# RELATION BETWEEN ORGANIZATIONAL – AND INFORMATION RESILIENCE: A WAY FOR IMPROVEMENT OF SYSTEM CAPACITY

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**Abstract:** *In today's business conditions, organizations worldwide operate with the transactions executed and communications received immediately after they are initiated. Tolerance in every aspect is shrinking and many organizations are outsourcing dependable. Disruption in business has widened, it includes traditional natural disaster and any event that disturbs this fast-paced operational flow — from an acquisition or organization growth to a new government regulation or to a scheduled system upgrade. This resulted in a new business paradigm organizational resilience. Impact of Information Systems (IS) on organizational resilience is through: (1) higher level of knowledge and transparency of business processes, (2) higher level of flexibility, agility and sustainability of organization, (3) enhancement of key competetiveness forces, (4) enhancements of awareness about business risks and vulnerability of organizations, (5) enhancement of speed of organization recovery, (6) enhancement of organizational culture and awareness about resilience and (7) supporting the organization sustainability. Each possible impact of IS varies and depends upon two sides and their relations: (1) characteristics of IS which is related to ICT characteristics and (2) characteristics of organization. Because that, authors contribution in this paper is to make clear different approaches to IS – and organizational resilience and establish the model for simulation of this impact. This model is evaluated on an example and presented as a case study.*
*Keywords: IT, ICT, organization, resilience*

## 1. INTRODUCTION

Information and communication technology (ICT) represents the basis for the information systems (IS) development. Information System (IS) is a model of the real system that helps the man to take control of certain processes. In the narrow sense, the IS include: (1) hardware, (2) software (3) processes and data, (4) database, (5) methods and techniques involved in the knowledge of employees, procedures and networks.

Selected ICT solution, which is applied to business processes in the organization together with the IS solution, enables the realization of the goals on a certain level. If the assessment's outcome, due to increasing competitiveness and enterprise development, is need to improve business processes using ICT, team management must define the requirements of the process according to the IS and ICT.Improved hardware and software solutions are often offered to the IS designers in different segments. These are computers with the new performances, communication hardware and software, database systems and systems for database management, etc., where the improvements are related to the speed, capacity, safety, accuracy, reliability, etc.

In the classic concept of ICT development and implementation in enterprises, an IS is viewed as a stable part of the organizational system, which can be effectively maintained and continually improved. However, the real circumstances are quite different. Exponential growth of ICT and the enormous market pressure in the terms of competitiveness often put in the spotlight shortcomings of the applied ICT and IS in the enterprise. They become "weak link" in the chain of value creation, the reason why the customers become dissatisfied or why the performances of key business processes significantly slow down. E.g. if the IS in a bank does not work for the 3h, it means the loss of a large number of the transactions multiplied with an average gain. An even greater loss is the loss of image, and an even greater loss represents clients who are rapidly orienting toward the other bank. From these relations, aspects of Vulnerability, Risk and Adaptive Capacity are very important.

All of the declared issues caused a review of the IS, especially an IS role and concept. Past theory and practice of IS design and maintenance is not enough. The same concept is necessary to be observed from its role in achieving organizational resilience as one of the key factors of competitiveness in a very turbulent market.

In these new business conditions, there is a stressed need of the rapid organizational response to the changes, especially in the crisis situations that can cause

a significant loss of performances and competitiveness, and even the work termination and the business crash.

The question is how an IS contributes to the sustainability, vulnerability, adaptability and resilience of the organization. To make this relationship between IS and organizational resilience more obvious, the paper describes approaches to solving this relatively new problem.

Based on the problems analysis and hypotheses, this paper presents the results obtained using the methods of the conceptual modeling. In addition to the initial IS resilience model, for the 12 selected organizations in Serbia, the level of IS and organizational resilience are established and the effects of IS organizational resilience are determined.

