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ENTREPRISES BEHAVIOR IN COOPERATIVE AND PUNISHMENT 'S REPEATED NEGOTIATIONS[1]

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Abstract: *Our paper considers a "negotiation game" between two players which combines the features of two-players alternating offers bargaining and repeated games. Generally, the negotiation game admits a large number of equilibriums but some of which involve delay and inefficiency. Thus, complexity and bargaining in tandem may offer an explanation for cooperation and efficiency in repeated games. The Folk Theorem of repeated games is a very used result that shows that if players are enough patience, then it is possible to obtain a cooperative equilibrium of the infinite repeated game. By this paper, I demonstrate a new folk theorem for finitely repeated games and I also present the new found conditions (under stage number and minimum discount factor value) such that players cooperate at least one period in cooperative-punishment repeated games. Finally, I present a study-case for Cournot oligopoly situation for n enterprises behavior under finitely and infinitely repeated negotiations. In this case, I found that discount factor depends only on players number, not on different player's payoffs.*

Key words: Negotiation Game; Repeated Game; Bargaining; Folk theorem; Bounded Rationality; Cournot oligopoly

1. Introduction

Our paper considers a "negotiation game" which combines the features of two-players alternating offers bargaining and repeated games. The negotiation game in general admits a large number of equilibriums but some of which involve delay and inefficiency. Thus, complexity and bargaining in tandem may offer an explanation for cooperation and efficiency in repeated games.

The Folk Theorem of repeated games is a very used result that shows if players are enough patience then it is possible to obtain a cooperative equilibrium of the infinite repeated game. A few contributions on folk theorem shows that the result survives more or less intact when incomplete (Fudenberg and Maskin, 1986) or imperfect public (Fudenberg, Levine, and Maskin, 1994) information is allowed, or when the players have bounded memory (Sabourian, 1998).

These findings are made precise in numerous *folk theorems*[3]. Each folk theorem considers a class of games and identifies a set of payoff vectors each of which can be supported by some equilibrium strategy profile. There are many folk theorems because there are many classes of games and different choices of equilibrium concept. For example, games may be repeated infinitely or only finitely many times. There are many different specifications of the repeated game payoffs. For example, there is the Cesaro limit of the means, the Abel limit (Aumann, 1985), the overtaking criterion (Rubinstein, 1979) as well as the average discounted payoff, which we have adopted. They may be games of complete information or they might be characterized by one of many different specifications of incomplete information. Some folk theorems identify sets of payoff vectors which can be supported by Nash equilibrium; of course, of more interest are those folk theorems which identify payoffs supported by subgame-perfect equilibrium.

Our paper develop Benoit and Krishna's (1985, 1993) idée developing a new folk theorem applied for finite repeated games. Player's strategies are "trigger" strategies. Players start by adopting a cooperative strategy and will play the same strategy as long as the other players also play cooperative strategies. If one player deviates from cooperative strategy (due on greater payoff) starting next stage he will be "punished" and his payoff will be "minmax" payoff.

Also, we found the conditions (the discount tare level) such that is is possible player's cooperation, and the minimum stage number such that at lest one stage our players cooperate.

Finally we present a study-case for Cournot oligopoly situation for n enterprises behavior under finitely and infinitely repeated negotiations, finding the discount factor level such that it is possible to enforce a cooperative behavior.

2. Literature

The Folk theorem gives economic theorists little hope of making any predictions in repeated interactions. However, as the aforementioned examples suggest, it seems that negotiation is often a salient feature of real world repeated interactions, presumably to enforce co-operation and efficient outcomes. Can bargaining be used to isolate equilibrium in repeated games?

Busch and Wen (1994) analyze the following game: in each period, two players bargain - in Rubinstein's alternating - offers protocol over the distribution of a fixed and commonly known periodic surplus. If an offer is accepted, the game ends and each player get his share of the surplus according to the agreement at every period thereafter. After any rejection, but before the game moves to the next period, the players engage in a normal form game to determine their payoffs for the period. The Pareto frontier of the disagreement game is contained in the bargaining frontier. The negotiation game generally admits a large number of subgame-perfect equilibrium, as summarized by Busch and Wen in a result that seems to be as the Folk theorem in repeated games.

Considerable effort has gone into introducing considerations that reduce the equilibrium set of a repeated game. For instance, depending on the stage game, the set of equilibrium payoffs is known to shrink by varying degrees when complexity costs are (lexicographically) taken into account (Rubinstein, 1986, Abreu and Rubinstein, 1988, Piccione, 1992, Piccione and Rubinstein, 1993), when strategies and beliefs are restricted to be Turing-computable (Anderlini and Sabourian, 1995, 2001), or when asynchronous choice is allowed (Lagunff and Matsui, 1997).

Obara (2009) proves a folk theorem with private monitoring and communication extending the idea of delayed communication in Compte (1998) to the case where private signals are not correlated.

We should mention that many folk theorem results without communication have been obtained recently. However, most of them assume almost perfect monitoring (Bhaskar and Obara (2002), Ely and Välimäki (2002), Hömer and Olszewski (2006), and Mailath and Morris (2002)).[4] One exception is Matsushima (2004) that allows for noisy private monitoring. However he assumes a certain type of conditional independence of private signals as in Compte (1998). The result of this note may be useful to deal with noisy correlated private signals even without communication, but that is left for future research.

Olson (1965) was among the first to formally pose the puzzle of group formation and cooperation, and this has provoked a large literature seeking to understand group behavior. Thorsten and Lim (2009) introduce two incentive mechanisms to sustain intra-group cooperation with prisoner's dilemma payoffs. They examine three-agent groups where relations may either be triadic one person interacting with two others/or tripartite, where all agents interact. Due to shirking incentives, sustained group cooperation requires a system of endogenous enforcement, based on punishments and reward structure and they found that both can ensure cooperation.

Fudenberg and Levine (2007) proves a Nash-threat folk theorem when players' private signals are highly correlated. Ashkenazi-Golan (2004) assumes that deviations are perfectly observable by at least one player with positive probability and proves a Nash-threat folk theorem. These results, as well as the result of this note, apply to repeated games with two or more players. Finally, McLean, Obara and Postlewaite (2005) prove a folk theorem when private signals are correlated and can be treated like a public signal once aggregated. But this result requires at least three players.

Also, there is an existing literature that seeks to model institutions and social networks in terms of endogenous enforcement. The use of incentive slackness in triadic relations to tie strategies across two party games or domains, has been studied by Aoki (2001); Bernheim & Whinston (1990) while exogenous superior information or enforcement capability among group members compared to non- group members is used in (Fearon & Laitin 1996; Ghatak & Guinnane 1999). Moreover, such an institutional arrangement may itself be endogenous (Okada 1993).

Fong and Surti (2008) study also the infinitely repeated Prisoners' Dilemma with side payments and they found that Pareto dominant equilibrium payoffs are implemented by partial cooperation supported by repeated payments. That seems to confirm folk theorems for infinitely repeated games.

The literature on repeated games with different time preferences is still relatively small. In an important contribution, Lehrer and Pauzner (1999) have studied how players in a repeated game exploit the difference in their time preferences by the intertemporal trade of instantaneous payoffs to enhance efficiency. Their paper provides the key insight that, by letting the impatient player consume more in the near future and the patient player consume more in the farther future, the set of feasible payoff vectors becomes larger than the convex hull of IR stage game payoffs identified by the folk theorem. They demonstrate that, keeping constant the relative patience of the players, as both become arbitrarily patient, they can achieve outcomes in equilibrium that would be infeasible were their time preferences identical.

Benoit and Krishna (1985, 1993) analyze particular folk theorems for finite repeated games. They show that under such hypothesis it is possible to reinforce collusive equilibrium that not require any binding agreements to ensure that players conform. An important example given by Benoit and Krishna show that for constant cost Cournot duopoly with linear demand it is possible to obtain enterprises cooperation if finite repeated game contains enough stages and discount factor is close to 1.

3. The Model

A (one-shot) game, *G*, in normal or strategic form, consists of a set of n players, the strategy sets of the players, and their payoff functions.

Thus, we define $G = (S_1, S_2, \ldots, S_n; U_1, U_2 \ldots, U_n)$, where S_i is player *i*'s strategy space and $U_i : S \to R$ is *i*'s payoff function, where $S = S_1 \times S_2 \times \ldots \times S_n$. The strategy space is represented by player's offers in negotiation process.

We may also write $U_i : S \to R^n$ as the function whose *i*-th component is U_i. We will assume that the strategy spaces are compact sets and that the payoff functions are continuous. *G(T)* denotes the game that results when G is successively played T times (T is a positive integer). Let $\delta_i \in (0, 1)$ be the *i*'th player discount factor ant T enough large (eventually ∞).

For $t = 1, 2, \ldots, T$ if $s_i \in S$ denotes the outcome of the game *G(T)* at time *t*, player *i*'s average payoff in *G(T)* is given by $u_i(s) = \frac{1-\delta_i}{1-\delta_i^{T+1}} \sum_{t=0}^{T} \delta_i^t u_i(s^{*t})$.

A strategy for player *i* in the game *G(T)* is a function s_i which selects, for any history of play, an element of S_i. A Nash equilibrium of G(T) is an n-tuple of strategies s^*, such that for all *i*, and any strategy or for player *i*:

$$u_i(s^*) = \frac{1-\delta_i}{1-\delta_i^{T+1}} \sum_{t=0}^{T} \delta_i^t u_i(s^{*t}) \geq \frac{1-\delta_i}{1-\delta_i^{T+1}} \sum_{t=0}^{T} \delta_i^t u_i(a^t) \quad (\forall) a \in S .$$

Let *N(T)* denote the set of Nash equilibrium outcome paths of *G(T)*. We will assume that *N(1)* is not empty.

Let $\underline{u}_i$ denote player *i*'s minmax payoff and let $m_i \in S_i$ denote a corresponding strategy combination. A payoff vector *u* is said to be individually rational if for all *i*: $u_i > v_i$. Again, for the game G, consider the set of all payoff vectors which may result from players' choices (the range of the function *U*). The convex hull of this set, denoted by *F*, will be called the feasible region of payoffs. Note that in both *G* and *G(T)*, we are restricting attention to pure strategies only. The effect of this restriction is that minmax payoffs, which will play a significant role in what follows, may be higher than those attainable using mixed strategies.

The notion of a subgame perfect equilibrium is made precise as follows:

Definition: The strategy profile a is a (subgame) perfect equilibrium of *G(T)* if (i) it is a Nash equilibrium of *G(T)*, and (ii) for all *T' < T* and all *T'* period histories h (*T'*), the restriction of *s* to *h(T')* is also a Nash equilibrium of *G(T –T')*.

In our paper we use an alternative offer negotiation game. Each player makes offers at every stage but they don't have the possibility to reject the opponent's offer. We study next two different situations. For the first situation we consider the infinitely repeated negotiation and for the second case, the finitely repeated negotiation.

We suppose there exist in our negotiation game three different types of solutions: minmax equilibrium, corresponding to a punishment situation, a cooperation solution and a deviation situation. The relationships between the payoffs of these three strategies are: deviation payoff is greater than cooperation payoff that is greater than minmax payoff.

First case: the three phases of the game are:

- Cooperation phase (T' periods) from $t = 0$ to $t = T' - 1$, with cooperation payoffs;
- Deviation phase – one period – for $t = T'$: with deviation payoff for the player that deviate;
- Punishment phase starts from $T' + 1$ phase and continue all the game for the player that deviate from cooperative strategy

The variables:

- v_i – cooperative payoff;
- v_i^D – deviation payoff;
- $\underline{u}_i$ – minmax payoff/punishment payoff ;
- Relationships: $v_i^D \geq v_i > \underline{u}_i$;
- $\underline{\delta}$ - minimum discount factor to cooperate;
- δ_i - player *i* discount factor.
- a parameter $A = \frac{u_i^D - v_i}{v_i - \underline{u}_i}$ that shows the relative gap between deviation from cooperation payoff and punishment payoff.
- *T* is the number of game stages and *T'* is the stage where player *i* deviates from cooperative phase.

A. Infinitely repeated games

First we consider the situation of infinitely repeated game ($T = \infty$). Game solution of infinitely repeated game result from next theorem:

Theorem 1. Folk Theorem

Let G be a static, finite game of complete information and G(∞) the infinitely repeated game. Let $\underline{u}_i$ the minmax payoff of G for any player *i*, so for any payoff vector v so that $v_i > \underline{u}_i, (\forall) i$, there exists a minimum level of discount factor $\underline{\delta} < 1$, such that $(\forall)\delta \in (\underline{\delta}, 1)$ there exists a subgame perfect Nash Equilibrium that achieves *v* as average payoff. (see proof in Appendix)

This theorem show as also some interesting findings related to player's behavior:

The minimum level of discount factor such that the cooperation strategy depend on relative gain from deviation related on punishment possible to be implemented. Starting on these hypotheses we proof the following results:

- If deviation payoff is close to cooperation payoff then players cooperates in every period of the game;
- If cooperation payoff is close to punishment (minmax) payoff, then cooperative situation is not possible;
- If deviation payoff is very large, then player's cooperation is not possible for any period of the game.

Corollary 1. If there exist a minimum level for discount factor $\underline{\delta}$, then $\underline{\delta} = \frac{u_i^D - v_i}{u_i^D - \underline{u}_i}$. (1)

This corollary shows the discount factor depends on deviation payoff, cooperation payoff and punishment payoff.

Corollary 2. If deviation payoff is close to cooperation payoff ($\boldsymbol{u_i^D} \to \boldsymbol{u_i^C}$) then $\underline{\delta} \to 0$ and players cooperates in every period of the game.

Corollary 3. If cooperation payoff is close to punishment payoff ($\boldsymbol{u_i^C} \to \boldsymbol{u_i^P}$), then $\underline{\delta} \to 1$ and cooperative situation is not possible.

Corollary 4. If deviation payoff is very large, ($\boldsymbol{u_i^D} \to \infty$), then $\underline{\delta} \to 1$ and players cooperation is not possible for any period of the game.

B. Finitely repeated games

In the second situation we consider the finitely repeated negotiation game, where T represents the final stage of the game. The strategies and the payoffs situation still are the previous ones. The game phases are:

- Cooperation phase (t' periods) from *t = 0* to *t = T' – 1;*
- Deviation phase – one period – for *t =Tt';*
- Punishment phase, for *T - T'-1* periods (from *t = T' + 1* to *t = T*).

The backward induction solution of finite repeated games shows that in every period of the game the players must play and repeat the Nash Equilibrium of stage game. However, a large number of authors show there exists equilibrium of repeated game different from repetition of Nash equilibrium of stage game (see Benoit-Krishna Theorem).

Theorem 2. Benoit-Krishna Theorem

Let G(T) a finite repeated game and s^* a Nash equilibrium for stage game. Let $\hat{s}$ a strategy such that $u(\hat{s}) > u(s^*)$. Then it exists for T enough large, a time limit *T'<T*, such

finite repeated game equilibrium is $\hat{s}$ repetition for T′ periods and s^* repetition for T – T′ periods.

Benoit-Krishna theorem does not show the discount factor limit or the minimum number of game stages such that players cooperate.

We solve this problems extending Benoit-Krishna Theorem.

The first question we answer is: If *T* is enough large, which is the discount factor level starting players became the have a cooperative behavior?

Corollary 5. If the discount factor not exceed $\frac{u_i^D - u_i}{u_i^D - \underline{u}_i}$ then cooperation is not possible.

Corollary 6. There exists $\underline{\delta} \in (0,1)$, solution of the equation:

$$\delta_i^{T-T'+1} - \delta_i \cdot (A+1) + A = 0 , \qquad (2)$$

such that for every $\delta_i > \underline{\delta}$ the players cooperate for T′ periods.

Corollary 7. If T is very large, then the condition form C1 is satisfied and we retrieve the folk theorem with $\underline{\delta} = \frac{u_i^D - v_i}{u_i^D - \underline{u}_i}$, and $\delta_i > \underline{\delta}$.

If we know players discount factors, which is the necessary number of stages (T) need to played to be possible the cooperative situation?

Corollary 8. The minimum number of stages to can obtain a cooperative game for T′ stages is $T > T' - 1 + \frac{\ln[(\underline{\delta} \cdot A + \underline{\delta} - 1)/A])}{\ln \underline{\delta}}$. (3)

Corollaries proof are retrieved in Theorem 3:

Theorem 3 (Roman)

Let G be a static, finite game of complete information and G(T) the finitely repeated game for T stages. Let $\underline{u}_i$ the minmax payoff of G for any player *i*, so for any payoff vector v so that $v_i > \underline{u}_i, (\forall) i, (\exists) \underline{\delta} < 1$, (there exists a minimum level of discount factor $\underline{\delta} < 1$), for T enough large, $(\forall) \delta \in (\underline{\delta}, 1), (\exists) T' > 0$ there exists a subgame perfect Nash Equilibrium that achieves *v* as average payoff for the first T′ stages and for T-T′ stages the Nash equilibrium is the strategy that achieves $\underline{u}_i$ as average payoff.

Proof

We suppose also there exists a deviation payoff, $v_i^D = \max_a u_i(a) >$ v_i. So $v_i^D \geq v_i > \underline{u}_i$. v_i represent the *i*'th player cooperation payoff, and $\underline{u}_i$ represent the punishment payoff.

Player *i* will play v_i for *T'* periods with v_i payoff, then deviate, and his payoff will be $v_i^D = \max_a u_i(a)$, and for the rest of the game (*T-T'-1* stages) all other players will punish player *i* and he will receive minmax payoff $\underline{u}_i$.

If player *i* cooperates for *T* periods then his average cooperation payoff is:

$$u_i^C = \frac{1-\delta_i}{1-\delta_i^{T+1}} \sum_{t=0}^{T} \delta^t v_i \tag{4}$$

If player *i* cooperates for *T '* , then deviates at *T' +1* period and for the rest of the game (*T-T'-1* periods) his payoff will be $\underline{u}_i$ (punishment payoff) then his average deviation payoff is:

$$u_i^D = \frac{1-\delta_i}{1-\delta_i^{T+1}} \left(\sum_{t=0}^{T'-1} \delta^t v_i + \delta^{T'} v_i^D + \sum_{t=T'+1}^{T} \delta^t \underline{u}_i \right) \tag{5}$$

We found two different situations for our game. The first one give us the discount minimum level such that players cooperate (with *T* and *T'* done), and the second one show the minimum number of stages needs to repeat games such that at least *T'* periods our players cooperates (if discount factor is done).

So equilibrium condition such that players cooperate is:

$$u_i^C \geq u_i^D \Leftrightarrow \frac{1-\delta_i}{1-\delta_i^{T+1}} \sum_{t=0}^{T} \delta^t v_i \geq \frac{1-\delta_i}{1-\delta_i^{T+1}} \left(\sum_{t=0}^{T'-1} \delta_i^t v_i + \delta_i^{T'} \cdot v_i^D + \sum_{t=T'+1}^{T} \delta_i^t \underline{u}_i \right) \Leftrightarrow$$

$$\Leftrightarrow \delta_i^{T'} (v_i^D - v_i) \leq \sum_{t=T'+1}^{T} \delta_i^t (v_i - \underline{u}_i) \Leftrightarrow \delta_i^{T'} (v_i^D - v_i) \leq (v_i - \underline{u}_i) \frac{1-\delta_i^{T-T'}}{1-\delta_i} \cdot \delta_i^{T'+1} \Leftrightarrow \tag{6}$$

$$\Leftrightarrow \frac{1-\delta_i}{\delta_i - \delta_i^{T-T'+1}} \leq \frac{v_i^D - v_i}{v_i - \underline{u}_i}$$

Case. 1. For given $\delta_i > \underline{\delta}_i$ we find the minimum stage periods such that players cooperate:

$$T > T' - 1 + \frac{\ln[(\delta_i \cdot A + \delta_i - 1)/A])}{\ln \delta_i}, \text{ where } A = \frac{v_i^D - v_i}{v_i - \underline{u}_i}.$$

Case 2. For given *T* and *T'*, $\underline{\delta}_i \in (0,1)$ is solution of equation:

$$A \cdot \underline{\delta}_i^{T-T'+1} - \underline{\delta}_i \cdot (A+1) + 1 = 0 \tag{2}$$

Obs. It is easy to show there exists a unique solution of equation (1) in (0,1) interval.

Let $\underline{\delta} = \max_i \underline{\delta}_i$. So there exists a minimum level of discount factor $\underline{\delta} < 1$, such that $(\forall)\delta \in (\underline{\delta},1)$ there exists a subgame perfect Nash Equilibrium that achieves *v* as average payoff. q.e.d.

4. Study-case: Cournot oligopoly application

We consider the Cournot case of oligopoly with linear demand functions, with n identical enterprises. Let x_i denote the quantities of a homogeneous product produced by enterprise *i*. *Let* *P(X)* = *a* – *b* X, (and *b* > *1*) be the market clearing price function, where X is the aggregate quantity on the market ($X = \sum_{i=1}^{n} x_i$). More precisely, inverse demand function is $P(X) = \begin{cases} a - b\,X, & for\ X < a/b \\ 0, & for\quad X \geq a/b \end{cases}$.

We assume that the total cost for firm *i* is $C_i(x_i) = c\,x_i$. For simplicity, there are no fixed costs for firm *i* and the marginal cost is equal with average cost and constant, *c* (we assume also *c* < *a/b*). Following Cournot suppose that the firms choose their quantities simultaneously. Each firm's strategy space can be represented as $S_i = [0,\infty)$, the nonnegative real numbers. In this case a strategy is a quantity choice, x_i . From players rationality principle, neither firm will produce a quantity $x_i > a/b$ (otherwise *P(X)* = *0* and no firm will have a positive profit). The payoff for firm *i* will be represented by profit function:

$\pi_i(x_i, x_{-i}) = P(X)\cdot x_i - C_i(x_i) = P(\sum_{i=1}^{n} x_i)\cdot x_i - c\cdot x_i$.

(where $x_{-i} = (x_1, x_2, ..., x_{i-1}, x_{i+1}, ..., x_{n)}$), quantities vector chosen by other players).

A. One stage game

a. Non-cooperative game situation

We obtain the Cournot-Nash equilibrium solving for each firm the problem:

$$\max_{x_i \in S_i} \pi_i(x_i, x_{-i}^*) = \max_{x_i \in S_i} P(\sum_{i=1}^{n} x_i)\cdot x_i - c\cdot x_i \tag{7}$$

The first order conditions for *i*'s firm optimization problem is both necessary and sufficient (if $x_j^* < a/b - c$, as well be shown to be true), it yields:

$$x_i = \frac{1}{2\cdot b}\cdot\left(a - c - b\cdot\sum_{j=1, i\neq j}^{n} x_j\right),\ i,j = 1,\ldots,n \tag{8}$$

Solving the linear equation system (8) we obtain Cournot –Nash solution:

$$x_i^* = \frac{1}{n+1}\cdot\frac{a-c}{b} \tag{9}$$

which is indeed less than *a*/*b* – c, as assumed.

The *i*'s player payoff is: $\pi_i = \left(\frac{1}{n+1}\right)^2 \cdot \frac{(a-c)^2}{b}$ (10)

for non-cooperative situation, that represents also the minmax payoff.

b. The cooperative situation

We obtain the solution of cooperative situation solving following problem:

$$\max_{X \in S_i} \Pi(X) = \max_{X \in S_i} P(X) \cdot X - c \cdot X \text{ ,} \quad (11)$$

where $X = \sum_{i=1}^{n} x_i$, with equal payoffs for each player.

First order conditions for (10) optimization problem is also both necessary and sufficient and we obtain:

$$X^C = \frac{1}{2} \cdot \frac{a-c}{b} \text{ , so } x_i^C = \frac{1}{2 \cdot n} \cdot \frac{a-c}{b} . \quad (12)$$

Total payoff is:

$$\Pi^C(X) = \frac{1}{b} \cdot \left(\frac{a-c}{2}\right)^2 \quad (13)$$

and each firm cooperation payoff will be:

$$\pi^C{}_i(x_i) = \frac{1}{n \cdot b} \cdot \left(\frac{a-c}{2}\right)^2 \quad (14)$$

We can observe that $\pi_i^C > \pi_i$ for *n* > *1* and *b* > *1,* so enterprise's payoffs are greater if firm cooperates (that means they form a cartel) rather them adopt a non-cooperative behavior.

c. The deviation situation

There is another situation which one firm deviate from cooperative behavior trying to maximize his payoff (profit). In this case player *i* maximize his payoff for given quantities from cooperative situation: $x_j = \frac{1}{2 \cdot n} \cdot \frac{a-c}{b}, \quad i \neq j, j = 1,\ldots,n$:

$$\max_{x_i \in S_i} \pi_i(x_i, x_{-j}^C) = \max_{x_i \in S_i} P(x_i, x_{-j}^C) \cdot x_i - c \cdot x_i = \max_{x_i \in S_i}[a - b \cdot (x_i + \sum_{j=1, j \neq i}^{n} x_j^C)] \cdot x_i - c \cdot x_i \quad (15)$$

First order conditions for (15) optimization problem is also both necessary and sufficient and we obtain:

$$x_i^D = \frac{3n-1}{4 \cdot n} \cdot \frac{a-c}{b} \quad (16)$$

and the deviation payoff is

$$\pi^{D}{}_{i}\left(x_{i}\right)=\frac{(n+1)(3n-1)}{16\cdot n^{2}\cdot b}\cdot(a-c)^{2}. \tag{17}$$

It is easy to verify that $\pi_i^D((x_i)>\pi_i^C(x_i)$, so it exist temptation to deviate from cooperative situation for any firm *i*.

B. Infinitely repeated game

For infinitely repeated game, the minimum discount factor so that companies cooperate is : $\underline{\delta}=\frac{u_i^D-v_i}{u_i^D-\underline{u}_i}$ (see formula 1), so for our game we obtain:

$$\underline{\delta}=\frac{\pi_i^D-\pi_i^C}{\pi_i^D-\pi_i}=\frac{\frac{(n+1)(3n-1)}{16\cdot n^2\cdot b}\cdot(a-c)^2-\frac{1}{n\cdot b}\cdot\left(\frac{a-c}{2}\right)^2}{\frac{(n+1)(3n-1)}{16\cdot n^2\cdot b}\cdot(a-c)^2-\left(\frac{1}{n+1}\right)^2\cdot\frac{(a-c)^2}{b}}= \tag{18}$$

$$=\frac{\left(3n^2-2n-1\right)\cdot\left(3n^2+2n-1\right)}{\left(3n^3+5n^2-3n-1\right)\cdot\left(3n^3+5n^2+5n-1\right)}<1$$

for n > 1.

We can observe that discount factor depends only on firm numbers in oligopoly.

Table 1. Evolution of minimum discount factor depending on enterprieses number

Enterprises number n	Minimum discount factor $\underline{\delta}$
2	0.0535
3	0.0394
4	0.0285
5	0.0212
6	0.0163
7	0.0129
8	0.0104
9	0.0086
10	0.0072

C. Finitely repeated game

If we consider to need at lest 20 stages of cooperation, for $A=\frac{\pi_i^D-\pi_i^C}{\pi_i^C-\pi_i}$ the minimum level for discount factor is (0,1) solutions of equation $\delta_i^{20}-\delta_i\cdot(A+1)+A=0$ (see Corollary 6) are presented in table 2.

Table 2. Evolution of minimum discount factor depending on enterprises number and for 20 stages of cooperation

Enterprises number n	Minimum discount factor $\underline{\delta}$	A factor value	Stage number
2	0.1127	7.875	20
3	0.1304	6.667	20
4	0.1287	6.771	20
5	0.1220	7.200	20
6	0.1142	7.758	20
7	0.1066	8.381	20
8	0.0996	9.040	20
9	0.0933	9.722	20
10	0.0876	10.419	20

5. Conclusions

In this paper I present the enterprises behavior on repeated negotiations. Based on new folk theorem for finitely repeated games I found conditions such that players cooperate at least some stages even backward induction told as this situation is not an Nash subgame perfect equilibrium. Other findings in this paper are:

- For infinitely repeated negotiations there exists the possibility to implement a cooperative solution if player's discount factor is close to 1 and cooperative payoff are not fare away from deviation payoff and punishment payoffs;
- If deviation payoff is very large or cooperation payoff is close to punishment payoff then it is not possible to obtain a cooperative solution for infinitely repeated negotiations;
- For finitely stages negotiations, first rational solution is to repeat Nash equilibrium of stage game every period (backward induction);
- Another solution for finitely repeated games depends on limited (bounded) rationality of players: they starts with cooperative strategies and continue so on until one of other players deviate from cooperative strategy. Starting on this moment of negotiation, the other players punish deviating player for all periods until negotiations end. In this case it is possible to obtain some cooperative stages of the game but this situation is more complex;
- Even we have the minimum stage number, if players discount factor is smaller like a certain level, cooperation it is not possible;
- If the deviating payoff is enough large, the cooperation also it is not possible for any period of the game;
- If the cooperative payoff is closer to the punishment payoff, then cooperation it is not possible;
- There exists a minimum stages number such that it is possible to implement a cooperative behavior;
- If stage number and cooperation stage number are known then it is possible to find the discount minimum level such that players cooperate.

My study-case shows that it is possible to reinforce a cooperative behavior between players that play Cournot oligopoly following bounded rationality and trigger strategies. Also, we find that discount factor minimum level does not depend on payoff's levels, only dependency factor is firm number. As long as firm number increases, we obtain a lower level of discount factor and if n tend versus infinity then δ is closer to zero and all players cooperates all game stages.

References

1. Abreu, D. and Rubinstein, A. **The Structure of Nash Equilibria in Repeated Games with Finite Automata,** Econometrica, 56, 1988, pp. 1259-1282
2. Anderlini, L. and Sabourian, H. **Cooperation and Effective Computability,** Econometrica, vol. 63(6), 1995, pp. 1337-1369
3. Aoki, M. **Modeling Aggregate Behavior and Fluctuations in Economics: Stochastic Views of Interacting Agents,** UCLA Economics Online Papers 142, UCLA Department of Economics, 2001
4. Ashkenazi-Golan, G. **Confession and pardon in repeated games with communication,** Mimeo, 2004
5. Aumann, R. J. **An Axiomatization of the Non-transferable Utility Value,** Econometrica, vol. 53(3), 1985, pp. 599-612
6. Benoit, J.P. and Krishna V. **Folk Theorem for Finitely Repeated Games: Benoit-Krishna,** Econometrica 53, 1985, pp. 905–920
7. Benoit, J.P. and Krishna V. **Renegotiation in finitely repeated games,** Econometrica 61, 1993, pp. 303–323
8. Bernheim, B. D. and Whinston, M. D. **Multimarket Contact and Collusive Behavior,** RAND Journal of Economics, vol. 21(1), 1990 pp. 1-26
9. Bhaskar, V. and Obara, I. **Belief-based equilibria in the prisoners' dilemma with private monitoring,** Journal of Economic Theory, 102, 2002, pp. 16–39
10. Busch, L-A. and Wen, Q. **Perfect Equilibria in a Negotiation Model,** Econometrica, 63, 1995, pp. 545-565
11. Compte, O. **Communication in repeated games with imperfect private monitoring,** Econometrica, 66, 1998, pp. 597– 626
12. Ely J.C. and Välimäki, J. **A robust folk theorem for the prisoner's dilemma,** Journal of Economic Theory 102(1), 2002, pp. 84–105
13. Fearon, J.D. and Laitin, D. **Explaining interethnic cooperation,** American Political Science Review, 90 (December), 1996, pp. 715-735
14. Fong, Y. and Surti, J. **The optimal degree of cooperation in the repeated Prisoners' Dilemma with side payments ,** Games and Economic Behavior YGAME, 1606, 2008, pp. 1-16
15. Fudenberg, D. and Levine, D.K. **Efficiency and observability with long-run and short-run players,** Journal of Economic Theory, 62, 1994, pp. 103–135
16. Fudenberg, D. and Levine, D.K. **The Nash-threats folk theorem with communication and approximate common knowledge in two player games,** Journal of Economic Theory, 132, 2007, pp. 461–473
17. Fudenberg, D. and Maskin, E. **The Folk Theorem in repeated games with discounting and with incomplete information,** Econometrica, 54, 1986, pp. 533- 554
18. Ghatak, M. and Guinnane, T. W. **The economics of lending with joint liability: theory and practice,** Journal of Development Economics, 60, 1999, pp. 195-228

19. Hömer, J. and Olszewski, W. **The folk theorem for games with private almost-perfect monitoring,** Econometrica, 74, 2006, pp. 1499–1544
20. Kandori, M. and Matsushima, H. **Private observation, communication and collusion,** Econometrica, 66, 1998, pp. 627–652
21. Lehrer, E. and Pauzner, A. **Repeated games with differential time preferences,** Econometrica, 67, 1999, pp. 393–412
22. Mailath, G.J. and Morris, S. **Coordination failure in repeated games with almost-public monitoring,** Theoret. Econ., 1, 2006, pp. 311–340
23. Mailath, G.J. and Morris, S. **Repeated games with almost-public monitoring,** Journal of Economic Theory, 102(1), 2002, pp. 189–228
24. Matsushima, H. **Repeated games with private monitoring: Two players,** Econometrica, 72, 2004, pp. 823–852
25. McLean, R., Obara, I. and Postlewaite, A. **Informational smallness and private monitoring in repeated games,** Mimeo UCLA, 2005
26. Obara, I. **Folk theorem with communication,** Journal of Economic Theory, 144, 2009, pp. 120–134
27. Okada, A. **The possibility of cooperation in an n-person prisoners' dilemma with institutional arrangements,** Public Choice, Volume 77, Number 3, November, 1993, pp. 629-656
28. Olson, E. **The logic of collective action,** Cambridge: Harvard University Press, 1965
29. Piccione, M. **Finite Automata Equilibria with Discounting,** Journal of Economic Theory, 56, 1992, pp. 180-193
30. Piccione, M. and Rubinstein, A. **Finite Automata Play a Repeated Extensive Game,** Journal of Economic Theory, 61, 1993, pp. 160-180
31. Roman, M., Marin, D. and Stancu, S. **Teoria jocurilor pentru economisti,** Ed. ASE, Bucharest, 2005
32. Roman, M. and Roman, M. **Fiscal System Competition and Inefficiency of Public Good Production,** Economic Computation and Economic Cybernetics Studies and Reserch, vol. 36, no. 1-4, 2003, pp. 77-87
33. Roman, M. **Teoria Jocurilor si a negocierilor,** Ed. AISTEDA, Bucharest, 2000
34. Rubinstein, A. **Finite Automata Play the Repeated Prisoner's Dilemma,** Journal of Economic Theory, 39, 1986, pp. 83-96
35. Rubinstein, A. **Perfect Equilibrium in a Bargaining Model,** Econometrica, 50, 1982, pp. 97-109
36. Rubinstein, A. **Strong perfect equilibrium in supergames,** Int. J. Game Theory, 9, 1979, pp. 1–12.
37. Sabourian, H. **Bargaining and Markets: Complexity and the Competitive Outcome,** Journal of Economic Theory Elsevier, vol. 116(2), 2004, pp. 189-228
38. Thorsten, J.T. and Lim, J. J. **Sticks and Carrots: Two Incentive Mechanisms Supporting Intra-Group Cooperation,** Economic Letters, 2009, pp. 1-8
39. Wen, Q. **The "folk theorem" for repeated games with complete information,** Econometrica 62, 1994, pp. 949–954

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- Game theory
- Macroeconomics
- Economic cybernetics

- Economic models, statistics and econometrics

Over 130 published papers (6 ISI Thomson quoted), 23 books and university courses, 35 research grants, 15 national prizes for economic research.

[3] The strongest folk theorems are of the following loosely stated form: "Any *strictly individually rational* and *feasible* payoff vector of the stage game can be supported as a subgame-perfect equilibrium average payoff of the repeated game." These statements often come with qualifications such as "for discount factors sufficiently close to 1" or, for finitely repeated games, "if repeated sufficiently many times."

Appendix

Proof of Theorem 1 (Folk Theorem).

Suppose that there exists a pure strategy such that $u(a) = v$ (with $v > \underline{u}$) and every player will play next strategy: *„ I will play a_i at stage 0 and I will continue to play a_i such time previous period all players played a. Anywhere I'll play minmax strategies for the rest of the game."* How it is this possible for player i to improve his payoff playing this strategy?

We suppose also there exists a deviation payoff, $v_i^D = \max_a u_i(a) >$ v_i. So $v_i^D \geq v_i > \underline{u_i}$.

Player *i* will play a_i for *t* periods with v_i payoff, then deviate, and his payoff will be $v_i^D = \max_a u_i(a)$, and for the rest of the game all other players will punish player *i* and he will receive minmax payoff $\underline{u_i}$.

So average deviation payoff at *t* stage is:

$$u_D = (1-\delta_i^t)u_i + \delta^t(1-\delta)\cdot v_i^D + \delta^{t+1}\underline{u}_i$$

This payoff is greater like v_i as long as discount factor δ_i is smaller like a minimum level of discount factor $\underline{\delta}_i$, given by relationship:

$$(1-\underline{\delta}_i)\cdot v_i^D + \underline{\delta}_i \cdot \underline{u}_i = v_i$$

So $\underline{\delta}_i = \dfrac{v_i^D - v_i}{v_i^D - \underline{u}_i}$.

Let $\underline{\delta} = \max_i \underline{\delta}_i$. So there exists a minimum level of discount factor $\underline{\delta} < 1$, such that $(\forall)\delta \in (\underline{\delta},1)$ there exists a subgame perfect Nash Equilibrium that achieves v as average payoff.

q.e.d.

Proof of Theorem 2 (Benoit-Krishna Theorem).

To proof this theorem we use players rationality principle, so that our players try to maximize total payoff. If they play s^* strategy T periods then their mean payoff is:

$$v_i(s^*) = \frac{1-\delta_i}{1-\delta_i^{T+1}} \sum_{t=0}^{T} \delta_i^t u_i(s^{*t})$$

If they play for T′ periods $\hat{s}$ strategy and Nash equilibrium s^* for T – T′ periods then expected payoff is:

$$v_i(s^{'}) = \frac{1-\delta_i}{1-\delta_i^{T+1}} \left(\sum_{t=0}^{T'} \delta_i^t u_i(\hat{s}^t) + \sum_{t=T'+1}^{T} \delta_i^t u_i(s^{*t}) \right),$$

$$s^{'} = (\hat{s}^1, \hat{s}^2, ...\hat{s}^{T'}, \hat{s}^{T'+1}, ...s^{*T})$$

From hypothesis $u(\hat{s}) > u(s^*)$, that means $u_i(\hat{s}) > u_i(s^*), (\forall)$ for every player i, let be i_1 the player such that it obtain $\min_{i \in I}(u_i(\hat{s}) - u_i(s^*))$. So for player i_1 we have:

$$v_{i_1}(s') - v_i(s^*) = \frac{1-\delta_{i_1}}{1-\delta_{i_1}^{T+1}} \left(\sum_{t=0}^{T'} \delta_{i_1}^t u_{i_1}(\hat{s}^t) + \sum_{t=T'+1}^{T} \delta_{i_1}^t u_{i_1}(s^{*t}) \right) - \frac{1-\delta_{i_1}}{1-\delta_{i_1}^{T+1}} \sum_{t=0}^{T} \delta_{i_1}^t u_{i_1}(s^{*t}) =$$

$$= \frac{1-\delta_{i_1}}{1-\delta_{i_1}^{T+1}} \left(\sum_{t=0}^{T'} \delta_{i_1}^t (u_{i_1}(\hat{s}^t) - u_{i_1}(s^{*t})) \right) > 0 .$$

So, for each player is better to play at least T′ periods strategy $\hat{s}$, that is not a Nash equilibrium for stage game.

q.e.d.

