	CJ	15.644,60	234.074,10
EXHAUST SYSTEMS	5,0	CJ	16.575,00	
CHOCK FAST	500,0	KG	75.000,00	
		SOMA	1.159.394,60	12.459.885,20

DESCRIPTION POWER GENERATION	QUANTITY	UNIT.	TOTAL COST P. NATIONAL	TOTAL COST P. IMPORTED
EMERGENCY GENERATOR	1,0	UNIT.		168.861,35

Figure 4 - OS-5 Sheet - *EQUIPMENT* - Group *MACHINES* – Example

Sapnav

COPPETEC FUNDACAO

Menu | Verify

TABLE II - SALES PRICE COMPOSITION
TOTAL COSTS

Shipowner	:	OCEANA NAVEGACAO S.A.
Shipyard	:	OCEANA ESTALEIRO S.A.
Vessel	:	PSV
Hull	:	OC 426

Data Base
06/09/2011

Currency	REAL
Cotation	1,0000

1 - DIRECT COSTS (TABLE II)	94.994.648,84			
2 - OTHER PRODUCTION COSTS (TABLE IV)	25.621.581,40			
3 - SUBTOTAL		120.616.230,23 (1 + 2)		
4 - PROFIT	6.030.811,51		5,00%	%
5 - SUBTOTAL		126.647.041,75 (3 + 4)		
6 - IMPORT EXPENDITURE (Estimated to be confirmed)	2.409.527,54		4,00%	%
7 - PRODUCTION COST		129.056.569,29 (6 + 7)		

Figure 5 - FMM OS-5 Standard Production Cost Composition

4. SHIP PRODUCTION BUDGET APPRAISING SUPPORT

The basic objective of new projects budget assessing, from the FMM-Bank point of view, is to verify if the ship sale price is compatible with the production cost benchmarks, considering the production practices and facilities, as well as the industry-wide efficiency level in Brazil. This analysis aims at detecting overpricing or excess of inefficiency.
Generally, the usual approach would be the sale price statistical analysis. In fact, there is a large international bibliography on ship price econometrics, for both newbuildings and second hand tonnage (Pruyn et al (2011), Haralambides et al (2004)).

The ship price formation process depends on a large number of influencers, both market-driven and characteristics of the own ship. For this reason, the ship price econometric models tend to be very complex and require large samples.

This approach is not suitable to the FMM-Bank case, for two basic reasons.

Firstly, the Brazilian shipbuilding is segregated from the international market, in terms of price formation process. The Brazilian flagged fleet is concentrated in protected market niches, like cabotage, harbour and offshore support, and inland navigation.

In all these segments, there are heavy tax duties for newbuilding import (around 50%); second hand tonnage import is prohibited; and the chartering of foreign ships is severely restricted (Pires and Casanova (2012)). Moreover, the FMM financing system itself, which is available only to domestic construction, significantly contributes to that segregation.

Secondly, due to the market size, both in terms of volume of production and number of players (shipyards and shipowners), it is difficult to obtain data samples with the size necessary to estimating statistical models with reasonable significance levels.

Therefore, the FMM-Bank's analysis requires an alternative approach.

The herein proposed methodology, which was incorporated in SAPNAV DSS, consists in statistical assessment of cost influencers or components that may allow robust conclusions, even in the case of small samples.

The following are examples of relevant cost influencers or components:

- steel work man-hours;
- total man-hours;
- unit cost of man-hour;
- total hull construction direct material cost;
- steel plates weight;
- steel profiles weight;
- piping material cost;
- indirect cost.

Of course, the statistical analysis of each cost component or influencer requires specific models and the selection of specific sample data. The SAPNAV system includes a support tool for selection of relevant indicators and respective samples, running the statistical analysis, and generating reports.

For example, the sample for analysis of total man-hours should include different types of ships, if a mh/cgt indicator is employed. On the other hand, in the case of man-hours for steel work, encompassing hull fabrication, assembling and erection, the indicator $\frac{mh}{hullweight}$ should be considered, and the sample should consider only vessels of same type.

As a further example, the price of steel plates should be analysed taking a sample with all kinds of vessels, but only for shipyards with similar steel procurement models, in terms of purchase volumes, kind of supplier, and access to international steel market.

On the other hand, some indicators exhibit economies of scale. For example, indexes like $steelweight/dwt$ or $MachineCost/bhp$ tend to vary with dwt and bhp, respectively. Therefore, statistical analysis, like the estimation of confidence intervals, must consider a regression model.
Other cost influencers or components do not exhibit effects of scale and then should be analysed through univariate models, as is the case of unit cost of man-hour or indirect cost.