## 2. PROBLEM DESCRIPTIO

The concept of resilience had a turbulent history in the last 20 years. It originated in the study of ecosystems, but later, it became the subject of study in biological, economic, organizational and information systems. The paper considers some typical approaches of resilience defining which are used by the authors for building influence model of IS resilience on organizational resilience.The content of these concepts and relations between them are given in the paper of Gallopin [1]. Vulnerability is presented as a composite concept that consists of an exposure to the perturbations, stress, or shock hazard, change or transformation of the system, sensitivity, capacity of response. Hazards are threats to a system, comprised of perturbation and stress. Perturbations are magnitude in the pressure. Stress is continuous or slowly increasing of the pressure (e.g. loss of competitivity). Very important aspect of a change or transformation is its degree or depth. System is not vulnerable if the effect of change is ephemeral and those changes are quality as "transformation" or "damage" of system. Distinction between vulnerability and resilience is in different characteristics: vulnerability refers to the capacity to preserve the structure of system while resilience refers to its capacity to recover from crisis situations. In this concept of resilience very important is role of sensitivity. According Gallopin [1] sensitivity is measured by δ transformation / δ perturbation, where δ is difference.

Capacity to response or adaptive capacity is a component of the resilience of system. Some authors distinguish "coping ability" to short term capacity and ability to survive or long-term capacity called "adaptive capacity". Capacity of response is a characteristic of the system that exists prior to the perturbations.

Second central concept related to the vulnerability is exposure, expressed as degree, duration, and/or extent of relation to the perturbation. Exposure is the characteristic of the relationship between the system and the perturbation.In the literature related to this research area, there are a lot of concepts of resilience, from different points of views. So we can distinguish ecological resilience, engineering resilience, social resilience, enterprise resilience. Each term has its own structure and more or less is similar in structure and behavior with the other concepts. Resilience is related to the capacity of response component of vulnerability. Adaptive capacity has two components: (1) capacity of system and (2) capacity to improve its conditions. Some authors treated adaptive capacity as resilience, and some as component of resilience that reflect the learning aspect of system behavior to disturbance.In the field of information system organizational resilience there is not much published papers. One of the major works in this area is the work of Riolli and Savicki [2]. Besides defining the basic concepts and their relationships, the authors emphasized the importance of stress on ICT professionals and employees and defined the model of organizational resilience in IS. In this model, acute stress may come from the environment (e.g. economic downturn, natural disaster, loss of competition) or from the internal source (e.g. downsizing, reorganization, introducing of new technology). The role of the competence is especially important as a resilience factor. Employees in the ICT sector should have the capacity and skills to meet the demands in the fast changing technological environment.

Oh and Theo [3] discussed the impact of information technology and management proactiveness in building net-enabled organizational resilience in net-enabled organizations. They emphasize building blocks of organizational resilience: (1) innovative capability, (2) agility capability. In this purpose they define net-enabled organizational resilience (NERO) as "the capacity of organizations on the sense environmental changes and responses swiftly with a business model and technology innovation through the use of electronic networks to effectively withstand turbulence in the environment "with relation among it.Galliers [4] emphasize the strategic importance of IS for business, because ICT should align with business strategy. He stresses three issues: (1) dynamic nature of the business environment and the need for the flexible or agile IS, (2) or inability to foresee the future and need to have predictions, based on relevant information, (3) the role of information in informing agile responses and the need to be proactive, rather than reactive. In that direction, he stresses the role of IS in defining business strategy and development of the appropriate strategic oriented IS.

Pham and Jordan [5] emphasize the importance of the IT capability, organizational capability and the core capabilities. Also, they discussed the concept of the improvisation, especially in the crisis situations. The positive result of improvisation is learning: (1) how to improve, (2) through the reutilization of improvisation,

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(3) through the action component of improvisation. On the example of the IT use in an insurance company, they analyzed the various situations and taken actions in the process of the IT solutions improvisation. Also, they analyzed the necessary competencies at the level of the company for successful improvisation.Milligan and Hutcheson [6] discussed the outsourcing of ICT and its impact on business resilience. They believe that this influence is dominant at the outsource tasks and not at the adequate service or controls. After the analysis of reasons for outsourcing, they proposed reasons for outsourcing and business risks and resilience.

Scott et all [7] discussed the aspect of enabling technology for organizational resilience through the development of the virtual teams using enabling technologies such as video - conferencing. They investigated the supporting innovation in the virtual teams, video - conferencing and resilience. The examples of implementing XP in the multicultural conference, collaborative problem - based learning environment are severely important.

