In the recent years, there has been an increasing interest by the countries in expand their exportation volume. Although large amount of goods are exported, in some countries as Brazil, the major contribution in the exporting balance is derived from the primary goods. Thus, a possible way to increase the country’s wealth is to increase the participation of added-value goods. In this context, the aim of this study is to present a new approach to analyze the behavior of the collaboration in the maritime transportation in order to reduce freight costs pertinent to the manufactured goods’ exportation process. Firstly, the general exportation process is described considering the main agents involved in the logistic chain. In the sequence, two possible methods to model and analyze such problem are described (Agent Based Modeling and Simulation - ABMS and System Dynamics - SD). After a comparison between both methods, SD method is chosen as the best appropriated and its primary implementation considering causal-loop diagram is presented. As a further step, a stock-flow diagram is developed, considering the main dynamic variables included in the exportation process, permitting a better comprehension of the transportation offer-demand mechanism, freight price definition and the collaboration formation.

Palavras-chaves: Collaborative transportation management, Manufactured goods’ exportation, Maritime carriers, System Dynamic, Decision-making
1. Introduction

It is becoming increasingly difficult to ignore the logistic relative cutting-edge phase concerning the collaboration among the participants of the Supply Chain. Despite the lack of abundant scientific works, some authors affirm that is possible to find material nominating this phase as the “logistic new wave”. The past decade has seen the fast development of collaboration among the companies in order to share their expertise and provide better results for the logistic network instead of searching individual results (Silva et al. 2009 (b), 2010). The term “collaboration” applied to logistic problems became popular with the CPFR (Collaborative Planning, Forecasting and Replenishment) approach, which is an evolution in the companies integration in order to obtain sales increase, inter-organizational alignment as well as operational and administrative efficiency.

Among its diverse applications one of them which deserves special attention is related to CTM (Collaborative Transportation Management). The CTM focus on providing reductions in the transactions and risks’ costs, enhancing the performance of service and capacity, as well as achieving a more dynamic Supply Chain (Silva et al., 2009). Therefore, the present paper, part of a thesis in development, seeks to describe a real problem existing in the exportation process in order to evaluate the collaborative action through the Supply Chain. The general exportation process involves the manufacturing industries, which need to export their manufactured goods and the maritime carriers, which offer their ships to transport goods.

Among the several existing barriers to fulfill this goal as the exigency of technical standardization and restrictions of environment nature, the maritime freight price whilst the cheapest transportation mode, is also a problem for a company when deciding to export. In most cases each industry individually negotiates the freight price with the maritime carriers and there is no bargain power involved in the negotiation; as a consequence, the system loses.

Thus, there is a gap to be explored in order to propose a reasonable manner to negotiate maritime freight prices and spread out the Brazilian exportations of manufactured goods, which is the proposal of this study.

1.1 Objective and methodology
The current study has the objective to present a new approach to analyze the role of the collaboration in the maritime transportation in order to reduce freight costs pertinent to the manufactured goods' exportation process. In order to facilitate the reader comprehension, an initial description of a general exportation process was presented including the main involved agents in the maritime transportation chain and a review about CTM, its definition and potential benefits were pointed out.

After examining the literature, System Dynamics (SD) method was chosen to properly model the problem in study due its appropriated characteristics in modelling logistic problems with a high level of abstraction, proportioning the visualization of the interrelations between the involved variables through the time. Thus, extending the causal-diagram language proposed by Silva et al. (2011), a preliminary stock and flow-diagram was employed in order to analyze the behavior of the collaboration in the maritime transportation process. In order to simplify the problem, only the manufactured goods’ industries and the maritime carriers were considered in such model.

Although the developed model is a simplification of the real problem, the first results allowed the examination of the connection between the partner’s collaboration and the bargain gains. This leads to reinforce the necessity in expanding the model, including all the other agents of the exportation process as showed in

**Figure 1** in order to completely evaluate the process.

2. The General Exportation Process
Figure 1 shows shortly the stages of the exportation process adopted by Brazilian companies.

The negotiation begins by the manufacturing industry (1) which can act alone being responsible for all the arrangement through the distribution chain. In this situation the manufacturing industry hires the land carrier (4) (in case the industry does not have its own truck fleet) to transfer the manufactured goods from the industry to the port. There is also a possibility or, in many cases, a necessity to firstly transfer the manufactured goods to a warehouse (3) to maintain a stock which can be useful to solve quick delivery problems or to retain the cargo up to the time that all the bureaucracies are solved.

