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INTERDISCIPLINARY DESCRIPTION OF COMPLEX SYSTEMS

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WEALTH, GROUPS, ETHICS

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ABSTRACT

For centuries, many scientists, many disciplines focused on how people make decisions. These approaches tend to be incompatible, if not orthogonal most case. In this article we attempt to give guidelines to a modeling approach, that will allow the description of a human "state vector", which can be the basis for many decision making algorithms.

First we will introduce a categorization of the things that determine the decisions of the individuals, and describe their characteristics and trade. Since the trade of things in separate groups is done in different fashion, they form groups on different grounds. These groups, formed by interaction among individuals, adhere to governing ethics – which serve the purpose of defining the rules of exchange where these have not been explicitly stated. And finally, we take a look how the two dominant ethics, the Commercial and the Guardian dominate the Teacher.

KEY WORDS

ethics, commercial ethics, guardian ethics, state vector

CLASSIFICATION

JEL: P51

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MOTIVATION

The validity of every theory depends on the used axioms and the introduced concepts. Our investigation in this field was started by a mathematical model of a micro- and macroeconomic synthesis, that tried to take the physical realities – namely the laws of thermodynamics – into consideration [1]. In that model, the decision making entities (humans and corporations) focused on material goods and services. This approach – although it supplied a large number of beautiful answers – prevented the modeled individuals to perform many activities, since they were sorely focused on material wealth.

In order to expand that theory, we introduce five empirical facts, and create a model that takes these into consideration. Our postulates are:

(i) a human cannot live without consuming material goods,

(ii) material goods cannot be created out of thin air, only produced from other goods and natural resources,

(iii) the process of production is always a real, material process, but it is the human who decides which process to choose. The human decides, which realized possibility can come to be,

(iv) we always choose, what we perceive as "best",

(v) everybody wants to be happy.

The fifth, last axiom seems to be a triviality, but we state this as the fundamental rule of human decision making. In this, we accept Aristotle's view about happiness: everybody strives to be happy [2]. Without going into details about happiness, or fully accepting the "justice, health and fulfillment of desires" conceptualization, we believe that there is strong evidence suggesting that there is a strong correlation between happiness and the existence of attainable desires.

In the following, we focus on well-being, that we define as the relationship between the desired and realized goals. This well-being is different from the "utility" of economics, since it contains all subjective, emotional and material capital, and the expectations about the future, too. Although both happiness and well-being depend on the individual, they have a portion that can be objectively observed. In order to be able to use this terminology in a scientific discussion, we introduce the quantifiable factors of well-being.

FACTORS OF WEALTH

In order to easily describe the quantifiable aspects of well-being, we break the term down into discrete groups. First let's see what we understand under the whole term, and then we will introduce the like-behaving components.

DEFINITION OF REAL WEALTH

For the sake of this discussion, we define the *real wealth* as **internal factors that determine, how an individual feels**, how she experiences the state of the world. In this view, "real wealth" is equivalent of a kind of "human state vector"; it is something that describes the physical, physiological, social and intellectual "possessions" of an individual – and thus it becomes the present component of well-being: real wealth and expectations together is the well-being of a person. This definition coincides with the old conceptualization of wealth: somebody can be "rich" not only because she has a lot of material possessions, but also

because she has many friends, or knows a lot ("only what you know is truly yours"), is beautiful or healthy.

The definition is, of course, self-serving, since we are concerned about the factors that determine the decisions of an individual. It is our empirical experience, when people make a decision, at the time of the decision they choose what is "best" for them. We do not claim to know all the factors that come into play, but we do attempt to give lifelike categories, groups of factors that are alike in behavior.

These factors all enable the individual to change the world – but also through these factors the world changes the individual. The definition allows us to avoid the inherent causality problem here. The internal part in the definition relates to the changing of the world: even if all factors of wealth remain the same for the individual, the changing of the world will change the way she feels, yet her human state remained the same. At this point, she can make decisions, can choose to reallocate the components of her wealth into a portfolio that makes her feel better. In essence, these factors are *the basis for human decision making*.

These factors have two common properties. One is, that they all can be accumulated in some fashion, the other is, that they all have some kind of natural deterioration. We also use the assumption, that these factors are measured in a zero-based ratio scale, and typically a higher value in one of the components of the state factor ceteris paribus means, that the individual is "better off".

FACTORS OF REAL WEALTH

To determine the components of this "real wealth" all we need to do is conduct a thought experiment: which factors of a person's life can be changed so that she will experience a change in her perceived real wealth? We define four groups as the factors of wealth. These are the material, the physiological, the human and the knowledge factors.

The material factors are the easiest to comprehend: they contain all material items an individual possesses (X), plus all the accumulated money (M) they own. These goods are alike, since they are governed by the like physical rules, they exist in material form. The difference between the two types is that money can be created (that is how banks do it, the artificiality about the creation of the money is it's boundary, not the creation itself)[1]. They both deteriorate: normal goods through usage (food is consumed, a car is worn out, houses need repairs etc.), while money through inflation[2].

The physiological factors (P) contain all the intrinsic abilities and attributes of a given individual (for example strength, agility, reasoning ability, general health, body size, looks, etc.). These factors are easily perceptible from the material factors, since they cannot be traded for. Physiological factors can only be created, and on the market one can only purchase services, that enable or help one to create or improve these (gym passes, beauty salons, even plastic surgery). The natural deterioration is also present here: fitness has to be kept up, beauty is eaten away by the years, intelligence fades if one does not use one's brain, etc.

The human resources (H) are very much like the physiological factors, in the sense that they cannot be purchased. They contain all the inter-human interactions and social networks an individual has, her friends, family, acquaintances; in some case clan or gang membership, belongingness to a minority group, etc. These factors are either given, or changeable by the individual through social interaction (going to parties to meet people, talking to the friendly storekeeper, attending schools or conferences, or lately increasingly, taking part in Internet phenomena such as creating a MySpace page, submitting YouTube videos or engaging in a virtual world like World of Warcraft or Second Life). These resources decrease with time,

and have to be kept up through direct action. Friends need to be humored, clans need to be honored and gangs have to be satisfied to be considered part of the human factors of wealth.

The last factor is knowledge (K), or more precisely, transferable knowledge[3]. It is different from intelligence, which, as earlier shown, is part of P, and it has to do with the accumulated information the individual has. Its deterioration is also automatic: people forget.

BALANCE EQUATIONS

We can use balance equations to describe the trading, exchanging or changing the various factors of wealth. Each equation pair will describe how the stock of a certain factor changes for both parties in the exchange. We will use the values X, M, P, H and K to describe the stock of factors, the parameter will show the time dependence (where "t" is for the state before the transaction, and "$t + 1$" is afterwards), and the lower index denotes the individual (in most cases, the transfer is in the direction of A → B). These equations show the basic difference between the three main groups, the material (X, M), the personal (P, H) and knowledge (K) types.

MATERIAL FACTORS

Trading material goods is a zero-sum game: what one gains the other one looses. If we denote with X the amount of material good a person has (lower index differentiates between the individuals), then the transfer of S amount of material good can be described in the following form:

$$X_A(t + 1) = X_A(t) - S,\ X_B(t + 1) = X_B(t) + S. \tag{1}$$

Usually such exchanges have a counterpart, since in this example "A" lost S amount of goods, while "B" gained the same S amount. In the real life there is usually an inverse process, the payment, where B transfers some amount of money to A (M denoting the amount of money each participant has before and after the transaction):

$$M_A(t + 1) = M_A(t) - Y,\ M_B(t + 1) = M_B(t) + Y. \tag{2}$$

So in other words, A sold S amount of goods to B for Y amount of money[4].

