

# The effects of various forms of inter-organizational trust on competitiveness

Lucio Biggiero<sup>1</sup>, Enrico Sevi<sup>2</sup>

<sup>1</sup>*University of L'Aquila, Piazza del Santuario 19, 67040 Roio Poggio, biggiero@ec.univaq.it, lbiggier@luiss.it*

<sup>2</sup>*University of L'Aquila, Piazza del Santuario 19, 67040 Roio Poggio, e.sevi@ec.univaq.it*

## Abstract

CIOPS (Cognitive Inter-organizational Production System) is an agent-based simulation model integrating structural and cognitive aspects of industry competitiveness. The model links firms profitability to the quality of their suppliers, thus firms purpose is to manage their cognitive space in order to find out the best supplier. This work analyses performance of firms using different decision making patterns which define the way clients select their suppliers. Four decision making patterns are observed: when firms make decisions using only their own past experiences, when they consider also others' experiences, when they rely on reputations assigned to suppliers, and finally when they make decision randomly. Results show that decision making patterns based on others' experiences and reputation are more profitable but that they are extremely sensitive to opportunist behaviours.

## Keywords

agent-based models, decision making processes, industry profitability, reputation, trust.

## 1 Introduction

A common approach of organizational scholars and evolutionary economists is the idea that static theories and models do not help very much, because real organizations and industries are dynamics and nonlinear, and thus, its behaviour cannot be studied with traditional approaches. The appropriate tool for theory building and testing becomes that of simulation, and specifically of agent-based simulation, because it allows as much complexity as the designer is able to implement and as the theorist is able to interpret in terms of results. Industry modelling through agent-based simulation has been devoted mostly, though not exclusively [Merlone and Terna 2006; Tesfatsion and Judd 2006], to apply Kauffman's [1993] approach of fitness landscape [Chang and Harrington, 2000, 2003, 2006; Kauffman 1993]. However, though it actually works in that sense, fitness landscape approaches are still too poor for being really appealing. Agents are extremely simple, as well as the decision space, and the interaction mechanisms among agents.

Other scholars followed a different modelling approach [Ashworth and Carley 2007; Davis et al. 2007; Dooley 2002; Lomi and Larsen 2001; Lomi and Pattison 2004]. In this perspective, Carley's work in bridging organization science with artificial intelligence [Carley and Gasser 1999; Carley and Newell 1994] and cognitive science has been fundamental [Ashworth and Carley 2007, Carley 1995, 2002]. The models developed in this perspective are characterized by cognitively richer agents and more complex and realistic interaction mechanisms.

This paper exploits the CIOPS (Cognitive Inter-organizational Production System) model that is a network of agents who represents firms interacting through structural and cognitive relationships. Firms are considered cognitive agents [Carley and Newell 1994] with a certain computational (bounded) capacity, a unique main goal, a set of expectations, and a (bounded) ability to recognize other agents, to cumulate knowledge and treat information. This repertoire of capabilities allows them to improve their choices of selecting the best suppliers, and even of

selecting the most effective among different types of decision making patterns. And this latter is clearly a truly advanced learning capacity.

The structural network is a productive system constituted by agents connected each other by (vertical) economic relationships, and interacting through orders, products, and information. It is supposed that industry were market-driven, and thus, that clients select subcontractors but not vice versa. Firms and the whole industry are supposed to compete in terms of product quality, and therefore this is the criterion used by firms to search for the best supplier.

At the same time each agent develops his own cognitive representation of the structural network. If clients cannot find a satisfying and available supplier among those with whom they had previous (positive) direct experience, they ask other agents information concerning the quality of other suppliers. Informers can tell truth or falseness depending on their inclination toward opportunism. Consequently the question of informers' reliability promptly raises up. Agents learn by building and managing memory about suppliers, informers, and types of decisions, and by constantly confronting current information with previous knowledge.

CIOPS model is used here to understand how inter-organizational trust and cheating attitude affect industry profitability. Three types of trust are considered: direct and indirect experience-based, and reputation-based. To each one a specific decision making process does correspond and, through a cumulative way, four decision making patterns are simulated: the simplest one is random choice; the second one adds direct experience; the third one adds indirect experience; and finally the fourth one considers also reputation-based trust. The effects of these four decision making patterns are confronted each other in different cheating environments.

Given a certain structural and socio-cognitive context CIOPS model is able to answer a number of questions among which the following are experimented in this paper: which is the most efficient decision making pattern? Does the decision making patterns effectiveness depend on firms opportunist behaviours?