MODELING RESEARCH PROJECT RISKS WITH FUZZY MAPS

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Abstract: *The authors propose a risks evaluation model for research projects. The model is based on fuzzy inference. The knowledge base for fuzzy process is built with a causal and cognitive map of risks. The map was especially developed for research projects, taken into account their typical lifecycle. The model was applied to an e-testing research project: the probability of not obtaining quality results was computed considering the over-budget sum and the quality level of research idea. The computed risk is situated on the highest level in risks map. A software system for evaluating risks in e-testing research project was also developed. The research was funded by the Ministry of Education and Research, National University Research Council, Grant PCE_ID_873.*

Key words: *risk management; research project; model; fuzzy logics; risks map*

1. Introduction

Identifying, prioritizing and treating risks represent common management activities. For a long time, hazard risks, as well as financial ones have been actively managed. But, the variety, number and interactions between risks are continually increasing. The operational and strategic risks have increased due to the failure of the control mechanisms in a very dynamic business environment. In these circumstances, the organizations admit the importance of managing all risks, both the standard and the new risks.

Different organizations, such as: rating agencies, stock exchanges, institutional investors, shareholders, and corporate governance induced an external pressure to the company management for managing risks systematically and comprehensively. One solution is to adopt the portfolio approach, the company management considering the portfolio risk as the risk to the entire organization. The risks are managed considering the implications for the whole company, in a holistic approach.

There is a growing tendency to quantify risks. The risk quantification allows managers to develop "what if" scenarios and make informed decisions. Advances in technology and expertise have made the quantification possible. Despite real advances, there will always remain risks that are not easily quantifiable, such as those related to human intervention and the newer ones. There is a continuing effort to quantify the portfolio risks, based on the individual risks and the interactions quantification. This can be extremely difficult if a high degree of precision is required. But, this is not usually the case.

Over time and with practice, companies become more familiar with and more capable of managing risks, and even seeking out opportunities to assume risks. Companies understood that informed risk-taking is a means to competitive advantage.

2. Research projects management

The research project management is full of uncertainty and complexity. Research has elements of creativity and innovation and accurate prediction of the research outcome is therefore very difficult. It is the research project manager job to manage both the complexities stemming from the culture(s) of researchers/research work and the uncertainties associated with generating research results [4][3].

The research project managers should make the following statement to the project team members: "If you do not have several failures, you are not doing a good job" [7]. Researchers acting safe are more likely to produce conservative and expected results. In order to obtain innovative results, the researchers should have a risk-taking behavior, increasing the probability of failure. This behavior should be a characteristic at the research system, even at the individual level, it is expected that the researcher will seek to avoid failure. In the majority of research projects, the purpose of project management is also to avoid such failures. It is an apparent conflict between the need for predictability of project output, "on time" and "on budget" and the unpredictability of research outcome and new research opportunities arising in the course of the project. Usually, the quality of output may improve if deviations from plan are allowed.

The researchers ask a large degree of autonomy in their work and democracy in decision making. They co-operate in a research project, but, in the same time, they are strongly competing each others to obtain credit for the results generated in the project, such as: authorship of conference contributions or articles, patents. This competition may lead to conflict between the joint goals of the co-operation and individual goals of researchers.

In addition, the relationship between the research project manager and the project participants is characterized by an asymmetric distribution of knowledge where individual researchers know a lot more about the potential – negative and positive – of their research contributions than the project manager does ([4]).

3. Risks modeling methods

According the manner in which the calculations are carried out, there are analytic and simulation methods for risk modeling. The *analytic methods* require a set of assumptions, especially related to the probability distributions. The *simulation methods* require a large number of "trials" to approximate an answer. They are relatively robust and flexible, can accommodate complex relationships and depend less on simplifying assumptions and standardized probability distributions. Considering the manner in which the relationships among variables are represented, there are statistical and structural methods. The *statistical methods* are based on observed statistical qualities of random variables without regard to cause/effect relationships while *the structural methods* are based on explicit cause/effect relationships. Figure 1 presents the most important risk models developed using this methods, with their advantages.

Calculation technique / Representation of the relationships	Analytic (*closed-form formula solutions*)	Simulation (*solutions derived from repeated "draws" from the distribution*)
Statistical (*based on observed statistical qualities without regard to cause/effect*)	Statistical-analytical models (*speed, easy replication, use of available data*) **Example**: RBC	
Structural (*based on specified cause/effect linkages; statistical qualities are outputs, not inputs*)		Structural simulation models (*flexibility; complex relationships, incorporation of decision processes, scenario drivers examination*) **Example**: DFA

Figure 1. The risk model classes (source: [2])

The methods used to model the risks are usually customized according to the specific risks which occurred in the company. There are a wide variety of methods that can be applied to model risks. According the extent to which they rely on historical data or expert input ([2]), they are lying in a continuum of the sources information (figure 2).

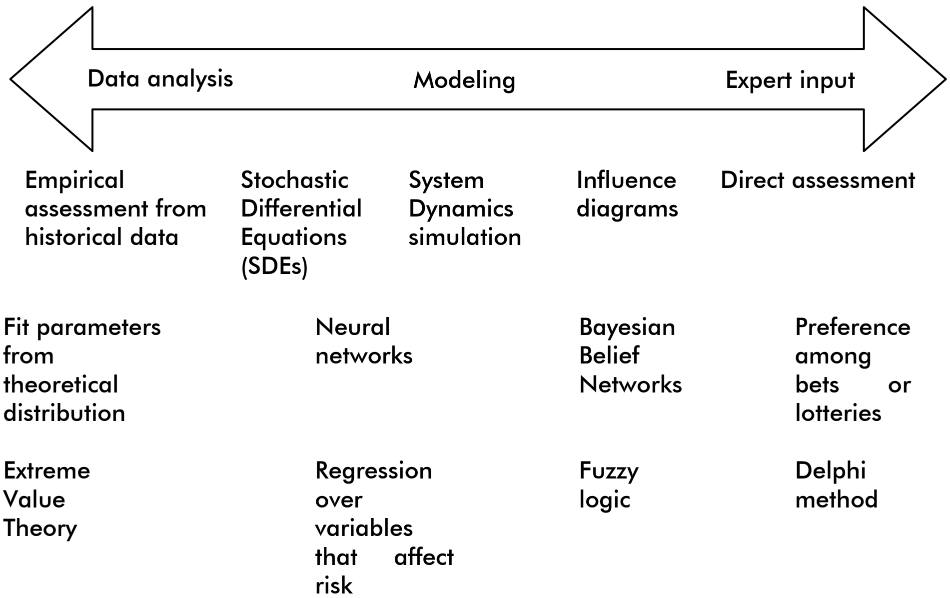

Figure 2. The continuum of methods for risk modeling

Although there are numerous techniques for risk modeling, more and more experts are afraid to use them for making precise risk estimations. Fuzzy representations are a solution to obtain realistic risks assessments in projects management [3], within certain limits. A fuzzy abordation for risk modeling can be improved by considering causal and cognitive risks mapping [1], which are diagrams reflecting cause-effect relations within projects.

4. Fuzzy Model for Risk Evaluation in Research Projects

The proposed fuzzy model brings a solid contribution to risk management by adapting existent techniques in risks evaluation to research projects. The model has two important stages: risk identification from an expert database, using risk maps and building model components for fuzzy inference. The model allows risk quantification by knowing the crisp values of risk sources. Thanks to fuzzy logics mechanisms, the result has a higher estimation value.

4.1. Risks Identification using Causal and Cognitive Maps

A common approach in project risks identification is considering the risks source: management, cost, technology, production, environment or schedule. The fuzzy model considers risks not only in correlation with their source, but in correlation with project lifecycle, too [1]. "While it is futile to try to eliminate risk, and questionable to try to minimize it, it is essential that the risks taken be the right risks." [5]

It si known that research projects are highly risky: in research project, the added value should be as high as possible and should be obtained as quickly as possible. [8] For better managing risks, it is useful to create a causal and cognitive map of risks, based on experts experience [1]. This map describes the propagation of risks throughout the project. Risks occurred at a certain moment of project lifecycle (see Fig. 3) will create other risks in the following moments. Risks are felt during all phases of a research project: idea conceptualization, project proposal development, project funding source, project initiation, project execution and project closing down.

Figure 3. Research Project Lifecycle

Starting from the research project lifecycle (Fig.4), following risks are identified:

- environmental risks: lack of interest on the market, precarious economic situation, unfavorable legislation;
- management risks: unrealistic duration estimation, poor negotiation capacities, poor planning, unclear objectives, poor communication, poor control, misunderstood overall vision, behind- schedule risk, acceptance of a poor idea, loss of a good idea;
- financial risks: unrealistic budget estimation, over-budget risk;
- production & technology: poor innovation capacities, lack of experienced collaborators, multidisciplinary implications, lack of quality results, low embedded quality of the idea;

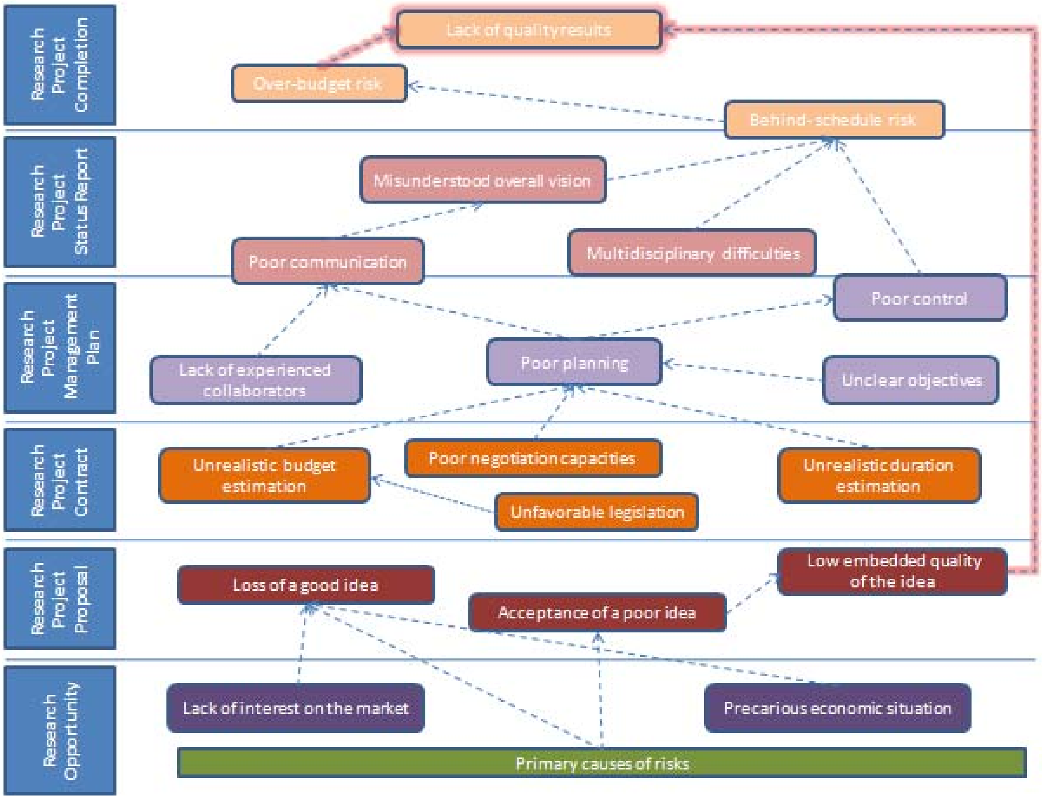

Figure 4. Risks Propagation Map in Research Projects

After creating the risks propagation map, it is also useful to create a risks register or a risks log, in which each identified risk from the map should have a code, a name, a description and a source (type). A fragment of such a register is shown in Table 1. The identified risks are the knowledge base for creating the fuzzy model rules.

Table 1. Fragment of Risks Register in Research Projects

Risk Code	Risk Name	Risk Description	Risk Type
RSK01	Low embedded quality of the idea	The accepted idea can't be properly developed.	Production & Technology
RSK02	Over-budget risk	The project is behind schedule and extra budget is necessary for finishing the research.	Financial

4.2. Model Components for Fuzzy Inference

The proposed model for risk evaluation in research projects has the typical components of a fuzzy model [9]: input variables, output variable, fuzzy rules. The rules used in fuzzy risks modelling are built on the two well-known concepts from risks management (probability of risk occurance and impact of it on project development) and on primary causes of risks, identified in the risks map. The model can be generally stated as: „The more over-budget is and the more embedded quality of the research idea, the lower the degree of risk encountered in the research project." The risk situated at the highest level of the map was the only one taken into account when stating the model, because of the transitivity principle in risk propagation chain. In fact, the model consists from a set of rules used in defining project risks, which are incorporated in "Lack of quality results" risk. The model can be applied to calculate the value of any risk represented in risks map, using numerical values of its factors. An interesting situation, specific to research projects, is the fact that the presence of an inner risk (over-budget) diminishes the over-all risk of having poor quality results.

Usually fuzzy models are used in decision making and they offer two types of answers: the risk can be either accepted or rejected [6]. The proposed model offers only a quantitative value of risk, because the decision of accepting the risk is taken by the human agent: project manager, risks manager or any other stakeholder. In conclusion, the output of the developed model isn't a form of decision, but an important parameter to make a proper decision. The model components are further described, using fuzzy formalization [9].

4.2.1. Input Variables

The model has two forms of input variables: input functions and input constants.
Input functions have the form of:

P(Rsk) = probabily of Rsk occurance
I(Rsk) = impact of Rsk on research project
where Rsk = considered risk code

They are described in Table 2, according to fuzzy logics concepts.

Table 2. Input Variables Description in Risk Analysis Model

Fuzzy Variable Name	Universe of Discourse	Linguistic Grades
P(Rsk)	[0,100] %	VL(very low), L(low),M(medium), H(high), VH(very high)
I(Rsk)	[0, 50]	VL(very low), L(ow),M(medium), H(high), VH(very high)

Input constants have the form of:

RskCause1 = cause 1 of Rsk occurance
RskCause2= cause 2 of Rsk occurance
where Rsk = considered risk code

They are described in the same manner as input functions, the only difference being the defined universe of discource: it is specific to each identified cause.

4.2.2. Output Variables

The output variable is the value for an identified risk and is notated as:

V(Rsk) = quantitative value of Rsk, where Rsk = considered risk code

It is described in Table 3 and graphically represented in Fig. 5. In fact, both input and output variables can be graphically represented by fuzzy sets: on Ox axis the value of fuzzy variable is represented and on Oy axis the value of μ (function of belonging to a fuzzy set) is represented. The "triangles" are fuzzy sets.

Table 3. Output Variables Description in Risk Analysis Model

Fuzzy Variable Name	Universe of Discourse	Linguistic Grades
V(Rsk)	[0, 10]	VL(very low), L(ow),M(medium), H(high), VH(very high)

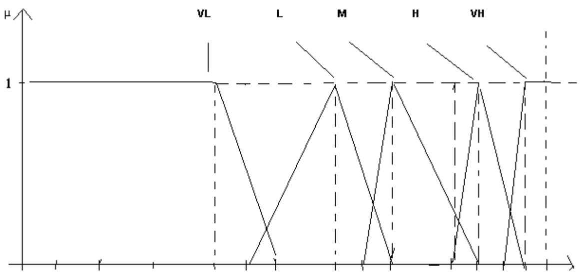

Figure 5. Fuzzy Sets Representation for Risk Value in Research Projects

4.2.3. Model Rules

The risk evaluation model consists from a set of predefined rules for establishing risks value in research projects. These inference rules are mentioned in Table 4. The connective used to bind conditions in rules is "and". Besides the linguistic values of model variables (VL, L, M, H and VH), some restrictors are used:

- "somewhat"= $\sqrt[3]{\mu}$
- "very"= μ^2

where μ is the function showing if a numeric value belongs to a fuzzy set and it has values between 0 and 1 (a greater value shows a stronger membership).

Table 4. Inference Rules for Analysis Risk "Rsk" in Research Projects

P(Rsk)/ I(Rsk)	VL	L	M	*H*	VH
VL	VL	somewhat VL	L	somewhat M	very H
L	L	L	L	H	VH
M	M	M	M	H	VH
H	H	H	H	very H	VH
VH	VH	VH	VH	*H*	very VH

An example of a rule is (R1):

(R1): if P(Rsk) is H and I(Rsk) is VH then Rsk is VH

The interpretion of rule (R1) is:

If risk Rsk has a high probability of occurance and the impact of this risk is very high, then its value is also very high. (See the underlined values from Table 4)

5. Application of the Fuzzy Model to Evaluate Risks in an E-testing Research Project

The fuzzy model for risks evaluation is validated by applying it to a real research project. The project has the main goal of studying e-testing methods in e-learning environments and of discovering and improving those which has applicability in project management. Among research objectives, there are: education in a globalized society, e-learning in present times, tools for implementing e-learning systems, defining the place of e-testing in e-learning platforms, development of an e-testing model suitable for knowledge evaluation in project management field. Being a research project, the quality of the final results depends on the quality of the research idea and on budget constraints (see the highlighted elements from Figure 4). The risk of having a poor quality idea has attached a number of points (from 0 to 10), reflecting the level of innovation and applicability of the idea. The risk of having a low quality idea as the starting point of the project depends on the risk of accepting that idea. Over-budget risk is a well-known risk in projects, but in research projects it can add value to scientific results, thus enhancing the satisfaction level of the stakeholders.

5.1. Formalization of Risk Evaluation Model for E-testing Research Project

In order to compute the probability of "Lack of quality results" risk (notated "P(Rsk)"), low embedded quality of the idea is reflected in "LowQAIdea" variable and over-budget sum in "OverBudget" variable. Both variables are defined in Table 5. Inference rules for showing the effect of "LowQAIdea" and "OverBudget" changes on "Rsk" value are presented in Table 6.

Table 5. Fuzzy Variables for Computing Risk in E-testing Research Project

Fuzzy Variable Name	Variable Type	Universe of Discourse	Linguistic Grades
OverBudget	input	[0,5] thousands of Euros	VL, L, M, H, VH
LowQAIdea	input	[0,10] points	VL, L, M, H, VH
P(Rsk)	output	[0,100]%	VL, L, M, H, VH

Table 6. Inference Rules for Computing "P(Rsk)" in E-testing Research Project

OverBudget / LowQAIdea	VERY LOW	LOW	MEDIUM	***HIGH***	***VERY HIGH***
VERY LOW	somewhat M	somewhat M	L	VL	very VL
LOW	H	H	L	VL	VL
MEDIUM	VH	H	M	***L***	***L***
HIGH	VH	VH	H	***M***	***M***
VERY HIGH	VH	VH	VH	M	M

Membership functions of input variables are illustrated in Fig. 6 and 7 and the one for output variable in Fig. 8.

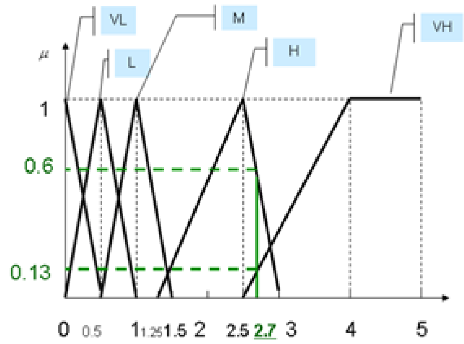

Figure 6. Membership Functions for "Over-budget" variable in Evaluating Research Project Risk

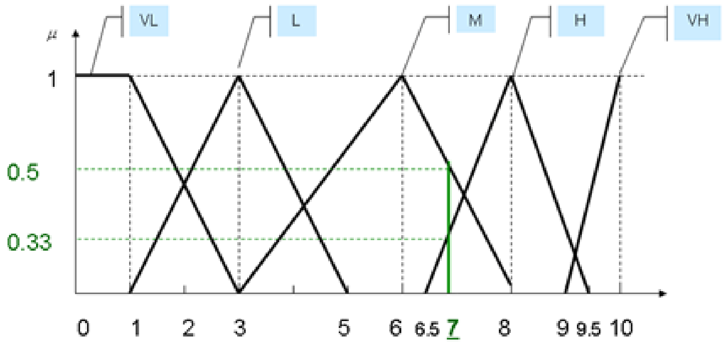

Figure 7. Membership Functions for "Low embedded quality of the idea" variable in Evaluating Research Project Risk

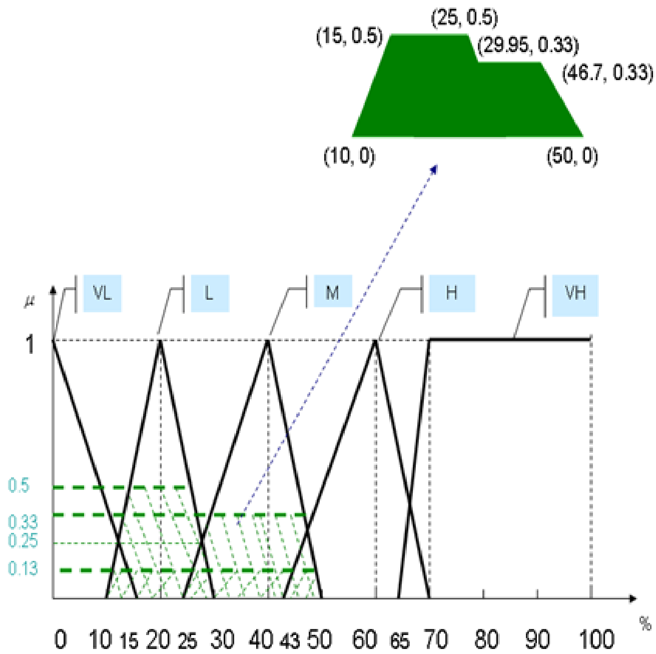

Figure 8. Membership Functions for Fuzzy Output Variable in Evaluating Research Project Risk

5.2. Steps in Applying the Risk Evaluation Model in E-testing Research Project

The fuzzy model transforms the input values to output value, in four steps. For exemplification purposes, two numerical values are considered as input values in risk evaluation model of an e-testing research project.

Step 1: Insert values for input variables

OverBudget = 2.7 (the research needs an extra sum of 2,7 thousands Euros to be finished)

LowQAIdea = 7 (the risk of having a low quality idea is 7/10, according to experts)

Step 2: Classify crisp input values in suitable fuzzy set: they gain semantic meaning.

According to Fig. 6, the over-budget sum can be high and very high. According to Fig. 7, the risk of a poor idea can be medium or high.

Step 3: Establishes membership level of each input value to a fuzzy set; an input value can belong to one or two fuzzy sets, but in a different proportion, named "trust level"; this trust level is the Oy value of the intersection point between input singleton and fuzzy set. [9] Trust level is calculated using the following formula:

$$trustLevel_x(A) = b.y + m(x - b.x) \quad \text{(F1)}$$

where *a* and *b* are two successive points from a fuzzy set, *m* is the slope of the line determined by these two points, A represents a fuzzy set and *x* represents an input value;

For LowQAIdea:

$$trustLevel_7(M) = 0.5$$

$$trustLevel_7(H) = 0.33$$

For OverBudget:

$$trustLevel_{2.7}(H) = 0.6$$

$$trustLevel_{2.7}(VH) = 0.13$$

Following sentences are considered:

(S1) "An idea of medium quality is the starting point in e-testing research project."

(S2) "An idea of high quality is the starting point in e-testing research project."

(S3) "The over-budget used in e-testing research project is high."

(S4) "The over-budget used in e-testing research project is very high."

According to above calculated trust levels, (S1) has a 50% value of truth, (S2) has 33% value of truth, (S3) a 60% value of truth and (S4) a 13% value of truth.

Step4: Apply inferences rules, in 4 stages. The resulted fuzzy sets are "cut" by a horizontal line. This line is determined by the minimum of the trust levels. Intersections between fuzzy sets and lines are obtained: this intersection has, usually, a trapezoidal shape. In the end, the reunion of "cut" fuzzy sets is made (see Fig. 8)

Step5: Restrictors (*very*, *somewhat*) are applied, if necessary.

Step6: Two defuzzification methods are applied to the final fuzzy set. Two similar values for over-all risk in e-testing project should be obtained.

In Centre of Gravity (COG) Defuzzification, the final fuzzy set is decomposed in simple shapes: triangles, rectangles and trapezes, as shown in Fig. 9. For calculating the probability of risk occurrence, the following formula is used:

$$P(Rsk)_{COG} = \frac{\sum_i center_{fig(i)} area_{fig(i)}}{\sum_i area_{fig(i)}} \qquad \text{(F2)}$$

where *fig* is the shapes vector, $center_{fig(i)}$ is the center of gravity of a figure and $area_{fig(i)}$ is the area of a figure.

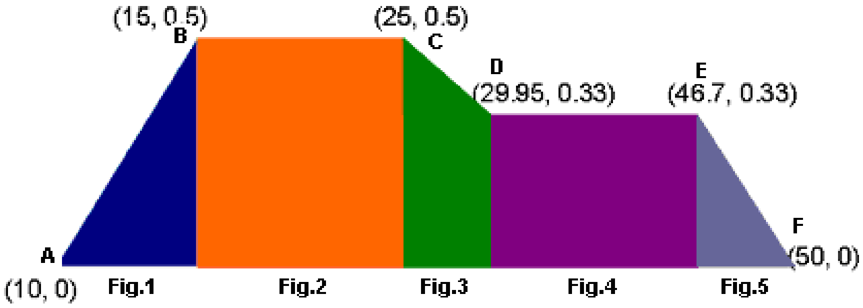

Figure 9. COG Defuzzification in Risk Evaluation Model

According to COG method, the probably of risk "Lack of quality results" for the considered input values is:

$$P(Rsk)_{COG} = \frac{13.33*1.25+20*5+28.05*2.05+38.33*5.53+47.8*0.54}{1.25+5+2.05+5.53+0.54} \Rightarrow$$

$$P(Rsk)_{COG} = \frac{16.67+100+57.7+212+25.81}{14.37} \Rightarrow$$

$$P(Rsk)_{COG} = 28.68\%$$

In Middle of Maximum (MOM) Defuzzification, the following formula is used:

$$P(Rsk)_{MOM} = \frac{\sum_i locMax_i^x locMax_i^y}{\sum_i locMax_i^y} \qquad \text{(F3)}$$

where $locMax_i^y$ is the Oy value of a local maximum (see Fig. 10), $locMax_i^x$ is the Ox value of a local maximum point and *locMax* is the vector of local maximum points.

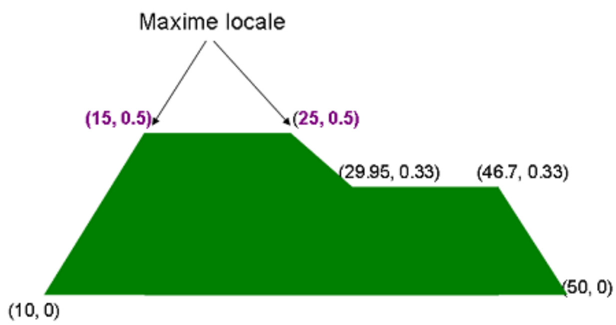

Figure 10. MOM Defuzzification in Risk Evaluation Model

According to MOM method, the probably of risk "Lack of quality results" for the considered input values is:

$$P(Rsk)_{MOM} = \frac{0.5*15+0.5*25}{0.5+0.5} \Rightarrow P(Rsk)_{MOM} = 20\%$$

The two defuzzification methods revealed similar results (28,68% and 20%): the applied model is validated. The membership function of output variable is analyzed (see Fig. 8) and the conclusion is that the "Lack of quality results" risk has a low probability of occurance for an e-testing research project.

5.3. Software for Risk Evaluation based on Fuzzy Model

The fuzzy model for analyzing the over-all risk in the e-testing research project was used to develop a fuzzy system. A Windows based application was created. The interface is intuitive (see Fig. 11): the end user has to insert the value of "over-budget" risk and of "low embedded quality of the idea" risk and will obtain the probability of over-all risk occurrence in the e-testing research project.

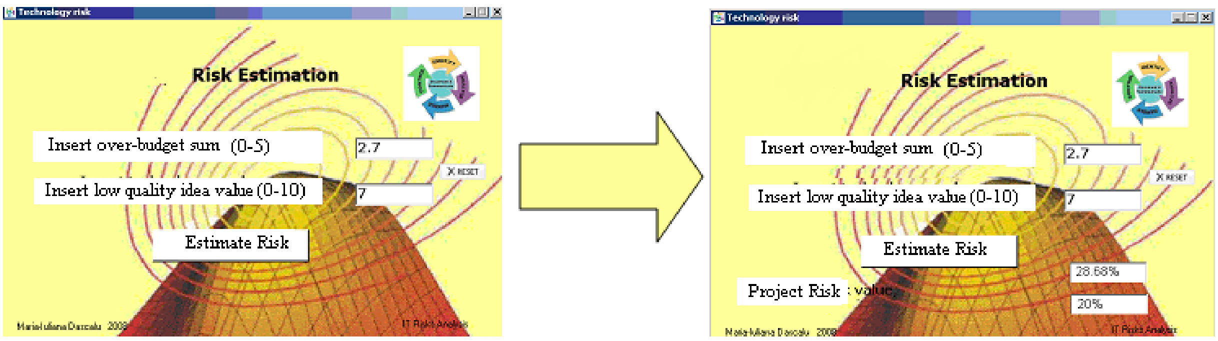

Figure 11. Software Product for Risk Evaluation Model in E-testing Research Project

The algorithm used to create the software reflects entirely the steps described in current paper. Three specific classes are used to implement the algorithm (see Fig. 12):

- FuzzySystem: it contains the inference rules;
- FuzzySet: it contains defuzzification methods, union, intersection, restrictor functions;
- FuzzyPoint: elements of fuzzy sets;

FuzzySystem class has to be changed, in order to create other fuzzy systems.

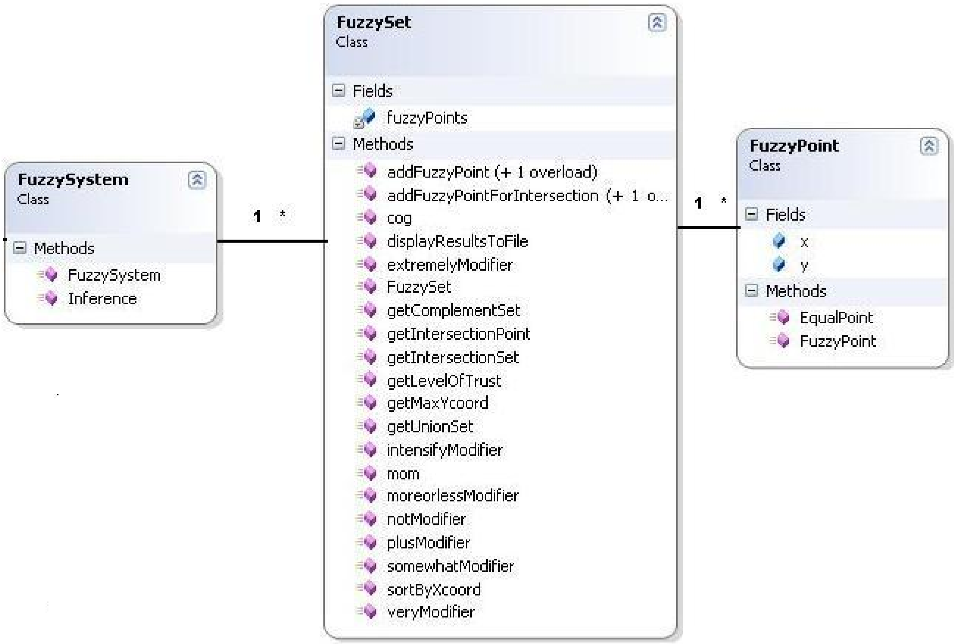

Figure 12. Class Diagram for Fuzzy Risk Evaluation System

6. Conclusions

The proposed model offers an easy-to-use tool for risk evaluation in research projects. The model lies on fuzzy inference. The knowledge base used by fuzzy rules is built on causal and cognitive maps of risks. Although research projects are known for their high level of risk, very few dedicated risk systems were developed especially for them. Therefore, the fuzzy model for risk evaluation in research projects is an innovative instrument which can be used to forecast project failure: stakeholders can save money, time, effort, without giving up the quality of predictions. The model was used to develop a software system for evaluating risk in an e-testing research project, so its applicability was validated. The system can be further developed to evaluate all risks from the map, not only the one from the highest level, as it does now.

References

1. Al-Shehab, A. J., Hughes, R. T. and Winstanley, G. **Modelling Risks in IS/IT Projects through Causal and Cognitive Mapping**, The Electronic Journal of Information Systems Evaluation, Brighton, UK, vol. 8, 2005, pp. 1-10
2. Chen, J.-H. and Chen, S.-M. **A New Method for Ranking Generalized Fuzzy Numbers for Handling Fuzzy Risk Analysis Problems**, Joint Conference on Information Sciences Proceedings, 2006
3. Ernø-Kjølhede, E. **Project management theory and the management of research projects,** Politics and Philosophy Copenhagen Business School, January 2000
4. Hodge, B. **Developing Risk Management Plans**, University of Waterloo, 2004 (http://www.cs.uwaterloo.ca/~apidduck/CS480/Lectures/RiskMgmt.pdf)
5. Hussain, O. K., Chang, E., Hussain, F. K. and Dillon, T. S. **A Fuzzy Aproach to Risk Based Decision Making** , Lecture Notes in Computer Science, Springer Berlin/Heidelberg, vol. 4278, 2006, pp. 1765-1775

6. Jain, R. K. and Triandis, H. C. **Management of Research and Development Organizations. Managing the Unmanageable**, John Wiley & Sons Inc., New York, 1997
7. Lin, Y., Poschen, M., Procter, R., Voss, A., Goble, C., Bhagat, J., De Roure, D., Cruickshank, D. and Rouncefield, M. **Agile Management: Strategies for Developing a Social Networking Site for Scientists**, University of Southampton - School of Electronics and Computer Science, ECS EPrints, 2008
8. Teodorescu, H. N., Zbancioc, M. and Voroneanu, O. **Knowledge Based Systems. Applications**, Performantica, Iassy, 2004
9. * * * **Overview of Enterprise Risk Management**, Casualty Actuarial Society, Enterprise Risk Management Committee, May 2003

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[3] Codification of references:

[1]	Al-Shehab, A. J., Hughes, R. T. and Winstanley, G. **Modelling Risks in IS/IT Projects through Causal and Cognitive Mapping**, The Electronic Journal of Information Systems Evaluation, Brighton, UK, vol. 8, 2005, pp. 1-10
[2]	* * * **Overview of Enterprise Risk Management**, Casualty Actuarial Society, Enterprise Risk Management Committee, May 2003
[3]	Chen, J.-H. and Chen, S.-M. **A New Method for Ranking Generalized Fuzzy Numbers for Handling Fuzzy Risk Analysis Problems**, Joint Conference on Information Sciences Proceedings, 2006
[4]	Ernø-Kjølhede, E. **Project management theory and the management of research projects,** Politics and Philosophy Copenhagen Business School, January 2000
[5]	Hodge, B. **Developing Risk Management Plans**, University of Waterloo, 2004 (http://www.cs.uwaterloo.ca/~apidduck/CS480/Lectures/RiskMgmt.pdf)
[6]	Hussain, O. K., Chang, E., Hussain, F. K. and Dillon, T. S. **A Fuzzy Aproach to Risk Based Decision Making** , Lecture Notes in Computer Science, Springer Berlin/Heidelberg, vol. 4278, 2006, pp. 1765-1775
[7]	Jain, R. K. and Triandis, H. C. **Management of Research and Development Organizations. Managing the Unmanageable**, John Wiley & Sons Inc., New York, 1997
[8]	Lin, Y., Poschen, M., Procter, R., Voss, A., Goble, C., Bhagat, J., De Roure, D., Cruickshank, D. and Rouncefield, M. **Agile Management: Strategies for Developing a Social Networking Site for Scientists**, University of Southampton - School of Electronics and Computer Science, ECS EPrints, 2008
[9]	Teodorescu, H. N., Zbancioc, M. and Voroneanu, O. **Knowledge Based Systems. Applications**, Performantica, Iassy, 2004

INCREASING E-TRUST: A SOLUTION TO MINIMIZE RISK IN E-GOVERNMENT ADOPTION

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Abstract: *In the last decade, governments around the world have been working to capture the vast potential of the Internet to improve government processes. However, the success of these efforts depends, to a great extent, on how well the targeted users for such services, citizens in general, make use of them. Even e-government brings a certain level of transparency and offers good scope for innovative ways of servicing, some people remain suspicious of IT use in relation with government. For this reason, the purpose of the presented study was to identify what factors could affect the citizens' trust in e government services. The study was conducted by surveying 793 citizens from all Romanian regions. The findings indicate that citizen's higher perception of technological and organisational trustworthiness, the quality and usefulness of e government services, the Internet experience and propensity to trust, directly enhanced the trust in e-government. Opposite, age and privacy concerns have a negative influence over trust.*

Key words: *trust; e-government; information technologies; trusting factors*

Introduction

Since the mid 1990's, information and communication technologies have influenced the society in a spectacular way, mainly because of the development of the Internet. The dependence on information technology has grown far beyond our expectations. Many institutions have recognized the advantages of this development and entered the digital highway. Governments worldwide have began to recognize the potential opportunities offered by ICT to fit with citizens' demands, and have started to introduce information and transactions online in what is now called e-government.

Regardless of how advanced is a country in terms of ICT infrastructure and deployment, many technical and non-technical obstacles must be faced in the adoption and dissemination of e-government. Concerns about inadequate security and privacy safeguards in electronic networks can lead to unconfidence in applications of eGovernment that might pose risks, such as through unwarranted access to sensitive personal information or vulnerability to online fraud or identity theft (Eynon, 2007). Such concerns can be a major impediment to the take-up of eGovernment services. This can be also be affected by general trends in perceptions of trust in government, such as those caused by the attitude of a public administration to transparency and openness issues.

For example, a study conducted by Wauters and Lörincz (2008) showed that only about 124 millions Europeans are eGovernment engaged, and 86 millions of Europeans using the Internet regularly are non-users of eGovernment services. Overall, these ratings suggest that nonusers haven't favorable attitudes towards the use of electronic services in relation with the governamental agencies. Enhancing take-up remains a policy challenge at a time when citizens and businesses expect the higher levels of quality and responsiveness from government services, streamlined administrative procedures and a government that takes their views and knowledge into account in public decision-making. Citizen characteristics need to be properly understood, before developing an effective e-Government adoption strategy

Many studies focused the citizen adoption of e-government services suggest that trust (Srivastava and Thompson, 2005), security (Colesca, 2007) and transparency (Marche and McNiven, 2003) are the major issues for e-government adoption. In the present article our attention was directed on the relation between trust and e-government. To fulfill this aim, an exploratory survey on 793 citizens from all Romanian regions was undertaken with the goal to identify what factors could affect the citizens' trust in e-government services.