Ignatiadis and Nandhakumar [8] have emphasized three determinants (differential power, role of the values in problem solving, initiated impact of the consequences) in the organizational resilience. The first determinant have influence on the increased control, and the second and third have possible influence to the drill that in turn influence the lack of information embedding in ERP. Too much control of system can make system rigid when it needs to absorb system disturbances and recover from the events that may occur.Mc Grath, Mc Grath [9] analyzed the importance of simulation in the network - centric emergency response. Using Distributed Interactive Simulation (DIS) protocol they defined the emergency response network and synthetic environment with roles of humans as first responders, emergency operations and incident commands.Consideration of the expansion of the resilience concept on the entire economy (Resilient economy), is generally given in [10]. In this report, Council on Competitiveness for corporate executives, the top 10 risk priorities are presented: (1) Reputation, (2) Business interruption, (3) Third party liability, (4) Supply chain failure, (5) Market environment, (6)

Regulation / legislation, (7) Talent (8) Market risk, (9) Physical damage (10) Merger acquisition.

According the experience from Australia and New Zeeland, in the paper [11], the goal is not just recovery or continuity, but transformation from reactive to proactive and adaptive practices. The four properties of resilience indicated: (1) Robustness, as strength or ability of systems to withstand a given level of stress without suffering degradation or loss of function, (2) Redundancy, as extent systems which are substitutable, i.e. capable to satisfy functional requirements in the case of disruption, degradation or loss, (3) Resourcefulness, as ability to supply resources, (4) Rapidity, as capacity to meet priorities and achieve goals. ICT is integrated in each of them.From this description of the problem, which is very complex in its structure and relations between the components of the system and relations with the environment, this work stands out impact of the IS aspect on the organizational resilience

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## 3.MODEL OF IS IMPACT ON ORGANIZATIONAL RESILIENCE

As an initial model for determining the organizational resilience, the models of McManus [R12] and Afgan [13] are used. Each of these models is analyzed in the terms 1 to 7 (from Abstract) from the view of IS impact on organizational resilience.From the aspect of resilience improving, increasing of the knowledge and transparency of business processes needs to be promoted in order to:

- Quickly detect a significant disruption of the system, which can cause great vulnerability of the system,
- Use knowledge of processes, as well as basic knowledge to quickly identify the causes of hazards, strategic, and give tactical and operational responses to the gradual recovery of the system (process) and return to its original operating level of work (Fig. 1).
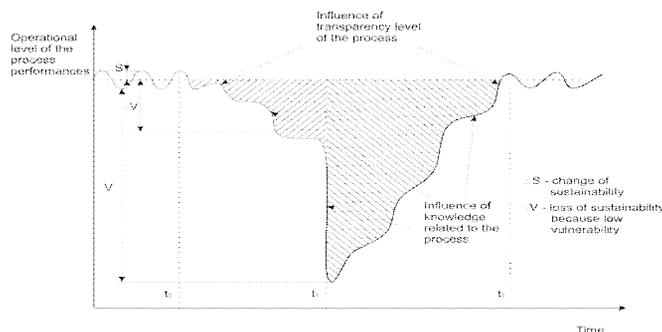


*Fig. 1. Basic terms in resilience area*

The IS impacts on increasing flexibility through:

- Installation of flexible equipment and increasing the level of automation of it (Flexible automatization),
- Improving the knowledge about the process through KM,
- Improving of the flexibility of the process course,
- Using IS for managing the processes.

Some authors emphasize the impact of the flexibility. In the paper [14] super – flexibility is defined as "an enterprise's ability to address both sides of spectrum; much like an entrepreneurial company, coupled with the capacity to remain robust and resilient, attributes historically associated with established operations". From this definition can be concluded that super – flexibility concept includes related concepts.

In our opinion, it is necessary to investigate each of these concepts, define their ontology, and relationships with others, and depending on the object of research, emphasize some of the relations between them.

Each of the listed objects is more or less affected by ICT. Impact of ICT on sustainability is the most pronounced since it impacts on the performance of the IS and the organization as a whole. For example, the paper [15] claims that as an ICT solution, for e-commerce may be defined the benefits and limitations.

Agility is also much undetermined subject and it is used and interpreted in different ways. In the field of organizational systems, agility is related to: (1) Reducing product development time, work in the small batches and effectiveness increasing by using the concept of lean production. (2) Integration of people,

technology and business processes towards a common goal.

ICT in the era of digital economy becomes "an important tool for defining new strategic opportunities and building the capabilities needed to execute them". According the paper [16] in USA in 2003, companies spent approximately 4 percent of revenues on ICT, and globally ICT service market was expected to reach 621 billion dollars in 2005. When the impact of ICT on the organization's strategy is analyzed, the following questions are especially considered:

Can ICT change the basis of competition?