## 2 Relation to Existing Theories and Work

It is widely recognized that, especially in developed countries, quality is a crucial competitive factor for industry competitiveness. Especially in hi-tech industries, product quality plays a decisive role. Moreover, it is now well recognized that products and environmental complexity tend to fragment production in many segments and many suppliers. Final producers, that is the downstream firms, should more and more develop managerial capabilities in terms of outsource coordination, because organizational structures are deeply de-verticalized. Thus, a key competitive factor for final producers is the ability to find the best suppliers in terms of product quality. When diffused among many final producers, this ability turns to be a competitive advantage for the whole industry, either because it improves cost management on the supply side, or because it allows selling better, and thus more competitive products, which are supposed to allow higher profit margins. In fact, though not conclusively and clearly demonstrated by empirical studies, the hypothesis of a strong causal relationship between product quality and average profit at industry level is commonly shared.

However, as clearly stated by transaction cost theory [Williamson 1985], outsourcing means market transactions, and these latter have high costs, especially when subcontractors are few and its products are complex. Both these factors raise transaction costs respectively due to opportunistic behaviours and idiosyncrasy. If this latter is kept constant, the crucial variable becomes opportunism and the ways to reduce it. The main way is by effectively allocating trust, which would enhance the probability to find the best suppliers and thus, to increase firms profitability. Choosing the best suppliers becomes a key factor of competitiveness.

The relevance given to this matter by management studies and economics is well witnessed by the extant literature on the ways to create, analyze, maintain and improve trust within and

between organizations [Lane and Bachmann 1998]. According to its source, it is possible to identify the following types of trust: calculativeness-based, knowledge-based, identification-based, and reputation-based. Knowledge-based trust refers to direct and indirect experience occurred between business parties, and it rounds on the idea that agents' behaviour do not change so quickly, especially when occurring between the same actors. Identification-based trust concerns a very special form, because, being related to symbolic or to issues somewhat external (and partially independent) to single agents, it is de-personalized. Reputation-based trust refers to collective opinions that have been formed and are recognized by single agents.

Recently management literature is devolving a growing interest to corporate reputation since it is considered one of the most important intangible assets and a crucial variable to ensure good economic performance. It is generally agreed that a good reputed company attracts new clients, has a good rating from finance actors, is able to easily overcome crisis events, and it is considered as good partner for alliances [Martinez and Norman 2004]. Although researchers do highlight the role of corporate reputation for economic performance, at the moment there is not a uniform view on its definition and the way to measure it [Cornelissen and Thorpe, 2002; Fombrun and Von Riel 1997; Grunig 1993; Martinez and Norman 2004; Williams and Moffitt 1997]. However academic mainstream considers reputation as the aggregated and whole evaluation shared by firms stakeholders [Cornelissen and Thorpe 2002; Wartick 1992].

CIOPS model adheres to this approach and models reputation as resulting from a given number of convergent images. As it will be shown in next section, reputation emerges when an agent acknowledges that an organization is perceived in a coherent manner by a given critical mass of other agents. Moreover, since an organization may be evaluated in a different manner by different agents, different reputations on the same agent may be formed. Thus, in this model reputation is not necessarily a global evaluation, but it could emerge as a local evaluation shared by a small group of agents: «reputation is perceived not just at the aggregate level but also among groups of similarly situated stakeholders» (Martinez and Norman, 2004, p. 26). In our model reputation is referred to suppliers' trustworthiness in terms of product quality. A high reputation means that a certain number of clients directly or indirectly new that a given supplier is trustful. That is, he is expected to make high quality products. This will be called reputation-based trust.

### 3 Research Approach: the agent-based model

Due to space requirements in this section it is impossible to provide any detail on CIOPS modelling and behaviour, nevertheless authors are willing to be contacted in order to give clarifications. After discussing structural and cognitive variables, this section focalizes on decision making patterns and ends up with an explanation of simulations setting.

#### 3.1 Structural variables

A final product requires more than one phase of production, each one composed by a set of specialized firms: final producers (downstream firms) get its intermediate product from first tiers (intermediate firms), which are on its own supplied by second (or source) tiers (upstream firms). A one-to-one relationship holds between suppliers and clients, that is in each step and in each market a client orders products to just one supplier. Suppliers are selected according to their quality. However, actual suppliers' quality is verified only after transactions, because clients either could not know it in advance or they could have incorrect information. Clients' individual performance depends on their profits, which in turn depend on quality of their suppliers. Supplier quality is distributed according to a uniform distribution between 0.5 and 1. Producer profits are 450.000 when the quality of the chosen supplier is maximum (equal to 1) and they lower proportionally to the decrease of supplier quality until -150.000, when the worst supplier is

selected (with a 0.5 quality). In this paper the main performance index we use is the industry average profit.