2. The concept of trust

Trust appeared once with the humanity and the development of social interaction. Almost every aspect of a person life is based in one or another way in trust. So, trust is a very rich concept, covering a wide range of relationships, conjoining a variety of objects. The concept of trust is intimately linked to risk and expectations: trust is used as a substitute for risk, but it also creates a risk for the truster (Bouckaert and Van de Walle, 2001). As Baier (1986) states "*Trust involves the belief that others will, so far as they can, look after our interests, that they will not take advantage or harm us. Therefore, trust involves personal vulnerability caused by uncertainty about the future behavior of others, we cannot be sure, but we believe that they will be benign, or at least not malign, and act accordingly in a way which may possible put us at risk*."(Baier 1986).

The concept of trust has been studied extensively in many disciplines long before the apparition of Internet or e-government, but each field has its own interpretation. Generally, researchers have difficulties in definition and operationalization of this concept (Emurian and Wang, 2005). Most often they define the concept of trust in a particular context.

Grandison and Sloman (2006) report that the presence of various definitions of trust in the literature is based on two reasons:

- First, trust is an abstract concept, often used in place of related concepts, such as reliability, safety and certainty. Therefore, clear definition of the term and the distinction between it and related concepts have proved a challenge for researchers.
- Second, trust is a psychological concept with many facets, incorporating of cognitive, emotional and behavioral dimensions (Johnson and Grayson, 2005).

In order to present a reference point for understanding trust, we present some general definitions from existing research (Table 1).

Table 1. Definitions of Trust

Source	Definition of Trust
Deutsch (1958)	An individual may be said to have trust in the occurrence of an event if he expects its occurrence and his expectation leads to behavior which he perceives to have greater negative motivational consequences if the expectation is not confirmed than positive motivational consequences if it is confirmed.
Rotter (1967)	Expectancy held by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied upon.
Lewis and Weigert (1985)	Trust exists in a social system insofar as the members of that system act according to and are secure in the expected futures constituted by the presence of each other or their symbolic representations.
Mayer et al. (1995)	The willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.
Rousseau et al. (1998)	Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another.
Grandison and Sloman (2000)	Trust is the firm belief in the competence of an entity to act dependably, securely, and reliably within a specified context
Mui et al. (2002)	Trust is a subjective expectation an agent has about another's future behavior based on the history of their encounters."
Olmedilla et al. (2005)	Trust of a party A to a party B for a service X is the measurable belief of A in that B behaves dependably for a specified period within a specified context (in relation to service X)

Because of its complexity, the concept of trust has attracted much attention from a number of different perspectives including:

- the economical approach, where the focus is on actors' reputation and their effect on transactions (Cave, 2005; Guerra and all, 2003)
- the managerial approach, where the focus is on strategies for consumers' persuasion and trust building (Cavoukian and Hamilton, 2002; Fogg, 2002)
- the human computer interaction approach, where the focus is on the relation between user interface engineering, the usability of a system and users' reactions (Riegelsberger and all, 2005, Lee and all, 2000)
- the sociology approach, where trust has been studied as an interpersonal and group phenomenon (Scot, 1980; Salovey and Rothman, 2003).
- the technological approach, where the focus is on the adoption of the new tecnologies (Misztal, 1996; Fukuyama, 1995; Gambetta, 1988).

Empirical evidence shows that the level of trust does not necessarily develop gradually over time (Berg et al., 1995; Kramer, 1999). Trust building is a cumulative process where the level of trust in the earlier stages affects the level of trust in the later stages and impacts the development of longer-term trust relationships. In this context, there are several overlapping and consistent factors that impact the building of trust. These factors could be classified in two major categories:

1. Preinteractional factors:

a. Individual behavioral attributes: individual demographics, culture, past experiences, propensity to trust, benevolence, credibility, competency, fairness, honesty, integrity, openness, general intention to use e-services
b. Institutional attributes: organizational reputation, accreditation, innovativeness, general perceived trustworthiness of the organization
c. Technology Attributes: interface design, public key encryption, integrity

2. Interactional factors:

a. Service attributes: reliability, availability, quality, and usability

b. Transactional delivery atributes: usability, security, accuracy, privacy, interactivity, quality
c. Information content attributes: completeness, accuracy, currency, quality.

3. E-Government - Trust Relation

Trust in e-government is an abstract concept that underlies a complex array of relationships, so the method used to quantify trust in e-government should therefore account for this abstract nature.

Citizens' trust, leading to adoption and use of e-Government systems, has two dimensions: trust on the governments and trust on Internet. Before trusting e-government initiatives, citizens must believe that government possesses the managerial and technical resources necessary to implement and secure these systems. For adopting e-Government services, citizens must have intention to 'engage in e-Government' which encompasses the intentions to receive and provide information through on-line channels (Warkentin, Gefen, Pavlou and Rose, 2002).

Citizen confidence in the ability of an agency to provide online services is imperative for the widespread adoption of e-government initiatives. A low level of citizen's trust on the ability of government to implement e-Government initiatives coupled with a low level of citizen's trust on Internet will lead to a condition where the citizens are adversaries to technology as well as government. (Srivastava and Thomson, 2005). In this situation, lack of trust on both dimensions will lead to unfavorable outcomes as regards acceptance of e-Government initiatives. Such a situation is not conducive for the implementation or success of e-Government programs.

A low level of trust on the government coupled with a high level of trust on Internet leads to a situation where citizens might use technology as a competitive tool against the government (Eynon, 2007). Implementation of e-Government services in such situations will lead to unpredictable and sporadic results. In such a scenario, the citizens will view the e-Government initiatives with suspicion and cynicism.

A high level of trust on the government but a low level of trust on the Internet indicates a scenario where the citizens will try to cooperate with the government efforts but the lack of their trust on the technology will inhibit this cooperation. The Internet technologies are poorly understood by large numbers of people, even some of them are a ubiquitous part of daily life. How far the pervasiveness of the new technologies is generally understood is not clear. More particularly, bad personal experiences, and news of large-scale computerisation failures or inadequacies, may reinforce distrust or reduce a high level of trust in Internet and in the agencies that use them. Though the citizens cooperate with the government, they are not able to contribute to the e-Government initiatives (due to their lack of trust on technology) hence the full potential will not be realized.

A high level of trust on the government's ability, motivation and commitment for the e-Government programs coupled with a high level of trust on the enabling technologies leads to a synergy of the government and citizens. Warkentin, Gefen, Pavlou and Rose (2002) posit that trust in the agency has a strong impact on the adoption of a technology. This collaborative behavior leads to proactive effort by the citizens as well as government towards the success of e-Government programs.

Transition to electronic services for the public sector is more than a technical or organisational change, but involves ethical dimensions of state-citizen interaction in which, in a democracy, trust and consent are at least as important as legal authority. Alongside face-to-face and other interactions amongst mutually known actors, virtual transactions with strangers and abstract systems extend chains of (inter)dependence into new territory in which familiar ways of establishing trust are absent and the reliability of new mechanisms remains to be tested.

Citizen's trust in e-government has some unique features because the impersonal nature of the online environment, the extensive use of technology, and the inherent uncertainty and risk of using an open infrastructure (Al-adawi and Morris, 2008). The online environment does not allow the natural benefits of face-to-face communications and to directly observe the service provider behavior, assurance mechanisms on which humans have depended on for ages. Based on trust, new service paradigms could emerge, developing passive citizen participation into active citizen participation in public service delivery (Hein van Duivenboden, 2002)

4. Research design

As features of online communication could erode or enhance trust, it would be valuable to understand what factors, if any, can ensure that citizens place the appropriate level of trust in e-government. So, the purpose of the present research was to identify the determinants of trust in e-government. Based on previous literature, a trust model has been developed (figure 1). Twelve interrelated variables were identified as trust determinants and twelve hypotheses were formulated based on the research model. The aim was to test the hypotheses and determine the strength of the relationships.

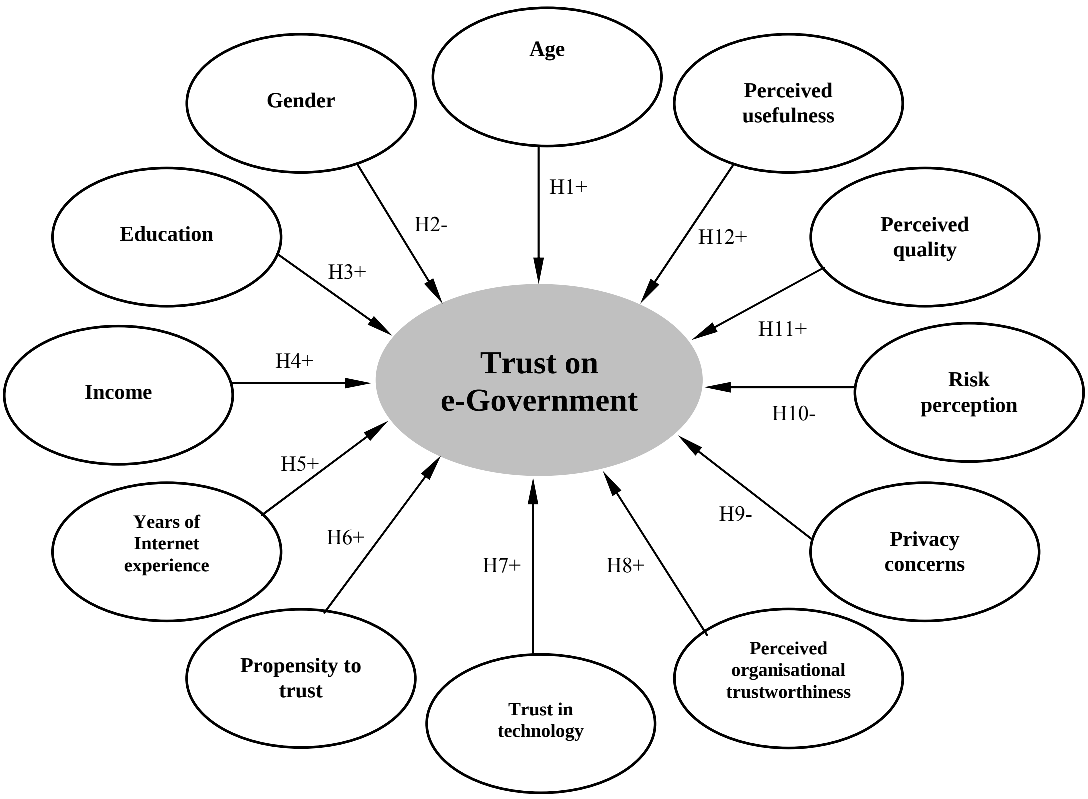

Figure 1. The research model

The following hypothesis were tested:

H1: The age will negatively influence the trust in e-government services.
H2: The gender will influence the trust in e-government services. Women will trust more than mans.
H3: The education will positively influence the trust in e-government services.
H4: The income will positively influence the trust in e-government services.
H5: The years of Internet experience will positively influence the trust in e-government services.
H6: The propensity to trust will positively influence the trust in e-government services.
H7: The trust in technology will positively influence the trust in e-government services.
H8: The perceived organizational trustworthiness will positively influence the trust in e-government services.
H9: The privacy concerns will negatively influence the trust in e-government services.
H10: The risk perception will negatively influence the trust in e-government services.
H11: The perceived quality will positively influence the trust in e-government services.
H12: The perceived usefulness will positively influence the trust in e-government services.

Several specific criteria were used to measure the trust factors. Appendix 1 contains the list of items that were analyzed.

5. Methodology

To test the research model for this study a survey was conducted. A questionnaire was designed to gather the necessary information. Each item in the model had a corresponding question in the questionnaire. According to Lehmann and Hulbert (1972), "if the focus is on individual behavior, five to seven point scales should be used." Accordingly, we have used a seven-point scale, each item of the questionnaire being measured on a Likert scale with end points of "strongly agree" (7) and "strongly disagree" (1).

The questionnaire was administered to 835 Romanian citizens older than 18 years, living in urban and rural areas, from all Romanian regions (8 regions), who responded that are Internet users. 814 responses were received. After eliminating incomplete responses, we selected 793 usable responses as the sample. The sample is representative for the Romanian population, with a 3.2 % maximum error at 95% confidence level.

6. Analysis of sociodemographic variables

As showed in previous studies (Colesca and Dobrica, 2008), the Romanian citizens are interested in e-government opportunities. Even many Romanians are unfamiliar with the term "e-government", the public sees great potential in the government using technologies.

The public's vision of governmental use of technologies goes beyond a more efficient government that offers accessible high-quality services on-line, to a more informed and empowered citizenry and a more accountable government. In the same time the Romanians' concerns are clear, and their familiarity still is relatively low. Concerning the use of e-government services, 51.32% (407 persons) of the respondents declared they have experienced these services at national or local level.

Appendix 2 shows the almost of the sociodemographic variables for the present study. The proportion between women and men is 1.13. Most of the respondents are between 25–40 years of age (34.17%), have finished the high school (56.87%), work in the private sector (35.44%), have an monthly income between 401 and 600 Euro (36.86%) and have between 3 and 10 years of experience in Internet use (65.32%).

Asked which sites they visited most frequently, 34.99% of e-government users said it was national Web sites and 65.01% said it was local sites. The rest either said they frequented all types of sites equally or didn't know what sites they visited most.

In terms of experience level, the most common mentioned experience is searching for information (86.21%), followed by downloading forms (43.59%). The percent of citizens that initiated an on line transaction with a public institution is very low (5.27%). E-government users search a variety of items on government sites, including material about what public administration do, the facts that are contained in government databases and documents, information related to civic issues, and insights into the business climate or opportunities in various communities.

7. Data analysis

To verify how closely the survey measurements met the objectives of this study, before testing the proposed model, we performed a reliability analysis for the constructors composed by many items. Reliability is an assessment of the degree of consistency between multiple measurements of a variable. One type of diagnostic measure that is widely used and employed here is the Cronbach's alpha. The generally agreed upon lower limit for Cronbach's alpha is 0.70 (Nunnaly, 1978). The results of the reliability analysis are presented in Table 2. As the table shows, the reliability analysis gave alpha coefficients exceeding .70, which are regarded as acceptable reliability coefficients. Hence, the results demonstrate that the questionnaire is a reliable measurement instrument.

Table 2 – Reliability analysis

Construct (number of items)	Cronbach's Alpha
PT (3)	0.815
TT (3)	0.873
POT (4)	0.904
PC (5)	0.808
RP (6)	0.812
PQ (4)	0.859
PU (4)	0.931
TE (4)	0.889

To test the hypotheses we conducted multiple regression analysis. In Table 3, we summarize the findings regarding the research hypotheses. The analysis proved that 8 hypotheses are supported and 4 hypotheses aren't supported. Figure 2 is a graphical description of the analysis results.

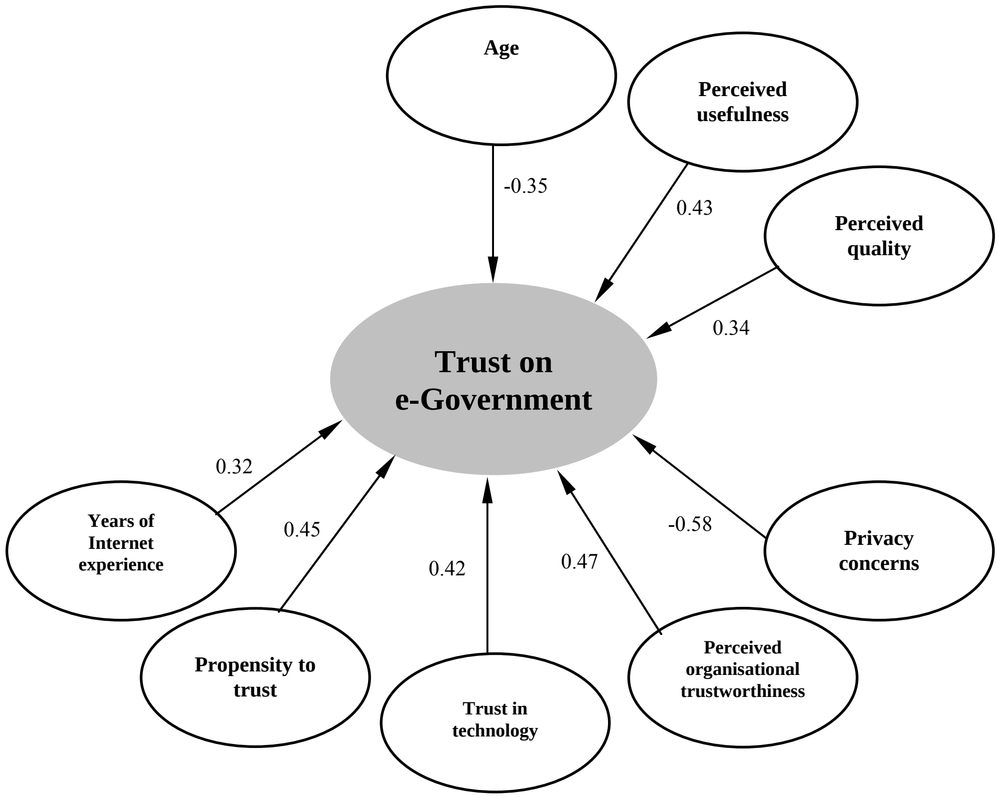

Figure 2. Graphical description of the results

Table 3 - Hypotheses results

Hypotheses	Variable	β	Significance	Supported
H1	AG-TE	-0.35	0.2734	YES
H2	GE-TE	0.02	0.0120	NO
H3	ED-TE	0.09	0.0279	NO
H4	IN-TE	0.13	0.0040	NO
H5	YI-TE	0.32	0.4418	YES
H6	PT-TE	0.45	0.3159	YES
H7	TT-TE	0.42	0.2389	YES
H8	POT-TE	0.47	0.2612	YES
H9	PC-TE	-0.58	0.1443	YES
H10	RP-TE	-0.29	0.0359	NO
H11	PQ-TE	0.34	0.4975	YES
H12	PU-TE	0.41	0.3907	YES

8. Discussions

The study confirms many of the hypotheses proposed in the model. Privacy concerns (H9, β=-0.58) was found to have the greatest influence on trust in e-government. Individuals want to be able to release personal information in the confident belief that it will only be used in the way the individual intended. Providing this assurance is the key to demonstrating trustworthiness. This finding is important because it provides useful strategic implications for the implementation of e-government services in the future. To adopt e-Government processes, citizens must have the intention to "engage in e-Government", which encompasses the intentions to receive information, to provide information, and to request e-Government services. Without confidence in the e-government services, processes, procedures, and other aspects of government, the vision of fully electronic service delivery will remain a challenging target. The survey found that 70 percent of the Romanians is extremely concerned about hackers breaking into government computers. Given the potential of e-government to help restore public confidence, it is all the more imperative that public concerns with respect to privacy and security are thoroughly examined and addressed in the move to e-government. Ease of use and the reliability of technical infrastructure could be two keys for the public's ability to use it. Another will be broad public confidence in government's ability to keep personal information private and to make systems safe from inappropriate efforts to gain access.

The analysis of the sociodemographic variables proves that age has a significant influence (H1, β=-0.35) on e-government trust. The β value for Age is negative, meaning that younger respondents are more likely to trust e-government services than the elders. Younger respondents tend to be more open to the idea of using e-government services than older respondents. This finding is consistent with previous research in e-government area, which found that age has statistically significant effects on the decision to adopt e-government.

Opposite with a previous Romanian research in e-government adoption (Colesca and Dobrică, 2008), which showed that e-government services are most accessible to more highly educated people, the present study proved that the education level (H3) hasn't any influence over the trust in e-government. Perhaps, individuals with more formal education tend to be somewhat more skeptical of the information and people accessible on the Internet.

People with different life experiences, personality types and cultural backgrounds vary in their propensity to trust. In concordance with other studies (Mayer and all, 1995), the present research highlights a positive relation between propensity to trust and e-government trust (H6, β=0.45). On another hand, the study fails to attest the importance of gender (H2) and income (H4) in influencing trust in e-government.

Internet experience appears to have influence over trust (H5, β=0.32). As the frequency of access and use of the Internet increases so will increase the understanding about existing and potential uses of the technology for information dissemination, online transactions, and interactive communication. In fact, the risks experienced in using the Internet are most often less than the risks imagined by non-users. As people use the Internet and gain expertise and capabilities and gain greater access to Internet resources, they are also likely to be less concerned over the risks of Internet use. And as consequence of risk reduction trust will increase.

The study shows empirical evidence that perceived organizational trustworthiness (H8, β=0.47) and trust in technology (H7, β=0.42) are statistically significant factors influencing users' trust in e-government. This highlights the importance of citizens' trust in both the government agency and the technology used to provide electronic services. Hence, government agencies should first emphasize their general competence in their particular areas of expertise, and then highlight their ability to provide their services via the Internet. Citizen distrust can arise when governmental agencies are perceived to systematically use or block use of technology in ways that misinterpret or misrepresent expected cultural, political, or social norms.

Trust is a method of dealing with uncertainty. Following this, risk is inherent in trust. Although, the model hasn't revealed any relation between perceived risk and trust in e-government (H10). This outcome was amazing because in other fields, for example in e-commerce, there is a strong relation between trust and risk perception. One explication for this result could be the small percent of citizens who initiated an on line transaction with a public institution (5.27%). The risk associated with finding information and downloading forms is reduced in these circumstances. Another reason could be the fact that citizens perceive businesses differently than government (Belanger and Carter, 2008). Perhaps the perception of risk in e-commerce is more prevalent than in e-government. Or, perhaps different trust constructs impact risk in e-government. Future research should address these potential differences.

The analysis of the model revealed that the citizen's higher perception of quality (H11, β=0.34) and usefulness (H12, β=0.41) enhanced the level of trust in e-government. A well-designed and high quality system can provide to citizens a signal that the e-service operator has the competence to carry out online services. Therefore, e-government websites should not only be designed as pure technological artifacts with functional properties but they must also incorporate sociological elements that cater to customers' social needs.

9. Conclusions

This study provides an understanding of the determinants of trust in e-government. The analysis revealed that the citizen's higher perception of technological and organizational trustworthiness, the quality and usefulness of e-government services, the Internet experience and propensity to trust, directly enhanced the trust in e-government. Opposite, age and privacy concerns have a negative influence over trust.

Before drawing definitive conclusion from these results, it is important to consider the study's limitations. This research was conducted in the Romanian context, so the analysis is based on the perception of the Romanian citizens. The limitation of the study to one country bears the danger that the findings are context-specific because citizen's behavior differs between countries. Another limitation is that the questionnaire approach is not free of subjectivity in the respondent and was taken at one point in time. User reactions change in time and may depend on the environment.

References

1. AlAwadhi, S. and Morris A. **The Use of the UTAUT Model in the Adoption of E-government Services in Kuwait**, In Proceedings of the 41st Hawaii International Conference on System Sciences, 2008, pp. 1-11
2. Baier, A. C. **Trust and Antitrust**, Ethics 96, 1986, pp. 231-260
3. Belanger, A. and Carter, L. **Trust and risk in e-government adoption**, Journal of Strategic Information Systems 17, 2008, pp. 165–176
4. Berg, J., Dickhaut, J. and McCabe, K. **Trust, reciprocity and social history,** Games and Economic Behavior, 10, 1995, pp. 122-142
5. Bouckaert, G. and Van de Walle, S. **Government Performance and Trust in Government. Paper for the Permanent Study Group of Productivity and Quality in the Public Sector**, EGPA Annual Conference, Vaasa, Finland, 5–8 September, 2001
6. Cave, J. **The economics of cyber trust between cyber partners,** in Mansell, R. and Collins, B.S. (eds.) "Trust and Crime in Information Societies", pp. 380–427, Cheltenham: Edward Elgar, 2005
7. Cavoukian, A. and Hamilton, T. **The Privacy Payoff. HowSuccessful Business Build Consumer Trust**, McGraw-HillRyerson Trade, 2002
8. Colesca, S. **The main factors of on-line trust**, Economia. Seria Management, ASE Publishing House, vol. 10, no.2, 2007, pp. 27-37
9. Colesca, S. and Dobrica, L. **Adoption and use of e-government services: the case of Romania**, Journal of Applied Research and Technology, Universidad Nacional Autonoma Mexico, Vol. 6, No. 3, 2008, pp. 204-217
10. Deutsch, M. **Trust and suspicion**, Journal of Conflict Resolution, 2, 1958, pp. 265-279
11. Eynon, R. **Breaking Barriers to eGovernment: Overcoming Obstacles to Improving European Public Services,** European Commission, Brussels, 2007
12. Fogg, B. **Persuasive Technology: Using Computers to Change What We Think and Do**, Morgan Kaufmann, 2002
13. Fukuyama, F. **Trust: The Social Virtues and the Creation of Prosperity**, Harmondsworth, Penguin Books, 1995
14. Gambetta, D. **Trust: making and breaking cooperative relations**, Oxford, Basil Blackwell, 1988
15. Grandison, T. and Sloman, M. **A Survey of Trust in Internet Applications**, IEEE Communications Survey and Tutorials, 3, 2000
16. Guerra, G. A., Zizzo, D. J., Dutton, W. H. and Peltu, M. **Economics of Trust in the Information Economy: Issues of Identity, Privacy and Security. Technical report**, Oxford Internet Institute, Research Report No. 1, 2003
17. Johnson, D. S. and Grayson, K. **Cognitive and Affective Trust in Service Relationships**, Journal of Business Research, 58(4), 2005, pp. 500-507
18. Kramer, R. **Trust and distrust in organizations: emerging perspectives, enduring questions**, Annual Review of Psychology. v50, 1999, pp. 569-598
19. Lee, J., Kim, J. and Moon, J. Y. **What makes internet usersvisit cyber stores again? Key design factors for customer loyalty**. in "CHI '00: Proceedings of the SIGCHI conference on Human factors in computing systems", pp 305–312, NewYork, ACM Press, 2000
20. Lehmann, D. and Hulbert, J. **Are Three-point Scales Always Good Enough?,** Journal of Marketing Research, 9(4), 1972, pp. 444-446
21. Lewis, J. D. and Weigert, A. **Trust as a Social Reality**, Social Forces 63, 1985, pp. 967-985
22. Marche, S. and McNiven, J. **E-Government and E-Governance: The future isn't what it used to be**, Canadian Journal of Administrative Sciences, Vol. 20, No. 1, 2003, pp. 74–86

23. Mayer, R. C., Davis J. H. and Schoorman, D. F. **An integrative model of organizational trust**, The Academy of Management Review, 3, 1995, pp. 709–734
24. Misztal, B. A. **Trust in Modern Societies**, Cambridge, The Polity Press, 1996
25. Mui, L., Mohtashemi, M. and Halberstadt, A. **A computationalmodel of trust and reputation**, in "Proceedings of the35th Hawaii International Conference on System Sciences", 2002, pp. 2431- 2439
26. Nunnaly, J. **Psychometric theory**, New York: McGraw-Hill, 1978
27. Olmedilla, D., Rana, O., Matthews, B. and Nejdl, W. **Security and trust issues in semantic grids**, in "Proceedings of the Dagsthul Seminar, Semantic Grid: The Convergence of Technologies", volume 05271, 2005
28. Riegelsberger, J., Sasse, M. A. and McCarthy, J. D. **The Mechanics of Trust: A Framework for Research and Design**, International Journal of Human-Computer Studies, 62(3), 2005, pp. 381–422
29. Rotter, J. B. **A New Scale for the Measurement of Interpersonal Trust**, Journal of Personality, 35, 1967, pp. 651-665
30. Rousseau, D., Sitkin, S., Burt, R and Camerer, C. **Not so different after all: a cross discipline view of trust,** Academy of Management Review 23 (3), 1998, pp. 393 – 404
31. Salovey, P. and Rothman, A. **Social Psychology of Health**, Psychology press, 2003
32. Scott, C. L. **Interpersonal trust: A comparison of attitudinaland situational factors**, Human Relations, 33(11), 1980, pp. 805–812
33. Srivastava, S.C. and Thompson, S. H. **Citizen Trust Development for E-Government Adoption: Case of Singapore**, In "Proocedings of Pacific Asia Conference on Information Systems", 2005, pp. 721-724
34. Wang, Y. D. and Emurian, H. H. **An overview of on-line trust: Concepts, elements and implications**, Computers in Human Behavior, Vol. 21, 2005, pp. 105-125
35. Warkentin, M., Gefen, D., Pavlou, P. A. and Rose, G. **Encouraging Citizen Adoption of eGovernment by Building Trust**, Electronic Markets, 12(3), 2002, pp. 157-162
36. Wauters, P. and Lörincz, B. **User satisfaction and administrative simplification within the perspective of eGovernment impact: Two faces of the same coin?**, European Journal of ePractice, no. 4, 2008, pp.1-10

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Appendix 1.

Factors of trust in e-government

Sociodemografic factors	
Age (AG)	<25
	25-40
	41-60
	>60
Gender (GE)	Male
	Female
Education (ED)	Middle school or less
	High school
	College or more
Income (IN)	< 200 Euro

	201-400 Euro	
	401-600 Euro	
	601-1000 Euro	
	>1000 Euro	
Years of Internet experience (YI)	<3 years	
	3-10 years	
	>10 years	
Constructor	**Item**	
Propensity to trust (PT)	**PT1**	It is easy for me to trust a person/thing.
	PT2	My tendency to trust a person/thing is high.
	PT3	I tend to trust a person/thing, even though I have little knowledge of it.
Trust in Technology (TT)	**TT1**	I believe the technologies supporting the system are reliable all the time.
	TT2	I believe the technologies supporting the system are secure all the time.
	TT3	Overall, I have confidence in the technology used by government agencies to operate the e-government services.
Perceived organizational trustworthiness (POT)	**POT1**	I think I can trust government agencies.
	POT2	I trust government agencies keep my best interests in mind.
	POT3	In my opinion, government agencies are trustworthy.
	POT4	The trust in a governmental agency increase once with its reputation.
Privacy concerns (PC)	**PC1**	My personal information given to a governmental website may be shared with other government agents to whom I do not want to provide the information.
	PC2	The governmental websites may allow another party access to my personal information without my consent.
	PC3	My personal information may be used in an unintended way by the governmental agency.
	PC4	Someone can snatch my personal information while I'm sending the information to a governmental website.
	PC5	Hackers may be able to intrude governmental websites and steal my personal information stored on the web
Risk perception (RP)	**RP1**	I feel vulnerable when I interact with an e-government service.
	RP2	I believe that there could be negative consequences from using an e-government service.
	RP3	I feel it is unsafe to interact with an e-government service.
	RP4	I feel that the risks outweigh the benefits of using an e-government service.
	RP5	I feel I must be cautious when using an e-government service.
	RP6	It is risky to interact with an e-government service.
Perceived quality (PQ)	**PQ1**	Generally, the e-government services provide useful information.
	PQ2	Generally, the e-government services are effectively organized.
	PQ3	Generally, the e-government services provide significant user interaction.
	PQ4	Generally, the e-government services provide feedback mechanisms.
Perceived usefulness (PU)	**PU1**	Using e-government services can save my time, compared to dealing with real people for the same service.
	PU2	Using e-government services can improve the service quality that I will receive, compared to dealing with real people for the same service.
	PU3	Using e-government services increases the effectiveness in my transactions with the government.
	PU4	Overall, the e-government services are useful for my transactions with the government.
Trust on e-government (TE)	**TE1**	I expect that e-government services will not take advantage of me.
	TE2	I believe that e-government services are trustworthy.
	TE3	I believe that e-government services will not act in a way that harms me.
	TE4	I trust e-government services.

Appendix 2.

Demographic Profile of Respondents

Measure	Item	Frequency	Percentage
Gender	Female	372	53.09%
	Male	421	46.91%
Age	<25	92	11.60%
	25-45	271	34.17%
	45-65	243	30.64%
	>65	187	23.58%
Occupation	Private sector employee	281	35.44%
	State employee	247	31.15%
	Students	58	7.31%
	Unemployed	49	6.18%
	Retiree	158	19.92%
Education	Middle school or less	53	6.68%
	High school	451	56.87%
	College or more	289	36.44%
Income per month	< 200 Euro	124	13.52%
	201-400 Euro	298	32.50%
	401-600 Euro	338	36.86%
	601-1000 Euro	103	11.23%
	>1000 Euro	54	5.89%
Years of Internet use	<3 years	134	16.90%
	3-10 years	518	65.32%
	>10 years	141	17.78%

DEVELOPMENTS IN ANALYSIS OF MULTIPLE RESPONSE SURVEY DATA IN CATEGORICAL DATA ANALYSIS: THE CASE OF ENTERPRISE SYSTEM IMPLEMENTATION IN LARGE NORTH AMERICAN FIRMS[1]

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Abstract: *This paper explores the analysis of survey data with multiple response variables. After describing the problem with analysis of multiple response variables, the historical developments in identifying and analyzing multiple response variables, based on an extensive literature review, are discussed. After we explored the developments in this area from 1968 to 2008, we employed the first Order Rao-Scott Corrected Chi-Square to analyze a recently collected set of data on the practice of Enterprise System (ES) implementation among North American large corporations. The data analyzes the success of ES implementation, challenges of ES implementation, and the success of utilization of ES across two categories of firms: process-oriented and not process-oriented. The first Order Rao-Scott Corrected Chi-Square confirms that process-oriented firms in our sample are more successful in implementing the ES, face fewer challenges in implementing the ES, and are more successful in utilizing the ES.*

Key words: *Complex Survey Data; Enterprise System Implementation; Empirical; Multiple Response Variable; Categorical Data*

1. Introduction

Analyzing complex data collected from the surveys is one of the challenges facing the researchers. The complexity of the data is a multifaceted issue and has different implications. One of these challenges (facets) comes when researchers working with categorical data are working with multiple response variables. This problem arises when, for a single observation, a variable or some variables may be classified into more than one category. We should note that the cause of this type of complexity is "the multiple-response nature of the data, not from the sampling mechanism" or the design of the questionnaire (Thomas and Decady, 2004). When more than one answer may be selected by the respondents, the response for a single observation can be classified into more than one category. The problem of multiple response variables can be observed and studied in n-way contingency tables. The focus of this study is on the problem of multiple response variables in two-way contingency tables, while the situation of Enterprise System (ES) implementation presents a case of single-by-multiple marginal independence. The research problem is explained in section two by presenting a generic example. The next section explores the historical developments in identifying and understanding the multiple response variables in categorical data analysis. Section four presents the application of new statistical tools in analyzing data recently collected from a sample of large North American firms; the data is examined to determine the success in implementing ES, the challenges of implementing ES, and the success of utilizing ES. Finally, section five presents the conclusion and gives suggestions for future studies.

2. The Problem with Multiple Response Variables in Categorical Data Analysis

The issue of multiple response variables is becoming more and more visible and, therefore, has attracted the attention of researchers and practitioners, specifically in the past decade. For example, in a recent guideline prepared by the Australian Institute of Health and Welfare for those involved in collecting and presenting the data regarding alcohol and other drug treatment, the issue of multiple response variables as an "indigenous status question" has been identified (Australian Institute of Health and Welfare working paper, 2008).

Although the existence of multiple response variables may be easily identified, the implication of analyzing multiple response variables has received less attention. There are numerous studies dealing with multiple response variables. However, in some cases, the researchers simply ignored the fact that when they are dealing with multiple response variables. Specifically the chi-square test is not a reliable test when multiple response variables are being analyzed. One example is the Stallings and Ferris (1988) study on public administration research where, despite the recognition of multiple response variables, the researchers have used the simple chi-square test to identify the difference between different categories of data. Decady and Thomas (2000) explicitly described two main reasons that the Pearson chi-square test is not appropriate in dealing with multiple response variables. Here we will describe the problem with multiple response variables using a generic example. Consider the 2x2 contingency table (Table 1). First, we assume that there are no multiple response variables.

Table 1. A 2-by-2 table of observations with no multiple response variables

	Y1	Y2	
X1	$\mathbf{a_{11}}$	$\mathbf{a_{12}}$	$a_{11}+a_{12}=N_{1+}$
X2	$\mathbf{a_{21}}$	$\mathbf{a_{22}}$	$a_{21}+a_{22}=N_{2+}$
	$a_{11}+a_{21}=N_{+1}$	$a_{12}+a_{22}=N_{+2}$	$=N=a_{++}$

In this table, the observed counts are presented in four cells. X is the independent variable and Y presents the response variable. The marginal values are presented by N_{+1}, N_{+2}, N_{1+}, and N_{2+}. In each row and column the marginal values present the summation of that row or column. The Pearson chi-square test is calculated by the following formula:

$$X^2 = \sum \frac{(\text{observed - expected})^2}{\text{expected}} \tag{1}$$

We have the observed variables in Table 1. We also need the expected value of each observation, based on the marginal totals, for the ability to calculate the Pearson chi-square. Table 2 presents the way the expected values are calculated.

Table 2. A 2-by-2 table of expected values with no multiple response variables

	y1	y2	
x1	$(N_{1+} * N_{+1})/N$	$(N_{1+} * N_{+2})/N$	N_{1+}
x2	$(N_{2+} * N_{+1})/N$	$(N_{2+} * N_{+2})/N$	N_{2+}
	N_{+1}	N_{+2}	N

Here the two components of the Pearson chi-square are displayed: observed (Table 1) and expected (Table 2) values. However, this presentation is based on the assumption that none of the independent (e.g., rows) and response (e.g., columns) variables have multiple response variables.

Now if we assume that some variables can receive multiple responses for any row and/or column, then the marginal values of that row or column (there may be more than one of either) would be greater than the total observations of the variables. In this situation, the calculation of expected values using the model proposed above would be problematic. This is the first reason that Decady and Thomas (2000) gave when they stated that the traditional chi-square test is not appropriate for these circumstances. The second reason is that since one observation in this circumstance may yield multiple responses, the "standard assumption" of independence of rows and columns in he table is violated (Decady and Thomas, 2000). Further to these theoretical explanations, Rao and Scott (1981, 1984, and 1992) empirically showed that "classical chi-squared tests are invalid when applied to data from complex sample survey because the complexities of the survey design violate[s] the assumptions on which these tests are based" (Decady and Thomas, 2000).

3. Historical Developments in Analyzing Multiple Response Variables

Previously, two main reasons were given to explain why the classical Pearson chi-square is not appropriate for analyzing the complex survey data with multiple response variables. In this section of the paper, we explore how the researchers in academia deal with the analysis of the multiple response variables. To explore the evolution of studies in this area, we conducted an extensive literature search. We used a number of academic databases to identify the data on the evolution of studies in this area. The following presents the result of our literature analysis.

