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Structural Engineering

Energy dissipation - an indicator of potential degradable structural items

Nicolae Daniel Stoica

Abstract – Determining the damage regions of a structure (even it is only about the tendencies) concerning all structural vulnerabilities, otherwise than using building physical natural models and testing them in laboratory conditions, just using computational models and structural design programs (ETABS, SAP2000) is a goal of all specialists in the field.

Keywords – dissipation, energy, ETABS, virtual, work.

1. INTRODUCTION

Although used for thousands of years, the masonry as a building material is still not sufficiently well known. For most young engineers, the using of masonry for structures (in the form of ceramic blocks or solid bricks, various mortars, unreinforced or reinforced or confined) by all the calculations requests to be made, according to both Romanian codes P100 (Eurocode 8) and CR6 (Eurocode 6) begin to be easily avoided passing to other structural types.

Reinforced concrete theory provides answers much easier to understand and easier to apply, so it is more convenient to accept a reinforced concrete structure (a frame or dual one) instead of masonry building with structural masonry walls.

Generally speaking, when theorists cannot consistently establish a behavior theory (or a constitutive law) for a structural material and for the structures made with this material, appeals to testing models, preferably in natural scale.

Costs are absolutely significant and the models cannot be no matter how large, depending of the height of laboratories, shaking table surface and weight they can carry, etc. And it should be noted that no laboratory (usually private) will build a natural model directly on the shaking table, careless of the material engineered in the structure, because it means that during that period, the shaking table is unusable. It is not economically acceptable to have the shaking table "locked" because it must work to obtain funds for laboratories. Actual models are built in another area of the

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laboratory and then are moved on the shaking table. For this reason, the weight patterns cannot be higher than existing equipment can carry in laboratories.

Determining the damage regions of a structure (even it is only about the tendencies) concerning all structural vulnerabilities, otherwise than using building physical natural models and testing them in laboratory conditions, just using computational models and structural design programs (ETABS, SAP 2000) is a goal of all specialists in the field.

2. ABOUT THE USING OF ENERGY DISSIPATION

In what follows we try the comparisons between structural responses for real models and numerical models, determining a method to provide sufficiently clear answers and precise about the behavior and tendencies.

As a “tool” to work is preferably using a computer program very well-known and appreciated by specialists who have decades of testing and successive improvements: ETABS, in the latest 2013 version 3.1.3. Practically 99% of all the world's major buildings were designed with the program. After the appearance like mushrooms of dozens of similar programs, answers more or less similar, yet it is not hard to say that the "old" ETABS in a young shape version remains a leader of structural analysis tools. And that there is an inter-communication continues with similar oriented products, the same company offers unlimited solutions.

To determine the damage trends or tendencies, with structural responses in the form of dissipated energy (called virtual work, in the program) can get very specific information.

Using simplified calculations with strong seismic forces introduced as "unitary" or basic seismic base coefficient, regardless of the intensity of the forces, the program provides clear trends/tendencies of energy dissipation in the structure.

This is provided in percent and going the simple idea that any damage means to exceed 50%, low (50-60 %), moderate (70-80 %) or heavy (90-100 %) can form a general picture on the entire structure behavior.

Knowing the sensibilities or structural vulnerabilities, experts can focus their efforts in order to avoid or mitigate them so that they can be avoided local collapses and especially progressive collapses inevitably lead to general collapse, significant loss of lives and economic.

So after all the studies conducted and are presented in what follows, concluded that using structural responses provided in the form of dissipated energy is favorable for engineers and scientists.

Research purposes, starting from the information coherent and concrete can be made specific and complex computational models that provide answers clear enough for theorists to create rules, simple, easy to use and clear, instead of copying formulas given by various specialists from different areas of the world, using different units of measurement.

After you have used dozens of types of modeling, simple or complex, with a much more cumbersome responses obtained, it seems that the simplest form "picture" of energy dissipated in a structure (in this paper of masonry, but in the end it does not matter any type of structure or material) offers the most natural responses on upcoming degradation and especially areas where they will develop.

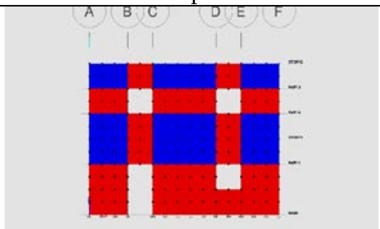
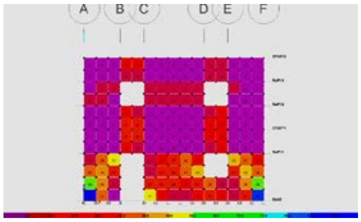
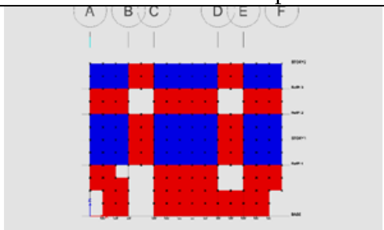
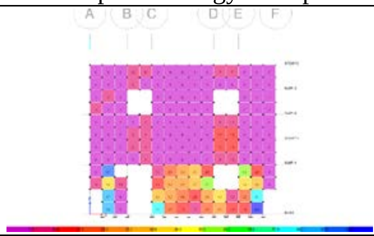
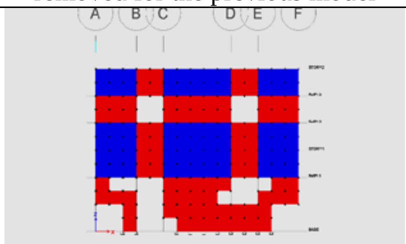
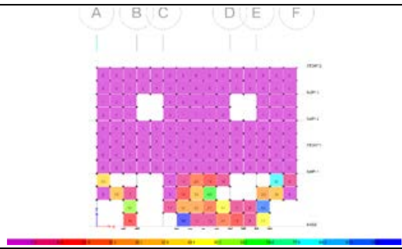
Next studies (four in number) come mainly from attempts to achieve numerical validations on seismic tests performed on shaking tables.

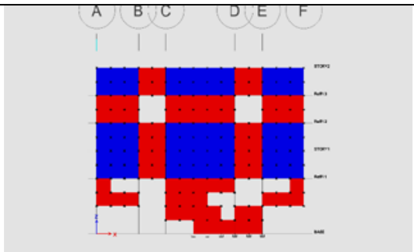
After determining failure modes and areas of sensitivities or vulnerabilities, engineers will know what they have to do.

3. STUDY CASES – VERSION 1 – WALL 1

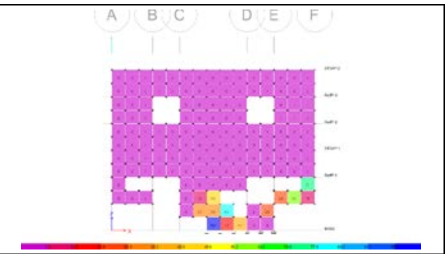
- Red areas models - real characteristics masonry spandrels and piers
- Blue areas models - infinitely rigid joints

Table 1 – Figures with models and energy dissipation

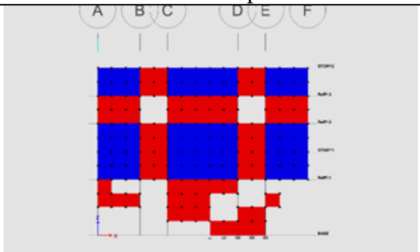
Structural Computation Model	Dissipated Energy [%]
	
Initial Model – step 1	Dissipated Energy in step 1
	
Model 2 – step 2 – the regions with more than 50% of dissipated energy were removed for the previous model	Dissipated Energy in step 2
	
Model step 3	Dissipated Energy in step 3



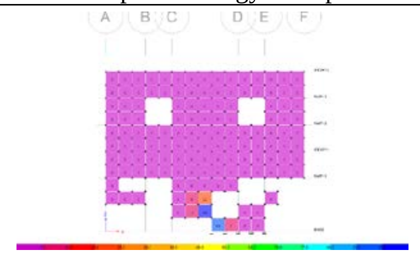
Model step 4



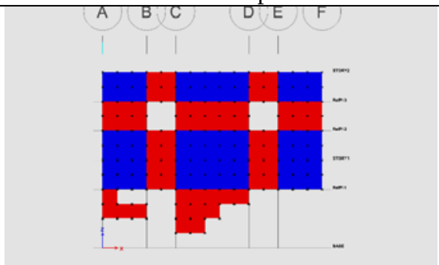
Dissipated Energy in step 4



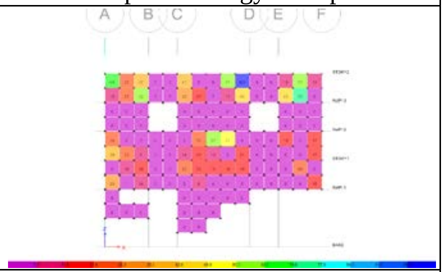
Model step 5



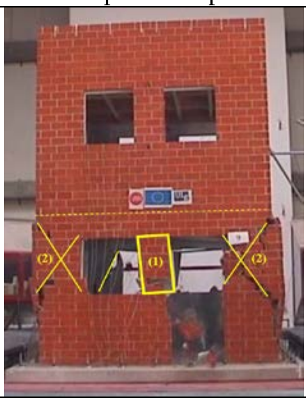
Dissipated Energy in step 5



Model step 6 – colaps total



Dissipated Energy in step 6



a - Real Model 1

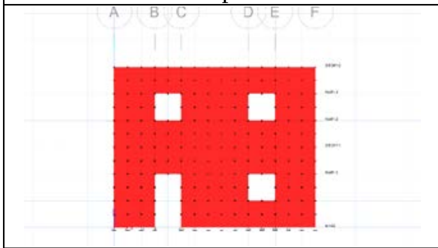
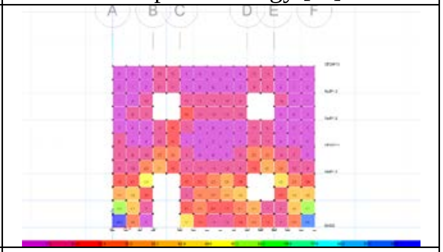
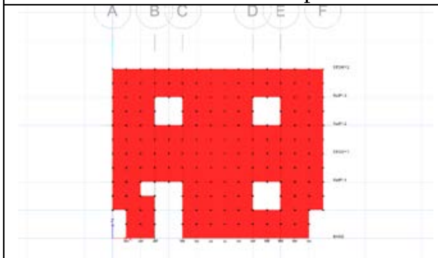
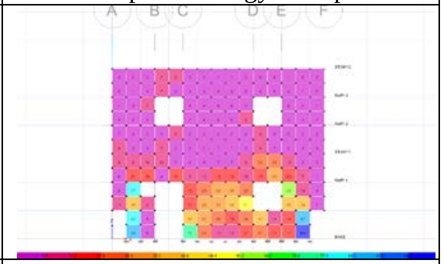
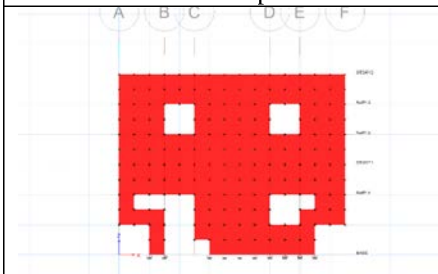
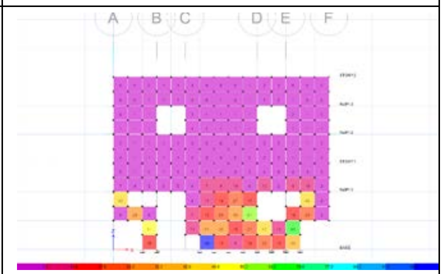
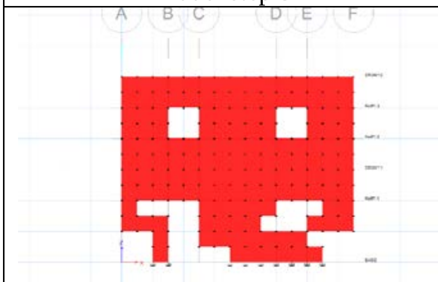
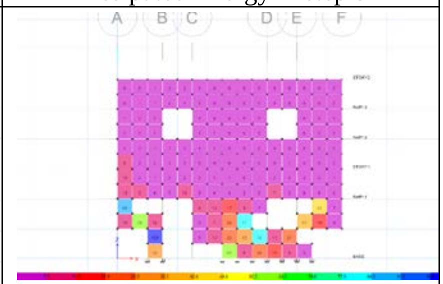
b - Real Model 2

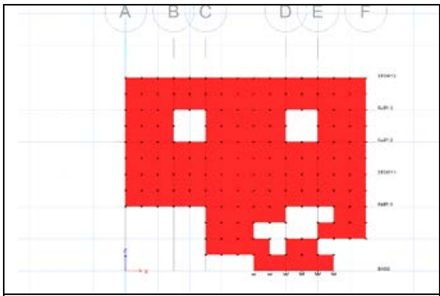
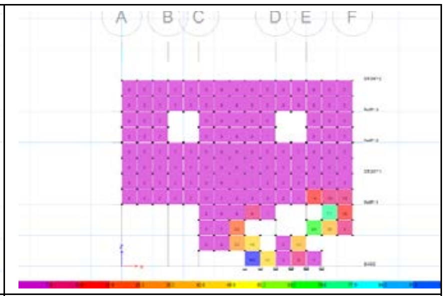
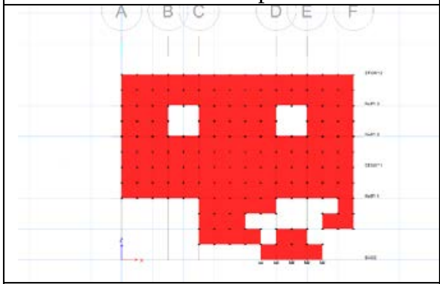
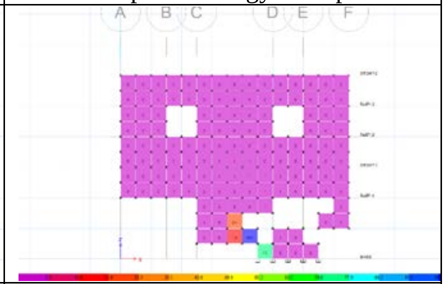
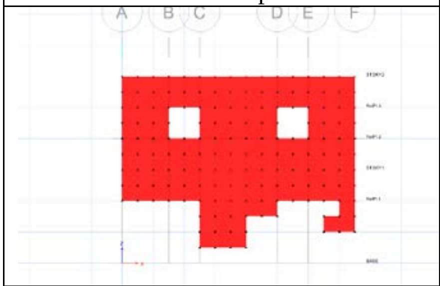
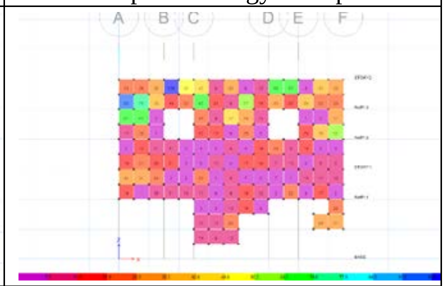
Fig. 1 - The colaps mechanisms of the models

4. STUDY CASES – VERSION 2 – WALL 1

- Red areas models - real characteristics masonry spandrels and piers
- Blue areas models – normal/real joints

Table 2 – Figures with models and energy dissipation

Structural Computation Model	Dissipated Energy [%]
	
Initial Model – step 1	Dissipated Energy in step 1
	
Model 2 – step 2 – the regions with more than 50% of dissipated energy were removed for the previous model	Dissipated Energy in step 2
	
Model step 3	Dissipated Energy in step 3
	
Model step 4	Dissipated Energy in step 4

	
Model step 5	Dissipated Energy in step 5
	
Model step 6	Dissipated Energy in step 6
	
Model step 7	Dissipated Energy in step 7

It is found that there is not a big difference between the models with rigid joints and the normal joints behavior both types of models are relatively similar in terms of dissipated energy. The difference consists just in one step more.

Between variant modeling with rigid nodes and the normal nodes are found with a difference of two steps before collapsing, but ultimately it is but a matter of modeling and model your response time. Finally, the behavior is correct, and the same. It can thus be considered, taking into consideration the calculations that follow, that whatever type of modeling local convergence and partial collapses the general collapse is the same.

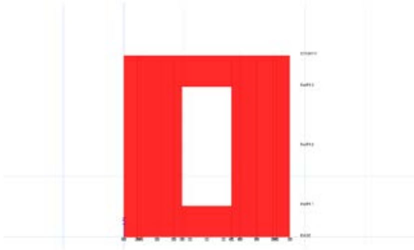
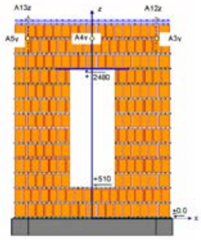
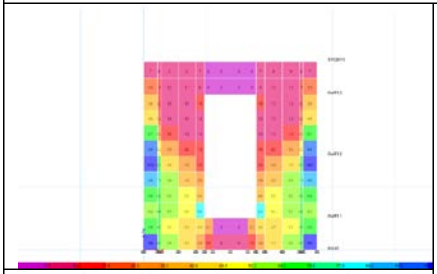
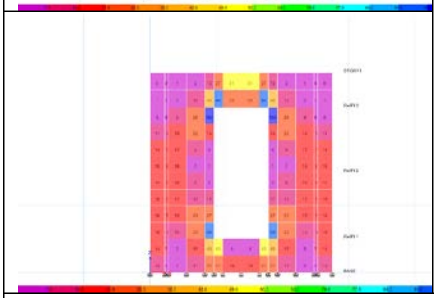
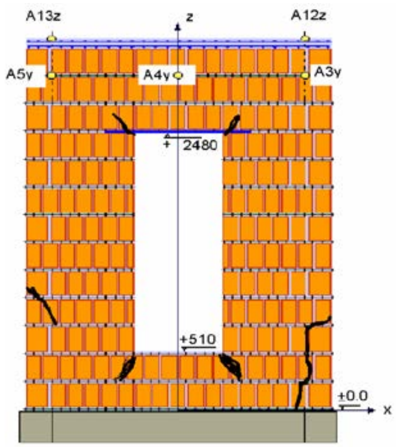
For these models tested at LNEC Lisbon Laboratory, the answers were similar for the real 3d models on the shaking table and the models “tested” in the ETABS program.

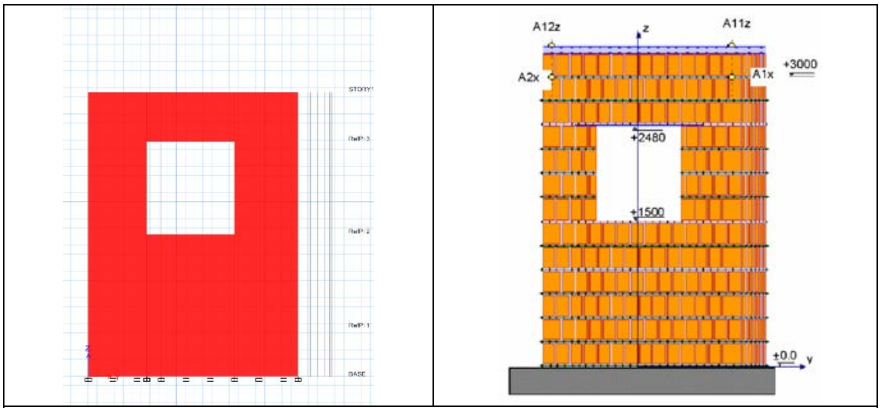
After the first sets of tests, both on shaking tables and by numerical procedures, the failure mechanisms obtained are more or less similar.

5. Study cases – version 3 – model 1 – ceramic blocks

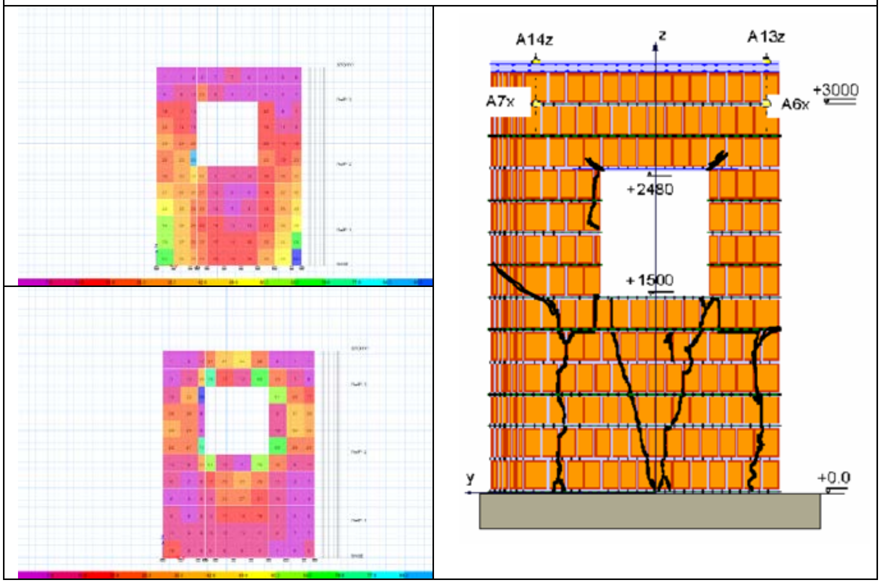
- Unreinforced masonry with ceramic blocks with RC slab

Table 3 – Figures with models and energy dissipation

Structural ETABS computation model	Real 3d model tested on the ISMES shaking table
	
Front wall – initial	
	
Front wall – after tests	
 	
Lateral wall - initial	



Lateral wall – after tests



In the tests carried out on the shaking table the following schedule were followed it resulted a template of collapse mode.

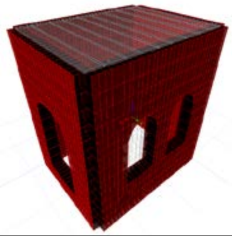
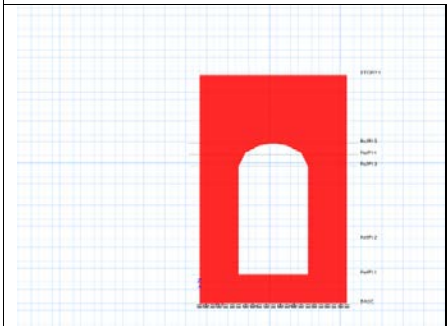
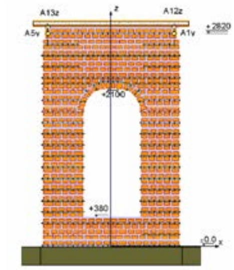
6. STUDY CASES – VERSION 4 – MODEL 2 – SOLID BRICKS

- Unreinforced masonry with solid bricks with wooden slab

One can observe a strong correlation between the shaking table faults and indications provided by the energy dissipated in models made with ETABS program.

Most fissures and cracks found are pierced. For solid bricks the fragile / brittle premature failures did not fiind. Usualy the solid bricks fissure later than the cored/ceramic blocks.

Table 4 – Figures with models and energy dissipation

<table>
<tr><td>Structural ETABS computation model</td><td>Real 3d model tested on the ISMES shaking table</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Front wall – initial</td></tr>
<tr><td></td><td>
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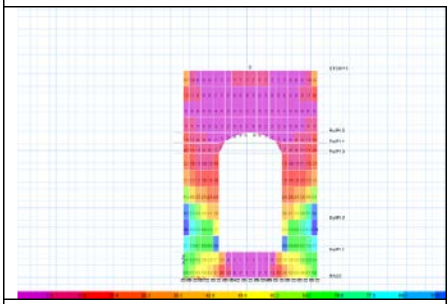
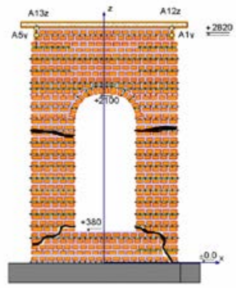
<tr><td colspan="2">Front wall – after tests</td></tr>
<tr><td></td><td>
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<tr><td colspan="2">Lateral wall – initial</td></tr>
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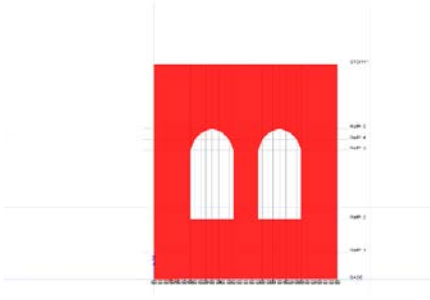
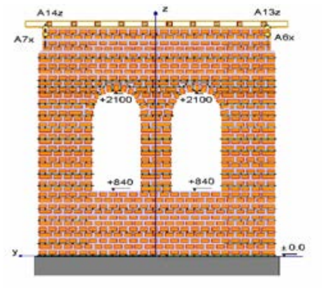
<tr><td></td><td>
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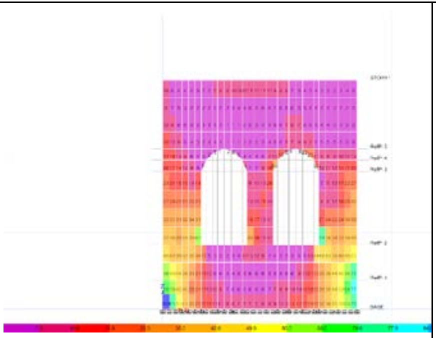
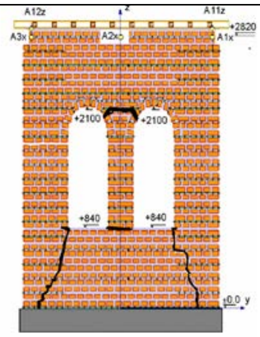
<tr><td></td><td>
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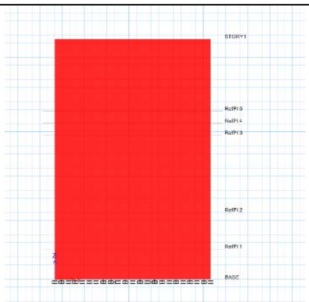
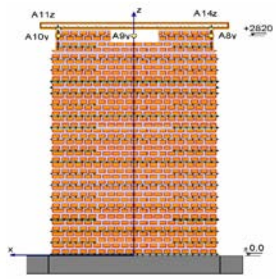
<tr><td></td><td>
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<tr><td colspan="2">Rare wall after tests</td></tr>
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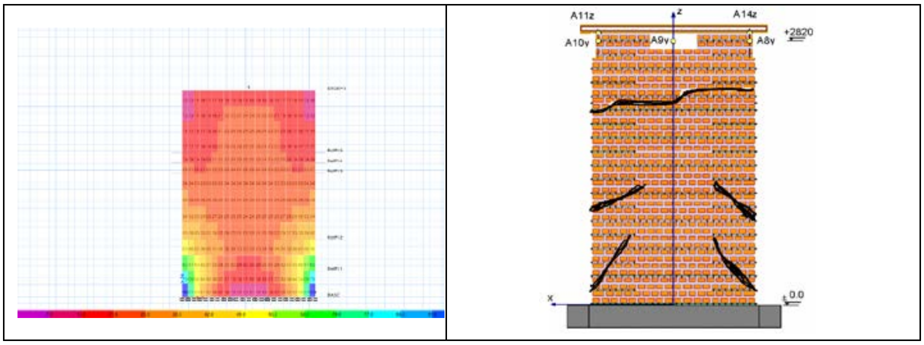

In the tests carried out on the shaking table the following schedule were followed it resulted a template of collapse mode.

7. GENERAL CONCLUSIONS

Using a numerical tool - the program ETABS 2013 - models were made similar to the real 3D structural model analysis carring onto shaking table.

It is found that the structural responses of the 3D system analysis form of the energy dissipation pattern provide sufficiently close the colapse tendencies like in the real 3D shaking table procedure.

It is estimated that in the future, based on dissipated energy paths, depending on the size of the finite element (FE) using numerical models provides sufficient information about the structural vulnerabilities, so to avoid the realization of real expensive models.

It is found that the structural responses of the a 3D system calculation by the form of dissipated energy provide sufficiently close the same results to what was found in the real model.

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Influence of the Actual Seismic Code Provisions P100-1/2013 on the Progressive Collapse Behaviour of an Old 13-story RC Frame Building

Teodora S. Moldovan, Adrian G. Marchiș, and Adrian M. Ioani

Abstract – **Based on Applied Element Method (AEM), the resistance to progressive collapse of a typical 13-story RC frame building designed according to the actual Romanian seismic code P100-1/2013 is evaluated. In order to validate the AEM approach, the experimental test performed by Yi et al. (2008) on a planar frame is modelled in the Extreme Loading® for Structures (ELS®) software. The numerical results show a good agreement with the experimental ones. Following a nonlinear dynamic analysis, recommended by the GSA (2003) Guidelines, it is found that the 13-story model is not expected to fail when a corner column is suddenly removed. Moreover, the structure is able to sustain a much higher load, about 255% of the standard GSA loading.**

Keywords – **Applied Element Method, Extreme Loading® for Structures, nonlinear dynamic analysis, progressive collapse.**

1. Introduction

Progressive collapse is defined as the spread of an initial local failure from element to element resulting, eventually, in the collapse of an entire structure or a disproportionately large part of it [1]. In 1968, in London, a gas explosion from the 18th floor caused the partial collapse of the Ronan Point Building. This event was due to the lack of structural integrity, there was no alternate load path for redistribution of forces resulted from suddenly failure of a bearing wall. Recently, in Romania took place two gas explosions, in an apartment building from Zalău (2007) and in a public building from Sighetul Marmației (2012), resulting human casualties and significant material damages.

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The General Services Administration and the Department of Defense have provided two guidelines GSA (2003) [2] and DoD (2009) [3] to evaluate the risk for progressive collapse of the new and existing buildings. Both Guidelines [2], [3] consider the progressive collapse as a nonlinear dynamic event and have adopted the *Alternative Path Method*, which requires that the structure to be capable of bridging over a missing structural element.

In order to mitigate the potential for progressive collapse, the buildings should be designed with an adequate level of continuity, ductility and redundancy, characteristics which are found also in the Romanian seismic design codes (Eurocode 8[4], P100-1/2013 [5]). Recent numerical studies [6]-[9] have shown that the mid-rise RC frame structures which are seismically designed have a low potential for progressive collapse when a column is suddenly removed. Sasani et al. [10], [11] have experimentally demonstrated that the existing RC frame buildings of 11 and 20-story resisted to progressive collapse following the controlled explosions of the columns on the first floor.

In the previous research [12], it was found that an existing 13-story RC frame building, located in Brăila and designed in 1972 according to the old seismic code P13-70 [13], is not expected to fail when a corner column is suddenly removed. Moreover, the structure is capable of sustaining a maximum load of 1.72 times the standard GSA loading before the collapse initiation. Due to the fact that in Romania there were major earthquakes (in 1977, 1986 and in 1990), in the last 40 years the seismic design code has suffered many changes. The objective of this study is to assess the influence of these changes on the structures progressive collapse resistance. For this, the existing 13-story building is re-designed according to the provisions of the actual seismic code P100-1/2013 [5] and then is evaluated to progressive collapse.

The risk for progressive collapse of the structure is assessed by nonlinear dynamic analysis performed using the Extreme Loading® for Structure (ELS®) software. The structure is subjected to corner column removal case, following the procedure described in the GSA (2003) [2] Guidelines. In order to estimate the ultimate load bearing capacity of the building to progressive collapse, a series of nonlinear dynamic analyses are carried out for different levels of loading.

2. CALIBRATION OF THE AEM NUMERICAL MODEL

The Applied Element Method (AEM) can capture the crack initiation and propagation, reinforcement yielding, the element separation, debris falling as rigid bodies, the contact between elements and collision with the ground or with the adjacent structures. In this approach, the structure is modelled as an assembly of small elements connected on each adjacent face by a series of normal and shear springs, generated automatically by the ELS® software. These springs represent the continuity between elements and reflect the properties of the material used (concrete and reinforcement bars). In **Fig. 1** are presented the constitutive models for concrete and reinforcement bars adopted in the ELS® software.

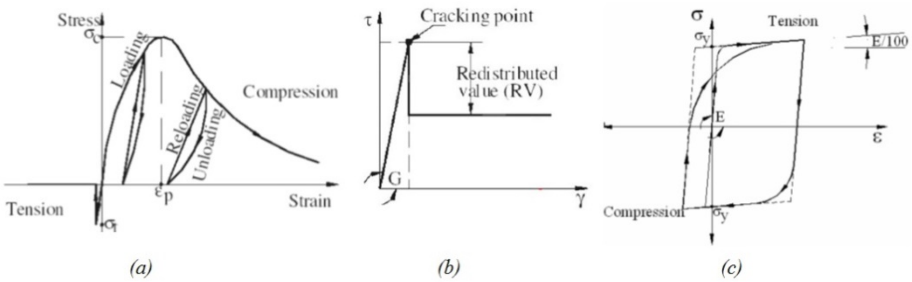

Fig. 1. Constitutive models of the materials [14]: (a) concrete under axial stresses; (b) concrete under shear stresses; (c) reinforcement under axial stresses

In order to validate the results obtained with the AEM, the experimental test performed by Yi et al. [15] on a planar frame is numerically simulated in the ELS® software. A one-third scale model representing the lower three-story of the original eight-story RC frame building was statically tested until failure. The frame model, presented in **Fig. 2**, consists of four 2.667 m bays and three stories with the story height of 1.10 m, except for the first level which has 1.567 m in height. The dimensions and the reinforcement details of the structural elements are given in **Table 1**. The measured material properties are presented in the following:

- the cubic concrete compression strength is 25 MPa;
- the yield strength for longitudinal reinforcement is 416 MPa and for lateral reinforcement is 370 MPa;
- the ultimate tensile strength is 526 MPa;
- the ratio of elongation is 27.5%.

Table. 1. Dimensions and reinforcement details of the beams and columns [15].

Element	Dimensions [mm]	Longitudinal reinforcement		Lateral reinforcement
		top	**bottom**	
Beam	100x200	2ϕ12	2ϕ12	Φ6/150
Column	200x200	4ϕ12		Φ6/150

As in the experiment, a step-by-step unloading process is conducted to simulate the failure of the first-story middle column in a displacement-controlled manner. A vertical load of 109 kN, representing the gravity load of the upper floors is applied to the top of the middle column. Then, a vertical displacement of the node above the first-story middle column is gradually increased until the collapse initiation.

The load-displacement curves of the removed middle column experimentally and numerically determined are presented in **Fig. 2**. It is observed that the AEM numerical results are very close with the results obtained experimentally by Yi et al. [15]. The numerical AEM model can capture the catenary action in the beams and the rupture of the reinforcement bars. The collapse of the frame occurs when the bottom reinforcement bars from the first-story beam (adjacent to the middle column) are breaking, at a vertical displacement of 440 mm (compared to 456 mm experimentally obtained). Consequently, after this calibration the ELS® software can be used with high confidence in the progressive collapse analyses of RC frame structures.

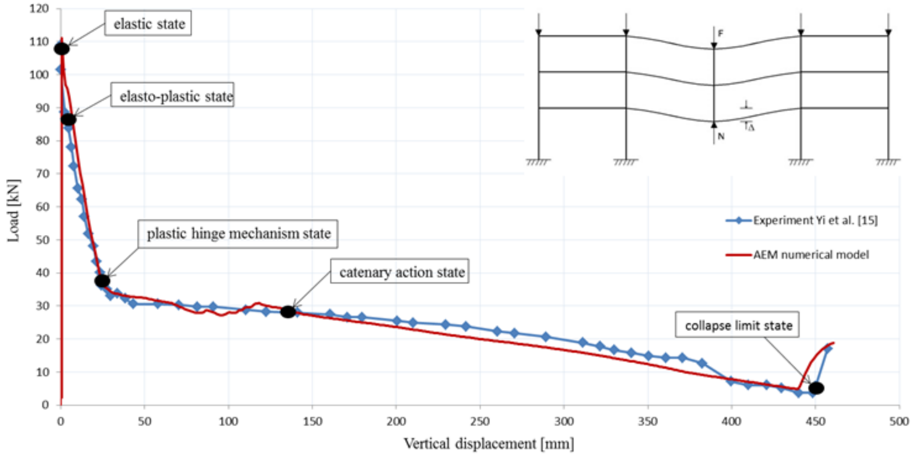

Fig. 2. Force-displacement response of the failed first-story middle column

3. NUMERICAL MODEL OF THE 13-STORY BUILDING

The existing 13-story RC frame building was design in 1972 in Brăila, a region with high seismic risk from Romania. The structure consists of five 6.0 m bays in the longitudinal direction and two 6.0 m bays in the transverse direction. The height of the first two floors is 3.6 m, while all the other floors are 2.75 m high. In addition to the self-weight of the structural elements, supplementary dead loads of 2.0 kN/m^2 are applied to the roof floor and 2.2 kN/m^2 to the other floors; due to the exterior walls a load of 6.5 kN/m on the first floor beams and 5 kN/m on the rest of the exterior beams are taken into account. Live loads of 2.5 kN/m^2 to the roof floor and 2.0 kN/m^2 to the others floors are considered as well. The dimensions of the beams and columns sections are given in **Table 2**.

Table. 2. Dimensions of the structural elements [cm].

Levels	Columns	Longitudinal beams	Transverse beams
1, 2	70x90	35x65	35x70
3→5	70x75	35x65	35x70
6→9	60x75	30x65	30x70
10→13	60x60	30x55	30x60

The structure designed 40 years ago according to the old Romanian seismic code P13-70 [13] is re-designed following the provisions of the current seismic code P100-1/2013 [5], similar with Eurocode 8 [4], and detailed according to the design code for concrete structures Eurocode 2 [16]. The building is situated in Brăila, where according to the actual seismic code P100-1/2013 [5] the pick ground acceleration is a_g = 0.30g and the magnitude of the seismic base shear force is F_b = 0.104G, where G is the total weight of the structure. Following the provisions of the old seismic code P13-70 [13], the existing building was designed for a much lower seismic force F_b =

0.037G. A concrete class C25/30 with the design compressive strength f_{cd} = 16.67 N/mm^2 and steel type S500 with the design yield strength f_{yd} = 434.78 N/mm^2 are considered. The reinforcement details of the structural elements are not provided herein.

A 3D model of the 13-story building is generated in the ELS® computer software (**Fig. 3**). Beam elements are modelled with T and L sections to include the effect of the slab. According to the building code ACI 318-11 [17] the effective flange width on each side of the beam is taken by four times the slab thickness, value adopted by Sasani et al. [10], [11] as well. The material properties used in the numerical model are given in **Table 3**. As recommended by the GSA (2003) Guidelines [2], to determine the expected capacity, the materials strengths (the concrete compressive strength, the yield and ultimate tensile strength for steel) are multiplied by a strength-increase factor of 1.25 for reinforced concrete structures.

Table. 3. Material properties.

Material	Characteristic	Value
Concrete C25/30	Young's modulus [GPa]	31
	Compressive strength [MPa]	31.25
	Tensile strength [MPa]	2.6
Steel S500	Young's modulus [GPa]	200
	Yield strength [MPa]	625
	Ultimate tensile strength [MPa]	687.5
	Ultimate strain [%]	15

4. PROGRESSIVE COLLAPSE RESISTANCE OF THE 13-STORY AEM MODEL

GSA (2003) Guidelines [2] recommends for typical structural configurations the progressive collapse analysis for the instantaneous loss of a first-story column. The Guidelines [2] specifies that the column should be located in four distinct points: at or near the middle of the short side (case C_1), at or near the middle of the long side (case C_2), at the corner (case C_3) and at the interior of the building (case C_4). In the paper only the case C_3 is presented.

In order to assess the progressive collapse behaviour of the structure the following two steps are considered in the nonlinear dynamic procedure:

Step 1: the combination of loads given by (1) is applied downward to the structure under investigation:

$$Load = DL+0.25LL \quad (1)$$

Where, DL is dead load and LL is live load.

Step 2: the corner column is suddenly removed from the model. The time removal is set to 0.005 s. As recommended by the DoD (2009) Guidelines [3], the time for removal of the column must be less than one tenth of the period associated with the structural response mode for the vertical motion of the bays above the removed column, as determined from the analytical model with the column removed

(T = 0.15s). A time step of 0.001s, as recommended by the ELS® Theoretical Manual [14] for reinforced concrete structures analysis is considered. Also, a damping ratio of 5%, similar with Sasani et al. [10], [11], Tsai and Lin [8] is adopted in the nonlinear dynamic analysis.

The response of the 13-story AEM model during a time of three seconds is displayed in **Fig. 3**. The maximum vertical displacement of the column removed point is only 2.14 cm, attained at a time of 0.09 s. Consequently, under the standard GSA loading (DL+0.25LL) the structure is able to resist progressive collapse if a corner column is suddenly removed.