Can ICT change the nature of relationships and balance of power in buyer – seller relationships?

Can ICT build or reduce barriers to entry?

Can ICT raise or lower switching costs?

Can ICT add value to existing products and services or create new ones?

Determining the key success factors is obtained by applying ICT in the analysis of markets and value creation chain. Each of these success factors is studied, some are eliminated or reduced, and some gain greater importance or new success factors are introduced.

The result of this analysis of ICT support is a list of key success factors (Key Success Factors - KSF). The right time to enter a market is gaining increasing importance, which indicates better: (1) learning effects, (2) brand and reputation, (3) switching costs, and (4) network effects. Of course, premature market penetration has disadvantages because: (1) market uncertainty, (2) technologies uncertainty, and (3) free-rider effects.
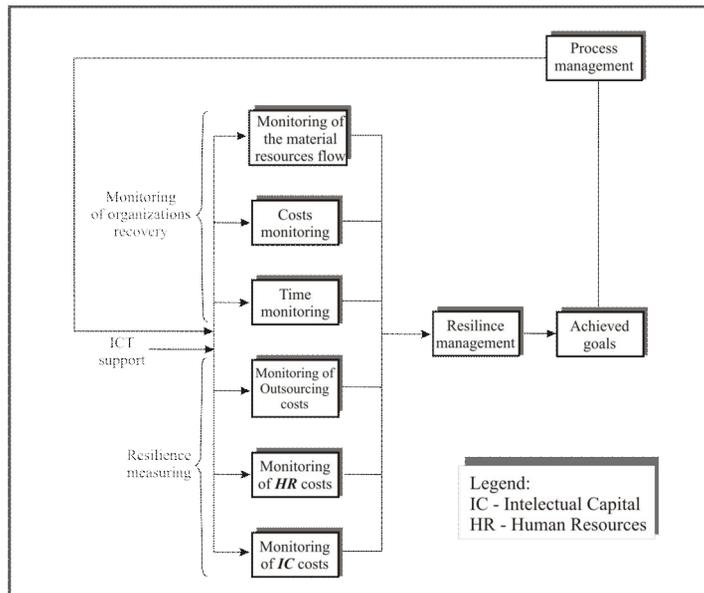


*Fig 2. Resilience and Process Management*

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Effective process control is the "classic" role of ICT, which depends on the type of process, process requirements, customer requirements and restrictions. Some processes, such as marketing finance, etc. are relatively suitable for ICT usage, because they are very well structured, often repetitive and ICT support costs are relatively low. In contrast, the costs of logistics application or products planning are less repeatable and relatively high. Management processes using ICT is accomplished in three levels: (1) strategic, (2) tactical, (3) and operational within an enterprise or the chain of value creation (Fig 7).

Measuring resilience of the organization on ICT solutions is based on the previous monitoring and the utilization of intellectual capital (IC) and human resources, using outsourcing (Fig. 2).

In accordance with the increased competition on the global level, organizations need to learn quickly and adapt to new technologies. A group of technology belongs to the ICT sector. This creates the preconditions for change in the nature of work, which is less direct and more indirect because of the increasing levels of automation. It also increases the share of outsourcing in the products realization.

ICT utilization has impact on the organization redefining in the sense of: (1) new and improved product capabilities, (2) new industry order and business models, (3) improving the supply chain, (4) impact on Manufacturing (CIM, CIE, virtual manufacturing), (5) impact on finance and accounting, (6) impact on human resources management and training. All of this affects on the organizational culture change [17, 18, 19, 20].

ICT impact on increasing awareness of the vulnerability and resilience through:
- The feeling of helplessness in the case of ICT solutions components fault or the fault of the whole ICT,
- Trust in the quick recovery of an organization that offers ICT solutions based on:
  - Built an external communication with stakeholders,
  - Using specific ICT supported procedures,
  - Confidence in the technological progress and technological wizards.

Both awareness characteristics of vulnerability and ICT resilience are present in every organization. Which characteristic of these is dominant depends on the degree of ICT impact on the performance, ICT and organization sustainability and organizations concept of ICT in terms of resilience.