The analysis of complex survey data has been of interest to researchers outside the field of mathematics and statistics since the 1970s. For example, Irving Roshwalb (1973) mentioned the "need [to] improvement" of analytical techniques for handling the complex survey data. In the 1980s, advancements were made by statisticians to provide more sophisticated analytical tools. For example, Fellegi (1980) focused on the tests of independence in complex samples. As mentioned previously, the complexity of sample data has different dimensions and the focus of this study is on the "multiple response variables," which is only one facet of complex survey data. It is not clear when exactly the problem of multiple response variables as a research topic and statistical problem was introduced. Our review of the literature in different domains showed that an early recognition of the attention to the multiple response variables came in 1968 in the work of Murphy and Tanenhaus (1968) in the U.S. Survey Research Center. In another study, Schriesheim et al. (1974) explored the development of response categories in the validity of multiple response alternative questionnaires. However, in these works, Murphy and Tanenhaus (1968) and Schriesheim et al. (1974) have provided no discussion regarding the data analysis; they gave basically a mention of the existence of the multiple responses due to the nature of the data. Not until the early 1980s did some statisticians publish papers specifically addressing this topic as a research issue.

The review of the studies in this area showed that some of the studies have simply ignored the problems with multiple response variables in analyzing categorical data. An example is the study of Stallings and Ferris (1988) on the two categories of policy and management topics in the journal of public administration review, which was mentioned previously. In this study, while Stallings and Ferris (1988) recognized the existence of multiple response variables, they used the classical (Pearson) chi-square in their analysis, which is not an appropriate tool (as explained previously) for analyzing such complex data. In some other studies where the collected data could lead to the issue of analyzing multiple response variables in some cases, the researchers preferred to change the method of collecting or analyzing the data in order to avoid dealing with multiple response variables in contingency tables. While this approach is effective in avoiding multiple response variables, in some cases it may lead to partial collection of data.

One of the early approaches in providing a tool for dealing with this problem was done by Umesh (1995). In his study, Umesh recommended the use of a modified pseudo-chi-squared test instead of the classical Pearson chi-square test. Umesh's recommendation was tested by Loughin and Scherer (1998) and the evidence showed that, under some conditions, this method fails to provide a strong control of test levels. In the late 1990s, Agresti and Liu (1998, 1999) advanced the understanding of the multiple response categorical variables. Furthermore, Loughin and Scherer (1998) proposed the use of the bootstrapping technique for estimating the p-value of their proposed statistic. This method attracted the attention of academia, where it was recommended that the Imhof (1961) methods of evaluating the probability density function (pdf) could also be used to estimate the p-value (Decady and Thomas, 2000). Further, scholars proposed solutions to continue exploring the application of bootstrapping in analyzing contingency tables with multiple response variables. For example, Bali et al. (2006) proposed a bootstrapping technique considering the residuals of cells. While bootstrapping showed good control variables, Decady and Thomas (2000) tried to provide a simpler method that not only required less computation but also was more familiar to the practitioners. For achieving this goal, Decady and Thomas (2000) "cleverly draw the connection between the MMI (multiple marginal independence) testing problem and the Rao and Scott (1981) analyses of complex survey data" (Bilder and Loughin, 2001). They "note[d] the parallel between an application of an adjusted Pearson statistic to multiple-response categorical variables and the use of the Pearson statistic in non-multinomial sampling structures as studied by Rao and Scott (1981)" (Bilder and Loughin, 2007).

Although Bilder and Loughin (2001) recognized the contribution of the modified chi-square proposed by Decady and Thomas (2000), they questioned the control of the first order modified Decady-Thomas chi-square. In 2004, Thomas and Decady presented the extension of Rao and Scott modified chi-square, which was based on the second order Rao and Scott test. This recent procedure showed a good control of the test levels (Type I errors). More recently, Bilder and Loughin (2003, 2007) helped to further advance this area by exploring the extension to multiple-response categorical variables, which was originally proposed (but not conducted) by Agresti and Liu (1999, 2001).

4. The Case of ES Implementation: First Order Rao-Scott Corrected Chi-Square

In this paper, the first order Rao-Scott modified chi-square has been employed in a case of multiple response data recently collected from the survey of large North American corporations (V. Kumar et al., 2008; U. Kumar et al., 2008). In this empirical study, the authors measured the following four constructs of implementing ES:

- Process orientation
- Success of ES implementation
- Challenges during implementation of ES
- Successful utilization of ES

Each of these constructs is assessed by several measured constructs that are explicitly explained by the authors. Here is a brief description of the measured constructs.

ES in this survey is defined by the authors as an integrated, customized and packaged software based system that handles the majority of systems requirements in all or any of the functional areas of a firm, such as marketing, finance, human resources, and manufacturing. Almost every medium and large organization has at least a number of Enterprise Systems (ES) modules, such as Company-wide Accounting Software Package, Marketing Software Package or Manufacturing Software Package.

Furthermore, the concept of Process Orientation is described as "the activity of transforming an organization's structure from one based on a functional paradigm to one based on a process paradigm. Business process orientation implies that the procedure of doing tasks in firms should be more cooperative and integrated towards satisfying the customers' needs. This view is in contrast with the mechanistic functional view of the firm, which emphasizes the division and isolation of functions from each other and from the customers. While the challenges of ES include different dimensions of ES implementation, the concept of success is explored in two contexts: ES implementation and ES utilization. The questionnaire was sent to approximately 3,000 large North American firms. The survey yielded a response rate of approximately 10 percent; 195 of the surveys were found to be complete enough to be used in a contingency table for the purpose of this study.

For analyzing these data, a 2x3 way contingency table was constructed (Table 3). For the construct of process orientation, each observation can only have a single response (whether process-oriented or not-process-oriented); for the other three constructs each observation can be multiple responses. In other words, in each observation the firm, whether process oriented or not, is actually process oriented. However, irrespective of its process orientation, a particular firm that was observed may:

- Be successful or unsuccessful in ES implementation,
- Face or not face significant challenges during ES implementation, and
- Be successful or unsuccessful in utilizing ES.

Table 3. Contingency Table of Constructs of ES Implementation

	Success in Implementation	Faced No Significant Challenge	Success in Utilization	Total Responses	Total Subjects
PO	88	100	101	**289**	**101**
Not-PO	71	36	77	**184**	**94**
	159	**136**	**178**	**473**	**195**

Marginal values in this contingency table (Table 3) clearly show the existence of multiple response variables in the data. In this case we are facing a single-by-multiple marginal independence.

4.1. First Order Rao-Scott Corrected Chi-Square

As described earlier, the use of traditional chi-square is not appropriate when dealing with multiple response data. Following Decady and Thomas (2000) in this study, a corrected Rao-Scott chi-square test will be applied. The corrected Rao-Scott chi-square test is presented as Equation 2:

$$X_C^2 = X^2/\tilde{\delta}, \quad (2)$$

Where:

χ^2_c Presents the Corrected Rao-Scott Chi-Square

χ^2 Presents the Traditional (Pearson) Chi-Square

$\tilde{\delta}$ Presents the Correction Factor

The correction factor ($\tilde{\delta}$) was calculated using Equation 3:

$$\tilde{\delta} = 1 - \frac{m_{++}}{n_+ C} \quad (3)$$

Where:

m_{++} Presents the total count of multiple responses, which here is equal to 473
n_+ Presents the total number of subjects, which here is equal to 195
C Presents the number of multiple response variables, which here is 3 (columns)

⇨ $\tilde{\tilde{\delta}}$ = 1-(159+136+178)/(195x3)= 0.1915

Additionally, the degree of freedom here is calculated as follow:
$(R-1)C_{d.f.}$

Where:

R Presents the number of rows related to the single response variable, which here is equal to 2

⇨d.f.= (2-1)*3=3

Now having $\tilde{\tilde{\delta}}$, d.f, and the (Pearson) chi-square, we can calculate the corrected Rao-Scott chi-square as follows:

X^2 = 12.4774[5] ⇨ X^2_c = 12.4774/0.1915 = 65 ⇨ *p*-value=0.000

Based on the corrected chi-square test, we have concluded that the process-oriented firms, in comparison to the not-process oriented firms:

- Are more successful in implementing ES
- Face fewer challenges in implementing ES, and
- Are more successful in utilizing ES.

It is important to note that the traditional chi-square test also showed almost similar results in the p-value (see footnote 1). This was due to the fact that differences between the two categories of process oriented and not-process oriented firms were significantly wide. However, it by no means justifies the use of traditional chi-square in this circumstance, as was described earlier.

5. Conclusion and Future Studies

In this study, one dimension of complex survey data – multiple response variables – was explicitly explored. The analysis of multiple response variables in contingency tables is a relatively (as compared to some other statistical research topics) new research problem. This study presented the historical developments of the studies in this area. In reviewing the historical developments of the complex research data and, specifically, the multiple response variables, several academic databases were employed.

The first order Rao-Scott chi-square was employed to analyze our data. The findings confirm that process-oriented firms in our sample – in comparison to the not-process oriented firms – were more successful in implementing ES, faced fewer challenges in implementing ES, and were more successful in utilizing ES. Furthermore, the first order Rao Scott corrected chi-square was employed to assess the results of the current survey data.

Table 4. Comparison of First and Second order Rao-Scott chi-square

	First order Rao-Scott chi-square	Second order Rao-Scott chi-square
General Formula (Simple-by-Multiple)	$X_C^2 = X^2/\tilde{\delta},$	$X^2_{SM}(AL)/(1+\hat{a}^2)$
Correction Factor	$\tilde{\delta} = 1 - \frac{m_{++}}{n_+ C}$	$\hat{a}_*$
Degree of Freedom	df: (r – 1)c	df: (r – 1)c/(1 + â^2)

*$\hat{a}$ **:** is an estimate of the variability, among the weights that takes the form of a coefficient of variation

The comparison of first and second order Rao-Scott chi-square is displayed in Table 4. In future studies, the second order corrected Rao-Scott chi-square test could be employed.

References

1. Agresti, A. and Liu, I.M. **Strategies for modeling a categorical variable allowing multiple category choices**, Sociological Methods and Research, 29, 2001, pp. 403-434
2. Agresti, A. and Liu, I.M. **Modeling responses to a categorical variable allowing arbitrarily many category choices**, Technical Report 575, University of Florida, Department of Statistics, Gainesville, 1998
3. Agresti, A. and Liu, I.M. **Modeling a categorical variable allowing arbitrarily many category choices**, Biometrics, 55, 1999, pp. 936-943
4. Bali, G. Ch., Czerski, D., Klopotek, M. A. and Matuszewski, A. **Residuals for Two-Way Contingency Tables, Especially Those Computed for Multiresponces**, Advances in Soft Computing, 5, 2006, pp. 201–210
5. Bilder, C. R. and Loughin, T. M. **On the first-order Rao-Scott correction of the Umesh-Loughin-Scherer statistic**, Biometrics 57, 2001, pp. 1253-1255
6. Bilder, C. R. and Loughin, T. M. **Strategies for modeling two categorical variables with multiple category choices**, American Statistical Association Proceedings of the Section on Survey Research Methods, 2003, pp. 560-567
7. Bilder, C. R. and Loughin, T. M. **Modeling association between two or more categorical variables that allow for multiple category choices**, Communications in Statistics: Theory and Methods, 36, 2007, pp. 433-451
8. Bilder, C. R. and Loughin, T. M. **Estimation and Testing for Association with Multiple-Response Categorical Variables from Complex Surveys**, Proceedings of the Survey Research Methods Section, ASA, 2007
9. Decady, Y. J. and Thomas, D. R. **A simple test of association for contingency tables with multiple column responses**, Biometrics, 56, 2000, pp. 893-896
10. Fellegi, I. **Approximate Tests of Independence and Goodness of Fit Based on Stratified Multistage Samples**, Journal of the American Statistical Association, Vol. 75, No. 370, 1980, pp. 261-268
11. Imhof, J. P. **Computing the distribution of quadratic forms in normal variables**, Biometrika, 48, 1961, pp. 419-426
12. Kumar, V., Lavassani, K. M., Kumar, U., and Movahedi, B. **An Exploration on the Role of Process Orientation in Enterprise Systems Implementation,** Proceedings of Production Operation Management Society, 2008, California, USA
13. Kumar, U., Movahedi, B., Kumar,V. and Lavassani, K. M. **Measurement of Business Process Orientation in Transitional Organizations: An empirical study**, in Abramowicz W. and Fensel D. (Eds.) "Business Information Systems", Berlin, Germany, Springer, 2008, pp. 357-368
14. Loughin, T. M. and Scherer, P. N. **Testing for association in contingency tables with multiple column responses**, Biometrics, 54, 1998, pp. 630-637

15. Murphy, W. F. and Tanenhaus, J. **Inter-university Consortium for Political and Social Research US Survey Research Center 1966 American National Election Study: Post-election Interview**, Nov. 9, 1966
16. Rao, J.N.K. and Scott, A.J. **On Chi- Squared Tests for Multiway Contingency Tables with Cell Proportions Estimated from Survey Data**, Annals of Statistics, 12, 1984, pp. 46-60
17. Rao, J. N. K. and Scott, A. J. **A simple method for the analysis of clustered data**, Biometrics, 48, 1992, pp. 557-585
18. Rao, J. N. K. and Scott, A. J. **The Analysis of Categorical Data From Complex Sample Surveys: Chi-Squared Tests for Goodness of Fit and Independence in Two-Way Tables**, Journal of the American Statistical Association, Vol. 76, No. 374, Jun. 1981, pp. 221-230
19. Roshwalb, I. **Review: A Timely Festschrift Probing the State of the Arts in Behavioral Economics**, Journal of Marketing Research, Vol. 10, No. 3, 1973, pp. 354-356
20. Schriesheim, C. and Schriesheim, J. **Development and Empirical Verification of New Response Categories to Increase the Validity of Multiple Response Alternative Questionnaires**, Educational And Psychological Measurement, vol. 34, no. 4, December 1974, pp. 877-884
21. Stallings, R.A. and Ferris, J.M. **Public Administration Research: Work in PAR', 1940-1984**, Public Administration Review, Vol. 48, No. 1, Jan. - Feb., 1988, pp. 580-587
22. Thomas, D. R. and Decady, Y. J. **Testing for Association Using Multiple Response Survey Data: Approximate Procedures Based on the Rao-Scott Approach**, International Journal of Testing, Vol. 4, Issue 1, 2004, pp. 43 – 59
23. Umesh, U. N. **Predicting nominal variable relationships with multiple responses**, Journal of Forecasting, 14, 1995, pp. 585-596
24. * * * Australian Institute of Health and Welfare, **Alcohol and other drug treatment services NMDS specifications 2008–09**, Data dictionary, collection guidelines and validation processes. Working paper, 2008, URL: http://152.91.62.50/publications/hwp/hwp06/hwp06.pdf [Visited on June 1st, 2008]

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[5] p-value $_{X2}$=0.000

A MODEL FOR COORDINATING NEGOTIATIONS AMONG VIRTUAL ENTERPRISES

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Abstract: *This paper presents a model for coordinating negotiation processes in concurrent inter-organizational alliances. The IT system preserves the autonomy of organizations grouped in an alliance while enabling concurrency of their activities, flexibility of their negotiations and dynamic evolution of their environment. The purpose of this work is to offer support for small and medium enterprises which cannot or do not want to fulfill a big contract alone. This approach is illustrated by a sample scenario where partners are printshops grouped in an alliance to better accomplish customers' requests.*

Key words: *negotiation; virtual enterprises; multi-agent systems; coordination services*

1. Introduction

The advent of the Internet has led to the development of various forms of virtual enterprises which try to exploit the facilities of the network to achieve higher level collaboration goals.

We try to provide support to the collaborations within an alliance and we propose negotiation as a fundamental mechanism for these collaborations.

In this paper we present how organizations participate and control the status of the negotiations and how the negotiation processes are managed. We propose a model for coordinating different negotiations that may occur in a virtual alliance.

We consider a scenario of collaborations within an alliance of distributed autonomous printshops. The alliance is a dynamic entity where new printshops may join or leave [1][2]. A printshop manager interested in joining an alliance fills in an adhesion contract with information on his printshop competencies and preferences. If the alliance committee accepts it as a new partner, the new member commits to respecting the rules of the alliance and the adhesion contract and introduces itself to the other partners. Each printshop autonomously manages its contracts and schedules. When a print request reaches a printshop, the manager analyses it to understand if it can be accepted, taking into account job schedules and resources availability. If the manager accepts the print request, he may decide to perform the job locally or to partially outsource it, given the printshop resource availability and technical capabilities. If the manager decides to outsource a job, he starts a negotiation within the alliance with selected participants. The manager may split the job into slots, notifying the partners about the outsourcing requests for the different slots. If the negotiation results in an agreement, a contract is settled between the outsourcer and the insourcer printshops, which defines an inter-organizational workflow enacting the business process fulfilling the outsourced jobs and a set of obligation relations among participants [8].

The printshops alliance scenario shows a typical example of the e-alliances: virtual alliances where partner organizations may *a priori* be in competition with each other, but may want to cooperate in order to be globally more responsive to market demand.

E-Alliance main goal is to provide a software support for inter-organizational alliances enabling management of an alliance's life-cycle and collaborative activities among alliance partners [1]. E-Alliance should flexibly support negotiation processes in the alliance respecting the autonomy of the partners.

The main objective of this work is to propose a model for coordinating negotiations in a dynamical system with autonomous agents where each agent is in charge of its own negotiations (Section 4). In Section 5 we present an example to use this model in describing a particular coordination service, namely Block. Finally, Section 6 concludes the paper.

2. E-Alliance infrastructure

The e-Alliance infrastructure is organized in three layers as shown in Figure 1:

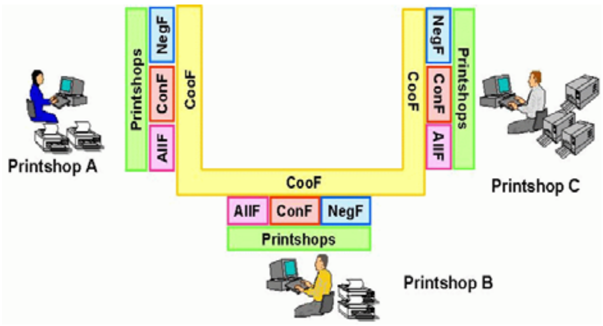

Figure 1. E-Alliance software infrastructure

A first layer is dedicated for different applications according to the specific domain in interaction with the Manager of each organization of the alliance (e.g., the printing domain). A second layer is dedicated to support the insourcing/outsourcing job within an alliance and comprises three facilities: AllF (alliance life-cycle management), ConF (contract management) and NegF (negotiation). The third, middleware and coordination layer (CooF) offers generic mechanisms to support negotiations in a distributed environment [5]. It is a global layer common to the different sites in which the partners of the alliance operate, while the two other layers are duplicated on the different sites.

Figure 2 shows the architecture of the NegF agent:

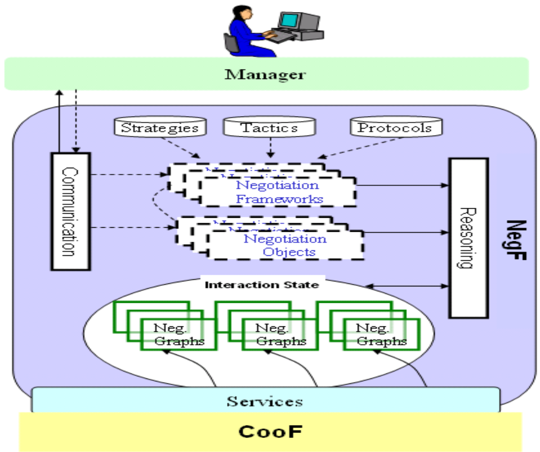

Figure 2. The architecture of the negotiation system

A NegF agent assists its printshop manager at a global level (negotiations with different participants on different jobs) and at a specific level (negotiation on the same job with different participants) by coordinating itself with the NegF of the other partners through the CooF, coordination and negotiation middleware.

Each negotiation is organized in three main steps: initialization; refinement of the job under negotiation; and closing. The initialization step allows to define what has to be negotiated (*Negotiation Object*) and how (*Negotiation Framework*). A selection of negotiation participants can be made using history on passed negotiation, available locally or provided by the AIIF [4]. In the refinement step, participants exchange proposals on the negotiation object trying to satisfy their constraints [6]. The manager may participate in the definition and evolution of negotiation frameworks and objects. Decisions are taken by the manager, assisted by his NegF agent. Decision functions operate in the "Reasoning" box (Fig.2). For each negotiation, a NegF manages one or more negotiation objects, one framework and the negotiation status.

A manager can specify some global parameters: duration; maximum number of messages to be exchanged; maximum number of candidates to be considered in the negotiation and involved in the contract; tactics; protocols for the NegF interactions with the manager and with the other NegFs [7]. Differing from [11], where tactics are defined for managing the negotiation, here tactics define constraints on the negotiation process. For example, a tactic may state that a job has to be outsourced as a block, another one that it has to be split in several slots. Executing a tactic corresponds to activating a combination of *services*, implemented above the CooF, producing a coordinated modification of alternatives within the current negotiation. Each service manages a local view of the global negotiation, translating negotiation decisions to modifications on the set of the visible alternatives on the job under negotiation using primitives of the CooF.

3. Coordination services

In order to handle the complex types of negotiation scenarios, we propose six different services:

- *Outsrc* (resp. *Insrc*), for outsourcing (resp. insourcing) jobs by exchanging proposals among participants known from the beginning [9];

- *Block* service for assuring that a task is entirely subcontracted by the single partner;
- *Split* service manages the propagation of constraints among several slots, negotiated in parallel and issued from the split of a single job;
- *Broker*: a service automating the process of selection of possible partners to start the negotiation;
- *SwapIn/SwapOut* services implement a coordination mechanism between two ongoing negotiations in order to find and manage a possible exchange between their two tasks;
- *Transport* service implements a coordination mechanism between two ongoing negotiations in order to find and synchronize on the common transport of both tasks.

These services are able to evaluate the received proposals and, further, if these are valid, the services will be able to reply with new proposals constructed based on their particular coordination constraints.

In the following sections we build the model for coordinating negotiations in a dynamical system with autonomous agents and, further, we describe the Block service based on this model.

4. Building the model

4.1. Basic concepts

In this setup, at a *local* level, the model requires a formal description of the rules of coordination that manage the behavior of the agent in a negotiation; at a *global* level, the model must provide a global coordination of all negotiations of an agent.

The fundamentals of the negotiation model are given by the following basic concepts:

An *alliance* is defined as a quintuple $\mathcal{A} = <\mathcal{T}, \mathcal{P}, \mathcal{N}, \mathcal{R}, \mathcal{O}>$ where:

1. $\mathcal{T}$ denotes the *time of the system*, assumed to be discrete, linear, and uniform;
2. $\mathcal{P}$ denotes the *set of participants* in the alliance. The participants may be involved in one or many negotiations within the alliance;
3. $\mathcal{N}$ denotes the *set of negotiations* that take place within the alliance;
4. $\mathcal{R}$ denotes *the set of policies of coordination* of the negotiations that take place within the alliance;
5. $\mathcal{O}$ denotes the common ontology that consists of the set of definitions of the attributes that are used in a negotiation.

A *negotiation* is described at a time instance through a set of negotiation sequences.

Let $Sq = \{s_i \mid i \in \mathbb{N}\}$ denote the *set of negotiation sequences*, such that $\forall s_i, s_j \in Sq$, $i \neq j$ implies $s_i \neq s_j$. A *negotiation sequence* $s_i \in Sq$ such that $s_i \in N(t)$ is a succession of negotiation graphs that describe the negotiation N from the moment of its initiation and up to the time instance *t*. The negotiation graph created at a given time instance is an oriented graph in which the nodes describe the negotiation phases that are present at that time instance (i.e., the negotiation proposals sent up to that moment in terms of status and of attributes negotiated) and the edges express the precedence relationship between the negotiation phases [10].

The *negotiation phase* (*ph*) indicates a particular stage of the negotiation under consideration.

The *Status* is the possible state of a negotiation. This state takes one of the following values (*Status*∈{ *initiated, undefined, success, failure*}):

- *initiated* – the negotiation, described in a sequence, has just been initiated;
- *undefined* – the negotiation process for the sequence under consideration is ongoing;
- *success* – in the negotiation process, modeled through the sequence under consideration, an agreement has been reached;
- *failure* – the negotiation process, modeled through the sequence under consideration, resulted in a denial.

Issues is the set of attributes with associated values that describe the proposals made in a negotiation phase.

Snapshot is the set of combinations between a negotiation aspect (*Status*) and the information that is negotiated (*Issues*).

The functions *status* and *issues* return, respectively, the state (status) of a negotiation instance and the set of the attributes negotiated (issues) within a negotiation instance.

A *coordination policy* is the set of coordination rules that are used to establish various relationships between negotiations regarding the information that may be distributed among many participants and many sequences (global rules) or that may be recovered as a whole in the same sequence (local rules).

4.2. Metaphor Interaction Abstract Machines (IAM)

The metaphor Interaction Abstract Machines (IAM) will be used to facilitate modeling of the time evolution of a *multi-attribute, multi-participant, multi-phase* negotiation [2]. In IAMs, a system consists of different *entities* and each entity is characterized by a state that is represented as a multiset of *resources* [3]. It may evolve according to different laws of the following form, also called "*methods*":

A1@…@An <>- B1@…@Bm

A method is executed if the state of the entity contains all resources from the left side (called the "*head*") and, in this case, the entity may perform a transition to a new state where the old resources (*A1,…,An*) are replaced by the resources (*B1,…,Bm*) on the right side (called the "*body*"). All other resources of the entity that do not participate in the execution of the method are present in the new state.

The operators used in a method are:

- the operator @ assembles together resources that are present in the same state of an entity;
- the operator <>- indicates the transition to a new state of an entity;
- the operator & is used in the body of a method to connect several sets of resources;
- the symbol T is used to indicate an empty body.

In IAMs, an entity has the following characteristics:

- if there are two methods whose heads consist of two sets of distinct resources, then the methods may be executed in parallel;

- if two methods share common resources, then a single method may be executed and the selection procedure is made in a non-deterministic manner.

In IAMs, the methods may model four types of transition that may occur to an entity: *transformation*, *cloning*, *destruction* and *communication*.

Through the methods of type *transformation* the state of an entity is simply transformed in a new state. If the state of the entity contains all the resources of the head of a transformation method, the entity performs a transition to a new state where the head resources are replaced by the body resources of the method.

Through the methods of type *cloning* an entity is cloned in a finite number of entities that have the same state. If the state of the entity contains all the resources of a head of a cloning method and if the body of the method contains several sets of distinct resources, then the entity is cloned several times, as determined by the number of distinct sets, and each of the resulting clones suffers a transformation by replacing the head of the method with the corresponding body.

In the case of a *destruction* of the state, the entity disappears. If the state of the entity contains all the resources of the head of a transformation method and if the body of the method is the resource T, then the entity disappears.

In IAMs, the *communication* among various entities is of type broadcasting and it is represented by the symbol "^". This symbol is used to the heads of the methods to predefine the resources involved in the broadcasting. These resources are inserted in the current entity and broadcasted to all the entities existent in the system, with the exception of the current entity. This mechanism of communication thus executes two synchronous operations:

i) transformation: if all resources that are not pre-defined at the head of the method enter in collision, then the pre-defined resources are inserted in the entity and are immediately consumed through the application of the method;
ii) communication: insertion of the copies of the pre-defined resources in all entities that are present in the system at that time instance.

4.3. Program Formula

In a multi-entity system, the metaphor IAMs allows the modeling and control of the autonomous evolution process for each entity in the system. Each entity may change its state independently of others, using its own resources and the methods of its computational space. This approach allows us to model in parallel the evolution of multiple negotiation phases. By using the metaphor IAMs, the evolution of the negotiation phases, associated to the nodes of a negotiation sequence, will be managed through different methods that are put together in a *Program Formula* (*PF*).

Program Formula of a negotiation sequence *s* - *PF(s)* – represents the set of the methods used to manage the evolution of the sequence *s*. In our negotiation model, a negotiation phase is connected to the set of snapshots of the negotiation status and of the instants of the attributes negotiated that are present in a node of the negotiation graph. In this way, to specify not only the information regarding the negotiation state and the attributes values but also the actions that will contribute to the evolution of the negotiation, we model the nodes of a graph of the negotiation sequence as sets of particles, called *negotiation atoms*. Therefore, a negotiation atom, denoted *atom(s,ph),* is a set of resources, called *particles*, that describe the negotiation state in terms of the negotiation sequence *s* for the negotiation stage *ph*. We defined in this way five types of particles: *representation* particles, *event* particles, *message* particles, *control* particles, and *computational* particles.

In our negotiation model, a negotiation sequence keeps, in the nodes of the graphs, sets of snapshots, images that a participant has about the negotiation status and about the attributes that are negotiated in the current sequence as well as in all other sequences for which there is a distribution of information. This information is modeled within the negotiation process as representation particles that are described by three parameters: *Name, S*, and *I*

- *Name* is defined by concatenation of the identifiers of the participants with the sequence under consideration (e.g., p_is_i).
- *S* takes values in the set *Status*= {*initiated, undefined, success, failure*}. This value corresponds to the value returned by the function *status()*.
- *I* takes values in the set *Issues* of the negotiated attributes with the associated values (e.g., *I*= {*size =1k, cost =9.5k, delay =5*}). This value corresponds to the value returned by the function *issues()*.

In this way, a representation particle of an atom, associated to a sequence *s* for a phase *ph*, is a snapshot of the sequence *s* for the phase *ph*. To provide a detailed description of the negotiation sequences involved in a negotiation phase, we define the following particles:

- *localr(Name, S, I)* : local representation particle. This particle holds the local snapshot of the current sequence;
- *extr(Name, S, I)* : external representation particle. This particle holds the external snapshot that describes the modality in which another sequence perceives the same negotiation phase;
- *firstr(Name, S, I)* : external negotiation particle. This particle holds the external snapshot associated to the sequence that generated the current sequence.

In this way, a new node of a negotiation sequence may be described through a set of representation particles that are part of the same atom.

The particles *event* specify the types of transitions used by IAMs in terms of the message types that are exchanged within a negotiation. A particle event is described by three parameters:

- *Id* identifies the atom to be cloned;
- *New_id* identifies the newly created atom;
- *Msg* contains the negotiation message with data that will contribute to the evolution of the negotiation in the newly created atom.

To facilitate the identification of both the cloning operation and of the direction in which the new negotiation atom will evolve, we propose four particles event: *clone_propose, clone_accept, clone_reject,* and *clone_create*. The particles clone_propose(Id, New_id, Msg), clone_accept(Id, New_id, Msg), and clone_reject(Id, New_id, Msg**)** are modeling an event that signals the existence of a new negotiation message of type *propose*, of type *accept*, and of type *reject*, respectively. The particle clone_create(Id, New_id, Msg) models an event that signals the existence of a new negotiation message that announces creation of a new sequence for the current negotiation.

The particles *message* model the messages sent to allow their processing in terms of their interpretations in a typical negotiation process. The particles *message* have the following parameters:

- *Rname* and *New_r_name* are identifiers of the sequence that generates the message and of a new sequence that is invited to negotiation, respectively.
- *Content* represents the content of the message which is a proposal regarding the negotiation task.
- *Type* represents an identifier of the new coordination policy that satisfies a certain pattern and that must be managed by the sequence invited to negotiation.

We propose four types of message particles: *propose, accept, reject,* and *create*. The particle *propose(Rname, Content)* signals the existence of a new proposal in the negotiation process, and the particles *accept(Rname)* and *reject(Rname)* signal the existence of an acceptance of a proposal and the existence of a denial of a proposal, respectively. The proposal to accept and, respectively, to deny was sent by a participant in the negotiation through the sequence *Rname*. The particle *create(New_r_name, Type)* signals the existence of a new sequence that is part of the current negotiation phase and that is identified by *New_r_name*.

To properly formulate a coherent execution of a negotiation process, we introduced the *control* particles. These particles have several functions in the computation space of a negotiation sequence:

- an identification function (e.g., *name(Id)*) that identifies the negotiation atoms by specifying an unique value to the parameter *Id* for each atom. This unique value allows only to the specified atom to consume various events introduced in the system that are addressed to this atom;
- a limitation function (e.g., *start(), enable(), freeze(), waiting())* that introduces the concept of control over the methods that may induce errors in negotiation. This type of particles limits the number of methods that may be executed in a given state. In this manner, we may establish a proper succession in the execution of certain methods. For example, we will use the particles *enable* and *freeze* to favor the methods to consume the events and to consume the messages, respectively. Through the aid of these two methods we will introduce a well-defined order in the negotiation process, first the creation of a negotiation atom and, second, the evolution of the negotiation phase in this newly created atom;
- a notification function (e.g., *stop(Accord), ready(Accord))*.

4.4. Description of the negotiation process

According to our approach regarding the negotiation, the participants to a negotiation may *propose* offers and each participant may decide in an autonomous manner to stop a negotiation either by *accepting* or by *rejecting* the offer received. Also, depending on its role in a negotiation, a participant may *invite* new participants to the negotiation. To model this type of negotiation, we will make use of the previously defined particles and we will propose the methods to manage the evolution of these particles.

Through the use of the metaphor IAMs, the evolutions of the negotiation phases correspond to the evolutions at the atoms level. The evolution may be regarded as a process consisting of two stages: a *cloning* operation of the atom existent in the initial stage and a *transformation* operation within the cloned atom to allow for the new negotiation phase.

The cloning operation is expressed by a set of methods involving the particles *event* and these methods are used to facilitate the evolution of the negotiation. We propose the following methods associated to the particles event to model the cloning of an atom where new message particles are introduced:

- The method *Propose* is associated to the particle event *clone_propose(Id, New_id, Msg)* and models the introduction of a new proposal (*clone_propose*) by one of the participants to the negotiation. This method is expressed:

name(Id) @ enable @ clone_propose(Id, New_ id, Msg)<>- (enable @ name(Id)) & (freeze @ name(New_ id) @ propose(Rname, Content))

- the atom identified by the particle *name(Id)* is cloned. The new proposal contained in the particle *propose(Rname, Content)* will be introduced in the new atom *name(New_id)*.

- The method *Accept* is associated to the event particle *clone_accept(Id, New_id, Msg)* and models the case when one of the participants sent a message indicating acceptance (*clone_accept*) of an older proposal. This method is expressed:

name(Id) @ enable @ clone_accept(Id, New_ Id, Msg) <>- (enable @ name(Id)) & (freeze @ name(New_ Id) @ accept(Rname))

- the atom identified by the *name(Id)* is cloned. The message to accept that is contained in the particle *accept(Rname)* will be introduced in the new atom *name (New_id)* .

- The method *Reject* is associated to the event particle *clone_reject(Id, New_id, Msg)* and models the denial of an older proposal (*clone_reject*) made by one of the participants. This method is expressed:

name(Id) @ enable @ clone_reject(Id, New_ Id, Msg) <>- (enable @ name(Id)) & (freeze @ name(New_ Id) @ reject(Rname))

- the atom identified by the particle *name(Id)* is cloned. The message of denial contained in the particle *reject(Rname)* will be introduced in the new atom *name(New_ id)*.

- The method *Create* is associated to the event particle *clone_create(Id, New_id, Msg)*. This method models the invitation of a new sequence (*clone_create*) made by one of the participants toward the distribution of the newly created negotiation phase. This method is expressed:

name(Id) @ enable @ clone_create(Id, New_Id, Msg) @ <>- (enable @name(Id)) & (freeze @ name(New_Id) @ create(Rname, Type))

- the atom identified by the particle *name(Id)* is cloned and a particle *create(Rname, Type)* is introduced in the new atom *name(New_ id)* that will subsequently generate a new representation particle for the new sequence that is participating to the negotiation.

The particles message participate to transformation methods that change the negotiation phase of an atom by replacing the representation particles of the negotiation sequences involved in the generation or in the receiving of the messages that are exchanged. Next we propose the following transformation methods:

- The transformation method associated to the particle *propose(Rname, Content)* contributes to the local evolution of a negotiation phase regarding the status and the attributes negotiated. This evolution takes place by replacing, in the existing atom, all representation particles that are involved (depending on the method) with the new particles that have the status changed to *undefined*, and the set of the negotiated attributes (Issues) contains the new proposal expressed in the *Content* of the message particle.
  freeze @ localr(Rname1, S1, I1) @ extr(Rname, S2, I1) @ propose(Rname, Content)<>- enable@ localr(Rname1, undefined, I) @ extr(Rname, undefined, I)

- The transformation method associated to a particle *accept(Rname)* leads to the local evolution of a negotiation phase regarding the status. The evolution is made by replacing, in the existing atom, the representation particles involved with the new particles whose status has been changed from *initiated* or *undefined to success :*
  freeze @ localr(Rname1, S1, I1) @ extr(Rname, S2, I1) @ accept(Rname) <>-
  localr(Rname1, success, I1) @ extr(Rname, success, I1)

- The transformation method associated to a particle *reject(Rname)*. This is similar to the method of particle *accept(Rname)*, the distinction being that the evolution of the negotiation phase is made through modifying the status of the representation particles involved from *initiated* or *undefined* to *failure*:
  freeze @ localr(Rname1, S1, I1) @ extr(Rname, S2, I1) @ reject(Rname) <>-
  localr(Rname1, fail, I1) @ extr(Rname, fail, I1)

- The transformation method associated to a particle *create(New_r_name, Type)* contributes to the evolution of a negotiation phase regarding the number of the sequences that participate to this negotiation phase. This evolution is made by introducing in the corresponding atom a new representation particle:
  freeze @ create(Rname, type) <>- extr(Rname, init, ∅) @ enable

As soon as this sequence is invited to the negotiation, its status is *initiated* and its set of the negotiated attributes is the empty set.

The evolution of all negotiation atoms and the negotiation phases take place in parallel. To model the coordination of the execution of the negotiation process perceived within a sequence, we used the communication mechanism among the existing negotiations. This type of particles that are part of the communication process among different negotiation atoms communicate to all negotiation atoms a certain result.

In the negotiation processes, the messages hold meta-information regarding the content of the messages that describe the proposals in terms of the value of different attributes of the negotiation object. To handle the negotiation proposals we use the concept of *"raw" computation* introduced within IAMs. We assume that each of the atoms implicitly contains in its state particles for processing different proposals in terms of mathematical operations or of strings manipulations.

In the next section, we will present, as an example, the description of the Block service using the model proposed above.

5. Description of the Block service

The service Block is used in the negotiations where the task must be executed in its totality by a single partner of the negotiation process. Its main role is to mediate the negotiation between the printshop that initiated the negotiation and all other printshops that are invited to the current negotiation. The mediation is made with the goal of establishing a contract regarding the execution of the whole task by a single participant.

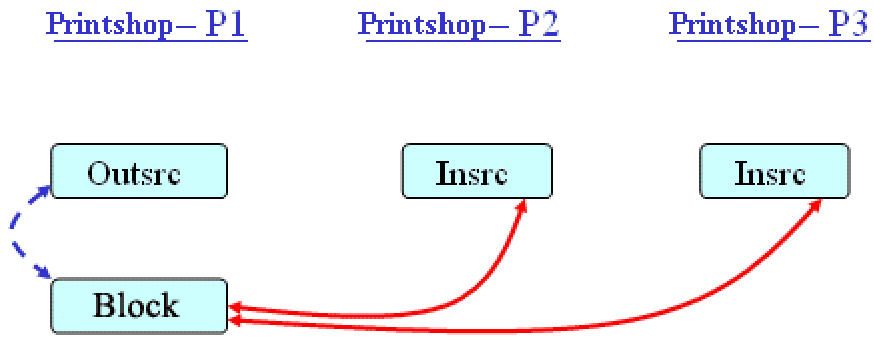

Figure 3. **Interactions of the Block Service**

In this way, a service, called "Block", is set to manage the constraint to not split the subcontracted task in different slots. In figure 3, we presented the services involved in a negotiation among a printshop P1 and other two printshops P2 and P3. In this case the negotiation begins by the initialization of Outsrc that invites to the negotiation the service Block. Subsequently, Block connects the services Insrc of each partner and will coordinate bilateral negotiations with the two partners P2 and P3, simultaneously. As soon as all services are connected, the interaction process between the participants may begin. During this process, the NegF's of each printshop involved in the negotiations begin to generate and exchange proposals and counter-proposals regarding the task at hand.