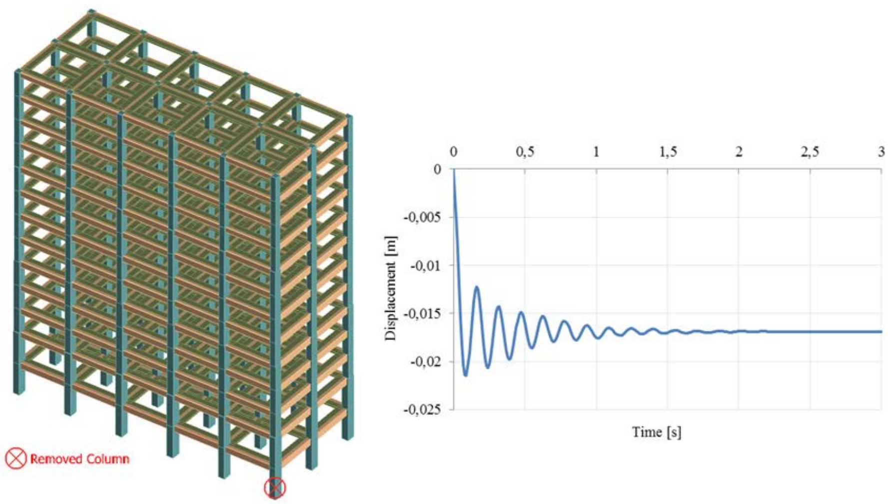

Fig. 3. Time-displacement curve for the column removed point

In order to evaluate the ultimate load bearing capacity to progressive collapse of the building, the gravity load given by (1) is gradually increased until the structure will fail. This assumes that a series of nonlinear dynamic analyses are performed for different levels of the standard GSA loading = DL+0.25LL. The value of the loads (as a percentage of the standard GSA loading) and the maximum vertical displacement of the column removed point are collected to construct the capacity curve of the structure. This method was also adopted by Tsai and Lin [8], Marchiș et al. [9] to establish the progressive collapse resistance of mid-rise RC frame buildings.

Twelve loading steps: 0.50, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.40, 2.45, 2.50, 2.55 and 2.60 times the standard GSA loading are considered until the structure collapses. The capacity curve of the structure, obtained with the results from nonlinear dynamic analyses is presented in **Fig. 4**. The vertical axis represents the percentage of the standard GSA loading and the horizontal axis represents the vertical displacement of the column removed point. It is shown that the 13-story RC frame structure designed according to the actual seismic code P100-1/2013 [5] is capable of sustaining a maximum load of 2.55 times the standard GSA loading before the collapse initiation. In the previous study [12], it was shown that the existing 13-story building, designed according to the old seismic code P13-70 [13], can sustain a maximum load of 1.72 times the standard GSA loading. Consequently, it is observed a better resistance to progressive collapse (with about 50%) if the structure is designed according to the provisions of the actual seismic code P100-1/2013 [5]. This means that the changes in the Romanian seismic design codes had a good influence on the progressive collapse behavior of mid-rise RC frame buildings.

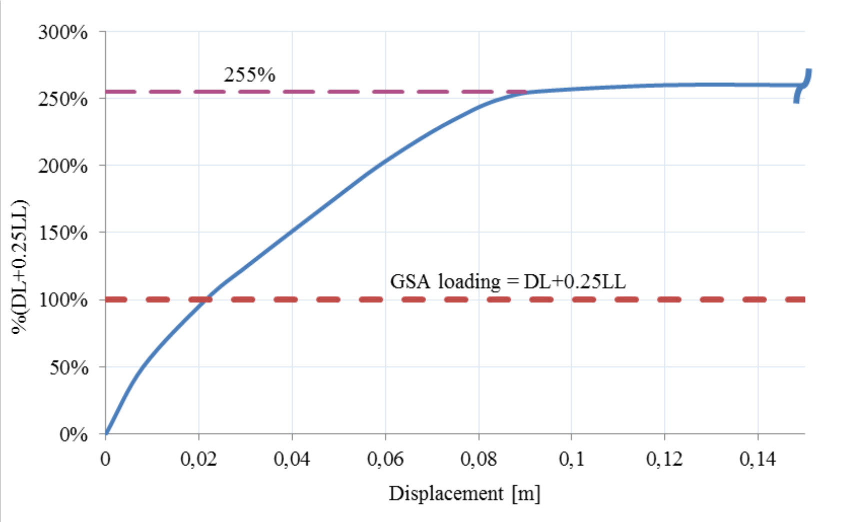

Fig. 4. Load-displacement curve of the 13-story AEM model

5. CONCLUSIONS

The progressive collapse resistance of a typical mid-rise RC structure is evaluated in this paper. The 13-story building is located in a region with high seismic risk from Romania (Brăila), with a_g = 0.30g according to the actual seismic design code P100-1/2013 [5]. In order to assess the vulnerability to progressive collapse of the structure a nonlinear dynamic analysis following the GSA (2003) [2] Guidelines is carried out. Also, to estimate the ultimate load bearing capacity of the building a series of nonlinear dynamic analyses are performed until the structure fails. Based on the results obtained with ELS® software, the following conclusions can be drawn:

- After the calibration based on experimental test performed by Yi et al. [15], was found that the Applied Element Method is an accurate method that can be used with high confidence in the progressive collapse analyses of RC frame structures.
- The results obtained by the nonlinear dynamic analysis show that the 13-story building has a low potential to progressive collapse, when a corner column is suddenly removed. Moreover, the structure is capable to sustain a maximum load of about 2.55 times the standard GSA loading (DL+0.25LL) before the collapse initiation.
- The capacity to resist to progressive collapse of an existing building, designed 40 years ago, may increases with about 50% if the structure respects the provisions of the actual Romanian seismic code P100-1/2013 [5].

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Section II

Management in Civil Engineering

Risk analysis in the case of special rehabilitation in continuous operation
Case study – rehabilitation platforms and airport runways

Gabriela Draghici, Gabriela Brindusa Cazacu

***Abstract* – When we talk about construction, we must distinguish the civil buildings, industrial buildings. Also we need to separate the new industrial buildings of existing ones, the last being subject to rehabilitation. Neither here nor can we stop with the classification, in this latest special subject construction sub-group have rehabilitation after being taken out of operation or special constructions rehabilitated while they are under continuous operation and/or operating. Of the latter we will deal in this article.**
Analysis of risk in this situation is a complex one because it includes a variety of risk factors. The share of each setting is not simply given that almost every risk factor depends on both the causes of internal and external causes

***Keywords* – Analysis of risk, airport runways, air traffic, operational services, rehabilitation**

1. INTRODUCTION

Airports, including all airport buildings inside are designed to ensure the safe conduct of activities related to air transport and operational services provided by airports. They refer to running in optimal conditions by aircraft operations at the entrance and exit to the controlled airspace and airport land. In these conditions, airport runways have rehabilitated properly maintained so as not to disrupt air traffic.

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2. REHABILITATION OF AIRPORT RUNWAYS

Risk analysis as technical regulations in force air traffic density can be mild, moderate or severe, depending on the number of "movements in critical time" [1], ie the number of operations in the busiest time of day, measured over a calendar year.
For the design and organization of rehabilitation of airport construction must comply to the basic principle in aeronautical air traffic safety concerns. Hence any solution design and / or execution both in solving technical problems and the technological progress of events.

Technological processes that take place within an airport may be operational or ancillary. Rehabilitation of airport runways can be done without stopping or stopping air traffic.

Project management, in this case includes the step of documentation and their implementation phase, ie without stopping the execution of the work of air traffic.
For successful Project Manager both from the point of view of delivery - on time and without incident - Financial and called for an risk analysis to identify potential risks that can affect it and provide solutions to mitigate them.

3. CASE STUDY. REHABILITATION OF AIRPORT RUNWAYS WITHOUT TRAFFIC INTERRUPTION AERIAN

In Reaction at risk generally involve: measures for risk reduction, risk elimination strategies, the distribution of risks.

The underlying legislation, identify and evaluate the risks consists of:

- ISO 31000: 2009 Risk Management (Risk management Principles and guidelines)
- ISO/IEC 31010: 2009 - Risk management risk assessment Techniques
- ISO Guide 73: 2009 Risk management. Vocabulary; it completes ISO 31000, offering a set of terms and definitions in the field in addition to those in the design and implementation of standard

For the investment objective mentioned above, the management personnel (head board) will monitor risks in all activities, namely:

- human communication risks
- human risks with designers
- institutional risk with State institutions, in the work of the issue of the legality of the project, the necessary approvals
- human risks, technical and/or technological needs related to the actual execution of works at a target in operation (works under continuous flow);
- human risks and/or materials with the data provided by the client for the drafting and execution of the occurrence of unforeseen obstacles in existing infrastructure, to modify the project and execution;
- human personnel risks;
- human risks and/or supply financial (design and execution);
- human risks and/or equipment, technical equipment and means of transport;
- financial and economic risks in general

- risks to the environment (climaterial risk, seismic risk , risk of soil erosion, flood risk);
- political and economic risks of the country;

For realization of the investment have been taken into account both the risks and external risks internal. Internal (RI) risks are risks to investor's management team we can influence, manage and control in order to diminish the effects, while external risks (RE) are not under its control. This resulted in the following data (**Table 1**):

Table 1

	Process/activity name:				No: Data Job opening date: contract signature date			
No.	**Code hazard**	Name operation	General	Specific components of the hazard	Risks associated	Measures for reducing the risk and the risk index	Future actions for risk reduction and risk product index	Responsible for the implementation of the
01	RI_RU_01	The design phase and the phase of execution	Human Risk	**Faulty communication** Difficulties of horizontal cooperation between the provider/ contractor and team principal and vertically between bosses and subordinates	offset terms for completion of the project additional costs for recovery	Index of the occurrence of the risk: low Given the motivation that has led to collaboration among entities included, communication is desired by all parties involved	Management will establish communication rules and working procedures to ensure traceability information (journey) the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager Job manager appointed by the investor

02	RI_RU_02	The design phase and the phase of execution	Human Risk	**accident at work** the accident may occur due to non-compliance with the regulations on safety and health at work, the use of equipment and/or equipment	temporary interruption of work and deadlines for completion of offset project additional costs for recovery	Index of the occurrence of the risk: low the severity of this risk is determined by the specifics of the activity of design and preparation of employees involved in elaborating the design	Training and information to all participants in the works regarding compliance with the rules concerning health and safety at work the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager
03	RE_RU_01	The design phase and the phase of execution	Human Risk	**accident at work** crash on route to or from the place of employment of a person in the team project or project implementation	temporary interruption of work and deadlines for completion of offset project additional costs for recovery	Index of the occurrence of the risk: low the severity of this risk is given by the general road traffic conditions and preparation of employees involved	Making available to the employees of a common carrier to transport employees involved in project work and work at home Verification according to the laws in force of technical condition of transport vehicles ; the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager

04	RE_RU_02	The design phase	Human Risk	**technical data are incomplete** topographical, geotechnical data and dimensional, made available by the investor are not updated and not true to the real situation on the site	the delay time for completion of the project additional costs for editing and for recovery	Index of the occurrence of the risk: moderate the severity of this risk is given, the fact that there is only an opinion, not a preliminary geotechnical study of the geotechnical and networks are permanently carried out 40 years ago	Efficient communication with the airport management to avoid rounding errors; the final risk index (residual risk): low	Senior management of the company Boss design Project Manager
05	RE_RI_03	Phase for obtaining permits, agreements, permits for design	Institutional risk	**too many approvals** Approvals may be required, in order to be able to be obtained, it is necessary to other approvals	the delay time for completion of the project additional costs for recovery	Index of the occurrence of the risk: moderate the severity of this risk is generated by the country's legislation;	The leadership will have an efficient communication with State institutions the final risk index (residual risk): low	Senior management of the company

06	RI_RT_03	The process of execution ; stage 1 and stage 2	Technical risk	**Equipment failure and/or equipment** used in construction work	accident at work temporary interruption of work and deadlines for completion of offset project additional costs for recovery	Index of the occurrence of the risk: low the severity of this risk is determined by the efficiency of the company's collaboration with companies like entrepreneur so that the equipment malfunctioned or damaged equipment can be replaced with a function in the shortest time	It will establish the rules of communication between all those involved and working procedures for establishing traceability information concerning maintenance of machinery or equipment and replacing them in such situations without affecting the functionality of the runways; the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager
07	RE_RT_04	The process of execution ; stage 1	Technical risk	**Difficulty in finding a site for the Organization of the site, off the premises of the airport, to obtain approval of the A.A.C.R**	the delay time for completion of the project additional costs for the Organization of building site	Index of the occurrence of the risk: low Entrepreneur rents a place at the time of the offer	Conclusion of a rental location promises Organization of building site, with all the necessary utilities the final risk index (residual risk): low	Senior management of the company

08	RI_RTH_04	The process of execution ; stage 1 and stage 2	Technological risk	**Special building conditions in order not to disrupt radio communica-tions at the airport**	You may not use the emission-reception apparatus	Index of the occurrence of the risk: low the severity of this risk is given by the fact that there are multiple ways of replacing this type of communication	It will establish the rules of communication between all those involved and working procedures for establishing traceability information the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager
09	RI_RTH_05	The process of execution ; stage 1 and stage 2	Technological risk	**Special building conditions in order not to reduce the visibility of the control tower due to air contamination with dust particles**	Slowing the pace of work by increasing the number of operations to reduce the amount of dust dispersed in the atmosphere. additional costs for special working technologies	Index of the occurrence of the risk: moderate the severity of this risk is given by the fact that there are operations that generating dust in excess, in climatic conditions, with the wind permanently, in Dobrogea	wet technologies will be used for both construction and demolition in order to limit the amount of dust in the air transport trailers will be covered with tarps; temporary storage of unpackaged material (bulk) or ost material will be regularly moistened or coated; the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager

10	RI_RTH_06	The process of execution ; stage 1 and stage 2	Technological risk	**Temporary abandonment of the construction, for short durations of time, arising from the need for airport operation in continuous flow**	Temporary cessation of work in order not to endanger air traffic; additional costs for special working technologies	Index of the occurrence of the risk: moderate the severity of this risk is given by the fact that we are working on the tracks and platforms that are not taken out of service and that you need to work safely	The design phase will require specific technologies and reserves time in order not to affect the final date of commissioning; the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager
11	RI_RM_07	The design phase ; The process of execution ; stage 1 and	Risk material	**Syncopation in sourcing occurred because the contract or employees**	Decrease in the pace of work due to lack of materials; offset dates of completion in stages; additional costs for recovery	Index of the occurrence of the risk: low the severity of this risk is that the entrepreneur has rich experience and works only with companies that supply credible;	The design phase will calculate quantities of materials required and there will be a supply schedule in order not to affect the final date of commissioning; the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager

12	RE_RMD_05	The process of execution ; stage 1 and stage 2	Environmental risk	**Environmental Accident irrespective of the will of the proprietor or the weather covered cases of force majeure**	The pace of decline or even cessation of building; the delay of completion deadlines for various stages of work; additional costs for recovery	Index of the occurrence of the risk: low the severity of this risk is that the entrepreneur has a rich experience in the field and can solve such situations	The entrepreneur has the working procedure for his management of such cases; the final risk index (residual risk): low	Senior management of the company Boss design The Chief of construction site Project Manager
13	RE_RF_06	The design phase ; The process of execution ; stage 1 and	Financial risk	**Syncopation in making payments to the contractor, the other beneficiaries**	Decrease in the pace of work; the delay time of completion stages; additional costs for delays recovery	Index of the occurrence of the risk: low the severity of this risk is that the entrepreneur can support financially, a period of time, the execution	The entrepreneur has the working procedure for his management of such cases; the final risk index (residual risk): low	Senior management of the company

14	RE_PE_07	The design phase ; The process of execution : stage 1 and	Risk of political-economic country	**Syncopation in carrying out the work, due to the cessation of funding**	Decrease in the pace of work; the delay time of completion stages; additional costs for delays recovery Sistarea lucrărlor	Index of the occurrence of the risk: moderate the severity of this risk is that the entrepreneur can support financially, a period of time, the execution	The contractor will have to take at the end with losses as small as the final risk index (residual risk): low	Senior management of the company

4. CONCLUSIONS

Based on risk analysis, for each identified risk were developed, one or more procedures, as applicable (each procedure includes a technical data sheet) so that air traffic will not be disrupted or put in danger during the execution of works.

Applied technologies that are not generating dust, were used with a gauge-controlled equipment and the area has been properly marked.

There was good communication between the persons designated by the client (investior) and implementer for tracking project implementation.

The consequence of this approach has meant quality work completed and handed over on time without human or technical incidents, with the additional costs generated by the reznabile airport and no history of human error.

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Economic crisis and perspectives of the construction firm

Aneta Marichova

***Abstract* – In the context of globalization and the increasing scarcity of resources, the effect of the economic crisis of 2008 year is not only a decline in GDP and employment, increasing the number of bankruptcies, but primarily a sharp drop in foreign direct investment limit access to international financial resources. All this creates a risk to the operation of international supply chains that are the basis for innovation, knowledge, training, transfer of resources, access to foreign markets and business contacts and economic growth. However, every crisis creates conditions for the state and the private sector for strategic changes, transformation and sustainable long-term development. The aim of the study is to show the necessary strategic changes to construction firm and adapting their activities to the changing global demand and growing demand for "green building" and the new role and actions of the state, aimed at increasing investment in research innovation, training and incentives for sustainable development in construction market.**

Keywords – Construction firm, Construction market, Economic crisis, New role of the state Strategic changes, Sustainable development, Sustainable construction

1. INTRODUCTION

Economic crises are often set as "creative destruction" [1] and by definition during the industrial restructuring and implementation of long-term effectiveness. Introduction of innovation into new consumer goods, new services and/or new technologies enabling cost reduction, development and deployment of new business models are the main impulse that sets and maintains economic growth. Under these conditions, associated with changes in the supply of less efficient firms fail and appear and expand more efficient and dynamic.

The current economic crisis, however, is not due to the emergence of new innovation, structural changes in the supply of competitive technical models,

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alternative solutions or transformation of business models and that to show that existing technologies are outdated and ineffective. Instead, today's economic crisis is the result of a sudden change in demand conditions resulting from a severe financial crisis, leading to a significant credit squeeze. Such a demand crisis creates itself destructive forces that weaken the dynamics of innovation and industrial upgrading leads to the failure of the long-term prospects for economic growth and reduces the competitiveness of the economy due to the following expected effects [2]: restricts the entry of innovative start-ups due to the high barriers market entry; accelerated the decline of young innovative companies that have more limited financial resources; may force established companies downsizing their operations and to abandon new projects, and may be delayed knowledge transfer, distribution, creation of effective vertical supply chains. These negative effects of the crisis pose a threat to the ability of any industry to adapt and overcome the crisis. Along with this, however, construction is under the influence of several factors (rising production costs, having limited financial resources, the outflow of investors, strong imbalance between demand and supply especially of the building construction market, torn vertical connections, increasing government requirements and regulations), which in its integrity pose the question: *how to operate construction company today and what changes to implement in future.*

The new conditions, resulting primarily from the impact of the economic crisis showed that construction firms need to take and implement strategic changes in its activities (innovation, specialization in green buildings, successful management and lower operating costs, increasing reputation, image and customer loyalty) to ensure their major business opportunity for sustainable development, building competitive advantage and close cooperation of the private and public sector. This defines the two main objectives of the study: 1) defining the necessary strategic changes in the activity of construction firm, 2) defining the necessary changes in public policy to support the activities of construction firm.

The study not aimed to develop and test hypotheses, but is exploratory and seeks evidence of the ability of construction firm to implement the necessary changes in activity in response to the dynamics of the external environment. For this purpose the author explores, analyzes information and statistics and makes its findings on the problems and prospects of development of the construction firm on the basis of estimates of shared views, experiences and expectations of managers. They agree that the guideline of successful developed to be green building.

2. STRATEGIC CHANGES IN THE ACTIVITY OF CONSTRUCTION FIRMS

In times of economic crisis when declining market prospects and financial constraints, the allocation of resources for adaptation and modernization of production becomes more difficult and requires entirely new solutions. Opportunities for firms to adjust their business skills to changes in demand and in favour of further specialization in the chain of creating added value to improve performance through additional investments in human capital, knowledge and innovation or in equity is problematic. A major shift in the ability of firms may be a result of investment in new relationships, new business models, entering new markets, developing new business lines in the direction of diversification, marketing new products and services, after sales services, training and etc., that will allow meeting the high requirement for sustainable construction, as part of the sustainable development of the countries by 2020. Strategic changes in any company related to the need for a break with traditional thinking and traditional technologies and demonstration of feeling conscious about the environment. This means that the development of green building and green infrastructure should be a key to the company's activity. Green building as a basis for product differentiation and competitive advantage is not just wishful, but a trend imposed by a number of factors such as rising prices of resources, climate change and not the least concern for nature. New requirements for construction and construction firms are challenging for their activities and the need for **new management solutions, development of adaptive abilities and innovative capacity.**

In this chapter, the author explores the need for strategic changes in the activity of construction firm as a function of the influence of: 1) the external factors (market and technology), 2) internal factors, which requires organizational and managerial changes.

2.1. Influence of external factors requiring a change in the activity of construction firm

In the medium and long term, several key external factors influence and require strategic changes in the activity of the construction company:

• **Globalization of markets**

Globalization of markets and the increasing mobility of resources even in such traditional markets such as construction facilitate the access of national companies to global markets and an opportunity to expand their market position. At the same time, every company is facing ever-increasing competition, both internal and external, foreign companies, which creates a threat to the activity and survival. This dynamic makes it even more clearly the need for mergers, acquisitions, establishment of strategic alliances. The process of globalisation, the development of information and communication technology is accompanied by an increasing freedom and deregulation of the activity of construction companies, which increases their chances of entering new markets, developing new products and at the same time increase the control and regulatory functions of the state of national level.

• Demographic changes

In all developed countries there are a number of unfavorable demographic changes. They are associated with aging, declining population, high emigration of young people, which is the logical outcome and reduce the purchasing power of the population and others. Under these conditions change the market structure, changing customer requirements, etc. An essential factor that can reduce these negative demographic changes is the development of tourism. This is an important factor, which stimulates the development of construction. Those demographic changes have a very negative impact in terms of providing the construction market with the necessary manpower and quality and quantity. Past years experience of qualified construction workers at any level can be lost in the absence of young people tend to realize this so difficult and responsible work.

• Changes in demand

Demand from consumers, market dynamic and new requirements for sustainable development are the dominant forces in the construction market. In the last five years have been dramatic changes in demand of the construction market, particularly the segment housing - from simple property search within a budget to find a product with certain characteristics. Consumers are becoming more pronounced tastes and preferences to the desired product. Buying a home is a long-term investment, which means that buyers are looking for quality, comfort, energy efficiency, and infrastructure. The new realities of this market has shown that consumers are becoming more demanding, informed and growing market power to large number of mainly small construction companies that offer market housing. In the face of strong competition, especially in a sharp drop in construction, buyers can express more clearly their preferences and impose their requirements for quality, timeliness and accuracy in execution of contracts. After the bursting of the construction bubble crisis will obviously clear market failures and put in the equivalent position buyer and seller.

• Green and sustainable construction

The developed countries in recent year shows that the actions of the government and construction firms should focus from traditional development to sustainable development, whose main core is sustainable construction, because construction activity is associated with higher costs of resources, including the most scarce resources-land. Sustainable development that allows them to be met as fully as possible the needs of current generations without compromising the future generations to meet their own needs, therefore require less consumption of energy and materials, less pollution and better protection of natural resources and arable land that protection, which provides humanity today [3]. Poor models of building development often lead to congestion and inefficient use of land, increasing energy consumption and travel time, loss of productivity. The result is more pollution of water sources, loss of agricultural land, residential areas and fragmented financial burden on municipalities. Due to these facts, the EU is to more strictly obliging institutions to respect the principles of energy efficiency and sustainable construction. According to Directive [4] of EU, until 2020 to achieve the following objectives: to reduce 20% energy consumption, 20% of the electricity produced comes from renewable sources and 20% to reduce gas emissions. After 2020, all new buildings will be nearly zero energy consumption, but for public buildings that will apply after 2018. Directive requires governments to adopt and appropriate regulation that will ensure the achievement of these goals and will introduce the evaluation criteria. According to a report [5] on trends in green building, which covers 62 countries, the share of green building in 2012 in the world is 38% of the total by 2015 this percentage is expected to increase. Overall, between 2012 and 2015 the sector expect with the greatest potential in the field of green building (new or projects related to the renovation of existing buildings) and in the area of commercial sites (including offices and hotels). Up from 63% of construction firms are planning the launch of new green projects, 45% of investors have plans for new public buildings that use elements of sustainable architecture (including schools and hospitals) and 50% have plans for sustainable activities related to the introduction of energy efficient solutions for existing buildings.

2.2. Evaluation of internal resources and the necessary changes in them

The focus of this chapter is on the evaluation of internal resources and the necessary changes in them that provide opportunities for sustainable advantages of the construction company. Complex relationship and interdependence of these resources means that they must be evaluated in their unity. The future success of any company will result from the creation of the right combination of them.

• **People and skills**

Strategic changes in the construction market, combined with changes in demand require changes in production and technology, increasing demand for skilled and flexible workforce management skills, which is a major factor in increasing the competitiveness of the construction market and realization of benefits from any construction firm. Despite high unemployment, low rates of employment and high mobility of construction, there is still an acute shortage of skilled workers with the necessary skills, qualifications and experience, which are themselves sought by employers. This deficiency leads to increased production costs, low quality of the final product, increasing inefficiency and loss of business as a whole and reduce the competitiveness of the firm. For these reasons, increasing the percentage of the organization of training courses, training, apprenticeships offered by employers. At the same time, it should be recognized that training and human resource development of the construction market is low due to the high proportion of self-employed who are often faced with the dilemma of "work or learn".

• Management skills

Management skills are essential for the implementation of strategic changes in the construction market. Specifics of the construction activity related long supply chain, involving multiple actors in it and the individual nature of the project/object require a high degree of dependence and successful coordination and management of activities on site and throughout the supply chain. In the high degree of integration in a greatly improved efficiency of operation, the construction firm made adaptive to changes in the external environment.

• **Access to finance**

The construction market is a growing volatility of cash flows, which means planning the investment cost in a given period, but the receipt of payments of proceeds from the realization of the object after a long period of time, i.e. companies rarely receive money promptly and precisely to the signed contract. For this reason, construction companies remain less cash with which to operate, to cover their costs and expand their business. At the same time increasing the number of auctions in which companies earn dumped that does not even cover their costs, which puts into question their survival in the future. Ability of construction companies to have access to the right type of funding is essential for them. Funding is used to purchase fixed assets or to finance expansion, but also to finance working capital. Bank lending is a common form of financing for construction companies. In times of economic crisis and a sharp drop in construction activity, bank lending is strongly decreased both in absolute terms and relative to other sectors. Along with this growing high bank requirements and guarantees necessary to grant the desired credit, making financing impossible. Remains stable financing of large companies that get state and municipal object of infrastructure and through them provides funding for smaller companies that are subcontractors of these objects.

Under these conditions, short-term trade credit plays an important role in the construction sector. Usually construction firms receive trade credit from companies outside the industry, which then allows them to provide trade credit to other contractors participating in the supply chain, and ultimately the customer. This cascading nature of lending suggests that if the executors of the lower levels experienced problems accessing trade credit and servicing this could have consequences throughout the supply chain, leading to increased inter-company indebtedness in the line of provider-contractor-subcontractor. Furthermore, construction firms do not have sufficient financial skills to successfully apply for a bank or other funding to demonstrate that their project is viable investment. Access to finance is one of the constraints to the growth of construction companies. The chance for the construction firm is chiefly the growing role of the private investor who can help to create greater value for customers by providing expert estimates, forecasts and information of the required capital for national or regional expansion pooling firms in a major company for effective implementation of large orders and objects and use of professional management and control.

• **Supply chain development**

Key factors for successful transformation and adaptation of the construction firm to changes in demand is the development of best practices in the design, implementation, maintenance and reconstruction of buildings. Standard construction practices led by short-term economic objectives often show little concern for energy efficiency or more on economic, social or environmental impact of the built up area. Sustainable development seeks to end these practices by integrating a wide range of design, construction, operating and maintenance practices to provide healthier living, better working atmosphere and reduce environmental impact. Important to the success of sustainable development appears to be the application of integrated design principles - the approach to completing construction systems that collect key professional designers and developers to work together from the beginning to the end. In the traditional design approach in the initial phase the possibility of assessing a building in its entirety is quite small. No coordination work of various designers leads to permanent changes and sometimes necessary changes are noticed too late, only when starting the works and their removal can cost a lot more expensive. Therefore, sustainability in construction starts from the earliest stages of the project and requires a responsible commitment of all stakeholders: planners, administrative authorities, investors and customers, which means significant changes in the organization and coordination of the company's management at all levels.

• **Innovations in "green building" - guidelines for strategic change and development of the construction firm**

In modern conditions (the development of new high-tech global communications, increasing competition, etc.), the success of any company is mainly associated with the development, effective management and use of intangible assets - knowledge and innovation. The innovation firms can develop in two directions: product innovation (creation and market introduction of new or improved product) and innovation in the production process (design and introduction of new or improved manufacturing process, which means significant technological changes). In practice, very often innovation in the production process implies the creation of a new product and vice versa. This process a continuous improvement of their level of skill and productivity of production factors, resulting in reduced production costs and increasing production.

The construction sector is highly competitive, dynamic sector, which should mean that the survival of companies and the conquest and preservation of competitive advantages to be realized through innovation. Low barriers to entry in the industry are also a stimulus for existing firms to develop innovation that can reduce this risk and prevent new entrants in this market. At the same time, construction in general has a bad reputation for susceptibility and development of innovation. It shows the statistics in all countries of EU28, where innovations are reported on the basis of standard indicators. The most commonly used indicator is the main share of the costs that firms in an industry and the industry as a whole made for research and development. In construction, the countries of the EU28 average of this indicator is around 0.25%, which is quite low compared to industry sectors. The reasons for the apparently low levels of innovation in construction can be summarized as follows: a high level of fragmentation and limited cooperation in the construction market, a small number of orders affecting the level of cooperation, uncertainty in the demand for an innovative product, ineffective knowledge, transfer and training, limited access to finance, greater elasticity of innovation in construction at risk and specific of this market.

In the creation of a project and its implementation involves a range of different subjects (public and private investors, end users, designers, architects, consultancies, distributors, suppliers, contractors and subcontractors) with different characteristics and preferences. Links between them are often torn, based on short-term contracts, suggesting opportunism in their behavior. The desire for innovation comes mainly from investors, public, private, engineers, architects, designers and much less limited by customers, users of the final product. Higher activity and pressure for innovation on construction companies have major investors in the market for non-residential construction. Delivering innovation in the project site, they require guarantee them greater demand and higher rental price which ensures a faster and higher return on investment. The state as an investor chooses to offer the lowest price, but lowest price does not create conditions for innovation and development. Moreover, in the limited tangible and intangible resources, many companies remain conservative with an innovative propensity and risk that accompanies any change and the introduction of the new. Given these specificity, the research done on innovation of construction companies in the UK, classified innovation in this sector in the following three types [6] which set the guidelines (program) for the development of any construction company:

1) Innovation at the level construction market. They are the most visible and radical innovations that lead to big changes in the industry and its structure: 1) Changes in regulations and standards for the whole product or some of its properties and characteristics. Increasing requirements for safety, health, sustainable development, require radical innovations in the process of design and construction. 2) Changes in desires, preferences, requirements of investors and end users, leading to comprehensive, radical innovation that change the industry as a whole.

2) Innovation at the level "business". These innovations are related and focused on resources and their effective use in the whole and not only in the implementation of a separate project and include: 1) the development, improvement of the raw materials and components. 2) innovation related to the implementation of new systems of organization and management improvement activities through new relationships throughout supply chain, management human resources and new business practices. Generally these innovations at the level of "business" are less visible, unclear, but a longer period of time lead to radical changes in the industry.

3) Innovation at the level "project". These are the most hidden and most difficult to understand innovation in construction, but their number is most significant. They have a major impact on productivity and efficiency in the industry as a whole. These innovations include improvements, improved design solutions, architectural, design activities and improving the links between architects, designers, civil engineers. The base is the accumulation and exchange of knowledge, experience, training, coordination, integration of the assets of the company in a new more efficient way and "Learning by doing".

Therefore, innovation in construction can be radical resulting from the increasing demands of investors and customers, numerous innovations in projects and the connection between them ensure the innovation of business level.

So in terms of the specifics of the innovation process in construction use other indicators for reporting this activity, not just share the costs of research and development. They can be grouped into three major groups [7] and have the following relation to the three types of innovation in construction:

• Economic indicators related to customer satisfaction and their construction products which are primarily the result of the realized innovation in "project" and include assess customer satisfaction of the product and after-sales service shown and remove defects.

• Economic indicators related to the contracting company and the result of the realized innovation in level "business" include evaluation profitability, a value added per employee, satisfaction and motivation of employees.

• Evaluation of environmental impact is a result of radical innovation include environmental impact of products created and construction process, evaluation of the energy cost and assess the amount of waste generated throughout the life cycle of the product.

Compared with many other industries innovations in construction are objectively limited, but the accompanying activities and share their effect is extremely large. Innovation in this sector should not be regarded only as innovations in the production process (materials, human resources, technology) but as 'integration' innovations that are mainly related to the management, coordination of activities, i.e. innovative planning and management of key factors - time, resources, costs, quality, integrated with new technologies and solutions for proper communication. The aim is to minimize the cost and the optimal allocation of resources, which leads to optimal schedules, reduce the time of construction, and increasing the quality.

The success of any innovation is a function of the development of strategic partnerships throughout the supply chain in order to combine knowledge, technology, experience and application of integrated design principles. They suggest the creation of complete building systems that collect key developers and professional designers to work together from the beginning to the end. Effective management means permanent contract or vertical relationships with various companies subcontractors and suppliers who are responsible for various activities, stages, work independently, but dependent on each other. Basis for effective collaboration in the chain of vertical relationships is trust. These new business practices create greater transparency in the sector and provide competitive advantages.

3. NEW ROLE AND ACTIONS OF THE STATE TO SUPPORT AND PROMOTE THE STRATEGIC CHANGES IN THE CONSTRUCTION MARKET

Traditionally stimulating construction is realized through the creation of better conditions for attracting and increasing new foreign and domestic investment, the public procurement system, fiscal and monetary policies by which to achieve the desired macroeconomic effect. Practice shows that these measures depend on the capabilities of each country. Fiscal policy action (through investment in infrastructure and public buildings, and tax cuts) and monetary policy of the Central Bank (reduction in the interest rate on loans) in each country have a stimulating role in the construction and stabilization activities of the sector reducing the drop in and survival of the majority of small businesses, such as contractors and subcontractors to state contracts for a short period of time. After achieving it again in many countries there are signs of recession in the industry. At the next stage the state limited its direct involvement and provides conditions to encourage foreign investment, development of public private partnerships and private financing of projects, through the intensification of banking. Under the new conditions now associated with a qualitative change in the demand for construction output, the main role of the state is meant to create mechanisms for updating models, guarantee funds, regulation, and fiscal incentives for investors and users of the products of sustainable construction.

In the first place each state must create the conditions for sustainable development and energy efficiency and therefore requires certification of buildings as proof that they meet the established criteria for a sustainable approach to construction, including: location, water, energy, transportation, building materials, health and tone, waste. To achieve these objectives the state shall adopt these mechanisms to regulate and stimulate the process of sustainable development:

- Validation of energy standards that increase the requirements for construction activities and construction firms are forced to follow and meet those requirements.

- Adoption of regulations, which should include not only requirements for the building itself, but also requirements for what happens from the time of its design, construction, operation her to her destruction According to experts, only 20% of the experts in Europe these problems are of the opinion that their countries have clear criteria for evaluating green buildings.

- Accelerate the building certification on accepted standards, taking into account the specifics of each market, which is a factor for attracting foreign investors, who want to work anywhere in the known rules and a familiar pattern. Implementation of management systems building energy efficiency through computer monitoring software that automates and manages the building and allows control of electricity, lighting, electrical power and other systems.

Secondly, each country should develop a short-term program to stimulate demand and medium-and long-term program to stimulate supply, which should include the following measures and decisions:

- •Active promotion of the various options that can be used end-user - soft loans, tax incentives, the possibility of utilization of funds under various programs of EU and change in thinking, information, education and persuasion of the benefits of sustainable construction. For example, most construction companies refuse to use green building materials due to the higher price, and consumers are not very active in this regard. Moreover, most of them use recycled materials creates uncertainty, discomfort in the new home, though their quality is not worse than the new ones, according to experts.

- •All these policies and associated construction standards should be supported with financial incentives. In a short period government action should focus on stimulating demand through financial incentives, tax rebates and higher taxes, penalties for polluters, financial aid and programs, interest-free loans, reduced VAT on the purchase of green homes. Especially effective is the creation of a uniform policy for the construction of "eco-villages". If a man decides to turn his home into "green", it means that you will be put back after a number of years. If the state encourages such initiatives, the performance will increase many times.

- •The banks are often passive participants in this process. Their proposals should be limited to program efficiency, but also must include initiatives related to green building and directed to investors, companies and end users. In more countries, a major factor in this respect is the actions of the insurance and pension companies that invest and plan to invest heavily in "green" construction.

- •Medium and long-term government action should be aimed at stimulating supply through investment in research, innovation, education, support small and medium enterprises, the establishment of a fund to support start-ups, increasing investment in green infrastructure and environment. Measures to support the construction does not have to be protectionist and protect businesses that are in trouble and uncompetitive because it would lead to a distortion of the market mechanism.

4. CONCLUSIONS

In this study the author aims to analyze the possibilities of the construction company to implement the necessary strategic changes in their operations to adapt successfully to the dynamics of the environment in which it operates. Analyzed information, estimates and expectations of managers allow the following conclusions on the prospects for its development:

1) A crucial factor for successful long-term development of the construction company is building a system of people and management skills, to ensure its adaptation to changes in the external environment.

2) Overcoming the negative effects of the global economic crisis requires strategic changes to internal resources. This includes innovation, acquiring new knowledge, technologies and successful business models. Successful business model includes fair financing conditions and payment; active participation in the supply chain in the whole process of development and implementation; strong relations and cooperation with suppliers; opportunities for effective management of the site, including the ability to respond flexibly to changes in the external environment.

3) Only companies that can implement the necessary strategic changes and to meet the challenges of the environment in which they work and the new requirements for sustainable development will stabilize its position and realize sustainable competitive advantage.

According to the author, the future development of the construction market requires cooperation between the private and public sectors. Government actions should include not only measures to stimulate demand in the short term, but also activities provide long-term growth. The main objective of the state should be the promotion of innovation, the development of intangible assets and facilitate the transfer of information and knowledge. This will create the necessary conditions for restructuring, upgrading and modernization of the sector, which is a factor for increasing productivity and its ability to respond to environmental challenges.

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The dynamic capabilities of the firm - a major factor for sustainable competitive advantage

A study of Bulgarian construction industry

Aneta Marichova

Abstract – **The main objective of the study is to analyze and explain in theoretical and practical terms, the ability of long-term development the construction firm by providing a model through which to develop potential, successful strategies that provide sustainable competitive advantage and the realization of the corporate goals. In practice this include: determination of the strategic factors that influence on the strategic behavior of the firm, identification the sources of competitive advantage, major strategic decisions and evaluation of the effect of the realization competitive advantages of the firm.**

In view of the the objectives, in the paper is developed conceptual model "Dynamic capabilities - Competitive advantage - Performance" that can be applied to study the strategic behavior of the construction company and its long-term dynamic capabilities for sustainable competitive advantage. It focuses specifically on the dynamic capabilities of the firm as a key factor for competitive advantages, which in turn have a bridging role between them and the realization of firm goals.

Keywords – Competitive advantage, Construction firm, Construction market, Dynamic capabilities, Functional competencies, Performance

1. INTRODUCTION

The prevailing view in the economic literature is that overall research on strategic management of firms in the construction market to competitive advantages, occupies limited space in the theoretical analysis, compared with similar analyzes of other industries. The reasons for this conclusion are related to the general characteristics of the construction market in almost all countries - in this market there

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are too many, mainly small firms that normally have no strategy, as well as the specific characteristics of the construction market and create product, limiting the theoretical analysis.

In the first in-depth theoretical studies, strategic management consider practical problems of the construction company in a short period (transaction costs, vertical chain links and relationships and scope of activities - diversification or specialization), its specific organization, management and planning activity as a consequence of the specifics of the construction and rarely associated with the company to use these capabilities to achieve competitive advantage and corporate goals. Lacking depth study of strategic, long-term behavior, which provides advantages in the market. Since the beginning of the XXI century theoretical research on strategic behavior of the construction company is now moving towards a comprehensive analysis of the problems. The focus of research is on the impact of external factors [1] or on the impact of internal factors [2], but not both together. There are no comprehensive studies of the dynamic capabilities of the construction company as a factor of competitive advantage. In most studies, resources and capabilities are accepted for specify and determining the competitive advantages, but does but does not analyze the possibility of their development and change as a result of dynamic changes.

In the last 4-5 years research problems in the construction market is moving to link theory based on resource (RBV) [3] and theory M.Porter [4] for strategic positioning of the firm in a market as competitive advantages are displayed as a function of two factors: 1) the role and influence of competitive forces and 2) the development and change of the capabilities of the firm under the influence of external changes. Some studies on the construction market and the behavior of the firm [5], point to define dynamic capabilities as the capabilities of the firm to develop the knowledge, innovation, intangible assets, its ability to adopt innovations and changes in the competitive business environment in general and on this basis to achieve competitive advantages.

The main objective of the study is to analyze and explain in theoretical and practical terms, the ability of the company to develop by providing a model for long-term development through which to develop potential, successful competitive strategies that provide sustainable competitive advantage and performance. More specifically, the objectives of the study are defined as follows: 1) Determine the strategic factors affecting strategic behavior and the competitive advantages of the construction company. 2) Identifying the sources of competitive advantage. 3) Identification of the major strategic decisions. 4) Evaluation of the effect of the realization of competitive advantages for the company.

2. THE THEORETICAL FRAMEWORK FOR ANALYSIS DYNAMIC CAPABILITIES OF THE FIRM AS A KEY FACTOR FOR COMPETITIVE ADVANTAGES

In this chapter we will develop and describe: 1) conceptual model, which will be applied in the analysis of the strategic behaviour of the construction company. The model focuses on the dynamic capabilities a major factor competitive advantage, 2) based on the model will define working hypotheses to be tested. The main task of the author is to clarify the relationship between the working hypotheses and objectives of the study.