The industry is also responsible for choosing the origin port to be used and at the same time it should negotiate with shipowners (7) the freight prices, choosing one of them to carry
the manufactured goods. In this stage it is quite common to hire a NVOCC (6). This agent is responsible for managing several industries maritime transportation demand in order to negotiate with shipowners the freight prices and the availability of ships to the destinations of the industries’ manufactured goods.

In the destination side, there is another necessity by the manufactured industries concerning the definition of the destination port (8), which should be the most appropriated in order to deliver its goods to the clients (11). To fulfill the deliveries the manufactured industries must also hire land carriers (10) to transport its goods to intermediaries warehouses (9) or to final destinations in the destination’s country.

The red flow in

**Figure 1** is almost the same as the blue flow excepting by the fact that there is the presence of the freight forwarder (2). In this case the manufacturing industry hires this agent to be responsible for contracting and controlling all the stages in the distribution chain. It is normally a practice adopted by small and medium industries which do not have expertise in such process and then, the freight forwarder, who manages several industries’ transportation demand, can be agile in the negotiation.

As a consequence of a good planning in the distribution’s logistic it is possible to: reduce storage time and costs, reduce time in the course, and reduce problems in the delivery to better attend the sales contract, as well as influence the freight prices definition.

Normally, the shipowners define in a *Freight Conference* the prices to be practiced in the regular liner maritime transportation (as a monopoly) and in such situation if the manufacturing industries negotiate individually the freight prices with the shipowners, they do not have bargain power to attain better prices. This is the point where the collaboration can be applied in order to create groups of industries with the same goal, negotiating with the
shipowners in order to depress the monopoly created by them and getting economies of scale as well as other benefits like major time to execute the payment of the freight and free time on shipping.

3. Comprehension about CTM

Preliminary study about CTM dates from 1993 with the introduction of the ECR (Efficient Consumer Response) concept, when the agents of the Supply Chain started working in collaboration mainly with the use of the communication networks as EDI (Electronic Data Interchange) in order to improve the flow’s management from the suppliers until the consumers (Silva et al., 2009). With the intention to improve the application of the collaboration, CTM concept emerged to propose a new trade concept focusing on the transportation process. Therefore, the main objective of the CTM is to reduce or to eliminate the inefficiencies occurring in the transportation process (Esper and Williams, 2003). According to the authors, “CTM aims to develop collaborative relations among the buyers, sellers, carriers and logistic operators (3 PL’s) to increase service, efficiency and costs’ reductions associated with the transportation process.”

3.1 Potential CTM benefits

As a consequence of CTM’s use, companies have obtained reductions in costs’ transactions and risks, increased the service and capacity performance as well as obtained a more dynamical Supply Chain. A benefit of CTM is the reduction of uncertainties in the offer and supply through an improvement in the communication and collaboration among the partners of the chain. Another benefit found in the literature concerns about the visibility of the loading status (waiting time, execution time). It facilitates the management of the carrier service when permitting pro-active actions and, thus CTM allows freight prices economies, reductions in human resources and the improvement in the service level offered to the clients.

4. Choosing a method to deal with the study’s problem

There is not a pattern model to be followed in order to attract companies to get into a collaborative distribution chain. In this case it is possible to extend this truth to the maritime
transportation problem in the exportation chain, which still has only few published scientific studies, especially for the Brazilian scenario. So, the challenge is to find a better way to deal with this problem.

In order to determine an appropriated method to study the behavior of the collaboration in the exportation process a foregoing study was developed by Silva et al. (2011). In such study the methods System Dynamics (SD) and Agent Based Modelling and Simulation (ABMS) are presented due both of them are indicated to model systems containing large numbers of active objects (industries, people, vehicles, warehouses, products) and their applications vary according to the required level of abstraction, which can consider more or less involved details. These authors consider that logistic and supply chain problems involve several elements which cannot be modeled with such detail (varying from medium to high level of abstraction), so the SD and ABMS approaches fit better in these problems.

4.1 System Dynamics

Developed by Forrester (1961), SD studies the behavior of systems over time, containing two fundamental languages: causal diagrams and stock-flows. Both of them allow the modeler graphically represent the system being modeled (Sterman, 2000). For the purpose to exemplify the SD application, Silva et al. (2011) presents a possible causal-diagram to model the hole of collaboration in the manufactured goods’ exportation process. See Figure 2.
Considering the first step when modelling with SD is to define the system’s boundary, the aforementioned authors considered as agents only the manufactured goods’ industries and the maritime carriers. Such consideration represents a simplification of the system showed in Figure 2.