The negotiation ends when the printshop P1 reaches an agreement with one of the partners (e.g., P2) regarding the set of attributes that describe the task being negotiated. At the same time, P1 ends the negotiation with P3, this coordination being provided by the service Block. It should be noticed that the negotiation may also end without reaching an agreement (e.g., a time limit set for the negotiation has passed or the two partners P2 and P3 are no longer interested in the negotiation).

The following actions will be modeled:

- initialization of the negotiation: the sequence *s*1 invites sequences *s*2 and *s*3 to the negotiation;
- processing of the negotiation proposals;
- processing of the messages to accept a proposal ;
- implementation of the constraint to accept the task as a whole (i.e., the constraint regarding the size of the task contracted);
- processing of the messages to reject a proposal;
- end of the negotiation.

We assume that for each partner involved in the negotiation N there is a negotiation sequence. By using *Program Formula* we define all methods that model the entire negotiation process that must be managed by a certain sequence (e.g., sequence *s*1). We have identified this behavior using a particular negotiation sequence named s_{Block}.

Assume that the first atom of the negotiation sequence s_{Block} initially contains the following particles: **name**(Id), **start**, **localr**(Rname1,initiated,∅) – the representation particle of the sequence Block, **firstr**(Rname2,initiated, ∅) – the representation particle of the sequence Outsrc, **test_size**(value) – the particle that contains the size of the task fixed by the participant p_1.

Assuming that the sequence s_{Block} sees all the bilateral negotiations, this sequence will participate in the negotiation from the beginning, thus from the moment when invitations are transmitted to the potential participants. For each event **clone_create**(Id, New_Id, Msg) a new atom is generated - method (1.). The particle {**string_create**(Msg, Rname, Type)} will call a local computational particle to determine in the variable Msg the values of the parameters of the particle **create**(Rname, Type). The second method (2.) generates a new representation particle **extr(**Rname,initiated,∅) that represents the image of the new sequence over this new negotiation phase. The control particle **start,** that is only present in the first atom, limits the introduction of events **clone_create** to the first atom. In this way, all of the cloned atoms, starting with the first atom, will be negotiation phases distribute between the participant p1 and only one other participant.

(1.) **name**(Id) @ **start** @ **clone_create**(Id, New_Id, Msg) @ {**string_create**(Msg, Rname, Type)} <>- (**start** @ **name**(Id)) & (**freeze** @ **name**(New_Id) @ **create**(Rname, Type))

(2.) **freeze** @ **create**(Rname, type) <>- **extr(**Rname, initiated, ∅) @ **enable**

The following two methods manage the dependence of the size of the task negotiated, according to the principle Block service. Next, starting from the newly created atoms, we will continue the negotiation with the newly received proposals - method (3.). The proposal will result in the evolution of the new negotiation phase, only if the constraint imposed on the size of the task is satisfied - the computational particle {**substring**(value,Content,true)} verifies this constraint – method (4.).

(3.) **name**(Id)@**enable** @ **clone_propose**(Id, New_ Id, Msg) @{**string_propose**(Msg, Rname, Content)} <>- (**enable** @ **name**(Id)) & (**freeze** @ **name**(New_ Id) @ **propose**(Rname, Content))

(4.) **freeze** @ **test_size** (value) @ **localr**(Rname1, S1, I1) @ **firstr**(Rname2, S2, I1) @ **extr(**Rname3, S3, I1) @ **propose**(Rname, Content) @ {**substring**(value,Content, true)}@ {**construct**(I1,Content,I)}<>- **enable**@ **localr**(Rname1, undefined, I) @ **firstr**(Rname2, undefined, I) @ **extr(**Rname3, undefined, I)

The methods (5.) to (9.) model the dependencies regarding the status. In all the negotiation phases that are valid (those having the control particle **enable**), the negotiation partners may accept the current proposal - method (5.). In the event that the two partners will reach an agreement, in the newly created atom, the representation particles for a single partner will be in the status *success* (6. and 7.). We introduce a new control particle (**waiting**) to preserve the negotiation atom only for events of type **clone_accept** or **clone_reject** (8. and 10.). An agreement is reached only in the event that all three representation particles are in the status *success* – method (9). In this situation, all other negotiation atoms are instructed to stop the negotiation (the particle **stop** is introduced through the broadcasting mechanism in all atoms of the negotiation sequence s_{Block}).

(5.) **name**(Id) @ **enable** @ **clone_accept**(Id, New_ Id, Msg) @ { **string_accept**(Msg, Rname)}<>- (**enable** @ **name**(Id)) & (**freeze** @ **name**(New_ Id) @ **accept**(Rname))

(6.) **freeze** @ **localr**(Rname1, S1, I) @ **firstr**(Rname2, S2, I) @ **accept**(Rname2)<>- **localr**(Rname1, success, I) @ **firstr**(Rname2, success, I) @ **waiting**

(7.) **freeze** @ **extr(**Rname3, S3, I) @ **accept**(Rname3)<>- **extr(**Rname3, success, I) @ **waiting**

(8.) **name**(Id) @ **waiting** @ **clone_accept**(Id, New_ Id, Msg) @ { **string_accept**(Msg, Rname)}<>- **name**(Id) @ **freeze** @ **accept**(Rname)

(9.) **localr**(Rname1, success, I) @ **firstr**(Rname2, success, I) @ **extr(**Rname3, success, I) @ ^**stop** <>- **ready**(I)

Next we present in methods (10.) and (11.) the event of type **clone_reject** and, in method (12.), the message of type **reject**.

Method (10.) models the transformation of the event **clone_reject** in a negotiation atom where one of the participants has made a proposal of type accept in the current negotiation phase (the particle **waiting** is created only in a method processing a message of type accept – method 7.). The method (11.) models the transformation of the event **clone_reject** into a negotiation atom where, temporary, the proposal made is neither accepted nor rejected. The two methods introduce the message particle **reject** in the current negotiation atom. In processing the message **reject**, we choose to preserve the negotiation phase associated to the current atom by modifying all statuses to *failure* and preventing all possible evolutions of the atom through the use of all control particles – method (12.).

Method (13.) is a rule that completely destroys all the negotiation atoms visible through the sequence s_{Block}, except the negotiation atom that contains the agreement regarding the negotiation (the particle **stop** has been created through this atom – method 9.).

(10.) **name**(Id) @ **waiting** @ **clone_reject**(Id, New_ Id, Msg) @ { **string_reject**(Msg, Rname)}<>- **freeze** @ **name**(New_ Id) @ **reject**(Rname)

(11.) **name**(Id) @ **enable** @ **clone_reject**(Id, New_ Id, Msg) @ { **string_reject**(Msg, Rname)}<>- **freeze** @ **name**(New_ Id) @ **reject**(Rname)

(12.) **freeze** @ **localr**(Rname1, S1, I) @ **firstr**(Rname2, S2, I) @ **extr(**Rname3, S3, I) @ **reject**(Rname)<>- **localr**(Rname1, failure, I) @ **firstr**(Rname2, failure, I) @ **extr(**Rname3, failure, I)

(13.) **stop** <>- **#t**

6. Conclusions

This paper aims at modeling the negotiation process at least at three levels (middleware, multi-agent and human).

We propose a decentralized multi-issue negotiation model in which a set of agents can conduct several one-to-one conversations in a concurrent manner according to the coordination services.

This kind of alliance is typical of virtual enterprises, e-business, and e-commerce networks.

References

1. Alloui, I., Andreoli, J.M., Boissier, O., Bratu, M.B., Castellani, S. and Megzari, K. **E-Alliance: a Software Infrastructure for Inter-Organizational Alliances**, In "9th ISPE International Conference on Concurrent Engineering: Research and Applications (CE2002)", Cranfield University (UK), 2002
2. Andreoli, J.M **Object Orientation with Parallelism and Persistence**, chapter Coordination as negotiation transactions, Kluwer Academic Publishers, 1996
3. Andreoli, J.M. **Coordination in LO**, in "Coordination Programming: Mechanisms, Models and Semantics" Imperial College Press, 1996
4. Andreoli, J.M., Castellani, S. and Munier, M. **AllianceNet: Information Sharing, Negotiation and Decision-Making for Distributed Organizations**, in "Proc. of EcWeb", Greenwhich, U.K., 2000
5. Andreoli, J.M. and Castellani, S. **Towards a Flexible Middleware Negotiation Facility for Distributed Components**, in "Proc. of DEXA <<E-Negotiation>> workshop", Munich, Germany, 2001
6. Bui, V. and Kowalczyk, R. **On constraint-based reasoning in e-negotiation agents**, in "AMEC III", LNAI, 2003, pp. 31-46
7. Carron, T., Proton, H. and Boissier, O. **A Temporal Agent Communication Language for Dynamic Multi-Agents Systems**, in "Proc. of 9th MAAMAW", LNAI 1647, 1999
8. Cretan, A. **Virtual Alliances among Autonomous Organizations**, in "Digital Economy – The sixth International Conference on Economic Informatics", Bucharest, Romania, 2003, pp. 725-731
9. Cretan, A., **Intelligent Solutions for Virtual Negotiations**, in "Information & Knowledge Age – The seventh International Conference on Informatics in Economy", Bucharest, Romania, 2005, pp. 441-446
10. Cretan, A., **Negotiation processes within inter-organizational alliances,** in "Economic Informatics Journal", Vol. XII/No. 3 (47), 2008
11. Faratin, P. **Automated service negotiation between autonomous computational agent**, Ph.D. Thesis, Department of Electronic Engineering Queen Mary & West-field College, 2000
12. Keeny, R. and Raiffa, H. **Decisions with Multiple Objectives: Preferences and Value Tradeoffs**, JohnWilley & Sons, 1976
13. Smith, R. and Davis, R. **Framework for cooperation in distributed problem solving**, IEEE Transactions on Systems, Man and Cybernetics, SMC-11, 1981
14. Sycara, K. **Problem restructuring in negotiation**, Management Science, 37(10), 1991

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[2] Codification of references:

[1]	Alloui, I., Andreoli, J.M., Boissier, O., Bratu, M.B., Castellani, S. and Megzari, K. **E-Alliance: a Software Infrastructure for Inter-Organizational Alliances**, In "9th ISPE International Conference on Concurrent Engineering: Research and Applications (CE2002)", Cranfield University (UK), 2002
[2]	Andreoli, J.M **Object Orientation with Parallelism and Persistence**, chapter Coordination as negotiation transactions, Kluwer Academic Publishers, 1996
[3]	Andreoli, J.M. **Coordination in LO**, in "Coordination Programming: Mechanisms, Models and Semantics" Imperial College Press, 1996
[4]	Andreoli, J.M., Castellani, S. and Munier, M. **AllianceNet: Information Sharing, Negotiation and Decision-Making for Distributed Organizations**, in "Proc. of EcWeb", Greenwhich, U.K., 2000
[5]	Andreoli, J.M. and Castellani, S. **Towards a Flexible Middleware Negotiation Facility for Distributed Components**, in "Proc. of DEXA <<E-Negotiation>> workshop", Munich, Germany, 2001
[6]	Bui, V. and Kowalczyk, R. **On constraint-based reasoning in e-negotiation agents**, in "AMEC III", LNAI, 2003, pp. 31-46
[7]	Carron, T., Proton, H. and Boissier, O. **A Temporal Agent Communication Language for Dynamic Multi-Agents Systems**, in "Proc. of 9th MAAMAW", LNAI 1647, 1999
[8]	Cretan, A. **Virtual Alliances among Autonomous Organizations**, in "Digital Economy – The sixth International Conference on Economic Informatics", Bucharest, Romania, 2003, pp. 725-731
[9]	Cretan, A., **Intelligent Solutions for Virtual Negotiations**, in "Information & Knowledge Age – The seventh International Conference on Informatics in Economy", Bucharest, Romania, 2005, pp. 441-446
[10]	Cretan, A., **Negotiation processes within inter-organizational alliances,** in "Economic Informatics Journal", Vol. XII/No. 3 (47), 2008
[11]	Faratin, P. **Automated service negotiation between autonomous computational agent**, Ph.D. Thesis, Department of Electronic Engineering Queen Mary & West-field College, 2000
[12]	Keeny, R. and Raiffa, H. **Decisions with Multiple Objectives: Preferences and Value Tradeoffs**, JohnWilley & Sons, 1976
[13]	Smith, R. and Davis, R. **Framework for cooperation in distributed problem solving**, IEEE Transactions on Systems, Man and Cybernetics, SMC-11, 1981
[14]	Sycara, K. **Problem restructuring in negotiation**, Management Science, 37(10), 1991

THE EMPIRICAL ANALYSIS OF THE EFFECTS OF ECONOMIC GROWTH AND EXCHANGE RATE ON CURRENT ACCOUNT DEFICIT: ROMANIA AND TURKEY SAMPLES

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Abstract: *The aim of this study is to analyse the effects of economic growth and real effective exchange rate on current account deficit for Romania and Turkey using Structural Vector Autoregressive Analysis (SVAR). For this purpose, GDP, Real Effective Exchange Rate and Balance of Current Account Data of Turkey and Romania between the dates including 1997q2-2007q3 were used. Consequently, the shock of economical growth has revealed 82 % of variance fault estimation for Turkey and 79 % for Romania. Thus, It can be said that the changeability of economical growth is the most important reason for national current account deficit for both countries.*

Key words: *Current Account Deficit; Economic Growth; Structural Vector Autoregressive Analysis; Turkey; Romania*

1. Introduction

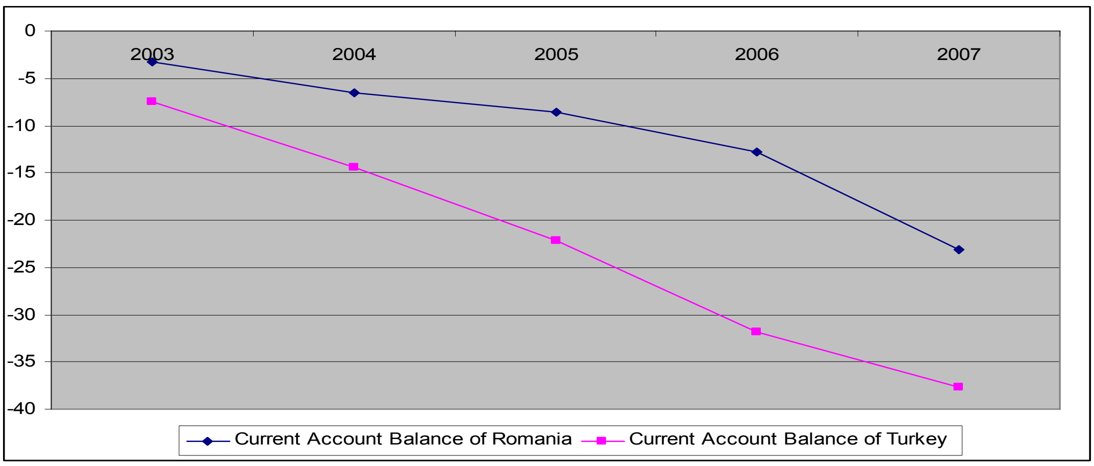
The subjects about on the current account deficit of developing countries have been debated latterly since the current account balance was seen as one of the sensitive and important components in economies. Because the current account balance gives the balance of the commodity trade of real sector and foreign money income-outcome of manufacturer factors.(Yeldan, 2005). At this point, the current account deficit is the mirror of economy in one sense.

It is possible to divide the discussed subjects into two groups[1] concerning the current account deficit. The second debate group deals with which were held the reasons for the deficit. there are two point of views regarding to the reason of deficit seen in the studies.

The economic growth has been seen as one of the most important reasons for current account deficit. The current account deficit is the quantitive difference between national savings and investments. It means, the deficit is occured as a result of either increase in investments or decrease in savings. The economic growth increases the confidence in economy by establishing higher expectations of profit. In this way the investments increase. On the other side, it decreases savings because of demand rising and then it causes the deficit to increase. The economic slowdown caused by the current account deficit effects the investments and savings in opposite direction so the increase in current deficit falls down automatically. (Roubini ve Watchel, 1998).

As for the other view, the reason for the current account deficit is the overvalued national monetary unit which is independently determined. It is claimed that, there is a mechanism in which the exchange rate is determined by the short-term capital input, the current account deficits are determined by the exchange rate delayingly and the exchange rate is determinded by the current account deficits delayingly. Working of this mechanism will lead the real exchange to increase and lead to weaken the competition force of the country. Consequently, the importation of intermediate and consumption goods will increase and it will cause the current account balance distorted. (Türel, 2004).

The current account balance has become an important indicator for economies since the capital mobility was liberalized and the national economies became global. The current account deficit of Turkey and Romaina within the years 2003-2007 was shown in Graph 1.

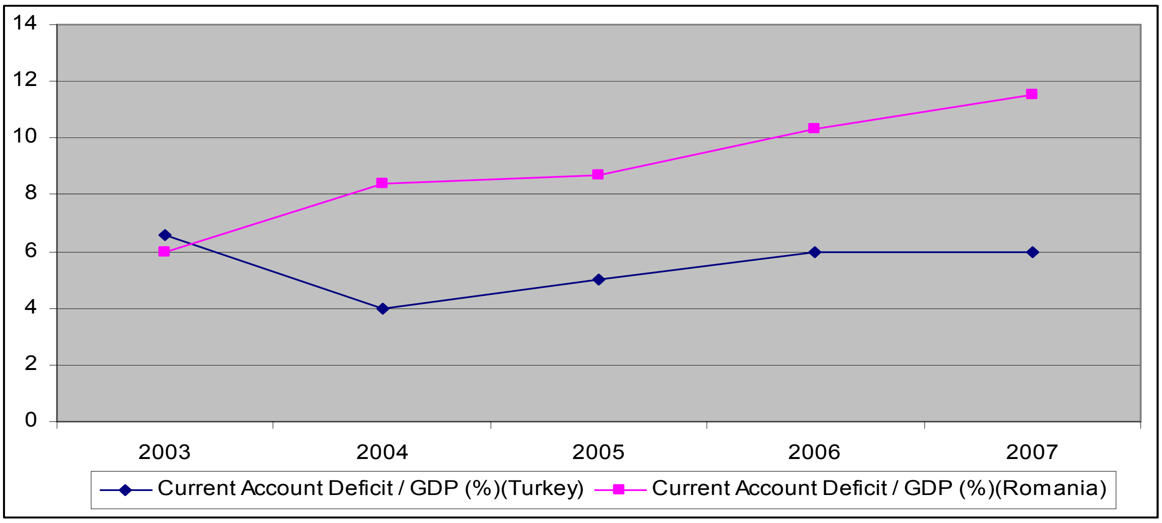


Graph 1. Current Account Balance of Turkey and Romania (2003-2007) (Billion USD)
Resource: IMF Country Stats

While examining the first quarter of 2008, It is seen that, the current account deficit in Turkey which has been continuously increased within these years will increase in the same way. The current account balance reached 3.4 billion $ current extra in 2003, 1.5 billion $ in the following year, and during the following four years it reached 8.1 billion $, 15.6 billion $, 22.1 billion $ and 31.8 billion $ respectively. In 2007 the deficit reached 38.2 billion $.

Romania which became the member of EU in 2007 is one of the countries faced with Current Account Deficit Problem. Its current account deficit, which showed changes between 1.3-2.5 billion $ in the last ten years period until 2003, reached 3.3 billion $ in 2003. During the following three years, it reached 6.4 billion $, 8.6 billion $, and 12.8 billion $ respectively. In 2007 the deficit reached 23.1 billion $.

On the other hand, the current account deficit/GDP ratio was given in Graph 2. Contrary to current values, if taking these values into consideration as a proportion, the situation is not too bad for Turkish Economy. Furhermore, it can be said that it is relatively much balanced when proportioning current deficit with GDP. Because, the ratio which was 4 % in 2004 rose to 6 % level increasing only 2 % in 2006 and 2007.



Graph 2. Current Account Deficit/GDP Ratio for Turkey and Romania (2003-2007)
Resource: IMF Country Stats

When looking at the Romania's GDP ratio of current account deficit of last five years, We see that the 6 % level in 2003 rose up nearly double to 11.5 %. In that respect, it is seen that the deficit is quite above the threshold value.

The aim of this study is to analyse the factors economic growth and real effective exchange rate which effects current account deficit for Romania and Turkey and to analyse which factor is much effective one.

This sudy consists of five parts. the first part includes the theory, the following part gives the literature concerning the subject, the third part explains the method and the data used in this study. The obtained estimated results are given in the fourth part. The last part gives conclusion and implications.

2. Literature

There are so many studies available investigating the reasons for current account deficit. In these studies, analyses were carried out by using different econometrical methods and data concerning different countries and years. The obtained results have mostly showed that there are causality relations between current account deficit and real effective exchange rate or/and economic growth.

Findings obtained in some studies examining the relation between current account deficit and real effective exchange rate show that there is a strong relationship between two variables [Sarcinell (1982), Khan ve Knight (1983) ve Howard (1989)]. In his study Freund (2000) examined 25 developed countries using ordinarily least squares method and states expressly that loss in value of real effective exchange rate (consequently loss on current account balance) has lagged responses on trade balance. In his study including the period between 1980-1988. Eken (1990) came to the conclusion that there was a strong relationship between real effective exchange rate and foreign trade balance in Turkey. Furthermore it was concluded that high economic growth lead to balance of payment matter. Calderon et al. (2002) performed estimation and inference on panel data including the years between 1966-1994 of 44 developing countries. According to the study, a rise in the reel effective exchange rate caused higher current account deficit. Boyd et al. (2001) analyzed the data of 8 OECD countries using vector error correction model and found that there was a statistically significant relationship between reel affective exchage rate and its effects on trade balance.

Herwartz and Siedenburg (2007) carried out a panel data study in which the data of 16 OECD countries including the years between 1980-2004 were used. In this study, there were 4 factors stated as reasons for current account deficit. These were, past current account deficit, budget deficits, differences in production output and changes in trade situations. Erbaykal (2007) carried out a Toda and Yamamoto casuality analysis for Turkey including the years between 1987-2006. Results showed that both real effective exchange rate and economic growth had effects on current account deficit.

The main findings of the studies which examined the casuality relation between current account deficit and economic growth differ among one another. Kandil and Greene (2002) performed cointegration test using both quarterly and monthly data including the years between 1960-2000, in order to find the raeason for current account deficit of United States. Consequently, they found that the changes in real GDP was effective on current account balance. Hooper ve Tyron (1984), Karunaratne (1988), Bagnai ve Manzocchi (1999) and Freund (2000) showed in their studies that there were strong relations between economic growth and current account deficit.

However, some researcher defend that there is no strong relationship between above mentioned subjects. Chinn ve Prasad (2000) carried out a panel data and a cross-sectional study using the data of 18 industrialized and 71 developing countries including the years between 1971-1995. As a result of the study, they determined a weak relatioship between current account deficit and economic growth. They also found that the reasons for current account deficit showed differences between industrialized and developing countries. The findings obtained by Calderon et al. (2002), Yücel (2003) and Eken (1990) support the findings of Chinn ve Prasad (2000) in terms of the relation between current deficit and economic growth.

3. Methodology

Since the economic relations are complicated, many economic situations need to be examined by simultaneous equation models rather than one-eqauation models. It has been observed that macro economic variables are mutually effected. Consequently, It will be difficult to divide the variables into two groups as pure endegenous and exagenous variables. The VAR method is used to solve the mentioned problems (Adrian,1990:114-116).

In this study the effects of economic growth and real effective exchange rate on current account deficit were tested with SVAR analysis. While the variables in VAR analysis were chosen, The empirical studies[2] were taken into consideration and three variables were used in our study including the period between 1997q2-2007q3.

The variable vector used in this study is as follows

$x_t = [\,REDK_t,\ BO_t,\ CA_t]$

Here, $REDK_t$, denotes real effective exchange rate at *t* period and BO_t denoting growth rate at *t* period were estimated by GDP which were projected by expenses. CA_t, denoting the current accounts balance at *t* period. This variables are made seasonal adjustment using Tramo-Seats method in the paper.

In this researach quarterly data including the time between 1997q2- 2007q3 were used.[3] The data and resources were shown at Table 1.

Table 1. The Data Set

Variables	Explanations	Resources
CA	Current Account Deficit, $	IMF
BO	GDP Growth Rate, %	IMF
REDK	Real Effective Exchange Rate, PPI based (1995=100)	IMF

Econometric Views (Eviews, version 5.1) program was used to test the data and estimate the results.

In our study, SVAR analysis was used to test the effects of economic growth rate on current account deficit. Performing the analysis depends on obtaining deconstructive terms (ε_t). Variance-covariance matrix of Choloskey decomposition and reductived VAR resids are used for this. Relation between structural destructive term and reductived VAR resid is given below:

$$\begin{bmatrix} u_t^{REDK} \\ u_t^{BO} \\ u_t^{CA} \end{bmatrix} = \begin{bmatrix} S_{11} & 0 & 0 \\ S_{21} & S_{22} & 0 \\ S_{31} & S_{32} & S_{33} \end{bmatrix} = \begin{bmatrix} \varepsilon_t^{REDK} \\ \varepsilon_t^{BO} \\ \varepsilon_t^{CA} \end{bmatrix}$$

S matrix[4] is triangular matrix (a lower–triangular matrix) which denotes that some structural shocks has no simultaneous effect on some other variables when the ranking of internal variables is constant in model. According to this, structural model is determined by putting k(k-1)/2 constraint on S matrix. In here, k denotes number of internal variables. Thus, comparing with structural VAR model, coefficients for each variables are not forecasted like unrestricted VAR model in the same number with each variable. Consequently in each equation some variables are left out of account[5]

In VAR analyse, rank of variables is an important level in determining structural shock. Ranking can be both implemented by Granger Causality test and by Economic theory. variables must be ranked from external to internal. In this paper, variables are ranked as follows: Real effective exchange rate, economic growth and current account deficit by using Granger Causality test and economic theory.

4. Estimation results

Variables which will be used in VAR analyse, must be stationary. In this paper, whether variables are stationary were examined by Augmented Dickey Fuller (ADF) unit root test and the results are shown in Table 2.

Table 2. ADF Unit Root Test of Results

	Turkey							**Romania**						
	REDK		**BO**		**CA**		**Critical Values**	**REDK**		***BO***		**CA**		**Critical Values**
	***I*(0)**	***I*(1)**	**I(0)**	**I(1)**	***I*(0)**	***I*(1)**		***I*(0)**	***I*(1)**	***I(0)***	***I(1)***	***I*(0)**	***I*(1)**	
1	-0.39	-9.02	-3.69	-6.23	0.11	-5.57	0.01= -3.61 0.05= -2.94 0.10= -2.61	0.01	-3.68	*-3.95*	*-8.29*	3.69	-5.82	0.01= -3.61 0.05= -2.94 0.10= -2.61
2	-2.92	-9.03	-4.44	-6.10	-1.78	-5.74	0.01= -4.23 0.05= -3.54 0.10= -3.20	-0.97	-3.71	*-4.75*	*-8.39*	1.49	-7.65	0.01= -4.23 0.05= -3.54 0.10= -3.20

[1] Intercept (c) term; [2] Trend (t) and intercept (c) term.

Note: MacKinnon (1996) critical values was used. All variables was made ADF test according to Schwarz information criterion.

As it is seen in the table, except economic growth variable, other variables are stationary after first differentation [*I*(1)]. Therefore, coentegration test was not performed as variables did not move coentegrated. Instead of this, VAR model which has no stationary condition in the same level was performed. According to this result, except economic growth variable, other variables will be given place with their first differentation in structural model which will be forecasted.

In order to analyse the effects of economical growth and real effective exchange rate on current account deficit using data belonging to Turkey including the period 1997q2–2007q3, the delay number was researched by autocorelation test within the structural model which has three variables and it was determined as five for Turkey and three for Romania. This test is shown in appendix 1 and 2.

Impulse-Response Functions

Impulse–response functions of variables in the structural model are shown in Table 3 as twenty periods.[6] Answer of variables to a structural shock of one standart deviation in all variables in system are shown in Table 3. For both countries, the real effective exchange rate (refdk) reacts negatively in the first quarter, then reacts positively and negatively in the other quarters against to a structural shock of one standart deviation in economic growth rate (bo). Then, the reaction of real effective exchange rate to the current account deficit (ca) shock is considerably low level. This finding is an evidence for low effect of real effective exchange rate on current account deficit.

Table 3. Impulse Response Functions

Variables	Period	REDK		BO		CA	
		TR	RO	TR	RO	TR	RO
REDK	1	0.101	0.101	-0.010	-0.010	0.001	0.001
	2	-0.057	-0.008	0.054	0.032	-0.006	-0.004
	3	0.047	-0.032	-0.081	0.011	0.008	-0.001
	4	-0.029	-0.018	0.036	0.030	-0.003	-0.003
	5	-0.027	0.003	0.027	-0.046	-0.003	0.005
	10	-0.001	-0.006	-0.015	0.005	0.002	0.000
	15	0.007	-0.001	0.004	0.000	-0.000	0.000
	20	0.002	0.000	0.008	0.000	-0.001	0.000
BO	1	-0.010	-0.010	0.101	0.101	-0.010	-0.010
	2	0.013	-0.007	0.011	-0.077	-0.001	0.008
	3	-0.012	0.001	-0.011	0.006	0.001	-0.001
	4	0.012	-0.017	-0.011	0.036	0.001	-0.003
	5	-0.001	0.021	-0.057	0.043	0.006	0.004
	10	0.005	-0.005	0.023	0.002	-0.002	0.001
	15	0.003	0.001	0.001	-0.007	-0.001	0.001
	20	-0.001	0.001	0.002	0.001	0.000	0.000
CA	1	0.000	0.000	0.000	0.000	0.100	0.100
	2	-7.936	-0.766	18.903	-2.824	-1.869	0.269
	3	-1.766	-0.816	0.885	-1.992	-0.119	0.226
	4	-0.351	-1.218	-2.598	-0.018	0.269	0.046
	5	-0.132	-1.096	6.422	-2.430	-0.632	0.240
	10	-0.335	-0.410	-1.595	-0.004	0.175	0.016
	15	0.585	0.077	-0.134	-0.584	-0.014	0.061
	20	-0.109	-0.047	1.744	0.023	-0.174	0.004

Economic growth reacts in the same way and in the same value for both countries in the first quarter to one standart deviation shocks in current account deficit and real effective Exchange rate; when it closes to twentieth quarter, the reaction falls down.

Current account deficit does not react in the first quarter to structural shocks of one standart deviation in economic growth and real effective exchange rate. In both economies, current account deficit reacts negatively to real effective exchange rate from second quarter to twentieth quarter (except for fifteenth quarter). On the other hand, we can say that, current account deficit generally reacts negatively to economic growth shock in Romania and positively in Turkey. Accordingly, reaction of current account deficit to economic growth shock, occurs in a higher rate than the other shocks and this situation can be interpreted as an important finding about the effect of economic growth on current account deficit.

On the other hand, the continuation of effects of real effective exchange rate and economic growth shocks in both countries continue for twenty quarters, means that real effective exchange rate and economic growth (especially) effect the current account deficit for a long time. It can be regarded as an important result for this paper.

Variance Decomposition

Results of variance decomposition process of variables used in structural model, is shown in Table 4.[7] Variance decomposition process shows that forecasting error variance in each variable arises depending on their shocks and shocks of other variables in economy.

For both economies, the main sources of variance in each variable are their own shocks. We can not say the same thing for current account deficits. In the first period, the change of current account deficit can be explained by its own shock at 100 % (Table 4). In short term and middle term, economic growth is an important source of change in the current account deficit. For example, It is seen that the economic growth explains the change in current account deficit at 84.31% in Turkey and at 92.26% in Romania in the second quarter, also it explains the change in current account deficit at 85.26% in Turkey and change in current account deficit at 81.21% in Romania in the fifth quarter. Finally, economic growth explains the change in current account deficit at 86,93% in twentieth quarter in Turkey and at 82.18% in Romania. In the same periods, explanation levels, for the change in the current account deficit of other variables are probably weaker than economic growth.

Table 4. Variance Decomposition

Variables	Period	SHOCK					
		REDK		BO		CA	
		TR	RO	TR	RO	TR	RO
REDK	1	99.00	99.00	0.99	0.99	0.01	0.01
	2	81.50	90.22	18.30	9.68	0.20	0.11
	3	61.89	90.15	37.73	9.75	0.38	0.10
	4	60.05	84.44	39.56	15.39	0.39	0.18
	5	59.50	73.25	40.11	26.47	0.40	0.28
	10	59.43	70.29	40.17	29.40	0.40	0.31
	15	58.59	69.95	41.00	29.74	0.41	0.31
	20	57.89	69.91	41.70	29.77	0.41	0.32
BO	1	0.98	0.98	98.04	98.04	0.98	0.98
	2	2.46	0.93	96.58	98.09	0.96	0.98
	3	3.68	0.94	95.36	98.08	0.95	0.98
	4	4.91	2.44	94.15	96.60	0.94	0.96
	5	3.82	4.36	95.23	94.70	0.96	0.94
	10	3.88	5.43	95.16	93.63	0.96	0.93
	15	4.01	5.51	95.03	93.56	0.96	0.93
	20	4.03	5.52	95.02	93.55	0.96	0.93
CA	1	0.00	0.00	0.00	0.00	100.00	100.00
	2	14.86	6.79	84.31	92.26	0.83	0.95
	3	15.45	9.40	83.72	89.60	0.82	1.00
	4	15.24	18.47	83.94	80.62	0.83	0.91
	5	13.91	17.91	85.26	81.21	0.84	0.88
	10	12.52	17.49	86.62	81.62	0.85	0.90
	15	12.42	16.90	86.73	82.19	0.85	0.90
	20	12.21	16.92	86.93	82.18	0.85	0.90

As it is emphasized when analysing with impulse–response functions, current account deficit occurs owing to the change (especially) in economic growth and in real effective exchange rate. In other words, the effect of change in economic growth on current account deficit occur in a high rate. Consequently, it is seen that the change in the economic growth explains the four fifth of current account deficit.

5. Conclusion and Implications

In this study, the effects of economic growth and exchange rate changeability of Turkey and Romania on the current deficit were analyzed by using Structral VAR method by evaluating the data concerning the period between 1997:II and 2007:III. within the frame of related literature. The obtained theoretical and empirical results can be summarized as follows.

Economic growth has been seen as one of the most important reasons for current account deficit. The current account deficit is the quantitive difference between national savings and investments. It means, the deficit is occured as a result of either increase in investments or decrease in savings. Economic growth increases the confidence in economy by establishing higher expectations of profit. In this way the investments increase. On the other side, it decreases savings because of demand rising and then it causes the deficit to increase. The economic slowdown caused by the current deficit effects the investments and savings in opposite direction and so the increase in current deficit falls down automatically.

According to empirical findings of our study, it has been obtained that, the changes appeared in current account deficit is highly sensitive to the changes in economic growth in the economies of Turkey and Romania. It has been seen that, the response of current account deficit to the shock of economic growth was happened largely compared to the shocks of other variables in the impulse-response functions of the model. Besides, according to results of variance decomposition, it has been seen that, the changeability on growth has effect on current account deficit in the proportion of 4/5.

According to the results of this study, the changeability of economic growth has been proofed to be one of the basic determining factors on economies of Turkey and Romania. However, As the economic growth is indispensable for the economies of both countries, It is necessary to determine the structural factors effecting the current account deficit increases and to implement the reformist strategies, policies and precautions. For instance, applying regulations such as decreasing the dependency of exportation on importation, promoting domestic intermediate input, implementing reforms at micro and macro level supporting competition power, adopting growth, employment and competition power based policies.

References

1. Adrian, C. and Darnell, A. **Dictionary of Econometrics,** Edward Elgar Pub., England, 1990
2. Bagnai, A. and Manzocchi, S. **Current-Account Reversals in Developing Countries: The Role of Fundemantals,** Open Economic Review, No. 10, 1999, pp.143-163
3. Bernanke, B.S. **Alternative Explanations of the Money-Income Correlation,** Carnegie-Rochester Conference Series on Pubkicy, 1986, pp. 49-100

4. Boyd, D., Caporale, G.M. and Smith, R. **Real Exchange Rate Effects on The Balance of Trade:Cointegration and The Marshall–Lerner Condition,** International Journal of Finance and Economıcs, no. 6, 2001, pp. 187–200
5. Calderon, C.A., Chong, A. and Vloayza, N**. Determinants of Current Account Deficits in Developing Countries,** Contributions to Macroeconomics, vol. 2, issue 1, 2002, pp. 1-31
6. Chinn, M.D. and Prasad, E.S. **Medium-Term Determinants of Current Accounts in Industrial and Developing Countries: An Empirical Eploration,** IMF Working Paper, No. 46, 2000, pp. 1-39
7. Eken, A. **Cari İşlemler Dengesi Üzerine Model Çalışması,** Türkiye Cumhuriyet Merkez Bankası Ekonomik Araştırmalar Dergisi, Sayı 2, 1990, pp. 73-87
8. Erbaykal, E. **Türkiye'de Ekonomik Büyüme ve Döviz Kuru Carî Açık Üzerinde Etkili midir? Bir Nedensellik Analizi,** Zonguldak Karaelmas Üniversitesi Sosyal Bilimler Dergisi, Cilt:3, Sayı 6, 2007, pp. 81–88
9. Freund, C.L. **Current Account Adjustment in Industrial Countries,** International Finance Discussion Papers, No. 692, 2000, pp. 1-27
10. Herwartz, H. and Siedenburg, F. **Determinants of Current Account Imbalances in 16 OECD Countries:An Out-Of-Sample Perspective,** Review of World Economics, Vol. 143(2), 2007, pp. 349–374
11. Hooper, P. and Tyron, R. **The Current Account of the United States, Japan, and Germany: A Cyclical Analysis,** Board of Governors International Finance Discussion Papers, No. 236, 1984, pp. 1–39
12. Howard, D.H. **Implications of the U.S. Current Account Deficit,** Journal of Economic Perspectives, Vol. III, issue 4, 1989, pp. 65–153
13. Kandil, M. and Greene, J. **The Impact of Cyclical Factors on the U.S. Balance of Payments,** IMF Working Paper, 02/05, 2002
14. Karunaratne, N. D. **Macro-economic Determinants of Australia's Current Account, 1977-1986,** Weltwirtschaftliches Archiv, No. 124/4, 1988, pp. 713-728
15. Kasman, A., Turgutlu, E. and Konyalı, G. **Cari Açık Büyümenin mi Aşırı Değerli TL'nin mi Sonucudur?** İktisat İşletme ve Finans Dergisi, Cilt. 20, Sayı. 233, 2005, pp. 88–98
16. Khan, M.S. and Knight, M.D. **Determinants of Current Account Balances of Non-Oil Developing Countries in the 1970s,** IMF Staff Papers, Vol.4, No. 30, 1983, pp. 819–842
17. Milesi, F. and Razin, A. **Sustainability of Persistent Current Account Deficits,** NBER Working Paper, No. 5467, 1996
18. Roubini, N. and Watchel, P. **Current Account Sustainability in Transition Economies,** NBER Working Paper, No. 6468, 1998
19. Sarcinell, I.M. **Current Account Deficit, Foreign Borrowing and Monetary Policy: The Italian Experience,** Banca Nazionale del Lavoro-Quarterly Review, No. 141, 1982, pp. 147–160
20. Sims, C.A. **Are Forecasting Models Usable for Policy Analysis?,** Federal Reserve Bank of Minneapolis Quarerly Review, 1986, pp. 2-16
21. Türel, O. **Döviz Kur, Carî Açık ve Reel Ekonomi,** Döviz Kuru, Carî Açık ve Politikalar Konulu Tartışmalı Toplantı 2004/3, Türkiye Ekonomi Kurumu, Ankara, 2004
22. Yeldan, E. **Türkiye Ekonomisi'nde Dış Açık Sorunu ve Yapısal Nedenleri,** Çalışma ve Toplum, No. 4, 2005, pp. 47–60
23. Yücel, Y. **Dynamics of the Current Account Of Balance of Payments in Turkey,** 7. İktisat Kongresi, ODTÜ, Ankara, 2003
24. * * * IMF Country statistics, www.imf.org (14.08.2008)
25. * * * Türkiye Bankalar Birliği, Ekonomik Göstergeler, www.tbb.org.tr (14.09.2008)

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[1] The frist subject is about to continuity of the curent account deficit. According to the Lawrance Summer the former minister of finance of USA, so as to the current account deficit being contunious, the current account deficit of a country should not excess the 5% of the GDP ratio of the country. To this view if the deficit excess the 5% threshold value, it will be the indication of crisis (Kasman, 2005). On the other hand, some studies show that these excessions are not thought strong enough to cause crisis. According to Sebastian Edwards. It will be deceiving to estimate a continuable thershold value for current account balance in which the macro economic variables are in interaction. (Edwards, 2001). According to Milesi et. Al. (1996) The current account deficit should be tried to explain by structural factors such as Exchange rate policies, rate of opennes, the quality of financial system, saving and investment levels.

