ADVANCES IN MODELING PROBLEMS OF RESOURCE ALLOCATION

Marin ANDREICA[1], Eugen ALBU[2], Loredana Ionica STAN[3]

Abstract

The paper highlights progress in shaping resource allocation problems.

Key words: *models, resource allocation, objective function, distribution*
JEL classification C51, C61, D04

1. INTRODUCTION

Whether they deal with operational or outlook problems, managers have to confront a major issue regarding harmonization of existing or virtual resources with the targeted goals. This translates in assigning resources to specific objectives, so that the organization's economic performance is maximized. The problems which arise from the resource allocation process have certain characteristics. They have to answer to a set of inquiries such as:

1. Which are the resources that need to be allocated?
2. Availability of these resources ? (supply)
3. The amount of resources needed? (demand)
4. The suppliers?
5. The beneficiaries?
6. The period of time predicted for allocation?
7. Restrictions?
8. Objectives and strategies?
9. Consequences of allocation process?
10. The economical status?

The answers to these questions become components of the resource allocation problems. Moreover, the diversity in their status leads to different classes of allocation problems. Therefore, a classification can be made, based on criteria such as:

- ***Relationship between supply and demand*****:** *problems regarding surplus, balanced and deficit resources.* The last class of problems can also be subdivided in:

-global allocation**,** which establishes the amount from the available resources that can be assigned to every beneficiary

-resources assignment, which makes correspondences between beneficiaries and suppliers according to the solution of the first sub-problem

- ***The number of resources*** subject to allocation**:** *one or several resources***,** which can also be *homogen* or *heterogen***.** The homogen type can be *substitutable* (partially or totally) or *non-substitutable.*

Moreover, the *resources* can be *perishable or not, storable and non-storable.*

- If the resources are *perishable/non-perishable*, it may be needed to take into consideration the ***time factor*****,** which is a **non-storable** resource. In this case, the problems will consist in *dynamic allocation* and will aim to identify solutions to harmonize the supply and demand during the total period of time requested for allocation.

[1] Prof.dr.Bucharest University of Economic Studies, marinandreica@gmail.com
[2] PhD Student at The Bucharest University of Economic,, albu.privat@yahoo.ro
[3] PhD Student at The Bucharest University of Economic, stan_ionica_loredana@yahoo.com

- ***Time horizon*** *in* connection with the *hierarchic level* where the allocation process is decided leads to the following types of allocation problems: *strategical, tactical and operational* problems.
- ***The number of performance evaluation indicators*** leads to *multiple criteria* problems or *single criterion* problems.
- The ***number of variants*** for components in the allocation problem and the ***possibilities to quantify the consequences***, leads to classification of allocation problems in conditions of *uncertainty, certainty and risk.*
- ***The origin of resources (suppliers)*** generates *allocation problems with one source* or *several sources*. Regarding the one source case, the problem is a global allocation issue and it involves determining the amount of the total which is to be assigned to every beneficiary. If there are several resources, the allocation problem is mainly a *distribution problem*: with intermediate centers or a direct one, if the suppliers and beneficiaries have a direct relationship.
- ***Correspondences between suppliers and beneficiaries*** lead to problems with *biunique correspondences* or *multiple correspondences*, which are *repartition problems*

2. CORRESPONDENCES BETWEEN PROBLEMS AND MATHEMATICAL MODELLING METHODS. CLASIFICATIONS

Formulating allocation resources problems can be done in many ways, depending on the objective and the context of allocation. In attempting to sketch these problems, one will discover that in a hierarchical organization, the allocation process takes place either on different levels or at the same level. Generally, the term „allocation" implies the existence of an entity which decides who takes from who, how much and furthermore, to whom and how much it gives. This entity can be outside the organization or within it, but in both cases, it is responsible with coordinating the process where the allocation problem has appeared. Otherwise, we would witness the old proverb „the lion's share...". Therefore, in most of the resource allocation problems, there is a superior hierarchic level who manages the framing of resources (homogene, substitutable, etc) and an inferior level, where the emphasis is on ensuring the minimum amount of resources needed, the functional and structural correlation, the local performances of allocation. The allocation strategy is established on the superior hierarchical level, aiming for maximum performance on the allocated resource unit.

