Game Theory Employment in the Context of Ports Management

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ABSTRACT

The port management is a complex activity. It is so due to the many variables involved that could take in account the climatic, environmental, ships features and its cargo. In this context the forecasting about how many ships a certain port will be able to receive and how long time each ship will need to perform its operations in a certain period of the year can be uncertain, once it is impacted by external factors such as the climatical conditions. In this context this paper proposes a forecasting mechanism based on the game theory which utilizes data collected during four years for each ship that has moored in two different Brazilian ports. Based on these data we have defined a game theory model for forecasting the port behavior in a future time period. A first implementation is presented as well as a first analysis of provided outputs.

KEYWORDS

Game theory, statistics, port management, risks management.

1 Introduction

The management of a port is considered a complex activity, once there are many variables and risks involved in such activity [1]. It is not only because the steady flow of ships, but also due to the many environmental factors involved. Among these factors there are the wind speed, waves high, rain, fog, and so on [2]. Considering that environment factors may not be controlled, the port administration has to deal with the risk management related to this activity. Aiming to use software possibilities to assist in this risk management, data from two different ports in Brazilian cost has being systematically collected during four years. These data includes information about each ship that moored in each port, including data about the date and time it has entered in port, the date and time it has leave the port, and also if its ship was negatively affected by environment factors in the period it has accessed the port. Such impact can imply in more time needed to the whole operation be concluded, what can than generate more traffic and queue to access the port, reflecting in a comprehensive financial impact, including costs with personal in ship, in the port and also the delivery time itself. Aiming at assisting in the forecasting of such costs this paper presents a proposal of game theory [3] which based on the historical data we perform a simulation for forecasting the costs the port will face due to the climatical factors.

2. Background

2.1. Game theory

The game theory is a branch of maths which study strategic solutions which the player choose different alternatives aiming at obtaining the optimized results [3]. Specially in the context of electronic games, the game theory may utilize random factors that can impact in results, providing to the player the felling of luck and uncertain expectations [4].

3. The collected data

This proposal presented in this paper has utilized data collected from two ports in Brazilian cost: Porto de São Francisco do Sul (https://www.portosaofrancisco.com.br/) and Porto do Rio Grande (https://www.portosrs.com.br/). These data includes for Porto de São Francisco entries from 2017 to 2021 and for Porto do Rio Grande still just data from 2020. Each dataset includes the exactly date and time each ship has entered in the port, delivered its cargo, and leave the port. It also contains information about what type of ship and what type of cargo is being transported. It also contains climatical features information including what was the wind speed or the wave high during the ship mooring, as well if the operation of this ship was negatively affected by climatic conditions.

4. The proposed model

Considering the available data and the premises of game theory it was utilized two variables from dataset for preparing the model, they are:

a) **The time the ship stay in the port:** it includes the difference of time from the arrival of the ship and its leaving, after concluding the operations.

b) **Impracticability**: a boolean information if a certain ship was affected or not by environmental factors. It means the ship stays more hours in the port due to the environmental factors.

The model also preview the following inputs from players:

a) **Port:** Which port the model will run. It will point to a proper dataset, being currently two possible options: Porto de São Francisco do Sul and Porto do Rio Grande.

b) **Period:** a time interval from a day and a month for begin and a date and a month for end. It is useful to take data from this same interval in the selected dataset.

c) **Cost hour:** How much costs a hour of a ship in the port. As this information still is not precise it may be informed by user.

Based on the available data and the provided input the processing can be executed, including the following steps:

1. Calculate how many ships will arrive in the selected period. It takes the amouth of ships that has arrived for the same period in the previous years we have data registered, calculates the average and then utilizes a random factor for varying the value within a range of one standard deviation for more or less.

2. Once it is defined how many ships will arrive it is verified for each ship if it will be affected or not by the impracticability. For this purpose it is calculated the mean of the proportion of ships that were affected by impracticability in the same period of previous years available in the dataset and utilizes that as a threshold. Based on the uniform random function it is verified if the ship will be affected by impracticability.

3. For each ship affected by implacability it is then calculated how many hours it was additionality necessary for the operations of this ship. This time is calculated using the standard deviation of time of stay for all ships from period varying from 0.5 to 1.

Then as the output for the proposed model it is presented to player: a) how many ships are forecasted to arrive in selected period; b) how many hours will be additionally necessary due to impracticability factors; and c) how much these hours will cost, using as parameter the cost hour inputted by user.

5. The implemented software

Aiming at experiencing the proposed model it was implemented a web- based software (Figure 1) which reads automatically the provided dataset and based on the input parameters automatically runs the model and calculates its outputs.

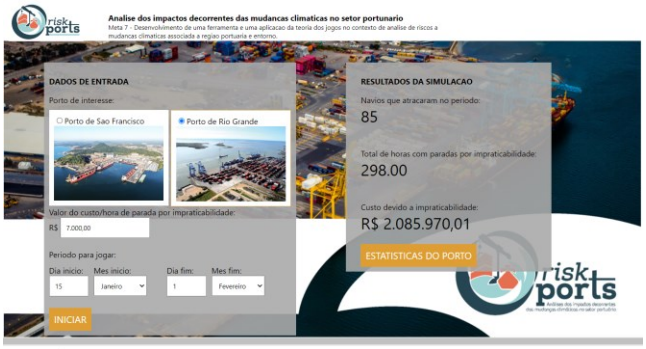

Figure 1: Software tool which implements game theory applied to the port management

This software is currently available to be utilized and can be accessed by any web browser using the following URL: https://cassiengine.org/risk_ports_teoria_jogos/. The game theory can be experienced considering that even based on the same inputs the output almost always varies once it is influenced by random factors, but which are within statistical coherence, maintaining the outputs within a range that may reflect a possible scenario from real world.

6. Conclusion

The proposed model was an initial attempt to evaluate the possibility to use the game theory to assist in port management. This model besides still in an initial stage of maturity based on its experimentation tough the developed tool it is possible to observe a possibility of usage for a better comprehension about how the ships arrivals and its costs may vary accordingly the period of the year and the port. This model still may be improved as soon as more data are available and also adjusted to utilized more variables that are already available in the dataset as the cargo and ships categories.

ACKNOWLEDGMENTS

This work was supported by the CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico - www.cnpq.br), Project RISKPORTS, Proc. No. 441818/2020-0, an entity of the Brazilian government focused on scientific and technological development.

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