In this context, a very important function of the SAPNAV system is the support to the modelling process.

This process consists of selecting the indicators, selecting the currencies and monetary adjustment factors, selecting the data samples (vessel types, kind of shipyard, geographic region, time period), criteria to outliers elimination, etc.

Figure 6 shows the base screen for sample selection.

Since the indicators that will be analysed are selected and the respective sample data are defined, the system automatically performs the relevant statistical analysis.

In the cases of regression analysis, the results are considered if the model shows level of significance higher than 5%. If it is not the case, the system proceeds a univariate analysis.

Figure 7 presents a typical statistical analysis screen, and Figure 8 illustrates the screen that synthesizes the results. The latter shows the set of selected indicators along with the reduction in final price resulting from the respective individual analysis. There is also a graph showing the comparative effect of the adjustments derived from each indicator analysis.

The SAPNAV budget analysis module allows a high level of customization, in order to consider particular aspects of each project, as well as different criteria.

The system is a powerful instrument to detect cost components or factors not compatible with the national or regional shipbuilding benchmarks, so that the FMM-Bank technical staff might be able to recommend the proper reduction on the loan amount.

5. CONCLUDING REMARKS

An extensive shipbuilding production cost database is an invaluable instrument for ship design, production planning and policymaking. In Brazil, due to the characteristics of the national financing system for ship construction and acquisition, it is possible to gather data from almost every vessel constructed in domestic shipyards. Thus, the implementation of a large database is feasible. On the other hand, the banks in charge of shipbuilding loan contracts management are supposed to assess each submitted budget, aiming at checking for distortions in comparison with the Brazilian shipbuilding benchmarks. This article discussed the main features of the Brazilian financing system. Moreover, the article discussed the functionalities of a computer system specifically developed to production cost database management and support to budget assessment.

