ABSTRACT

MATHEMATICAL AND ECONOMICAL TOOLS FOR QUANTITATIVE MANAGEMENT OF TRANSPORT PROBLEMS

(INSTRUMENTE MATEMATICE ŞI ECONOMICE PENTRU MANAGEMENTUL CANTITATIV AL PROBLEMELOR DE TRANSPORT)

Habilitation thesis

The paper that constitutes the ability thesis presents synthetically the main scientific results that I obtained in the scientific research activity between 1996 and 2018. In 1996 I was awarded the title of PhD for the doctoral thesis titled "Analysis and optimization of port activities". This paper presents some of results obtained after obtaining the PhD degree and it was elaborated in accordance with the national regulations in force

Licenses acquired in Mathematics (first) and in Cybernetics (second) have allowed me to approach the field of maritime transport and port logistics from an optimization perspective with very special mathematical tools.

The field of maritime transport and port operations provide services for the transport of huge quantities of goods and therefore optimizations, when produced, can generate huge revenues. Although they are highly bidding for specialists, they often require specific developments with a variety of peculiarities and therefore may not have come in the attention of specialists in Operational Research (abbreviated OR). An explanation can be the following, with axiomatic value:

- When the economic criterion conflicts with the ship's safety criterion, the decision gives priority to the safety criterion!
- When weather conditions do not allow safe passage through the passport (sea entry port), it closes in order not to endanger the ship, cargo, or port infrastructure! From an economic point of view, the days when ports are closed generate large losses for transport actors and cause dysfunctions, but once again, safety and security criteria prevail.

In the first three decades after the launch of linear programming (1950-1980), only 40 scientific papers were produced in OR field. This is surprising because Koopmans launched the maritime field among the pioneering domains in terms of the use of mathematical optimization algorithms. As shipping operates with large volumes of commodities, high fuel and time consumption, long-haul routes, and port platforms of the 4^{th} generation have steadily grown, generating huge costs after 1990's streamlining has led a continued growth of interest for cost reduction and optimization. Thus, the increasing of the scientific interest could be explained more than three times. The content of this paper is in line with the following actual trends in OR :

- widening the scope of Operational Research to the field of port logistics or maritime transport activities;
- the approach of problems for which optimization solutions already exist, with methods of Numerical Analysis. From the comparative analysis of the computational performances and the results of the two categories of methods (classical or new methods of numerical analysis), often the usefulness of the new approaches has emerged.

For this reason, the two current research directions preoccupied me a lot and the results presented here, heading towards:

- improving the performances of algorithms already developed by getting as close as possible to the real phenomenon, by refining the significance of the variables and parameters involved in a containerized transport problem;
- identifying new theoretical chapters of numerical analysis that could model port or shipping logistics problems. In this case, changes, simplifications, and essentials must be made in both areas for the best possible fit.

The habilitation thesis is structured in four major chapters:

1. Minimize ballast navigation: hypostases and paradox,
2 Optimizations in the field of Port Logistics and Containers Transport,
3. Economic Impact of Maritime Ports in Constanta County,
4. Algorithms for the numerical solving of Inconsistent Systems of Linear In-equations.

In Chapter 1 I presented the Koopmans's Problem that was formulated and published in 1939-1942, i.e. before Danzig published the SIMPLEX algorithm, so it can be considered the zero point of Operational Research. The starting point was the transport of war goods during the Second World War in the United States in England and Return (Koopmans, 1947), (Koopmans, 1949). Since the quantities of products transported were different in both directions, ships sometimes circulated empty or incompletely loaded (partly in ballast). As the entire trip was under continuous threat of submarines and German aviation, it was the question of ensuring such use of means of transport in order to minimize the unused transport capacity, measured in tonne-kilometers, and implicitly to reduce the period the ship's exposure, and consequently the loss of vessels. The concept of ballast has changed, and as at present, shipping ships are changing their cargo from one port to another. I have also presented other models that aim to minimize ballast gait. I included here also the "paradox of transports" because the problem “more much for less”, is shown to have a solution if and only if there exists free transport space, so if there exists a ballast!

Chapter 2 is dedicated to the mathematical modeling that we have developed for various container shipping and terminal location issues. The field of maritime transport is a very specific area: decisions have a higher degree of difficulty because they are often taken in a very short time, the choices sometimes have consequences in the life-dead alternative, the sea routes change during the march and require a rapid change to avoid a storm, (any delay complicates the maneuver, etc.). Applying the Operational Research models, results can be obtained if the time period to which the data relate is very short, so that all the coefficients involved in the optimization are constant, or if stochastic models are applied.

I presented in the paper the case study for the best location of an intermediate storage platform in Constanta County.

There are three seaports and four river ports in Dobrogea. Thus, in addition to the Constanta sea port, which provides the largest volume of cargo, its satellite ports are also of particular importance: Mangalia (38 km south of Constanta marina) and Midia (25 km north).