Sustainability of the organization is measured by a series of indicators (productivity, sustainability, financial performances, etc.) and it largely depends on the ICT. Cobb - Douglas function is the most used when there is a need for this impact analysis.

Intensity of ICT usage can be measured through: (1) ICT expenses, (2) Number of computers per employee, (3) Shore of computerized workplaces, (4) Shore of workers that have access to the internet.

Influence on the organization sustainability is manifested through firm – specific strategy variables: (1) Introduction of new products or services, (2) ICT – based process innovation, (3) ICT related training programs, (4) New management methods based on ICT (CRM, six sigma), (5) Organization of enterprise.

The provision and promotion of sustainability is the main task of management. Thereby two different approaches are distinguished:
- Constant improvement,
- Break - through management.

In both approaches, the impact of ICT is inevitable especially in the second because it significantly changes the concept of ICT operations and chain of value creation, emphasizing the concept of the virtual organizations. Of course, steady growth can't be expected, but the fluctuations about the realized level of sustainability or the occasional drop in sustainability.

This decline of sustainability occurs because vulnerability of the organizational system. The question is what level of vulnerability may be understood as temporary and objectively conditioned and what level of sustainability decrease requires the activation resilience mechanisms. It depends on the decisions of management and shareholder.

If the difference between desired and real level of sustainability is set with very small value it means that the strategy of management for each variation is treated as described and appropriate mechanism for resilience will be initiated. ICT has indispensable role in:
- Increasing communication of all stakeholders,
- Automation of partial solutions and minimizing the damage,
- Supporting for choosing the optimal solution for effective resilience program,
- Appling of the resilience program through information and communication channels,
- Monitoring of homeostatic state implementation of the system.

If the assessment shows that the system vulnerability is large and permanent, it is not possible to act on it, the solution is to increase system sustainability.

An ICT increases sustainability through:
- Better understanding of disruptive innovations,
- Discovering the underlying reasons for incumbent's failure,
- Raising the right questions to recognize the threats of disruptive innovations,

- Finding ways to deal with disruptive innovations, and
- Selection and application of the appropriate mental frame form for efficient reactions.

System sustainability over the ICT security is realized through the technological tools. (Fig. 3).
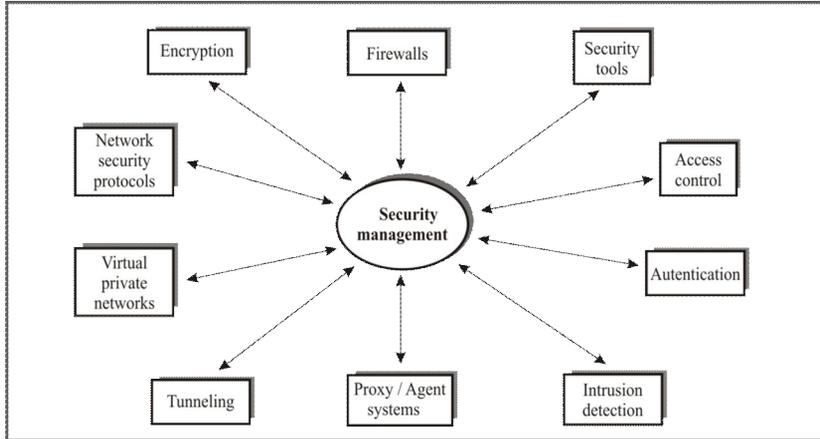


*Fig.3. The ICT security factors*

Every organization disruption or vulnerability, caused by the violation of ICT security solutions, influences on the sustainability of the system and therefore on its overall resilience. The level of this impact depends on the degree of the ICT implementation in the organization.

According the model of McManus [12], organizational resilience can be assessed through the three system indicators:

**1. Situational awareness (SA):**
SA1 : rules and responsibilities
SA2: understanding of hazards and consequences
SA3: connectivity awareness
SA4: insurance awareness
SA5: recovery priorities

**2. Management of Keystone** Vulnerabilities (KV):
KV1: Planning Strategies
KV2: Participation in Exercises

KV3: Capability and Capacity of Internal Resources
KV4: Capability and Capacity of External Resources
KV5: Organization Connectivity

**3. Adaptive Capacity (AC):**
AC1: Silo Mentality
AC2: Communications and Relationships
AC3: Strategic Vision and Outcome Expectancy
AC4: Information and Knowledge
AC5: Leadership, Management and Government Structure