The paper of Andreica, M. (2011) details the architecture of such problems, aiming to put together under the same theme several terms from the operational research, such as problems of assignment, distribution, transport, etc, which apparently serve other economical objectives and couldn't otherwise fit into the research allocation theme.

The existence of a diversity of terms regarding the resource allocation problems comes from the emphasis sometimes put on the solving method, and not on the economical phenomenon from which the problem arises. Therefore, the same problem has different denominations, depending on the profession of the person in charge to solve it (economist, IT specialist,mathematician, etc).

The most eloquent example in this sense is the term „transportation problem", found in the operational researches. For an economist, it's a problem of resource distribution, with one or more suppliers and beneficiaries.For mathematicians, it is a transportation problem, because it is solved with models and specific algorithms. If it has intermediate centers, it is seen as a distribution problem with intermediate centers, and for mathematicians it is a transportation problem with intermediate centers.

The attempt to even the terminology used in this field is based on an indisputable reality: most of the problems are extracted from the economic activity and the results return back to the economical field. Therefore, the starting point must be **the formulation of the economical problem.**The wording **must respect the fundamental elements in the logic of problems. A correct formulated problem is half solved**!If the person solving the problem uses mathematical models method, than the problem's formulation must provide the data needed to build the model. If the problem is to be solved by an ordinary person, than the formulation has to be made according to the person's level of knowledge and understanding.

The allocation problems are usually complex or large sized. The complexity arises from the uncertainty present in the evaluation of several parameters or relations between variables, from the risk associated with the allocation process in the sense of unfavorable consequences, and from the big number of variables, parameters and inter-relations, which generates a high-complexity calculations. All these premises lead to finding means to decrease the complexity in order to better solve the problem; the most successful method for this is mathematical modeling. Therefore, the methods of operational researches are used for solving complex allocation problems. With these methods, models for research allocation can be developed; in the process of solving them, one has to address algorithms with rapid rate of convergence and acceptable degree of precision. For solving algorithms, one uses informatic programs designated in this purpose.

To summarize, a person in charge with solving economic problems regarding resource allocation must have know how in the **economical field**, know how regarding the **logic** of problem solving so that he can accurately formulate the issue, knowledge on **mathematical modeling** and mathematical model building, how to solve mathematical models based on **algorithms** and basic knowledge on how to use **IT programming** for solving these models based on internal algorithms. Also, one must have meta knowledge (at least level 1) which can allow him to choose the appropriate modeling method, the most efficient algorithm for solving the model and the appropriate IT solution which integrates the chosen algorithm (according to the available calculating technique and the desired performances).

3. PROBLEMS OF RESOURCES DISTRIBUTION

As regard to the problems concerning the resources distribution,it is commonly agreed that they were more often encountered in the centralized economy. These type of problems involve making correspondences between one or more suppliers and more beneficiaries.
In real life economy there are many problems regarding distribution;the simplest of all is the distribution of a single resource.This is an elementary distribution problem, and many problems with several independent resources can be cut down tot this type. For the sake of simplicity in the solving process, the unbalanced problems are equilibrated by introducing fictional suppliers or beneficiaries who appear in the function with zero cost, and in this manner, the conditions for equilibrium are fulfilled.

As a result, the distribution problems, seen through modelling methods, represent *variants of the transportation problem,* such as: unbalanced, with prohibited routes (when the restriction to distribute a resource from a certain supplier to a certain beneficiary arises), with bounded centers (when there are more suppliers in the same place), with groups of bounded centers (when the beneficiaries from different bounded centers all take resources from deposits of a certain company), with intermediate centers(when the resources are temporary stocked before going from the suppliers to the beneficiaries), tridimensional (when more resources are being distributed), with partially substitutable resources, with limited transportation capacities, etc. When the resource is uneven, homogenization coefficients must be introduced (transformation of the supplier's resource i in the supplied resources h (i=h),), which is considered standard .

 If the transportation capacities D_{ij} from the supplier i to the beneficiary j are taken into consideration, then the problem's solution includes the resource's transportation plan.