### 3.2 Cognitive variables

Each agent has her own representation of the structural network, that is of who produces what (and with what) quality, and who knows what. Thus, while each agent has her own specific cognition of each other, each agent is perceived in a potentially different way by each other. As concerning the content, cognitive variables deal with two aspects of the acknowledged agent: i) product quality; ii) trustworthiness as informer. Information on these aspects differs according to the structural and cognitive role of the following three types of source:

- direct experience-based trust (DEBT), which comes from previous direct experience;
- indirect experience-based trust (INDEBT), which is transmitted from a third part, the informer, who has had direct experience;
- reputation-based trust (REBT), which is formed when many informers' opinions do converge.

The three sources feed three different branch of agents' memory. In essence, agents' memory is specific of each client and it is composed by DEBT, INDEBT and REBT information referred to a certain number of suppliers.

### 3.3 Decision making patterns

As firms' performance directly depends on suppliers' quality, they have to manage their cognitive networks in order to find out the highest quality suppliers. This model is implemented with four types of decision making patterns based on different information sources of trust:

1. RND: random choices;
2. Led by DEBT: choices are based only on direct experience. Among available suppliers, clients choose the ones which gave the highest quality in past direct transactions. If nobody of them records the minimum average expected quality, then the supplier is chosen randomly;
3. Led by INDEBT: choices are based also on indirect experience. Looking for information, clients become inquirers, who ask informers about the expected quality of available suppliers. Informers can tell truth or falseness: true informers indicate the best supplier they know, while cheating informers indicate the worst supplier as if it were their best. Informers' opportunist behaviour depends on their inclination to cheat which is modelled as the probability that in each interval is given false information. When inclination to cheat is zero, then agents pass always true information, when it is 0.50 it means that in each interval agents have a 0.50 likelihood of cheating. Finally, when inclination is 1, they always lie. When a given inquirer follows the indication of a given informer, then it could evaluate informer's reliability and update its own memory of informers' reliability. Notice that inquirers exclude unreliable evaluated informers from future researches, thus each inquirer is inclined to ask only full reliable informers. By scanning all indirect experiences cumulated in her own life, the inquirer chooses the supplier with the highest quality score. However, before reaching the final decision, the quality of the supplier selected this way is confronted with that coming from the DEBT decision making process. It will be finally chosen the highest among the two. If none of the DEBT or INDEBT based decision making patterns will give any supplier with a sufficient average expected quality, then choice will be made randomly. Thus, when INDEBT is activated, agents trust information based on direct and indirect experience;
4. Led by REBT: clients consider also suppliers' reputation, and in case there is more than one with a reputation, then they choose the highest one. A given clients build the

reputation of a given supplier when the former receives as indirect experiences a number of converging evaluation on the latter. Thus, reputation emerges when a supplier is perceived in a coherent manner by a given critical mass of clients. Even in this case results deriving from this decision making pattern will be compared with those coming from INDEBT and DEBT, and it will be chosen the highest one. Again, if no satisfying result is got with these choice strategies, then the supplier is chosen randomly. Thus, agents using REBT decision making trust information from direct and indirect experience, and reputation with the same confidence.

### 3.4 Simulations setting

Next simulations are executed on an industry made up by 400 firms in downstream segment, 800 firms in the intermediate and 800 in the upstream segment. Tendency to cheat and decision making pattern will be manipulated as independent variables, while other parameters are kept constant. We label simulations as follows:

RND: industry where RND decision making pattern is activated;

DEBT: industry where DEBT pattern is used;

INDEBT: industry where INDEBT pattern is activated, by distinguish situation where agents do not cheat (INDEBT.0), where they cheat with a 0.5 inclination (INDEBT.50), and finally where they always lie (INDEBT.1);

REBT: industry using REBT decision making pattern and agents always telling truth (REBT.0), lying with a 0.5 inclination (REBT.50), and always cheating (REBT.1).