Regarding domestic transport, we find that there are three representative river ports: Murfatlar (located at km 25 on the right bank of the Danube-Black Sea Canal), Medgidia (located on the right side of the Danube-Black Sea Canal at km 37.5) and Cernavoda (situated on the right bank of the Danube). The problem was solved with a genetic algorithm that established that the Midia port gives optimal location.

We further adapted the classical transport problem to container shipping and applied an original algorithm to solve it. The results of the application of Han's algorithm, the application of Han Generalized algorithm and the Simplex algorithm are presented. Critically analyzing the solutions we have applied the viability of the new algorithms.

In Chapter 3 I presented the first economic impact study of the Romanian maritime ports conducted by me, coordinating a team of specialists from the two Constanta universities, the Ovidius University and the Maritime University. The study referred to the 2000-2005 period and extrapolations were made for the period 2006-2010. To generate Impact Multiplication Indicators we used MARAD PortKit software produced by the US Maritime Administration.

The economic impact of a set of economic activities estimates the social and economic effects produced by them in a certain geographical area. If the area is located near the seas or oceans, then the effects generated are all the more important, knowing that more than 75% of the world's population lives in the coastal area.

The regional and local economic effects are grouped as follows: direct impact (main) and the secondary impact, formed in turn from the indirect impact and induced impact.

The result of economic activities carried out by firms providing different port services directly related to the transfer of goods within the port system or operating on port platforms in shipping-related fields that will be further categorized as Port Industries, is called direct impact in the literature. The economic indicators through which the Direct Impact was quantified are: turnover, number of employees and annual average income of employees in the maritime and port sector.

All activities in the analyzed region that interact economically with primary activity, in this case the maritime transport activity are indirect impacts. These can carry out their activity and independently, in the absence of ports in that region.

The impacts induced, even if they are a result of economic activities, are quantified by purchases of goods and services for personal use by employees (employees) of port and port industry companies.

The secondary impact consists of the multiplier effect generated in that economic area by the activities included in the main impact, activities dependent on the existence of the port.

Chapter 4 contains the mathematical fundamentals of the algorithms used in Chapter 2, namely Han's (H) algorithm, Han's (GH) algorithm generalization, Modified Han algorithm (MH)

, and the extended Kaczmarz algorithm (KE). Some of this are elaborated by our team as follows: Modified Han (Carp *et al.*, 2015), Regularized Han (Carp *et al*. 2014). For MH we introduced a general algorithm for projection (at the first step) (Carp *et al*., 2016). We also developed a set of applications for MH (Carp *et al*. 2018).

In this chapter, I presented Han-type algorithms for numerical solution of unbalanced and inconsistent transport problems. Initially, the transport problem is equivalently transformed into an inconsistent system of linear inequalities. Then Han original algorithm, as well as our development (Modified Han and Regularized Han) act as an iterative solver for these inconsistent systems of linear inequalities and provide a least squares solutionIn this way the inconsistent transport transport problems can be solved, so the whole range of solving transport problems is expanding!

The multidisciplinary of the research in the area of Applied Mathematics for Maritime Transport and Logistic required the collaboration with specialists in Numerical Analyze, in Maritime Transport, in Port Activities.

The research results were capitalized by:

a. books, manuals, application guidance and laboratory: 20 (to publishers like Lambert, AGIR, Editura Didactica si Pedagogica, Printech, Nautica, Societatea Autonoma de Informatica, Ex Ponto, Economica),
b. introducing new disciplines to undergraduate and master study: 1undergraduate, 1 Master
c. published articles:
    - indexed in the ISI Thomson Reuters database: 8
    - national journals and volumes of scientific events indexed in BDIs recognized by CNATDCU committee: 11
    - in national journals and volumes of non-indexed national and international scientific events: 35
d. research themes as project director:4
e. papers published in prestigious publishing houses and congresses
    - Lambert Academic Publishing: 1
    - Archives of Transport of Poland: 1
    - Journal of Costal Research (Springer): 2

f. citations of the elaborated papers (in magazines only) -12 citations
g. scientific guidance and coordination of students
    - student scientific sessions ()
    - developing diploma projects

Evolution in teaching career:
2016- 2000 professor- Constanţa Maritime University,
1997-2000 associated professor- Constanţa Maritime University,

1991-1997 lecturer- Constanţa Maritime University,
1990-1991 assistant- Constanţa Maritime University,
1979-1990 assistant - Institute " Mircea cel Batran" Constanţa,
1974-1979 high school teacher, High school Nr.2, Constanţa.

Participation in Education Area of Activities:
2016, 2017 two internships of a Visiting Professor, Gdynia Maritime Academy Poland, Faculty of Navigation and Logistics;
2007-2010 National Representative for the Working Group to Adult Education, European Commission ;
2010-2009 General Director Romanian Ministry of Education;
2009-2007 Director of National Center for Teachers Continuous Education, Bucharest.