 When the problem's dimension is large, it is possible to decompose it into two sub-problems, with the first being the distribution of resources to intermediate centers, and the second concerning the elaboration of a plan to supply the beneficiaries with resources from the intermediate centers.

4. PROBLEMS REGARDING THE HARMONIZATION OF OBJECTIVES WITH RESOURCES

There is a class of problems which can be seldom found in the real life economy, that focuses on harmonizing the existing resources with the targeted goals in a given period of time. If the given period is a year, a semester or a month, it can lead to planning problems. In the case of a short time period, problems regarding ordering or operational resource allocation can occur.

The problems concerning planning have as goals the creation of products and value indicators under given technical conditions, resource supplying and existing technologies, so that the economical performance is maximized, also taking into consideration the following aspects:

- Production nomenclature and the new products that are to be assimilated
- The required resources (technical capacities,work force, basic and raw materials
- The available amount from these resources
- The production technologies
- Coefficients of specific consumption
- Calculation of the economical indicators
- Objectives, performance criteria

Usually, these planning problems can be solved through linear programming. In the economic environment, there are also other modelling methods used for solving them, such as linear-dynamic programming, stochastic programming, numerical simulation and fuzzy mathematical programming. The progress obtained through this methods is highlighted in the paper „Microeconomic forecasts" (Andreica,M. 2011).

The paper „*Modern approaches of forecast management for economic organizations"* (Andreica,M., Popescu,M.E.,Micu, D.,2016) develops this class of problems in an adaptive one to the economical environment's evolution. The explanation is based on the fact that economic systems, unlike others, are linked to the market's evolution, to the overall economic and social environment, which are in a continuous and sometimes unpredictable evolution at the moment of modelling. Therefore, after the elaboration of optimization modelling and/or evolution simulating, it is imperative to define the parameters which are going to be altered in order to adapt them to the „gearing" and also to define the rules governing the adaption process. Usually, the trajectories are customized through measurable goals which can be partially or entirely altered. The vulnerability of the solution structure can be tested by analysis of their sensitivity and stability.This can be easily accomplished if the development programmings are based on optimization models .

The introduction of imprecision (relaxation of inexact data) leads to ***robust programming,*** where the unknown coefficients and (or) the constant terms vector are vague sets. According to Soyster, the robust programming problem can be replaced by a set of inexact programming problems. Therefore, it can be stated that the vague modelling is a compact representation of a deterministic models set.This is the method that allows the decision maker to deal with complexity:as it grows, the process representation scale decreases, details disappear enhancing the essential data.Manipulation of inexact data nuances the decision, leading to ***flexible programming (***programming with restrictions and vague objectives).

The fuzzy linear programing methods are extremely elaborated, therefore one must analyze if by using this methods, the expected results compensate the additional efforts , in comparison with the conventional optimization modelling. Moreover, although these methods manage to capture imprecision in the problem's formulation or in the parameters quantification, in the end, solving the problem is still based on traditional solving methods.In this way, starting from imprecise data or formulations gets us to precise results. The results' imprecision degree can be quantified in some methods case, although the solving method doesn't always directly associate it.

5. ALLOCATING RESOURCES ON MORE HIERARCHICAL LEVELS

Often, allocating resources on more hierarchical levels is taken as a separate problem, appart from other allocation problems (planning).

The planning methods for holdings contain a set of coupling restrictions at the central level and a distinct model for harmonizing objectives with resources at each subsidiary's level. The coupling restrictions aim to reach the goals set for the holding, regarding the economical indicators and the cooperation between subsidiaries indicators.

In order to solve them, iterative planning methods are used, also known as decomposition methods for large systems optimization, together with Dantzig-Wolfe, Rosen, Benders methods etc. (Lasdon,L, 1975).

The iterative planning methods decompose the global model matrix in sub-matrices for each of the subsidiary, setting up local models.