This model applies to the IS aspect of resilience, with the indicators considered from the IS perspective. The basis for this is the fact that IS is a real system model and therefore it reflects the structure and workflow of the real system (the business organization). In this way, the inputs can be obtained in order to determine the IS resilience and IS impact on organizational resilience (figure 4).
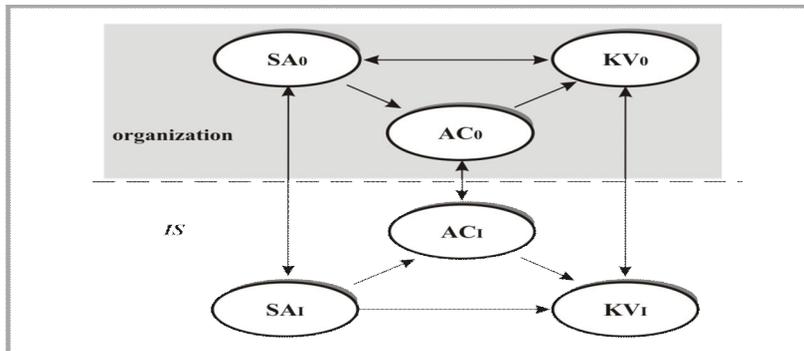


**Fig. 4. Relations among resilience components of organization (O) and IS (I)**

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From the settings of the model [12], the impact of ICT and Environmental Turbulence is incorporated into new model. Using this model, the level of IS resilience and IS impact on the organizational resilience is established. In this connection, the following hypotheses are set:

**H1:** There is a strong dependence between IS and Organizational resilience

**H2:** The greatest level of impact is achieved through the KV (Keystone Vulnerabilities)

**H3:** In the AC area, the greatest impact on organizational performances has KV5 (Connectivity and Knowledge).

## 4. RESULTS OF MODEL TESTING

Using the initial model of McManus [12] for the organization resilience, we applied modified model for the assessment of IS resilience. The basis for this is can

be presented by the fact that the IS also includes material, financial and human resources and organization.

To test the impact of IS resilience on the organizational resilience 12 organizations in Serbia are selected, as follows: CS1 ÷ CS4 (large organizations), CS5 ÷ CS8 (medium organizations), CS9 ÷ CS12 (small organizations) in different sectors (industry, public enterprises, food industry, services). Using the method of expert evaluation, the mean values of these organizations resilience factors (on a scale of 0 ÷ 5) are determined.

In the next step, aggregated values of each indicator are determined (ie. SA, KV and AC) for the organization resilience (information in the front of the slash) and IS resilience (information in the field behind the slash). For the each of them minimum and maximum value and variation ($\Delta R$) are established, which is shown in Figure 7, 8, 9
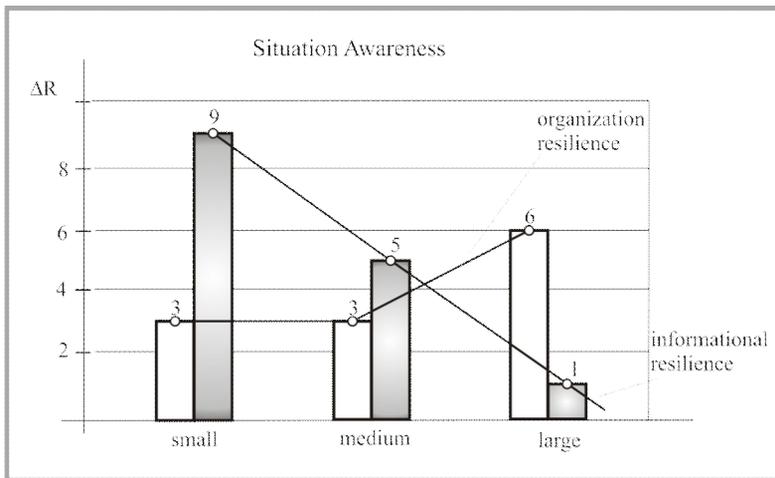