2.1. Basic conceptual model: "Dynamic capabilities - Competitive advantages - Performance"

The theory of dynamic capabilities of the firms that provide competitive business advantage was developed by D. Teece, G.Pisano [6] in the period 1994 - 2010 years. The authors set as their main objective to develop and propose a general theoretical framework for the study of the dynamic capabilities of the company, taking into account the influence of external factors, which means they should be flexible, constantly evolving and most importantly to be associated with the practice, not academic, closed and workable managerial concept. Goal of any firm should be not only the realization of competitive advantage but sustainable competitive advantages. Competitive advantages mean that the company creates and offers greater value for its customers with a strategy that is not used by current competitors. Therefore sustainable competitive advantage meaning the ability of the company to create and offer more value to their customers compared not only with this but with potential, future competition, applying the strategy that they even applied could not achieve the same results. The sustainable competitive advantage should be seen as a result of strategic management of the firm and can not be simply associated with operational efficiency and organizational success. In practice, this means that the assessment of competitive advantages should include primarily customer rating, companies whose business is related to the activity of a given, reputation and customer loyalty to the company.

Theoretical studies of the representatives of this new theoretical direction can be summarized as follows:

1) The dynamic capabilities are identified and treated **as a system of specific**, identical for a given firm strategic actions, decisions and organization that create higher value compared to competitors and therefore sustainable business advantage.
2) Dynamic capabilities are regarded **as a process** [7] that involves a static concept (ability of the company to coordinate and integrate internal and external resources of the company in a new way, mainly through the development of technology), dynamic concept (related to training, development of human resources, innovation, which in turn has a reverse affect the ability of the company) and the concept of transformation (need to change the external and internal resources of the company, organization and structure as a function of changes in the environment).
3) Dynamic capabilities as a process which determine not only current, but also **future positions and new guidelines** for the development of the firm that defines its competitive advantages. For this purpose, according D. Teece managers need to use three types of activities, namely: sensing, seizing and transforming (evaluation of alternatives and possibilities of variation) [8].

4) To exit of the complex often described as clumsy, academic explanations of the concept **of "dynamic capabilities"** the author adheres to the idea that they be examination **hierarchically** [9] and composed of:

- **Functional competencies** involved in the direct production and include **market and technological resources/factors** that allow the company to operate in a competitive environment and determined to improve their outcome.
- **Dynamic capabilities** that are not directly involved in production. They stimulate the process of organizing, managing and effectively combine resources and business skills, thus creating conditions for change and development of functional competencies.

Hierarchical representation of dynamic capabilities allows to make quantitative assessment (cost of branding, revenue, expenses, profit, innovation, patents, licenses, etc.) and to reveal the realized competitive advantages and performance.

These theoretical basis for the development of basic conceptual model "Dynamic capabilities - Competitive advantage - Performance" (Figure 1) and definition of five research hypotheses which must be substantiated by empirical analysis:

Fig.1. Basic conceptual model "Dynamic capabilities - Competitive advantage - Performance"

2.2. Defining the research hypotheses

Hypothesis 1: The dynamics of the external environment has a strong positive influence on dynamic capabilities, functional competencies, competitive advantages and performance.

Hypothesis 2: The functional competencies have a positive relationship with the competitive advantages of the firm.

Hypothesis 3: The dynamic capabilities have a positive relationship with the competitive advantages of the firm.

Hypothesis 4: The competitive advantages have rights, positive relationship with firm performance.

Hypothesis 5: The dynamic capabilities have a positive relationship with functional competencies that build competitive advantages.

The conceptual model "Dynamic capabilities - Competitive advantage - Performance" (and the five hypotheses based on the conceptual model, whose testing and evaluation) was developed on recent theoretical studies and practices of construction companies in economically developed countries synthesized two approaches: theory based (internal) of resources (RBV) and model of M. Porter's "Five Forces" (external resources). The union of the two approaches allows both to explore the impact of external (market structure, level of concentration and competition, hierarchies, dynamics of demand, etc.) and internal resources (technology, workforce skills, raw materials used , innovation, financial resources and organizational structure) of the company, which by definition defines its "dynamic capabilities" as a key factor for building competitive advantages and firm performance, therefore competitive advantages are bridging role between them.

Five hypotheses considered in unity and attached to the basic conceptual model can be represented as follows (Figure 2):

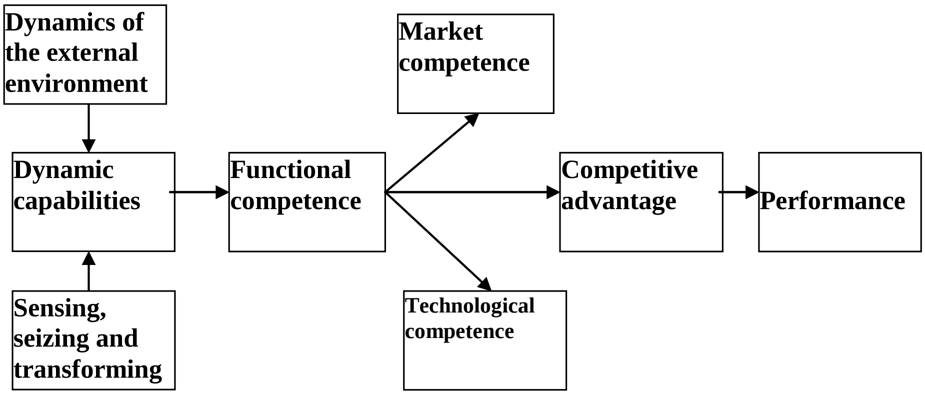

Fig. 2. Five hypotheses considered in unity and attached to the conceptual model

3. APPLYING THE MODEL TO STUDY THE CONSTRUCTION MARKET

In this chapter we will describe the method, summarize the results of the research and identify strategic factors (external resources) and sources of competitive advantage (internal resources) for the company.

3.1. Method and restrictive conditions in the study

The empirical study was conducted based on the methodology developed and approved for the research of strategic management of firm in the construction market in order to create sustainable competitive advantages under restrictive conditions that take into account the specifics of the construction as a business, product, process, organization and management. On this basis the author defined horizontal and vertical boundaries of the construction market, within which any empirical testing of hypotheses. The criteria for defining the market is: produced by the construction firm product (residential, no residential and civil engineering (consumer demand), territorial allocation of the company (producers and supply) and the national market. The study defines two levels of analysis and verification of hypothesis - market/industry and individual firm. Empirical analysis at the level of industry/market is based and developed on statistical data of the National Statistic Institute in Bulgaria (NSI) and Eurostat [10], the Chamber of Construction Bulgaria (CCB) and the Central Register of Professional Builders (CPRB) [11] for the construction sector and activity construction companies in Bulgaria. Data used and processed in the analysis at the firm level were collected from workshops, shared opinions, evaluations, experience of managers, employees in construction companies, interviews, publications and analysis in specialized journals, financial reports of the firms. Surveyed construction firms are included in the "Top 20" of the construction market in the country, work in different market segments, have different levels of diversification or specialization in the relevant market segment different range of activities (considered as three flow-supplies of raw materials and materials, design and construction), different story, regional localization and business model.

The analysis of five research hypotheses and interpretation of the results were made as follows:

- The research of the first hypothesis: "The dynamics of the external environment has a strong positive influence on dynamic capabilities, functional competencies, competitive advantage and performance" include:
    - demand analysis, assessment of the elasticity of demand for three market segments residential, non-residential and civil engineering;•determining the market structure of the construction market and the intensity of competition based on three objective criteria (number of participants, nature of product and barriers) and two objective meters (market share, concentration ratio) and assess the potential for profit;
    - analysis of the impact of institutional factors and state requirements;
- Testing of the second hypothesis: "The functional competencies have a positive relationship with the competitive advantages of the firm" includes analysis and assessment of:
    - market competencies as a part of the functional competencies in terms of the applicable policies of the construction company that provides its competitive advantages;
    - technological competencies on the basis of indicators used by Eurostat, the development of vertical connections and relationships, vertical integration in building companies, defining structural barriers;
    - assessment of functional competence as a factor of competitive advantage through two quantitative variables: the Larnar index and Bain index.
- The role and importance of dynamic capabilities to create competitive advantages, i.e. third hypothesis in the study: "The dynamic capabilities have a positive relationship with the competitive advantages of the firm" is evaluated based on:
    - analysis of the possibilities of the company for coordination and integration for the implementation of new systems of organization and management of activities in the leading construction companies (static concept).
    - analysis of the dynamic concept using training systems staff and use of experience;
    - the concept of transformation, as the third element of the dynamic capability is related to assessment of business opportunities for strategic change (development of new products, entering new markets, participation in strategic alliances). They are the result of the

changes and developments in external and its internal resources to develop and implement long-term strategies, flexible solutions in the short term, strategic moves to the actions of competitors, adaptation of the company and people to technological and market developments.

- Fourth hypothesis: "The competitive advantages have rights, positive relationship with firm performance" is tested by evaluating:
  - financial performance - revenues, profit, return on capital and assets, indebtedness and long-term risk;
  - analysis of consumer assessment of the effectiveness of the company;
- When examining the fifth hypothesis: "The dynamic capabilities have a positive relationship with functional competencies that build competitive advantages" is applied theoretical framework for the dynamic capabilities of the company, developed by D.Teece as an extremely useful tool for empirical analysis of the processes of construction market/industry:
  - sensing activities as a strategic part of the dynamic capabilities of the construction firm which define opportunities and threats from the external environment for its activity (i.e. its functional competence) and the realization of competitive advantages.
  - seizing evaluation of alternatives for the development of the company and choice the strategy, positioning and creating a business model;
  - transforming - presentation of alternatives for management decisions which development dynamic capabilities, functional competencies and build competitive advantage.

3.2. Main results of the analysis of the conceptual model and hypothesis testing

The analysis of the collected wealth of information and statistics from the author allow the following summary conclusions from the testing of the five working hypothesis at the level of the construction market and firm.

The first hypothesis: "The dynamics of the external environment has a strong positive influence on dynamic capabilities, functional competencies, competitive advantage and performance" was demonstrated in the condition that the strategic factors for each company have a strong influence, though not always positive (in controversial impact on the demand), which, however, is a strong dynamical factor for each market. The demand in the construction market as a whole is a key strategic factor for the development of the construction company, but with its cyclical fluctuations have contradictory effects on the activities and capabilities for competitive advantage. The economic boom in the country and increasing demand facilitates the activity of the construction company for all market segments, offering any product. The economic downturn and falling demand raises the issue of specialization, the effective range of choice where it works, issue clear profile and competitive advantages of the company. Examination of the impact of market factors proves that the market structure is a strategic factor that reveals the strategic position of the firm on a market competitive mechanism and has a strong positive impact on its dynamic possibilities for the realization of competitive advantages and higher profits.

The dynamics of the external environment and the new challenges it demonstrate the need for a complete change in attitude and policy construction companies - reorientation of policy short-term profit to a policy of long-term stabilization of market positions, which means strategic behavior and competitive advantage.

The second hypothesis: "The functional competencies have a positive relationship with the competitive advantages of the firm" has been demonstrated in reporting a strong influence on market competences compared to technological. Expansion of market competence of the construction market can be realized through policies to protect or expand the horizontal and vertical borders and restricting the entry of new companies, policy of mergers, differentiation and specialization of the construction firm, market segmentation and target market selection. The study of technological competence as a factor of competitive advantage proves conclusively that the construction market prevailing labor intensive production with relatively low labor productivity, low average costs per employee, a low share of the value added created, low propensity to invest and therefore the limited possibilities of technological competence even the leading construction companies to achieve competitive advantages. Along with this, however, the technological competence of the construction company is objectively determined by the influence of a number of negative factors (rising production costs, having limited financial resources, the outflow of investors, etc.). The research proves that these negative factors are the result of the development of the material resources of the construction firm, but which create new opportunities, related to the development of intangible assets (knowledge, information, innovation), diversification or specialization of its business.

The final conclusion of the study of the second hypothesis proves functional competences regarded as composed of market and technological competencies, create strong potential for competitive advantage, but they now realize differently to different market segments. Need to develop functional competencies as a result of the dynamic external environment, but also the development of knowledge, education, training, innovation, implementing new business models of organization and management leads us to the analysis and verification of third hypotheses.

The third hypothesis: "The dynamic capabilities have a positive relationship with the competitive advantages of the firm" is strongly evidenced in the market of civil construction and controversial in the market of building construction. Evaluation of the individual components of the dynamic capabilities of the company proved the following conclusions:

1) Static concept in the activities of the leading construction companies associated with the coordination and integration of enterprise resources in a new, more effective way, is realized through the implementation of integrated management system including an effective system of customer relations, quality control, environmental protection and providing safe working conditions, giving them competitive advantages through higher reputation, loyalty and customer evaluation.
2) Dynamic concept in the activities of the leading construction companies is realized through their constant efforts to develop intangible assets (training, motivation and incentives for staff, "investment in the future", etc.). Practice shows that this is the most important factor in the creation of high

value, rarity, and difficult to imitate resource that provides a sustainable competitive advantage in new, dynamic conditions.

3) The concept of transformation, as the third element of the dynamic capability is relevant in assessing the company's opportunities for strategic changes as a result of the changes external and internal resources and develop and implement long-term strategies, flexible solutions in the short term, strategic moves to the actions of competitors, adaptation of firms to technological and market developments.

In the practice of the leading construction companies this concept is realized in the following areas:

• On the market of civil engineering strategic changes in the company in order to protect and/or enhance market position and competitive advantages, include policy of development and creation of new product for existing markets and/or entering new markets, diversification, development of public-private partnership (PPP) and strategic alliances and building an effective system of vertical relationships and the integrated supply chain between suppliers on the basis of competition.

• On the market of residential and non-residential (building) construction guidelines for strategic change and development of the construction firm that will provide its product differentiation and competitive advantage is "green building". Regardless of the findings of experts that companies have the knowledge, new skills, the ability to meet all the requirements of "green", sustainable development, the necessary changes lack in the market. The reasons are internal - the firms that operate in this market are relatively small limited resources, skills and opportunities for changes in organization, management, but of course and external - tight income consumers, the outflow of foreign investors which have shown the greatest willingness to invest in green building and etc.

The fourth hypothesis: "The competitive advantages have rights, positive relationship with firm performance" is proven fully and unconditionally and can draw the following conclusions: there is a stabilization of the overall liquidity of the leading construction companies, a trend of reduction of the financial indebtedness of most of companies, greater efficiency realized in construction companies result of management decisions and management. Overall rating proves the hypothesis that greater efficiency and realization of company goals is the result of market and technological changes, the development of dynamic capabilities of the company that build competitive advantages.

The fifth hypothesis: "The dynamic capabilities have a positive relationship with functional competencies that build competitive advantages" proves too strongly. The influence of the dynamic capabilities of the company on its competitive advantages through the development and mediation of functional competencies was studied using a theoretical framework for the dynamic capabilities of the firm (D. Teece), comprising three groups of activities of managers: sensing, seizing and transforming. The general conclusion in this analysis is: The success of the construction companies (strong market position in the long term and sustainable competitive advantage) is connected mainly with the choice of strategy and positioning in one of the following ways: high efficiency of the firm as a result of realize economies of scale, which means lower average cost or differentiation of product - creation a project/object which distinguishes the firm apart from other competitors. This means that it can find its unique skills, resources, distinctive capabilities (new design concepts, technologies and facilities for customers) that are understandable and storable buyers, which in turn is sufficient reason such company to offer its product at a high price market.

3.3. Factors and sources of competitive advantages

In view of the objectives can derive and summarize the following links and dependencies between the dynamic external environment (strategic factors) with the defined dynamic (internal) opportunities (sources of competitive advantage) and strategic business solutions that ensure the realization of competitive advantage and performance:

1) Strategic factors influencing the construction company are mainly related to the impact of market (demand and market structure) and institutional factors analyzed in the first hypothesis.
2) The sources of competitive advantage for any company in the development of its dynamic capabilities and functional competencies tested in the second and third hypothesis.
3) The strategic decisions are a function of the choice of strategy and positioning the company as a result of the monitoring and evaluation of various alternatives for development in a dynamic external environment studied in the fifth hypothesis.
4) Competitive advantage function of the dynamic business opportunities related to the ability of the company to create and offer higher value to their customers compared to competitors through product differentiation or leader in costs and firm performance (fourth hypothesis).

The results of testing five hypotheses, identifying the factors and sources of competitive advantages are the basis for the development two models of strategic behavior of a firm operating in a market with different market characteristics, demonstrate the need for management to link information dynamic external environment (strategic factors), dynamic capabilities (sources of competitive advantage) and strategic decisions.

4. CONCLUSIONS

In the presented publication author summarizes his results of a wide-ranging theoretical and empirical study of the construction industry. The author demonstrates the critical importance of dynamic capabilities through functional competence of the company determine building competitive advantage and the realization of business objectives. The study develops and applies a new theoretical approach (linking economics and management theories, or new microeconomics) with practical application in the strategic management of the firm through a conceptual model "Dynamic capabilities - Competitive advantage - Performance" and check the defined five hypotheses. Multifactorial analysis proves crucial place and importance of dynamic capabilities to build competitive advantages by connecting role functional competencies. Proven is a positive correlation between the characteristics of internal and external resources with competitive advantages that play the role of mediator to firm performance.

Developed and probated original methodology for evaluation of dynamic capabilities and competencies of the firm in order to study the strategic behavior of the construction market allow the author to make the following conclusion: Significant structural changes in the market and the impact of external factors on the company's activities, which require a new management strategies and solutions that aim to change the dynamic development opportunities, and in turn change and develop functional competencies. In their unity they can protect the firm position and build sustainable competitive advantage. Sustainable competitive advantage requires managers ongoing development of resources, searching for new, more efficient combination of them new ways of organization and management of the company. If managers fail to develop dynamic capabilities and realize sustainable competitive advantage, it is a major factor in this result is the focus on the basic elements of intangible assets - **people and systems**.

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Risks associated with investment projects in construction and their impact on objectives pursued

Mădălina Stoian, Ana-Maria Nica

***Abstract* – Today's business world is constantly changing, becoming unpredictable, volatile and more complex every day. The business environment around the world is characterized by a strong degree of uncertainty and risks are found everywhere. Identifying, quantifying and developing measures to avoid or mitigate the impact of project risks, becomes necessary and mandatory for entities that wish to ensure project success and business success.**

***Keywords* – investment, uncertainty, project, risk.**

1. INTRODUCTION

In a continuous changing society, investment occupies a central place, providing specific adaptation to new market requirements. Continuous technological developments, the need of increasing and maintaining a certain level of competitiveness in the business environment and reducing disparities between the economies of different countries are just some of the elements that determine involvement in investment projects.

The importance of investments is given by increase their capacity to provide goods and services and thus generate additional revenues both in the directly affected sector and the related sectors, upstream (suppliers) and downstream (distributors), thereby causing an increase of income chain economic entities involved and engaged.

Came as a result of general strategies and as a prerequisite to achieving the objectives set out therein, investments are inherent in the current socio-economic context, given that they can ensure the development of the micro and macro level of world states.

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Efforts to achieve an investment project are significantly higher than current activities related efforts. This difference occurs because of specific features of the investments: [3]

- **duration:** any investment has its own life cycle, each phase can have different durations depending on the complexity of the project, the expected life, the impact it will have after implementation, etc.
- **efficiency:** a desired parameter by any organization initiating an investment project but equally difficult to achieve. Obtaining superior benefits depends on the efforts of the management team to manage the project, by its scale, but also a range of other elements.
- **risk:** with less impact or greater is typical to all investment projects and can occur at any specific phase of the project life cycle.

All the above features are considered important and worth exploring because they are or can contribute to the success of a project.

Given the impact that it may have on the duration of the project implementation and ultimately its effectiveness, it is absolutely necessary to analyze the risk associated with investments. Its size, measured by the impact it may have on the project, is dependent on the scope, the scale of the project, its duration, the criteria for funding, the moment when effects are recorded, the ability of the developer to effectively manage risk.

In relation to the risks associated, investments can be grouped as: [4]

- **investments with similar risk** – under these conditions, the risk of investment projects is similar to that attached to the current activity of the initiating entity. Specific projects are absolutely necessary for the specific activities of the organization;
- **medium risk investment** – occur when the company seeks to extend or upgrade the current production capacity in order to request certain liability;
- **high risk investment** – specific activities undertaken for entering new markets or to respond to a need identified but unsatisfied. In this case the effects of actions are unknown and uncertain in medium and long term;
- **”white” risk investments** – focused on improving the working conditions of human resources. In such a situation it is difficult to estimate the effects of actions;
- **"imposed risk" investment –** required to align with the legal reglementations, institutional and administrative (for compliance with the Directive 99/31/EC, Framework Directive 2008/98/CE and national ban regarding construction and demolition landfill that can be capitalized, investment have been made in this scope) [2]

Major concerns to increase the competitiveness of an organization and to obtain a competitive advantage, characteristic of a competitive economy, had the effect of moving from a similar risk investments to high risk or imposed.

2. LIFE CYCLE OF A PROJECT AND RELATED RISKS

According to standard SR ISO 31000 – " Risk management. Principles and guidelines", risk can be defined as the effect of uncertainty on the final objectives of the project. [1]

In the classical approach risk is considered as a possible register of a loss due to unforeseen events in the development of activities.

The nature of risk and the impact they may have on the objectives of the project depends largely on the time of occurrence, they are changing from a different phase of the project to another during its life cycle: **Fig. 1.**

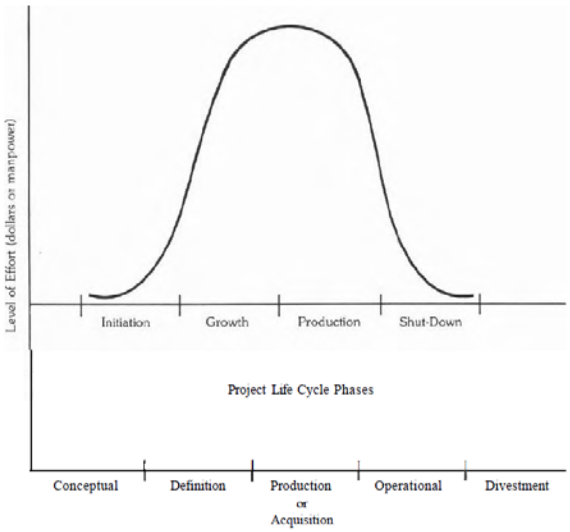

Fig. 1. The life cycle stages of a project [5]

Therefor, risks associated with the phases of the life cycle can be:

1. **Risks specific to pre-investment stage** – associated to initiation period (conception and definition) of the project (**Fig. 2.)**:

R.1. Identifying an unreal market need – appears in the stage of project idea from a misidentification of market need and is characterized by a low impact on project objectives;

R.2. Misleading commercial forecast affect the feasibility of the project which may have a significant impact on its objective;

R.3. Development of inappropriate studies, due to excessive optimism, low hnow-how, overestimate the possibilities of performance;

R.4. Setting targets hard to achieve – occurrence of this type of risk is due to the often exaggerated optimism of those responsible for planning;

The main ways to reduce the probability of occurrence of this type of risk are:

- formulate SMART objectives;
- the time required to achieve results is less than the life cycle of the project, this period starts in the operational stage;

- acceptance objectives by all members of the project team.

R.5. Improper identification of funding sources – may have the effect of extending the date for starting the execution of the project and implicitly of the date of completion of it, situation which may lead by new risks (market risk, political risk etc.);

R.6. Development and approval of a deficient technical solution - noncompliance with conditions on the ground, noncomplying with the rules and regulations in force, difficulties in tracking and transmission of information, underestimating project complexity etc.;

R.7. Poor planning of specific activities duration of the project (errors while compiling graphs);

R.8. Poor estimation of the resources associated with the project (human, material and financial);

R.9. Poor quantifying risk impact and therefore inappropriate measures of response to risk;

R.10. Lack of incentives for all stakeholders involved in achieving project objectives;

R.11. The risk of changing the legislative framework – can occur at any time but at this stage of the project associated impact is higher, given that most laws do not apply retroactively.

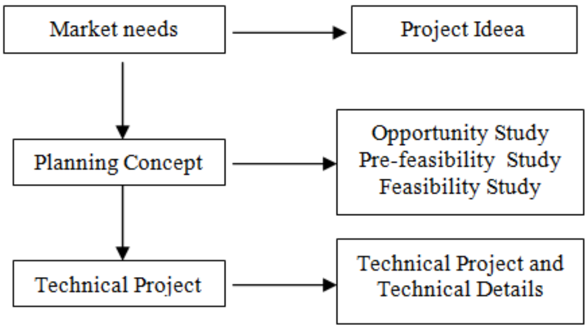

Fig. 2. Risks specific to pre-investment stage

2. **Risks specific to the implementation phase of the project** – associated period of production and the operations of the project:

R.12. Incapacity of insurance resources at the right time, in the quantity and quality required

To avoid this type of risk is indicated:

- to consider the balance of power customer-supplier – provides information regarding the ability of suppliers to provide raw materials necessary to achieve the investment objective and the level of interest in the contract;
- to establish policy on stocks
- to establish criteria for choosing suppliers for each category of material that will be used (level of compliance with prior contractual terms, production capacity and actual occupancy, the transport distance etc.)

R.13. The term risk - emergence of a gap between receipts and payments. A good planning of inputs and outputs can contribute to reducing the probability of occurrence of this type of risk. For projects made from european funds is indicated that the entity initiating the project to ensure the existence of their own money necessary to cover the initial expenses.

R.14. The exchange rate risk – occurs when debits and credits are denominated in different currencies

R.15. The technological risk – caused by technical malfunction.

R.16. Risk caused by the form of implementation of the investment (enterprise / direct labor operations / mixed system). The degree of specialization of the future objective, the objective size, the administrative capacity of the organization, experience and resource of time available, are a number of factors that must be analyzed by the initiating entity in choosing way of the execution investment choice.

3. Specific risks of the operational period of the project

R.17. The solvability risk

R.18. Overestimation of the useful life of the project (the period when are obtained staggered estimated useful results) – is a risk with a high probability of occurrence in the operational phase of the project but on which you can take measures to avoid in the stage of planning.

In determining the useful life of the project should be taken into account: physical duration of the asset, technological life duration and the lifetime of the product.

R.19. The risk of increasing interest rate.

4. The specific risks of the period of closing / decline of the project

R.20. The legal framework for the decommissioning of certain equipment, decommissioning of buildings - situation which can generate higher decommissioning costs resulting from the capitalization of material price.

After the identification of risks associated with the project following stages are necessary:

- Drawing up a list of the risk events
- Analysis of the risks - consists in examining each identified risk to estimate more correctly the probability of materialization of the risk and the impact it could have on the project.
- Estimating the probability of manifestation and the impact – as shown in **Fig. 3**., depending on the probability of risks and the impact they could have on the project, there are three risk categories: low risk, medium risk and high risk.
- Prioritisation and integration risks – it can be determined depending on the probability by risk occurrence and the impact it can have on the project, by realization probability impact matrix shown in **Table 1.**

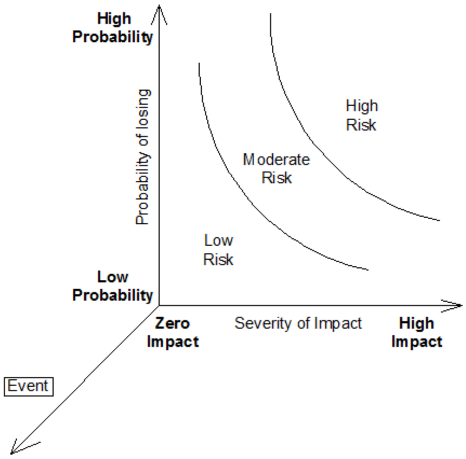

Fig. 3. Risks as a function of its components

Table. 1. Probability-Impact Matrix

		IMPACT				
		1	2	4	8	16
PROBABILITY	0.1	R1, R20			R10, R11, R17	
	0.3			R15, R16		
	0.5		R2	R3, R6, R18	R5, R12, R13	R4, R7, R8, R9
	0.7			R14, R18		
	0.9					

Green Risks – less important risks
Yellow Risks – important risks
Red Risks – very important risks

- List of the serious risks (red risks) - will include those risks that could significantly affect the project. These risks categories are associated concurrently a high probability of occurrence and a significant impact.
- Elaboration of the risk management strategy

After identifying and determining the risk category to which they belong are determined response strategies:

- accepting the risk
- reducing the risk
- avoiding the risk
- transferring or sharing them with a third party.

The purpose of a risk response strategy is to eliminate uncertainty, associated with the visible part of risk.

- Monitor risks throughout the project life cycle

The implications which the investment process has on the organization, determined by the mobilization of large amounts of money, in the medium and long term, have the effect of increasing concerns for identify some efficient methods of analyzing the risk associated with investment projects. We define two categories of risk analysis methods of individual projects:[4]

a.”Subjective” risks – it is based on the intuition of who takes part in the process. From this category being part methods based on global subjective assessment, method based on numbers, cash flow adjustment method based on specific risk and updating them each a rate "free risk" and the method of adjusting the minimal profitability objectives.

b.”Objective” risks – uses probabilistic risk measurement tools. From this category being part methods based on probabilistic risk analysis, methods based on risk analysis portfolios, method of the standard deviation and the coefficient of variation, sensitivity analysis and simulation technique.

4. CONCLUSIONS

In a world characterized by a high level of competitiveness, social, economic and technological development becomes an essential condition for survival maintenance and growth.

The investments necessary to achieve the objectives set at the macro or microeconomic level, are characterized by a high level of risk and uncertainty. In this case, risk analysis is a very important step in the process of planning, implementation and good operation of the project.

Nature of the risks and the impact they can have upon the project varies from one phase to another of its life cycle. The success of the project depends greatly on the analysis and anticipation made in conception and design stage, most of the specific risks to following stages can be avoided if the first stage of the project is properly covered.

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Section III

Integrated Water Management

Impact of climate change on the income of small farms in an irrigated area in Tunisia

Saïda Mlaouhi Salah, Abdelhamid Boujelben, Mohamed Elloumi

Abstract: **The expected climate change may affect crop yields therefore the loss of income for farmers if we do not take adequate measures. We studied the effect of temperature rise *of 1 and* 2 degrees Celsius, and the effect of increasing doses of irrigation on crop yields and their impact on gross margins of 3 typical small farms. We used a bio-economic approach and the simulation results showed that the gross margin of small farms is affected by temperature rise and rectified by increasing irrigation doses.**

Keywords**: small farm, modeling, simulation, environment, irrigation, gross margin.**

1. INTRODUCTION

The African continent is already warming faster than the global average and its people can expect more intense droughts, floods and more frequent storms. North and Southern Africa may become up to 4 ° C warmer in the next 100 years. This ties the forecasts made in 2007 [13], which indicate an increase in temperature of 2° C in the next 15 to 20 years, that could reach 4 to 6.5°C in the end of the 21st century. Studies in climate projections used specific models applied to the Mediterranean countries. They estimate a temperature increase of 1° C in the year 2030 and 2° C in the year 2050. It will be exacerbated by more intense droughts, floods and storms more frequent especially in Tunisia [15].

For North Africa, water resources are vulnerable to climate variations. That could put these countries in uncomfortable situations because the maximum

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mobilized volume of water would be deficit in year 2020. The process of climate change will raise the arid and desert areas. Studies predict a decline in agricultural yields in North Africa due to the acceleration of lands degradation and loss productive lands.

Climate change will also affect the production of vegetables whose yields would decrease by 10 to 30% and wheat yield will decrease to nearly 40%. Some authors note that North Africa and the Middle East countries expected impacts result in a decline of gross domestic product about 0.4% to 1.3%. It may even reach 14% to the year 2020 [11] if no control measures and adaptation to climate change is adopted.

Our work fits into the overall framework of environmental preservation and sustainable agriculture. We investigated the long-term effects of climate change on cropping systems of three small typical farms located in an irrigated area in the lower valley of Medjerda in Tunisia. We interested to small farms since they represent the largest number of farms in Tunisia and 70% of farms surveyed in our work.

Our objective is to contribute and propose technical solutions to initiate a strategy for agricultural development which preserve soil fertility and ensure sustainable income for farmers in the study area.

In this context, we used a model based on mathematical programming to represent the technical and economic activities of farms and simulate the impact of exogenous changes (technical and agricultural policies) on their decision variables [8]. We simulated climate change effects on yields and therefore on farmers' incomes. We studied increased irrigation doses and their effects on farmers' gross margins.

2. EXPERIMENT DESCRIPTION

We conducted surveys of 83 farms with areas ranging from 1 to 170 ha in the irrigated perimeter. We selected by typology [9]-[16] three representatives small farms. We built individual bio-economic models for those farms. We considered the activities of farmers, their production techniques, crop practiced and irrigation adopted. The characteristics of farms are summarized in Table 1.

Table 1. Typical farms selected and their characteristics

Farm number	EXP6	EXP20	EXP64
Area (ha)	4.5	5.5	4
Crop	T. alexandrinum, maize and sorghum forage irrigated	Dry Barley, Oat, T. alexandrinum and maize forage irrigated	Dry oat and T. alexandrinum
Soil Type: *Texture	Silt / sand	Sand	Sand / silt

* Soil salinity (dS / m) [1]	0.7 to 1.2	0.4 to 0.7	0.2to 8.4

[1] *Iinitial salinity for each typical farm*

We chose a preventive bioeconomic methodological approach [7]. It is based on the coupling of a biophysical model "CropSyst" [2]-[6] that allows for long-term simulations returns with another economic model "GAMS" based on mathematical programming that calculates the gross margin [4].

We tried to reproduce the actual behavior of farmers. Indeed, we followed the same production techniques (same amounts of fertilizer and irrigation water applied by the farmer) and kept the same crops for speculation (tab. 2).

For answers to long-term cultures, we generated from real data of climate and with a sub "ClimGen" program "Cropsyst" climate data for 30 years from 2011 to 2040.

To measure the sustainability of agriculture, we used the model “CropSyst” (Croping System Simulation). It is a daily time simulation model [16].

Table 2 shows the amount of water applied per crop per farm. This information was collected through a survey made in this case.

Table2. Quantities of irrigation water initially applied per farm per crop (m^3)

farms/crop	Barley	Oat	T. alexandrinum	Maize	Sorghum
EXP6	0	0	2000	7000	8000
EXP20	0	500	3000	6000	0
EXP64	0	0	0		0

EXP: Exploitation

It was established seven scenarios (SC) to investigate the behavior of different soils, crop response and the impact climate change on crop yields. These scenarios are:

SC1: Scenario control applied by the farmer (simulation over 30 years); SC2: SC1 + simulation with climate change (+1°C); SC3: SC1 + simulation with climate change (+2°C); SC4: SC1 + 20% increase of irrigation dose; SC5: SC1 + 40% increase of irrigation dose; SC6: SC1 + 60% increase of irrigation dose; SC7: SC1 + 100% increase irrigation doses initially applied by farms.

The simulations were performed first on 30 years (2011-2040) to study the effects of long-term production of typical farms. Second, we studied the impact on predictable increases in temperature respectively 1 and 2 degrees C based on forecasts of the Mediterranean region. Third, we simulated the effects of four scenarios providing irrigation farming activity studied.

Positive Mathematical Programming (PMP) was used to simulate the behavior of three farms through the GAMS (General Algebraic Modeling System). It allowed us to calculate the "target" function formulated to optimize the choice of production systems taking into account the climatic conditions, the accumulation of salt in the soil each year and the amount of irrigation water.

The "objective" function represented by gross margin of the farm to maximize in this work is written as follows:

$$\mathbf{MBG}(\text{exp}, \text{s}, \text{a}) = \sum_{(\text{c,t})} \boldsymbol{x}(\text{exp}, \text{c}, \text{t}, \text{s}, \text{a})\, \mathbf{Rd}(\text{exp}, \text{c}, \text{t}, \text{s}, \text{a})\mathbf{pprodc}(\text{c}) - \sum_{(\text{c,t})} \boldsymbol{\alpha}(\text{exp}, \text{c}, \text{t}, \text{s}, \text{a})\, \boldsymbol{x}(\text{exp}, \text{c}, \text{t}, \text{s}, \text{a}) + \frac{1}{2}\boldsymbol{\beta}(\text{exp}, \text{c}, \text{t}, \text{s}, \text{a})\, \boldsymbol{x}^2(\text{exp}, \text{c}, \text{t}, \text{s}, \text{a}) \quad (1)$$

with

$MBG_{(exp,\ s,\ a)}$: Annual overall gross margin per farm per scenario and per year.

Margin is calculated per hectare for each crop. It represents the total proceeds realized by sales (cereals, fodder) after amputation direct expenses such as costs of supply fertilizer, water, and labor and product treatment.

$\boldsymbol{x}_{(exp,\ c,\ t)}$: Area per farm per crop and per technique

exp: Typical farm

c: Crop

t: technique (crop management: Dry or irrigated)

s: Scenario

a: Year

$Rd_{(exp,\ c,\ t,s,a)}$: Yield per crop per farm per technique per scenario and per year

$pprodc_{(c)}$: prices of crop products

$\boldsymbol{\alpha}_{(exp,\ c,\ t,\ s,\ a)}$ and $\boldsymbol{\beta}_{(exp,\ c,\ t,\ s,\ a),}$: they are non-linear terms of cost function added in the "target" function using dual values generated by the calibration phase expressed as follows:

$$\text{VD}(\text{exp}, \text{c}, \text{t}) = \text{calib.m}(\text{exp}, \text{c}, \text{t}) : \quad \text{dual values} \quad (2)$$

These terms are calculated as follows:

$$\beta(\text{exp}, \text{c}, \text{t}) = \frac{2\text{VD}(\text{exp}, \text{c}, \text{t})}{\text{occ}(\text{exp}, \text{c}, \text{t})}; \quad \text{for } occ_{(exp,c,t)} > 0 \quad (3)$$

$$\alpha(\text{exp}, \text{c}, \text{t}) = \text{cpr}(\text{exp}, \text{c}, \text{t}) - \text{vd}(\text{exp}, \text{c}, \text{t}) \quad (4)$$

with

$occ_{(exp,\ c,\ t):}$ the cultivated area per farm per crop and per technical

$cpr_{(exp,\ c,\ t)}$: the cost of production per culture, per technique and per exploitation

3. RESULTS AND SIGNIFICANCES

The simulation results yield of different crops for three farms studied were as follows:

- During the first decade the average of cultures yields simulated were between 3.7 and 5.5 tons per hectare will decreases in the second decade experience between 0.1 and 0.2 tons per hectare. The percentages of reduction are between 1.6% and 5.5% compared to the first decade.

- During the third decade these reductions will be between 0.3 and 0.5 tons per ha. The percentages of reduction are between 8% and 10% over the first decade. They are also between 0.2 and 0.3 tons per ha compared to the second decade and percentages are between 3.6% and 6.9%. We deduce from this simulation that the reduced yields are inevitable in a long term.

The simulation results of gross margins of typical farms studied over 30 years are shown in Figure 1. We noted decrease in average gross margins simulated of all farms. Taking account climate change scenarios (SC2 and SC3), these declines are between 8 and 91% compared at the initially situation (SC1).

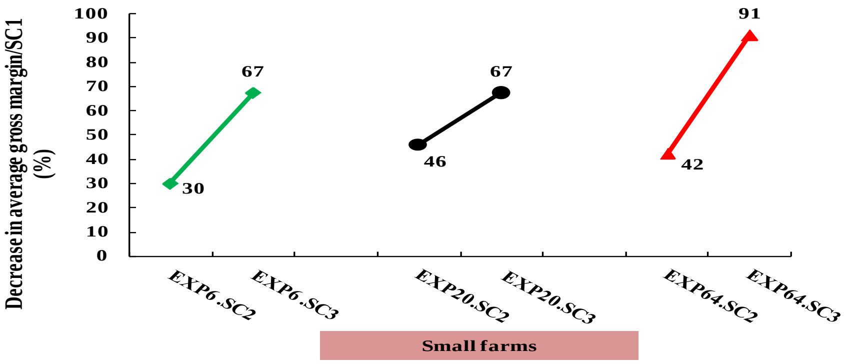

Fig.1. Evolution of the mean simulated gross margin per farm by raising temperature scenario / SC1 (%)

The evolution of the simulated gross margin per farm is presented in figure 2. This margin is the result of farming systems adopted by each farm based on land uses and crops management per farm.

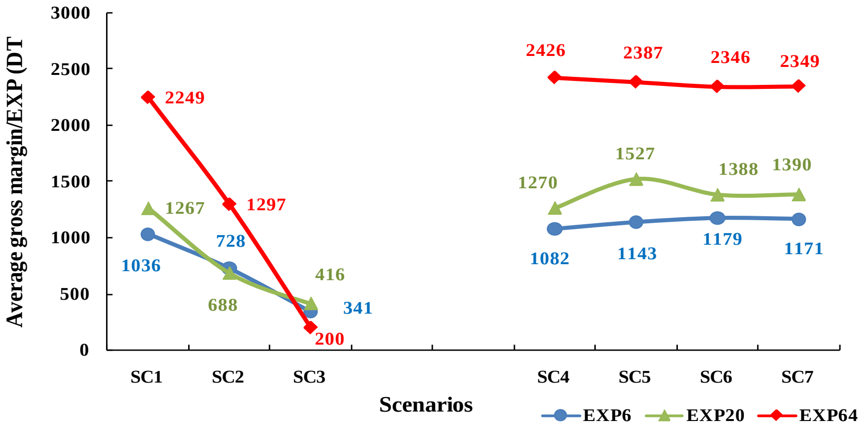

Fig.2. Average simulated gross margin of small farms per scenario (DT)[2]

(2) 1 DT= 2.2€

Analysis of figure 2 shows that the irrigation effect on gross margin is significantly positive for all farms studied. Indeed, the behavior of crop and soil is different and depending on environmental conditions relating to farms, their agricultural area, the amount of water initially applied and adopted scenarios.