PHYSIOLOGICAL FACTORS

As mentioned earlier, neither physiological, nor human resources can be created. This means, that the person selling healthcare products or operating a fitness salon does not loose "healthiness" or fitness by doing so; although she has to invest material resources, she does not loose the factor that is the primary in the exchange. So when A sells some healthcare services for B, it will register as a loss for A in X, and a gain for B in P, while a reverse monetary transaction follows. In the example below, A sold S amount of healthcare services for Y to B, who gained Q amounts of "health" due to this transfer:

$$X_A(t + 1) = X_A(t) - S,\ P_B(t + 1) = P_B(t) + Q, \tag{3}$$

$$M_A(t + 1) = M_A(t) - Y,\ M_B(t + 1) = M_B(t) + Y. \tag{4}$$

In reality, equation (3) depicts the sale of a service. To keep the balance equation clean, this can be broken up to two steps: first there is the transfer of the service (5, S amounts of material goods get exchanged), that gets used up immediately (6, nearly the same time – hence the epsilon term – as 5, B uses up the S amount of healthcare services to produce Q amount of health):

$$X_A(t + 1) = X_A(t) - S,\ X_B(t + 1) = X_B(t) + S, \tag{5}$$

$$X_B(t + 1 + \varepsilon) = X_B(t + 1) - S,\ P_B(t + 1 + \varepsilon) = P_B(t + 1) + Q, \tag{6}$$

$$M_A(t+1) = M_A(t) - Y,\ M_B(t+1) = M_B(t) + Y. \quad (7)$$

So in essence, A is spending some of her resources to create a service for B, who purchases S amount of it for Y money. Since B has no way of actually "storing" a service, it is immediately used by B to produce Q amounts of P for herself. This shows that there is no trading for P, there is only trading for the material good that allows the self-creation of P.

The reverse of this transaction is not a reverse in the balance equation. Taking away P from someone (administering physical punishment, for example) is a sorely destructive process: the attacker does not gain what he takes away from the target. If A attacks B and does S amounts of harm to her, then the balance equation would be:

$$P_A(t+1) = P_A(t),\ P_B(t+1) = P_B(t) - S. \quad (8)$$

HUMAN FACTORS

Describing human resources is a rather complex problem. The best approach would probably be through using some kind of graph-based approach, where the nodes are the individuals, and the weights on the directed edges would describe the strength of a relationship. In this approach, there would be multiple ways of enhancing the real wealth in H: one could strengthen a pre-existing relationship (transform an acquaintance to a friendship, thus increasing the weight on a certain edge), make new acquaintances (build up new links to other nodes), or try to use the existing social capital to increase the value of her current social network (using the graph-theoretic description, enhancing the weight of an edge between one of her "children" and her "children"). This field is rather new and expands exponentially, and going into even this much detail is usually unnecessary for us. Our concern is mainly that the human relations can be "measured" in some kind of way, and this can be described in a ratio scale.

Human resources work similarly to the physiological components of real wealth, but have slightly different balance equations. When social networks develop, they develop for both parties; when A gets to know B, B also gets to know A. So building social networks, increasing H is not only a positive sum game, but is also a win-win game. If H denotes the amount of human resources an individual has, the lower index differentiates among individuals and the parameter shows the differentiation according to time, then the following events describe, that A meets B in an event, where the attendance cost is Y_A for A, Y_B for B:

$$H_A(t+1) = H_A(t) + T_A,\ H_B(t+1) = H_B(t) - T_B, \quad (9)$$

$$M_A(t+1) = M_A(t) - Y_A,\ M_B(t+1) = M_B(t) - Y_B. \quad (10)$$

Note, that A and B gain different amount of human resources by meeting each other (A gained T_A, while B gained T_B), since they do not necessarily experience the other one equally pleasant or useful[8].

The reverse of this process, when someone takes away social state from another individual, is usually another negative process. It can happen in three distinct ways. If B manages to turn some friends against A through befriending them, then it is a loss-win scenario:

$$H_A(t+1) = H_A(t) - S,\ H_B(t+1) = H_B(t) + S. \quad (11)$$

Another possibility is, that while B tries to befriend and turn some friends of A's against A, she only partially succeeds, resulting in a loss-null scenario:

$$H_A(t+1) = H_A(t) - S,\ H_B(t+1) = H_B(t). \quad (12)$$

The last option is when the decrease in human resource is a one-sided aggressive act. An example for this could be, when B decides to kill a friend or acquaintance of A. In this case A would loose some (in the example, S) amount of social wealth, but at the same time – if B's role becomes common knowledge among A's (or S's) friends, B looses some (in the following example, Q) amount of social capital, getting into a loss-loss scenario:

$$H_A(t+1) = H_A(t) - S,\ H_B(t+1) = H_B(t) - Q. \tag{13}$$

KNOWLEDGE

Knowledge is the traditional win-win scenario. Knowledge can be gained through teaching, and teaching is a process through which the teacher does not loose the information she gives out – and in most cases she has a chance to refine her knowledge by passing it on. In case the student pays the teacher, there is a monetary aspect of it, too, but this is not really necessary. In the following example, K denotes knowledge, the lower index denotes the individual (here A is the teacher, B is the student), S is the amount of knowledge gained for each participant, and Y is the (optional) payment:

$$K_A(t+1) = K_A(t) + S_A,\ K_B(t+1) = K_B(t) + S_B, \tag{14}$$

$$M_A(t+1) = M_A(t) - Y,\ M_B(t+1) = M_B(t) + Y. \tag{15}$$

Of course, in this case we do not know about the relationship of S_A and S_B (either of them can be larger), but the positive feedback is definitely present here.

Taking away knowledge is usually a disruptive process Most of the time it involves lying (for example, a conman might do this, or some social systems base their workings on intensive misinformation). This, however, does not necessarily mean that the originator believes the misinformation:

$$K_A(t+1) = K_A(t),\ K_B(t+1) = K_B(t) - S. \tag{16}$$

It is easy to see the resemblance of (16) to that of (8).

GROUP FORMATION

For the purposes of our investigation, a **group** is a **set of individuals, among whom certain activities are more common, than the same activity with non-members**. This definition does not require the group to be formal, or even the emergence of group interest.

As already discussed, the different factors are traded in different ways, and these ways have different balance equations. Using the definition above, these trades define groups among the individuals – and the structure of these groups differ just as much as the trades themselves. For example, the relationship among a convenience store worker and the customers is different than the relationship between club members, or between teacher and students.

The trade of material goods is strictly businesslike, both parties are in there for mutual material gain, so they form *trading groups*. Since these interactions are governed by self-interest, individuality is emphasized, and no group interest emerges. The group forming force is reliability and trustworthiness: buyers will frequent a seller only if the seller offers something the other traders can not. This explains why some customers knowingly do not shop at the cheapest place: they are willing to pay premium price for the service they trust. These groups are ad-hoc, time and place determined.

The development of human resources focuses on interpersonal relationships, both parties are in it for mutual benefit and protection, thus they form "*acquaintance groups*", friendships, clubs, gangs, etc. In this case, the individual becomes part of a more formalized community, where group interest appears, and individuality becomes (at least partially) subjected to the group. The group forming force here is belongingness: the feeling of being part of a greater community itself is what keeps the group together. These groups tend to partition the social space: most of the time an individual can only belong to one of them (good example for this are gangs, religions, home owners' associations, labor unions).