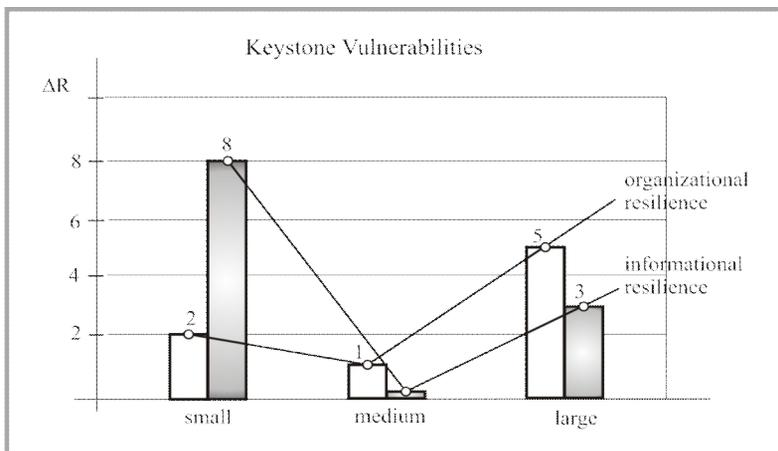**Fig. 7. Variation of Situation Awareness**
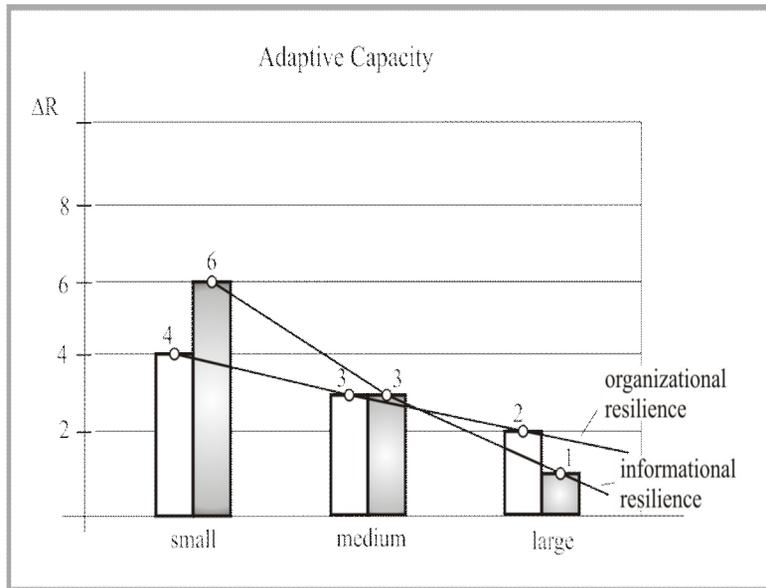


**Fig. 8. Variation of Keystone Vulnerabilities**

*Fig. 9. Variation of Adaptive capacity*

Size of variations of ΔR for small, medium and large enterprises is different for each system of indicators. Obviously, there is high specificity of each selected system so that it cannot reliably be claimed that there is a correlation between IS and organizational resilience. However, this tendency can be noticed: Δr is decreasing with the increasing size of the enterprise IS resilience and Δr is increasing with the growth of the organizational resilience, (Fig. 10).
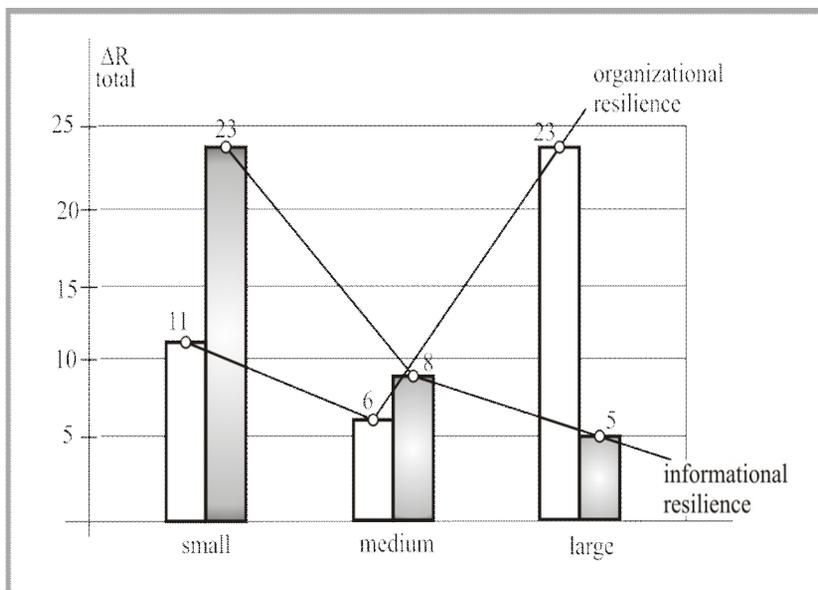