**Figure 2** - Reinforcing and balancing loopings between manufactured goods’ exporters and maritime carriers’ negotiation
Source: Silva *et al.* (2011)

Figure 1. The next step was to define the objectives of the agents and the main variables which influence these objectives. The manufactured goods’ industries aim to increase their competitiveness in the market and reduce logistics costs, while the maritime carriers aim to reduce the transportation offer-demand gap and to increase their profit. These objectives can be reached based on the actions of both agents: increasing collaboration among the export industries and changing the maritime transportation offer, as is showed in the Balancing and Reinforcing loopings in Figure 2.

**4.2 Agent-based Modelling Simulation**

This method is widely used to understand and analyze systems with several interacting active objects generally when there is a decentralized decision-making. The main idea of this method is to consider the interrelations among the several components of a system. In such consideration the system is greater than the simple sum of its components (North and Macal 2007). In general, these components are named *agents* and they have their own set of rules and behaviors, which provides them the ability to affect in greater or lesser degree the system’s global behavior.
For the purpose to exemplify the ABMS application Figure 3 (developed by Silva et al., 2011) shows an UML class diagram as a possible form to model the role of collaboration in the manufactured goods’ exportation process.

![Figure 3 - Agent UML class diagram](source: Silva et al. (2011))

Considering there is not an ABMS pattern model to represent a system, the above diagram was built following the steps proposed by Macal and North (2006):

a. Agents: Identification of agents’ types and other objects (classes) along with their attributes - industry, NVOCC, 3PL, maritime carrier, land carrier and customer.
b. Environment: Define the environment where the agents will live in and interact with - the market where the agents negotiate the transportation.

c. Agent Methods: Specify the methods by which agent’s attributes are updated in response to either agent-to-agent interactions or agent’s interactions with the environment – at every time period must be solved the following sequence: search a partner, choose a NVOCC and/or a carrier and finally, send the shipment.

d. Agent Interactions: Add the methods that control which agents interact, when they interact and how they interact during the simulation - an interaction can be the choice of a maritime carrier or the choice of the route.

e. Implementation: Implement the agent model in computational software - in such example the authors used Anylogic® software.

5. Modelling with System Dynamics method

After analyzing Silva et al. (2011) approach, SD method was chosen to model the collaborative behavior between the manufactured goods’ industries and maritime carriers regarding the reduction on freight costs. As was previously described, SD method is appropriated to abstract from single events and entities and to take an aggregate view concentrating on policies. To approach the problem in SD style one has to describe the system behavior as a number of interacting feedback loops, Balancing or Reinforcing.

Figure 4 presents the stock-flow diagram used to express the ships’ offer-demand system. The stock of Ships is unique and each unit cannot be distinguished from the others and the analyses occur globally. The maritime transportation has an offer-demand system which is represented by the flows supply and operation, respectively. Both flows influence directly the stock of Ships and are affected by the Freight price practiced on the market.

The conversors supply price scheduled and demand price scheduled are modeled as a LOOK UP function (Vensim® software), containing a relation price x amount of ships; in other words, for each value adopted by Freight price, there is an admissible amount of ships which is affordable to the manufactured goods’ industries transportation demand and, simultaneously there is an admissible amount of ships which is interesting to the maritime
carriers offer in the market. Therefore, the main objective of the negotiation is to achieve the market equilibrium with a reasonable price acceptable to both (the industries and the carriers).

In such stock-flow diagram it is considered the existence of a price change delay; it means the Freight price do not change immediately but it takes some units of time (days, months) to react to changes in offer-demand. The change in price rate is modified by the converter desired price. The desire price is defined by the actual value of the Freight price and the coveresor effect on price. A LOOK UP function is used to define the converter effect on price, expressing the variations on prices based on the inventory ratio. The inventory ratio is given by the desired inventory (demand* desired inventory coverage) and the actual amount of Ships in stock. So, the effect on price regulates price change. When the inventory (Ships) > desired inventory then the inventory ratio is > 1 and Freight price must be reduced. When the inventory ratio is < 1, Freight price must be increased.