The figure 3 shows the evolution gross margins percentage per studied scenarios for the three farms.

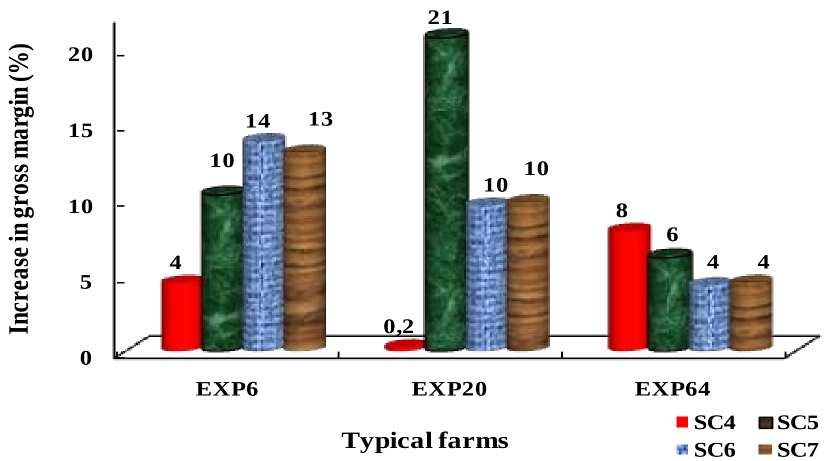

Fig. 3. Evolution of the simulated gross margin for small farms per irrigation scenario (%)

4. DISCUSSIONS

The simulation results for thirty years for typical farms studied (EXP6, EXP 20, EXP 64) show that crop yields will generally decrease over time. These results are supported by previous studies [10]. They concord with those obtained by other authors in similar cultures studies and practiced by small farms [15]-[12]-[5]. So we noted yield variability over time and between farms. This variability is related to cultivation techniques adopted by farms, to types of soil and to crop behavior depending of the environment of each farm. Yield variability and crop losses will decline over time [14]. This demonstrates the relevance of practices and adaptation programs to mitigate the impact of extreme weather and droughts.

Climate change effect is felt by small farms studied [17]. Indeed, the simulated gross margin will tend to decrease on average between 30 and 46% with temperature increase to 1° C (SC2). This decrease will be aggravated by temperature increase to 2° C (SC3) and could reach 91%.

For small farms, simulated gross margin increases between 0.2 and 21%. For the farm EXP6, scenario (SC6) in which the amounts of irrigation water are increased by 60% is the most profitable. The simulated gross margin increase will reach 14%.

For the farm EXP20, gross margin increases to 21% for 40% of water irrigation quantity increase (SC5). For the farm EXP64, the amount of water should be increased by 20% (SC4) to improve the simulated gross margin of 8%. The average gross margins during simulated thirty years for small farms are between 200 and 2426 DT.

For the farm EXP6 which produces green fodder irrigated, the gross margin value, which was about 1036 DT, increases to an average of 688 DT for temperature elevation of 1°C and to 341 DT for temperature increase of 2°C. It should be canceled in year 2031.

The farm EXP20 has a culture system consisting with green fodder, dry winter forage and irrigated cereals (Tab.1). Gross margins are affected by temperature rise to 1°C and more with 2°C. The average of this margin which was about 1267 DT will pass respectively to 728 and 416 DT. It will be very low around 17 DT in year 2035.

For the farm EXP64 which produces green and dry forage, decline gross margin is important. It will pass from 2249DT to 1297DT for temperature increase to 1°C. It is reduced to 200 TD for temperature increase to 2°C. Its value will become negligible from the year 2030.

After simulations crops practiced by farms [3], we noted that the model simulates faithfully the region conditions [1]. The simulation results obtained show that the yields will tend to decline with or without climate change [17]. Therefore, we adopted new technical routes increasing irrigation rates [2]-[6] that improve crop yields and consequently recover gross margin of small farmers.

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5. CONCLUSIONS

In conclusion, the simulations were performed over 30 years. So, we could predict that gross margins will be affected by lower yields decreased by climate change. Current systems will not be sustainable.

Small farmers in the region can adapt to foreseeable climate change for Tunisia by adopting new crop management. Indeed, a supply of supplementary irrigation water will improve yields and will recover margins gross of crops grown.

The farms should increase the amount of irrigation water applied initially. The additional water doses will reduce the impact on the natural environment and preserve it.

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The importance of rehabilitation works to hydrotechnical constructions of port

Mari-Isabella Stan, Dragoş-Florian Vintilă, Diana-Doina Ţenea

***Abstract* – While the port is the gateway to transport networks of a country, the breakwaters have the role to protect the entrance into the port and outside of it. The breakwaters are the coastal engineering constructions constantly subjected to the water action and which require rehabilitation works in time. The methods of rehabilitation for hydrotechnical constructions of port protection are different, constructive solutions being adopted for each individual situation, depending on the damaged areas. Also, lack of rehabilitation works done on time can lead to possible failure mechanisms of the breakwaters, mainly under the action of waves, thus resulting in a greater volume of work and higher costs as well as negative consequences on the environment. The purpose of this article is to show the importance of rehabilitation works to hydrotechnical construction of port having as a case study "The extension and the rehabilitation of the breakwater (North)" of Constanta Port.**

***Keywords* – rehabilitation, hydrotechnical constructions, breakwaters, Constanta Port.**

1. INTRODUCTION

Hydrotechnical constructions are complex works that are done both for the use of water resources for various purposes as well as to combat any destructive effects of water.

Hydrotechnical constructions differ from other engineering constructions in that they are subject, in addition to ordinary actions and solicitations, to water [2].

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Water is a specific stress factor for hydrotechnical constructions that acts with the highest weight on a wide range of intensities, durations and forms. Physical or chemical, static or dynamic, water affects hydrotechnical constructions not only when, above certain stress levels, it destabilizes constructions and causes failure phenomena, from incidents to accidents and destructions, but also during periods of normal behavior [3].

Hydrotechnical constructions are one of the forms of active nature management and along with their known economic effect, they are often associated with various negative ecological and socio demographic consequences and losses [6].

Hydrotechnical constructions of port are different from the other engineering constructions mainly in the following aspects:

- the execution of the major part of the structure is performed under the water level and sometimes in difficult conditions caused by waves, currents, etc.
- they use to the maximum the large size prefabricated elements put into practice with specialized naval equipment;
- constructions are subjected to solicitations both vertically as well as horizontally, with important values and dynamic character;
- the construction materials are subjected to the aggressive action of the aquatic environment and especially the marine [1].

Due to their complexity and not only, the hydrotechnical constructions should be subjected to continuous monitoring throughout their period of existence regarding the state and their functionality in order to take adequate measures of maintenance and repair or of rehabilitation in the event of deterioration or accidents.

2. THE IMPORTANCE OF REHABILITATION WORKS TO BREAKWATERS

For the main exploitation of a port to be efficient it depends on the size of ships that can be operated, which is closely related to water depth in the port basin. The port basin depth is determined by the deposition of sediments, which in turn depends among others on the port infrastructure, i.e. sheltering or protective breakwaters of port.

Outer defense works are generally works to protect areas of interest against the waves, mainly, but also against the currents and the sediment they carry. These works of harbors protection are generally the breakwaters [4].

The breakwater is defined as a solid coastal structure extended in the sea that blocks normal longitudinal alluvial transport and it is normally associated with port protection [10]. Efficient repair of coastal structures is very important because the performance of the old structures is reduced and has a high maintenance cost. However, insufficient repairs may lead to catastrophic damage to coastal structures and the surrounding area [5].

Dams defense of maritime port enclosures have the role to achieve aquatory quiet in which propagated wave height acceptable by manhole port does not exceed acceptable values for the safe conduct of shunting operations and the operation of ships [13].

The natural factors are those that influence the durability and strength largely to the hydrotechnical constructions of port. The aggressive actions are caused by: waves, currents, river deposits, ices, water freezing in concrete pores, temperature variations, salt crystallization in the variable horizon of the water, chemical corrosion of concrete and metal, hydrobiological factors, and so on. On the other hand, these constructions are subjected to the action of exploitation factors which refer to: loading regime of the port territory, binding and mooring mode of ships and the rules established by the project [1].

Rehabilitation works represent any kind of works of intervention needed to improve safety performance and exploitation of existing constructions, including the installations, in order to extend their useful life by bringing the essential quality requirements [14].

Hydrotechnical constructions of port have certain particularities regarding the constructive solutions, the technology execution, the calculation methods, the materials, the technical conditions for these and the importance category [1]. Therefore, the methods of rehabilitation for hydrotechnical constructions of port protection are different, constructive solutions being adopted for each particular situation, depending on the deteriorated zones, both on water and on land. A modern method for evaluating an optimal section that considers all technical aspects and allows assessment of the economy of the work is "the probabilistic dimension", taking into account the probabilistic aspect of the factors involved in assessing behavior in time [9].

Using the stochastic methods to dimension the defense breakwaters makse it possible to act properly and efficiently in the choice of technical solutions by solving the optimization problem which involves the acceptance of possible mechanisms of breakwater failure under the action of waves [8].

Generally rehabilitation works to hydrotechnical constructions of port for defense are: reconstruction of berms and protective mantles of stone or of prefabricated elements, restoration of guard walls and concrete slab from the level of the crest, restoration of the foundation bed, concreting caverns in areas where they were found or even resizing the cross section in damaged areas.

The rehabilitation methods must be adopted after a thorough examination to determine the causes of deterioration. Therefore, first the possible causes are eliminated, and then the constructive solutions are established to restore damaged parts of the construction or the construction as a whole, and there is the possibility to redesign the defense construction of port.

3. CASE STUDY: EXTENSION AND REHABILITATION OF THE NORTHERN BREAKWATER OF CONSTANTA PORT

Constanta Port is the largest port on the Black Sea and the fourth as importance in Europe, covering a total area of 3,926 ha, which 1,313 ha of land and 2,613 ha of water. The two breakwaters located northwards and southwards shelter the port, creating the safest optimal conditions for port activities. The present length of the North breakwater is 8,34 km and the South breakwater is 5,56 km [15].

The execution of the North and the South breakwaters which close inside the port of Constanta South began in 1976, their routes are established taking into account the predominant wind direction, the favorable routes for ships entering the port, the local hydrogeological conditions [12]. To create the enclosure, two sheltering breakwaters were designed in sections (**Fig. 1**): the North Breakwater with a length of 5,900 m and the South Breakwater with a length of 5,560 m [11].

Fig. 1. The sheltering breakwaters of Constanta Port [11]

In 1990, works on the two breakwaters were stopped for lack of funds, they remain in various stages of execution. In the years 1990-1996 works were executed to complement and protect the whole South breakwater and the North breakwater to km 4+850. In 1996, works for completion and repairment of sheltering breakwaters were resumed on the basis of the documentation prepared by S.C. IPTANA S.A. In 1998 works for rehabilitation and completion of the breakwaters were financed by the European Investment Bank, which were finalized in 2001. The rehabilitation works were composed of the following elements: excavation and reuse existing materials, reconstruction of breakwater protective coatings with sorted materials, realization the prefabricated elements of concrete, reconstruction of protective coatings with precast concrete to breakwaters (hollow blocks and stabilopods), pouring new concrete crest and rehabilitating the existing one [11].

Between the years 2003-2007, the general designer S.C. IPTANA S.A. elaborated a feasibility study and technical project "Completing of the Breakwater of Constanta Port" [12]. In 2010, a financing contract was signed through the Sectorial Operational Programme Transport (SOP-T 2007-2013) of the European Union structural funds and from the state budget. In 2013, a contract was signed for the execution of the extension by 1050 m to Breakwater of Constanta Port [15].

The North Breakwater was originally designed to have a length of 5,900 m starting at the North Breakwater head of Constanta Nord Port (km 0+0,00), this length also included the breakwater head. The general direction of this breakwater is North West - South East, this route having two fragments, one in right of Km 3+300 and another in right of Km 4+000 to guide the manhole of the Constanta Port to S-SE.

The North Breakwater project mainly contains three sections, according to the type of depth zones, namely:

- -13,0 m; -17,0 m (Km 0+00 – Km 1+815)
- -20,0 m; -24,0 m (Km 1+815 – Km 3+300)
- -24,0 m (Km 3+300 – Km 4+850).

On the date of commencement of the execution for the completion of the North Breakwater, the works up to Km 4+850 are completed including a temporary head and South Breakwater is fully constructed.

The constructive solution proposed for the section km 4+850 – 5+900 has the following composition in cross section (**Fig. 2**) [12]:

- the breakwater's trapezoidal nucleus made of unsorted stone (1–500 kg/pcs.) with a crest at the elevation +3.20 and 16.00 m wide, embankment slope from the port of 3:4 and toward broad slope of 2:3;

- the berms to support sheaths will be made of unsorted rock and stone blocks, they will be based on a rough stone mattress with berms, laid on geotextile;

- the berm quotas vary from one section to another, determined by the corresponding height of calculation wave, the stability conditions and how to make them;

- a first mantle of natural stone blocks of 0.5–1.50 t/pcs. by 1.50 m thick, enveloping the nucleus of the rough stone. Under the crest, in the mantle of blocks the spur of concrete will be incorporated, which serves to prevent ingress of water jets directly below the crest of the breakwater and wash the particulate material;

- the second mantle of stone blocks of 1.5–3 t/pcs. 2.20 m thick located on the whole exterior slope, in the shell provided to achieve concrete blocks type CORE-LOC of 8.5 cm/pcs. (14 pcs./100 sqm) placed in a single layer;

- on the interior slope over the mantle of blocks to 0.5–1.5 t/pcs. there will be a shell of concrete blocks type CORE-LOC of 2 cm/pcs. (38 pcs./100 sqm) placed in a single layer.

The constructive solution takes into account the extension of the North Breakwater to 1050 m with shell made of blocks type CORE-LOC. The use of this type of blocks mounted in the simple coat has brought about significant economies of resources.

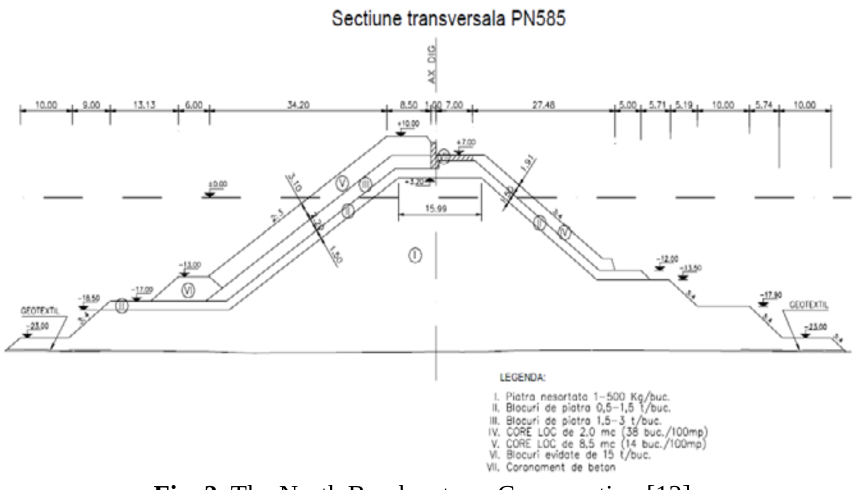

Fig. 2. The North Breakwater – Cross section [12]

The works connected with the execution the North Breakwater of Constanta Port (**Fig. 3**) consist in profiling the breakwater's berm, dismantling the existing breakwater head to achieve connection with its extension as well as controlled placement of the nucleus extending the breakwater.

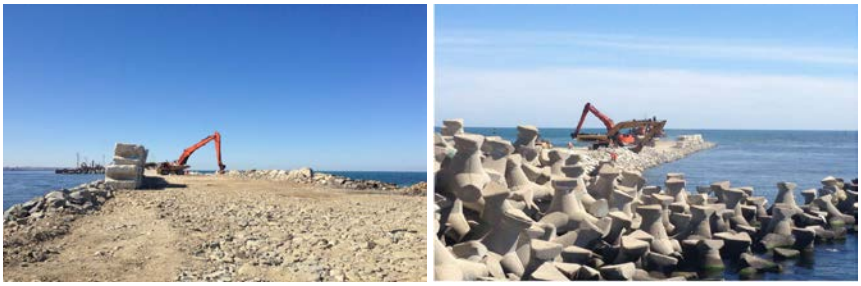

Fig. 3. Works on the North Breakwater [15]

During the period when the works on the North Breakwater were stopped until they have resumed in 2013, insufficient maintenance works were executed due to lack of financial funds, which through the new project "Completing of the Breakwater of Constanta Port" required the rehabilitation works as well.

The rehabilitation works on the breakwater (North) aim to improve the operating conditions by decreasing the waves agitation in the port aquatory, increasing the safety of vessels by ensuring the protection of the port channels and reducing the destructive effects of waves on the port facilities [15].

With the completion of this investment additional funds will be attracted for development of harbor infrastructure and superstructure of Constanta Port.

4. CONCLUSIONS

The construction of the shelter North and South breakwaters in Constanta Port aims to ensure optimal conditions for the port entry and basins in the southern area to be protected from the waves agitation for the construction of deep sea quays as well as for moving barges, and so on.

Harbor infrastructure is usually in the state administration which is responsible for repairing and maintenance of its minimal technical characteristics. These costs are expensive and cannot be borne entirely by the state budget, only to a very small extent, which makes the investments in this domain considered of national interest to have to be covered by other funding sources: the European Union structural funds or the initiation of a public-private partnership.

In this respect the National Company "Maritime Ports Administration" SA Constanta obtained financing through the Sectoral Operational Programme Transport (SOP-T 2007-2013) aimed to modernize and develop the national transport infrastructure in order to develop a sustainable national transport system and to modernize and develop the river and maritime ports for the project "Completing of the Breakwater in Constanta Port - extension by 1050 m" [15].

Through this regional strategic project in addition to extension works the rehabilitation works of part of the breakwater already executed will be carried out and with their completion the port basin has a chance to enter the safe operation becoming profitable in economic terms.

For resistance and durability of the hydrotechnical constructions of port it is of great importance to ensure the quality of workmanship and the compliance with technical conditions of exploitation, performing the maintenance ie periodical maintenance and repairs according to the standards [1].

Thus, failure to timely completion of works and repairing the shelter breakwaters can lead to deeper deterioration of the structures of port and therefore to rehabilitation works of a larger volume and a higher cost. On the other hand, there may be negative consequences for the environment, so the works must be done from the perspective of sustainable development that involves "the impact assessment of economic activities on the environment, biological diversity conservation through protected natural areas and the ecological reconstruction of damaged systems" [7].

In conclusion, the rehabilitation works of the hydrotechnical constructions impose responsible management, on one hand due to high costs, and on the other hand, these works should be carried out based on decisions taken by specialists given that delays could have serious consequences.

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"Additional yield – irrigation depth" relationship for white bearing rose (Rosa Alba L.)

N. Nedkov, Al. Matev, A. Ovcharova

Abstract: **The aim of this paper is to establish a relationship of "Additional yield - irrigation depth" for white oil bearing rose in conditions of Kazanlak's Valley (South part of Bulgaria). The field experiment was carried out during 2009 – 2011 period with following variants: 1) without irrigation; 2) irrigation with 50% of the depth; 3) irrigation with 75% of the depth; 4) full irrigation (100% of calculated irrigation depth). The irrigation was done by drip installation. The white rose (Rose Alba L.) oil has a much more intense aroma and components than the oil of red rose (Rose Damascena L.). The essential oil of white rose has health benefits with its medical properties and is a very important raw material for perfume industry, and export. That's way is necessary to establish the relationship between water and white rose oil yield. Based on the results obtained in this work, for calculation of the additional yield (for blossom and oil) depending on the amount of irrigation depth, is recommended equation:** $Y_i = 1 - (1 - x_i)^{1.1}$ **, where** Y_i **is relative additional yield and** x_i **– relative irrigation depth, that approximates with high accuracy experimental data (R>0.98).**

Keywords **- drip irrigation, yield of blossom, yield of oil, white bearing rose.**

1. INTRODUCTION

The relationship between yield and irrigation depth has been studied for all major crops, such as its parameters would serve farmers to optimize the components of the irrigation regime and irrigation system for maximizing the economic impact of irrigation. This relationship is represented mathematically by the equation, which parameters are established on the basis of existing experimental data. Applying

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particular equation it can be calculated the relative yield by each set of relative irrigation depth. There are different proposals for interpretation of this relationship in the specialized scientific literature. Some authors believe that it is linear (Al Garside and others., 1992; V.Petrova, 2009), but others consider that it is subjected to the equation of the second degree (I.Varlev, 1983, 1999, 2008; R.T.Diez etc.1998). This means that the increase of the yield is not in proportion to the increase of the irrigation depth. G.A.Senchukov and A.M.Oleynik (1986) have established the parameters of the relationship in a number of crops, as in each case the relationship is expressed graphically by a parabola. According to the authors the yields increase with the alternation of the irrigation depth in a certain interval, then with further increase they do not change or it begin to decline.

The aim of the study is to establish the parameters of the "Additional Yield - Irrigation depth" for white bearing rose (Rosa Alba L.) in the climatic condition of the Kazanlak Valley.

2. MATERIAL AND METHODS

Data from three-year field experiment (2009 – 2011) has been used for the purpose of the irrigation regime investigation of the white bearing rose (Rosa Alba L.) in the experimental field of the Institute of rose and essential oil crops, town of Kazanlak. The soil type at the site of experience is characterized as leached cinnamon forest, alluvial-diluvial, light to medium sandy loam. The experience was conducted by the method of long plots in four replications by a scheme of planting 3.0 m × 0, 7m (5950 plants per 1 ha).

The irrigation rates were done by drip system as the soil moisture contents in the optimal variant(variant 4) was maintained of 80 to 85% of field capacity in the layer of 0 -0,60m. Dynamics of soil moisture in the layer 0 - 1.00 m was monitored periodically (once a week) by a weighting method. The variants including in this study are the following: 1) non – irrigated; 2) irrigation with 50% reduction of the irrigation depth, calculated at the optimal variant (50% m); 3) irrigation with 25% reduction of the irrigation depth, calculated at the optimal variant (75 % m) and 4) optimum irrigation (100% m).

The parameters of "Additional yield - irrigation depth" relationship have been established by the method of least squares in two ways:

1) By regression of the type $Y_i = ax^2 + bx_i$ (1)

where: Y_i is sought additional yield under irrigation depth "x_i"

x_i - the amount of irrigation depth.

2) By exponent formula of Davidov (1982, 1994), which is as follows:

$$Y_i = 1 - (1 - x_i)^n \quad (2)$$

Where: Y_i is the yield by irrigation depth x_i;

x_i - the amount of irrigation depth;

n - exponent

The study was conducted in two directions – yield of blossom and yield of oil, and the data processing was done using a specialized computer program "YIELD" (D.Davidov, 1994).

3. RESULTS AND SIGNIFICANCES

Output data for determining the "Additional yield - irrigation depth" relationship average for tree-year experiment are presented in Table 1.

Table1. Output data for determining the parameters of "Additional yield - irrigation depth" relationship by white bearing rose (Rosa Alba L.)

Years	variant	$x_i = \frac{M_i}{M_0}$	Yield		Additional yield (absolute and relative)			
					Blossom *		Oil**	
			Blossom* (kg/ha)	Oil** (g/ha)	ΔY (kg/ha)	$\Delta Y_i/\Delta Y_0$	ΔY (g/ha)	$\Delta Y_i/\Delta Y_0$
1	2	3	4	5	6	7	8	9
2009 *ΔY_0=2670(kg/ha) **ΔY_0= 1480(g/ha)	1	0.00	5030	830	0	0.000	0.0	0.000
	2	0.50	6340	1500	1310	0.491	670	0.453
	3	0.75	6790	1980	1760	0.659	1150	0.777
	4	1.00	7700	2310	2670	1.000	1480	1.000
2010 *ΔY_0 =1030 (kg/a) **ΔY_0 =700 (g/ha)	1	0.00	4780	833	0	0.000	0.0	0.000
	2	0.50	5240	1053	460	0.447	220	0.314
	3	0.75	5370	1440	590	0.573	607	0.867
	4	1.00	5810	1533	1030	1.000	700	1.000
2011 *ΔY_0=1860(kg/ha) **ΔY_0 = 745 (g/ha)	1	0.00	2070	409	0	0.000	0.0	0.000
	2	0.50	3080	762	1010	0.543	353	0.474
	3	0.75	3460	1021	1390	0.747	612	0.821
	4	1.00	3930	1154	1860	1.000	745	1.000
Average *ΔY_0=1850(kg/ha) **ΔY_0 = 975 (g/ha)	1	0.00	3960	691	0	0.000	0.0	0.000
	2	0.50	4890	1105	930	0.503	414	0.425
	3	0.75	5210	1480	1250	0.676	789	0.809
	4	1.00	5810	1666	1850	1.000	975	1.000
M_0 – Maximum irrigation depth (mm);ΔY – Additional yield of blossom (kg/ha); oil(g/ha)								

• **Relationship between additional yield and amount of irrigation depth according to formula (1).**

For establishing the relationship "Additional yield of blossom - irrigation depth" have been used data from columns 3 and 7 of Table 1. In Figure 1 are presented graphically the receive results, averaged and total for the entire experimental period (including the parameters of the relationship). It is mandatory using quadratic equation to present graphically by a concave parabola the relationship for the first two experimental years. Since this contradicts the biological characteristics of crop, it is sought a compromise variant, namely the linear relationship of the type: Y = ax, with its accompanying restrictive conditions from 0 to 1 on both axes.

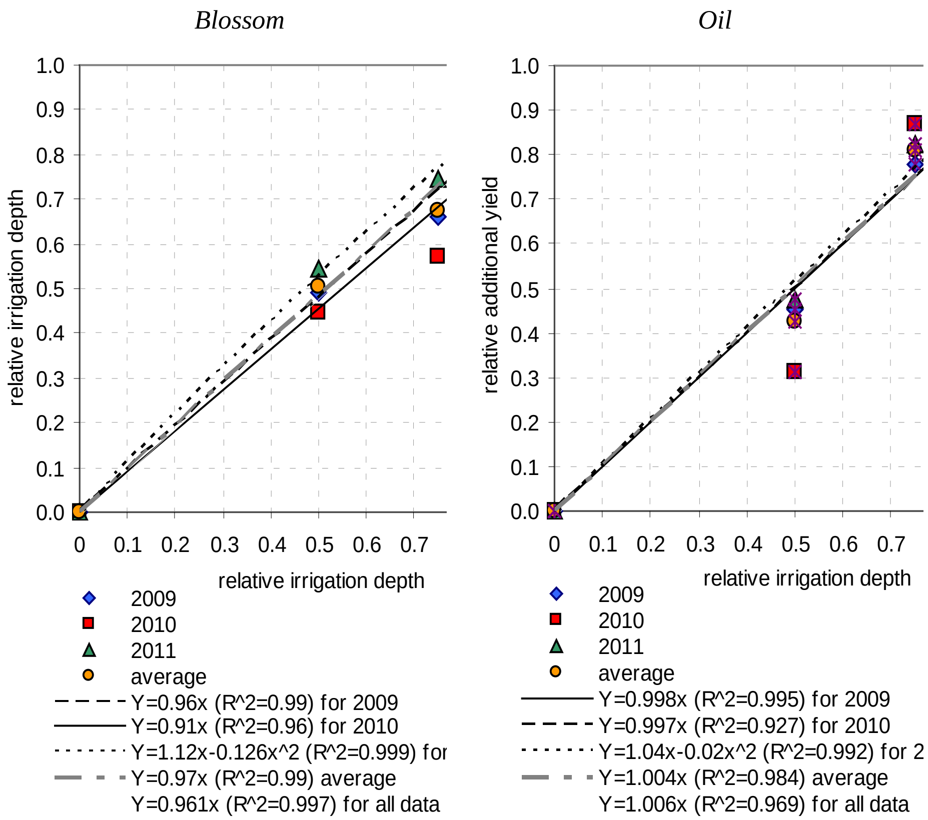


Fig.1 "Irrigation depth – additional yield" relationship by equation (1)

As a result, two linear equations are received with similar parameters at rather high values of the coefficient of determination R^2 = 0.99, and R^2 = 0.96 respectively. According to the equation valid for the first year's experience, the maximum yield of blossom could be achieved by increase of the maximum irrigation rate of 4%, and for the second year – by 10%. The relationship during the third year (2011) is expressed by equation of second degree with R^2 = 0.999 and plotted by a convex parabola. It is obviously that maximum yield would obtain at the irrigation rate practically equal to the actually supplied (+ 1% difference).

Averaged and total data points are approximated by linear equations with coefficient of determination $R^2 \geq 0.99$. Maximum calculated yield of blossom is obtained by minimal (with 3-4%) increase of actually supplied irrigation depth. According to the results obtained by the equation (1) can be considered that the step, which modifies the additional yield is practically equal to that, which varies with the amount of irrigation. This is the result of a weaker positive effect on total and additional yield of irrigation rate reduced by 25 and 50% (columns 4, 6 and 7 of Table 1).

By a similar way is established the relationship between additional yield of oil and irrigation depth, using data from Table 1, columns 3 and 9. In figure 1 are presented the results of rose oil during the experimental years averaged and total. Here the relationship for the first two years is linear but in the third – a square, as by the yield of blossom. The graph shows that the lines built to the appropriate equations almost coincide, and an additional estimated maximum yield of oil is obtained at the maximum calculated irrigation rate, differ from actual by ± 1% (Table 2), with a coefficient of determination $R^2>0.92$.

Table 2. Experimental and calculated additional yield and differences between them using formula (1)

M	Blossom				Oil			
	Additional yield kg/ha		Difference to the experimental yield		Additional yield g/ha		Difference to the experimental yield	
	exper.	calcul.	±kg/ha	±%	exper.	calcul.	±g/ha	±%
2009								
0.50	1310	1280	-30	-2.2	670	739	69	10.2
0.75	1760	1920	160	9.2	1150	1108	-42	-3.7
1.00	2670	2560	-110	-4.0	1480	1477	-3	-0.2
2010								
0.50	460	470	10	1.9	220	349	129	58.6
0.75	590	700	110	19.1	607	523	-84	-13.8
1.00	1030	940	-90	-9.0	700	698	-2	-0.3
2011								
0.50	1010	980	-30	-2.7	353	384	31	8.7
0.75	1390	1430	40	2.9	612	573	-39	-6.4
1.00	1860	1850	-10	-0.6	745	760	15	2.0
average for 2009 – 2011								
0.50	930	900	-30	-3.5	414	489	75	18.2
0.75	1250	1350	100	7.7	789	734	-55	-6.9
1.00	1850	1790	-60	-3.0	975	979	4	0.4
M – relative irrigation depth								

In Table 2 are presented the deviations in absolute and relative values of calculated yield from equation (1) to the experimental established. The differences of the yield of blossom are within ± 5 % in 2/3 of cases, and only in one case the difference is greater than 10%. The differences of the yield of rose oil are significant, as can be seen in Table 2, particularly in respect of the variant, irrigated with the smallest irrigation depth (50 % m). The calculated yield by this variant for the conditions of the experiment was greater than experimental during the three experimental years. By comparison with irrigation variant of 75% m it is always lower. As mentioned above, so located in the coordinate system points require approximation by concave curve, which would not be correct. Therefore the used linear relationships are loaded with larger deviations.

However, the differences between the experimental and calculated values are considerably smaller with respect to the absolute additional yield. The results in terms of yield of blossom are represented graphically in Figures 2 and Figure 3. Correlation between two sets of data is very high (R = 0.991), as there is a linear relationship between them (Figure 3) with R^2 = 0.981.

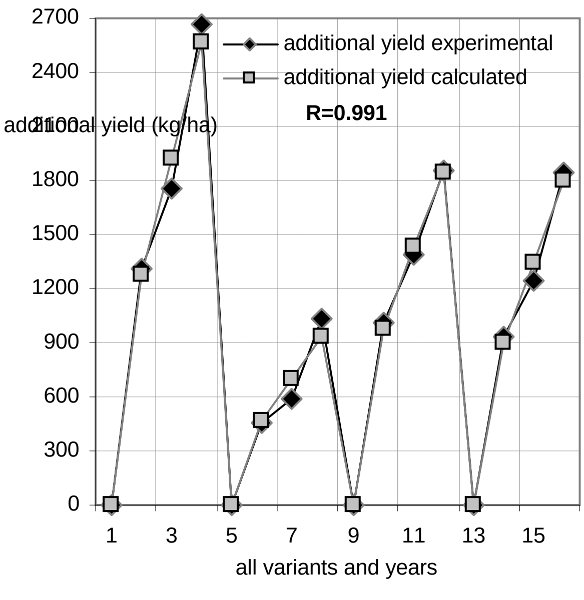


Fig.2 Additional yield for blossom – experimental and calculated by formula (1)

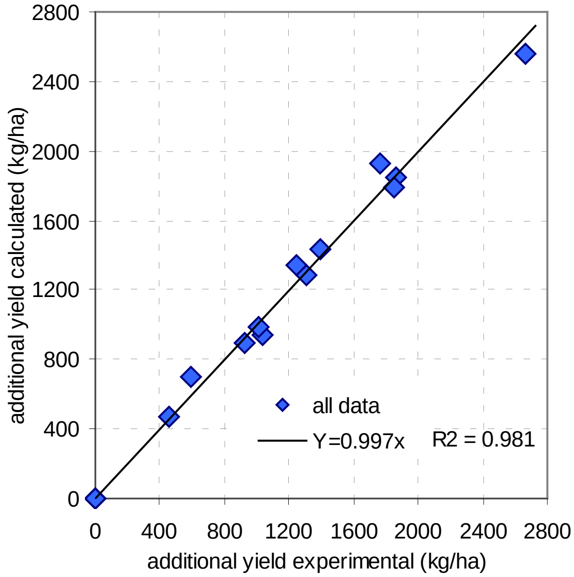


Fig.3 Relationship between experimental and calculated additional yield for blossom by formula (1)

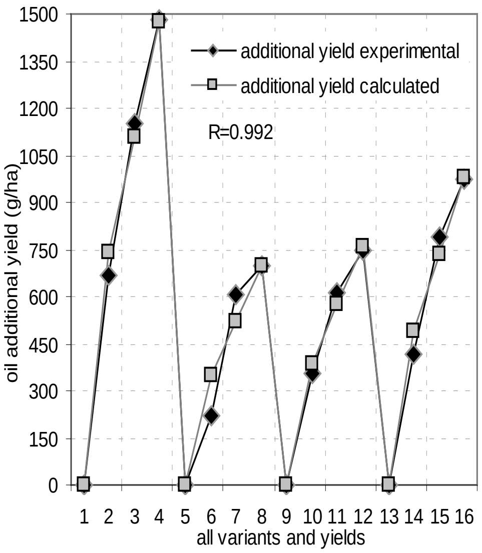


Fig.4 Additional yield of oil – experimental and calculated by formula (1)

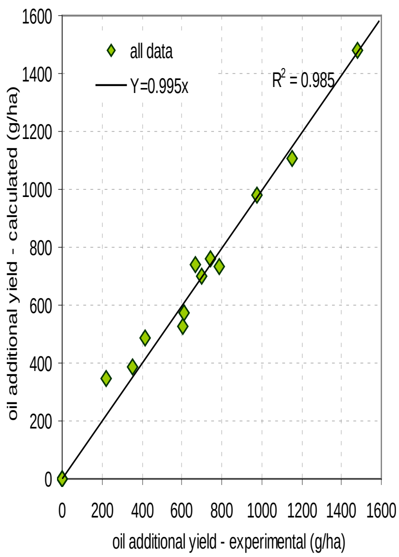


Fig.5 Relationship between experimental and calculated additional yield of oil by formula (1)

The correlation between the two sets of data by the yield of rose oil is also very high (R = 0.992), and here there is a linear relation between them with $R^2 = 0.985$ (Fig. 4 and 5).

• **Relationship between additional yields and amount of irrigation depth according to formula (2).**

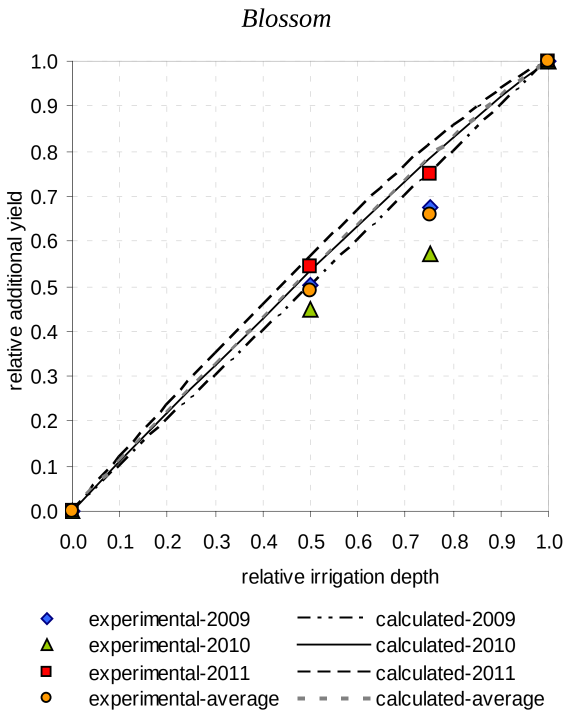
Data from columns 3 and 7 of Table 1 are used by the exponent formula of Davidov for establishing the relationship "Additional yield of blossom - irrigation depth". The results are presented graphically in Figure 6 by years, average, and total for the entire experimental period.

By this formula the calculated additional yields always coincide with the experimentally established, i.e. deviations in this regard can be taken into account by intermediate variants (irrigation with irrigated depth 50% and 75%).

Table 3 Parameters of relationship “Additional yield - irrigation depth” by formula (2)

Year	**Formula**	**Blossom**		**Oil**	
		n	R	n	R
2009	$Y_i = 1 - (1 - x_i)^n$	1.0	0.996	1.0	0.996
2010		1.1	0.973	1.1	0.962
2011		1.2	0.998	1.2	0.994
average		1.1	0.993	1.1	0.991
all data		1.1	0.988	1.1	0.985

In turns of the relationship of the additional yield of blossom and irrigation depth, it is linear for the first experimental year. During the second and third years, it is respectively with exponent n = 1.1 and n = 1.2, thus graphically expressed by slightly convex parabolas. The reason for this is discussed in the previous case. The used formula demonstrated a very high accuracy by the coefficient of correlation R> 0.97, as the approximation is simultaneously for all experimental points at R = 0.988 and n = 1,1.



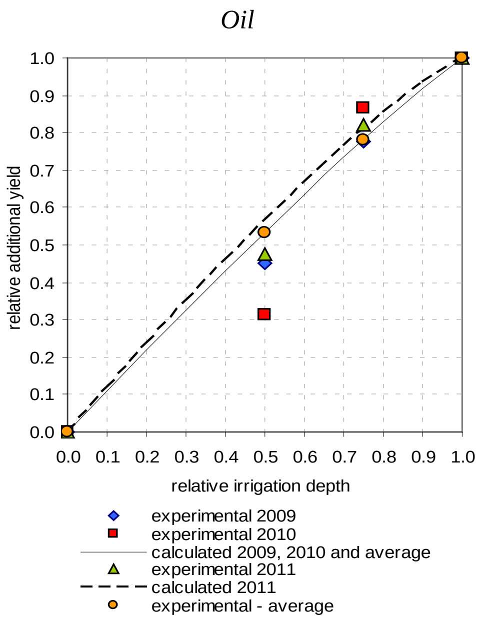


Fig.6 Relationship between additional yield and irrigation depth by formula (2)

In figure 7 are in parallel presented experimental and calculated yields of blossom by the formula (2) with coefficient of correlation of R = 0.994, while in Figure 8 – the linear relationship between them with R^2 = 0.988. According to the graphs of the two figures, the calculated yield of blossom by irrigation depth of 50%m exceeds the experimental one with 30-90 kg / ha, or an average of 6% (Table 4). The absolute differences are more significant (120-240 kg / ha) by irrigation with depth of 75% m, but they are obtained on the basis higher values of the additional yield.

The relationship between additional yield of rose oil and irrigation depth is characterized with exponent n = 1.1 for the first two experimental years, and n = 1.2 for the third one. It is expressed graphically by slightly convex parabolas, which in the years are or almost the same as by the yield of blossom. The used formula averaged the experimental data with coefficient of R> 0.97, and the approximation of all experimental points is with R = 0.985 and exponent of n = 1.1.

In Figure 9 are plotted absolute additional yields of oil, experimental and calculated using the formula, as the correlation between them is very high (R = 0.991). In Figure 10 is presented the relationship between them (also linear) with R^2 = 0.98. According to the graphs of the two figures by variant of 50% m, the calculated yield of rose oil exceeds experimentally established with 70-150 g / ha. But the values were generally lower, relative differences are more significant (Table 4). The trend is the opposite at the variant with irrigation depth of 75% m. The calculated yield by this variant is even slightly lower than the experimentally established, and the difference does not exceed 10%, as the average value for the three years is 3.3% (Table 4). The reasons for the obtained results are set out above.