The student-teacher relationships are the true win-win scenarios, where both participants benefit from enhanced knowledge. This, alongside with mind-seeding, leads to the formation of "*schools*" where like-thinking people develop and further their own field. The group forming force here is the common knowledge, the paradigm, which means, that these schools are hierarchical, just like the set of paradigms that define them. For example, a scientist might, at the same time, be a teacher, an economist, and a post-Keynesian, and her interactions with others belonging to other groups is what defines her group-belongingness for the given interaction (for the monetarist, he is a post-Keynesian, for the anthropologist he is an economist, and for the layman he is a scientist[6]).

GOVERNING ETHICS

In her 1993 book, Jane Jacobs [3] introduces two distinct "modes" of human behavior. One she called the Guardian, the other the Commercial, and she basically stated, that while these modes have conflicting values, they each are good for solving certain problems. Chris Phoenix, [4], building on her work, defines ethics as "the rules of behavior that are applied to a person by a system or institution they participate in". While that definition is accurate enough, we would like to focus on the fact that these ethics are the set of rules that govern the terms of an exchange in the parts where the exchange is incomplete.

The various kinds of groups introduced in the previous chapter conform to different ethics. The **Commercial** ethic, which governs the trade of the material goods, focuses on maximum profitability, total economic efficiency, and thus forces the production process of goods and services to be most efficient[7]. It speaks for individualism, hails selfishness, idealizes innovation but shuns away from force. As the pioneering economist Adam Smith said: "It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest." [5].

The **Guardian** ethic focuses on the protection of "our own", avoiding losses and damage to the "group". This is basically the opposite of the Commercial ethic, it's ideal is the self-sacrificing person, living for the group. The Guardian ethic is not worried about efficiency, instead about equality, safety, the preservation of the existing order. Instead of innovation, it focuses on tradition and morals, and is not shy to use force for the protection of the group. "Because just as good morals, if they are to be maintained, have need of the laws, so the laws, if they are to be observed, have need of good morals." [6].

To complete the set, Phoenix introduced what he called the ethics of Information. He based this ethic on the win-win scenario that he called "infinite sum" games, where the source of the information benefits from others possessing it. We argue, that this kind of behavior is not new, it has always been the basis of *knowledge*. We call this the **Teacher** ethic, where the focus is on knowledge and the dissemination of knowledge (thus it incorporates both the teaching and the researching aspect), the morals idealize intelligence and smarts, and it shuns away from both force and commercialism.

This last ethic is different since it governs a process with what the economists call *growing marginal utility*: the more one knows, the more questions one has, and the desire to know more just keeps growing. Parallel to this is the fact, that the balance equation of knowledge describes the ideal win-win scenario, so in essence this is a "utilitarian perpetum mobile": those abiding by the teacher ethic can infinitely generate real wealth among each other. Of course, those outside the ethic only experience the end result and not the process itself, but it is important to remember, that most research and education aims to understand the world, *not* to create something with an exact real world application.

SOCIAL NORMS AND GOVERNING ETHICS

A central theme in Jacobs' book is, that an ethic can only fulfill certain roles, and when it tries to do otherwise, that is usually a failure. An apt example is communism, where the guardian ethic was supposed to govern trade; its spectacular failure easily stresses her point. On the other end, when the Commercial ethic is allowed to take on roles normally reserved for the Guardian (for example, American corporation-managed towns), similar anomalies appear. Mixing the two ethics usually lead to what Jacobs called "monstrous moral hybrids", like the Mafia or a bribable government, which can be just as disastrous as the misuse of ethics.

Taking this into consideration, the prevalent and global problem of education is easier to understand. As we have shown, trading knowledge abides by a very unique balance equation, thus it forms its own, hierarchical groups. But the natural ways to interact within those groups do not conform to either the Commercial or Guardian ethics, they define their own ethic, the Teacher ethic. Despite this, today's education is usually forced to abide by the rules of some other form of ethics. In the communist countries, the prevalent Guardian ethic dominated scholarly work, which prevented the publication of scientific results in western magazines, thus blocking the dissemination and its positive effects. In the current capitalistic world governed by the Commercial ethics knowledge is made to be a product through the use of copyright laws and trademarks. Both of these ethics prevent the positive feedback knowledge needs to thrive.

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REMARKS

[1]The limit to the creation of money through the fractional-reserve banking practice is the reserve ratio. This can either be determined externally, like in most countries, or left for the banks themselves to decide, like in Great Britain. This topic is thoroughly discussed in [7].

[2]The debate about the role and necessity of inflation is still undecided. For more about this issue, among others see [8 – 10].

[3]There are some skills that incorporate both a transferable knowledge content (K), and a non-transferable, internal content (P). Example to these could be most sports, notably dancing, where some rudimentary knowledge can be taught, but the actual ability depends on personal practice, that cannot be transferred among individuals.

[4]It is easy to see, that trades of this kind are zero-sum games (or, including transaction costs, negative-sum games) in a purely accounting sense. However in a utilitarian sense, trade is a win-win scenario, since both parties feel, that what they got in the trade is of more value for them than what they paid – otherwise the trade would not take place.

[5]In a purely theoretical sense, if the entire social network of both individuals would immediately be available to the other person, then instead of (9) the expression

$$H_A(t+1) = H_A(t) + H_B(t)\backslash H_A(t);\ H_B(t+1) = H_B(t) + H_A(t)\backslash H_B(t)$$

would be true. This assumption, however, is highly unrealistic, and would only allow the social networks to be described in a partitioned space, thus $H_B(t)\backslash H_A(t) \equiv H_A(t)\backslash H_B(t) \equiv \varnothing$. We do not make this assumption.

[6]Pithagoras' followers were known to dress different than common people, wanting to strengthen the "group belongingness" this way.

[7]There are a number of clues which seem to indicate, that the governing ethic of the financial corporations and large multinational entities differ from the "standard" Merchant ethic. Further

research is needed to discern whether this "capitalistic" ethic is indeed separate, or just a form of the Merchant.

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BOGATSTVO, GRUPE, ETIKA

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SAŽETAK

Stoljećima, fokus mnogih znanstvenika i mnogih disciplina je kako ljudi donose odluke. Pristupi su nesukladni, ako ne i suprotni u većini slučajeva. U ovom radu nastojimo dati smjernice pristupa modeliranja koji će omogućiti opis ljudskog „vektora stanja", kao temelja mnogih algoritama donošenja odluka.

Kao prvo uvodimo kategorizaciju stvari koje utječu na odluke pojedinaca i opisujemo njihove značajke i razmjenu. Razmjena stvari u različitim grupama odvija se na različite načine, zbog čega su i same grupe nastale na različitim temeljima. Te grupe, ostvarene međudjelovanjem između pojedinaca, vezane su uz vodeću etiku – čija svrha je definiranje pravila razmjene u slučajevima u kojima ona nisu jasno iskazana. Naposljetku, razmatramo kako dvije dominantne etike; komercijalna i etika zaštitnika, nadvladavaju etiku učitelja.

KLJUČNE RIJEČI

etika, komercijalna etika, etika zaštitnika, vektor stanja

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FOUR QUESTIONS ON COMPLEXITY AND LEARNING

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ABSTRACT

Increasing interaction (in numbers, patterns and uncertain intensity) in innovation processes point at new and different methodologies of researching reality including complexity views of modern production. In post-modern era, where (informational) networks are evolving, learning can not be understood through the lens of organization, but through learning individuals. Such approach can be attained by Interaction analysis which gives typical pattern of connections among attributes describing phenomena. Interaction analysis is the first step to functional modeling as a method of multidimensional optimization for chosen criteria. Functional modeling satisfies processing approach which treats surroundings as complex, uncertain, full of changes and emergent phenomenon. Empirical analysis indicates that companies in Slovenia in the year 2003 are not characterized with category of Learning organization.