Below is the *general scheme for allocating resources on two levels*:

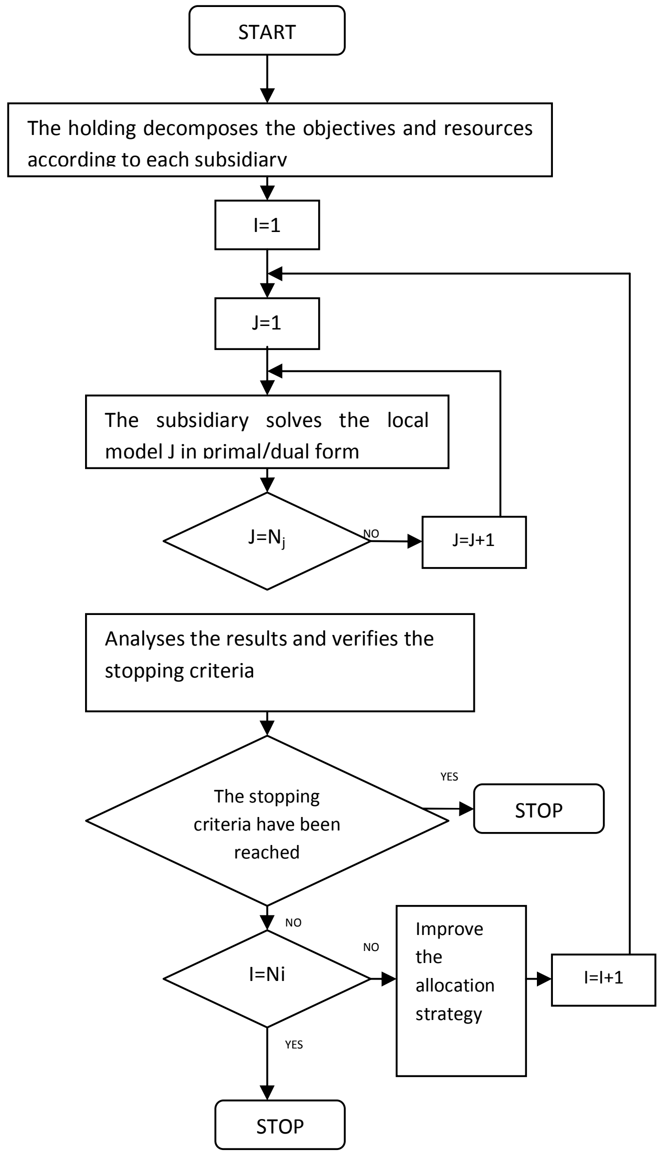

Fig. 1 General scheme for allocating resources on two leves
(Source: adaptation after Andreica, M. 1988)

6. CONCLUSIONS

Analysing the functionality of models for allocating resources on two levels, the following can be observed:
First, all of them start the initial iteration from a set of *command and state variables*, which are predefined by the decision makers according to their own experience.The values given must ensure the restrictions' compatibility and they must provide an admissible solution for each subsidiary (minus DOBSY)

The performance function's final value doesn't depend on the initial allocation,but there is a possibility to reduce the number of iterances by making an initial allocation as close as possible to the optimum one.

In case there are more alternatives who meet the required stopping criterion (optimum level), then the iterative process will lead tot the one closest to the initial plan.

Secondly, the problem that imperatively needs to be solved is the decrease of the iterances number and the acceleration of their convergence (if their convergence can be proved), and within an iterance it consists of the decrease of the work volume needed to solve the problems at the subsidiaries' level.

As the complexity and dynamics of the economical phenomena increases, there are some tendencies that can be observed: creating new concept models that can craft the complexity of the current processes; creating multilevel hierarchic management systems that can perform in real time; support offered by the current systems for decision making in real time.