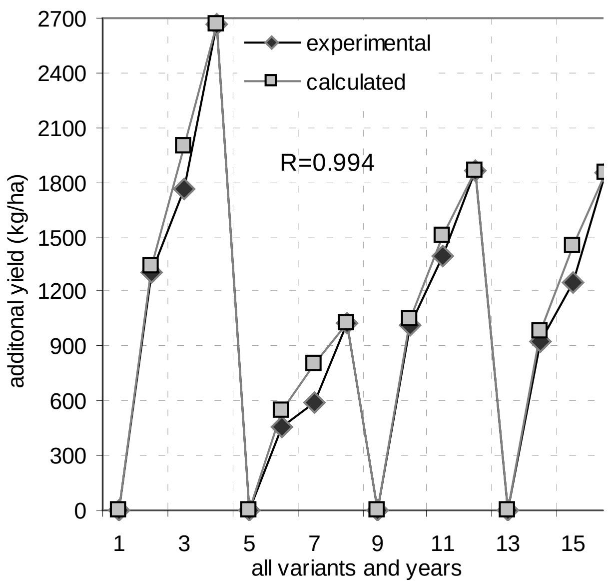


Fig.7 Absolute additional yield of blossom – experimental and calculated by formula (2)

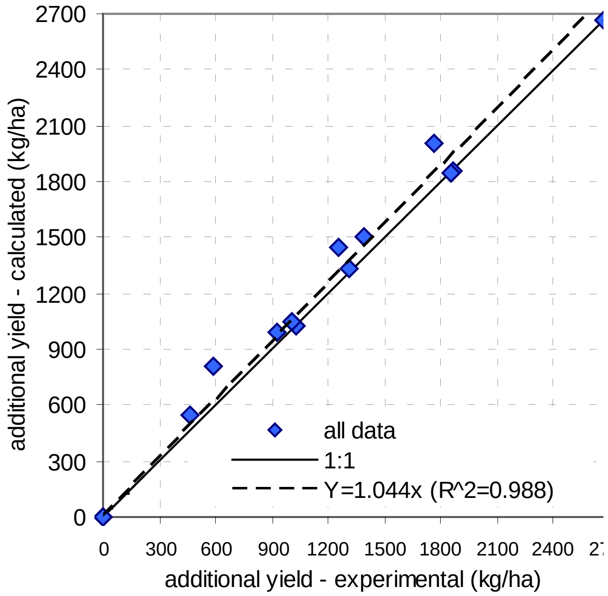


Fig.8 Relationship between experimental and calculated additional yield of blossom by formula (2)

Given the results of the relationship "Additional yield - irrigation depth", obtained by the exponent formula of Davidov, it can be considered that the equation $Y_i = 1-(1-x_i)^{1.1}$ fully satisfies the accuracy and correctly interprets the change of the additional yield, depending on the amount of irrigation depth. The equation can be used both for the yield of blossom and as regards the yield of white rose oil.

Table 4. Experimental and calculated additional yield and differences between them using formula (2)

M	**Additional yield of blossom kg/ha**		**Difference to the experimental yield**		**Additional yield of rose oil g/ha**		**Difference to the experimental yield**	
	exper.	calcul.	±kg/ha	±%	exper.	calcul.	±g/ha	±%
2009								
0.50	1310	1340	30	2	670	790	120	17.8
0.75	1760	2000	240	14	1150	1158	8	0.7
2010								
0.50	460	550	90	19	220	373	153	69.7
0.75	590	810	220	37	607	548	-59	-9.8
2011								
0.50	1010	1050	40	4	353	421	68	19.2
0.75	1390	1510	120	8	612	604	-8	-1.3

average for 2009 – 2011								
0.50	930	990	60	6	414	520	106	25.6
0.75	1250	1450	200	16	789	763	-26	-3.3
M – relative irrigation depth								

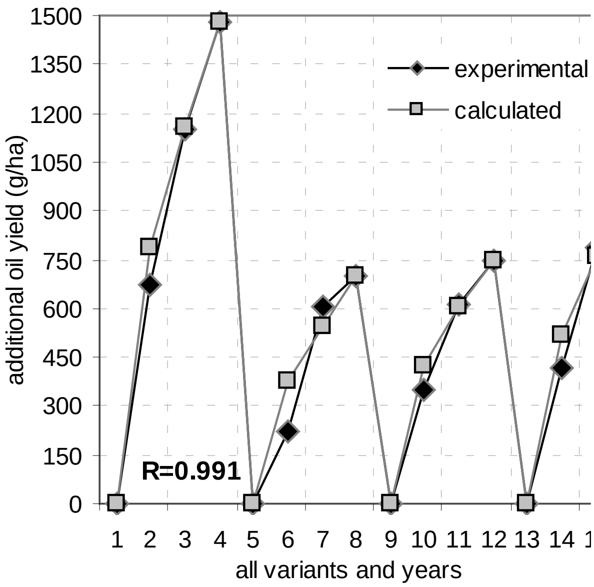


Fig.9 Absolute additional yield of oil – experimental and calculated by formula (2)

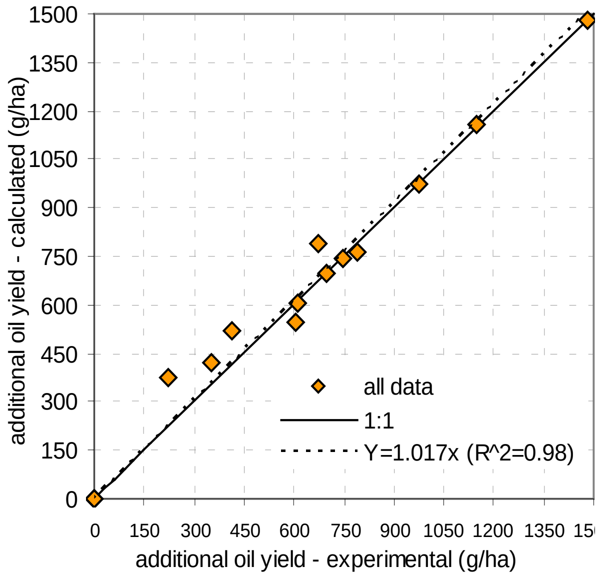


Fig.10 Relationship between experimental and calculated additional yield of oil by formula (2)

4. Conclusions

For the conditions of the experiment relationship "Additional yield - irrigation depth" can be expressed by the linear equation: $Y = ax$, where a ~ 1. This means that the relative change of the additional yield almost coincides with the relative change of the amount of irrigation. Regarding the yield of blossom relationship corresponds to the equation Y = 0.97x, where R^2 = 0.99, but in case of yield of rose oil - the equation is Y = 1.006x (R^2 = 0.969). The parameters of this relationship are valid in the relative range from 0 to 1 on both axes.

The exponent formula of Davidov (1994) fully satisfies the accuracy and correctly interprets the variation of the additional yield, depending on the amount of realized irrigation depth. That is expressed by equation: $Y_i = 1 - (1 - x_i)^{1.1}$, both in terms of yield of blossom and as regards the yield of rose oil, with R> 0.98.

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Study of climate variability and change in the Dobrogea region

Constantin Buta, Ana Nicoleta Popescu, Geanina Mihai

***Abstract* – The purpose of this paper is to study the impact that climate variability and change have had on hydrological extremes in Dobrogea. The main objective of this work was to create a climate analysis for the period 1965-2005 in Dobrogea using mean temperatures and monthly averages, maximum and minimum rainfall for each year from 1965 - 2005 period and also monthly averages, maximum and minimum flows for each year of the 1965 - 2011 period from eight hydrometric stations and eight meteorological stations.**

For this purpose were analysed especially climate and hydrological extremes events using several evaluation indices such as: Angot rainfall index, Moduli coefficients, Deciles, Peguy climographs, de Martonne drought index and Thornthwaite index.

***Keywords* – temperatures, rainfall, flow regime, hydro-meteorological indices**

1. INTRODUCTION

Climate variability and change is one of the global challenges of the 21st century. The changes in climate will have direct and indirect impacts on natural environment as well as on human societies.

According to the United Nations Framework Convention on Climate Change (UNFCCC) [10], climate change is defined as "changes in climate which is attributed directly or indirectly to human activity that causes global atmospheric composition change, overlapping the natural climate variability observed over the same period ".

So UNFCCC does distinction between "climate change" due to human activity that involves changing in the atmospheric composition, and "climate variability" that is due to natural causes.

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Although, in theory, climate change is a natural process that takes place over a long period of time, in practice this is happening much faster and with greater intensity. The consequences of climate change is reflected in: the average temperature increasing with significant variations at regional level, the water resources for the population decreasing, the volume of ice caps decreasing, the sea levels rising, hydrological cycle changing, changes in the course of the seasons, frequency and intensity of extreme weather events increasing, biodiversity reducing. The effects produced by climate change are multiple, but of great interest to this paper are the following hydro-meteorological variables:

- Changes in air temperature;
- Changes in rainfall amount on the surface, another meteorological variable of interest to global environmental change.

Hydrology and water resources are closely linked to climate variability, so they will be the first to be affected. Considering the importance of water resources for the life and the evidence of climatic variability in the recent decades, the paper aims to address issues of climate change impact that they have on hydrological extremes, namely droughts and floods.

What happens now in Romania, referring here at the two categories of hydro-meteorological phenomena - droughts and floods - are the consequences, firstly, due to the global climate change or climate variations at regional and global level, and secondly due to the anthropic intervention in the specific landscape. The aridity trend manifested especially in the last two decades of the last century and continued in the current century is due to increasing in air temperatures associated with decreased rainfall. But on this climate background, namely dry, at least in Romania and at local level in Dobrogea region, are produced numerous floods, caused by large amounts of rainfall, falling in short intervals of time by the order of hours, and sometimes even minutes.

The purpose of this paper is to study the impact of climate variability and changes have had during 1965-2005 period on hydrological extremes in a well-known region of Romania, namely Dobrogea.

Dobrogea is a region located in the south-eastern part of Romania (**Fig. 1**). It is bounded in the north by the Danube Delta and the Macin Mountains, in east by the Black Sea and in west by the lower Danube. This includes north-eastern part of Bulgaria: Dobrich and Silistra regions.

Fig. 1 Location of Dobrogea territory

The analysis of this paper, regarding the impact of climate change on hydrological extremes in Dobrogea was performed using the climatic database of National Institute of Meteorology and Hydrology and literature references [1].

For this purpose were used temperatures and monthly averages, maximum and minimum precipitations for each year from 1965 - 2005 period and also monthly averages, maximum and minimum flows for each year of the 1965 - 2011 period from eight hydrometric stations and eight meteorological stations.

The hydrometric and meteorological stations (**Table 1**) considered were divided into two distinct regions: North Dobrogea - three stations and South Dobrogea - five stations (map delineation between the two regions the Casimcea River, or administrative limit of Tulcea and Constanta counties (**Fig. 2**).

Table. 1. The analyzed stations from North Dobrogea and South Dobrogea

North Dobrogea		South Dobrogea	
Hydrometric stations	**Meteorological stations**	**Hydrometric stations**	**Meteorological stations**
Poşta (Teliţa river)	Tulcea	Saraiu (Topolog river)	Hârşova
Ceamurlia (Slava river)	Jurilovca	Cuza Vodă (Agi Cabul river)	Medgidia
Casimcea (Casimcea river)	Corugea	Lumina (Neagra valey)	Constanţa
		Albeşti (Albeşti valey)	Mangalia
		Negureni (Negureni valey)	Adamclisi

Meteorological and hydrometric stations chosen for this study are also highlighted in **Fig. 2**, according to the legend.

Fig. 2 Map location of the analysed stations of North and South Dobrogea – after [9]

2. Experiment Description

Correlation and study of hydro-meteorological extremes is performed using indices that take into account meteorological and hydrological parameters such as rainfalls, temperature, flow of rivers etc.

Climatic indices use different formulas, graphics, different scales of interpretation and analysis and are suitable for specific geographic regions.

Indices used for this study are:

1. *Angot rainfall index (k)* – it is used to point out the annual change in rainfall characteristics and, especially, to determine their types of variation during the year. It reveals, thus, rainy periods (k> 1) and dry periods (k <1) [3];

$$k = \frac{p \cdot 365}{P \cdot n} \tag{1}$$

where:
p - rainfall in a given month (mm);
P – mean annual amount of rainfall (mm);
n - the number of days in a month.

2. *Moduli coefficients (K)* – similar to Angot index, module coefficient is defined as the ratio between seasonal average flow Q_i (calculated per month, season or year) and annual average flow Q_{ma} [4];

$$k = \frac{Q_i}{Q_{ma}} \tag{2}$$

where:
Q_i - annual mean flows (m^3/s);
Q_{ma} – multi-annual mean flows (m^3/s).

3. *Deciles* – are quintiles, indicators which help realize the division of the series into a number of equal parts. Quintiles of order "r" parameter values studied are sharing the statistical series orderly "r" in equal parts. Thus, if r = 10, there are obtained quantiles of 10 order [4];

4. *Peguy Climographs*. Dryness and drought phenomena can be studied based on complex diagrams called climographs. These graphics have been imagined by Filippo Eredia and highlights termo-pluviometric features of months of the year. They establish graphic correlations between precipitations and temperature in a rectangular axis system [6].

- Very cold (G);
- Cool (R);
- Optimal (O);
- Tropical (T);
- Arid (A).

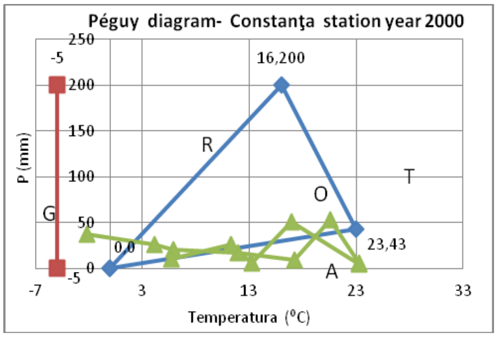

Fig. 3. Péguy diagram- Constanţa station year 2000[5]

Péguy method (**Fig. 3**) introduces critical thresholds of temperature and precipitations. Monthly temperatures [°C] is reported in the x-axis, monthly rainfall [mm] is reported in the y-axis. A triangular reference polygon with vertices having coordinates (0° C, 0 mm); (23 °C, 45 mm) and (16 °C, 200 mm) respectively, divide the Cartesian space in five climatic chronological regions correspondent to the dominant climatic character of the month.

5. *De Martonne aridity index* – this index is calculated over different periods (yearly, monthly or growing season), taking into account the amount of rainfalls in the period under review (mm) and average air temperature for the period under review (ºC) [2],[7].

$$I = \frac{P}{T+10} \quad (3)$$

where
- I – de Martonne annual index;
- P – mean annual rainfall, (mm);
- T - mean annual temperature, (ºC).

6. *Thornthwaite index* – Thornthwaite index reveals that segment from the total global amount of rainfall that is used by the plants to satisfy their hydration needs (table no. 3.2) [8].

$$I_{TH} = \frac{P - ETP}{ETP} \cdot 100 \quad (4)$$

where
- I_{TH} – Thornrhwaite annual index;
- P – mean annual rainfall, (mm);
- ETP - mean annual potential evapotranspiration, (mm).

On a global scale, the Thornthwaite index was defined by the humidity classes segmented by index units (Table 2).

Table 2 Thornthwaite index classes and units on a global scale [11]

Index units	**Humidity classes**
>100	A – excessively humid
80 - 100	B4 – very humid
60 - 80	B3 – highly humid
40 - 60	B2 – moderately humid
20 - 40	B1 – slightly humid
0 - 20	C2 – moist-subhumid
-33.3 - 0	C1 – dry subhumid
-67.7 - -33.3	D – semiarid
-100 – 67.7	E – arid

3. RESULTS AND SIGNIFICANCES

After studying the hydro - meteorological extremes using quantization indices, it resulted more or less similarities due of the fact that they take into account different meteorological and hydrological parameters such as precipitation, temperature and river flow. For accurate interpretation all indices studied were graphical represented as follows:

a) Angot rainfall index (k)

According to **Fig. 4**, throught computing the Angot index, calculated for the period 1961-2005, it is shown that in most examined areas, the values are distributed below the reference one.

Alternations of the rainy periods with dry periods are frequent, uneven and largely coincide at all analyzed stations. However, using this index, each station is individual in terms of obtained results due to different precipitation intake in targeted areas.

At the end of the year’s period it can be observed an upward trend, specific for rainy periods, at seven stations from all eight taken in consideration. Lumina station is the exception where the index recorded a sharp decline in the near threshold.

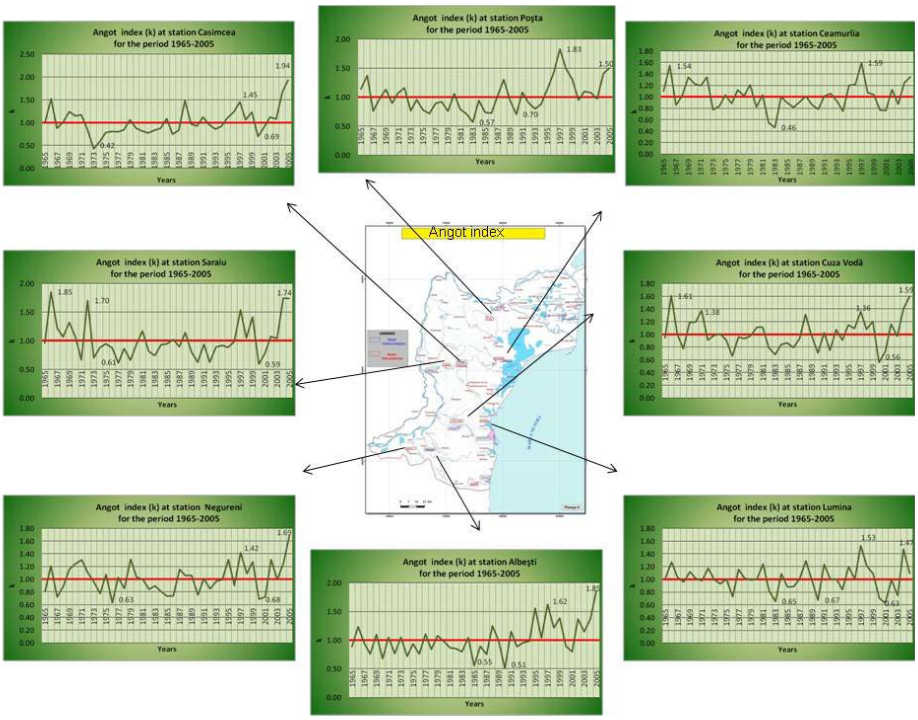

Fig. 4 Graphic representation of Angot index values

b) De Martonne index (I)

Index de Martonne highlights more the dry periods than the rainy periods. The main trend observed is semiarid-arid at all analyzed stations, with obvious droughts at stations Corugea-Casimcea and Hârşova-Saraiu (for the periods 1973 - 1984 and 1989 - 1996).

Periods with surplus of this index were recorded at stations such as: Tulcea-Mail (1996-1998), Adamclisi-Negureni (years 1969-1971 and 2004-2005) and Hârşova-Saraiu (2004-2005). The minimum value of this index was recorded in 1973 at stations Casimcea-Corugea, and its peak was reached in 2005 Adamclisi-Negureni stations.

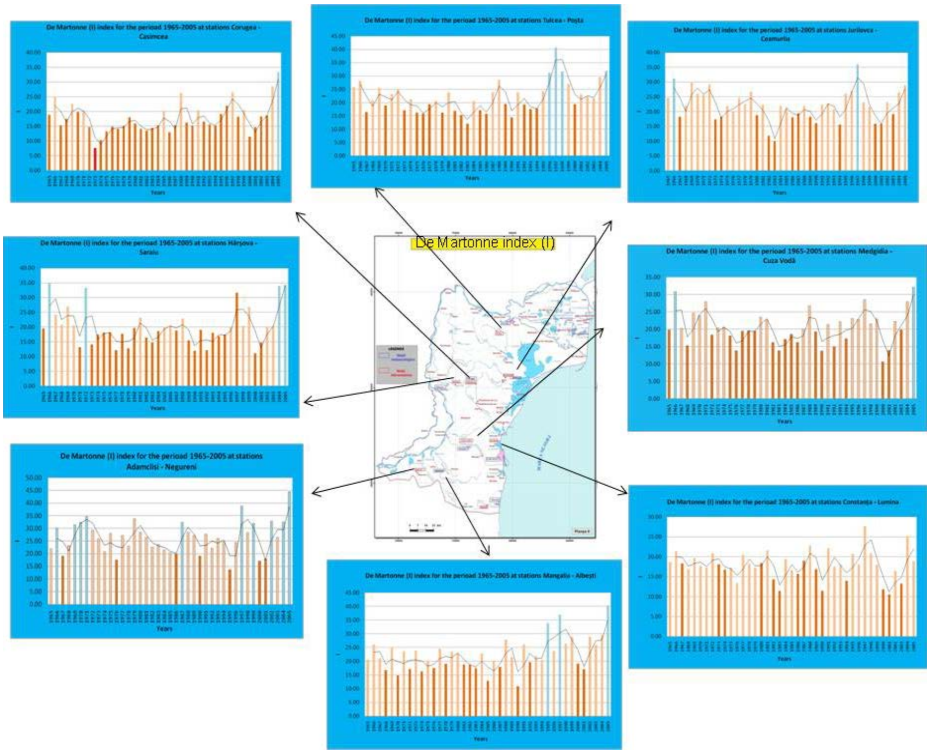

Fig. 5 Graphical representation of de Martonne index values

c) Deciles

The graphs presented in **Fig. 6** show the maximum extremes (with dark blue) – which represent years with excess moisture and minimum extremes (with red) - years of extreme drought.

Comparing the values of precipitations, it can be observed that some years had coincided with maximum extreme rainfall in all eight hydrometric stations, such as the years 1966, 1997 and 2004. This was not the case with minimal rainfall extremes, where drought was not found in certain years at all analyzed stations, which shows an uneven rainfall throughout Dobrogea. Extremes exhibit local, influenced by many factors such as the climate, physical geography, vegetation layout.

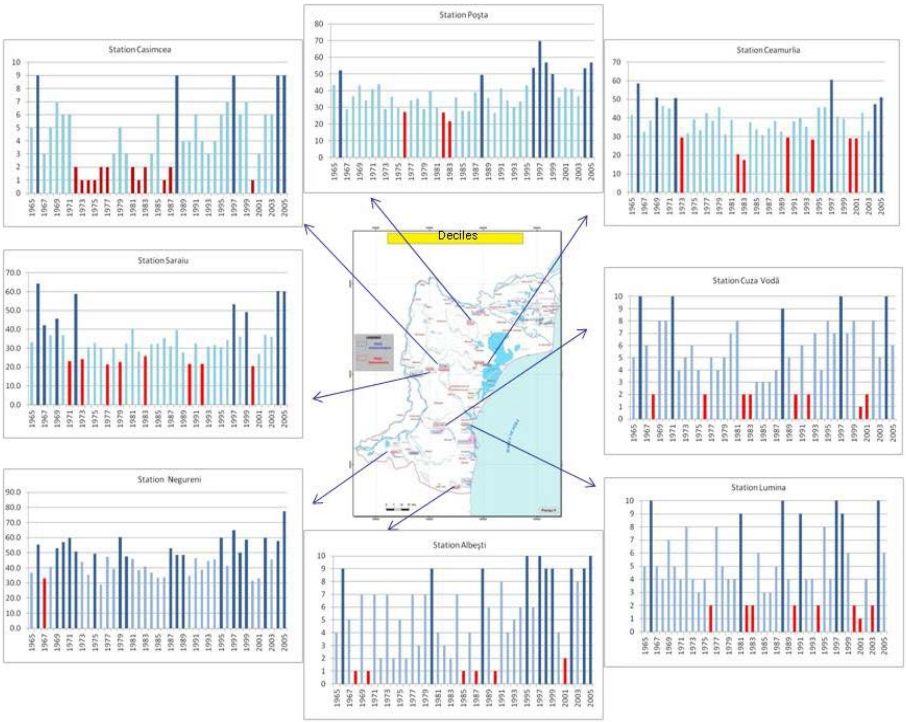

Fig. 6 Graphical representation of deciles

d) Moduli coefficients (K_i)

At moduli coefficients are more evident dry and rainy periods, compared with index Angot where these periods are short, thick and uneven.

In **Fig. 7**, we can observe exceeding periods, such as: years 1966 to 1973 during Casimcea station, 1966 to 1973 at Posta station, 1985 to 1991 at Albeşti station.

The maximum value recorded of 3.13 for moduli coefficients was registered in 1973 at Ceamurlia station, and the minimum extreme observed 0 was reached at Albeşti station in 1965 and 1967.

As opposed to these periods of surplus are the deficit periods, such as: 1977-1984 and at Casimcea and Saraiu station, 1989-1996 at Posta station, 2007-2011 at Ceamurlia and Cuza Voda station, 2000-2002 at Negureni station and 1965-1971 at Lumina station.

According to the graphic, Albeşti station follows a period of consecutive drought years 2001-2011, many of these years recording the value 0 for flow regime.

e) Thornthwaite index

According to Fig. 8, Thornthwaite index values given for each year of the period analyzed from the eight stations taken in consideration, stood below 0, with few positive exceptions. This, according to the scale of interpretation, falls Dobrogea in a characteristic climate oscillating between sub humid-dry (C1) for negative values and sub humid - wet (C2) for positive values.

Thornthwaite method is better adapted to humid temperate zones. In dry temperate tends to underestimate the evapotranspiration values.

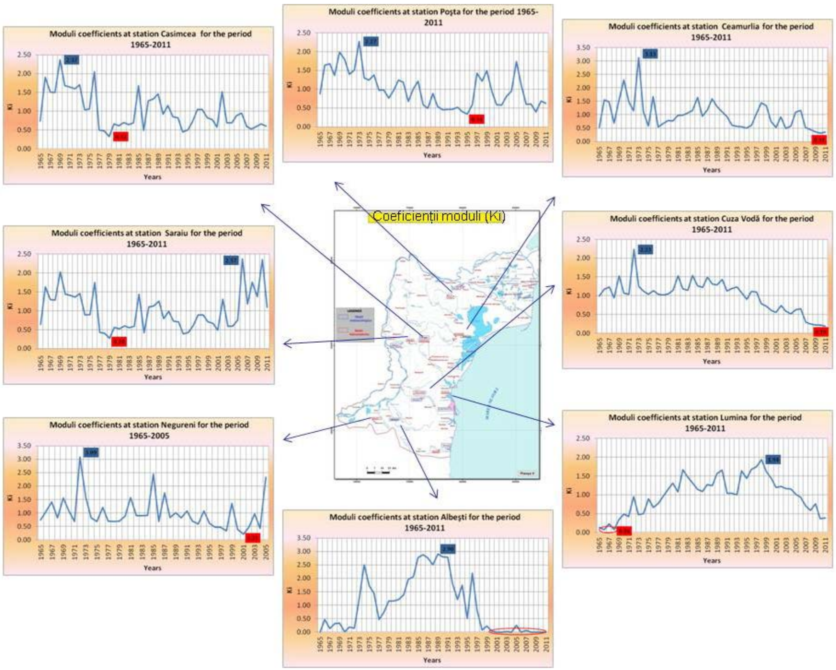

Fig. 7 Moduli coefficients from the eight stations analyzed for the period 1965-2005

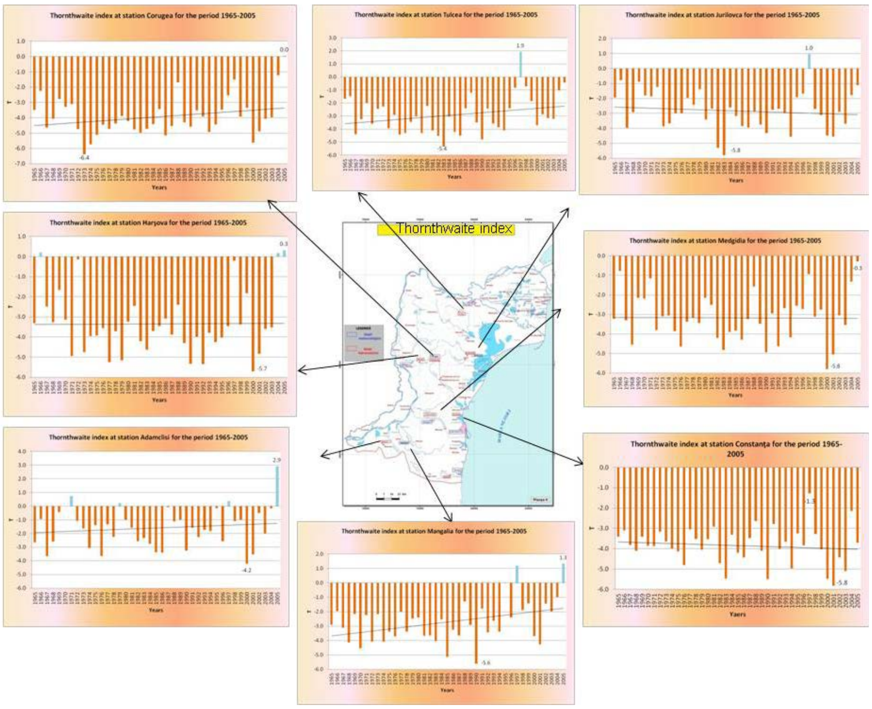

Fig. 8 Thornthwaite index calculated for the eight stations in the year period 1965-2005

4. CONCLUSIONS

According to this study and after calculating the presented indices it is pointed out that Dobrogea region has a tendency to have an arid climate which is emphasized by low rainfall between 200 - 450 mm/year, annual average temperatures lying around and above the average of 11ºC, a theory supported by numerous studies by other researchers[1].

As a general conclusion we can say that although global Dobrogea can be characterized as a semiarid-arid climate zone, with low and medium temperatures, we can also state that in some areas of those territory there can be extreme temperatures and extreme flows that can occur locally influenced by several factors such as the climate, physical-geographical factors, vegetation layout etc.

After studying the hydro-meteorological extremes using quantization indices, it resulted more or less similarities due of the fact that they take into account different meteorological and hydrological parameters such as precipitation, temperature and river flow.

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[10] www.unfccc.int
[11] www.globalbioclimatics.org

Aspects regarding the problem in extreme hydrological phenomena in the case of lower Danube

C. Borcia, C. Radulescu, R. Ciuca, V. Blendea, C. Petrea

Abstract **– Some extreme events that have had great implications on the ecosystem of the Danube and economic activities in the area include floods, drought and pollution. Among the causes that led to these phenomena can be taken into consideration human impact and climate change. In this context, the paper addresses the following issues on extreme events where the Danube: aspects of hydro along the main riverbed and floodplain of the Danube, variability of the water temperature, variability of maximum and minimum water flows, issues on sectorial study of extreme hydrological phenomena.**

Keywords **– hydrotechnical developments, variability, the Danube, flows extreme, sectoral study**

1. INTRODUCTION

Some extreme events that have had great implications on the ecosystem of the Danube and economic activities in the area include floods, drought and pollution ([6]).

Floods have several causes, among which we can mention: natural phenomena (river floods, water from rainfall or snowmelt, stagnant or running down the slopes, raising groundwater above ground level due to seepage, sea storms); random phenomena (rupture or damage of dams and other hydraulic structures; maneuvers acumuărilor evacuatorii wrong, slipping sharp slopes in lakes basin); human activities (artificial lakes basin filling, cutting deliberate defense dams, irrigation systems achieve large water losses without appropriate drainage, flooding caused by accumulation induced earthquake. Among the significant floods on the Danube products can remember those produced in the 1895, 1926, 1942, 1970, 1975, 1981, 2006.

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Droughts are prolonged absence or lack of rainfall, hydrological drought is defined as a period of abnormally dry enough to shoot a prolonged water shortage characterized by a significant decrease in runoff water courses, lake levels and / or groundwater, bringing them to values below the normal and / or abnormal dryness of the soil. Drought has several stages of development: atmospheric drought (low soil moisture), soil drought (significant drying of the soil and lowering water depth) and hydrological drought (when the water depth decreases significantly and there may be a reduction in river flow). Some years when there was a low drainage on the Danube, it can signal: 1985, 1986, 1990, 1992, 1994, 2003.

Water pollution occurs when, following the introduction of substances determined - solid, liquid, gaseous, radioactive - waters suffer significant physical, chemical or biological likely make them unfit or dangerous to public health, aquatic life, fishing industrial, industry and tourism. These extreme events are related, or are directly or indirectly affected by the variability of air temperature and thus water. How this parameter affects other parameters for the Danube shown briefly below.

2. ISSUES ABOUT HYDROTECHNICAL IMPROVEMENT ALONG MAIN RIVERBED OF THE DANUBE AND FLOODPLAIN

Among the most important hydrotechnical made, mentions ([5]) damming the Danube floodplain, hydropower and navigation systems Iron Gates 1 and 2 on the Danube, Danube-Black Sea canal, irrigation systems, shipyards, barring tributaries beds Cerna, Jiu, Olt, Arges county; Siret and Prut.

- *Damming the Danube floodplain*

1911 - began damming the Danube in Romania (engineer Anghel Saligni built the first barrier on the river in Oltenia Surlari-Dorobanţu, Calarasi County ([11])

1930 - 1972 - dams on the Romanian sector of the Danube, from an area of 21715 ha cumulative 1930-410227 ha in 1972. ([3]).

- *Hydropower and navigation systems Iron Gates 1 and 2 on the Danube*

1964 - 1971 - 1985 was conducted jointly by Romania and Yugoslavia hydropower and navigation system Iron Gates Iron Gates 1 and 2. Iron Gates 1 - hydro that consisted of closure of the Danube riverbed at Km 942.9 with a barrage reinforced concrete, having a central area 441 m long spillway and two hydroelectric side 214 m long with one contiguous navigation lock each located near shores. In order to improve hydrological influences downstream products of hydropower and navigation system Iron Gates 1 and hydropower for recovery of the Danube, was designed and built downstream hydropower and navigation system Iron Gate 2, located at Km 863 and put into operation in December 1984. landscaped retention Lake has a surface of 63.25 km2, with a total volume of about 0425 km3 of water. For safe navigation, Iron Gates hydroelectric node 2 is provided with two locks, which airlocks have lengths 310 m, width 34 m and 5 m depths thresholds

- *The Danube-Black Sea*

- 1949 - work began on Canal, the version unique route between the Danube (Port NPP) and the Black Sea (Midia port); Lucar Canal were discontinued in 1952.

- 1975 - 1984 were resumed and completed work on the Canal in a fuller version with unique route between the Danube (Cernavoda port) and Alba town branched Gate to the Black Sea on the two routes, the old one from the White Gate Midia port and new route with exit port of Constanta South - Agigea. After eight years working channel Cernavoda-Constanta route completed, came into operation in May l984. The channel length of 64.4 Km inland liaison between Cernavoda port (at Km 299.5) of the Danube and sea ports of Constanta South - Agigea and Midia on the Black Sea. Channel bed has a width of 90 m to the water table and depth of 7 m

- *Other works ([1], [2], [3], [4])*

In the land reclamation works have been developed in the postwar period and irrigation and drainage works, the construction of open channels and underground pipes.

• irrigation works carried out in the Romanian Plain and Dobrogea included farmland irrigation arranged on about 2284000 ha, equipped with facilities for water pumping from the Danube and complex Razelm-Zmeica.

• Hydraulic for irrigation water intakes were designed as facilities withdrawn from the bank of the Danube riverbed, where water access is through a supply channel, permanently maintained by dredging silt from clogging.

• dredging - in accordance with the recommendations of the Danube Commission and international obligations arising for maintenance of the fairway on the Danube river ports and port dredging works executed Romania who were averaged (for the period l961-1990) to amounts of about 2079300 m3/year.

• Improvement of Navigation - 1834 - 1837 - the first adjustment facilities for navigation, in the postwar period have executed a series of works to improve navigation conditions on the Romanian sector of the Danube. Among them recall the construction of groynes to calibrate the width of the river bed and the fork arms Borcea branch of the bed Ostrovul Turcescu (km 345).

• Work hydraulic fitting ports and shipyards - so of fitting ports were executed by the end of the nineteenth century in Moldova Veche, Orşova Drobeta-Turnu Severin, Calafat, ship, Turnu Magurele, Zimnicea, Giurgiu Oltenia, Calarasi, Cernavoda Hârşova, Braila, Galati, Isaccea, Tulcea and Sulina, and then at Baziaş, Drencova, Sviniţa, Vârciorova, Gruia, Citadel Bistreţ milled Isaccea and others. The oldest shipyards in the Romanian sector of the Danube at Galati are you Drobeta-Turnu Severin, designed the mid-nineteenth century. Between the two World Wars was adapted from Baziaş November shipyards, Oltenia and Braila. After the Second World War, the work of specific hydro grow considerably with the advent of new sites to Orşova, Giurgiu, Tulcea and Sulina.

• barring beds of tributaries. Romanian tributaries of the Danube, were made mainly works barring of whites in order to create water storage for energy and water management uses (industry, water supply and tourism). Such works were carried out on rivers Cerna (two dams until 1983) Jiu (dam until 1968), Olt (25 dams until 1988), Arges (5 dams until 1987), Dâmboviţa (2 Baranje until 1989), Ialomita (two dams until 1987), Siret (8 dams until 1986) and Prut (dam by 1980).

Hydrotechnical improvement influenced the hydrological regime of fluid flow, silt and salts of the Danube, so that may be a gradual relative hydrological regime of the Danube, as follows:

- The natural regime: by 1834 - 1837 - the first adjustment facilities for navigation.
- The semi-regime: after 1834 - 1837; the period 1911 - 1964:

1911 - began damming the Danube in Romania (engineer Anghel Saligni built the first barrier on the river in Oltenia Surlari-Dorobanţu, Calarasi county).
1930 - 1964 - continued damming the Romanian sector of the Danube, from a cumulative area of 21 715 ha to 405 597 ha in 1964.

- Transient period: 1964 - 1985:
- Continuation of the Danube floodplain floodplain impoundment (1964 - 1972);
- Iron fellowship hydropower constructions 1 and 2 (1964-1985)
- Danube - Black Sea (1949 - 1975 - 1984);
- Hydrotechnical Danube Delta to supply fresh water to the irrigation system in northern Dobrogea (isolation Razelm lakes, symbols, and Zmeica Goloviţa Black Sea);
- Barring beds of tributaries (Cerna, Jiu, Olt, Arges, Dîmboviţa county; Siret, Prut).
- The current regime after 1985, also characterized by: rectifying and regulating arm bed St. George, by cutting the large meander (6 rectification).

3. VARIABILITY OF WATER TEMPERATURE

The evolution of the water temperature has several aspects - diurnal evolution, the evolution of monthly and annual multi evolution ([10]). For example, regarding the monthly and annual shows that the lowest monthly average temperature in January and February are below 2 0 C, and the highest temperatures in July and August when water temperature exceeds 20 0 C. The water temperature decreases since September, but slower compared to rivers, reaching values of December - February 0 0 C - 3 0C.

Regarding multi evolution is found that the mean annual water temperature varies from year to year mainly due values during the year. Presence in certain years, in summer air masses wetter and colder temperature causes lower values of water, as noted in 1954, 1955 and 1965. Conversely, when in some years during the summer stabilizes the mass of dry air and warm water temperature values in summer are much higher, as was the case in 1962, 1963, 1967. Nevertheless, the difference between the highest average annual values and the average values lowered generally not exceed 3-4 0 C and 1.5^0 C rivers Danube and the difference between the average annual values and outliers is also reduced: under 2 0 C for rivers and under 0.8 0 C for the Danube. On the other hand, following the centralization of water temperature data, between the years 1954 - 2010 for hydrometric stations Turnu Severin, Giurgiu and Braila, it follows that there is an increasing trend of average and maximum water temperatures (Figures 1 and 2) ([6]).

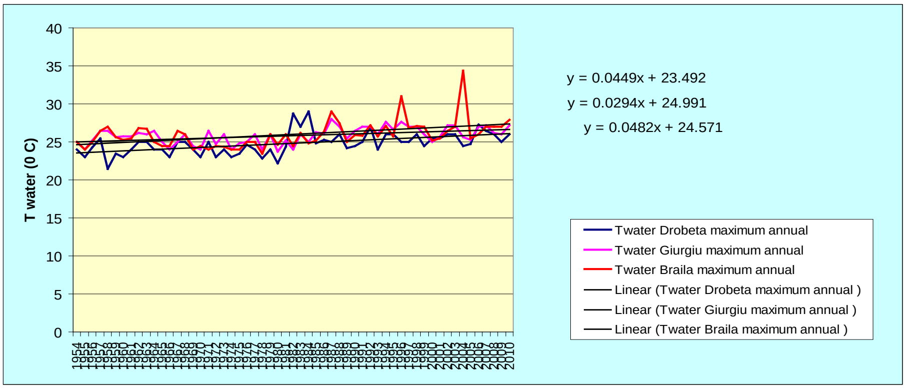

Fig. 1 Variability and trend of water temperature (annual maximum) during 1954-2010 to hydrometric station Drobeta, hydrometric station Giurgiu, hydrometric station Braila (T-temperature)

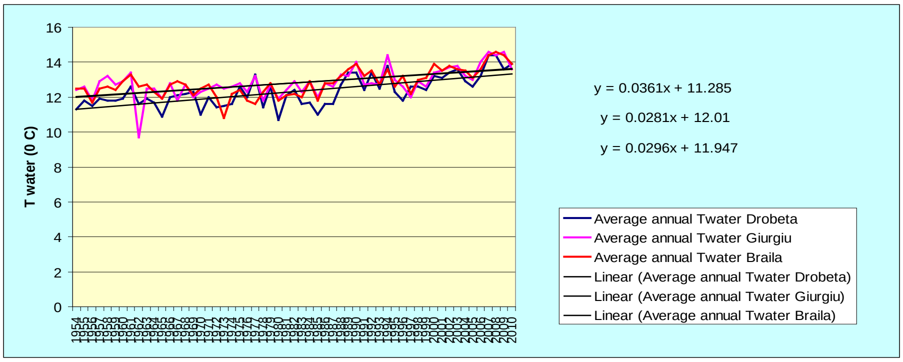

Fig. 2 Variability and trend of water temperature (annual average) during 1954-2010 to hydrometric station Drobeta, hydrometric station Giurgiu, hydrometric station Braila (T-temperature)

This trend of increasing water temperature is actually a consequence of a rise in temperature of the air and the existence of potential water pollutants.