KEY WORDS

interactions, innovation process, learning organization, view of complexity, uncertainty

CLASSIFICATION

JEL: D20, L25, O32

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WHY QUESTION OF COMPLEXITY IN PRODUCTION?

"Straight stream" economic science (where neoclassical economy is entirely in the focus) explore reality on presumptions that market and production are at all times shaped in the same complexity, so there is no need to expose complexity as the objective factor in understanding the laws regulating economic life. That practically means that exploring tools of 19th century world economic reality are the same as the ones of 21st century.

The heterodoxy economy is not satisfied with such presumption and takes into consideration specific and limiting characteristics of complexity. It is known that notions of systems and complexity have been developed as a response to dissatisfaction with the science that dominated in the early 1900s [1]. Science commonly referred to as »Newtonian« includes linearity, predictability, control and access to perfect knowledge.

An actual understanding of complex system is one where inferences require the insight of different disciplines operating at different scales, where there is irreducible uncertainty; and, where there are multiple phenomena like future states, predictability and perfect knowledge unattainable. Opposite to the Newtonian world a view of the emergence of post-modernism in the mid–1990s in the literature and social criticism had started to influence also other fields of the science. The new science called as Science of Complexity or Post-normal Science had started to reflex a new epistemological and ontological perception as follows:

- the core concept of the science of complexity is one in which the state of the phenomenon is uncertain,
- the science of complexity is with hypothesis of uncertainty avoiding complete information that why an epistemological variant of irreducible uncertainty, bounded rationality has to be practiced in theories and empirical models,
- sufficiently complex systems demonstrate behavior which could not be predicted as based on the separate behaviors of the system components, but can be only explained in terms of the component properties; consequently, complexity is irreducible and phenomena can not be simplified without losing their essential nature,
- irreducible uncertainty and bounded rationality certify the role of subject with different, equally valid, imperfect view of some portions of the phenomenon.

The economic theory representing views of complexities – evolving complex systems ("Santa Fe approach" [2, p. 3]) is answering the question what is complexity perspective in economics. The concept is based on the critique of conceptions of the "equilibrium" and "dynamic systems" approaches. In the first, the problem of interest is to derive, from the rational choices of individual optimizers, aggregate level of "states of economy" that satisfy some aggregate level consistency condition (market clearing, Nash equilibrium), and to examine the properties of these aggregate level states. The equilibrium approach does not describe the mechanism whereby the state of the economy changes over time and also how equilibrium comes into being. The second approach represents the states of economy by a set of variables. A system of difference equations or differential equations describes how these variables change over time and the problem is to examine resulting trajectories, mapped over the state space. The dynamical system approach generally fails to accommodate the distinction between agent and aggregate levels. Obscuring "representative agent", the emergence of new kinds of relevant state variables, even less new entities, new patterns, new structures, is not possible. The complexities of process and emergence approach are based on six features of the economy as phenomena which are called "adaptive nonlinear networks" [2, pp. 3-4]:

- the mechanism of the economy is based on the interaction of many dispersed, possibly heterogeneous agents acting in parallel,
- no global entity controls interactions,
- the economy has many levels of organization and interaction,
- agents continually accumulate experience and constantly adapt themselves,
- perpetual novelty is created by new markets, new technologies, new behaviors and new institutions,
- improvements are ongoing and occur regularly, so economy operates far from any optimum or global equilibrium.

Consequence of learning in an economy is technological change which is in the focus of a study of an innovation process and is a motive power of modern economies. The study of the technological change addresses questions relating to: the sources and the direction of potential improvements, the selection of actual changes of all potential changes, the process of introduction of such changes and their impact [3, p. 2]. Acquired knowledge is absorbed in the whole innovation process and encompasses improvements of a researching process of a new product, production processes, material and their development and intermediate inputs in management methods, new organizational concepts and knowledge of marketing in the economic system. Innovation process constructed of a complex technology involves not only firms own research and development (R&D) activities, but also their capabilities of outside technology, consequently point of a view of the whole economy is of a crucial importance. Therefore useful products and processes result from a variety of sources and meet performance constraints along multiple dimensions. Codified knowledge is not a sufficient guide to practice, because assimilation of outside technology and prediction of the operating performance of complex technological artifacts is not assured automatically. That why firms most of the time spend on development activities and not only on activities of invention (researching activities). Beside importance of a tacit knowledge [4] accumulated through experience and on-the-job experimentation, social interactions and transfers are also of crucial importance for firm's innovation progress. These characteristics of technology and organization of the innovation process have a major implication for the conceptualization of characteristics of the measurement of a learning process attributes. First we have to understand not only research & development activities as a complement to the absorption of outside technology [5, p. 18] but also all other organizational information receiving from several organizational level of socially created innovation process. Second, relations among several social actors at different social levels are explanations for filtrations of competitive information and acceleration of a diffusion of general transferable information. Third, an inevitable consequence of the complexity of technology is its variety. Because technological knowledge emerges mainly from several firms' development and production activities it is more accurate to speak of technologies of a social production [5, p. 19]. From the point of view the current period research is concentrating more on developmental processes of unlocking and path creation within a national economy [6]. In such context micro-macro interactions at different levels, providing structural and developmental orientations, are important.

The important cognition is that increasing interaction (in numbers, patterns and uncertain intensity) in innovation processes point at new and different methodologies of researching reality including complexity views of modern production. So social production of technologies asks for complex point of view in the sense of existing uncertainty in predicting interactions among specified (but not fixed) characteristics of phenomena and evolution of phenomena as a whole itself.

IS LEARNING IN A PRODUCTION A QUESTION OF ORGANIZATION OR HUMAN ENTITY?

Literatures of learning organization takes for true that organizations[1] learn. Such conclusion is avoiding complexity context and is dangerous in global condition for long term production prosperity. Global capital exerts pressure on social production, politically excluding human rights in production and consumption and with that on the main source of growing knowledge. Behind global capital stands power of control over all resources that may evolve its growth. Consequence of such development is world inequality, misery and ecological changes which destroy what has been produced with the assistance of the capital if we mention only the most visible results.

We will use the multilevel theory to show alternative concept in understanding category of learning which limits asymmetrical capital development in the benefit of all stock-holders in a production and enable a more integrated understanding of phenomena in a modern way of production. Fundamental to the level perspective is the recognition that micro phenomena are embedded in macro context and that macro phenomena often emerge through the interaction and dynamics of lower-level constitutive elements. The macro perspective neglects the means by which individual behavior, perceptions, motivations affect and interactions give rise to higher-level phenomena. In contrast the micro perspective has been "guilty" of neglecting contextual factors that significantly constrain the effects of individuals [7, p. 7]. As authors wrote organizations do not behave; people do and we add so they can not learn. Another very important category in the multilevel theory is a construct – abstraction used to explain apparent phenomena. A construct may appear on different levels. In the context of learning in organization we are describing the influence an individual learning exerts in unit knowledge. Such learning can not be captured by category of learning organization. It is more collective knowledge gained by interactions among organization members. It is necessary to make important distinction. Collective phenomena may emerge in different ways under different contextual constraints and pattern of interaction[2] [7, p. 59]. Collective knowledge may be conceptualized as the sum of individual knowledge. But alternatively knowledge may be conceptualized as configural spirals where some individual's knowledge is more useful than other knowledge. Organizational learning as category can be identified only by isomorphic models, where all knowledge converges to the same point. Interactions are stable, low dispersed and uniform. In such a case we talk about emergent process of composition. Organizational learning (better organizational knowledge – as a structural point of view) is sum of individual knowledge.