*Fig. 10. Total variations of organizational and informational resilience*

If the overall resilience is analyzed and it is expressed in points (maximum is 75 points), the Figure 11 shows that the level of organizational resilience in all of the three groups of companies is larger than IS resilience.
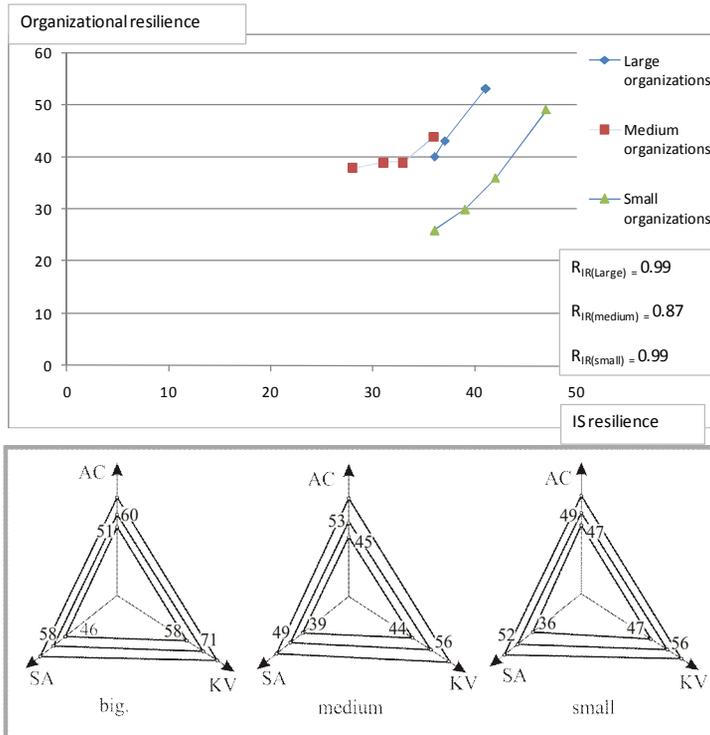Hypothesis H1 is confirmed by observing the data in Figure 11.

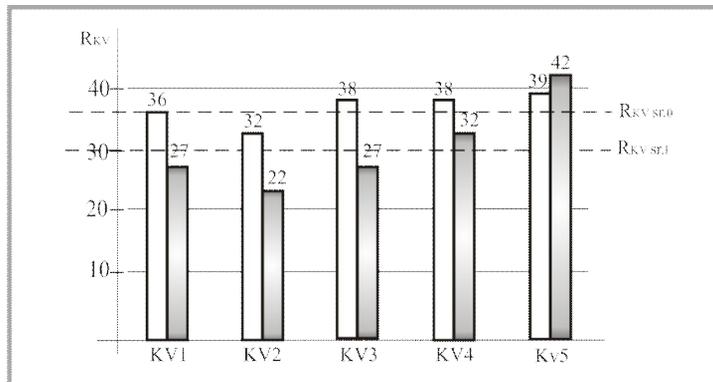Fig. 11. Relation between IS - and organizational resilience



Fig. 12. Levels of Keystone Vulnerabilities

If the IS resilience indicators are analyzed in the way to determine the most influential impact on organizational resilience, it can be determined that KV indicator is higher than average value for each of 12 treated organization. Hypothesis H3 is confirmed by observing the data in Figure 12.

## 5. CONCLUSION

Having on mind the many still unexplored application aspects of the ICT and IS organization resilience, the authors proceeded from the general model of information and organizational resilience and modeled their mutual influence and then determined:

- IS performance fall directly reflects on the sustainability of the organization,
- H1: There is a strong dependence between IS and Organizational resilience
- H2: The greatest level of impact is achieved through the KV (Keystone Vulnerabilities)
- H3: In the AC area, the greatest impact on organizational performances has KV5 (Connectivity and Knowledge).

The sample size of the research and the initial

research model promises that further improvements are expected in the areas of analysis of different sectors, ICT, IS and the organization behavior in real large disruptions conditions and connecting to Quality resilience.

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