Winter phenomena on rivers or streams is a particular manifestation of the thermal water in terms of its temperature drops below 0 0 C. ([10])

In direct contact with the atmosphere, under conditions of lower temperatures of the air, water yields gradually accumulated heat in the warm seasons, tending to balance the air temperature. Cooling water deeper river begins in November when temperatures appear first negative year cooling intensity increased further since establishing a period with its negative temperatures.

Analysis of data on phenomena winter stations on the Lower Danube, between 1997 and 2010 showed the following situation ([8]):

- Years 1997-2001. Could not reveal special winter events.

- Year 2002. Were recorded at different gauging stations, various phenomena winter (ice needles shore ice floes flowing rare, dense floes, thaw, ice bridge).
- 2003-2005. No events have shown outstanding winter.
- Year 2006. Were recorded at different gauging stations, various phenomena winter (ice on shore, shore ice needles ice floes flowing rare overcrowding of floes, ice floes to shore and flowing, thick floes, bridge ice).
- Year 2007. Registered No special winter events.
- 2008. Winter phenomena recorded at various stations Hydromet: flowing floes of rare and in some cases, thick floes.
- 2009. Has not been revealed special winter events.
- Year 2010. Was recorded at hydrometric station Cernavoda ice floes flowing ashore and rare.

4. VARIABILITY MAXIMUM AND MINIMUM WATER FLOWS

Maximum water flow variability – floods

There are two categories of extreme hydrological events: high water, floods and water floods that small and very small ([8]).

High waters occur normally be slow due to melting snow or rainfall of low intensity and long duration. General increase water flow and keeping them for a long period at high values without dramatic increases and peak flow rates, high values characterize phase mode waters. Flood waters differs by a large concentration of runoff in time, ie the relatively rapid increase in water flow and thus level by achieving higher peak flow and then by a relatively rapid decrease in water that is generally slower than growth. Floods are several ways after Genesis flood the rapid melting of snow (called flood nivale), floods of rain (rain) and floods mixed rain and snowmelt (pluvio-nivale).

Floods have several causes, among which we can mention: natural phenomena (river floods, water from rainfall or snowmelt, stagnant or running down the slopes, raising groundwater above ground level due to seepage, sea storms); random phenomena (rupture or damage of dams and other hydraulic structures; maneuvers acumuărilor evacuatorii wrong, slipping sharp slopes in lakes basin); human activities (artificial lakes basin filling, cutting deliberate defense dams, irrigation systems achieve large water losses without appropriate drainage, flooding caused by earthquakes, induced accumulation) ([9]).

Figure 3 shows the plot of variation of maximum water flow in the period 1931-2012, of which it may refer to the years in which there were high water flow and high.

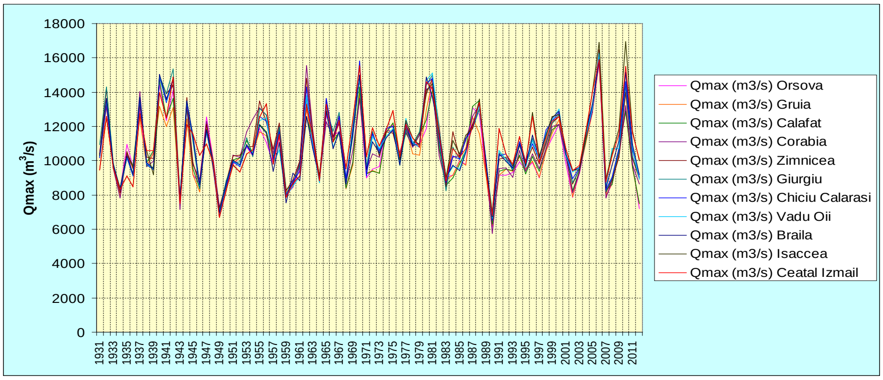

Fig. 3 Variability of high water flows during 1931-2012 at hydrometric stations characteristic (Qmax - maximum annual water flow)

Figure 4 shows, for selected hydrometric stations, years in which there were large water flows and the values of these flows.

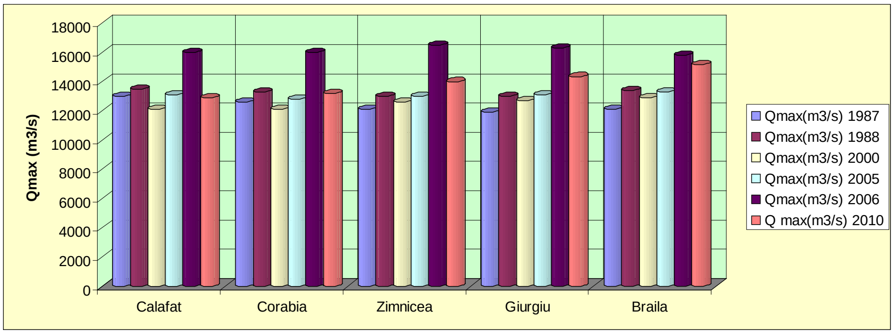

Fig. 4 Maximum water flow rates and the years in which there have been - in times of high water hydrologic regime (generally associated with flooding situations)

Aspects of the implications of floods

If you take into account the causes and their effects can be considered flooding three phases or stages: pre-production (pre-impact) - increasing the flow of water in a short time, the actual production stage (impact phase) in the water masses and the intercaţionează the final stage, after the passage of flood wave (post-impact) corresponding effects.

Within each phase, the situation is different in terms of hydrologic / hydraulic, environmental, economic, psycho-social, administrative / decision.

A summary of these differences is shown in Table 1 ([7]).

Table 1 Structure *Integrated implications floods*

Components	**The pre-impact**	**Phase impact**	**The post-impact**
Component of	*Monitoring,*	*Damage dams,*	*Reconstruction*

the hydrological / hydraulic engineering	*forecasting, consolidation, hydraulic structures*	*hydraulic structures, housing, etc.*	*analysis / risk maps*
Ecological component / hydrochemical / radiochemical	*Stationary situation, preventive protection*	*Environmental degradation, potential pollution, destruction of flora and fauna, land deposits of alluvial material affected areas affected biotope change, etc.*	*Ecological restoration*
Component of economic / financial	*Training funds, financial strategies for critical*	*Direct damage (destruction or damage) and indirect*	*Allocation of funds / finance - budget, donations, etc.*
Psychosocial component	*Education, information*	*Casualties (deaths, injuries). Panic. Disease, famine, immediately after impact, fear.*	*Social, medical, psychological assistance*
Component administrative / decisional / to alert	*Warning / alerting intervention evacuation of people*	*Interventions / rescue*	*Integrated management and psychosocial risk analysis*

Minimum water flow variability

Small and very small water occur during periods without precipitation during droughts weather. The rivers are fed exclusively from groundwater and their leakage is even lower as the underground water reserves reach more advanced stages of burnout. Shallows are defined for water flow below 2,500 m3 / s and very low water to water flow under 1600 m3 / s

Drought is prolonged absence or lack of rainfall, hydrological drought is defined as a period of abnormally dry enough to shoot a prolonged water shortage characterized by a significant decrease in runoff water courses, lake levels and / or groundwater, bringing them to values below the normal and / or abnormal dryness of the soil. Drought has several stages of development: atmospheric drought (low soil moisture), soil drought (significant drying of the soil and lowering water depth) and hydrological drought (when the water depth decreases significantly and there may be a reduction in river flow).

If Danube (and in particular on climate change) criteria for establishing minimum flows are those relating to ([8]):
• ensuring the free navigation on the Danube flow regime according to current requirements and develop the shipment according to the conventions of the riparian countries;
• determining the stock of available water from entering the country for cumulative sections, depending on the insurance needs of current and developing water utilities;
• providing the necessary water supply of population and industrial consumption and for irrigation of agricultural areas that have the necessary equipment available and future development;
• analysis of operating conditions of the catchment water current regime of low flows.

The average values for the minimum water flow rates (rate corresponding to "0" surprise), the Danube, range from 2000 to 2500 m^3 / s Under these values water navigation and land use can not be assured.

Figure 5 shows the plot of variation of minimum water flows in the period 1931-2012, of which it may refer to the years in which there were small water flow and very small.

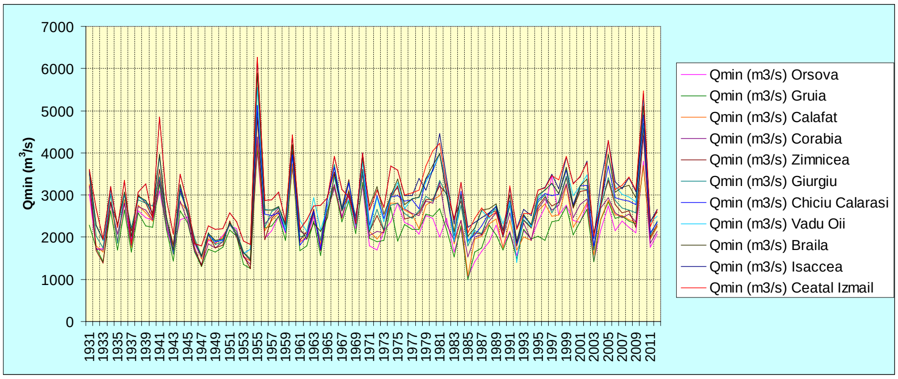

Fig. 5 Variability minimum water flow gauging stations in the period 1931-2012 the characteristic (minimal water flow Qmin-year)

Figure 6 shows, for selected hydrometric stations, years in which there were small water flows and the values of these flows.

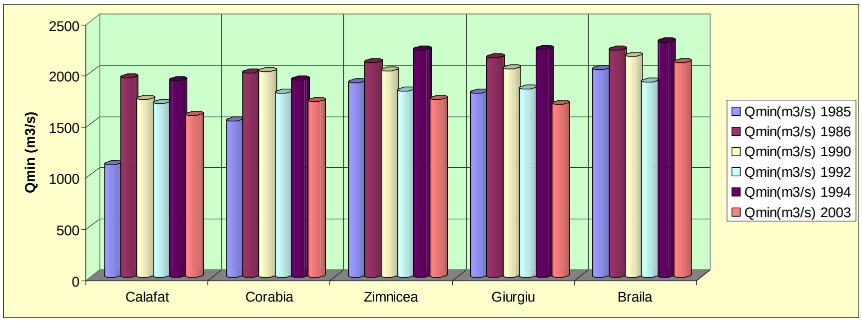

Fig. 6. Minimum water flow rates and the years in which there have been - generally associated with drought situations

5. SECTOR ISSUES STUDY OF EXTREME HYDROLOGICAL EVENTS

For an integrated analysis of extreme events on the Danube, zoning may be lower Danube and the Black Sea coast, as follows (Table 3) ([7]).

Table 3 Zoning lower Danube and the Black Sea coastal zone

Area	Comments
D1. Baziaş - Calafat	km 1072 – km 786.9; tributaries: Cerna, Timok; Hydro systems P.F.1 km 942, P.F.2 km 863
D2.Calafat – Chiciu Călăraşi	km 786.9 – km 379.6; tributaries: Arcear, Lom, Tibăr, Jiul, Ogosta, Iscăr, Vit, Oltul, Osâm, Iantra,Vedea, Rosenskii Lom, Argeşul
D3. Chiciu Călăraşi - Brăila	km 379.6 – km 167; Ponds(Ialomiţei, Brăilei)- braţe: Borcea, Dunărea Veche, Bala, Cremenea, Vâlciu, Măcin; Tributary: Ialomiţa
D4. Brăila – Ceatal Izmail	km 167 – km 80.5; tributaries: Siret, Prut
D.D. Area delta	Delimited sub delta arms: Chilia, Tulcea, Sulina, Sfântu Gheorghe
M1. Coastal zone 1	Contact area river-mouth big-shedding Chilia - Portiţa
M2. Coastal zone 2	Marine area– Portiţa – Mangalia – Vama Veche

Each of these areas have certain geomorphological and hydrological features that should be considered when performing integrated study encompassing all components specified in Table 1.

SWAT analysis (Strengths, Weaknesses, Opportunities, Threats or risks) for such an approach include the following:

1. Strengths - consider sector-specific processes and phenomena; highlights local processes; can draw attention to issues of local interest but can affect the whole

(ie if erosion in a particular sector highlighting these processes may draw attention to the possible influence of other sectors);

2. Weaknesses - in this type of study does not consider the overall perspective or otherwise not realized picture of the processes highlighted in a particular sector; for this should be made a separate summary.

3. Opportunities - whereas a fund accumulated data over time, it is useful to use and to systematize these data to perform this kind of study.

4. Risks - if this type of study is not done, there is a risk to neglect certain phenomena or processes that may evolve area over time, on the other hand, if the study is completed by integrating image or a summary , neglecting other processes may be overall, also called cutting process.

6. CONCLUSIONS

It is possible that, in the Danube area, droughts are amplified, these periods were followed by periods of flood also be becoming more intense. In other words, it is possible that extreme events might increase. Also, the overall signal change probably will be designed differently to local and regional level by setting areas where the variability and change to be much higher.

7. ACKNOWLEDGMENTS

Thanks Mrs. Prof. Dr. Carmen Maftei for support.

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Section IV

Applied Mathematics and Computation

The dynamics of unemployment and job creation using a time-delayed model

Klaus B. Schebesch, Dan S. Deac

Abstract – **Labor markets are meant to enable timely matching of supply and demand in complex systems like human societies. Empirical observation in many economies, however, provides clear indication that labor markets do in fact not function according to intuition or intention. Apart from specific economic conditions and their history this may also be rooted in systemic features peculiar to the dynamics of various types of work and employment. We propose to analyze the role of time delays in a time-continuous setting, in order to better understand the dynamics of unemployment and job creation. Misinterpreting the resulting dynamics may cause unwanted societal costs. The stylized approach may also lead the way towards more data-oriented model variants.**

***Keywords* – bifurcation point, labor markets, nonlinear dynamics with delay, numerical simulation**

1. INTRODUCTION

In biology and technology time-continuous processes with *memories*, expressible in time delays, often do explain important dynamical features of these systems [9],[7]. Knowledge about *too large delays* in replenishable resource systems, like that of the loss of shelter due to earthquakes, is discussed by Nikolopoulos and Tzanetis [3]. Other intriguing examples are those discussed in the models of Misra and Singh ([1], [2]), where the resource process refers to unemployment (job losses) and job creation. In economic systems the most basic classical production functions Y_{bas} use the easily *separable* production factors Labor and Capital. However, modern economic output (and welfare) Y_{mod} is more properly modeled by adding many more *partially interdependent* production factors, like Human Capital **H** and Intellectual Capital **I**.

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The two front-pages from The Economist of 2013 seem to suggest

$$Y_{bas} = F(L,K)$$
$$\ldots$$
$$Y_{mod} = F(L,\ldots,H,I,\ldots,K)$$

inefficient labor relations AND *efficient allocation of capital*

Are a probable of modern economics dynamics. As the interdependence of production factors in the above scheme indicates, it is feasible to model the dynamics concentrating on one side (i.e. labor or capital). The capital market has more standardized market procedures, more available public data, and it is more intensively studied. Here we take a labor market oriented view. The labor market can be addressed by different dynamical and structural modeling means, as they are a) implicit memories by means of fractional differential equations (DE),

a) Fractional DEs	b) Delay DEs	c) TAR-inspired DEs	d) Migration models
$D^\alpha x = f(x)$	$\dot{x} = f(x, x(t-s))$	$\dot{x} = I(.)h(x) + (1 - I(.))g(x)$	$\dot{x} = M(.)x - x$
$0 < \alpha < 1$	$s > 0$, a delay	$I(x,t)$ an (0,1)-indicator	$\sum_i x_i = 1,\ x_i \geq 0$
$\rightarrow$ long memory	$\rightarrow$ gestation effects	$\rightarrow$ asymmetric reactions	M_{ij} transitions probs

b) explicitly delayed *DE (DDE)* in order to specify known reaction delays, c) asymmetries in rising and falling unemployment by means of regime switching dynamics and d) migration of labor force or migration between occupational sectors by means of Markov chains or related dynamics. To a certain extent, these models may also be combined. In the sequel we choose to concentrate on the DDE approach.

2. DYNAMIC EQUATIONS OF LABOR AND UNEMPLOYMENT

The models of Misra and Singh ([1], [2]) describe the process of labor market fluctuations by a nonlinear dynamical model in four variables related to employment. It is based on the aforementioned model of Nikolopoulos and Tzanetis [3] which treats housing replenishment based on past information. The time delay for collecting reliable information about house losses due to e.g. earthquakes or landslides is typically substantial. Note, however, that when it comes to describe ways of measuring the labor markets, alternative classifications of variable or factors come to mind which may pose indeterminacies. They refer for instance to what type of people to include into the class of the “unemployed”, how to use different term structures to describe types of unemployment, etc. In order to facilitate a model-based analysis of the employment process (in a developed economy) one may use a set of variables $x_i(t)$, $i = 1, \ldots, 4$, defined at each moment in time $t \geq 0$:

- $x_1(t) \geq 0$, the number of unemployed (may include out-of-labor, part time labor),
- $x_2(t) \geq 0$, the number of persons with temporary employment,
- $x_3(t) \geq 0$, the number of persons with permanent employment, and
- $x_4(t)$, the vacancies or the newly created jobs (these may also be destroyed!)

With the passage of time, assume that a proportion of the unemployed may become permanently employed, and others temporarily employed. Furthermore some of the temporarily employed may become permanently employed. Finally, a part of both, the temporarily and permanently employed may lose their jobs and become unemployed. For simplicity, we also assume that all unemployed can initially cope with the tasks of any job on offer, but in time they are losing skills owing to attrition. Also, we assume that there should be no barriers to job acceptance imposed by reduced individual mobility. Furthermore, as a crude approximation, a constant rate of growth of unemployment is assumed (owing for instance to the continuous action of labor saving technical progress). Migration rate of unemployed is assumed to be proportional to their number and the total number of vacant jobs which can be created are bounded and constant.

The time evolution of the number of unemployed $x_1(t)$ is defined to depend on the following: (1) the rate of change of the number of the unemployed which will become permanently employed is proportional to $x_1(t)$ and to the number of permanent jobs $a_2 + x_4(t) - x_3(t)$, where $a_2 > 0$ is the total number of available permanent jobs, and, (2) allowing for the transition from unemployment to temporary employment, their latter rate of change is proportional to $x_1(t)$ as well as to the number of temporary jobs available and vacant $a_4 + x_4(t) - x_2(t)$, where $a_4 > 0$ is the total number of temporary jobs available in the system. Hence, we have

$$\begin{aligned} \frac{dx_1(t)}{dt} = \; & a - a_1 x_1(t)(a_2 + x_4(t) - x_3(t)) - \\ & -a_3 x_1(t)(a_4 + x_4(t) - x_2(t)) - a_5 x_1(t) + a_6 x_2(t) + a_7 x_3(t), \\ & \text{with initial condition } \; x_1(0) > 0. \end{aligned} \tag{1}$$

The coefficients $a_1, a_3 > 0$ are for scaling the single effects described and $a_5, a_6, a_7 > 0$ stand for migration rate of the unemployed, the transition rate of permanently and temporarily employed into the state of unemployment, respectively.

Turning now to the evolution of the temporarily employed persons, $x_3(t)$, we consider that the rate of change of unemployed into permanently employed will be proportional to $x_1(t)$ and to the number of vacant permanent jobs $a_4 + x_4(t) - x_2(t)$ (with $a_4 > 0$ being the number of vacant jobs permanently available). Again, the rate of transformation from being unemployed into temporarily employed is proportional to $x_1(t)$ and the number of temporary job vacancies $a_2 + x_4(t) - x_3(t)$, and where $a_2 > 0$ is the number of total temporary job vacancies. Hence the differential equation for $x_2(t)$ reads:

$$\begin{aligned}\frac{dx_2(t)}{dt} &= a_3x_1(t)(a_4 + x_4(t) - x_2(t)) - \\ &-a_8x_2(t)(a_2 + x_4(t) - x_3(t)) - a_9x_2(t) - a_6x_2(t), \\ &\text{with initial condition } x_2(0) > 0.\end{aligned} \tag{2}$$

Coefficient $a_8 > 0$ is a constant of proportionality and the constant decay rate $a_9 > 0$ describes the exit of temporarily employed persons from the system (due to death, old age, or migration, see a similar argument for $a_{10} > 0$ below).

The rate of change of the number of unemployed which will find a permanent job is proportional to $a_1x_1(t) + a_8x_2(t)$ and the number of vacant job positions for permanent employment is $a_4 + x_4(t) - x_3(t)$. Hence, the rate of change of the permanently employed $x_3(t)$ is given by the following differential equation:

$$\begin{aligned}\frac{dx_3(t)}{dt} &= (a_1x_1(t) + a_8x_2(t))(a_4 + x_4(t) - x_3(t)) + a_{10}x_3(t) - a_7x_3(t), \\ &\text{with initial condition } x_3(0) > 0.\end{aligned} \tag{3}$$

where the constant decay rate $a_{10} > 0$ describes the exit of permanently employed persons from the system (due to death, old age, or migration). Finally, the time evolution of newly created jobs is proportional to the time-delayed information about the unemployed in existence at $t - \tau$:

$$\frac{dx_4(t)}{dt} = a_{12}x_1(t - \tau) - a_{13}x_4(t),$$

with $x_1(\theta) = V(\theta),\ -\tau \le \theta \le 0,$ and with initial condition $x_4(0) > 0.$ (4)

Note that $V: R \to R$ is a differentiable function which has to be supplied by the modeler. The coefficients $a_{12}, a_{13} > 0$ are the rate of new job creation and the decay rate of permanent employment, respectively. The latter may be due to insufficient state funding or labor saving technical progress.

3. EQUILIBRIUM AND BIFURCATION ANALYSIS

In order to analyze the dynamics of a higher dimensional system which possibly escapes intuition, some symbolic term reduction and manipulation is in order. The easier part relates to determining the stationary points $0 = f_i(x_{10}, x_{20}, x_{30}, x_{40})$, $i = 1, \ldots, 4$, which allow for linearizing around these points and by which the qualitative dynamics of the system (stable orbits, oscillations) may be characterized. Determining the type of the dynamics as a function of the time delay $\tau > 0$, which viewed as a system parameter changes the eigenvalue spectrum of the linearized system, is a more complicated symbolic procedure just touched upon in the sequel and which is based on Normal Form Theory of bifurcation analysis (for a recent account on theory and computational approaches consult Han and Yu [8]).

At first we proceed by determining *equilibrium points* in the feasible region of the state space. Equilibrium or stationary points of the dynamic system 1–4 are solutions of the following system of algebraic (low order multinomial) equations:

$$\begin{aligned} a - a_1x_1(a_2 + x_4 - x_3) - a_3x_1(a_4 + x_4 - x_2) - a_5x_1 + a_6x_2 + a_7x_3 &= 0, \\ a_3x_1(a_4 + x_4 - x_2) - a_8x_2(a_2 + x_4 - x_3) - a_9x_2 - a_6x_2 &= 0, \\ (a_1x_1 + a_8x_2)(a_4 + x_4 - x_3) + a_{10}x_3 - a_7x_3 &= 0, \\ a_{12}x_1 - a_{13}x_4 &= 0. \end{aligned} \tag{5}$$

Upon adding the equations (5) we arrive at

$$a - a_5x_1 - a_9x_2 - a_{10}x_3 = 0. \tag{6}$$

From the $(4)^{th}$ equation of (5) results

$$x_4 = \frac{a_{12}x_1}{a_{13}}, \tag{7}$$

and from equation (6) results

$$x_3 = \frac{a - a_5x_1 - a_9x_2}{a_{10}}. \tag{8}$$

By replacing x_3 and x_4 in the second and third equations of system (5) leads finally to a reduced system of two equations in two variables:

$$\begin{aligned} f_3(x_1, x_2) &= (a_1x_1 + a_8x_2)(a_2a_{13}a_{10} + a_{12}a_{10}x_1 - a_{13}(a - a_5x_1 - a_9x_2)) - \\ &\quad a_{13}(a_{10} + a_7)(a - a_5x_1 - a_9x_2) = 0, \\ f_4(x_1, x_2) &= a_{10}a_3x_1(a_4a_{13} + a_{12}x_1 - a_{13}x_2) - \\ &\quad a_8x_2(a_2a_{13}a_{10} + a_{12}a_{10}x_1 - a_{13}(a - a_5x_1 - a_9x_2)) - \\ &\quad a_{10}a_{13}(a_6 + a_9)x_2 = 0. \end{aligned} \tag{9}$$

The two-dimensional system of equations (9) admits a positive solution $x_{10},\ x_{20}$, which is depicted in **Fig. 1** as the intersection of the graphs of $f_3(x_1, x_2) = 0$ and $f_4(x_1, x_2) = 0$. For a given set of parameter values

$a = 65000$ $a_1 = 0.00004$ $a_2 = 25000$ $a_3 = 0.0003$ $a_4 = 30000$ $a_5 = 2$
$a_6 = 0.0009$ $a_7 = 0.0008$ $a_8 = 0.0001$ $a_9 = 0.9$ $a_{10} = 0.9$ $a_{12} = 0.9$ $a_{13} = 0.2$

we obtain the equilibrium point $(x_{10}, x_{20}) = (5520{,}23370)$ and by using these values in (8) and (7) we obtain the third and forth coordinates of the equilibrium point, namely $(x_{30}, x_{40}) = (36585.55{,}24840)$. It can be proven that this equilibrium point is unique for positive values of x_1 and x_2. However, this should be regarded as a simple case without claiming genericity for this to happen in most models of labor dynamics (indeed, it is not very difficult to state much simpler, empirically relevant nonlinear models with multiple equilibria, see e.g. Guckenheimer & Holmes [4]).

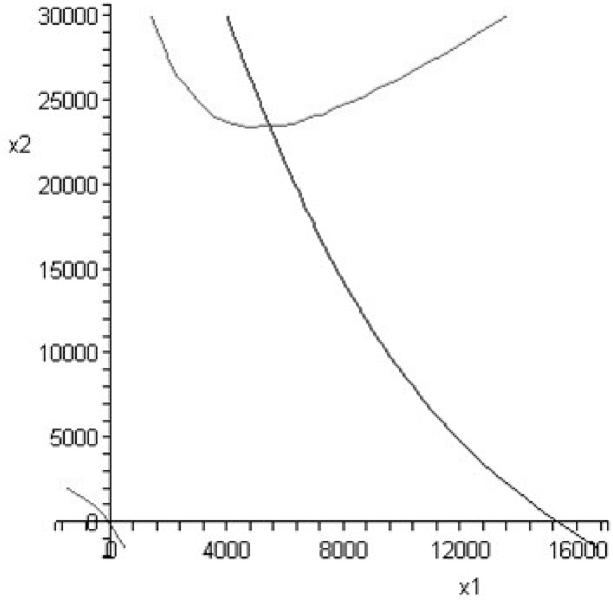


Fig. 1 Graphs of the functions $\boldsymbol{f_3(x_1, x_2) = 0}$ (red in colored display style) and $\boldsymbol{f_4(x_1, x_2) = 0}$ (black in colored display style) intersect at a unique point which is the $\boldsymbol{(x_1, x_2)}$-coordinate of the equilibrium.

For obtaining information concerning the nature of the equilibrium point we compute the characteristic equation (eigenvalue equation) of the dynamical system 1–4 linearized at the equilibrium point. Using the (numerically) instantiated parameter values from above this finally results for the special case of $\tau = 0$ in the equation

$$((\lambda + 11.97)(\lambda + 2.98)(\lambda + 3.45) - 96.36 - 18.85\lambda)(\lambda + .2) - 11.97 + 1.68(\lambda + 2.98)(\lambda + 3.46) + .5\lambda = 0$$

The solutions of this equation or the eigenvalues are (numerical values are rounded for convenience) $\lambda_1 = -13.37$, $\lambda_2 = -4.41$, $\lambda_3 = -0.41 - 0.11i$, and $\lambda_4 = -0.41 + 0.11i$, respectively.

The eigenvalues have negative real parts which, in the context of our dynamical system, implies that the equilibrium point $(x_{10}, x_{20}, x_{30}, x_{40})$ is *asymptotically stable*, i.e. the equilibrium point is attracting any orbit starting in its vicinity.

Next we employ *bifurcation analysis* which detects a qualitative change in the model dynamics. If we now allow for delay $\tau > 0$ then the structure of the eigenvalues of a linearized system along the system trajectories may change. In order to capture this by means of detecting a qualitative change in the systems dynamics, a value τ_0 will be determined for which the system undergoes a Hopf bifurcation. This may be achieved by way of a symbolic computation which applies Normal Form Theory from bifurcation analysis (Han and Yu [8]).

Note that in case of $\tau > 0$ the characteristic equation $h(\lambda)$ of a linear delay differential equation (or a “linearization”) is

$$\dot{x}(t) = Ax(t) + Bx(t-\tau) \quad \text{implying} \quad h(\lambda) := \lambda - A - Be^{-\lambda\tau} = 0,$$

in order to admit a solution of type $ce^{\lambda t}$, which then also implies that $|\lambda| \to \infty$ leads to $e^{-\tau \mathrm{Re}(\lambda)} \to \infty$, (and also $\mathrm{Re}(\lambda) \to -\infty$, i.e. stable solutions exist) see e.g. Hale and Verduyn Lunel[7]. Furthermore, a general system of (nonlinear) differential equations is assumed to be described by $\dot{x} = F(x) = Jx + f(x)$, where J is the Jacobian with $J_{ij} = \frac{\partial F_i(x)}{\partial x_j}$ (linear part) and it is also assumed that J has only purely imaginary eigenvalues (i.e. $\mathrm{Re}(\lambda) = 0$) which may be obtained by suitably varying model parameters in F (including delay τ). This then corresponds to a situation where bifurcation (change of qualitative model behavior, and, especially change of stability regimes) takes place by only slightly varying the model parameters. Normal form theory therefore seeks to represent such a suitably parameterized situation of $\dot{x} = F(x, \tau_0, .)$ by an approximation of the type

$$x = y + G(y) := y + G_2(y) + G_3(y) + \ldots + G_k(y) + \ldots$$

in such a way that the resulting differential equation system

$$\dot{y} = Jy + g(y) := Jy + g_2(y) + g_3(y) + \ldots + g_k(y) + \ldots$$

becomes “as simple as possible” and $G_k(y), g_k(y)$, are restricted to be k^{th} order polynomials (see [8]). Determining a $\tau_0(a, a_1, \ldots, a_{13}, .)$ by the Normal Form procedure is nevertheless tedious, resulting in long symbolic expressions.

A sequence of plots depicting a stylized (illustrative) Hopf bifurcation in 2-dimensions is given for convenience in **Fig. 2**.

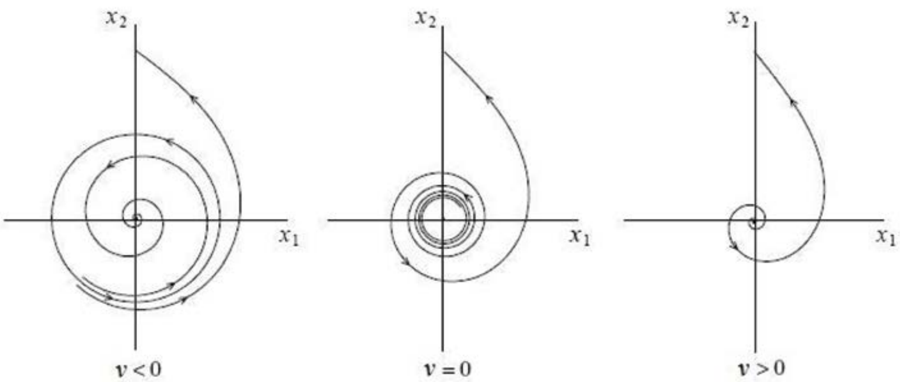
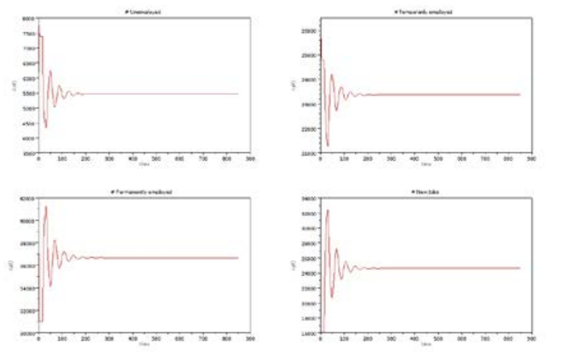


Fig. 2 A schematic representation of a Hopf bifurcation for a hypothetical dynamic model in two dimensions. Changing a model parameter $\boldsymbol{v}$ leads to a qualitative change in the eigenvalues of the linearized system (around the stationary point at the plot origins).

A change in qualitative behavior may come about by changing the parameters of the dynamical model. In the context of the DDE model a first question to ask is to whether the delay is assuming the role of such a critical parameter (as does $\boldsymbol{\nu}$ in **Fig. 2**). As we will see, the answer to this question is affirmative although the expected behavior cannot be observed immediately in numerical simulations. To this end, a Maple program developed in [8] for dealing symbolically with this kind of bifurcation analysis more than two dimensions was applied to our dynamical model. For the numerically instantiated parameter values of the model, a delay value of $\tau_0(a, a_1, \ldots, a_{13}, .) = 20.05768477$ results for locating such a bifurcation point. If $0 \leq \tau < \tau_0$, the solution of our dynamical system is asymptotically stable. For $\tau = \tau_0$ the solution exhibits a limit cycle and for $\tau > \tau_0$ the solution orbit for some initial conditions becomes unstable. More numerically oriented bifurcation analyses than the symbolic calculus based on Normal Form Theory may also be performed by using automatic differentiation and trajectory pursuit (Gukenheimer & Meloon [5]). For more details on the computer assisted determination of the equilibrium and bifurcation points of our dynamical system, the reader may contact the authors.

4. EFFECTS ON PARAMETERS ON SYSTEM DYNAMICS

At first, numerical simulation of the delay differential equations (DDE) is performed for alternative sets of initial conditions by using the model parameter values from expressions (9). In all cases we use the initial function $V(-\tau \leq \theta \leq 0) = x_1(0)$, i.e. we use the initial value at *t*=0 of the retarded variable. The software used in the sequel is the RADAR 5.2.1 FORTRAN code [6] for the DDE and Scilab 5.4.1 for the graphics which is checking (and confirming) the computations made with the DDE23.2 code under Matlab 12 we requested from another group of programmers.



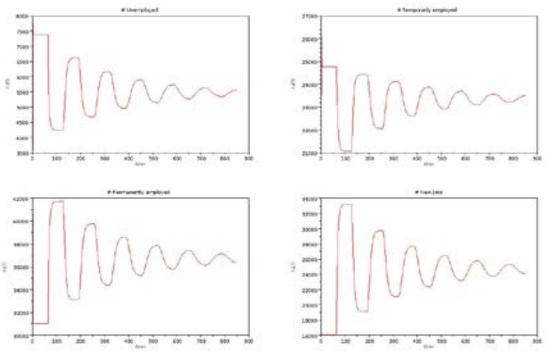


Fig. 3 Time evolution of the dynamical model variables $\boldsymbol{x_i(t), i = 1, \dots, 4}$, for the *small* delay $\boldsymbol{\tau}$ =15 (lhs plots) and for *large* $\boldsymbol{\tau}$ = 63 (rhs plots).

Figure 3 depicts a dynamical model which is asymptotically stable in all four variables, oscillating with diminishing amplitudes (left plot) and the same dynamical model with larger τ which is asymptotically stable in all four variables, oscillating with slowly diminishing amplitudes.

However, the previous chapter indicates a Hopf bifurcation as being a generic property of our dynamical system. The bifurcation delay point τ_0 certainly depends on the structural parameters $a, a_1, \dots, a_{13}$,. of the dynamical system as one may read from the symbolic evaluation by Maple-expressions. Conversely, one may ask what the reaction of the systems is like when the structural parameters themselves are subjected to change. A complete analysis of this high co-dimensional problem is out of reach in the present contribution and may also be rather difficult or at least highly resource consuming in general. In order to offer at least some insight into a presumably robust subset of dynamic behaviors we will proceed along a reduced intervention in parameter space aiming at tuning the effects of nonlinearity. As is evident from the systems equations 1-4 the DDE are defined by means of linear terms (which also include the delay) and some multinomial (*mild* nonlinear) terms, which are exclusively controlled by the parameters $a_1 > 0$, $a_3 > 0$, and $a_8 > 0$, respectively. The role of these parameters is that of dimensionless scaling of the influence of two distinct nonlinear terms, which are repeatedly used in the model equations. The approach here is to evaluate, by integrating the dynamical system trajectories, of what are the effects of

a) decreasing the magnitude of a_1, a_3, a_8 below their default values and by
b) increasing the magnitude of a_1, a_3, a_8 above that default.

In this way one obtains (a) systems where the linear dynamics tends to dominate and b) system which are highly nonlinear. Dependence on initial conditions will be highlighted, answering for example the question of whether memory concerning initial conditions is short or persistent? The next questions is concerning the possible qualitative change of systems trajectories, both for i) a highlighted single trajectory per dynamic variable and also for ii) a set of respective trajectories emanating from multiple initial values at t = 0. As in previous sections the starting function of the delayed variable $\dot{x}_4(t)$ given by means of $x_1([0, -\tau]), \tau > 0$ will be assumed to be equal to $x_1(0)$.

Owing to the continuous dependence of the solutions of the system on feasible initial conditions and structural parameters (mainly restricted to be semi-positive), one may, with high probability, infer from such simulations some generic subset of the dynamical behavior.

Finally, as our investigation method in this chapter is numerical simulation by DE integration some instabilities owing to the numerical discretization may well become apparent and are certainly of practical relevance to the modeler. Indeed, some instabilities which may well appear for certain parameter combinations can be overcome by drastically increasing the memory of the numerical integrator. Here we are also using the highly efficient FORTRAN-coded integrator in the package RADAR 5.2.1 [6] for DDE and a wrapper for experiment control and output post-processing written in Scilab and running under Linux.

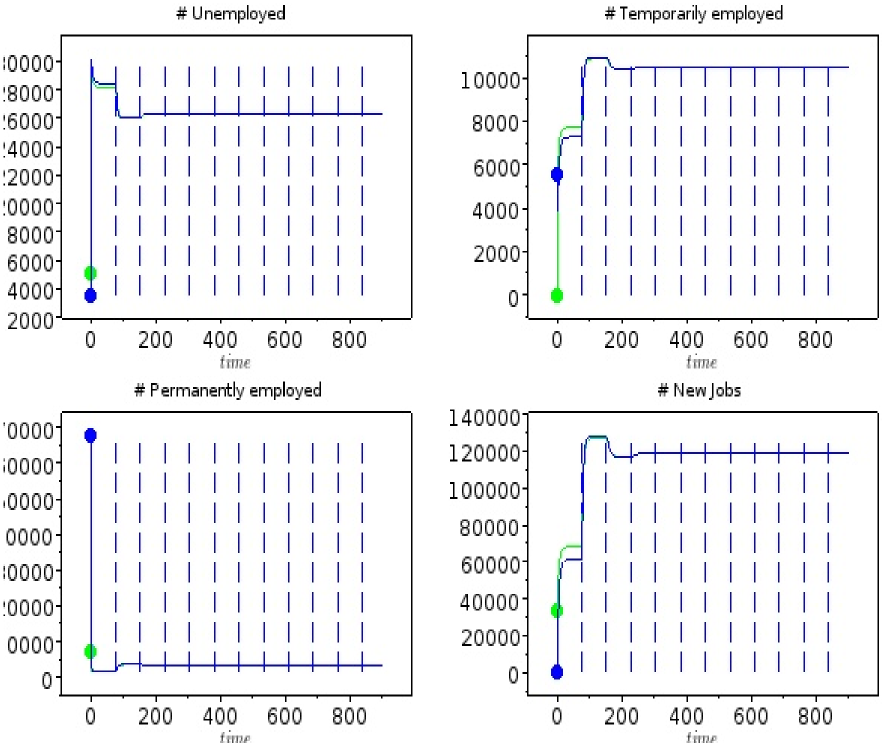


Fig. 4 The dynamic labour market variables $\boldsymbol{x_i(t), i = 1, \ldots, 4}$, with small non-linear effects (see main text). The vertical dashed lines denote the length of the delay covering the entire time horizon. Two different initial conditions $\boldsymbol{x_i(0)}$, where used as denoted by the fat points at t = 0.

The numerical integration of the DDE-system in **Fig. 4** is performed for a comparatively large delay of τ =76.3. In order to suppress the action of the non-linear term of the dynamics, we use values of the three pertinent structural parameters which 100 times smaller than the defaults (i.e. those used in previous figures), namely a_1= 4e-07, a_3= 3e-06, and a_8= 1e-06. This parameterization leads to rapid convergence of the dynamics to constant values in all four variables, having feasible but economically somewhat unrealistic relative magnitudes (rate of new job creations is much bigger the permanent plus temporarily employment). The two different initial conditions depicted in the figure lead to the same long term dynamics, pointing to a regime with a steep basin of attraction.