## 4 Findings

As firms purpose is to improve their performance, in order to find out the best supplier they enlarge their cognition by collecting experience and information. Since each client can change its supplier, at every simulation step the whole industry business network transforms its shape. As a consequence, during its virtual life industry configures itself in different structures, each one generating a different level of performance. Industry reaches the best performance when its firms are able to identify the best quality suppliers. Simulations findings show that changing in decision making strategy and tendency to cheat directly vary the industry structure and its average profit by shaping different business networks. Each simulation produces a specific path of performance and it draws a unique history of industry.

Figure 1 reports the average profit of honest final producers using the four different decision making patterns. Results show how RND choice is quite unstable around the 150 average profit, while DEBT permanently produces a worse performance than those scored by INDEBT and REBT decision making patterns. INDEBT and REBT strategies reach the maximum average profit very quickly. However, INDEBT occasionally suffers some slight decreasing, while REBT ensures more stability. Thus, when agents do not cheat, REBT decision making pattern results the best performance since it brings industry to the maximum average profit and keeps stable. This results is obtained because clients have to catch the best suppliers in a quite wide landscape (remember that they face 800 suppliers). Therefore reliable information turn out to be very strategic and the decision making pattern using the largest amount of information (REBT) results the best industry average profit.

By shifting the focus on cheating behaviours, figure 2 reports the effects of different inclinations to cheat in an industry where INDEBT decision making pattern is activated. It emerges how cheating deeply worsens performance by keeping it constantly away from its maximum. By observing the first 50 intervals, it appears that step by step agents collect indirect experiences, but, since most of them are deceptive, they increase their whole cognition with wrong items. Thereby, as simulation goes on, agents deteriorate their choices quality until they steady down in

a poor performance around the 30<sup>th</sup> interval. By observing differences among INDEBT.50 and INDEBT.1 it emerges that the growing of inclination to cheat produces a significant profit decreasing.

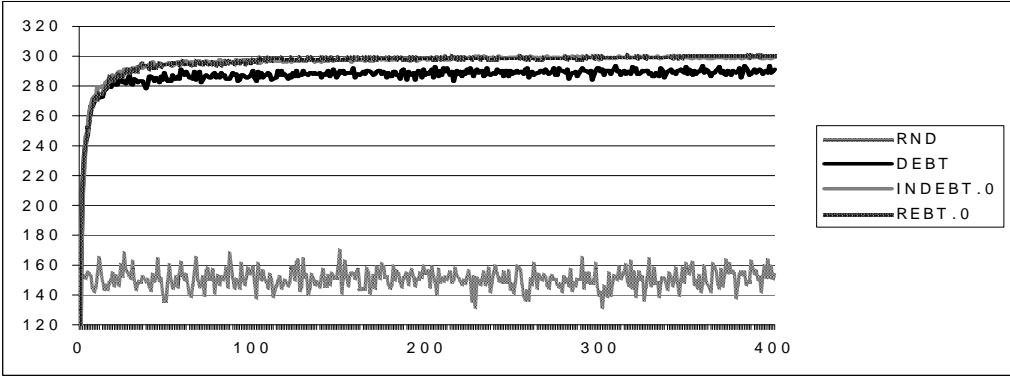


Figure 1: Industry average profit, comparing RND, DEBT, INDEBT and REBT patterns

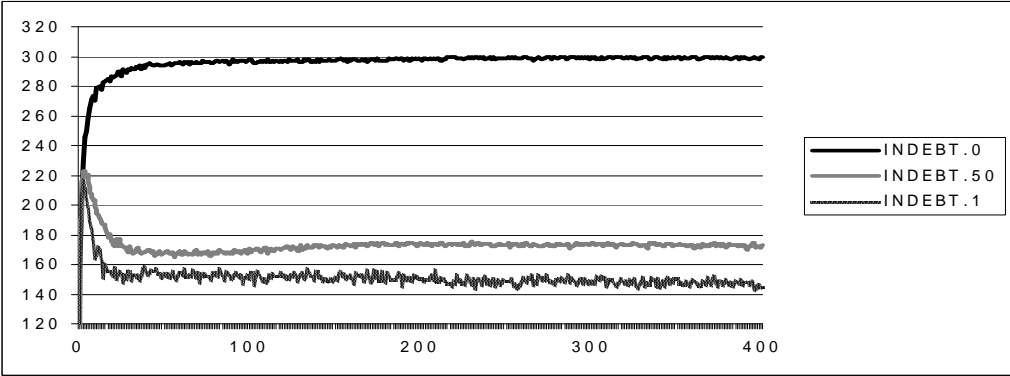


Figure 2: Industry average profit, comparing different inclinations to cheat in INDEBT pattern