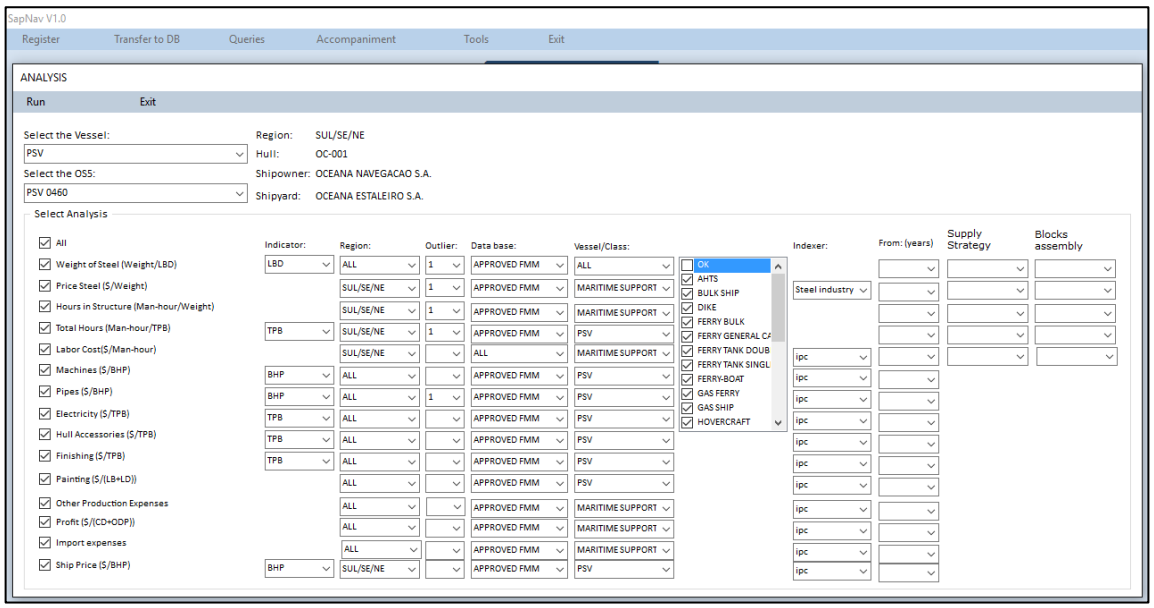

Figure 6 - SAPNAV - Data sample selection

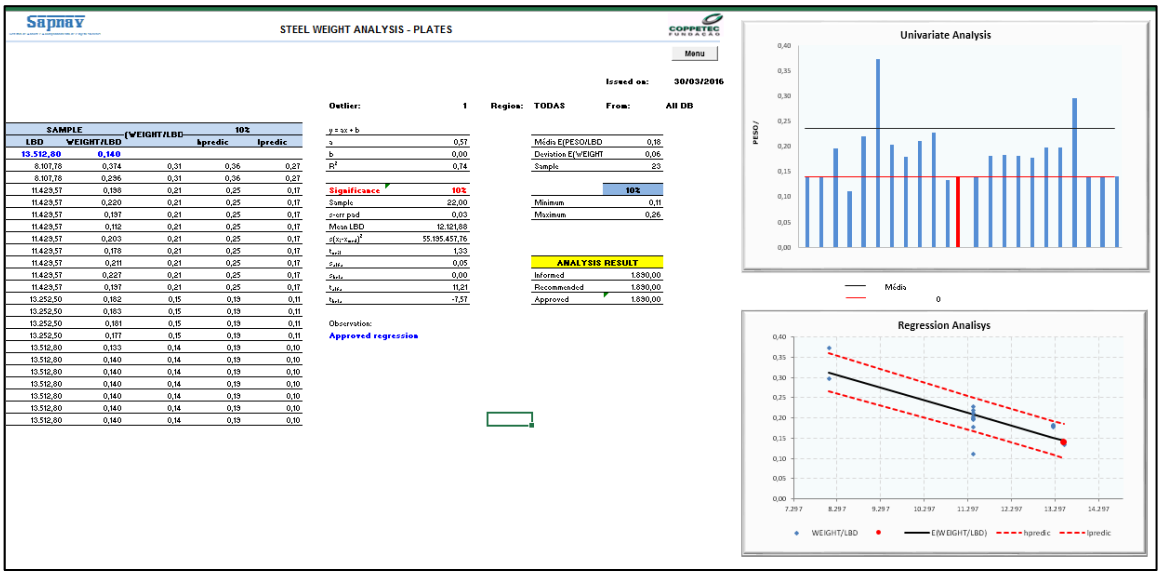

Figure 7 - SAPNAV - Statistical analysis example

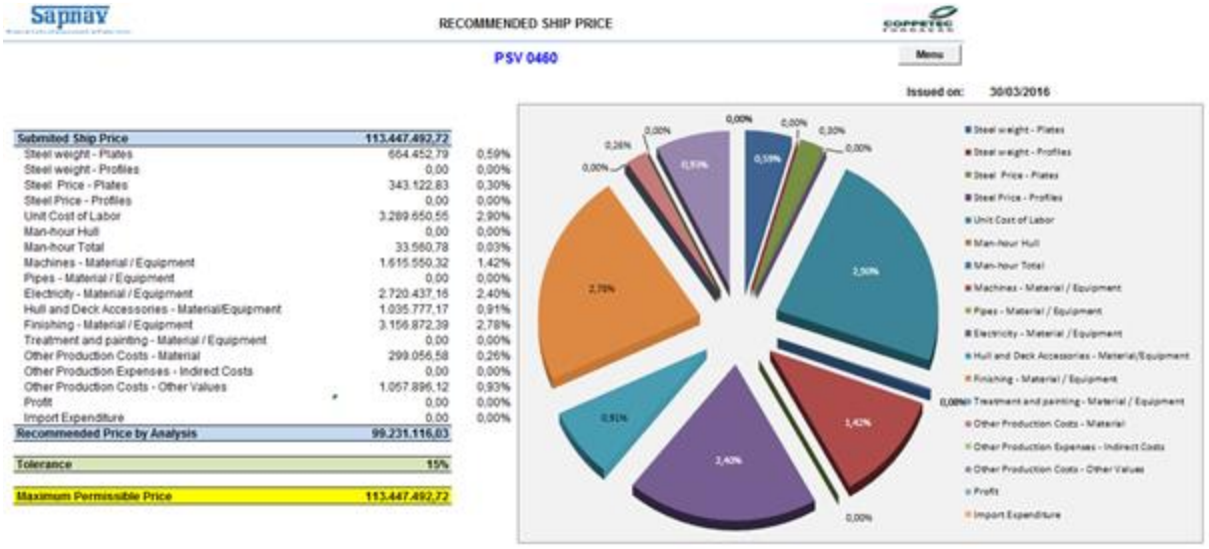

Figure 8 - SAPNAV - Result Screen

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