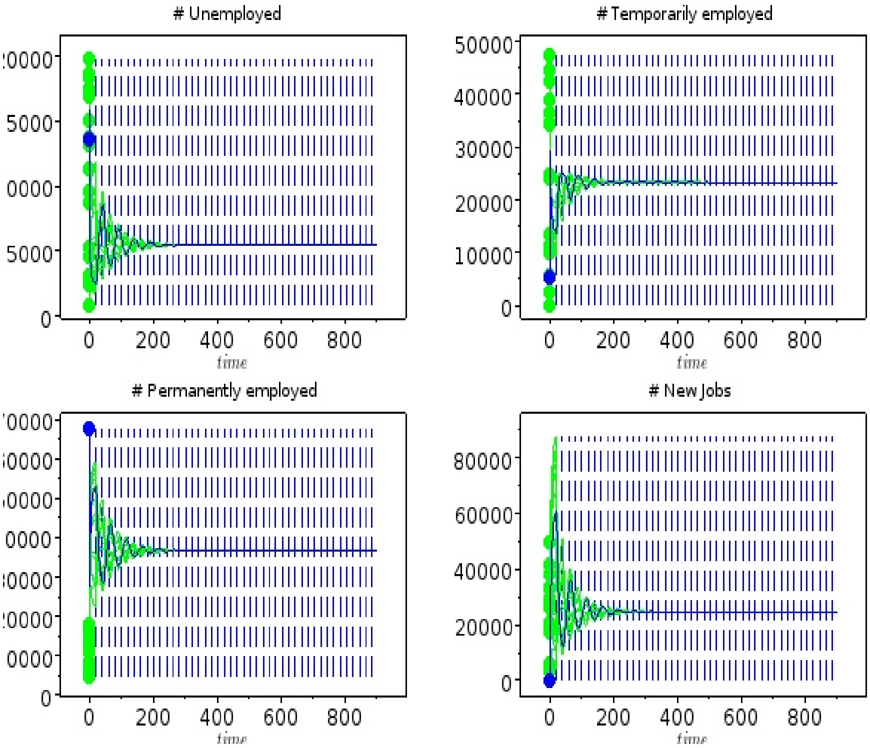


Fig. 5 The dynamic labour market variables $\boldsymbol{x_i(t), i = 1, \ldots, 4}$, with mild non-linear effects (see main text).

DDE-system of **Fig. 5** with a much smaller delay of τ =20.13 but with increased magnitudes of the structural parameters of a_1= 4e-05, a_3= 0.0003, and a_8= 0.0001, respectively, assuming the default values of the original model. Here, in addition, a multiple of 50 initial conditions is used. The resulting dynamics are somewhat similar to that of **Fig. 4**, although here we observe a less steep basin of attraction and the equilibrium values assumed for large $t > 0$ are perfectly plausible in an economic interpretation. Slightly increasing τ in order to surpass τ_0 does not bifurcate into a periodic solution as is expected by the symbolic calculations of the former section 4. In order to see this effect, the influence of the nonlinear parts of the system must be substantially increased above the default. The next simulations will attempt to achieve exactly that.

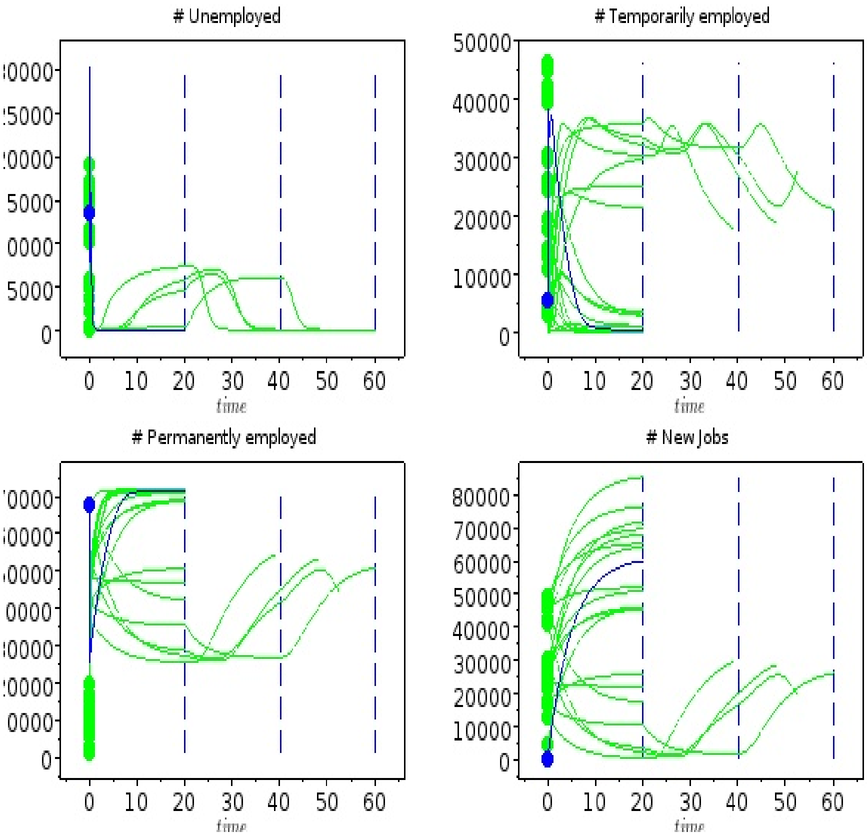


Fig. 6 The dynamic labour market variables $\boldsymbol{x_i(t), i = 1, \dots, 4}$, with strong non-linear effects, depicting failed trajectory integration, latest until $\boldsymbol{t \approx 60}$ (see main text).

The DDE-system of **Fig. 6** with a delay of τ= 20.0577, just above τ_0, but with still more increased magnitudes of structural parameters, assuming the values a_1= 0.004, a_3= 0.03, and a_8= 0.01, that is, which are now well above the default, is computed next. The result of this attempt is a failed (stopped) integration procedure from Radar 5.2.1. Nevertheless one may observe that different initial conditions give rise to different initial directions of trajectories and to a range of different failure times for the trajectory integration. This behavior may be somewhat surprising owing to the seemingly harmless nature of the nonlinearities involved in the dynamic equations. Numerical instability seems to appear in a quite surprising way, in that it is not preceded by visible divergence. From the economic point of view such instabilities are hard to comprehend, but a lesson to be learned is that an apparently very plausible relations may lead to dynamics which are highly sensitive to the discretization scheme.

Indeed, after massively increasing the integration memory (up to 100-fold) of the DE-integrator in Radar 5.2.1 routines these numerical instabilities do indeed disappear as is illustrated by the next numerical simulation.

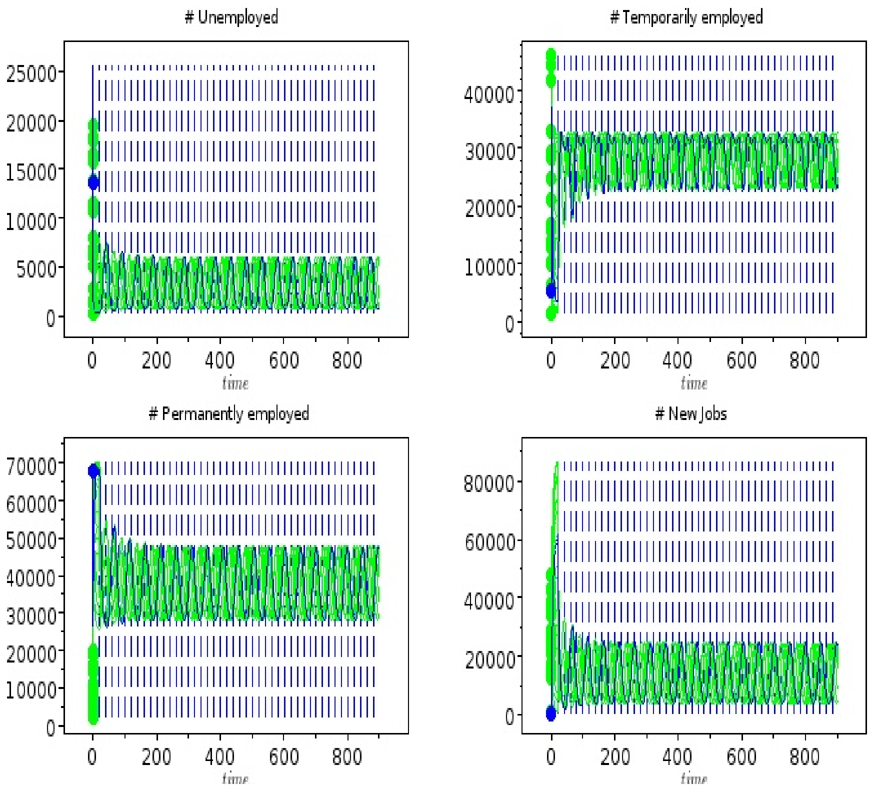


Fig. 7 The dynamic labour market variables $\boldsymbol{x_i(t), i = 1, \dots, 4}$, with strong non-linear effects, depicting successful trajectory integration (see main text).

This DE-system of **Fig. 7** uses a delay of τ = 20.0577, and structural parameters a_1= 0.004, a_3= 0.03, and a_8= 0.01, that is, exactly those of **Fig. 6** but employ much more memory (a much finer time scale) for DE trajectory integration. The result is a true limit cycle for every different initial condition. The single oscillations also exhibit a somewhat more complicated shape that those from the initial experiments depicted in **Fig. 3** which were exhibiting less persistent (slowly converging cycle with uniform shape). The shapes of the present cycles differ in the single dynamical variables and across trajectories generated by different initial conditions. The relative magnitudes of the variables over the cycles also appear economically plausible. More simulations have been performed which cannot be shown here all for obvious space restrictions. In these further simulations we also observe that the qualitative picture of persistent oscillations as depicted in **Fig. 7** is very stable for larger delays and also in more nonlinear interaction in the above sense. However, such cycles can only be obtained by increasing the time resolution of the more nonlinear model variants.

5. CONCLUSIONS

Our dynamical model is selected for representing certain aspects of the labor market in an advanced economy viewing unemployment and job creation as being robustly described by a system of four nonlinear differential equations with time delay. Depending on the strength of the nonlinear effects, this deterministic stylized model exhibits auto-stabilizing tendencies (i.e. the process is not run-away) in all four labor market variables pertaining to (un-)employment and job creation, although of persistent cyclical nature for a wide range of parameter values. A stochastic model version may lead to more empirically useful for short-term predictions. For instance, job creation is obviously having many more causes than those stipulated in our endogenous model. The existing model can be further generalized by using some of the mechanisms pointed at in the introduction. Furthermore, splitting up variables, e.g. by describing job creation in the private and in the public sector, or from a cross-border region between two or more countries, are also useful model candidates.

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Feature discovering in medical data sets using cluster algorithms

Ionela Maniu, George Maniu, Daniel Hunyadi

***Abstract* – In this article we used cluster algorithms i.e. hierarchical and K-Means clustering, with goal of convert data into knowledge and actionable information. After a short introduction on the general concepts of data mining and clustering algorithms we focus on analysis of input data and identifying the groupings of records and their features. Afterwards a comparison was made between the results obtained for the three data sets, considering different values of k.**

***Keywords* – data mining, cluster algorithms, K-Means algorithm**

1. INTRODUCTION

Extraction of information/learning from data/knowledge discovery from data is the primary goal of intelligent computational methods [4]. Learning from data can be done supervised or unsupervised. The objective of supervised learning is to predict the amount of output data based on the input data, and in unsupervised learning the objective is to describe associations and characteristics/structures of the input data.

First step in knowledge discovery consists in data exploration [1][5]. This first phase is descriptive and exploratory and analyse elements such as distribution, identification of atypical values, data transformations required by the distribution form or data standardization, means, cluster variance, correlation, classification, etc. This approach has as result an achieving of data descriptions that establish relationships among variables providing a first general idea of the data.

In this phase it can be considered two main objectives. The first objective is to explore one-dimensional and multidimensional or reduce the data dimension and the methods and the instruments used are: factor analysis, principal component analysis,

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analysis of simple correspondences. These methods consist in analysing a weighted point cloud into a space with a special metric, the cloud forms characterizing the nature and intensity of the relationships between variables and revealing information contained in data structures. The second objective is the classification or segmentation and it can be achieved by the following methods: hierarchical ascending classification (cluster progressive elements), the k-means (iterative aggregation elements around mobile canters) or mixed methods [3]. In this case we want the division and distribution into classes or categories by optimizing a criterion, each class having property that is as homogeneous in its entirety and report more distinctive compared to other classes.

2. CLUSTER ALGORITHMS

A cluster is a collection of records that are similar to one another and dissimilar to records in other clusters. Clustering refers to the grouping of records, observations, or cases into classes of similar objects. The clustering task does not try to classify, estimate, or predict the value of a target variable. Instead, clustering algorithms seek to segment the entire data set into relatively homogeneous subgroups or clusters, where the similarity of the records within the cluster is maximized, and the similarity to records outside this cluster is minimized.

2.1. Hierarchical clustering

In hierarchical clustering, is created a treelike cluster structure through recursive partitioning (divisive methods) or combining (agglomerative) of existing clusters. Agglomerative clustering methods initialize each observation to be a tiny cluster of its own. After that, in succeeding steps, the two closest clusters are aggregated into a new combined cluster. In this way, the number of clusters in the data set is reduced by one at each step. Eventually, all records are combined into a single huge cluster. Divisive clustering methods begin with all the records in one big cluster, with the most dissimilar records being split off recursively, into a separate cluster, until each record represents its own cluster.

Distance between records is rather straightforward once appropriate recoding and normalization has taken place. Further, we present several criteria for determining distance between arbitrary two clusters:

Single linkage, sometimes termed the nearest-neighbor approach, is based on the minimum distance between any record in first cluster and any record in second cluster. In other words, cluster similarity is based on the similarity of the most similar members from each cluster. Single linkage tends to form long, slender clusters, which may sometimes lead to heterogeneous records being clustered together.

Complete linkage, sometimes termed the farthest-neighbor approach, is based on the maximum distance between any record in first cluster and any record in second cluster. In other words, cluster similarity is based on the similarity of the most dissimilar members from each cluster. Complete-linkage tends to form more compact, sphere like clusters, with all records in a cluster within a given diameter of all other records.

Average linkage is designed to reduce the dependence of the cluster-linkage criterion on extreme values, such as the most similar or dissimilar records. In average linkage, the criterion is the average distance of all the records in first cluster from all the records in second cluster. The resulting clusters tend to have approximately equal within-cluster variability.

2.2 K-means algorithm

The k-means clustering algorithm [6] is a straightforward and effective algorithm for finding clusters in data. The algorithm proceeds as follows.

Step 1: Ask the user how many clusters k the data set should be partitioned into.

Step 2: Randomly assign k records to be the initial cluster center locations.

Step 3: For each record, find the nearest cluster center. Thus, in a sense, each cluster center "owns" a subset of the records, thereby representing a partition of the data set. We therefore have k clusters, C1, C2, . . . , Ck.

Step 4: For each of the k clusters, find the cluster centroid, and update the location of each cluster center to the new value of the centroid.

Step 5: Repeat steps 3 to 5 until convergence or termination.

The "nearest" criterion in step 3 is centroid distance (distance between the centroids of each cluster), although other criteria may be applied as well.

Technically speaking, the algorithm steps are:

Assume the existence of N vectors

$$x^l = (x_1, x_2, .., x_n)$$

Identify a representative set of k vectors cj, where j = 1, 2, ..., k;

Partition data in k disjoint subsets Sj containing Nj points, so to minimize the clustering function given by:

$$J = \sum_{j=1}^{k} \sum_{l \in S_j} \| x^l - c_j \|^2 \tag{1}$$

where cj is the average centroid data from the set Sj, given by:

$$c_j = \frac{\sum_{l \in S_j} x^l}{N_j} \tag{2}$$

One popular classification method involves the construction of a decision tree, a collection of decision nodes, connected by branches, extending downward from the root node until terminating in leaf nodes. Beginning at the root node, which by convention is placed at the top of the decision tree diagram, attributes are tested at the decision nodes, with each possible outcome resulting in a branch. Each branch then leads either to another decision node or to a terminating leaf node.

Classification and decision trees are used together to forecast membership of objects / instances in different categories, based on their measures in relation to one or more predictor variables. Classification tree analysis is a major data mining techniques. The flexibility of this technique makes it especially attractive, particularly because the benefit of present and suggestive views (tree which summarizes the classification obtained).

Conceptually, the construction algorithm and decision tree classification is as follows:
Let Dt training set which is at node t;
If Dt is the empty set, then t is a leaf labeled default C_{Φ} ;
If Dt contains instances belonging to the same class Ct, where t is a leaf labeled Ct;
If Dt contains several instances belonging to one class, then use an attribute node test to divide Dt in smaller subsets. The procedure is applied recursively for each node.
The strategy underlying the optimal partitioning of a node type is a greedy method, a recursive construction "top down" divide et impera type.
In principle, the methodology for classification and decision tree induction consists of two phases:
Construction of the original tree, using the available training set until each leaf is "pure" or almost "pure".
"Forming" tree as "increased" to improve the accuracy obtained by the test set.
Briefly, the algorithm behind the building and decision tree classification is as follows:

```
Build tree (training data T)
{
        Partition (T)
}
Partition (S data)
{
     if (all points of S are in the same class) then
         returns
    for each attribute A do
         evaluates the split on attribute A;
    using the best split found for partitioning S in S1 and S2
    Partition(S1)
    Partition(S2)
}
```

3. CASE STUDY

In the database used in this paper are analyzed indicators such as blood sugar, cholesterol, systolic and diastolic blood pressure, indicators that we see that are closely correlated with body mass index (IMC) based indicator which are established cases of overweight and obesity. The correlation between IMC and age was also studied [2]. A first set of data from the database is represented by the values of these indicators observed in the case of a factory employee (N=433), the second set are the values seen from a hospital employee (N=300) and a third for employees in the administrative field (N=70).

Dendrogram obtained by hierarchical cluster analysis, using the Between-groups linkage and the metrics Squared Euclidian distance shows that the variables are clustered in two groups, in fist group age (varsta) is clustered with IMC, and in the second one glucose (glicemie) is clustered with TAS, TAD, and cholesterol is not a part of any of the clusters (fig. 1). Approximately the same pattern was obtained for each of the three data sets.

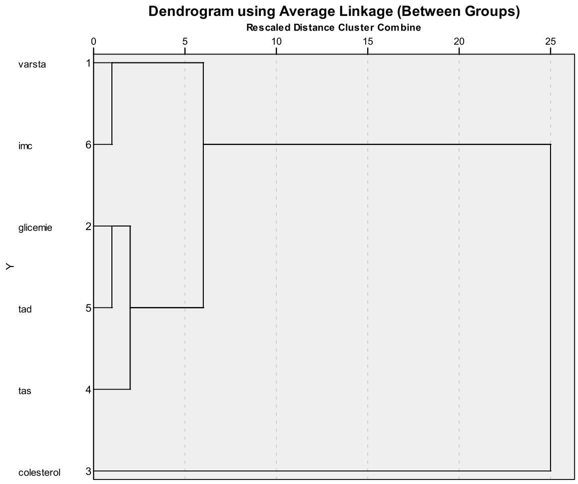

Fig. 1. Dendrogram obtained by cluster analysis

We have used SPSS Modeler to run K-Means cluster analysis to the data set. The results contains cluster size, profiles for each cluster, mean of the feature. All variables where continuous, and we request 20 iterations and 2 clusters. The feature importance was: age(1), TAD(0.90), TAS(0.76), IMC(0.74), cholesterol (0.22), glucose (0.04).

Table 1. Profiles of clusters

Cluster	Cluster 1 (53.1%- 426)	Cluster 2 (46.9% - 377)
Age (vârsta)	35.87	48.85
TAD	70.59	83.98
TAS	110.49	130.59
IMC	23.27	28.95
Cholesterol (colesterol)	182.72	209.41
Glucose (glicemie)	84.83	91.21

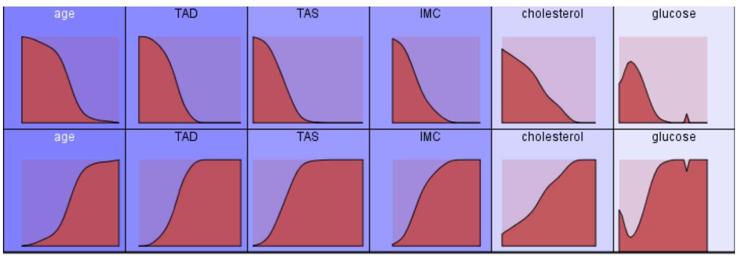

Fig. 2. Distribution of feature values

K-Means cluster analysis was then performed for each of the three data sets, for k=2. In case of factory employee, profile of the first cluster is: age around 30, optimal blood pressure, normal weight with optimum cholesterol and glucose while profile of the second cluster is: age around 50, normal blood pressure, overweight, with optimum cholesterol and glucose. In case of hospital employee profile of the first cluster is: age around 40, normal blood pressure, normal weight with optimum cholesterol and glucose while the profile of the second cluster is age around 50, normal high blood pressure, obese, with slightly raised cholesterol values and normal levels of glucose. In case of administrative employee profile of the first cluster is: age around 50, hypertension, overweight, with slightly raised cholesterol values and normal levels of glucose while the profile of the second cluster is age around 55, hypertension, obese, with high levels of cholesterol and glucose (**Table 2**).

Table 2. Profile of cluster for each of the three data sets

Cluster		40% (173)	60% (260)
Factory (433)	Age (vârsta)	33.61	48.46
	TAS	109.89	129.25
	TAD	69.93	80.58
	IMC	23.02	28.11
	Glucose (glicemie)	87.75	94.97
	Cholesterol (colesterol)	178.35	195.32
Hospital (300)		46.7% (140)	53.3% (160)
	TAD	72.82	89.66
	TAS	112.72	135.21
	IMC	23.89	30.32
	Age (vârsta)	40.67	47.69
	Cholesterol (colesterol)	192.24	217.23
	Glucose (glicemie)	78.14	83.82
Administrative (70)		95.7% (67)	4.3% (3)
	TAS	118.88	175
	Glucose (glicemie)	96.70	188.67
	TAD	77.76	105
	Cholesterol (colesterol)	216.97	305.67
	Age (vârsta)	48.08	56.33
	IMC	27.25	28.03

As it can be seen from the results in the table below, there are differences between the three groups. For k=2, in the first group, the most important factors are: age, TAS, TAD, and in the second group: TAD, TAS, IMC while in the third group order of importance is as follows: TAS, glucose, TAD. Can be seen as common factors in all three groups, the factors TAD, TAS, and as differentiation factors: age, IMC, glucose.

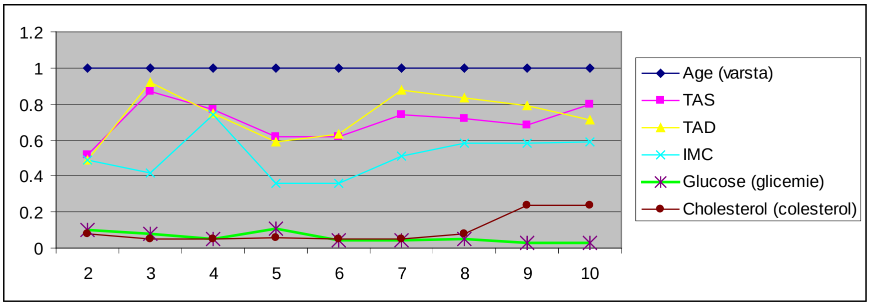

Fig. 3. Features importance, case of factory employee

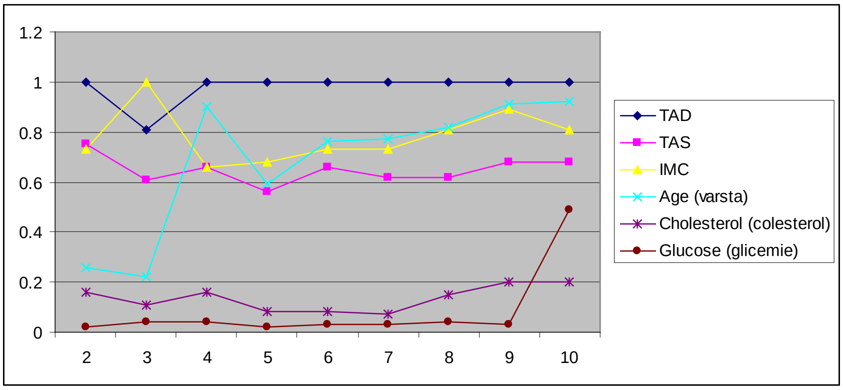

Fig. 4. Features importance, case of hospital employee

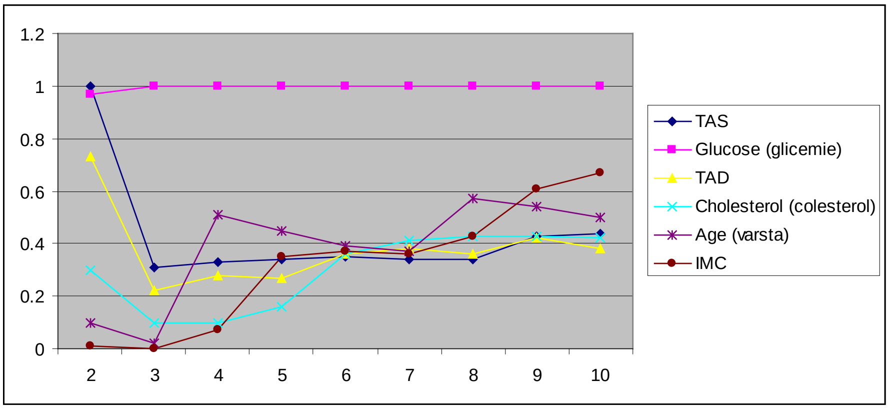

Fig. 5. Features importance, case of administrative employee

Running K-Means algorithm for k values from 3 to 10, we see changes in terms of order of feature importance especially in case of hospital and administrative employee. In case of hospital employee age is considered the second important feature followed by IMC and TAS. In case of administrative employee glucose is the most important feature and other features have close values.

4. CONCLUSIONS

Exploratory and explanatory methods are basic tools for data exploration. There is no best method, but experience in the choice of the method has an important role that is adapted to the types of database variables and having very good experience clarified the objectives of the study. There are some particularities in K-Means cluster analysis which must be taken into account (if not, it can make a large difference in cluster solutions): types of fields (with special scaling and distance measure), missing values, variable standardizations, the setting of initial clusters, number of iterations.

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Extracting associations rules with FP-Growth and Apriori from commercial transactions

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***Abstract* – Association rule mining is an important process in the field of data mining, discovering not trivial relationship between a large set of data items. For extracting association rules from an online retail transaction data set we used two of the most known algorithms i.e. FP-Growth and Apriori. Based on the particularities of processes built, we performed a statistical analysis to illustrate the efficiency, precision and accuracy of data mining techniques used.**

***Keywords* – Apriori, Data Mining process, FP-Growth.**

1. INTRODUCTION

The growing interest for Data Mining domain can be motivated through the pressing need, common to many areas of reference, to model and, especially, to understand large sets of data.

The process of knowledge discovery is equally old as the cerebral man. Since the discovery of fire and reaching out to the current studies on marketing, man made "data mining" without realizing it. Today, aided by tremendous computing power of computers, it can now adventure in exploring information by using the most effective means of working with existing data.

As can be seen in **Fig. 1**, it is difficult to formulate a single definition for data mining. On base of term roots (presented in **Fig. 1**), namely, exploring data analysis, artificial intelligence and database systems, the most frequently encountered significance for the concept of "data mining" is, in a few words, "knowledge-discovery in databases" (KDD), as it is named in reference [1]. Another definition, in the same work, is “extraction of interesting (non-trivial, implicit, previously unknown and potentially useful) patterns or knowledge from huge amount of data”.

A significant category of data mining techniques is that of mining frequent patterns, associations and correlations. Algorithms built for association rules are very

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useful from the perspective of marketing, because they develop methods for finding customers shopping patterns [6]. Applications of these special techniques are in basket data analysis, cross-marketing, catalogue design, sale campaign analysis, click stream of web logs analysis, and DNA sequence analysis [1].

From marketing perspective, the workings of these techniques are simple: purpose is to find correlations between articles sold. Association rules are based on two measures which quantify the support and confidence of the rule for a given data set.

The use of these techniques is to find trends and correlations in databases, which helps experts to take correctly and efficiently decisions in the future.

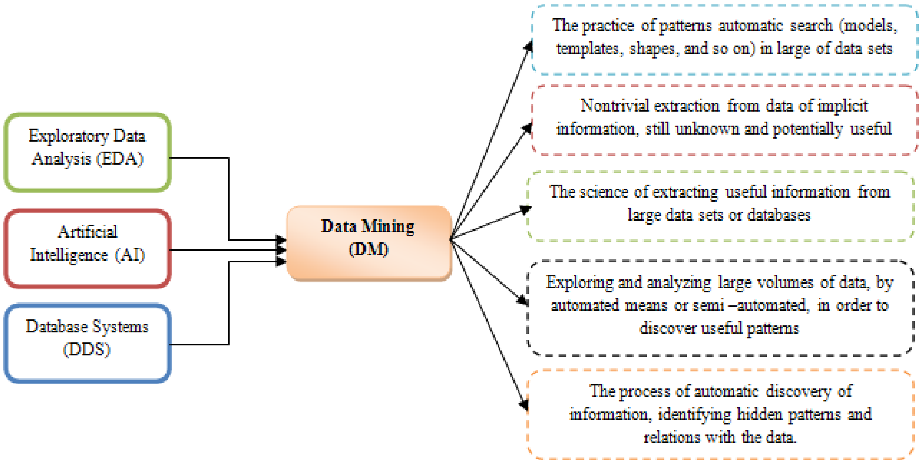


Fig. 1. Roots and significance of data mining

This article is an extension of the work [12], in this case, the comparison being made between FP-Growth and Apriori techniques.

After this introduction, the next section of this paper presents an experiment based on the algorithm used; after that, we described the processes constructed and the results obtained. A statistical analysis of the results was performed in the last section.

2. THE ALGORITHMS IN ASSOCIATION RULES MINING

The data set after which we will make the processing is described in Section 3 of this paper. To extract association rules from the products traded we chose operation by FP-Growth and Apriori. The FP-Growth algorithm, that means Frequent Pattern Growth Algorithm, was developed by J. Han, H. Pei, and Y. Yin [8]. This efficient, fast and scalable algorithm [6] is a method for mining the complete set of frequent patterns by pattern fragment growth, using an extended prefix-tree structure for storing essential information about frequent patterns, named FP-tree [8].

Among the advantages offered by this algorithm, we can mention that it is one of the fastest in obtaining association rules, as J. Han wrote in his paper [8], that the

FP-Growth algorithm has better performance than Apriori algorithm [3], Tree-Projection [9], RElim [10] or Eclat [11]. It also has disadvantages, namely, it is more difficult to implement that other approaches like a complex data structure and an FP-tree, and it can need more memory than a list of transactions [2].

2.1 Experiment based on FP-Tree algorithm

In our case study we randomly selected a set of ten transactions made. In order to not have a very wide range of products, articles of transactions we considered as being the name of category from which these products belong. Thus, if in a certain chosen transaction we will find at least two products from the same category, we keep only one item, namely, the name of that category. After all this, we obtained the following table:

Table. 1. Set of transactions chosen by category name

Tr. ID	**List of product categories**
0	Hair, Women fragrance, Tools and brushes
1	Skin care, Women fragrance
2	Skin care, Men fragrance
3	Hair, Men fragrance, Women fragrance, Bath and body
4	Women fragrance, Bath and body
5	Skin care, Men fragrance
6	Hair, Skin care, Women fragrance
7	Men fragrance, Women fragrance
8	Skin care, Men fragrance, Bath and body
9	Hair, Skin care, Women fragrance

After establishment of the list of transactions, it moves to the next level, namely, determination of frequency of individual items. In our case we have the next list: *Hair – 4, Skin care – 6, Men fragrance – 5, Women fragrance – 7, Bath and body – 3* and *Tools and brushes – 1*.

The next step is that of sorting descending items in transactions and removing those items that are infrequent for the parameters chosen in our case, in our case *Tools and brushes*. After that, the transactions are sorted lexicographically in ascending order. This is the last step before construction of frequent patterns tree. The result is presented in **Fig. 2**.

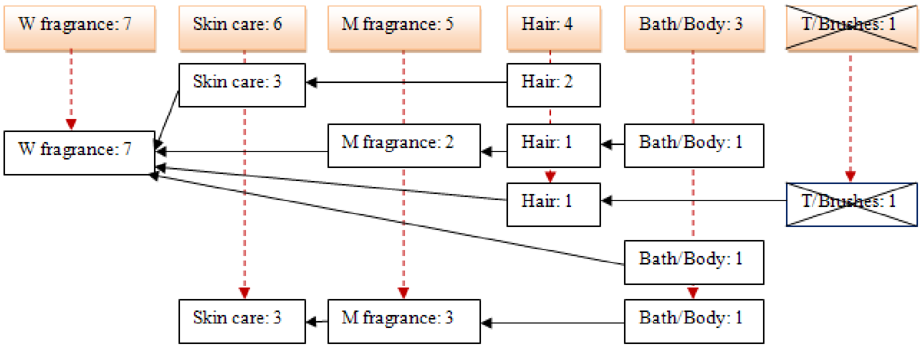


Fig. 2. FP Tree. Representation of transactions

The results obtained using FP-Tree algorithm, for our experiment, are presented in **Table 2**. For this, a value for minimum support (50%) is selected, relevant for our case. For establishing frequent sets of items we have chosen the same display mode of results like application RapidMiner.

Table. 2. Displaying of frequent sets

Size	Support	Item 1	Item 2	Item 3
1	0.700	Women fragrance		
1	0.600	Skin care		
1	0.500	Men fragrance		
1	0.400	Hair		
1	0.300	Bath and body		
2	0.300	Women fragrance	Skin care	
2	0.200	Women fragrance	Men fragrance	
2	0.400	Women fragrance	Hair	
2	0.200	Women fragrance	Bath and body	
2	0.300	Skin care	Men fragrance	
2	0.200	Skin care	Hair	
2	0.200	Men fragrance	Bath and body	
3	0.200	Women fragrance	Skin care	Hair

2.2 Experiment based on Apriori algorithm

Apriori algorithm, written by Agrawal and Srikant in 1994 [2], determines the support of frequent sets of items by the method BFS (Breadth First Search). First, it determines the support of the sets one item, than with two items, and so on.

The general scheme of the Apriori algorithm is following [2]: The first step is that to determine the support of the one element item sets and discard the infrequent items. The second is that through building form candidate item sets with two items (both items must be frequent). The next step is that through determine form candidate item sets with three items (all pairs must be frequent). Then, it continues by forming candidate item sets with four or more items, until no candidate item set is frequent.

Candidate generation and pruning are those two main steps that are the definition of the Apriori algorithm. All frequent item set mining techniques are based on steps above in some form.

Having as working hypothesis dataset from **Table 1**, and minimum support as being 20%, with the help of Apriori algorithm, we determined the set of frequent occurrences and associations between them.

Set of items	Support count
Hair	4
Women fragrance	7
Skin care	6
Men fragrance	5
Bath and body	3

1 – set of frequent items

Set of items	Support count
Hair, Women fragrance	4
Hair, Skin care	2
Women fragrance, Skin care	3
Women fragrance, Men fragrance	2
Women fragrance, Bath and body	2
Skin care, Men fragrance	3
Men fragrance, Bath and body	2

2 – set of frequent items

Set of items	Support count
Hair, Women fragrance, Skin care	2

3 – set of frequent items

Fig. 3. Generating sets of frequent occurrences

The final result of the frequent items sets is the general set:

L = {{Hair}, {Women fragrance}, {Skin care}, {Men fragrance}, {Bath and body}, {Hair, Women fragrance}, {Hair, Skin care}, {Women fragrance, Skin care}, {Women fragrance, Men fragrance}, {Women fragrance, Bath and body}, {Skin care, Men fragrance}, {Men fragrance, Bath and body}, {Hair, Women fragrance, Skin care}.

After that, we can determine the associations between sets of frequent occurrences generating. For this, we used an example, names the set {Hair, Women fragrance, Skin care} and with the minimum confidence being 50%. For this case, we obtained the following association rules:

R1: ({Hair, Women fragrance} → {Skin care}), with confidence 50%
R2: ({Hair, Skin care} → {Women fragrance}), with confidence 100%
R3: ({Women fragrance, Skin care} → {Hair}), with confidence 67%
R4: ({Hair} → {Women fragrance, Skin care}), with confidence 50%

3. PRESENTATION OF THE PROCESS BUILT

3.1 Description of the process built by FP-Growth

In our process programming we used the application RapidMiner. RapidMiner assures data mining and machine learning procedures, such as: pre-processing and visualization of data, transformation, modelling, evaluation, and deployment of data. RapidMiner is written in the Java programming language and uses learning schemes and attribute evaluators from the Weka machine learning environment and statistical modelling schemes from R-Project [7]. RapidMiner contains a collection of modular operators which allow the design of complex processing for a large number of data mining problems.

In order to program the desired process for analyzing associations of appearances frequent transaction sets, we used a dataset of an e-commerce company, operating in the field of perfumery and personal care products.

We have chosen a database of a company that operate exclusively online for several reasons, namely: the first reason is that the data set proposed for marketing is homogeneous and the second is that most transactions are composed of at least 2 – 3 products, and that from economic reasons related to saving the transport costs, promotions on the number of products, reasons helpful in analyzing associations based transactions.

The dataset used has over 600 lines, overall 200 transactions, and the following structure of fields:

- *ID of product* (a numerical value)
- *Name of product* (nominal value)
- *ID of transaction* (a numerical value)

Based on the dataset described above, we developed a data mining process developed using Rapid Miner, which will determine sets of frequent appearances from transactions, on which are generated association rules. Process built is based on other processes constructed through the works [3] and [4], and it is shown in **Fig. 4**.

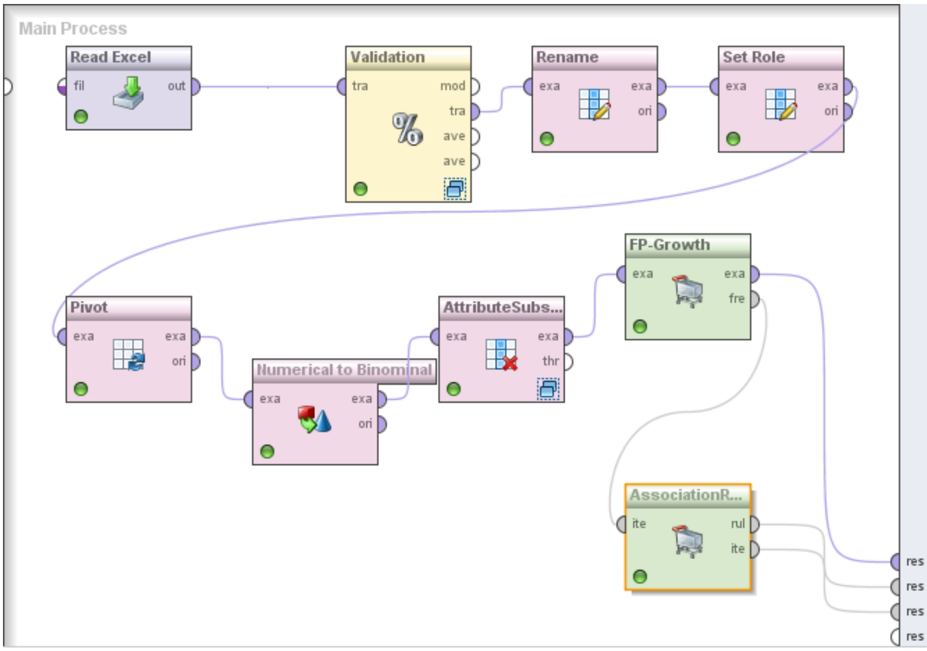


Fig. 4. The RapidMiner process for determining sets of frequent appearances and association rules generated with FP-Growth and Association Rules

For this process writing, created by facility GUI of RapidMiner and refined programmatically through adequate XML code, we used the following operators:

- *Read Excel*, through which we took the dataset, but eliminating those elements deductible, namely the information about product categories, and that is not to force later shift of all attributes in a binomial form, which is essential in process development.
- *Validation*, through which performs a simple validation, like randomly splits up our set into a training set and test set and evaluates the model. This operator performs a split validation in order to estimate the performance of a learning operator. We used it to estimate how accurately a model will perform in practice.
- *Rename* is used to rename fields, which by their nature, participate directly in the results, and as such, would hold their visibility.
- *Set Role* is used by RapidMiner to change the role of one or more attributes. In our case we put value ID of transaction to field attribute name, target role received value id. Through option set additional roles we have established Name of product as being regular type.
- *Pivot* is an important operator of this process and we used it to rotate the example set by grouping multiple examples of same groups to single examples. By option group attribute we selected the field ID of transaction, by index attribute we have chosen the field Name of product and through weight aggregation we selected the option count.
- *Numerical to Binomial* changes the type of the selected numeric attributes to a binominal type. It is an essential operator from this process, because the operator with name FP-Growth works only with binomial values. Because we applied before the operator Parse Number, in this case we chose the option all for the option attribute filter type.
- *Attribute Subset*, through which a subset is selected, composed of one or more attributes, from the input dataset and applies the operators in its subprocess on the selected subset.
- *FP-Growth* is a central operator of our construction. It calculates all frequent itemsets from the given dataset using the FP-tree data structure. The range of values within which we chose minimum support for establishing frequent sets of items is described in Section 4.
- *Association Rule Generator (Create Association Rule)* was written to obtain the association rules generated based on frequent occurrences of articles in transactions as they have been previous outcomes by using of operator, FP Growth. Data related to the values received by minim confidence attribute will be reported in Section 4, these constituting the support for the hypothesis of statistical analysis based on the results obtained. For this operator we have selected the output port ite, in order to see the frequent item sets obtained by FP-Growth operator.