[2] (Freund, 2000), (Kandil and Greene, 2002), (Kasman et.al., 2005) and (Erbaykal, 2007)

[3] Scope of study is restricted 1997q2-2007q3 period as absence data for Romania

[4] Here a lower triangular matrix S can be derived when positive determined symteric matrix Ω is constant. In other words, Cholesky decomposition of Ω specifies that $\Omega=PP^{|}$ when Choleski factor P is a lower triangular matrix. Because, under assumption that structural distorting terms are arthonormal, $\Omega=E(u_t u_t^{|})=SE(\varepsilon_t\ \varepsilon_t^{|})=SS^{|}$. In other words, $E(\varepsilon_t\ \varepsilon_t^{|})=I$ and a lower–triangular matrix S equals to Cholesky factor P.

[5] For detailed information: See Sims (1986) and Bernanke (1986)

[6] The Impulse Response functions are given in Appendix 3

[7] The results of variance decomposition process are shown in Appendix 3

Appendices

Appendix 1: Autocorrelation Test* (Turkey)

Legs 1		Legs 2		Legs 3		Legs 4		Legs 5	
LM-Stat	Prob	LM-Stat	Prob	LM-Stat	Prob	LM-Stat	Prob	LM-Stat	Prob
14.621	0.102	9.352	0.406	17.594	**0.040**	18.091	**0.0341**	9.534	0.390
11.393	0.250	9.554	0.388	12.954	0.165	13.859	0.1275	14.036	0.121
3.509	0.941	9.745	0.372	11.224	0.261	4.450	0.8794	7.854	0.549
20.792	**0.014**	20.278	**0.016**	18.921	0.026	8.907	0.4459	15.896	0.071
15.314	0.083	9.142	0.424	7.381	0.598	5.777	0.7620	6.072	0.733
2.467	0.982	2.404	0.983	6.971	0.640	5.979	0.7420	5.684	0.771
5.566	0.783	8.281	0.506	8.532	0.482	5.785	0.7613	4.385	0.884
11.097	0.269	11.634	0.235	17.088	0.047	11.974	0.2148	9.577	0.386
17.364	**0.043**	18.172	**0.033**	22.083	**0.009**	13.794	0.1298	6.655	0.673
13.06	0.160	10.041	0.347	8.807	0.455	15.108	0.0880	9.251	0.414
10.008	0.350	14.566	0.104	10.123	0.341	6.877	0.6500	6.680	0.670
10.673	0.299	7.799	0.555	8.981	0.439	11.679	0.2320	9.117	0.427

*Autocorrelation test was made according to Lagrange Multiplier (LM).

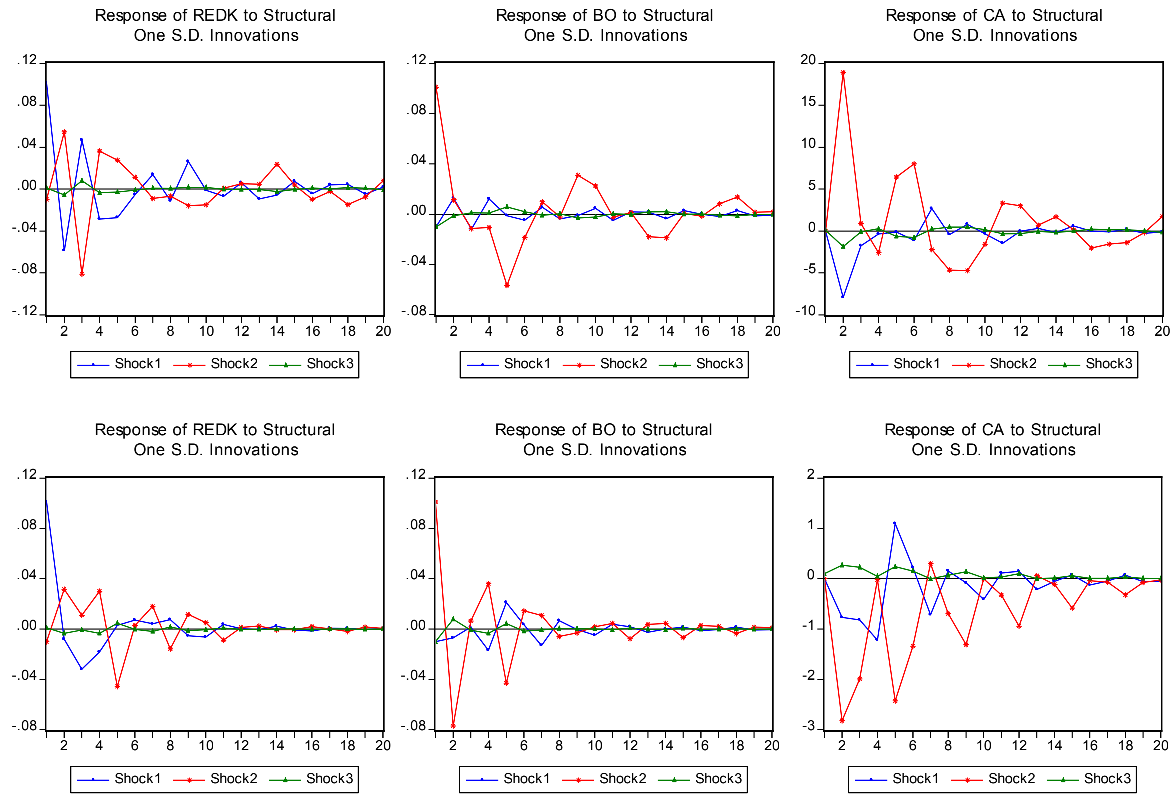
Appendix 2: Autocorrelation Test* (Romania)

Legs 1		Legs 1		Legs 1	
LM-Stat	**Prob**	LM-Stat	**Prob**	LM-Stat	**Prob**
16.437	0.058	19.755	**0.020**	10.099	0.343
26.186	**0.002**	8.201	0.514	10.155	0.338
26.719	**0.002**	18.196	**0.033**	1.261	0.997
11.626	0.235	11.108	0.268	4.538	0.873
19.319	**0.023**	14.548	0.104	7.047	0.632
16.769	0.053	13.759	0.131	7.701	0.565

7.697	0.565	6.387	0.701	6.716	0.667
18.518	**0.030**	6.405	0.699	6.454	0.694
11.519	0.242	13.68	0.137	11.670	0.233
7.296	0.606	6.396	0.700	4.164	0.900
22.018	**0.009**	11.857	0.222	11.532	0.241
4.203	0.898	5.425	0.796	13.322	0.149

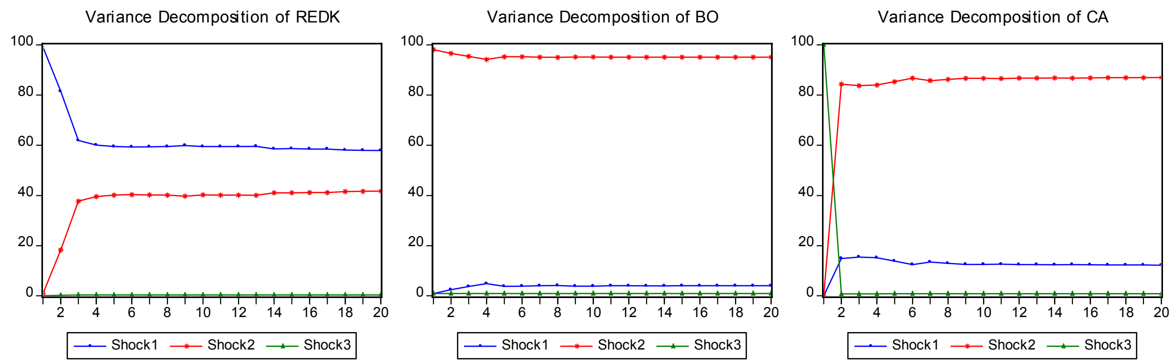
*Autocorrelation test was made according to Lagrange Multiplier (LM).

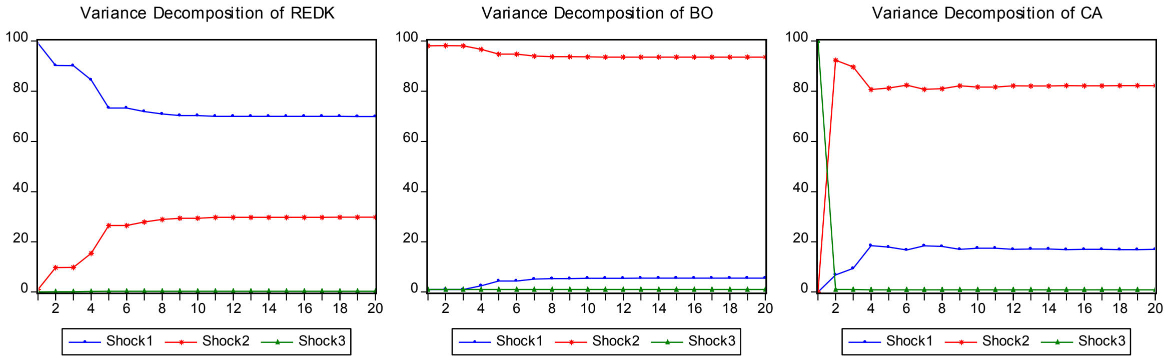
Appendix 3: Impulse-Respose Fuction of Turkey ve Romania Respectively*



*Shock1, shock2 ve shock3 represent redk, bo and ca respectively.

Appendix 4: Variance Decomposition of Turkey ve Romania Respectively




Variance Decomposition of REDK
Variance Decomposition of BO
Variance Decomposition of CA
100
80
60
40
20
0
2 4 6 8 10 12 14 16 18 20
Shock1
Shock2
Shock3

ABOUT THE IMPOSSIBILITY THEOREM FOR INDICATORS AGGREGATION

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Abstract: *This paper presents some aspects related to the issues of aggregating economic indicators. Departing from the research of Gh. Paun (1983) we will prove a theorem which states that under certain, natural assumptions, it is impossible to obtain an optimum aggregation. Unlike the original work of Paun, in this paper we are giving a rather simple proof of this theorem.*

Key words: *economic indicators; aggregate indicator; optimum aggregation; sensitive indicator; unexplosive indicator; system of indicators*

1. Statistic Indicators. Overview

Due to the complexity of the economic phenomena, the use of a single indicator for describing them is often useless. At the same time, an important component of the economic phenomena evaluation process is represented by the comparison and classification models (that submit to the comparing process of the economic agents, countries, processes, etc).
The speciality literature generally accepts the following features for the indicators[1]:

- The indicators are almost always used in comparisons
- In many situations the indicators are oriented towards action: adequate processes are planed precisely in order to modify the values of the indicators for a specific purpose.

It is widely accepted the fact that the economic domain imposes the use of some multidimensional indicators for characterizing various phenomena.

In order to quantify the performance of a portfolio in the capital market we use the average or expected rate of return as well as its risk, measured through the dispersions and covariance of the components. In order to describe the state of a national economy we use an entire list of macroeconomic indicators: gross domestic product, national product, etc.

The multidimensionality of the indicators used in such situations comes in contradiction with the two ideas referring to indicators, stated above. It is, indeed, difficult to compare two portfolios using the bi-dimensional indicator return-risk, the motivation being represented by simple linear algebra: the multidimensional vectorial spaces cannot be endowed with a relation of total order, i.e. we cannot compare two vectors of this nature.

In the particular situation presented, we can use other comparison methods, for example at the same risk level, we prefer the portfolio with a higher rate of return, and at the same rate of return we prefer the portfolio with a lower risk level.

In parallel, we use the criterion offered by the variation coefficient, as division between risk and expected return; according to this criterion we prefer portfolios with lower values of the variation coefficient.

On the other hand, in practice, other situations might appear such as: processes launched for the quality improvement of an indicator lead to unwanted consequences for the other indicators.

According to the statements above, it is imposed the reduction of the indicator systems dimensions, in such a manner that the reduced system contains at least the same quantity of information as individual indicators, while having the advantage of being more synthetic and easily manageable.

There are mainly two methods to reduce the number of indicators: selection and aggregation.

The selection reduces the number of indicators using statistic methods and techniques. If $S=\{i_1,...,i_n\}$ is the system of primary indicators, then the dimensional reduction can be performed by eliminating redundant information. If between two indicators there is a well defined functional relation, $i_k = f(i_j), k \neq j$, then there is no sense in including in the system both indicators, since the information held by one can be found in the other. For example, if the linear correlation coefficient is positive, $r_{kj} > 0$, it is redundant to use both indicators. This functional dependence can be tracked, for example, using regression techniques.

Another selection type can be accomplished by using elements from the classification theory; the system of indicators is divided into classes, using various criteria of maximizing the distance between classes and minimizing the distance between the elements in the same class (with the purpose of creating classes as homogeneous as possible).[2] Then there are chosen representative indicators from each class, the system formed by these representative indicators being used in the setting of the indicators system.

The primary indicators aggregation implies the building of a new indicators (called aggregated indicator), seen as a function between the initial indicators; if $S=\{i_1,...,i_n\}$ is the system of primary indicators, then the aggregated indicator can be seen as a function $f:\mathbb{R}^n \to \mathbb{R}$, $I_a = f(i_1,i_2,...,i_n)$.

Generally, in order to reduce the dimensions of the indicators systems we recommend the successive usage of selection and aggregation.

Through aggregation synthetic indicators are being produced, the disadvantage however is that in this case information are being lost. Indeed, through aggregation, the entropy of the indicators system is decreasing, which implicitly leads to a decrease in the quantity of information.

Being given S1 and S2, two subsystems of indicators of the initial system S; we can establish, in certain conditions, the relationship between the system total entropy and the entropy of the component subsystems.[3] Thus, we may have the following cases:

- If S1, S2 are independent, then H(S)=H(S1)+H(S2); in this case we are dealing with a preservation in the quantity of information from the system to its components;
- If S1 conditions S2 (the inverse situation is analogous), then $H(S)=H(S1)+H(S2/S1)\leq H(S1)+H(S2)$; in this case, the quantity of information contained by the total system is smaller than the quantity of information given separately by the individual subsystems.
- If S1, S2 condition one another, then we have a situation analogous to the one discussed above: $H(S)=H(S1/S2)+H(S2/S1)\leq H(S1)+H(S2)$.

Consequently we can draw two useful ideas for the activity of characterizing economic phenomena through indicator systems:

- Although an economic phenomenon, through its complexity it requires large systems of indicators, it is imposed, due to comparability reasons, the dimensional reduction of these selection and/or aggregation systems.
- Aggregation generally leads to a loss in information, presenting the additional disadvantage that there cannot be obtained "good" aggregations (the sense with this optimality will be revealed in the following section).

2. An Impossibility Theorem for Indicators Aggregation

The preoccupation to characterize various phenomena in the socio-economic domain through mathematic models is already a constant practice in the scientific activities in the last few decades.

In general, for the numerical expression of economic phenomena we have at our disposal, a set of indicators, in the sense of the prior definition, that taken separately say very little about the complex analyzed phenomenon; there intervenes the salvaging idea of building the so-called aggregated indicators that include in their meaning the entire quantity of information offered separately by the component elements, while offering a image concerning the studied phenomenon better than the one given by each individual indicator.

The first steps in this area were made by Arrow, with his theorem about the impossibility of aggregating preferences in the social domain. Gh. Paun (1983) proves that an aggregated indicator sensitive and anti-catastrophic is compensatory[4], using elements of fuzzy sets theory. Next we will present the sense of the terms used by the theorem.[5]

Thus, we say that an aggregated indicator is *sensitive* if an increase of a component indicator, initially positive, does not lead to a decrease of the aggregated indicator, as a decrease of the initial indicator does not lead to an increase of the aggregated indicator.

For example, the income increase should not lead to the decrease of the life quality level, just as the decrease of the alphabetization degree should not lead to an increase in the human development index.

The discussion can also be carried in a negative way, thus, the increase of the cases of tuberculosis in a region should not cause the increase in life quality in that region,

Also, we say that an aggregated indicator is unexplosive (anti-catastrophic) if a "small" increase of an initial indicator does not lead to a "large" increase in the aggregated indicator. For example, the increase of the income with 10 lei must not lead to an exaggerated increase of the life quality.

An aggregated indicator is *non-compensatory* if a "large" modification of one of the component indicators is not accompanied by a inverse modification of another indicator in such a manner that the aggregated indicator equals with two completely different situations.

It is decent to observe that all social and economic indicators are both sensitive and un-explosive (or at least it would be ideal), consequently they must be compensatory.

In what follows, we will demonstrate this theorem, whose conclusion will be the same although with completely different hypotheses and with another formal approach of the terms implied.

We will assume that we have two indicators that action on a known set, finite and un-void, their values being real numbers (this hypothesis of quantitative and qualitative expression is essential).

Let $A \neq \emptyset$ the support set with card $A < \infty$; for example A can be the the set of all companies listed at the stock exchange, the set of economic agents in a region, the set of countries in the world or the set of regions in a geographical area.

We will consider also $i_k : A \to \mathbb{R}, k = 1,2$ two indicators defined on the support set to be submitted to the aggregation process[6]. We can also consider that the two indicators taken in consideration represent the price indexes for the only two companies of a stock exchange, to be aggregated into one stock exchange index.

In general, in statistics, aggregating an indicator that presents contents and different forms of expression is difficult, that is why we use standardized indicators, the new values being calculated with the relation: $x_j^{normat} = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \in [0,1]$.

In this case we can restrict the indicators' codomain to the unit interval: $i_k : A \to [0,1], k = 1,2$.

We will then consider an aggregated indicator of the two primary indicators i_1 and i_2 as the function: $I_a \equiv f : \mathbb{R}^2 \to \mathbb{R}$, $I_a = f(i_1, i_2)$, for which we will state certain hypotheses.

In addition we will state that the aggregated indicator is compensatory if there is $\varepsilon > 0$ so that $f(i_1 + \varepsilon, i_2 - \varepsilon) = f(i_1, i_2)$.

Hypotheses for the aggregated indicator

H1. The aggregated indicator I_a is sensitive: if i_1 is a positive indicator(positive related to the aggregated indicator) then $\forall\ \varepsilon > 0$ we have $f(i_1 + \varepsilon, i_2) \geq f(i_1, i_2)$ and $f(i_1 - \varepsilon, i_2) \leq f(i_1, i_2)$.

As shown above, this hypothesis is natural (an increase of a positive primary indicator cannot lead to a decrease of the aggregated indicator).

H2. The aggregated indicator I_a has partial growths equally bounded:

$$\exists M > 0, \forall i_1, i_2 \in [0,1] \text{ and } \forall \varepsilon > 0 : \begin{cases} |f(i_1 + \varepsilon, i_2) - f(i_1, i_2)| \leq \varepsilon M \\ |f(i_1, i_2) - f(i_1, i_2 + \varepsilon)| \leq \varepsilon M \end{cases}$$

This hypothesis is an expression of the unexplosive aggregated indicator notion (a „small" increase of a primary indicator cannot lead to a "large" increase of the aggregated indicator). Indeed, a very small increase, infinitesimal, of any of the component indicator cannot lead, according to H2, to an explosive increase:

if $\varepsilon \to 0$ then $f(i_1+\varepsilon,i_2)-f(i_1,i_2)\to 0$ and $f(i_1,i_2)-f(i_1,i_2+\varepsilon)\to 0$.

In particular, if function *f* is partially continuous in relation to each argument, then H2 is verified. For example, the partial continuity in respect to the first variable involves an uniform continuity over the interval [0,1]:

$\forall \varepsilon > 0$ and $\forall i_1 \in [0,1]$, we have $i_1+\varepsilon-i_1 < 2\varepsilon$ so $|f(i_1+\varepsilon,i_2)-f(i_1,i_2)| \le \varepsilon$.

We can take in this case M=1.

Hypothesis H2 is also required by reality; the majority of the social-economic aggregated indicators, taking into account the way in which they are built, present the property of partial continuity, and implicitly H2 is verified.

Consequence:

The compensation function $g:\mathbb{R}\to\mathbb{R}, g(x)=f(i_1+x,i_2-x)$ is continuous, i_1 and i_2 being considered constant.

Indeed, if i_1 and i_2 are constant, then the continuity of *g* function returns in fact to the partial continuty of function *f*.

The impossibility theorem for indicator optimal aggregation

In the conditions of hypotheses H1 and H2, there is $\varepsilon > 0$ so that $f(i_1+\varepsilon,i_2-\varepsilon)=f(i_1,i_2)$ (the aggregated indicator is compensatory).

Demonstration

For x>0 we have the following:

$$|f(i_1+x,i_2-x)-f(i_1,i_2)| \le |f(i_1+x,i_2)-f(i_1,i_2)| + |f(i_1+x,i_2-x)-f(i_1+x,i_2)| \le$$
$$\le Mx+Mx=2Mx$$

(according to H1). Results that $\exists a > 0$ so that $-a \le f(i_1+x,i_2-x)-f(i_1,i_2) \le a$, $\forall x \in (0,a)$.

Knowing that the compensation function $g(x)=f(i_1+x,i_2-x)$ is continuous, presents the Darboux property, then there is $\varepsilon > 0$ so that $f(i_1+\varepsilon,i_2-\varepsilon)=f(i_1,i_2)$

(q.e.d.).

3. Observations

1. In proving the compensatory character, the sensitive aggregated indicator hypothesis did not intervene directly. Still, it is necessary in order to respect the relation between the model and reality.
2. In the case of aggregations with a number larger than 2 individual indicators, the idea being absolutely analogous, while the actual writing is somewhat harder.

A natural consequence of this theorem, with direct applicability in the study of capital markets, is that stock exchange indices, aggregated indicators, do not satisfy the optimality necessary conditions. In other words, there may be two situations on the market, apparently different, that are reflected by the same value of a stock exchange index.

A direct result concerns the comparability of stock exchange indices throughout time. Considering the conclusions of this theorem, we must show precaution when using stock exchange indices in comparisons.

References

1. Isaic-Maniu, Al. (coordinator) **Dictionar de statistica generala,** Ed. Economica, Bucharest, 2003, p. 133
2. Jaeger, R. **About educational indicators,** Review of Research in Education, 6, 1978, pp. 276-315
3. Paun, Gh. **Restrictii in problema indicatorilor sociali**, in Malita, M. and Marcus, S., (coord.) "Metode matematice in problematica dezvoltarii", Ed. Academiei RSR, Bucharest, 1982
4. Paun, Gh. **An Impossibility Theorem for Indicators Aggregation,** Fuzzy Sets and Systems; Vol. 9, No. 2; #351, February 1983; pp. 205-210
5. Paun, Gh. **Din spectacolul matematicii,** Ed. Albatros, Bucharest, 1983
6. Voineagu, V. (*et all*), **Analiza factoriala a fenomenelor social-economice in profil regional,** Ed. Aramis, Bucharest, 2002
7. *** * *** http://forum.europa.eu.int/irc/dsis/coded/info/data/coded /en/gl005032.htm

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[1] Paun, Gh.. **Restrictii in problema indicatorilor sociali**, in Malita, M. and Marcus, S., (coord.) "Metode matematice in problematica dezvoltarii", Ed. Academiei RSR, Bucharest, 1982

[2] Voineagu, V. (*et all*), **Analiza factoriala a fenomenelor social-economice in profil regional,** Ed. Aramis, Bucharest, 2002

[3] Ibidem.

[4] Paun, Gh. **An Impossibility Theorem for Indicators Aggregation,** Fuzzy Sets and Systems; Vol. 9, No. 2; #351, February 1983; pp. 205-210

[5] Paun, Gh. **Din spectacolul matematicii,** Ed. Albatros, Bucharest, 1983

[6] These can be, for example, the level of GDP per capita (reflecting economic development), the literacy rate (measuring the degree of education and culture of a population) or life expectancy at birth (reflecting the health status). These three indicators, through aggregation, contribute to defining the Human Development Index (HDI). See Isaic-Maniu, Al. (coordinator) **Dictionar de statistica generala,** Ed. Economica, Bucharest, 2003, p. 133

STATISTICAL ANALYSIS OF THE DIFFERENT SOCIO-ECONOMIC FACTORS AFFECTING THE EDUCATION OF N-W.F.P (PAKISTAN)

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Abstract: *A number of students in the urban and rural areas of N-W.F.P (Pakistan) and control group were collected to examine the various socio-economic factors which affect our education system. A logistic regression was applied to analyze the data and to select a parsimonious model. The response variable for the study is literate (illiterate) person(s) and the risk factors are Father literacy [FE], Father income[FI] Parents' attitude towards education[PA], Mother literacy [ME], Present examination system [PE], Present education curriculum [PC].*
The results of the analysis show that the factors Father Education combined with Parents' Attitude towards Education, Father Income combined with Mother Education, Father Income combined with Parents' Attitude towards Education are some of the factors which affect the education in N-W.F.P. Thus we concluded that there are a number of socioeconomic factors which affect our education.

Key words: *Logistic Regression; Stepwise Regression; Wald Test; Socio- economic Factors*

1. Introduction

Education is the basic need of human beings. It is also very important for the development of any country. Education is the responsibility of the state and government who should make every possible effort to provide it on an ever interesting and increasing scale in accordance with the national resources. The community should also realize its role in the development of education.

In Pakistan, 76% of the students in urban area are descendents of educated parents while in the case of the rural areas, this percentage is only 20%.

80% of the students in the urban area belong to high-income families while in the rural area 60% and 40% of the students belong to middle income and low-income families respectively, [8][3].

According to the 1998 census the adult literacy rate is 43.2%, this being a very low literacy rate. One of the main reasons for this low literacy rate, is the fact that only 1.1% of the GNP is invested in primary Education. That is why Pakistan is ranked 138 (out of 172) on the globe, [4]

The ultimate objective of development is to improve the living standards of people. In the present study, it has been tried to give a general structure of development particularly in Pakistan. In comparing the correlation of growth rates, GNP and literacy rates, Pakistan is found at the bottom of the world community. The physical quantity of life index (PQLI) is also computed, which is 40% in the case of Pakistan, being a very low value in comparison to other countries of the world,[1]

Pakistan is one of the countries of the world where the highest number of illiterates are concentrated. Being illiterate is not only an individual disability, it also has societal implications. Democratic institutions and values can hardly flourish in a society where half of the adult population is illiterate, and most of the voters cannot access information or read newspapers. The situation is particularly alarming for women and those living in rural areas. Illiteracy not only causes dependence, it deprives people of development of their fullest potential of participation in decision making at different levels, and ultimately rises to breed oppression and exploitation. Since its inception, governments in Pakistan have been endeavoring to eradicate illiteracy from the country. Although the overall literacy rate has increased gradually, the absolute number of illiterates has swelled significantly from 20.25 million in 1951 to 48.8 million in 1998, [3]

In Pakistan the strength of students in the class has little effect on the dropout rate. It is indicated that the dropout rate is higher in those schools where student/teacher ratio is lower. For instance in primary schools with strength of less than 70 students the students/teacher ratio is 28:1 and the dropout rate is 9%. On the other hand, in schools where the strength of students is around 1340 with a student/teacher ratio of 103:1, the dropout is amazingly less i.e. only one.

Looking at the opinions given by the teachers of GPS in Pakistan, in rural as well as urban areas, almost all the teachers agree that the main reasons for children dropping out from school at primary level are: limited opportunities of employment for educated youth and poverty i.e. boys from poor families have to help their fathers in farming and girls from poor families have to help their mothers in household activities. It is concluded that economic factors have a significant impact on children and they often drop out from schools due to poverty. It is also inferred that children often leave schools in early grades to become skilled workers.

It is concluded from the data collected that the average number of siblings in about 82% of the families of dropout children is four or more, whereas only 18% of the families have less than four children. Most of the fathers of dropout children are laborers, shopkeepers, helpers or attendants. Also a majority of them are either illiterate or have studied up to middle level only. In Pakistan poverty is major cause of dropout and thus students with a large number of sibling tend to dropout from school as the resources few,[5].

2. Methods and Materials

A sample of 500 students in the urban and rural area institutions of N.W-F.P (Pakistan) and control group was collected to examine the different socio-economic factors which affect our education system.

The response variable for the study is literate (illiterate) person(s).

Yi = 1, if literate
0, if illiterate

Risk factors selected for the study are

1. Father literacy [FE]
   FE= 1, if father is literate
   0, if father is illiterate
2. Father income[FI]
   FI= 1, if father income is more than Rs, 2000
   0, if father income is less than Rs, 2000
3. Parents' attitude towards education [PA]
   PA= 1, if parent's attitude is positive towards education.
   0, if parent's attitude is negative towards education.
4. Mother literacy[ME]
   ME= 1, if mother is literate
   0, if mother is illiterate
5. Present examination system[PE]
   PE= 1, if students like present examination system.
   0, if students not like present examination system.
6. Present curriculum of education[PC]
   PC= 1, if students like the present curriculum of education.
   0, if students not like the present curriculum of education.

The appropriate technique, used for model selection, in the case of binary response variable is logistic regression. Here we consider general linear models in which the outcome variables are measured on a binary scale.

The logistic regression model was first introduced by Berkson [2], who showed how the model could be fitted using iteratively reweighed least squares. Logistic regression is now widely used in social science research because many studies involve binary response variable. We look at basic notation underlying a logistic regression model.

The logistic model can now be written as

$$P = P(x) = \frac{e^{(\beta_0 + \sum \beta_i x_i)}}{1 + e^{(\beta_0 + \sum \beta_i x_i)}}, i = 1,2,...,m \qquad (1)$$

For a single explanatory variable X, the above model takes the form

$$P = \frac{e^{(\beta_0 + \sum \beta_1 x_1)}}{1 + e^{(\beta_0 + \sum \beta_1 x_1)}} \qquad (2)$$

We can draw inference from logistic regression. The main contribution in this case is that of [6], who provided general asymptotic results for maximum likelihood estimator, it follows that parameter estimator in the logistic models having large sample normal distribution. Thus a large sample 100(1-α) % confidence interval for parameter has the form

$$\hat{\beta} + z_{\alpha/2}\sigma\left(\hat{\beta}\right) \quad (3)$$

Where $\sigma\left(\hat{\beta}\right)$ is the estimated asymptotic standard error.

Let $\gamma = \left(\gamma_1, \gamma_2, \gamma_3, \ldots\ldots\ldots\ldots\ldots \gamma_q\right)$ denote a subset of normal parameters. Suppose we want to test H_0. Let M_1 denote the fitted model, and M_2 denote the simpler model with $\gamma=0$. Large sample test can use [7], likelihood ratio approach, with statistic test based on twice the log of ratio of maximized likelihood's for M_1 and M_2. Let L_1 denote the maximized log likelihood for M_1 and let L_2 denote the maximized likelihood for M_2 under H_0, the statistic test $-2\left(L_2 - L_1\right)$ has a large sample Chi –squared distribution with df=q. Alternatively, by the large sample normality of parameters estimator, the statistic

$$\gamma^{/}\left(Cov(\gamma)^{-1}\right)\gamma \quad (4)$$

has some limiting null distribution in large sample [6], This is called Wald statistic. When γ has a single element, this Chi square statistic with df=1 is the square of ratio of parameter estimate to its estimated standard error, that is

$$wald = \left[\frac{(estimate)}{s.e(estimate)}\right]^2 \quad (5)$$

In order to estimate the parameter we suppose that binomial data of the form y_i out of n_i trails $i = 1,2,3,\ldots,n$ are available. Where the logistic transform of the corresponding success probability p_i, or $\log it\left(p_i\right)$ is to be modeled as a linear combination of n explanatory variable, $x_{1i}, x_{2i}, x_{3i}, \ldots, x_{ni}$. So that

$$\log it(P_i) = \beta_0 + \beta_{1i}x_{1i} + \beta_{2i}x_{2i} + \beta_{3i}x_{3i} + \ldots + \beta_{ni}x_{ni} \quad (6)$$

In order to fit a linear logistic model to a given set of data the (n+1) unknown parameters, $\beta_0, \beta_1, \beta_2, \beta_3, \ldots, \beta_n$ have first to be estimated. These parameters are estimated using the method of maximum likelihood .The likelihood function is given by

$$L(\beta) = \Pi \overset{n_i}{\underset{y_i}{C}} P_i^{y_i}(1-p_i)^{n_i - y_i} \quad (7)$$

This likelihood depends on the unknown successes probabilities p_i which in turn depends on the β's the likelihood function can regarded as a function of β. The problem now is to obtain those values $\beta_{0,}\beta_{1,}\beta_{2,}\beta_{3,}.....,\beta_n$ which maximize L (β), or equivalently, $\log L(\beta)$

The logarithm of likelihood function is

$$\log L(\beta) = \sum_i \left[\log \overset{n_i}{\underset{y_i}{C}} + y_i\eta_i + n_i \log\left[1 + e^{\eta_i}\right] \right] \tag{8}$$

$\eta_i = {p_i}/{1 - p_i} = \sum \beta x_{ij}$ and $x_{0i} = 1$ for all values of i. the derivative of log likelihood function with respect to $n+1$ unknown β parameters are

$$\frac{\partial \log L(\beta)}{\partial \beta_j} = \sum y_i x_{ij} - \sum \eta_i x_{ji} e^{\eta_i (1+e^{\eta_i})}; j = 1,2,...,n \tag{9}$$

Once $\hat{\beta}$ has been obtained, the estimated value of the linear systematic component of the model is

$$\eta_i = \hat{\beta}_0 + \hat{\beta}_1 x_{1i} + \hat{\beta}_2 x_{2i} + \hat{\beta}_3 x_{3i} + ... + \hat{\beta}_n x_{ni} \tag{10}$$

this is unknown as the linear predictor. From this the fitted probabilities $\hat{p}_i$ can be found using

$$\hat{p}_i = {e^{\eta_i}}/{1 + e^{\eta_i}} \tag{11}$$

To fit an appropriate logistic model, which fits the data well, first we applied the forward methods to select the initial model for the backward elimination procedure. Logistic regression modeling is the appropriate statistical technique for this case because we wish to relate the chosen risk factors, which affect our education, which are binary variable. The objective of the study was to construct a model that could be used to predict the value of binary response variable. For fitting the models, we use the SPSS package. The variables used to determine an initial model are FE, MI, PA, ME, PE and PC. Different factors which were significant at different stages (at 5% level of significance) are FE is significant in one factor variable and the two factors which are significant $\mathrm{FE} * \mathrm{PA}, \mathrm{FI} * \mathrm{ME}, \mathrm{FI} * \mathrm{PE}, \mathrm{FI} * \mathrm{PA}$. While three factors FE*ME*PA, FI*PA*PE are significant, in four factors the interactions which are significant are FI*ME*MI*PA and FI*FE*PA*PE. For backward elimination we get model (FE, FE*PA, FI*ME, FI*PE, FI*PA, FE*ME*PA, FI*PA*PE, FE*ME*MI*PA, FI*FE*PA*PE).

Backward Elimination procedure

The best model is selected in one step automatically using SPSS. The model selected through SPSS is (FE*PA, FI*ME, FI*PA, FI*PA*PE). This model contains the main effect and two factor interaction. The following table gives information on log likelihood for the models selected in one step through backward elimination procedure.

Using SPSS we fit the model (FE*PA,FI*ME,FI*PA,FI*PA*PE) to estimate the model parameters and their standard error along with likelihood of the model. Also the odd ratios have been calculated and 95% confidence interval for odd ratio. The following table gives model summary.

Table 1. Variables in the equation

Step1		B	S.E	Wald	df	Sig.	Exp(B)	95% C.I For Exp(B)	
								Lower	Upper
	FE*PA	.243	0.325	14.671	1	.000	0.288	0.153	0.545
	FI*ME	0.797	0.321	6.158	1	.013	0.451	0.240	0.846
	FI*PA	0.734	0.368	3.982	1	.046	2.084	1.013	4.287
	FI*PA*PE	1.243	0.433	8.220	1	.004	3.465	1.482	8.103
	Constant	2.228	0.245	82.641	1	.000	9.280		

We see that the coefficients of the model parameters are highly significant. Hence the final selected model is

$$\text{Logit}(P) = 2.228+1.243\ FI{*}PA{*}PE +0.734\ FI{*}PA\ +0.797\ FI{*}ME + .243\ FE{*}PA$$

3. Conclusions

We have investigated the factors which affect our education in the model with one explanatory variable the main effect FE (father education) has a significant (p=.000) effect on education.

While the model having two factor variable FE*FI (father education and father income), variable FI*ME (father income and mother education), FI*PA (father income and parents attitude) has significant (p value=.000) on education.

The model having three factors, the factor FE*FI*ME (father education, father income and mother education), has significant effect on the education.