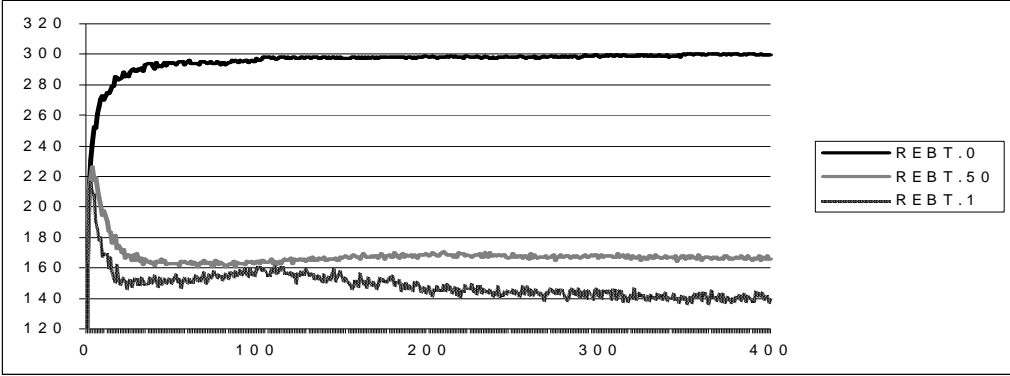


Figure 3: Industry average profit, comparing different inclinations to cheat in REBT pattern

When a REBT decision making pattern is activated (cf. figure 3), cheating effects become much more disruptive. It suggests that false indirect experiences produce false reputations that in turns result in a further loss of profitability. Thus, when REBT decision making is activated, the wrong reputations damages have to be add to those of false indirect experiences and the cheating depressing impact on performance becomes much stronger. Moreover, as inclination to cheat increases (comparing REBT.50 and REBT.1), the depressing effect grows to be more extensive and it results in a less whole profitability. It is worth noting that when all agents are totally cheater (REBT.1), performance stabilizes near the 200<sup>th</sup> interval when it oscillates around an average profit that is near, and sometimes below, that produced by RND decision making pattern. Thus, when only false information is shared and firms rely on reputation suggestions, agents cognitive efforts are totally wasted. Profitability pattern results in a steep and inexorable

downfall until it steadies to a level near to that of random choice, by producing the worst performance we observed.

## 5 Conclusion

From an overall view, the showed results make quite difficult to understand which decision making pattern returns the most effective performance. The trouble is that results may strictly depend on parameters and mechanisms we chose and, as concerning complex problems, every small change in modelling may produce very huge effects. Thus, future researches are needed to verify model robustness in order to understand to what extent these results depend on parameters and mechanisms we actually implemented. While keeping these caveats in mind, results do answer the two main questions raised in the introductory section:

- When firms are honest, indirect decision making patterns (INDEBT and REBT) become more effective than direct experience-based trust (DEBT); (reliable) communication makes easier and faster the information space exploration.
- When agents cheat, it is better to trust direct than indirect experience in order to avoid false information. Information reliability is more strategic than its quantity.
- When firms trust reputation, the depressing effect of opportunism grows to be more extensive and it results in a less whole profitability. When only false information is shared and firms rely on reputation, industry performance is near, and sometimes below, that produced by random behaviour. Thereby, agents' cognitive efforts are totally wasted and the worst performance is observed.
- Subsequently, the effectiveness of decision making patterns depends on agents' inclination to opportunism. When firms do not cheat, the most effective performance is reached by REBT pattern, followed by INDEBT and finally by DEBT. When agents cheat, the opposite order is obtained: DEBT results the best performance, followed by INDEBT and REBT in succession.

### Acknowledgement

Financial support was provided by a FIRB (Strategic Program on Human, Economic and Social Sciences) grant from the Italian Ministry for the University and the Scientific Research. We would like to thank our partners in the SOCRATE research project (<http://socrate.istc.cnr.it>): ISTC-CNR (Rome), LIUC University (VA), University of Brescia, ThinkinGolem, and Democenter. A special thank to Marco Valente (University of L'Aquila), who helped us refining the model.