Learning as a process and results in the sense of emergent characteristic explained with patterns of interaction allow that even small changes in individual knowledge and interactions yield to big nonlinear changes. Patterns as representation of emergence show discontinuity come out from personal diversity. Such consideration is able to capture the rich complexity of emergence and importance of adaptive team networks. Organization is not any more once for all the time accepted linkage among people (supported by legal regulation of the states). Inversely networks are flexible, irregular, high dispersed and no uniform, supported by knowledge of multiple solutions in decisions. Category of organizational learning does not cover the essential processing of networks. Political theories treating society as a system [8, pp. 7-10] are very often object of a critique as leading in reification, what means that theories ascribe actor characteristic to systems (instead of an action of actors they are ascribing an action to systems). Complication involving collective actor arise from misunderstanding the category "emergence" [8, p. 8] when the same is not connected with multilevel structure of society. Political theories (especially Sibeon's one) do not see that the transformational process

emergent result is located on the level of an organization, although organizational decision process is located on the level of actors. Actor and emergent results are connected with cross level transformational mechanism (in Bhaskar's theory). In multilevel theory position of actor is specified and not relativized like in Makarovič's theory where "it seems that organization is an actor who takes a decision and performs concrete decisions" [8, p. 9].

Multilevel theory says that all performances in organizations, regardless of the level of analysis, must ultimately be a function of individual-level behavior. Organizational behavior and corporate performance are really still a function of coordinated efforts by individuals [7, p. 131]. The term "organizational" accustom on the structure which in the accepted concept of appeared flexible networks freeze up "organizational relations" not allowing emergence of a new one. Adaptive networks are not just aggregates of individuals. Individuals always exist as a basis for all teams and other types of networks. Networks go beyond the individual where individuals learn interactive with other individuals how to integrate individual-level and team-level goals.

Networks top-down limit participants with the context of the existence of the whole network. In human resource literature such context is denoted as organizational climate comprehended as a shared or summary perception that people attach to particular features of the work settings. Organizational climate is distinguished from psychological climate, which is based on individuals' perceptions of possibilities how problems exist and how can be solved. If theory of learning organizations accedes to learning from the aspect of structure, its context presupposes system with determinated number and pattern of individuals (or entities). Multilevel theory solve the problem of learning via open system, what means that number and configuration of relations are no more fixed through abstraction, but allow new relations in time and new players in adaptive network. Networks are alive: so part of them are dieing and some are new born – this is an idea how to imagine category of process. The aim of this researching paper is to expose complex characteristic of learning and measurement possibilities.

Last point of view is to look on complex learning from the global point. If we connect attribute globally to phenomena capital than we can see that noun learning (organizational learning specifically) is by its substance closed system in the sense, that learning must be organized strictly to support profit maximization and no criteria of social production does exists. Capital and category of capitalist organization are complementary parts of category exploitation. Exploitation exists on closed organization where every not defined relation cause uncertainty in a way that when opened appear probability that some resources will be lost. Social context of capitalist production must minimize all risks. In that way inherent capital autonomy in its global function exclude learning components, which are socially acceptable, but entropic from the point of the individual capital. In post-modern era, where (informational) networks are evolving, learning can not be understand through the lens of organization, but through learning individuals who are not necessarily included in defined organization[3] but are for sure included in appearing adaptive networks.

WHICH IS CONSISTENT COMPLEX CHARACTERISTIC OF A LEARNING PROCESS ATTRIBUTES AND ABOUT ITS MEASUREMENT?

The first step would be working definition of emergency as one of the most important characteristic of complexity at all. Mitleton-Kelly [9, p. 19] defines that emergent properties, qualities, patterns, or structures, arise from interaction of individual elements; they are greater than sum of the parts and may be difficult to predict by studying the individual elements: Emergence is the process that create new order together with self organization. Organizational learning can be properly understood only in the context of emergence.

Knowledge and innovative ideas could be described as an emergent property in the sense that it arises from interaction of individuals, and is not just the sum of existing ideas, but could be something quite new and possibly unexpected [9, p. 21]. Articulated and implicated ideas form part of the history of each individual and the part of the shared history of the network as a whole. Only in this way network (organization) learn, as new ideas and new knowledge can be built upon to generate further new ideas and knowledge. Learning leads the whole organization to new behaviors and organization is adapted and evolved. New knowledge needs to be shared among individuals to generate further new learning and knowledge. If organizations have been understand as complex evolving systems, co-evolving within a social ecosystem, than organizations and social ecosystem can be viewed as self-organizing human information-processing and communications systems [10, p. 6]. The same author understands social systems as a dissipative structure [10, p. 7]. At the level of the individual perception, cognition and learning are activities which reduce apparent chaos to manageable proportions based on identifying apparent regularities. Cognition allows us to "fix" such regularities (symmetries, patterns). Repetition of the process and our observations allow us to distinguish a category (by van der Leeuw pattern of patterns) defined by the nature of dimensions involved and the ways they intersect. New pattern is in a substance a new point of view, providing a new perspective and new solutions of further problems. On the base of a new interpretation of phenomena – new cognitive categories can be formed interpreting the first. Such learning process is continuous, modifying meanings from interactions among perceptions.

Following the theory of complexity social systems are opened in exchange matter, energy and information with their environment [10, p. 10]. The exchange of matter and energy satisfies the condition of decreasing the uncertainty in the system when system is closed (the condition of the complete competition). When exchange of knowledge and information is included social systems are complex by its substance and opened to environment. Increase in the quantity of information among individuals leads to request in increase in participation and coherence [10, p. 10] – what means increasing the degree of organization and dissipating entropy. Social systems insisting in historical social structures may consist only on negative feedbacks, exporting its inherent tendency to system environment. Change to higher social coherence is attainable only with positive feedbacks which assure that between innovation and dissipation is sufficient time lag. If social structures, as in the case of global capital, are not evolving sufficiently, noise blocks necessary integration and leads to chaos. That why importance of complex characteristic of a learning process is present.

In accordance with Penrose's theory of resources learning organization is composed by not determined number of attributes, of which only determined number is important. Naïve presumption is that important attributes are independent. Data of attributes which are scarce or infrequent are especially not robust. Measuring methods used for exploring emergent properties on the filed of learning are of such characteristic. Their myopia is especially evident in the case of concept of excluding "or" – disjunction (in the exclusive sense): $C = X \vee (X, Y)$, where C is Boolean class and X, Y its attributes[4]. If we examine only attribute X, than C value is not evident. The reason is that the relation among X and C are crucially dependent of Y. For $Y = 0$, $C = X$, for $Y = 1$, $C \neq X$. The same misses also attribute. Only than X and Y together describe C. The theory says that exist positive and negative interaction among X and Y with regard to C. In the information theory information content is measured with entropy. If phenomena expresses primary metrics with random variable X and are N possible values (events) of that variable in the chosen context can be its differential distribution of possibility x_i, i = 1, …, N used for calculation appertained statistical parameters with uncertainty, for which measure can be used Shannon's type as the most simple probability entropy:

$$H(X) = -\sum_{i=1}^{i=N} p(X)\log_2 p(X) \tag{1}$$

where p is the probability of the phenomena. In the case of two random variables X in Y, which appertain to primary metrics of two different phenomena, the possibility that both characteristic are (probabilistically) independent is generally excluded; what means exclusion of the existence of equitation $p(X, Y) = p(X)\cdot p(Y)$. If random variables X and Y are distributed discreetly first with N and second with M events, exists maximally MN common events. Mutual entropy can be written as:

$$H(XY) = -\sum_{i=1}^{i=N}\sum_{j=1}^{j=M} p(XY)\log_2 p(XY)\,. \tag{2}$$

XY is a new probabilistic variable which sum of events is Cartesian product of sums of events which X and Y appertain to separately. Mutual entropy $H(XY)$ is minor or at the most equal to the sum of separate entropies $H(X) + H(Y)$. Minor is when variables are dependent. Dependency can be measured with mutual information or *information contribution*:

$$I(X) + H(Y) - H(X, Y). \tag{3}$$

Generalization of the concept of mutual information on more variables in a measured quantity is termed interaction information or *interaction contribution*. For the case of variables X, Y and C can be written:

$$I(X; Y; C) = I(XY; C) + I(X; C) - I(Y; C). \tag{4}$$

Interaction contribution can be positive or negative. Positive contribution expresses positive interactions or synergy, negative contribution inversely: negative interaction or dependency (redundancy originates in same information given by both variables).

Interaction among attributes gives their correlation – typical pattern of connections among attributes describing phenomena. Interaction analysis is the first step to functional modeling as a method of multidimensional optimization for chosen criteria (class C) respecting optimal direction of changes in the form of elasticity of chosen criteria regarding individual changes in attributes. Functional modeling satisfies processing approach which treats surroundings as complex, uncertain, full of changes and emergent phenomenon. Functional modeling is solving dilemmas of global changes in developing own knowledge, acquiring knowledge of others; assure forming of expectations and propensity to decisions which have higher probabilities to be realized.

HOW TO COMMENT SOME RESULTS OF "LEARNING ORGANIZATION" THROUGH THE LENS OF COMPLEXITY, LEARNING AND GLOBALIZATION?

Approaching problems of complexity and learning and its measurement we explore data from questionnaire for learning organizations in the project [11]. The path to learning organization collected in 2003 by Institute of learning organization, Ljubljana, Slovenia.

We apply interactive analysis which enables insight in relations among attributes. But numerical conception often does not associate relevant patterns in data which generalize understanding of the phenomena. Thus we may represent data as in statistical and mathematical visualization. In our research we used dendrograms and interaction graphs to present relations

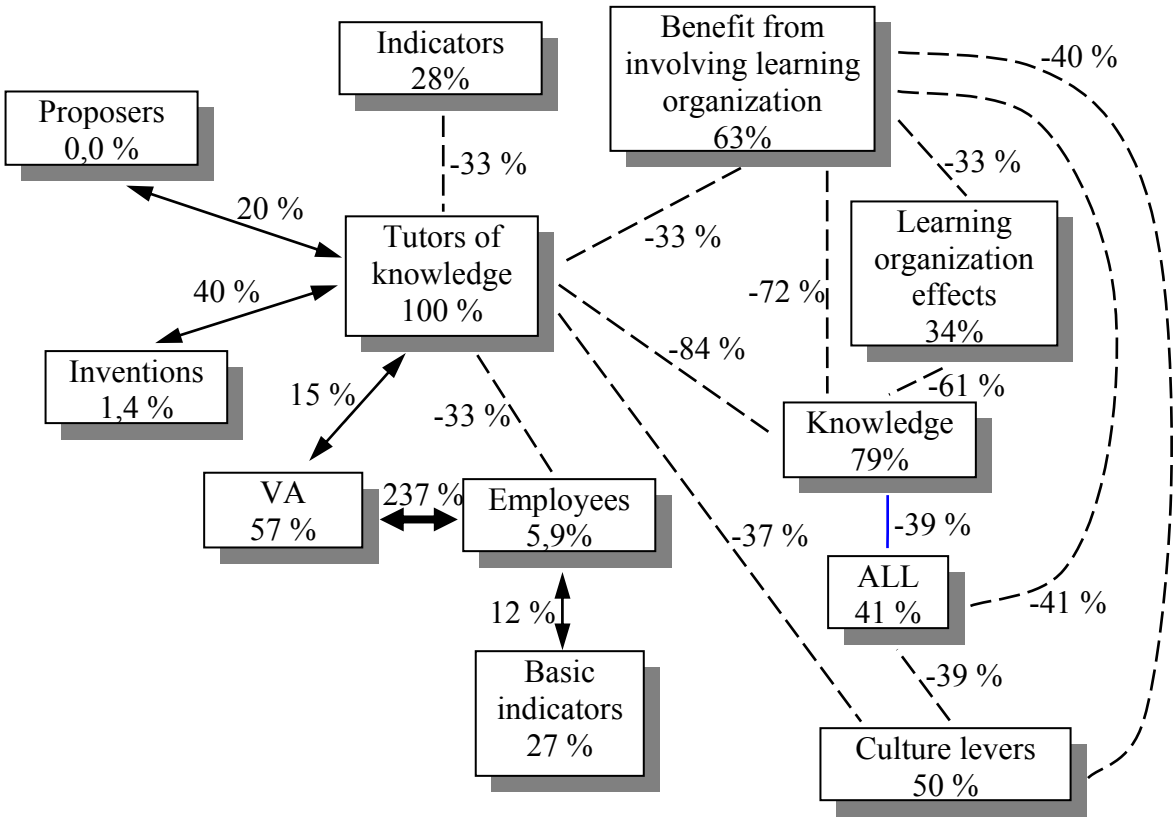

Figure 1. Interaction graph for linear, non-weighted model of attributes of the Learning organization in the year 2003 in Slovenia. Calculation from: *The path to Learning organization*, collected 2003, Institute of Learning organization, Ljubljana, Slovenia. Full (dashed) lines denote positive (negative) interactions. Numbers in squares are self-information of attributes.

Attributes are denoted as follows: *Learning organization effects* – Cite three most pozitive effects as a consequence of introduction of the concept of the Learning organization; *Indicators* – Cite three indicators which is used in firm to monitor effects of investments in the knowledge; *Benefit from involving learning org.* – Concept of the Learning organization has effected positively on efficiency of the firm; *Tutors of knowledge* – For strategic spheres of activity we named tutors of knowledge (How much per 100 employees); *Proposers* – percentage of employees which gave one useful proposal in the last year; *Inventions* – Number of registrated useful proposals and inventions per employee in the last year; *VA* – Value added; *Basic indicators* – Basic indicators in total; *Knowledge* – Acquiring and managing with a knowledge (in total); *Employees* – Number of employees; *Culture levers* – Levers of development of the organizational culture of the Learning organization; and *All* – All indicators.

among variables or attributes. Figure 1 gives one example of interaction graph for linear, not-weighted model of attributes of the learning organization. In Figure 1, let us concentrate on positive interactions: Attribute *Tutors of knowledge* suppresses alone 100 % of the uncertainty, *VA* (value added) 57%, *Basic indicators* suppress 27 % of the uncertainty, attributes *Tutors of knowledge* and *Proposers* additionally 20 %, *Tutors of knowledge* and *Inventions* 40 %, *Tutors of knowledge* and *Value Added* 15 % additionally. Correlation between *Value Added* and *Employees* is 237 % and means only that interaction between attributes is more informative than most informative attribute.

Negative interactions in Figure 1: Extremely great are percentages of a suppressing uncertainty in the case of attributes of *Learning organization effects* – 34 %, *Benefit from involving learning organization* 63 %, *Indicators* 28 %, *Knowledge* 79 %, *Culture levers*

50 % and *All* – 41 %. Mutual information among mentioned attributes is great because different pairs of attributes assure between 84 % (as in case of *Tutors of knowledge* and *Knowledge*) and 33 % (among four pairs).