![Figure 4 - Stock-flow diagram for Ships’ offer-demand](image)

To exemplify a possible permitted analysis generated by the stock-flow diagram, Figure 5 shows the correlation between the Ships and Freight price. It is noted that as the
Freight price increases, the stock of Ships in the market is decreased until the moment the market need more Ships and starts paying more for the freight, increasing the amount of Ships again (considering the time range is only 10 months in this application, it is not possible to see the increase in the stock of Ships after time 10).

![Selected Variables Chart]

Figure 5 - Correlation between Ships and Freight price by System Dynamics analysis.

Figure 6 presents the stock-flow diagram expressing the industries collaboration formation. The amount of industries operating in the market is given by the stock Industries. The stock is modified by its inflow and outflow: new industries attractiveness and collaboration abandonment, respectively. As the number of Industries increases, the power bargain on freight negotiations is also increased (expressed by the conversor power bargain effect on ships recruitment) and vice-versa. This conversor is given by a LOOK UP function. As the power bargain effect on ships recruitment increases, the cost of collaboration reduces since is given a discount on the freight price.

The converter profit ratio measures the ration between the cost of collaboration and the industry individual cost without collaboration. This result will influence the attractiveness effect (LOOK UP function), which directly influences the inflow new industries. As the profit ratio increases, the attractiveness also increases and new industries come into the collaboration. On the other hand, as the amount of profit ratio increases there is a decreasing
effect in the *profit effect on abandonment* leading to an increase in the *collaboration abandonment*. It means the *Industries* will receive less profit individually if there are a large number of them in the market, discouraging them to continue in the collaboration.

**Figure 6 - Stock-flow diagram for the industries collaboration formation**

### 5.1 Comments

As mentioned previously, the aim of the diagrams construction was to clarify the understanding about the negotiations of the maritime freight prices. Thus, to initiate the construction of the stock-flow diagram for analyzing the behavior of the collaboration in the manufactured goods’ exportation process, it was presented a drawing for the offer-demand system, considering as main agents the amount of *Ships* disposable in the market and the practiced *Freight price*. Such consideration was made in order to establish a growing drawing process, avoiding mistakes during the modeling process. It is quite common researchers start elaborating a complete stock-flow diagram but in the sequence, they discover failures in the model. In these cases it is easier to start a new model from the beginning then trying to fix it.

With the modeled diagram it is possible to analyze the process involving the Ships’ offer-demand and its correlation with the *Freight price* variations. As found in the literature the offer reduces as the profits are reduced, reinforcing the proposed model. The following step in the growing drawing process was to draw the stock-flow diagram for the industries
collaboration formation. With such scheme it was possible to analyze the main impressive factors in defining the behavior of the collaboration adopted by the manufactured goods’ industries in the maritime transportation process.

Although the developed diagrams represent the general behavior of the maritime transportation market, the suggested results do not represent the real world negotiations due the lack of real data to take into consideration in such analysis. For this reason it is recommended to test the model considering real data practiced by manufactured goods’ industries and maritime carriers, including demand data and freight prices. As an improvement of this study, it is expected to unify both diagrams in order to analyze simultaneously the behavior of the ships’ offer-demand system affecting the collaboration among the manufactured goods’ industries. If it shows some evidence of gains with the collaboration, it is expected to amplify the analysis considering all the other agents of the exportation process as proposed in

Figure 1.

6. Considerations

The purpose of the current study was to present a new approach to analyze the role of the collaboration in the maritime transportation in order to reduce freight costs pertinent to the manufactured goods’ exportation process. In this way the main stages of the exportation process were described.

In order to define a method to model and analyze the collaboration behavior ABMS and SD were briefly described, identifying the applications and pros and cons of both. After a comparison between them, SD method was chosen as the best appropriated method to
represent the behavior of the dynamic variables enclosed in the mechanism of exportation process of manufactured goods, due its aggregate view of the problem.

Following the systematics of SD method, a causal-loop diagram was presented by Silva et al. (2011) and as a further step in this study two stock-flow diagram were modeled, consolidating the informations and variables of the problem in analysis. The empirical findings in this study provided a new understanding of the exportation process (transportation offer-demand, freight price definition, collaboration formation) and the next step contemplates the unification of the stock-flow diagrams with all the other agents inserted in the exportation process (as in

![Figure 1](image)

including real data to validate de model. Hence, sharing crucial information, believing in the CTM’s partners and accomplishing the needful cultural change inside and outside the companies, it is expected to achieve excellent results in the manufactured goods’ exportation process.

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