### References

- Ashworth M.J., Carley K. (2007) Can tools help unify organization theory? Perspectives on the state of computational modelling. *Computational and Mathematical Organization Theory*, Vol. 13, 2007, pp. 89-111.
- Carley K.M. (1995) *Computational and Mathematical Organization Theory: Perspective and Directions*. *Computational and Mathematical Organization Theory*, Vol. 1, 1995, pp. 39-56.
- Carley K.M. (2002) *Computational organizational science and organizational engineering*. *Simulation Modelling Practice and Theory*, Vol. 10, 2002, pp. 253-269.
- Carley K.M., Gasser L. (1999) *Computational organization theory*. In Weiss G. (Ed.) *Multiagent systems: a modern approach to distributed artificial intelligence*. Cambridge (MA), MIT Press, 1999.
- Carley K.M., Newell A. (1994) The nature of the social agent. *Journal of Mathematical Sociology*, Vol. 12, 1994, pp. 221-262.
- Chang M-H., Harrington Jr. J.E. (2000) Centralization vs. decentralization in a multi-unit organization: a computational model of a retail chain as a multi-agent adaptive system. *Management Science*, Vol. 46, 2000, pp. 1427-1440.
- Chang M-H., Harrington Jr. J.E. (2003) Multi-market competition, consumer search, and the organizational structure of multi-unit firms. *Management Science*, Vol. 49, 2006, pp. 541-552.

- Chang M-H., Harrington Jr. J.E. (2006) Agent-based models of organizations. In: Tesfatsion L. and Judd K.L. (Eds.): Handbook of computational economics, Vol. 2. Amsterdam, North Holland, 2006, pp. 1273-1337.
- Cornelissen J., Thorpe R. (2002) Measuring a Business School's Reputation: Perspectives, Problems and Prospects. *European Management Journal*, Vol. 20, No 2, 2002, pp. 172-178.
- Davis J.P., Eisenhardt K.M., Bingham C.B. (2007) Developing theory through simulation methods. *Academy of Management Review*, Vol. 32, No 2, 2007, pp. 480-499.
- Dooley K. (2002) Simulation research methods. In Baum J.A.C. (Ed.) *Companion to organizations*. Oxford, Blackwell, 2002, pp. 849-867.
- Fombrun C., Van Riel C.B.M. (1997) The reputational landscape. *Corporate Reputation Review*, Vol. 1, No 1/2, 1997, pp. 5-13.
- Grunig J.E. (1993) Image and substance: from symbolic to behavioral relationships. *Public Relations Review*, Vol. 19, No 2, 1993, pp. 121-139.
- Kauffman, S. (1993) *The Origins of Order*. Oxford, Oxford University Press, 1993.
- Lane C., Bachmann R. (1998) *Trust Within and Between Organizations. Conceptual Issues and Empirical Applications*. Oxford, Oxford University Press, 1998.
- Lomi A., Larsen E.R. (2001) Introduction. In: Lomi A. e Larsen E.R. (eds.) *Dynamics of organizations: computational modeling and organization theories*. Cambridge (MA), MIT Press, 2001, pp. 3-36.
- Lomi A., Pattison P. (2004) Introduction to the CMOT Special Issue on mathematical representations and models for the analysis of social networks within and between organizations. *Computational & Mathematical Organization Theory*, Vol. 10, 2004, pp. 5-15.
- Martinez R.J., Norman P.M. (2004) Whiter Reputation? The effects of different stakeholders. *Business Horizons*, Vol. 5, No 47, 2004, pp. 25-32.
- Merlone U., Terna P. (2006) Population Symbiotic Evolution in a Model of Industrial Districts. In: Rennard J.P. (Ed.) *Handbook of research on nature inspired computing for economics and management*. Hershey, Idea Group Reference, 2006, pp. 301-316.
- Tesfatsion L., Judd K.L. (2006) *Handbook of computational economics (vol. 2)*. Amsterdam, North Holland, 2006.
- Tversky A. (1996) Rational theory and constructive choice. In: Arrow K.J., Colomatto E., Perelman M. and Schimdt C. (eds.) *The rational foundations of economic behaviour*. London, Macmillan Press, 1996, pp. 185-197.
- Wartick S.L. (1992) The relationship between intense media exposure and change in corporate reputation. *Business & Society*, Vol. 31, 1992, pp. 33-49.
- Williams S.L., Moffitt M. (1997) Corporate image as an impression formation process: prioritizing personal, organizational, and environmental audience factors. *Journal of Public Relations Research*, Vol. 9, No 4, 1997, pp. 237-258.
- Williamson O. (1985) *The Economic Institutions of Capitalism: Firms, Markets, Relational contracting*. London, Macmillan, 1985