Presumptions of the definitional[5] process of creating knowledge are given in the three following subsections.

IN THE SPHERE OF CREATING KNOWLEDGE WE TESTED STATEMENTS

Companies are knowledge creating entities because knowledge and capabilities to create and use a knowledge, the most important source of sustainable advantages on market competition [12, p. 1].

Learning as a company characteristic affect value added. We will confirm this statement through measuring the connection among attributes Employes who plan with managers their own learning and development and Value Added from the period.

IN THE SPHERE OF INTEGRATION OF KNOWLEDGE

Extent of a company [3, p. 35; 13. p. 85] is in correlation with the attribute that Companies sustain essential knowledge in collection of all knowledge, and the attributes that Changes in companies are planned.

Smaller firms are likely more opened to adopt a new knowledge [14, p. 71]. We expect that companies are aware of their knowledge and that they economize with it. We examine correlation between attributes Intensive exchange of knowledge and Value Added.

IN THE SPHERE OF MEDIATION OF KNOWLEDGE

Absorption capacity is defined as capability to learn from external sources. For this reason company as a complex system has to develop systems for receiving and mediation external decision information [15, p. 189, p. 192]. We examine if attributes Spreading information from bottom to the top and Introduction concept learning organization has positive effects on Value Added.

New theory or Theory of endogenous growth confronts a number of individual activities in company with condition of work, which create these activities. Theory is focusing on question: How collective learning and knowledge effect on an individual production process [16, p. 378]? Is possible that including extensive circle of employed on solving to their decision problems improve business effectiveness (and business effectiveness of an individual production processes)? For this reason we examine if attribute Employed regularly accept information of achieved aims and financial results of operations correlated with Value Added.

CLARIFICATIONS OF EMPIRICAL PROCESS OF CREATING KNOWLEDGE

In the sphere of **creating knowledge** in the weighted model of selected liner connected attributes growth the importance of the knowledge of modern organizational concepts (correlation with *Value Added* is ρ = 0,81). The analysis shows interaction contribution of attributes Decentralization of planning, Integration of activities, production concept and standard program.

In the sphere of **integration of knowledge** we have not found confirmation of the role of educational structure and connection with *Value Added*. Presumption that attribute Final product is correlated with attribute Standardization is verified in interaction in nonlinear graphs. In non-weighted model mutual information between attribute Final product and attribute Standardized program are weakly correlated (ρ = 0,055).

In the sphere of **mediation of knowledge** we couldn't find correlation among attributes Decentralization planning function, processing and control and Value Added. In interaction graphs of non-linear models is attribute Decentralization planning function positively interactive with attribute Integration activities.

CONCLUSIONS

Empirical analysis indicates that companies in Slovenia for the year 2003 are not characterized with category of Learning organization. Types of organization's are important for company's evolution of knowledge what expose the importance of the attribute Tutor of knowledge. Absorption capability is not strengthen satisfactory in complex organization of production because decision component is missing. We can conclude that developmental processes are more oriented in capital globalization than in the direction of self-organizing society of learning citizens.

REMARKS

[1]The term must be translated as "a firm", because the term organization has several other meanings in organizational science.

[2]Emergence is often equfinal rather than universal in form.

[3]In mentioned sense.

[4]Interaction analysis is described in [17-20].

[5]By Hierarchy Theory defines that *definitional entities* are postulated before a measurement is made. When a measurement is made a new class of entities arrives – *empirical entities* [21].

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ČETIRI PITANJA O KOMPLEKSNOSTI I UČENJU

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SAŽETAK

Rastuća međudjelovanja (po broju, vrstama i procijenjenom intenzitetu) u inovacijskim procesima traže nove i različite metodologije istraživanja stvarnosti, uključujući i pogled na modernu proizvodnju sa stajališta kompleksnosti. U postmodernom razdoblju u kojemu (informacijske) mreže evoluiraju, učenje ne može biti objašnjeno iz perspektive organizacije, nego iz perspektive učećih pojedinaca. Takav pristup može biti postignut Analizom međudjelovanja koja daje uobičajene vrste veza između atributa kojima se opisuju pojave. Analiza međudjelovanja je prvi korak prema funkcionalnom modeliranju kao metodi višedimenzijskog optimiranja za dane kriterije. Funkcionalno modeliranje zadovoljava procesni pristup koji uključuje okoline kao kompleksne i neodređene, emergentne pojave, pune promjena. Empirijska analiza ukazuje kako tvrtke u Sloveniji u 2003. godini ne mogu biti karakterizirane kategorijom Učećih rganizacija.

KLJUČNE RIJEČI

međudjelovanja, inovacija, učeća organizacija, stajalište kompleksnosti, nesigurnost

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A POLITICAL ECONOMY PATTERN OF CHINA'S HISTORY: ON REVOLUTION, REFORM, AND INVOLUTION UNDER DICTATORSHIP

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ABSTRACT

This paper aims to develop an integrated analytical framework for revolution, reform, and involution under dictatorship based on China's history. In order to grasp the essence of political and economic interactions in historic China, this paper gets some abstract variables from China's history, on the basis of which a political economy model is built. The autocrat plays an important role in determining authority form and development pattern, which endogenously brings about different outcomes of revolution, reform, and involution. When the economic system is closed, path-dependence plays an important role, however, when the system is open, we should not attach much importance to path-dependence.

KEY WORDS

revolution, reform, involution, dictatorship, path-dependence, China's history

CLASSIFICATION

JEL: D74, O12, P40

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INTRODUCTION

Many economists and social scientists believe that special-interest groups usually play a negative role in economic development. As most of us know, collective actions are often accompanied by the free-rider problem, which determines that small or strong special-interest groups are more powerful than large or weak ones, as the former can overcome this difficulty more effectively than the latter. Just as Olson says [1]: "Indeed unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interests."

If the small or strong special-interest group represents the autocrat and his ruling class, then what can we infer from this special-interest-group perspective? When will the autocrat choose efficient institutions on behalf of his interest-group? And when will not? As Acemoglu argues [2, pp. 620-623]: "These inefficient institutions and policies are chosen because they serve the interests of politicians and social groups that hold political power at the expense of the rest … The theoretical case depends on commitment problem inherent in politics. First, those in power cannot commit to not using their power, as long as they don't relinquish it, in ways that benefit them in the future. Second, if the rulers relinquish their power, the citizens cannot commit to making side payments to them in the future because the former rulers no longer possess the political power to enforce such promises." So there is no political Coasian theorem which ensures that political power can match with economic development by voluntary political exchange. However, based on China's history I argue that there is a political economy theory about revolution, reform, and involution under dictatorship, and that there lies an implicit mechanism that can ensure the acceptable efficiency of the political process. As such, this implicit mechanism can give rise to different outcomes of revolution, reform, and involution.

This paper tries to integrate historic China's revolution, reform and involution into a unified analytical framework, under which all of these phenomena are endogenously engendered by autocrat's choice. The rest of the paper is organized as follows. Section 2 presents the basic model. Section 3 extends the basic model. Section 4 makes some concluding remarks.

BASIC MODEL

In order to convey my idea, I assume that there are only three classes, the upper class representing the autocrat's interests, the middle class representing the commercial and industrial interests, and the lower class representing the agricultural interests[1]. During different development periods, there are different institutions that are determined by the autocrat, which bring about different outcomes. The so-called political Coasian theorem works to some degree through the interactions between revolution, reform and involution.