3.2 Description of the process built by Apriori

IBM SPSS Modeler is a set of data mining tools, offering a variety of modeling methods which allow to derive new information from data and to develop predictive models. In this article we used the Apriori algorithm from the association category of modeling methods.

The Apriori process requires that the data representation to be in the tabular data format, so we have transformed the initial data format (transactional data format) in the tabular data format, each record is a transaction and a flag (0/1) to represent a purchase or not.

For the Apriori process, created with SPSS Modeler, we used:

- An Excel data file node, from the "Sources" tab.
- A separate "Type" node where we specified field properties. We set the "Mesurement" property of all variables (except transaction_id) to "Flag" (0 or 1), and "Role" property to "Both", which means that the field will be input (predictor field) or target (predicted field) for the process.
- The "Apriori" node, which discovers association rules in the date. Running this it creates a new model (Apriori Results node), where we can observe a table that displays detected associations between data attributes.
- The "Web" node (from the "Graphs" tab) for having a visual view of how different data attributes are associated.

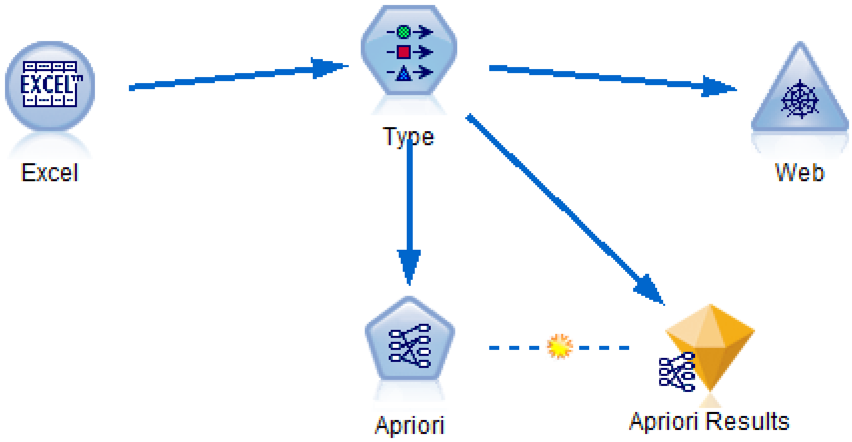


Fig. 5. The SPSS Modeler process for determining sets of frequent appearances and association rules generated with Apriori algorithm

3.3 The results obtained

In order to show the results, we selected a value for minimum support and one for minimum confidence. For reasons of space, we chose the maximum values from the range presented in Section 4, resulting the case with the fewest rules of associations obtained. So, we have chosen minimum support as 12%, and minimum confidence as 50%, as an example. The results generated by RapidMiner can be observed in the following list. It is quite obvious that if we choose smaller values for the parameters indicated, the number of generated rules will be greater, but including among themselves the rules presented below.

List of results. 1. The results obtained by FP-Growth process throw Rapid Miner

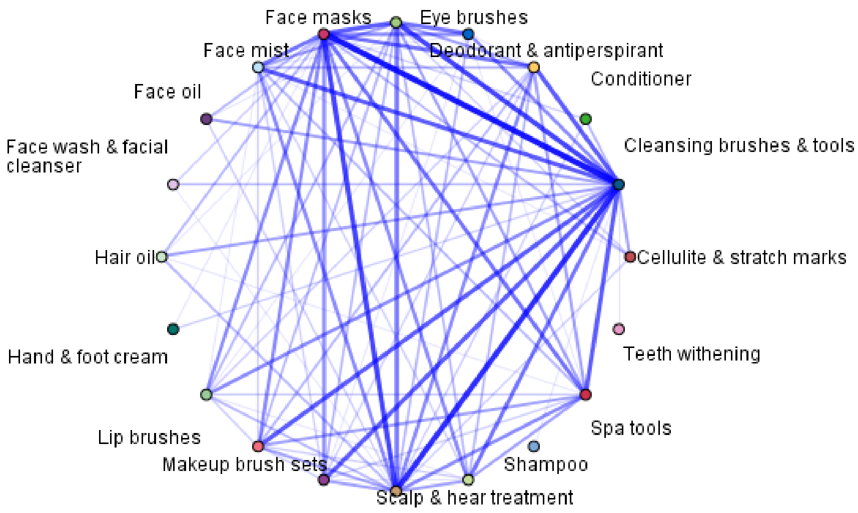
```
Association Rules
[Hand & foot cream] --> [Men's perfume] (confidence: 0.500)
[Gift sets] --> [Night cream] (confidence: 0.500)
[Makeup remover] --> [Hair color] (confidence: 0.500)
[Body lotions & body oils] --> [Hand & foot cream] (confidence: 0.500)
[Makeup remover] --> [Hair color, Exfoliators] (confidence: 0.500)
[Body lotions & body oils, Hand & foot cream] --> [Men's perfume, Face wash
       & facial cleanser] (confidence: 0.500)
[Hair color] --> [Night cream] (confidence: 0.538)
[Lip brushes] --> [Teeth withening ] (confidence: 0.571)
[Eye brushes] --> [Face brushes] (confidence: 0.571)
[Men's perfume, Body lotions & body oils] --> [Hand & foot cream]
       (confidence: 0.571)
[Body lotions & body oils] --> [Men's perfume] (confidence: 0.583)
[Hand & foot cream] --> [Body lotions & body oils] (confidence: 0.600)
[Face mist] --> [Body lotions & body oils] (confidence: 0.600)
[Men's perfume, Hand & foot cream] --> [Face wash & facial cleanser]
       (confidence: 0.600)
[Men's perfume, Hand & foot cream] --> [Body lotions & body oils, Face wash
       & facial cleanser] (confidence: 0.600)
```

These results were obtained from *Text View* option, generated by RapidMiner. If it is desired a visualization more complete of the results, one can choose *Table View* option.

The results generated by Apriori process, for the same minimum support and minimum confidence values can be observed in the following list.

List of results. 2. The results obtained by Apriori process throw SPSS Modeler

Consequent	Antecedent	Support %	Confidence %
Body lotions & body oils	Hand & foot cream	12.5	60.0
Men's perfume	Body lotions & body oils	15.0	58.333
Night cream	Hair color	16.25	53.846
Hand & foot cream	Body lotions & body oils	15.0	50.0
Men's perfume	Hand & foot cream	12.5	50.0
Night cream	Gift sets	15.0	50.0



Making a comparison between **List 1** and **List 2**, which means the combination results, we conclude that for the case of our data set, all the associations generated by Apriori is found among associations generated by FP-Growth, with approximately equal values of the calculated confidence, but RapidMiner process, built by FP-Growth technique, will generate more association rules.

4. STATISTICAL REPRESENTATIONS AND ANALYSIS BASED ON THE RESULTS

In this paper, for the experimental part, we used Rapid Miner pre-programmed process presented in Section 3, executing it several times. Execution numbers has been determined by a variety of values for the process key attributes: set minimum support and guaranteed minimum confidence. For our experiment, we used a minimum support of a range of values from the set [0, 0.12], which are in arithmetic progression with the ratio 0.02, each of which is assigned to a value from the set [0, 0.5] in arithmetic progression with ratio 0.05, for minimum confidence attribute. Thus 78 runs resulted in the process, enough to carry out a statistical experiment, based on our inputs.

In case of FP–Growth algorithm, for the entire database was obtain a negative correlation between parameters support ($r = -0.614$, $p = 0.000$) and number of association rules, and no significant correlation between parameters confidence ($r = -0.175$, $p = 0.146$) and number of association rules.

In case of Apriori algorithm, for the entire database was obtain a negative correlation between parameters support ($r = -0.764$, 0.000), confidence ($r = -0.313$, $p = 0.008$) and number of association rule, with a stronger link between support and rules number.

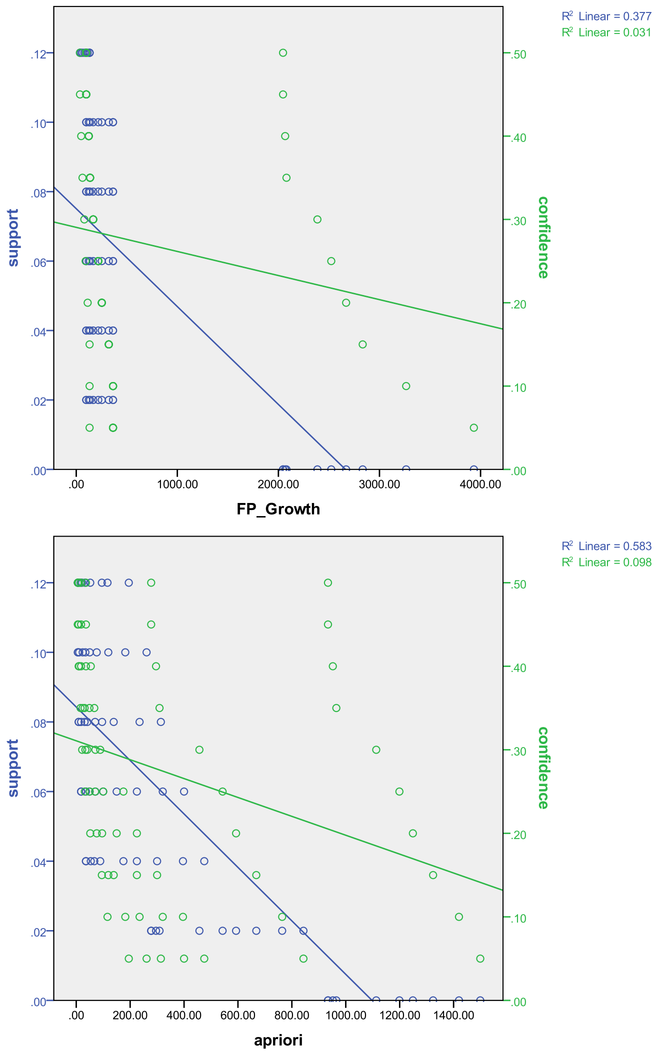


Fig. 6. Number of association rules vs. support – confidence and time, for the entire database

5. Conclusions

Techniques for determining the association rules are some very powerful tools in making decisions of marketing. Thus, based on them can be established some promotional packages, certain promotions, web page layout or arranging on the shelf, or simply, can track some trends of consumers.

From the experimental data presented it can be concluded that: the performance of both algorithms is influenced by support (decreases with this factor); the performance of the FP-Growth algorithm is not influenced by the confidence factor while the performance of the Apriori algorithm decreases with the confidence factor.

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An appropriate representation of a fuzzy controller enabling the determination of its parameters with an imperialist competitive algorithm

Stelian Ciurea

***Abstract* – We designed a fuzzy controller for the Truck Backer–Upper problem. We determined the parameters of the controller using an Imperialist Competitive Algorithm (ICA).**

Keywords – Fuzzy Controller, Imperialist Competitive Algorithm, Truck Backer–Upper problem

1. INTRODUCTION

Ever since 1975, fuzzy controllers have fully proved their usefulness in the most diverse applications. The design of such a controller involves setting up inference rules and values for a large number of parameters. There are situations where this is possible either through the expertise of a human operator or through a knowledge stock. If we cannot rely on such information, evolutionary algorithms are a good alternative to determine these values. The first condition in solving a problem by means of an evolutionary algorithm is the representation of the solution. In this paper, we present an Imperialist Competitive Algorithm that we designed with a view to determining the parameters of a fuzzy controller for the Truck Backer-Upper Problem (this problem is considered an acknowledged benchmark in nonlinear system identification). The representation of the solution used in this algorithm belongs to us.

2. THE FUZZY CONTROLLER FOR THE TRUCK BACKER-UPPER PROBLEM

2.1 The Truck Backer-Upper Problem

This problem, made famous by [5], has been investigated by many researchers.

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On the other hand, it is difficult not to notice that nearly anyone is able to drive the truck to the desired position if given some time to get used to the controls. The truck corresponds to the cab part of the Nguyen-Widrow's truck and trailer, referred to as the simplified Nguyen-Widrow problem. The truck position is determined by the three state variables $x \in [-50, 50]$, $y \in [0, 80]$ and $\varphi \in [-90°, 270°]$ - the angle between the truck's onward direction and the x-axis (Fig. 1). The width and length of the truck are 5 and 2 meters, respectively. The truck sets out from an initial position with the three state variables xi, yi and φi and must reach the loading dock with xf = 0, yf = 0, φf = 90°. The truck only moves backwards with the fixed speed. To control the truck at every stage, an appropriate steering angle $\theta \in [-45°, 45°]$ must be provided. Thus, the controller is a function of state variables θ = f(x, y, φ).

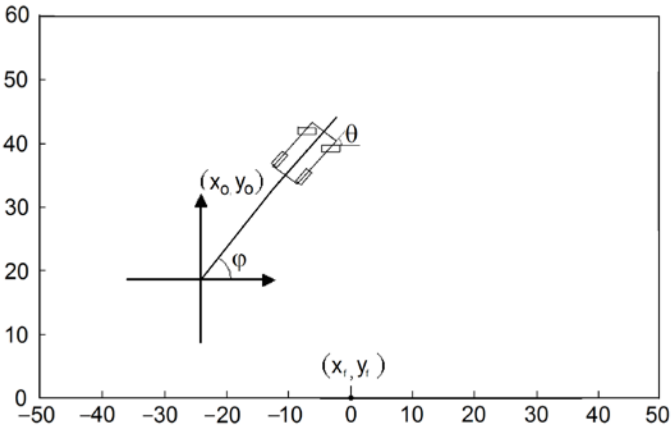

Fig. 1. Truck backer-upper system

Typically, it is assumed that there is enough clearance between the truck and the loading dock so that the truck position coordinate y can be ignored, simplifying the controller function to: θ = f(x, φ). For obvious reasons, such a controller does not perform very well if the distance between the truck position and the loading dock is small. The movements of the truck are described by the following system of equations:

$$\begin{cases} \dot{x} = -v\cos\varphi \\ \dot{y} = -v\sin\varphi \\ \dot{\varphi} = -\dfrac{v}{l}\tan\theta \end{cases} \qquad (1)$$

where l is the length of the truck and v is the backing up speed of the truck. These equations are applied to the current state, and the truck moves on until one of the following stopping conditions is met:

- $y \leq 0$ (the truck reached the loading dock);
- x, y or φ have an unacceptable value: $y>100$, $x \notin [-50, 50]$ or $\varphi \notin [-90°, 270°]$

2.2 The Fuzzy Controller

We implemented a Mamdani-type fuzzy controller. The input data are x and φ, and the output data is the steering angle θ. For x, we have opted for 5 fuzzy sets with the following linguistic variables: left - LE, left centre - LC, centre - CE, right centre-RC, and right – RI. For φ, we have settled on 7 sets: RB (right below), RU (right upper), RV (right vertical), VE (vertical), LV (left vertical), LU (left upper), and LB (left below). For θ, we have also selected 7 sets: NL (negative large), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium), and PL (positive large). The membership functions we have employed are trapezoidal or triangular (Fig. 2, Fig. 3 and Fig. 4). Starting from these sets, a fuzzy controller needs 5×7=35 inference rules based on fuzzy arguments. For example, if the *x* position is right centre, and the angle φ is vertical, then we want to steer positive medium. Symbolically, IF x is RC AND φ is VE, THEN θ is PM. Table 1 illustrates a possibility of defining these 35 rules.

Table 1 Matrix of the Rules for the control of the Truck Backer-Upper System:

x \ **φ**	**RB**	**RU**	**RV**	**VE**	**LV**	**LU**	**LB**
LE	NL	NL	NL	NM	NM	NS	PS
LC	NL	NL	NM	NM	NS	PS	PM
CE	NM	NM	NS	ZE	PS	PM	PM
RC	NM	NS	PS	PM	PM	PL	PL
RI	NS	PS	PM	PM	PL	PL	PL

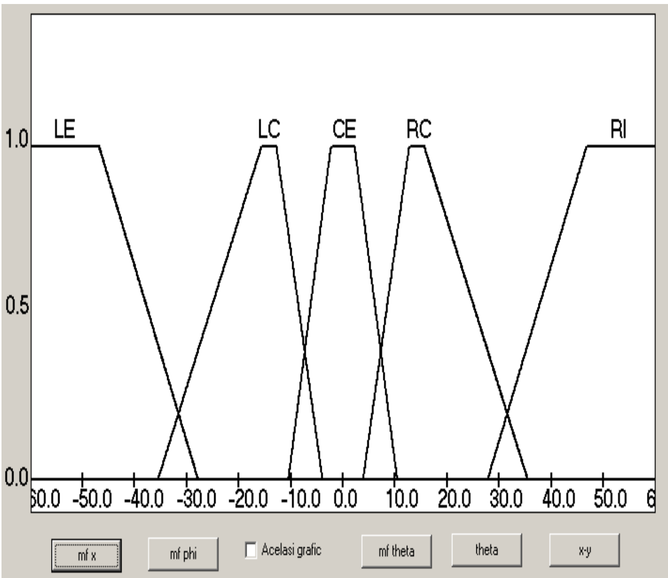

Fig. 2 Example of trapeziodal membership functions for variable x

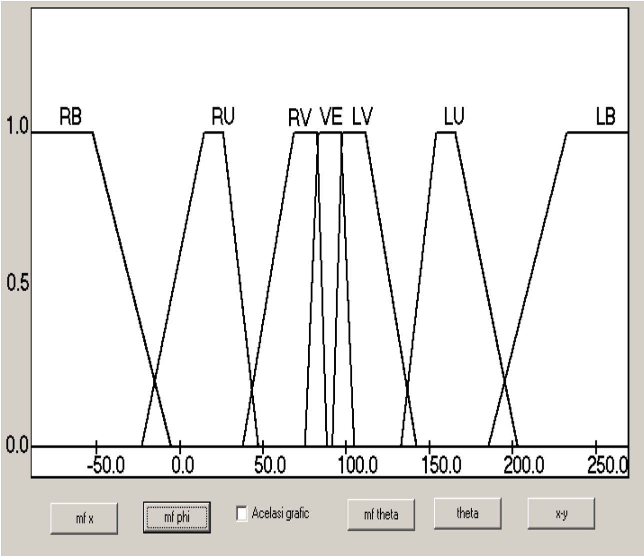

Fig. 3 Example of trapeziodal membership functions for variable φ.

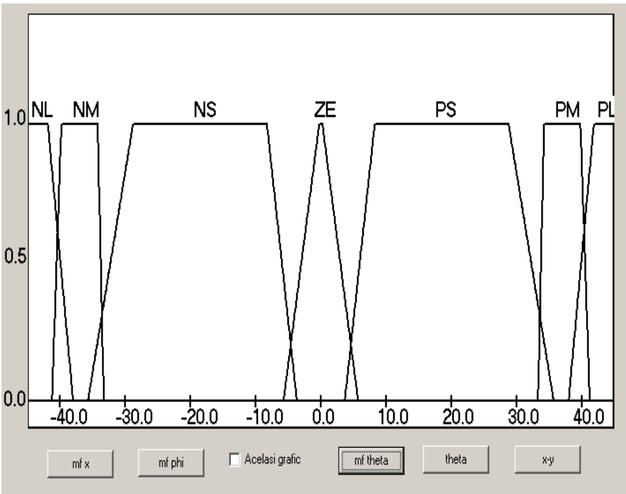

Fig. 4 Example of trapeziodal and triangular membership functions for θ

For the two input data variables – x and φ, the membership function is calculated for each of the 35 rules; we group the two results of these memberships function by means of an AND fuzzy operation, and then by means of an implication operation we obtain fuzzy sets for θ. We will have 35 θ sets corresponding to the 35 rules. These are grouped by means of the aggregation operation to get the output θ-set. Then, to find the actual control value, we must convert the output fuzzy set into a numerical value for θ by means of the defuzzification operation. There are various formulae for the fuzzy AND, implication, aggregation and defuzzification operations. It follows that, in order to fully define fuzzy controller, we need 35 inference rules and parameters that define the type and positioning of the fuzzy functions on the universe of discourse axis for the three variables (x, φ, θ), as well as the implementation of the fuzzy operations that occur in the calculating the response of the controller. There are no mathematical formulae to provide the values for these parameters.

3. THE IMPERIALIST COMPETITIVE ALGORITHM

Imperialist Competitive Algorithms belong to the category of probabilistic algorithms. Such an algorithm starts from a set of possible solutions (countries). The performance of each country is calculated by means of an evaluation function which appraises the accuracy of the solution provided by that country to the studied problem. The countries that have the best results become an imperialist countries, whereas the others are allotted to the empires. To colonies we have applied a specific operation designated ‘assimilation’, with the help of which the parameters of the colonies are modified so that the distance between them and the parameters of the empire can decrease. Then the colonies are re-evaluated with the help of the evaluation function. If the results of one of them surpass those of the imperialist country, the former becomes the new imperialist country, and the former imperialist country turns into its colony. The next stage is the competition between the empires. Following this competition, one of the colonies of the empire with the worst results is allotted to another empire. After a number of iterations, the search converges if only one empire is left, and its imperialist country represents the optimum solution.

3.1. The representation of the controller

The purpose of the genetic algorithm we have designed is to determine the parameters of the fuzzy controller optimal for solving the truck backer-upper problem. Because of the intrinsic symmetry of the problem, we have selected the member functions that are symmetrical to the median axis of the universe of discourse for each of the three variables. Thus, in a chromosome, for x, we have retained parameters for variables CE, RC and RI; variable LE mirrors RI symmetrical to axis x=0 and LC mirrors RC. Similarly, for φ we have represented parameters for variables VE, LV, LU and LB, and for θ, variables ZE, PS, PM and PL.

We coded the following parameters that typify a fuzzy controller:

- The interference matrix as a matrix with 5 rows and 7 columns, where each item can range between 1 and 7 corresponding to the 35 interference rules (1 means NL, 2 means NM, etc.);
- The type of fuzzy operations through 5 integer numbers for the type of fuzzy operations AND (0=min, 1=product), OR (0=max, 1=a+b-ab), the type of implication operation (0=min, 1=product), the type of the aggregation operation (0=max, 1=sum, 2=a+b-ab) and the type used in the defuzzification operation: a value between 0 and 3 corresponds to the methods based on integral calculus, while values between 4 and 6 are for elitist methods;
- The shape and position of the fuzzy sets in the universe of discourse. We point out that we chose the trapezoidal for the trapezoidal membership functions

corresponding to these sets (we assumed that the triangles are special cases of trapeziums with smaller bases of negligible length).

3.1.1. Representing classical trapezoidal membership functions

With the release of MATLAB 6, the "Fuzzy Logic Toolbox" library has been implemented [14]. Within it, a number of membership functions were defined for fuzzy sets, among which trapezoidal and triangular-shaped ones. Due to the popularity of MATLAB, the method by which fuzzy sets are represented in this software has become traditional, and most papers determining the parameters of fuzzy controllers by means of any evolutionary algorithms use it. Thus, a trapezoidal membership function is represented with the help of four parameters, marked a, b, c and d, with the mathematical expression (2) and shape illustrated in Figure 5:

$$f(x;a,b,c,d)=\begin{cases}0 & \text{x} \le \text{a or x} \ge \text{d}\\ \dfrac{x-a}{b-a} & \text{a} \le \text{x} \le \text{b}\\ 1 & \text{b} \le \text{x} \le \text{c}\\ \dfrac{\text{d - x}}{\text{d - c}} & \text{c} \le \text{x} \le \text{d}\end{cases} \tag{2}$$

where

$$a<b\le c<d \tag{3}$$

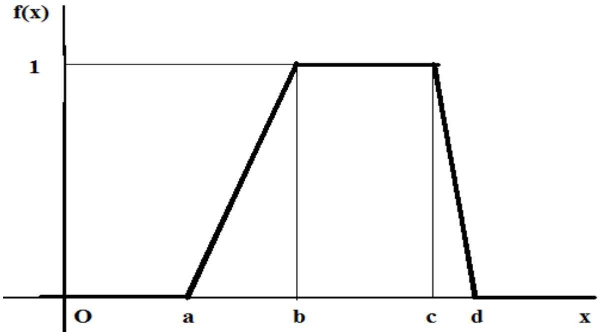

Fig. 5. Trapezoidal membership function

This representation is useful when we do the calculations required to determine the value of the output size of the controller or when we graphically represent memberships functions. However, it is not helpful when we apply the specific operations of the ICA because we need to introduce a number of restrictions where in the case of assimilation, so that for the resulting individuals relationship (3) is maintained, which burdens and slows down the genetic algorithm. We implemented this method of representation by means of the structure termed country:

struct country

```
{double parammfx[5][4];     /* parameters for the 5 memberships functions of x */
double parammfphi[7][4];    /* parameters for the 7 memberships functions of phi*/
double parammfteta[7][4];   /* parameters for the 7 memberships functions of theta*/
int typeand, typeor, typeimplication, typeagregation, typedefuzz, rules[5][7] ;
};
```

3.1.2 Our own representation of trapezoidal membership functions

We implemented the representation of trapezoidal membership functions as follows:

- for the membership functions for x 9 real parameters:
  - 3 values representing the ratio between the larger base of the trapezium and the average value of the universe of discourse – a value within the range [0.25; 2.0] for variables CE, RC and RI.
  - 2 values representing the percentage of the larger base of the trapezium overlapping the larger base of the trapezium placed on its left - a value within the range [0.05; 0.4] for pairs CE and RC, and respectively RC and RI
  - 3 values representing the ratio smaller base/larger base – a value within the range [0.01; 0.65] for CE, RC and RI.
  - a value representing the position of the smaller base for CE – a value within the range [0.05; 0.95] out of the available interval calculated depending on the large basis for RC (for RI the shape of the function is a rectangular trapezium, and for CE the trapezium is isosceles).
- 13 real parameters determined in a similar manner, but adding one value to each parameter to represent the functions for the other two variables (φ and θ).

The advantage of this representation is that, regardless of the method chosen for the operation of mutation or crossover, the resulting values will belong to the intervals considered, so no further validation tests are needed. In our application, we used a structure called cromozom2 corresponding to this way of representation:

```
struct country2
{int typeand, typeor, typeimplication, typeagregation, typedefuzz, rules[5][7]
/* memberships functions for x: */
 double rapx[3];        /* ratio larger base / average value of the universe of discourse */
 double suprax[2]; /* percentage of the overlapping of larger bases: 0.05-0.4 */
 double procx[3];   /* ratio smaller base/larger base: 0.05-0.65*/
 double pozrelx;     /* position of the smaller: 0.05-0.95 */
 double rapphi[4],supraphi[3],procphi[4],pozrelphi2,pozrelphi1;     /*rapphi1 results */
 double raptheta[4], supratheta [3], proctheta [4], pozreltheta2,pozreltheta1;
};
```

We used our own representation for the operations that are specific to the genetic algorithm, whereas for simulating fuzzy controllers, for the graphic representation and for the output files generated by the application, we used the traditional form. It was necessary to implement a function converted into the traditional.

3.2. The Imperialist Competitive Algorithm

In the Imperialist Competitive Algorithm that we have implemented, one country is a controller and it is a structure comprising a matrix with five rows and seven columns of integer values, 5 integer values and 35 real values that correspond to the parameters described in the previous paragraph. The ICA attempts to determine optimum values of all these 75 parameters.

Input data:

- for the fuzzy controller: the length and speed of the truck, the minimum and maximum values for x, y, φ, θ and the set of fuzzy rules;
- for the proper ICA: the total number of countries, the number of empires, the initial set of countries (potential solutions), the number of tests to compute the results, the maximum number of iterations, the weight of colony performance taken into account when computing empire performance, the approaching step used in the assimilation operation and the deviation.

Output data: the average performance of the set of countries, the performance of the best country and the numbers of colonies for each empire following each iteration; the parameters of all the controllers represented by the last set.

The implemented algorithm:

1. Generating an initial set of countries;
2. Initializing the imperialist countries;
3. Occupying the colonies;
4. Assimilating the colonies;
5. If a colony has better results than the imperialist country then
   Interchanging the colony with the imperialist country
6. The imperialist competition
   Computing the performance of the empires
   Occupying the weakest colony of the weakest empire by another empire
   If the weakest empire has no colonies left then
   Removing this empire and make it a colony
7. If the stopping requirements are met then
   a. Stop
   Otherwise
   b. Repeat the algorithm from step 3.

3.2.1. Assimilating the colonies

By means of this operation typical of ICA, the parameters of the colony controllers are applied a function with the help of which their values are "pulled" towards the values of the parameters of the imperialist country. As we have showed above, each country is a structure made up of eight integer values and thirty-five real numbers. In the case of the eight integer values of a colony, each of these will receive the value of the parameter corresponding to the imperialist country with a lower probability than a less-than-one-unit value p (designated approaching step). For each of the real-number parameters, in iteration n, we used the formula:

$$param\_colony_n = param\_colony_{n-1} + dev \times p \times (param\_imperialist\ country_{n-1} - param\_colony_{n-1}) \quad (4)$$

where
dev is the deviation – a real random a value within the range [0.5; 1.5].

3.2.2. Imperialist competition

This step of the algorithm begins by calculating the results of each empire. We used the following formula:

$$results\_empire = results\_imperialist\ country + weight \times (\Sigma\, results\_colonies) \quad (5)$$

where
weight is a less-than-one-unit value.

The weakest colony in the weakest empire was distributed to another empire using the Monte-Carlo method. To assess a country, we have simulated the way in which the controller it stands for takes the truck from the initial position to its final position (xf, yf, φf) and compute the fitness using the following function: from the initial position to its final position (xf, yf, φf) and compute the fitness using the following function:

$$fitness = \sum_{\text{test cases}} [2x_f^{\,2} + y_f^{\,2} + 5(\varphi_f - \frac{\pi}{2})^2] \quad (6)$$

Since the aim of the controller is to bring the truck to the coordinates point (0, 0, π/2), the function we have used is a penalizing one in relation to each of the three parameters that characterize the final state of the controlled system: the lower the value of the function, the better the country.

4. Experimental Results

We have written the application in the C language. We have used the following ICA parameters: the dimension of the initial set of countries (potential solutions): 55 or 108; the initial number of empires: 5 and 8; the maximum number of iterations: 100 and 150; the number of tests to compute the results: 10; the weight (W) of colony performance taken into account when computing empire performance: 0.0.1 and 0.001; the approaching step (ASt) used in the assimilation operation: 0.1, 0.2, 0.4 and 0.8. For the truck, we have chosen the following characteristics: length l = 5 m and backing up speed v = 1,4 m/s. The Imperialist Competitive Algorithm with the parameters thus established was run for 10 randomly generated initial sets. Table 2 shows the results that we have obtained. For each of the 10 sets it comprises the performance (computed with the help of expression (6)) of the best controller in the initial set and the performance of the best controller obtained as a result of applying ICA.

Table 2 Performance of best controller

	W	ASt	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	Avr
55 countries 5 empires	Init perform		8.69	12.0	6.81	12.3	3.70	8.40	5.99	13.8	7.52	8.35	8.77
	0.01	0.1	3.75	6.29	1.56	7.79	3.10	2.80	3.59	4.10	4.55	5.85	4.33
	0.01	0.2	3.39	5.94	2.32	3.42	1.90	2.66	2.91	3.83	2.00	5.78	3.41
	0.01	0.4	4.26	6.85	2.43	4.36	2.37	2.63	3.69	4.02	5.15	5.36	4.11
	0.01	0.8	3.18	2.99	0.71	1.83	1.39	1.44	3.36	0.97	0.83	2.44	**1.91**
	0.001	0.1	3.48	7.55	1.65	7.77	2.41	2.43	2.54	4.18	3.69	5.21	4.09
	0.001	0.2	2.81	6.03	2.92	3.43	2.18	3.01	2.91	3.83	2.29	5.48	3.48
	0.001	0.4	4.22	6.86	2.47	4.15	2.36	2.66	3.69	4.02	4.73	5.42	4.05
	0.001	0.8	3.19	5.73	0.82	2.23	1.39	1.45	2.80	0.96	**0.44**	2.56	2.15
108 countries 8 empires	Init perform		8.69	7.99	6.81	9.93	3.70	8.40	4.14	9.55	7.52	8.35	7.54
	0.01	0.1	2.90	4.36	2.48	4.72	2.59	2.87	2.16	5.05	2.58	3.29	3.40
	0.01	0.2	3.82	5.12	1.74	3.30	2.95	2.48	3.06	2.12	2.08	1.69	2.83
	0.01	0.4	2.84	4.59	1.79	4.59	2.74	2.40	2.94	2.83	2.25	1.63	2.86
	0.01	0.8	0.97	2.31	1.47	1.80	1.44	1.38	1.10	0.72	2.38	2.65	**1.62**
	0.001	0.1	2.93	4.34	3.05	5.47	2.48	2.25	2.98	5.00	2.43	2.63	3.42
	0.001	0.2	3.51	4.98	1.34	3.63	2.06	2.51	2.92	3.29	3.09	1.64	2.89
	0.001	0.4	2.56	3.51	2.11	4.46	3.08	2.33	2.80	2.34	1.89	3.87	2.89
	0.001	0.8	3.64	2.12	0.70	2.38	0.99	1.47	1.15	0.82	2.40	2.91	1.85

Figure 6 shows the variation in the number of colonies of the 5 empires (denoted emp #1,…, emp #5) in set #3 comprising 55 countries, and having a weight of 0.001, and an approaching step of 0.8.

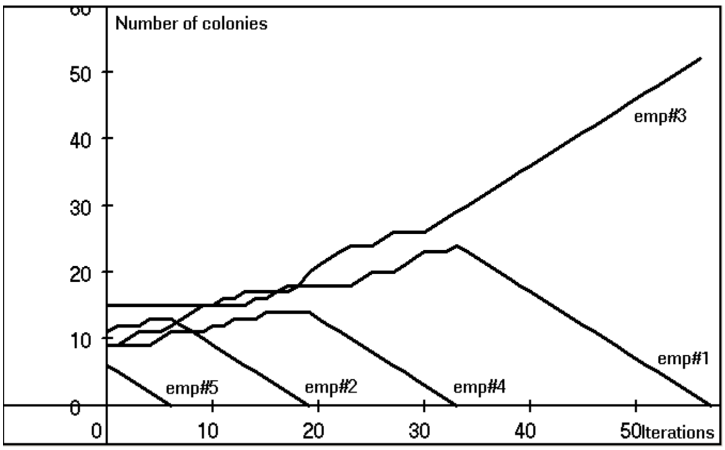

Fig. 6 Number of colonies versus iteration in ICA

Figure 7 illustrates the average performance of the set that provided the best controller (obtained from set #9 that comprises 55 countries, and has a weight of 0.001 and an approaching step of 0.8. Figure 8 illustrates the performance of the best country (controller) obtained.

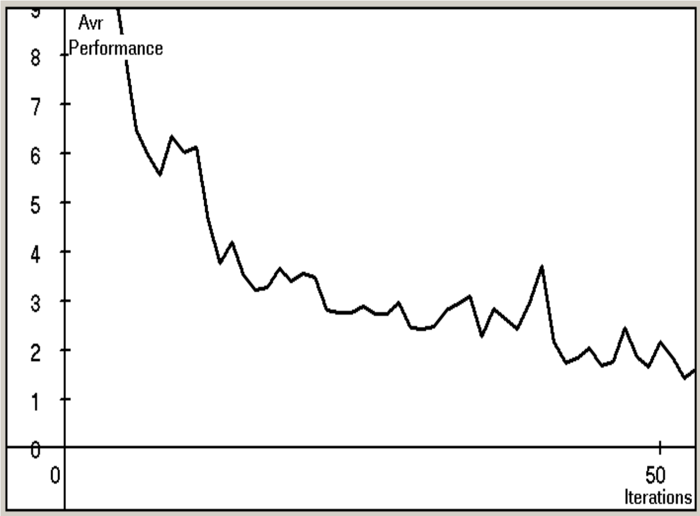

Fig. 7 The average fitness of set #9, 55 initial countries

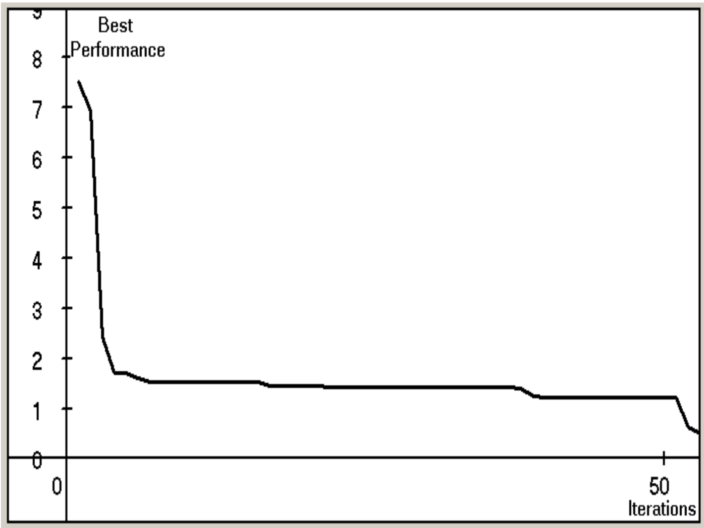

Fig. 8 Best fitness of set #9, 55 initial countries

For 6 starting items that are different from those used in ICA to evaluate the controllers we have illustrated in Fig. 9, the trajectories obtained by simulating the behaviour of the best controller obtained.

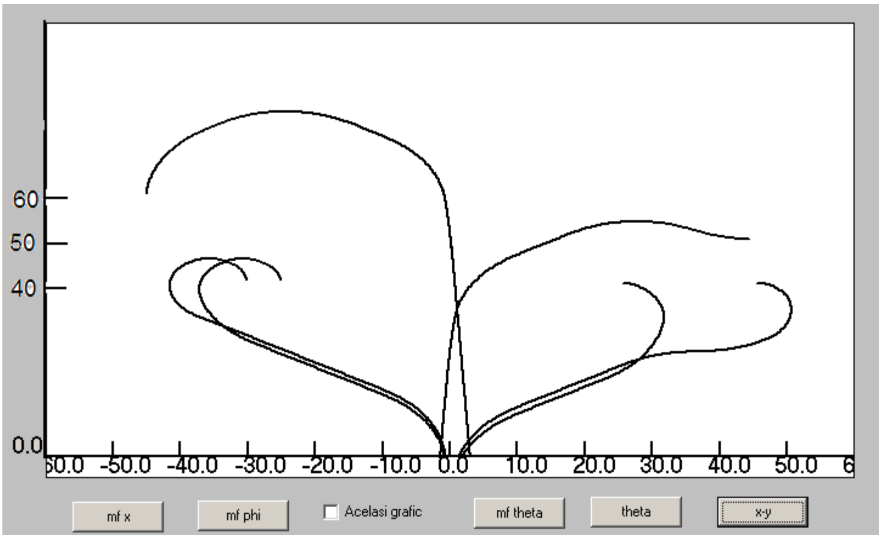

Fig. 9 Truck trajectories for 6 initial positions obtained with the best controller

The parameters of the best controller that we have obtained are the following: product for fuzzy-AND, maximum for fuzzy-OR, product for the fuzzy implication, sum for the aggregation of the fuzzy rules and defuzzification using the half-centroid method. The member functions for this controller are those illustrated in Fig. 2, Fig. 3 and Fig. 4. The Matrix of the Rules is similar to the one illustrated in Table 1.

5. CONCLUSION

We can notice the following:

The ICA proved its efficiency in all 160 tests we have performed. Thus, the ratio between the average of the results of best controllers of the initial set of countries and the average of the results of the best controllers of the final set of countries equalled:

- 2.78 for sets with 55 countries;
- 2.95 for sets with 108 countries;

The best average of the results of the controller obtained by applying ICA is the following:

- 1.91 for the sets that have 55 countries, for the tests having a weight of 0.01 and an approaching step of 0.8 ;
- 1.61 for the sets having 108 countries.

In both cases, these values were obtained for the tests that have a weight of 0.01 and an approaching step of 0.8.

The test carried out using sets of 108 countries resulted in controllers that have better results with 19.9% as compared to the results of the controllers obtained using sets of 55 countries.

The best controllers were obtained in the case of the tests carried out using ICA parameters with a weight of 0.001 and an approaching step of 0.8. The results of these controllers were the following:

- 0.44 in the case of a set comprising 55 countries;
- 0.70 in the case of a set comprising108 countries;

In the case of these controllers, the ratio between the results of the best controller of the initial set and the results of the best controller of the final set equalled:

- 17.09 for sets having 55 countries;
- 9.72 for sets having 108 countries;

The average lengths of time run on a computer equipped with a microprocessor AMD 1.67GhHz were the following:

- 10.5 minutes in the case of the sets having 55 countries;
- 57.2 minutes in the case of the sets having 108 countries;

In our future studies, we aim at improving the ICA algorithm by introducing new specific operations and expanding our investigation with regard to the efficiency of these algorithms in solving problems belonging to other categories.

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