REFERENCES

1. Andreica, M., Andreica, C.,Micu, D. (2016)-*Abordări moderne ale managementului previzional*, Editura ASE, București
2. Andreica,M**.,** Resteanu, C., Trandafir, R. (2014)-. Parallel and Distributed Software Assessment in Multi-Atribute Decision Making Paradigm Studies in *Informatics and Control*, Vol 23, Issue 2, p.133-142
3. Andreica, M., Andreica, C.,Micu, D. (2014) – Foresight management support system for SMEs, *Proceedings of the International Conference „Sustainable development in the economic instability conditions"*, 3rd Edition, Cybernetics MC Publishing House, Bucharest, p 23-27
4. Andreica, M., Popescu, M.E. şi Micu, D. (2014) – Progress in the adaptive forecast management of the economic organizations, *Proceedings of the 8th International Management Conference „Management challanges for sustainable development"*, Bucureşti, p. 378-388
5. Andreica, M., Andreica, M. E. ,Micu, D. (2013) - Conclusions on modeling development programs within economic organizations, *Proceedings of the 7th International Management Conference "New Management for the New Economy",* Bucureşti, p. 56-62
6. Andreica, M. (2011) - *Previziune microeconomică*, Editura Cibernetica MC, București, Ediția a doua,
7. Andreica, M, Partachi,I, Andreica C, Andreica, R,(2011) *Previziunea in afaceri,* Editura ASEM Chisinău, Editura Cibernetica MC, Bucuresti,
8. Andreica, M., Nicolae, D., Andreica,M.E,(2009)-Working out forecasts on the Basis of Statistical Extrapolation Principle, In *Economic Computation and Economic Cybernetics Studies and Research,* Nr.2/Vol. 43, pg.85-108
9. Andreica C., Andreica M., Andreica R., Miclăuş I. şi Ungureanu M. (2007) - Conclusions on Using the Statistical Methods in Forecasting the Structure Evolution of an Economic Indicator System, *Economic Computation and Economic Cybernetics Studies and Research*, Nr. 1-2,
10. Andreica, M. (2006) *Gestiunea previzională a societăților comerciale*, Editura AISTEDA, Bucuresti,
11. Andreica,M., Turlea,C., Andreica, R.,Jantea,L.(2003)-*Strategii de finantare a IMM*, Editura Cibernetica MC, Bucuresti
12. Andreica, M. (1988) - *Metode și modele de planificare*, Editura Științifică și Enciclopedică, București,
13. Andreica, M., Stoica, M. şi Luban, F. (1998) - *Metode cantitative în management*, Editura Economica, București

14. Andreica, M.E., Andreica, M., (2014)-Forecast of Romanian Industry Employment using Simulation and Panel Data Models In *Romanian Journal of Economic Forecasting,* Vol. XVII nr. 2, pp.130-140
15. Andreica, M.E. (2013*).* Early warning models of financial distress. Case study of the Romanian firms listed on RASDAQ, *Theoretical and Applied Economics*, Vol. XX No. 5(582), pp. 4-12
16. Andreica,M.E.(2013)- Modele de avertizare timpurie a firmelor neproductive.Studiul de caz al firmelor româneşti listate pe RASDAQ , *Economie teoretică şi aplicată, Volumul XX , No. 5(582), pp. 4-12*
17. Andreica, M.E. (2011)-*Modelarea deciziilor în operațiunile de leasing,* Editura Cibernetica MC, Bucuresti
18. Andreica, M.E. (2009). *Predicting Romanian Financial Distressed Companies, Advances in Economic and Financial Research* - DOFIN Working Paper Series 37, Bucharest University of Economics, Centre for Advanced Research in Finance and Banking – CARFIB
19. Kornai, J. (1974) - *Antiequilibrium.* Editura ştiinţifică, Bucureşti
20. Kornai, J. şi Liptak, P (1965) - *Two-Level planning*, în Econometrica, nr.33
21. Lasdon, L. (1975) - *Teoria optimizării sistemelor mari*, Editura tehnică, București
22. Stoica, M., Andreica, M., Nicolae, D, Andreica, R.- *Multimile subtile si aplicatiile lor*, Editura Universitara, Bucuresti,2008;
23. Stoica, M., Andreica, M., Nicolae, D. şi Cantău, D. (2006) - *Metode și modele de previziune ecomnomică,* Editura Universitară,București
24. Stoica, M., Andreica, M., Sandulescu,I.(1989)- *Introducere in modelarea procedurală*, Editura Scrisul românesc, Craiova
25. Stoica, M., Cătoiu, I. şi Raţiu-Suciu, C. (1983) - *Experiment si euristica in economie,* Editura Stiintifica si Enciclopedica, București
26. Stoica,M., Rațiu-Suciu,C., Andreica,M.(1982)- *Jocuri de întreprindere*, Editura Stiintifică si Enciclopedică, Bucuresti,
27. Zadeh, L. A. (1975) - *Fuzzy Logic and Aproximate Reassonning*, Synthese, vol.30