To obtain a best possible fitted logistic model, we use backward elimination procedures using SPSS package. We start form the model (FE, FE*PA, FI*ME, FI*PA, FE*ME*PA, FI*PA*PE, FE*ME*FI*PA, FI*FE*PA*PE), having four factors, three factors, two factors interaction and the main effect.

The best model is selected in one step automatically using SPSS. The model selected through SPSS is (FE*PA, FI*ME, FI*PA, FI*PA*PE). This model contains the main effect and three two factor interaction.

The factor which affects our education is "FE*PA", which means that the education of the child is depend on the education of the father and attitude of parents. The other factor are FI*ME means that father income and mother education also affect the education of the child. The father income and parents' attitude also affect the education of the child. The three factors are father income, parents' attitude and present examination system also affect our education.

References

1. Bahrawar, J., Iftihar, D. and Saima, M. **A comparative study of socio-Economic measures for development,** J. Sc and Tech., University of Peshawar, 1998
2. Berkson, J. **Application of the logistic function to bioassay,** Journal of American Statistical Association, 39, 1994, pp. 357-365
3. Breines, I. **Literacy trends in Pakistan,** UNESCO Office, Islamabad, 2003
4. Wald, A. **Test of Statistical Hypothesis concerning several parameters when the number of observation is large,** Transaction of American Mathematical Society, 54, 1943, pp. 426-482
5. Wilks, S.S. **The large-sample distribution of likelihood ratio for testing composite hypothesis,** Ann. Math. Stat, 9, 1938, pp. 60-62
6. Yousaf, M. **A comparative study of performances of rural and urban Students in science subjects at Secondary level in Mardan,** Bed thesis, Allama Iqbal Open University Islamabad, 2002
7. * * * **Census Report,** Statistical Bureau of Pakistan, 1998
8. * * * **Technical report,** National commission for human development Pakistan, 2005

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[3] Codification of references:

[1]	Bahrawar, J., Iftihar, D. and Saima, M. **A comparative study of socio-Economic measures for development,** J. Sc and Tech., University of Peshawar, 1998
[2]	Berkson, J. **Application of the logistic function to bioassay,** Journal of American Statistical Association, 39, 1994, pp. 357-365
[3]	Breines, I. **Literacy trends in Pakistan,** UNESCO Office, Islamabad, 2003
[4]	* * * **Census Report,** Statistical Bureau of Pakistan, 1998
[5]	* * * **Technical report,** National commission for human development Pakistan, 2005
[6]	Wald, A. **Test of Statistical Hypothesis concerning several parameters when the number of observation is large,** Transaction of American Mathematical Society, 54, 1943, pp. 426-482
[7]	Wilks, S.S. **The large-sample distribution of likelihood ratio for testing composite hypothesis,** Ann. Math. Stat, 9, 1938, pp. 60-62
[8]	Yousaf, M. **A comparative study of performances of rural and urban Students in science subjects at Secondary level in Mardan,** Bed thesis, Allama Iqbal Open University Islamabad, 2002

SPECIALISATION AND CONCENTRATION PATTERNS IN THE ROMANIAN ECONOMY[1]

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Abstract: *The economic specialisation of the regions and the spatial concentration of the economic activities are reflecting the same reality from two different perspectives. Our research is an attempt to capture the main patterns and the evolution of regional specialisation and sectoral concentration in the Romanian economy for selected years during 1996-2007 period, on the basis of the Gross Value Added and employment data, by branch and by region. We employed standard statistical measures of specialisation and concentration, combined with methods envisaging the amplitude and the speed of structural changes in order to highlight the various sides of these two complex phenomena.*

Key words: *specialisation; concentration; region; employment; Gross Value Added; Romania*

1. Introduction

Many studies in the regional economics literature have approached the issues of both industrial specialisation of regions/countries and geographic concentration of industries, considered to be two closely interrelated phenomena. The definitions of both regional specialisation and geographic concentration of industries are based on the same production structures, reflecting the same reality. Regional specialisation expresses the territorial perspective and depicts the distribution of the shares of the economic activities in a certain region, usually compared to the rest of the country, while geographic concentration of a specific economic activity reflects the distribution of its regional shares.

This topic is increasingly important to the economic policy and to the competitiveness: while the exploitation of the scale economies and of the specific endowments of the regions increases productivity, a highly specialised region is more vulnerable to the economic shocks in its leading sector. Structural shifts in the economy should be of high policy concern for Romania, as well. The transition of Romania to the market economy had already reshaped its economic structure, but the ongoing evolution of the global economy is currently bringing about new challenges and the need to adapt more rapidly.

The objective of this study is to contribute to the existing research by providing new empirical results on specialisation and concentration in the Romanian economy, from various perspectives highlighted by different statistical measures available.

The paper is organised as follows. Section 2 gives an overview of the relevant literature on this topic, while section 3 briefly describes the statistical indicators we selected for the measurement of concentration and specialisation in Romania. Sections 4 and 5 discuss the results, showing that the economic specialisation of the Romanian regions constantly decreased, while the degree of regional concentration of the main economic branches generally increased in the 1996-2007 period. The paper concludes with a summary of the main findings and directions for future research.

2. Theory and empirical evidence on specialisation and concentration

The industrial specialisation of regions is usually addressed in connection with the geographical concentration of industries, as “two sides of the same coin” (Aiginger and Rossi-Hansberg, 2006).

Regional specialisation describes the distribution of the sectoral shares in its overall economy compared to the whole country, whereas the geographical concentration of a specific industry reflects the distribution of its regional shares.

One of the main streams of the literature dedicated to regional specialisation refers to the mechanisms of this process, as described by Ricardo’s comparative advantage theory (1817) and Heckscher-Ohlin’s factor endowment theory (Heckscher, 1919, Ohlin, 1933). Then, neoclassical models and new models of trade also demonstrate how regional specialisation allows economies to benefit from their resource endowments (Krugman, 1991, Fujita, Krugman and Venables, 1999, Armstrong and Taylor, 2000).

Another category of models deals with the determinants of location and specialisation. Of a special interest are the mobile factors, considered the engine of the agglomeration process. The improvement of the factor endowment in the destination region increases its attraction as location for other manufacturing activities leading to a cumulative process. The location choice of the mobile factors is determined by the so-called centripetal and centrifugal forces (Krugman, 1998). Thus, the centripetal forces include the increasing returns to scale, localization and urbanisation economies, home market and price index effects. The centrifugal forces refer to the scarcity of immobile factors, congestion costs and the competition effects.

The size of the regions has been also taken into consideration in relation with the level of productive specialisation, being a priori assumed the existence of an inverse relationship between these two variables. Ezcurra et. al. (2006) discusses the idea that larger regions have a lower level of specialisation than the smaller regions owing to the more heterogeneous population and variations in physical factors. Though, when the role played by agglomeration economies is taken into consideration the increase in the level of specialisation in larger regions can be also demonstrated (Fujita et al., 1999, Fujita and Thisse, 2002).

The consequences of regional specialisation are highlighted by a series of growth models, including the classical core-periphery model (Myrdal, 1957 and Friedmann, 1977), growth pole model (Perroux, 1969), cumulative causation model (Dixon and Thirlwall, 1975), etc., applied at shifting scales (global, national, regional, local) and supporting either convergence or divergence in development level as a result of various inter-related, sometimes competing factors (Armstrong, 1994). The models based on product differentiation and economies of scale have demonstrated an increasing emphasis on intra-industry trade (world trade in similar products) rather than on inter-industry trade (world trade in different products), as predicted by traditional trade theories (Marshall (1920), as described by Krugman (1991)).

As mentioned before, regional specialisation is usually analysed in connection with industrial concentration, the latter being focused on "the distribution in the geographical dimension" (Aiginger, 1999, p.15).

The last two decades are characterised by special concerns with the development of special models and techniques and the adaptation of the existing ones for examining the particular aspects revealed by industrial concentration. Thus, Ellison and Glaeser (1997) propose a model able to motivate new indices of geographical concentration and co-agglomeration. They take into consideration localized industry-specific spillovers, natural advantages and pure random chance so that the resulted indices are able to reflect the differences in size distribution of plants and size of geographical areas. In their view location spillovers refer to both physical spillovers (as defined by Krugman (1991), who considers that the presence of one firm diminishes the transportation costs for another one) and intellectual spillovers (as defined by Glaeser et al., 1992). Subsequently, the authors demonstrate that by means of these indices "comparisons of the degree of geographical concentration across industries can be made with confidence" (p.889).

Other authors have deepened various existing techniques in order to open new directions of investigation and broaden the "classical" conclusions in the field.

For example, Acar and Sankaran (1999) have focused on "the trend towards specializing the Herfindahl index for measuring industry concentration and entropy measure for expressing firm diversity" (p.969). By decomposing both Herfindahl index and entropy they argue that the advantage of entropy measures with regard to decomposability is also shared by Herfindahl index, which proves to be even more versatile in terms of inversion than the entropy measure.

In another register, by comparing the results obtained for two different countries – United States and New Zealand - Michelini and Pickford (1995) have demonstrated that the high correlation between concentration ratio and Herfindahl index may be biased upward when estimated Herfindahl index is used. As a result, they propose a new family of Herfindahl indices estimators which is derived from the upper and lower limits rather than generalized assumptions about firm size distribution.

Although the bulk of the literature on specialization and concentration implicitly or explicitly treated the two phenomena as interrelated, there are some empirical outcomes suggesting they would rather be considered as independent processes since they "might not in all cases move in the same direction, and are probably going to take place at different speeds" (Dalum et al., 1998, p. 2). Furthermore, the model in Rossi-Hansberg (2005) was used for empirically proving that specialization and concentration may even go in opposite directions when transport costs change. More specifically, as transport costs lower the degree of concentration tend to increase, while the level of specialization decreases (Aiginger and Rossi-Hansberg, 2006).

Starting from these overall considerations this paper proposes an insight into regional specialisation and industrial concentration issues in Romania.

3. Statistical measures for specialisation and concentration

As emphasized by the existing literature, the definitions of both regional specialisation and geographic concentration of industries are based on the same production structures, reflecting the same reality (Aiginger, 1999). Specialisation of a certain region expresses the distribution of the shares of economic branches in its overall economy, usually compared to the rest of the country. A region is considered to be highly specialized if a small number of industries have a large combined share in the economy of that region. Geographic concentration of a specific sector reflects the distribution of its shares by region. A highly concentrated sector will have a very large part located in a small number of regions.

In order to explore the main patterns and the interaction between specialisation and concentration in the Romanian economy, we had to select the statistical indicators and the variables that give data for the quantification of the trends. We combined standard statistical measures with indicators of the amplitude and the speed of structural changes and we also combined static and dynamic analysis, by computing the same indicator for different years and by using indicators that explicitly consider time variation. As regards the variables to be addressed for measurements, we have chosen Gross Value Added and the number of employed population, both very popular in most of the empirical studies on this topic.

The first step in any concentration and specialisation empirical analysis consists of computing the ***concentration and specialisation ratios***:

$$g_{ij}^{C} = \frac{E_{ij}}{\sum_{i=1}^{n} E_{ij}} = \frac{E_{ij}}{E_j} \text{ and } g_{ij}^{S} = \frac{E_{ij}}{\sum_{j=1}^{m} E_{ij}} = \frac{E_{ij}}{E_i},$$

where:

g_{ij}^{C} - the concentration ratio: the share of the region/county i in the total national employment or Gross Value Added of industry j;

g_{ij}^{S} - the specialisation ratio: the share of the industry j in the total employment or Gross Value Added of region/county i;

E_{ij} - employment or Gross Value Added in industry j in the region/county i;
E_j – national employment or Gross Value Added in industry j;
E_i - total employment or Gross Value Added in the region i;
i – region/county; j- industry.

Although these ratios are used mainly as a basis for many of the more complex and sophisticated measures of concentration and specialisation, they can by themselves offer valuable information by depicting the general image of the spatial distribution of industries and by detecting spatial irregularities.

The first synthetic statistical indicator that we employed in this study is the ***Herfindahl-Hirschman Index***, an absolute measure of concentration/specialisation which is probably the most commonly used:

$$H_j^C = \sum_{i=1}^{n} (g_{ij}^C)^2 \quad \text{and} \quad H_i^S = \sum_{j=1}^{m} (g_{ij}^S)^2 ,$$

where: $g_{ij}^C = \dfrac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} = \dfrac{X_{ij}}{X_j}$ and $g_{ij}^S = \dfrac{X_{ij}}{\sum_{j=1}^{m} X_{ij}} = \dfrac{X_{ij}}{X_i}$

H_j^C - the Herfindahl index for concentration

H_i^S - the Herfindahl index for specialisation

i – region; j- branch
X – Gross Value Added or employment;
X_{ij} - Gross Value Added or employment in branch j in region i;
X_j – total Gross Value Added or employment in branch j;
X_i - total Gross Value Added or employment in region i;
g_{ij}^C - the share of region i in the total national value of branch j;
g_{ij}^S - the share of branch j in the total value of region i.

The Herfindahl index is increasing with the degree of concentration/specialization, reaching its upper limit of 1 when the branch j is concentrated in one region or the region i is specialized in only one branch.

The main weakness of the Herfindahl index is the sensitivity of its lower limit to the number of observations: the lowest level of concentration is 1/n (when all regions have equal shares in branch j), while the lowest specialisation is 1/m (when all branches have equal shares in region i).

As an absolute measure, this indicator has another important shortcoming: big regions, because of their larger shares, heavily influence the changes in the concentration/specialisation (the index is biased towards the larger regions).

When computed out of county level data, the Herfindahl Index ranges between 0.0238 and 1 in Romania. We also have to note that the results are very much dependent on the fineness of the industrial classification employed.

Another well-known indicator is the ***Krugman Dissimilarity Index*** used for measuring either the concentration (K_j^C) or specialisation level (K_i^S):

$$K_j^C = \sum_{i=1}^{n} \left| g_{ij}^C - g_i \right| \text{ and } K_i^S = \sum_{j=1}^{m} \left| g_{ij}^S - g_j \right| \text{, where } g_i = \frac{X_i}{X} \text{ , } g_j = \frac{X_j}{X}$$

and X stands for the total (national) Gross Value Added or employment.

The Krugman Index is a relative measure of specialisation/concentration which compares one branch/region with the overall economy. A slightly different form of the index may be used to compare two countries/regions. Its values range from 0 (when all territorial/sectoral structures are identical) to 2 (for totally different structures).

The third indicator, the ***Lilien Index*** captures the speed of the sectoral employment reallocation in the economy, as the main factor of differences in specialisation (Lilien, 1982). The Lilien Index is calculated for each region i as:

$$L_i^S = \sqrt{\sum_{j=1}^{m} \frac{X_{ij}}{X_i} (\Delta \log X_{ij} - \Delta \log X_i)^2} \text{ , where:}$$

$\frac{X_{ij}}{X_i}$ - the share of branch j in the total employment of region i;

X_{ij} - employment in branch j in region i;
X_i - total employment in region i;
Δ - the first difference operator

Based on his index, Lilien (1982) found that a large part of the time-series variation in the U.S. unemployment since World War II can be considered the result of employment reallocation shocks in the economy. The outcome is partly contested by some authors considering that it is the potential correlation between this index and the effects of aggregate cyclical disturbances that have to be taken into account. Nevertheless, the Lilien Index is still considered to be a useful measure of the speed of structural changes. The higher the value of this indicator, the faster the structural changes and the bigger the reallocations of employment between branches. It also indicates the ability of an economy to flexibly react and quickly adapt to changes in aggregate demand.

The fourth indicator is a ***clustering index of concentration*** originating in the gravity models. It measures the spatial dispersion of the economic activities by summing up the distance-weighted data of all the pairs of regions:

$$C_j^C = \frac{\sum_i \sum_k \left(\frac{X_{ij} X_{kj}}{d_{ik}} \right)}{\sum_i \sum_k \left(\frac{X_i X_k}{d_{ik}} \right)} \text{ with } i \neq k,$$

where:
X_{ij} - Gross Value Added or employment in branch j in region i;
X_{kj} – Gross Value Added or employment in branch j in region k;
X_i - total Gross Value Added or employment in region i;
X_k - total Gross Value Added or employment in region k;
d_{ik} – the geographic distance between capitals of regions i and k.

This indicator increases with the degree of concentration, indicating if similar economic activities take place in geographically low distanced regions.

The last indicator employed in our research is the ***coefficient of absolute structural changes***, used for measuring the average change in sectoral or territorial shares recorded in different units of time:

$$\tau_{g_1-g_o} = \sqrt{\frac{\sum_{i=1}^{n}(g_{1i} - g_{oi})^2}{n}},$$

where g_{1i} and g_{oi} are the sectoral or regional shares i in two time periods 1 and 0.

The indicator increases with the intensity of the time changes in either specialisation or concentration. We also used it for comparing concentration and specialisation ratios computed out of different data sets (Appendix 1).

The selected statistical indicators of concentration and specialisation have been calculated using data on Gross Value Added and the number of employed population. Sectoral and regional data sets for this study were provided by Romanian official statistics, the common sectorial classification available for the entire time span consisting of nine main economic branches. Comparable regional data were available only starting with the year 1996, therefore the entire time span envisaged by our research was 1996-2007, divided into a period of prevalent economic decline (until 2000), followed by sustained economic growth. The results will be discussed in the following two sections.

4. The economic specialisation of the Romanian regions

The Herfindahl index for specialisation clearly shows a decrease in the level of economic specialisation for all Romanian regions and for the entire period (Table 1). Although the results slightly differ depending on the variable used for measurements (Gross Value Added data yields smaller values of the index compared to employment data) this trend is followed by all regions.

As a high degree of specialisation entails economic vulnerability (e.g. the mining industry in Southern Romania) and is usually associated with a lower level of development, this a positive trend for Romania. Developed regions generally display smaller and further declining degrees of specialisation as revealed by recent EU studies (Marelli, 2006). The most developed region in Romania – Bucharest-Ilfov – has by far the smallest degree of specialisation in all selected years, if computed out of employment data (Table 1).

Table 1. The Herfindahl Index for the specialisation of the regions

	Herfindahl Index based on Gross Value Added data				Herfindahl Index based on employment data			
	1996	2000	2005	2007	1996	2000	2005	2007
NE	0.2044	0.1712	0.1484	0.1418	0.2785	0.3234	0.2600	0.2304
SE	0.1966	0.1599	0.1549	0.1550	0.2369	0.2682	0.2160	0.1921
S	0.2346	0.1783	0.1860	0.1991	0.2768	0.3089	0.2486	0.2202
SV	0.2181	0.1842	0.1712	0.1730	0.2841	0.3210	0.2589	0.2258
V	0.2010	0.1586	0.1675	0.1716	0.2288	0.2331	0.2071	0.1903
NV	0.2076	0.1528	0.1594	0.1633	0.2610	0.2849	0.2275	0.1998
C	0.2598	0.1829	0.1870	0.1865	0.2580	0.2393	0.2069	0.1890
BI	0.2105	0.1791	0.1625	0.1733	0.1907	0.1613	0.1519	0.1565

Specialisation in 2007 reaches its peak in the South region (specialised in industry), when measured out of GVA data, but its highest value is to be found in the North-East region (agriculture) when based on employment data (Table 1).

Table 2. The Krugman Dissimilarity Index for the specialisation of the regions

	Krugman Dissimilarity Index based on Gross Value Added data				Krugman Dissimilarity Index based on employment data			
	1996	2000	2005	2007	1996	2000	2005	2007
NE	0.1319	0.2570	0.1574	0.1843	0.1732	0.2031	0.2389	0.2505
SE	0.1007	0.1207	0.1068	0.0885	0.1588	0.1008	0.0973	0.0944
S	0.1412	0.1707	0.1844	0.2292	0.1184	0.1405	0.1505	0.1662
SV	0.1158	0.2338	0.1754	0.1856	0.1877	0.1938	0.2046	0.1961
V	0.1098	0.0479	0.0688	0.0698	0.1009	0.1193	0.1414	0.1440
NV	0.1303	0.1205	0.0685	0.0831	0.0969	0.0988	0.0912	0.0924
C	0.1637	0.1433	0.1387	0.1726	0.1870	0.1843	0.1583	0.1623
BI	0.4191	0.4263	0.3726	0.3725	0.6023	0.7050	0.6133	0.6060

Despite the decrease in the level of specialisation, the dissimilarities between the economic structures of the regions were significant (Table 2). The Krugman Dissimilarity Index diminished in some regions and amplified in many others illustrating the divergence among the regions as regards their sectoral structures.

Except for Bucharest-Ilfov, Krugman Index was relatively low in Romania in 2007 when compared to Poland (0.508) or Lithuania (0.328), but is much higher than in EU15, where it is below 0.150 for most of the countries, reaching a minimum of 0.063 in Austria and 0.064 in Deutschland (Marelli (2006), based on regional employment data).

The Herfindahl Index and the Krugman Dissimilarity Index of specialisation both showed significantly higher values when computed out of employment data, but the trend is similar irrespective of the variable employed (Tables 1 and 2). The regional variation of the Herfindahl Index is much smaller compared to the Krugman Dissimilarity Index (Appendix 3). For both indices, Bucharest-Ilfov region displays the strongest distance to the other regions: the smallest degree of specialisation and a structure of economic activities very different from all other regions. These results are in line with its privileged position as the most developed region in Romania, concentrating a big part of the national wealth.

Table 3. Regional changes in specialisation

	Coefficient of structural changes based on Gross Value Added data (pp*)			Coefficient of structural changes based on employment data (pp*)		
	1996-2000	2001-2005	2005-2007	1996-2000	2001-2005	2005-2007
NE	3.39	3.40	1.82	3.42	2.80	1.56
SE	4.70	2.69	1.33	2.39	3.35	1.63
S	5.10	3.49	1.22	3.74	3.20	1.58
SV	4.60	3.54	0.99	3.20	3.00	1.75
V	6.54	2.92	1.20	2.23	3.23	1.37
NV	7.41	2.30	0.78	3.05	3.60	1.78
C	5.83	2.91	0.90	2.97	2.90	1.56
BI	9.70	3.79	1.99	2.78	3.07	2.45

** percentage points*

The values of the coefficient of absolute structural changes (Table 3) had a relatively small variation from a region to another in the last two time periods envisaged. There was a slightly reduction of its values during the interval 2001-2005, a period of sustained economic growth, compared to the previous interval of economic decline, for all regions, irrespective of the data employed. The decline in the intensity of structural changes by region was even stronger in 2005-2007 period, mainly as a statistical effect of the shorter time span. In 2005-2007 period, the economic sectors changed their shares in a region on average by 0.78-1.82 percentage points based on production data and by 1.37-2.45 percentage points based on employment data.

The Bucharest-Ilfov region experienced the strongest changes in all time periods.

Table 4. The speed of changes in specialisation

	The Lilien Index		
	1996-2000	2001-2005	2005-2007
NE	0.1887	0.1887	0.1393
SE	0.1643	0.2079	0.1281
S	0.1986	0.2070	0.1183
SV	0.1928	0.1836	0.1351
V	0.1490	0.2019	0.1167
NV	0.1683	0.2178	0.1487
C	0.1678	0.2139	0.1315
BI	0.1855	0.2456	0.1958

The Lilien Index (Table 4) points to significant structural changes and reallocation of employment between sectors, thus proving that the economy is adapting to changes in the aggregate demand. Similar to the previous indicator, it reveals a decrease in the magnitude of structural changes. Nevertheless we should keep in mind that it only partially shows the region's ability to change, since the shift of resources that occurs within the framework of each sector cannot be captured by the Lilien Index.

5. Regional concentration of economic activities in Romania

The Herfindahl Index for concentration (Table 5) shows lower values than the specialisation Herfindahl Index and relatively little variation in respect to the data employed (GVA or employment data), possibly as a result of using broad economic sectors, because a finer regional disaggregation of branches was not available.

Opposite to the declining trend of specialisation, concentration of economic activities was bigger in 2007 compared to 1996 in all branches, except for education, where it felt slightly. As expected, health and social assistance is at the lower margin of concentration in production. Industry, as a whole, also has a small value of the indicator, but the degree of concentration is certainly bigger for most of its branches, as industries usually have high economies of scale, which determines their concentration in fewer locations.

Table 5. The Herfindahl Index for concentration

	Herfindahl Index based on Gross Value Added data				Herfindahl Index based on employed population data			
	1996	2000	2005	2007	1996	2000	2005	2007
Agriculture[1)]	0.1418	0.1435	0.1434	0.1434	0.1477	0.1489	0.1482	0.1484
Industry [2)]	0.1301	0.1286	0.1287	0.1309	0.1299	0.1287	0.1279	0.1281
Construction	0.1348	0.1364	0.1631	0.1502	0.1306	0.1298	0.1476	0.1427
Trade[3)]	0.1361	0.1618	0.1593	0.1582	0.1286	0.1282	0.1311	0.1329
Transport and communications	0.1407	0.1464	0.1517	0.1780	0.1322	0.1323	0.1386	0.1374
Real estate transactions and other services	0.1527	0.1841	0.1516	0.1627	0.1694	0.1652	0.1767	0.1952
Public administration and defence	0.1304	0.1991	0.1504	0.1490	0.1306	0.1318	0.1330	0.1323
Education	0.1317	0.1295	0.1309	0.1314	0.1300	0.1293	0.1304	0.1298
Health and social assistance	0.1280	0.1276	0.1293	0.1296	0.1290	0.1278	0.1286	0.1281

[1)] *including hunting and sylviculture, fishery and pisciculture*
[2)] *including electric and thermal energy, gas and water.*
[3)] *including hotels and restaurants*

From the production point of view, in 2007 transport and communications was the most concentrated sector (in Bucharest-Ilfov), while the biggest concentration in employment was recorded for real estate transactions and other services (Bucharest-Ilfov).

Table 6. The Krugman Dissimilarity Index for concentration

	Krugman Dissimilarity Index based on Gross Value Added data				Krugman Dissimilarity Index based on employed population data			
	1996	2000	2005	2007	1996	2000	2005	2007
Agriculture[1)]	0.3894	0.3927	0.3894	0.420	0.2721	0.2823	0.2773	0.2785
Industry [2)]	0.1934	0.1475	0.1446	0.188	0.1180	0.1112	0.1251	0.1368
Construction	0.1675	0.1131	0.2161	0.144	0.1964	0.1717	0.2953	0.2598
Trade[3)]	0.0774	0.1884	0.1665	0.142	0.1384	0.1403	0.1664	0.1843
Transport and communications	0.1117	0.0984	0.1650	0.233	0.1969	0.2068	0.2557	0.2251
Real estate transactions and other services	0.1512	0.2969	0.1412	0.165	0.3943	0.3794	0.4298	0.5030
Public administration and defence	0.2518	0.3547	0.1408	0.137	0.1275	0.1643	0.1643	0.1563
Education	0.2200	0.2096	0.1906	0.213	0.0879	0.0866	0.1119	0.1085
Health and social assistance	0.1897	0.1502	0.1315	0.149	0.0514	0.0684	0.0703	0.0723

[1)] *including hunting and sylviculture, fishery and pisciculture*
[2)] *including electric and thermal energy, gas and water.*
[3)] *including hotels and restaurants*

The increase in the degree of concentration was accompanied by a rise in the regional dissimilarities for most of the main economic branches, as Krugman Index points out (Table 6). The biggest dissimilarities were displayed by agriculture (dependent on the natural factors endowment) when using GVA data, and real estate (heavily concentrated in Bucharest-Ilfov) when employment data are used.

There is a relatively strong concordance between the results of Herfindahl and Krugman indices, but the variation of the Herfindahl Index by economic sector is much smaller compared to the Krugman Dissimilarity Index (Appendix 2).

Table 7. Structural changes by branch

	Coefficient of structural changes based on Gross Value Added data (pp*)			Coefficient of structural changes based on employed population data (pp*)		
	1996-2000	2001-2005	2005-2007	1996-2000	2001-2005	2005-2007
Agriculture[1)]	1.16	1.34	0.53	0.12	0.28	0.03
Industry [2)]	1.16	1.42	0.90	0.96	0.67	0.32
Construction	1.49	3.91	1.38	3.22	0.76	0.77
Trade[3)]	3.39	0.60	0.27	0.71	1.31	0.48
Transport and communications	1.63	1.34	2.60	0.91	1.83	0.56
Real estate transactions and other services	3.60	5.02	1.22	0.89	0.90	1.47
Public administration and defence	11.24	0.41	0.33	0.81	1.05	0.26
Education	0.78	0.82	0.32	0.58	0.33	0.27
Health and social assistance	1.31	0.89	0.29	1.12	0.93	0.31

** in percentage points*
[1)] *including hunting and sylviculture, fishery and pisciculture*
[2)] *including electric and thermal energy, gas and water.*
[3)] *including hotels and restaurants*

The coefficient of structural changes shows little movement in the territorial distribution of the economic branches, but our broad disaggregation of sectors may hide stronger internal changes within each one (Table 7).

Table 8. Clustering measures of concentration

	Clustering Index based on Gross Value Added data				Clustering Index based on employed population data			
	1996	2000	2005	2007	1996	2000	2005	2007
Agriculture[1)]	0.072	0.054	0.054	0.055	0.083	0.082	0.070	0.066
Industry [2)]	0.089	0.070	0.072	0.074	0.107	0.106	0.091	0.085
Construction	0.086	0.070	0.071	0.070	0.105	0.106	0.094	0.087
Trade[3)]	0.088	0.073	0.072	0.071	0.103	0.108	0.092	0.087
Transport and communications	0.089	0.072	0.070	0.071	0.101	0.108	0.094	0.089
Real estate transactions and other services	0.094	0.071	0.072	0.072	0.120	0.116	0.101	0.092
Public administration and defence	0.080	0.075	0.073	0.072	0.111	0.113	0.096	0.089
Education	0.079	0.064	0.064	0.063	0.099	0.100	0.085	0.080
Health and social assistance	0.082	0.065	0.066	0.066	0.100	0.100	0.087	0.082

[1)] *including hunting and sylviculture, fishery and pisciculture*
[2)] *including electric and thermal energy, gas and water.*
[3)] *including hotels and restaurants*

Not surprisingly, the clustering index (Table 8) displays its highest value in industry, as it is less spatially dispersed, exploiting the advantages of the economies of scale, while the agriculture and its production is more evenly dispersed.

All the previous statistical indicators of concentration and specialisation showed significant dissimilarities depending on the data employed: Gross Value Added or employment data. As the concentration and specialisation ratios are the basis for most of the synthetic indicators, we measured the average distance between their values computed out of GVA data against employment data and found out that the differences are important (Appendix 1), therefore the variables should be carefully considered when comparing the results coming from different studies on concentration and specialisation.

6. Concluding comments

In this paper we have explored the main characteristics and the interaction between regional specialisation and sectoral concentration in Romanian economy during 1996-2007 period using various statistical indicators. Production and employment data are the most popular data choices for the measurement of concentration and specialisation. We used both of them and found out important differences in the level of resulting values of the statistical indicators and in their regional and sectoral hierarchies as well. The values of the concentration and specialisation measures are also very sensitive to the level of dissagregation of the data. For instance, concentration increases with the number of sectors envisaged.

We found a low and decreasing degree of economic specialisation for all the regions, while the concentration level is slightly increasing for most of the economic sectors, in contradiction with the "traditional" theories which predict similar, if not identical, evolutions of concentration and specialisation. Even if concentration and specialisation are two different ways to look at the same data, given the unequal size of the regions/sectors and the fact that the synthetic indicators computed reflect the entire distribution of shares, concentration and specialisation may go in opposite directions. The outcomes of our research are in line with the new theories stating that divergent evolutions of specialisation and concentration are possible (e.g. the Rossi-Hansberg model), although the robustness these results still has to be check on a longer period of time and a finer dissagregation of data.

Important dissimilarities exist as regards the sectoral structures of the regions and the territorial distributions of the economic sectors, as well.

Another major finding of the study is that the speed of structural changes within regions was significant; important reallocations of employment took place in order to adapt to the changing economic environment.

Further research will be needed in order to explore the driving forces of specialisation and concentration in Romania. There is also a need to deepen the analysis, both in absolute and relative terms, by using a finer territorial and sectoral dissagregation which will bring more information.

References and Selected Bibliography

1. Acar, W. and Sankaran, K. **The Myth of the Unique Decomposability. Specializing the Herfindahl and Entropy Measures?,** Strategic Management Journal, Vol. 40, No.10, 1999, pp.969-975
2. Aiginger, K. **Do industrial structures converge? A survey on the empirical literature on specialisation and concentration of industries,** WIFO-Working papers, 1999
3. Aiginger, K. and Rossi-Hansberg, E. **Specialisation and concentration: a note on theory and evidence,** Empirica, vol. 33, 2006, pp. 255-266
4. Amiti, M. **Specialisation Patterns in Europe,** Weltwirtschaftliches Archiv, 135 (4), 1999, pp. 573-593
5. Armstrong, H. and Taylor, J. **Regional Economics and Policy,** Blackwell, 2000
6. Dalum, B., Laursen, K. and Villumsen, G. **Structural change in OECD Export Specialisation Patterns: De-specialisation and "Stickiness",** Department of Business Studies, Aalborg University, 1998
7. Dixon, R.J. and Thirlwall, A.P. **A model of regional growth differentials along Kaldorian lines,** Oxford Economic Papers, Vol. 27, No. 2, 1975, pp.201-214
8. Ellison, G. and Glaeser, E. **Geographical Concentration in the US Manufacturing Industries: A Dartboard Approach,** The Journal of Political Economy, Vol. 105, No.5, 1997, pp. 889-927
9. Ezcurra, R., Pascual, P. and Rapun, M. **Regional Specialisation in the European Union,** Regional Studies, Vol. 40, No. 6, 2006, pp. 601-616
10. Friedman, M **Inflation and Unemployment,** Journal of Political Economy, Vol. 85, 1977, pp. 451-472
11. Fujita, M., Krugman, P. and Venables, A. **The Spatial Economy,** MIT Press, Cambridge, 1999
12. Fujita, M. and Thisse, J.F. **Economies of Agglomeration. Cities, Industrial Location and Regional Growth,** Cambridge University Press, 2002
13. Glaeser, E.L., Kallal, H.D., Scheinkman, J.A. and Schleifer, A. **Growth in Cities,** The Journal of Political Economy, Vol. 100, December 1992, pp. 1126-1152
14. Goschin, Z., Constantin, D.L., Roman, M. and Ileanu, B. **Regional Specialisation and Geographic Concentrantion of Industries in Romania,** South-Eastern Europe Journal of Economics, No. 1, 2009, pp. 61-76
15. Heckscher, E. **The Effect of Foreign Trade on Distribution of Income,** Economisk Tidskrift, 21, 1919, pp. 1-32
16. Krugman, P. **Geography and Trade,** MIT Press, Cambridge, 1991
17. Krugman, P. **What's new about the new economic geography?,** Oxford Review of Economic Policy, 14, 1998, pp. 7-17
18. Lilien, D.M. **Sectoral Shifts and Cyclical Unemployment,** Journal of Political Economy, no 90, 1982, pp. 777-793
19. Marelli E. **Specialisation and Convergence of European Regions,** The European Journal of Comparative Economics, No. 2, 2006, pp. 149-178
20. Marshall, A. **Principles of Economics, 8th edition,** Macmillan, London, 1920
21. Michelini, C. and Pickford, M. **Estimating the Herfindahl Index from Concentration Ratio Data,** Journal of the American Statistical Association, Vol. 80, No. 390, 1995, pp. 301-305
22. Myrdal, G. **Economic Theory and Underdeveloped Regions,** London, 1957
23. Ohlin, B. **Interregional and International Trade,** Harvard University Press, Cambridge, 1933
24. Perroux, F. **L'économie du XX-e siécle,** Presses Universitaire de France, Paris, 1969
25. Ricardo, D. **On the Principles of Political Economy and Taxation (edition 1971),** Penguin, Harmondsworth, 1817
26. Rossi-Hansberg, E. **A spatial theory of trade,** American Economic Review, 95(5), 2005, pp. 1464-1491

Appendix 1.

Average diferences in the values of specialisation ratios depending on the data (Gross Value Added against employment data)

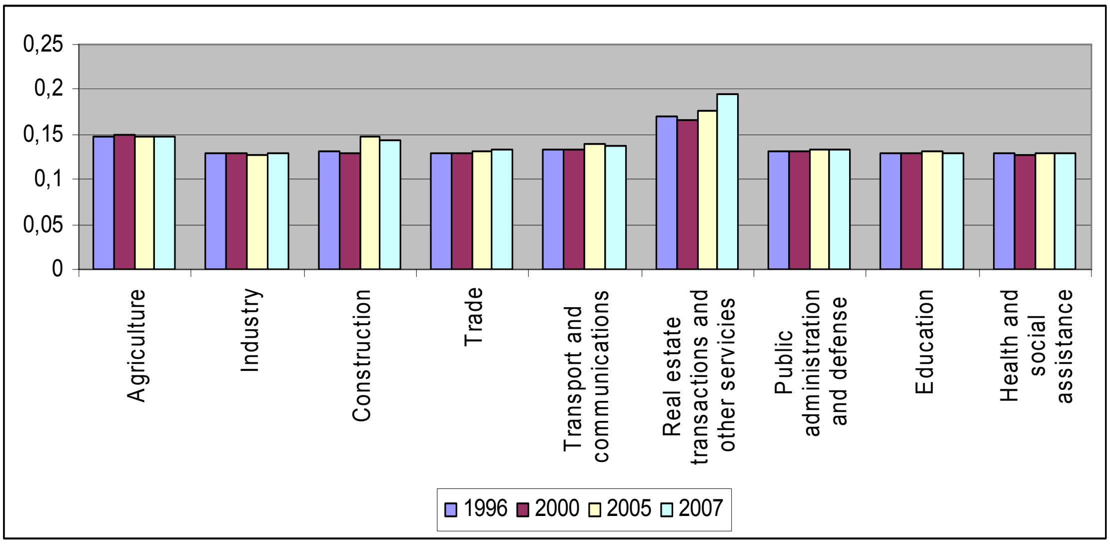
	1996	2000	2005	2007
NE	0.071834	0.122581	0.110759	0.103202
SE	0.066161	0.115035	0.091655	0.084518
S	0.063294	0.128728	0.106909	0.103046
SV	0.080508	0.140942	0.11597	0.107766
V	0.03053	0.099805	0.075259	0.074056
NV	0.054316	0.129365	0.095651	0.086891
C	0.040757	0.089038	0.072832	0.065679
BI	0.034053	0.082352	0.040819	0.04546

Average diferences in the values of concentration ratios depending on the data (Gross Value Added against employment data)

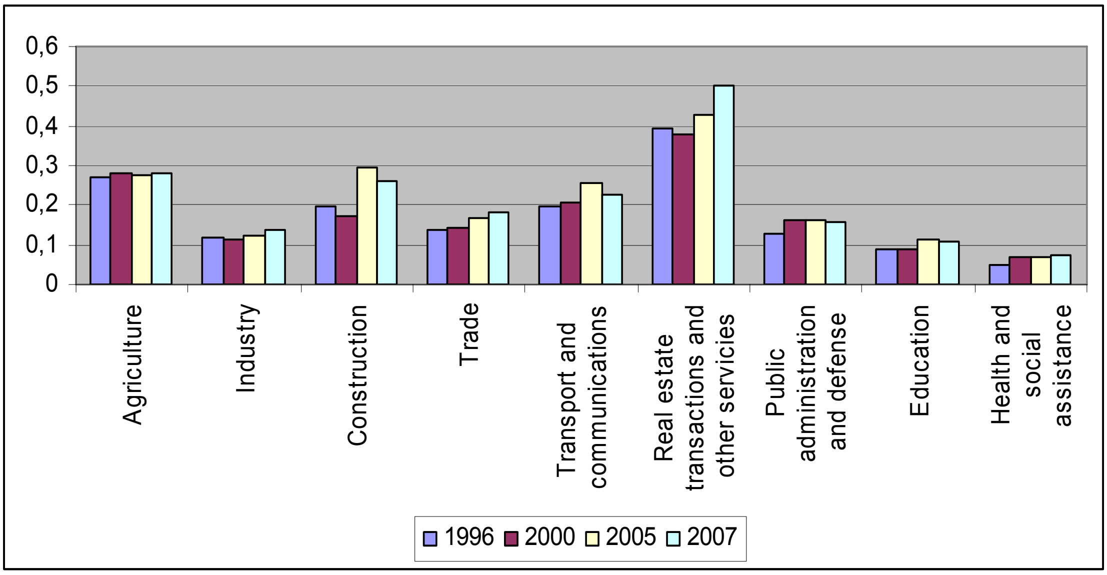
	1996	2000	2005	2007
Agriculture	0.020482	0.06552	0.018082	0.02005
Industry	0.014831	0.047787	0.020749	0.024712
Construction	0.012229	0.049696	0.017531	0.012438
Trade	0.028271	0.037162	0.041087	0.035919
Transport and communications	0.034124	0.066151	0.022524	0.047896
Real estate transactions and other servicies	0.019951	0.036997	0.026461	0.02746
Public administration and defense	0.033389	0.033965	0.026637	0.027267
Education	0.006448	0.012396	0.005221	0.006074
Health and social assistance	0.004322	0.006841	0.009046	0.010184

Appendix 2. Concentration measures based on employment data

The Herfindahl Index

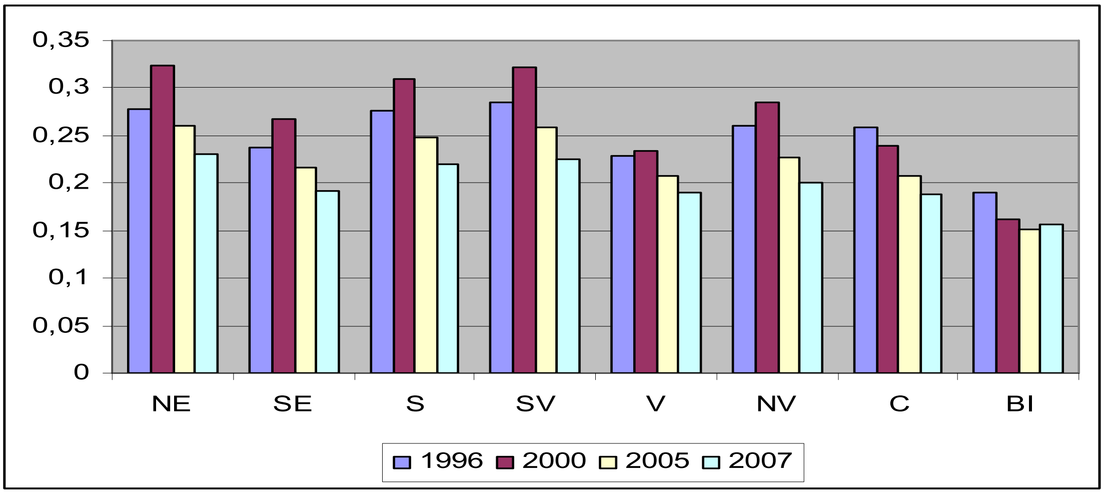


The Krugman Index

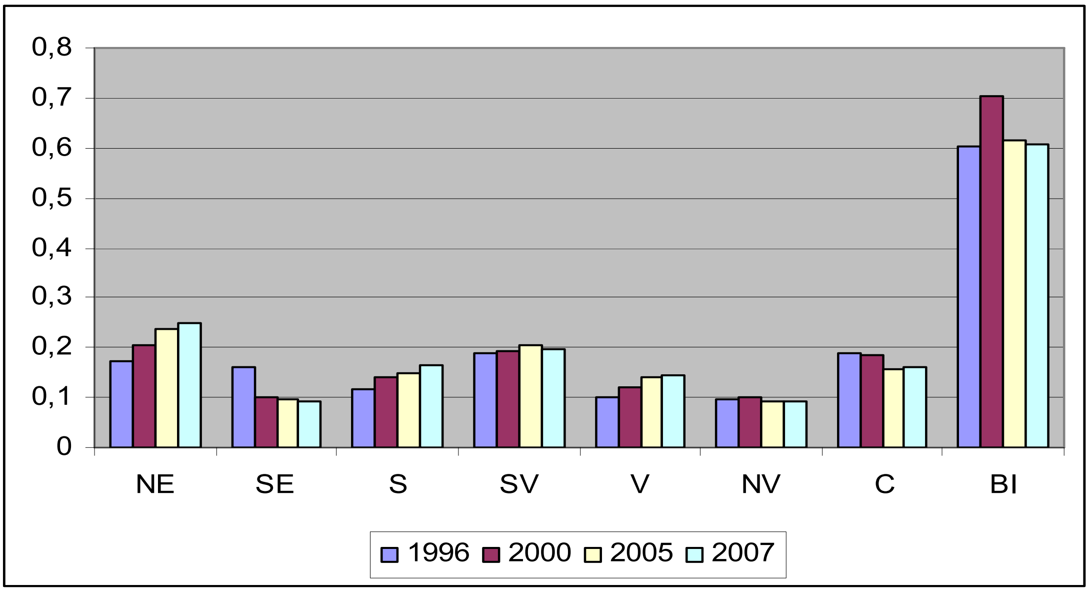


Appendix 3. Specialisation measures based on employment data

The Herfindahl Index



The Krugman Index



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- Creativitate şi inovare. Experienţe europene, CIDE, Colecţia Biblioteca economică, 2006.
- Statistică. Teorie şi aplicaţii, Editura ASE, 2006.
- Întreprinderi mici şi mijlocii în România. Inovare şi competitivitate în context european, Editura Expert, 2005.
- Statistică. Teorie şi aplicaţii, Editura Expert, Bucureşti, 2005.
- Statistică economică, Editura Tribuna Economică, Bucureşti, 2004.
- Statistică economică. Lucrări aplicative, Editura Tribuna Economică, Bucureşti, 2004.
- Evaluări ale dezvoltării durabile în România, Editura ASE, 2003.
- Cercetarea ştiinţifică. Efecte economico-sociale în România, Colecţia Biblioteca Economică, CIDE, Academia Română, 2003.
- Resursele umane în România. Mobilitatea teritorială, Editura ASE, 2002.

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STATISTICAL EVALUATION OF HIGHLY ARSENIC CONTAMINATED GROUNDWATER IN SOUTH-WESTERN BANGLADESH

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Abstract: *High Arsenic (As) in natural groundwater in most of the shallow sandy aquifers of the South-Western part of Bangladesh has recently been focused as a serious environmental concern. This paper is aiming to illustrate the statistical evaluation of the Arsenic polluted groundwater to identify the correlation of that As with other participating groundwater parameters so that the As contamination level can easily be predicted by analyzing only those parameters. Multivariate data analysis done with the collected groundwaters from the 67 tube-wells of the contaminated aquifer suggests that As may have substantial positive correlations with Fe, Mn, Al, DOC, HCO_3 and PO_4 whereas noticeable negative relationships have also been observed with SO_4, Cl and NO_3-N. Based on these relationships, a multiple linear regression model has been developed that incorporates seven most influential groundwater parameters as the independent predictor variables to estimate the As contamination level in the polluted groundwater. This model could also be a suggestive tool while designing the As removal scheme for the affected groundwater.*

Key words: *groundwater; arsenic; multiple regression; principal component; prediction*

1. Introduction

Arsenic a toxic, trace element is ubiquitous in nature [1][5]. It can easily be transported from the sediment to the surrounding pore-water. In the subsurface environment, As (arsenic) has generally been occurring in naturally driven sediments. Partitioning of As in the sediment-water interface has been controlled by a variety of geochemical factors [3,5]. When this As gets exposed in the groundwater in a higher concentrations, it then can pose a threat to the public health. Presence of As in excessive amount may also cause several skin diseases that may lead to cancer eventually [1].

Due to the easier accessibility coupled with having pathogen free nature, groundwater (GW) extraction promoted by the UNICEF had been thought as the proven resources for providing drinking water to the Bangladeshi villagers, who had shifted from the surface water sources to get rid of the water borne diseases over the past 30 years [5]. However, recent discoveries of high Arsenic contamination in GW put about 35 million people forward to a severe health risk [1,2,3,4,5,6,7]. Such type of high As concentration in the natural groundwater, has also been recognized as the serious public health problems in the other parts of the Southern Asia such as West Bengal (India), Vietnam, Cambodia, Taiwan, China and Inner Mongolia over the years [1]. In Bangladesh, since early 1990s, As pollution observed in the upper shallow groundwater was mostly reported in the Holocene deltaic and alluvial sedimentary aquifers [3,4,5,6,8]. The national survey conducted by the BGS and DPHE in 2001, stated that around 27% of the total 10 million shallow tube-wells have exceeded the safe drinking water limit of the WHO (10 μg/l) and the Bangladesh guide line value (50 μg/l) [3,7,8].

This ground water As distribution pattern appears to follow the regional geology [10]. Since the Pleistocene and Holocene period, sediments carried by the Ganges-Brahmaputra-Meghna river system had been consolidating to construct the deltaic aquifer near the coastal region [8, 9]. Silt, clay and fine to medium sand have frequently been observed in this Holocene sediment. Three principal types of aquifers have also been documented in these Holocene sediments depending on the depth, age and water availability. The ground water originated from the unconsolidated fine to finer sediments of the first aquifer (10-100m) has noticeably been contaminated with As [5]. The next aquifer which comprises mostly of fine to medium sand (110-170m) is the second aquifer and the deeper part composing of medium to coarse sand is the third aquifer [12]. This second and third aquifers have generally been reported to have lower As concentrations. Presence of impervious clay layers is the dominating factor that may act as the separator between two adjacent aquifers. This also restrict vertical As mobilization from upper to the underneath aquifers.

South-Western part of Bangladesh predominantly, is the worst hit region where almost 70% of the existing shallow tube-wells exceed the drinking water standard (50μg/l). Samples of groundwater were collected from one of the Arsenic hot spots located at a village named as Alaipur (22^0 51' 30.4" N, 89^0 03 ' 41.2 "E, around 300 km from capital city Dhaka) under Kolaroa upazilla of Satkhira district of South-Western Bangladesh. The topographic surface of that area is very flat and the land elevation with respect to the mean sea level does not exceed even 5 m [5]. The reason behind the selection of this affected area for this study is that several people of this area have already been identified to be badly infected with Arsenicosis diseases. Moreover, as that community is far from the capital city, that area has still been remaining unexplored.

According to the borehole investigations of the sub-surface geology, brown clay layers in the upper shallow part predominately were observed to have most of the detectable As. Just below this layer fine grey reduced sandy layers containing significant amount of As were also found up to a depth of 40 m where most of the shallow hand tube wells have been screened.

Slow aquifer flushing rate coupled with the relatively longer residence time have triggered the Arsenic problem in the alluvial aquifers [3]. Arsenic that may be leached from the upper source layer, mobilizes towards the surrounding groundwater and gets mixed after rearranging the equilibrium of the groundwater system.

Over the years, several researchers have been attempting to explore the As problems in various aspects. However, few of them have worked to present the correlation model of As with other groundwater ions. The purpose of this paper is to present the statistically correlated groundwater parameters that may have either positive or adverse influences on As mobilization and also to show the As concentration predictive model developed with these influential parameters by using multiple regression technique. This model will apparently help to efficiently carry out the As removal design from the contaminated groundwaters.

Multivariate technique in treating environmental data has long been practiced in assessing spatial or temporal groundwater contamination caused either by natural or anthropogenic factors. Cluster analysis (CA) and principal component analysis (PCA) are the two important tools of the multivariate techniques that are applied to determine the dominant interrelationships among the variables to understand the processes that may responsible in controlling the groundwater chemistry [7,13]. Multiple linear regression [14] model has also been applied in evaluating the level of an emerging groundwater contaminant that may have correlationship with other chemical elements [2]. Multiple linear regression (MLR) technique can further help to predict the level of a promising respondent pollutant by showing the relative influences of the other employed predictor pollutants.

2. Materials and Methods

Fifteen monitoring wells were installed by following local drilling practice such as percussion method. This method includes a systematic and synchronized action of continuous raising and lowering of a steel pipe attached with a lever and having a diamond cutter at its mouth. Apart from this, 52 other surrounding tubewells were selected for sampling of Arsenic contaminated groundwaters. Groundwater samples (GW) from these tubewells were collected using peristaltic pumps that were maintained a nearly constant flow rate of 200 ml/min along with an attached multi probe flow channel accommodating pH, DO (dissolved oxygen), ORP (Eh, redox potential) and EC (electrical conductivity) meters' electrodes in the flow line. Water samples from each well were collected in three different ways for serving different purposes such as filtered (0.45 μm filter) for examining anions, unfiltered for dissolved organic carbon (DOC) analysis and filtered and then acidified samples (ultra pure HNO_3) for analyzing major cations. Groundwater samples collected (GW) from the selected locations and depths of the targeted aquifer were subjected to carry out the aqueous phase analysis [11]. ICP-MS (Inductively Coupled Plasma Mass Spectrometry) and IC (Ion chromatography) were employed to do the aqueous analysis for determining major cations such as As (arsenic), Fe (iron), Mn (manganese), Al (aluminum) and anions such as PO_4 (phosphate), SO_4 (sulfate), Cl (chloride), NO_3-N (nitrate nitrogen), DOC (dissolved organic carbon) and HCO_3 (bicarbonate). Multivariate Data analysis (MVDA) technique was applied to find out the relationship among the participating ions.

The raw data were treated first with z-scale transformation to make the data standardized. Multivariate data analysis (MVDA) was utilized to identify the correlationship among the measured groundwater parameters. Principal component analysis was done to reduce the number of input variables. Spearman's correlation matrix was performed to illustrate the correlation coefficients among the variables. Finally, multiple linear regression (MLR) technique was employed to develop a model that can be applied to realize the level of As contamination by predicting the groundwater As from the other measured parameters. Chemometrics software and SAS were explored to perform the multivariate data analysis and also to develop multiple linear regression model.

3. Results and Discussions

3.1. Groundwater Data

The basic statistics of the geochemical data for the analyzed groundwater samples are presented in the Table A-1 (Appendix A). The maximum As concentration was found markedly in the upper shallow aquifer as 0.180 mg/L whereas minimum of that was reported in the comparatively deeper layer as only 0.010 mg/L. Groundwater having high As concentration was also reported to contain the high concentrations of Fe (12.3 mg/L), Al (0.48 mg/L), Mn (0.067 mg/L), DOC (6.87 mg/L), PO_4 (0.13 mg/L) and HCO_3 (508 mg/L). However, low concentrations of Cl (59 mg/L), SO_4 (0.89 mg/L) and NO_3-N (1.23 mg/L) were observed to be associated with the groundwater carrying elevated As. Moreover, this groundwater was noticed to have very low Eh (redox potential, 5 mV) which may indicate the reductive nature of the aquifer geo-environment where the As has always been mobilizing after being continuously leached from the sediment matrix. The strong correlations reportedly found among the parameters such as Fe, Al, Mn and As in the contaminated groundwater further suggest that these elements may have been releasing from the common source minerals in the sediments [5]. High Ca (calcium) concentration in As affected groundwater was also noticed remarkably in most of the samples.

DOC and HCO_3 that usually evolve with the potential microbial activities occurred in the younger sediments may also have positive influences on As, since As is supposed to be released concurrently with the Fe-oxide dissolution. PO_4 on the other hand, may appear in the aquifer groundwater either from the dissolution of the phosphate minerals or from the leaching of the used chemical fertilizers. The prevailing competition for searching of adsorption sites that is presumed to be occurred among the participating ions including As, PO_4 and HCO_3 may also enhance As mobilization. In addition, low sulphate content in high As affected groundwater reflects the likely occurrence of the sulphate reduction that might have a considerable contribution in mobilizing As in the aquifer. However, Cl has been noticed to have adverse influence on As. It has overwhelmingly been observed that due to the presence of elevated Cl concentrations, As content in the groundwater has significantly been found lower. Such type of finding has also been reported for the groundwater identified with high Na (Sodium) and EC (electrical conductivity) content. Low nitrate content was also another observation of the high As groundwater. The dominant pH was in the near neutral range. Na, Mg, K are the parameters that usually reflect either the evidences of the likely intrusion of the sea water into the aquifers or the presence of saline water trapped in the aquifer.

3.2. Loading Plot of Principal Component Analysis

Two principal components P1 and P2 explain notably the variances of the nature and influences of the selected variables. The loading plot of the principal component analysis portrays very well the correlations of the groundwater parameters in the Fig.1.

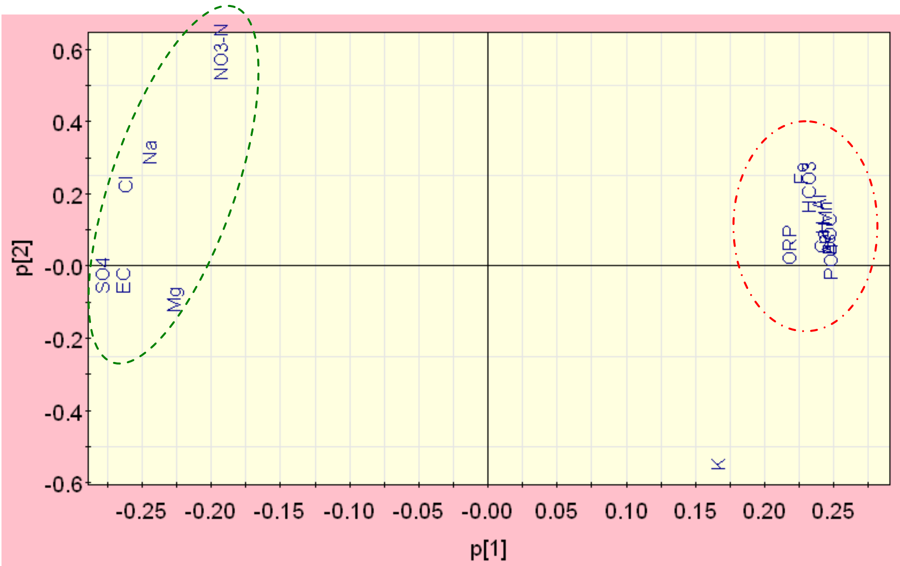

Figure1. Loading plot of the principal component analysis of the studied groundwater.

Parameters having positive influences on As have noticeably been found to make clusters among themselves. This strong relationship of As with other parameters such as Fe, Mn, Al, PO_4, HCO_3, and DOC can explicitly be visualized in the right circle of the loading plot (Fig. 1). Adversely influencing parameters particularly SO_4, Cl and NO_3, on the other hand, can also be recognized in the left circle of the loading plot (Fig. 1). It seems that K may have insignificant relationship with As, since this is placed dispersedly in the diagram. These findings are very much consistent with the bivariate analysis that can be found elsewhere [3,5].

3.3. Non parametric Correlationship of the GW Parameters

The non parametric Spearman correlation analysis was accomplished to identify the plausible statistical relationships that may exist among the observed As concentrations and other groundwater variables: Fe, Al, Mn, DOC, HCO_3, PO_4, SO_4, NO_3-N and Cl. The Spearman correlation coefficient usually presents the strength of the relationship that may exist between any two considered parameters by indicating either positive or negative magnitude.

The Spearman correlation matrix illustrated in Table A-2 (Appendix-A), shows the high correlation coefficients for As with Fe, Mn, Al, PO_4, HCO_3 and DOC. However, lower coefficients for Cl, NO_3-N and SO_4 with As are also listed in that Table. This coefficient matrix strongly supports the observations that were found in the loading plot analysis.

3.4. Hierarchical Cluster Analysis

Plot of hierarchical cluster analysis done with Ward's mode incorporating Euclidean distance, for the groundwater parameters is portrayed in Fig. 2. Showing the As, Mn and Al in the same cluster, this plot again reflect that the stronger correlations may exist among these parameters. Positions of SO_4 and NO_3-N in the same cluster may also reflect their very much distinguishable characteristics in compare to the other parameters. Fe here is seen to be very closely linked with DOC and this may also indicate the possible role of organic material in accomplishing the reductive dissolution of iron minerals which may again be considered to control the release of As by initiating the co-dissolution of the attached As compound [3,8].

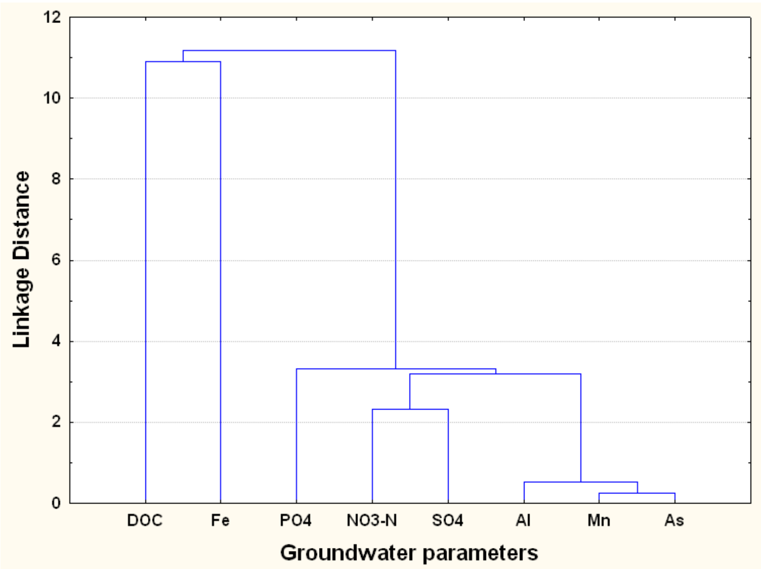

Figure 2. Hierarchical cluster analysis plot of the groundwater parameters

3.5 Multiple Linear Regression Model

Generally a multiple regression analysis attempts to fit the independent variables for predicting a single dependent variable. The general form of a model developed with multiple regression looks like [14]:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots.. + \varepsilon \quad (1)$$

Where,
X_1, X_2, X_3 denote the independent variables,
Y stands for the dependent variable,
β_0, β_1, β_2, β_3 represent the correlation coefficients,
and ε designates the error term.

The seven selected independent variables such as Fe, Mn, Al, PO_4, DOC, Cl and NO_3-N and one independent variable As were used as the input data for fitting the multiple regression model as shown in the equation no. 1. SAS was employed to develop the model. The results of the model are presented in Table 1 and Table 2.

Table 1. Analysis of variance

Source	Degree of Freedom	Sum of Squares	Mean Square	F value	p-value
Model	7	0.05661626	0.006291	10.404	<0.0001
Error	60	0.00003674	6.123E-6		
Corrected Total	67	0.05665300			

Table 2. Parameter estimation

Parameters	Estimate	Std Error	t-value	p-value
Intercept	-0.602392	0.355907	1.69	0.1415
Al	0.052438	0.056234	0.93	0.00011
Fe	0.0023208	0.00146	1.59	0.0029
Mn	0.1370394	0.565053	0.24	0.00015
DOC	0.0257569	0.006016	4.28	0.00032
PO_4	0.0030028	0.032017	0.09	0.00042
Cl	-0.000019	1.114E-5	1.71	0.00013
NO_3-N	-0.01882	0.006178	3.05	0.0026

Based on the analyzed parameters listed in the Table 2, the final model can be formulated as:

$$As = 0.052\ Al + 0.0023\ Fe + 0.137\ Mn + 0.025\ DOC + 0.003\ PO_4 - 0.000019\ Cl - 0.019\ NO_3\text{-}N$$

This model may suggest the prediction of the As contamination by measuring the seven predictor parameters of the groundwater variables in any contaminated aquifer. This model may also be a suggestive tool in predicting As contamination level while designing the As removal activities by the Environmental scientists.

4. Conclusion

Various statistical analysis techniques have successfully been applied in this study to evaluate the geochemical phenomena of the highly Arsenic affected groundwater in the shallow sandy aquifers of the South-Western Bangladesh. It has markedly been observed here that the As in that aquifer sediment has gradually been releasing with the great influence of the naturally driven geochemical factors. HCO_3 and DOC have been recognized as the two most responsible geochemical parameters that may have controlled As releasing mechanism. These two parameters may also have influenced the Fe, Mn and Al source minerals to initiate their dissolution reactions under the reductive geo-environment.

Loading plot coupled with the hierarchical plot has also presented either the possible relationships that may exist among the groundwater parameters. Positive influences of Fe, Mn, Al, PO_4, DOC and HCO_3 and adverse influences of Cl and NO_3-N on groundwater As that have been observed in the multivariate analysis as well as in the Spearman rank table, are also consistent with the Arsenic releasing as well as the mobilizing phenomena.

A predictor model, developed with seven dominant independent parameters of groundwater to perceive an estimation of the Arsenic contamination level, has been briefly portrayed in this study. This model may further guide the Environmental Scientists to design an efficient Arsenic removal plan while treating the groundwater that may have contaminated badly with that.

References

1. Aggarwal, P. K. *et al.*, **Isotope hydrology of groundwater in Bangladesh: Implications for Characterization and Mitigation of Arsenic in Groundwater,** IAEA-TC Project Report, BGD/8/016, International Atomic Energy Agency, Vienna, 2000
2. Ahmed, K.M., Bhatacharya, P., Hasan, M.A., Akhter, S.H., Alam, S.M.M. and Bhuyian, M.A.H. **Arsenic contamination in groundwater of alluvial aquifers in Bangladesh: an overview,** J. Appl. Geochem., 19, 2004, pp. 181-200
3. Ahmed, M.F. **Arsenic contamination: Regional and Global scenario,** in Ahmed, M.F. (Ed), "Arsenic Contamination: Bangladesh Perspective", ITN, BUET, Dhaka, Bangladesh, 2003, pp. 1-20
4. Ahsan, S.M.F., Islam, M.J., Uddin, M.J. and Uddin, M.T. **Statistical Modeling of the Groundwater Arsenic Contamination Level in Bangladesh Due to Chemical Elements,** Journal of Applied Quantitative Methods, 3(3), 2008, pp. 254-262
5. Bhattacharya, P., Chatterjee, D. and Jacks, G. **Occurrence of Arsenic contaminated groundwater in alluvial aquifers from delta plains, Eastern India: Options for safe drinking water supply,** J Wat. Res. Dev, 13, 1997, pp. 79-92
6. Harvey, C.F., Swartz, C.H., Badruzzaman, A.B.M. Koen-Blute, N., Yu, W. and Ali, M.A. **Arsenic mobility and groundwater extraction in Bangladesh,** Science, 298, 2002, 1602-1206
7. Kumar, A.R. and Riyazuddin, P. **Application of Chemometric techniques in the assessment of groundwater pollution in a suburban area of Chennai city, India,** Current Science, 94(8) pp. 1012-1022
8. Rahman, M.T., Mano, A., Udo, K.and Ishibashi, Y. **Geochemical Factors in Mobilizing Arsenic Transport in the Deltaic Aquifers; South-Western Bangladesh,** in Koprivanac, N. and Kusic, H. (Eds.) "Environmental Management, Trends and Results", Zagreb, Croatia, 2007, pp.197-205
9. Shrestha, S. and Kazama, F. **Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin; Japan,** Environmental Modeling and Software, 22, 2007, pp. 4119-4124
10. Umitsu, M. **Late qaternary sedimentary environment and landform evolution in the Bengal lowland,** J. Sedimentary Geology, 83, 1993, pp. 177-186
11. * * * **Arsenic contamination of groundwater in Bangladesh,** AAN, RGAG and NIPSOM, Interim report of research at Samta village, 1999
12. * * * APHA, AWWA and WEF, **Standard Methods for Analysis of Water and Wastewater,** Greenberg, A.E., Clesceri, L.S. and Eaton A.d. (Eds), eighteen ed, 1992
13. * * * BGS and DPHE, **Arsenic contamination of groundwater in Bangladesh,** in Kinniburgh, D.G. and Smedley, P.L. (Eds), "Final Report, British geological Survey Report", Vol. 2, 2001
14. * * * **Multiple Regression,** http://ordination.okstate.edu/MULTIPLE.htm , Accessed on 03-02-2009

Appendix A

Table A-1. Basic statistics of the GW parameters (mg/L)

Parameter	Mean	Minimum	Maximum	Std. Dev.
As	0.088	0.002	0.205	0.062
Al	0.193	0.010	0.520	0.146
Ca	57.700	12.300	114.200	33.204
Fe	5.603	1.010	16.200	4.184
K	2.621	1.030	4.500	1.024
Mg	25.626	14.700	36.230	6.560
Mn	0.039	0.010	0.081	0.022
Na	114.636	12.700	513.000	158.084
pH	6.881	6.590	7.290	0.191
EC	1609.125	886.000	2510.000	598.917
ORP	4.250	-7.000	45.000	23.621
DOC	4.354	1.670	7.650	1.862
PO_4	1.906	1.023	2.670	0.474
SO_4	0.855	0.310	1.420	0.320
As	0.088	0.002	0.205	0.066
Cl	452.750	31.000	1501.000	560.917
HCO_3	288.875	187.000	492.000	84.883
NO_3-N	1.386	1.070	1.900	0.254

Table A-2. Spearman correlation matrix for the groundwater parameters

	As	Fe	Al	HCO_3	Cl	DOC	Mn	PO_4	SO_4	NO_3-N
As	1.000									
Fe	0.610	1.000								
Al	0.524	0.517	1.000							
HCO_3	0.697	0.409	0.570	1.000						
Cl	0.072	0.053	-0.020	0.037	1.000					
DOC	0.468	0.559	0.291	0.172	0.125	1.000				
Mn	0.418	0.506	0.503	0.418	-0.038	0.367	1.000			
PO_4	0.394	0.244	0.415	0.609	-0.102	0.155	0464	1.000		
SO_4	-0.096	-0.132	-0.198	-0.351	-0.483	-0.026	-0.309	-0.187	1.000	
NO_3-N	-0.541	-0.293	-0.398	-0.411	-0.024	-0.414	-0.377	-0.225	0.034	1.000

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[5] Codification of references:

[1]	* * * **Arsenic contamination of groundwater in Bangladesh,** AAN, RGAG and NIPSOM, Interim report of research at Samta village, 1999
[2]	Ahsan, S.M.F., Islam, M.J., Uddin, M.J. and Uddin, M.T. **Statistical Modeling of the Groundwater Arsenic Contamination Level in Bangladesh Due to Chemical Elements,** Journal of Applied Quantitative Methods, 3(3), 2008, pp. 254-262
[3]	* * * BGS and DPHE, **Arsenic contamination of groundwater in Bangladesh,** in Kinniburgh, D.G. and Smedley, P.L. (Eds), "Final Report, British geological Survey Report", Vol. 2, 2001
[4]	Ahmed, M.F. **Arsenic contamination: Regional and Global scenario,** in Ahmed, M.F. (Ed), "Arsenic Contamination: Bangladesh Perspective", ITN, BUET, Dhaka, Bangladesh, 2003, pp. 1-20
[5]	Rahman, M.T., Mano, A., Udo, K.and Ishibashi, Y. **Geochemical Factors in Mobilizing Arsenic Transport in the Deltaic Aquifers; South-Western Bangladesh,** in Koprivanac, N. and Kusic, H. (Eds.) "Environmental Management, Trends and Results", Zagreb, Croatia, 2007, pp.197-205
[6]	Harvey, C.F., Swartz, C.H., Badruzzaman, A.B.M. Koen-Blute, N., Yu, W. and Ali, M.A. **Arsenic mobility and groundwater extraction in Bangladesh,** Science, 298, 2002, 1602-1206
[7]	Kumar, A.R. and Riyazuddin, P. **Application of Chemometric techniques in the assessment of groundwater pollution in a suburban area of Chennai city, India,** Current Science, 94(8) pp. 1012-1022
[8]	Ahmed, K.M., Bhatacharya, P., Hasan, M.A., Akhter, S.H., Alam, S.M.M. and Bhuyian, M.A.H. **Arsenic contamination in groundwater of alluvial aquifers in Bangladesh: an overview,** J. Appl. Geochem., 19, 2004, pp. 181-200
[9]	Umitsu, M. **Late qaternary sedimentary environment and landform evolution in the Bengal lowland,** J. Sedimentary Geology, 83, 1993, pp. 177-186
[10]	Bhattacharya, P., Chatterjee, D. and Jacks, G. **Occurrence of Arsenic contaminated groundwater in alluvial aquifers from delta plains, Eastern India: Options for safe drinking water supply,** J Wat. Res. Dev, 13, 1997, pp. 79-92
[11]	* * * APHA, AWWA and WEF, **Standard Methods for Analysis of Water and Wastewater,** Greenberg, A.E., Clesceri, L.S. and Eaton A.d. (Eds), eighteen ed, 1992
[12]	Aggarwal, P. K. *et al.*, **Isotope hydrology of groundwater in Bangladesh: Implications for Characterization and Mitigation of Arsenic in Groundwater,** IAEA-TC Project Report, BGD/8/016, International Atomic Energy Agency, Vienna, 2000
[13]	Shrestha, S. and Kazama, F. **Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin; Japan,** Environmental Modeling and Software, 22, 2007, pp. 4119-4124
[14]	* * * **Multiple Regression,** http://ordination.okstate.edu/MULTIPLE.htm , Accessed on 03-02-2009

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Key words: *Quality management; value engineering; process management; Ion Ionita*

QUALITY MANAGEMENT AND VALUE ENGINEERING (“MANAGEMENTUL CALITATII SI INGINERIA VALORII”) by Ion IONITA, ASE Printing House, Bucharest, 2008

The author, valuable teacher of the Academy of Economic Studies, known to the specialists for his contributions in the domains of technical-economic systems quality management and value engineering succeeds now in offering the economists a book special through the depth of the approach, the diversity of the approached problems, the complete character of the approach and through the special scientific level. The book is structured in two parts.

The first part treats the quality management and includes the historical evolution of the concept of quality and quality systems, the theoretical fundaments regarding the quality management and of total quality. The author analyses the standard’s requirements regarding quality management in the context of our countries’ economic development. Issues regarding the quality management at European organizations level are treated, taking into account the particularities regarding the production and the quality of the products form the European market. Issues regarding quality planning, quality audit and informational system associated to quality management are treated with remarkable clarity by the author. Starting with the costs involved by raising the quality level, the author develops issues regarding the optimization of the quality costs from a personal point of view. A special place is reserved to the certifying quality management systems processes, including the certification's planning and preparation stages, following the methodology based on recent standards.

To ensure the strictness of the grounding of the decisions that lead to the raise of the quality at the resource, process and product level, the author uses a special chapter to develop issues regarding modern techniques and instruments used in the representation of data that are gathered during the production processes. Results of the statistical processing and data analyses stand as a base for these.

The second part treats the value engineering, the theoretical fundaments of the domain and the methodology of applying the value engineering to the products being presented by the author. Using a rich reference material and his experience, professor PhD Ion Ionita accomplishes a complete study of the issues regarding value engineering proving special qualities regarding the exposure's clarity and the gradual approach that allows the detail study of complex issues bounded by the base principles of value engineering, as well as those regarding the stages for applying preparatory measures, the social need, the current situation's evaluation, product's design/redesign, the optimal solution, it's implementation and control.

The many figures and tables included in the book allow the understanding of the issues because the suggested examples create a representative image for each of the approached issues.

The bibliography selected by the author is representative and shows that this book joins a generous context that the Romanian specialists built in time, aligning the quality management problems at organization level to the newest tendencies from the specialty literature.

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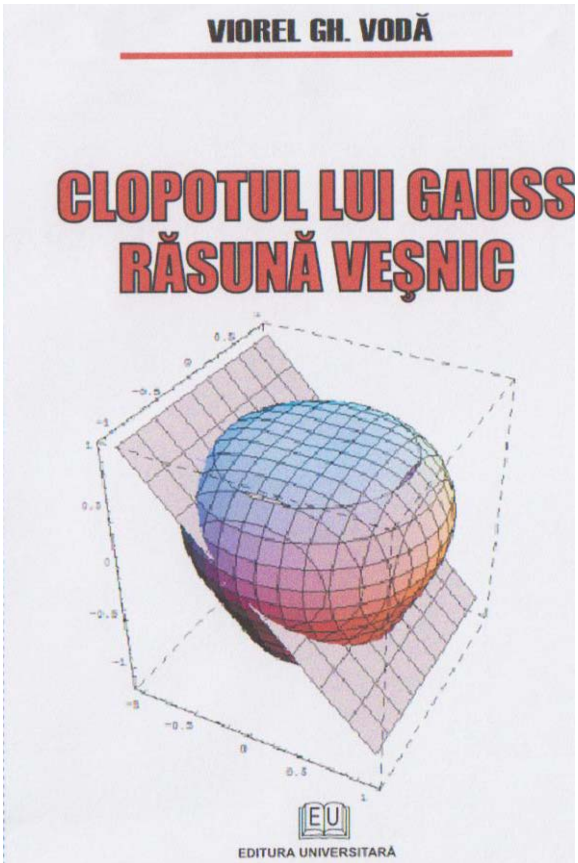
Key words: Gauss' Bell; Quality Control; Reliability; Six Sigma; Viorel Gh. Voda

GAUSS' BELL RINGS FOREVER
("CLOPOTUL LUI GAUS RASUNA VESNIC"),
by Viorel Gh. VODĂ,
Editura Universitara, Bucharest, 2009



We are delighted to acknowledge the recent publication of a well-known mathematician who channeled his career to an interesting field that has multiple elements of practical applicability. The use of the term "Gauss' bell curve" in the title is an excellent match to the profile of this paper that combines in a harmonious manner the theoretical elements of superior mathematics with case studies, operational procedures and exemplifications addressed to all practitioners who face them daily in various areas of their socio-economic life, with illustrations – mainly – from the quality control field.

Often containing fine and enjoyable ironic comments the paper logically reaches various levels (e.g. the chronological approach, the approach of the practitioner interested in using statistic-mathematical method and models, elements of theoretical synthesis, and in illustrating the current status of knowledge, etc) and is constituted in a reference point in the national, and even international scientific literature.

In this context, this (mini) monograph[1] is a good opportunity for the concerned public: practitioners, students, professors, to have at their disposal fundamental elements from both the practical perspective (there are numerous parallels and referrals to the ISO – and Six Sigma - standards and procedures) and the perspective of the evolution and the latest innovations in the vast theoretical foundation at the base of the most recent methodologies in qualitology.

[1] We borrow the term from the afterword signed by Marius Iosifescu, Vice-president of the Romanian Academy of Sciences