In the model, α ($0 < \alpha < 1$) and u are the proportion and unit interest of the upper class, respectively. Similarly, β ($0 < \beta < 1$) and m are, respectively, the proportion and unit interest of the middle class. Finaly, $1 - \alpha - \beta$ ($0 < 1 - \alpha - \beta < 1$) and l are the proportion and unit interest of the lower class, respectively. The so-called unit interest stands for each actor's economic gains which are normalized according to the total population. As for the upper class which is represented by the autocrat, the unit interest denotes each actor's normalized incumbent gains during the course of providing public goods and services (such as bureaucratic governance). As for the middle and lower classes, the unit interest denotes each actor's normalized economic gains which are related to his average productivity during the course of production and transactions. It is taken that[2] $m > l$.

Inspired by the spirit of Aghion and Tirole [3], I assume that the tax rate of the middle class is θ ($0 \leq \theta \leq 1$), and that the tax rate of the lower class is[3] ρ ($0 \leq \rho \leq 1$). However, taxation should not be seen as a straight division of the pie because the autocrat provides some kind of protection and other public goods and services for the lower and middle classes.

As for the autocrat, the lower class is easier to be controlled than the middle class, because the former is more immobile and honest than the latter. In order to control the middle class effectively and make the lower class have no incentive to become the middle class, the autocrat has to take the taxation as a tool, which means $\theta > \rho$. So the autocrat faces a tradeoff between controllability and profitability. As most of us know, controllability is mainly a political problem, while profitability is mainly an economic problem. However, the autocrat is not only an economic person, but also a political person. Moreover, the autocrat's idea about controllability and profitability maybe changes according to the dominant thinking of that time.

As I have stressed in the introduction (Section 1), the autocrat represents the ruling class. The autocrat's utility derives from three terms. The first term is the autocrat's gains from providing public goods and services (such as bureaucratic governance). The second term is the autocrat's gains from the middle class' taxes. The third term is the autocrat's gains from the lower class' taxes. In fact, the autocrat's utility can be seen as a proxy for the economic performance. In order to defend this point, I will give two channels through which the autocrat can improve the economic performance. The first channel is to promote the bureaucratic governance, and the second channel is to expand the middle class.

The autocrat's utility function, S, is[4]:

$$S = \alpha u + \theta\beta m + \rho(1 - \alpha - \beta)l. \tag{1}$$

The autocrat himself has certain beliefs which determine the authority form and development pattern. If he appreciates social stability or he faces no external pressure, he may suppress the middle class and support the lower class, as the agricultural economy is easier to be controlled. If he appreciates economic prosperity or he faces great external pressure, he may support the middle class, as the commercial and industrial economy is pregnant with wealth. When the economy is closed and the information is impacted, there is no or little knowledge-based exchange with the outside world, so competitive pressure is very small and the autocrat has no idea of imitation. However, when exchange cost between nations becomes less and less, the competitive pressure plays a more and more important role in motivating laggards to catch-up. In order to reflect the importance of the degree of openness, I introduce the concept of survival gains in the extension of the basic model (Section 3).

In most cases ρ is a constant parameter, but when there are wars or irrigation works, the autocrat has to raise his taxes on the lower class, which will increase ρ to some degree. That is to say, ρ is a variable which can be controlled by the autocrat. Thus, if ρ is too big (e.g., $\rho \geq \overline{\rho}$) to sustain the lower class' living, a rebellious revolution will be incurred. So there is a rebellious revolution constraint:

$$\rho \leq \overline{\rho}. \tag{2}$$

Variable θ can also be controlled by the autocrat. If it is too big to keep the middle class exist (e.g., $\theta \geq \overline{\theta}$), economic development will be trapped in a low-level equilibrium which is called an involution[5]. In fact, in most times in China's history, the autocrat keeps the middle class as small as possible through the taxation tool. The middle class can not start a rebellious revolution, because its quantity is too small to form a valid threat. So there is an involution constraint[6]:

$$\theta \leq \overline{\theta}. \tag{3}$$

When the economic system meets the revolution and involution constraints, but the autocrat is not satisfied with the economic performance (e.g., $S \leq \underline{S}$), there will be a reform constraint:

$$S \geq \underline{S}. \tag{4}$$

The autocrat plays an important role in increasing or decreasing economic performance, as $\underline{S}$ is a subjective value which is determined by the autocrat's judgment. If the autocrat is ambitious or able, he may set $\underline{S}$ at a big value. However, if he is fatuous or incapable, he may set $\underline{S}$ at a small value. Certainly, external factors may influence the autocrat's judgment. For example, if there is a tax income boom, the autocrat may suffer from some kind of "resource curse."

To summarize, we have the following result:

Result 1: If an economic system under dictatorship doesn't meet the rebellious revolution constraint, then a rebellious revolution will be incurred. If this system meets the rebellious revolution constraint but doesn't meet the involution constraint, then an involution will be incurred. If this system meets the rebellious revolution and involution constraint but doesn't meet the reform constraint, then a reform will be needed.

If the economic system under dictatorship takes market-supporting or market-augmenting measures to promote its economic development, then the middle class will swell in quantity. When θ is less than a critical vale (e.g., $\theta \leq \underline{\theta}$), the middle class will be so powerful as to start a constitutional revolution to overturn the autocrat. So there is a constitutional revolution constraint:

$$\theta \geq \underline{\theta}. \tag{5}$$

Thus we obtain the second result:

Result 2: If an economic system under dictatorship is stable, then it must meet one of the following conditions: (i) $\rho \leq \overline{\rho}$ and $\theta \leq \overline{\theta}$, or (ii) $\rho \leq \overline{\rho}$ and $\underline{\theta} \leq \theta \leq \overline{\theta}$. When condition (i) is met, the system is locked in an involution, which is called super-stability characterized with old dynastic China. When condition (ii) is met, the system is on the track of development, which is called dynamic-stability characterized with contemporary transitional China.

The basic model is obviously very descriptive, as it is based on China's complex history and tries to get the abstract variables from the whole development process. A richer economic environment can be added in order to analyze the autocrat's different choices under different conditions.

EXTENSION OF THE BASIC MODEL

In order to grasp the essence of the institutional change, especially the political change, I extend my basic model in a two-dimensional way. The extensions correspond to China's history, too. In fact, we will find that there does exist an implicit mechanism that can ensure the acceptable efficiency of the political process.

When the economic system is closed, it can learn little from the outside world, and at the same time this exerts no competitive pressure on the autocrat. During the course of the evolution of the system, path dependence will play an important role. In order to control the system at a low cost, the autocrat will make a tradeoff between controllability and profitability. In fact, the autocrat may smother up the knotty problem of profitability in the absence of competitive pressure.

As I have assumed, the instability mainly comes from the middle class' mobility and speculation. For simplicity, I assume that the autocrat's political gain, R, is β's function,

which is strictly decreasing and concave ($R' < 0$, $R'' < 0$). So the autocrat's rational choice is to increase θ to $\bar{\theta}$, and at the same time β will drop to $\underline{\beta}$.

Economic losses, EL, will be[7]:

$$EL = (\beta - \underline{\beta})[(\bar{\theta} - \theta)m - \rho l]. \tag{6}$$

Political gains, PG, will be

$$PG = R(\underline{\beta}) - R(\beta). \tag{7}$$

The rational autocrat will let economic losses be equal to political gains at the margin, which yields the following equation:

$$R'(\underline{\beta}) = \rho l - (\bar{\theta} - \theta)m. \tag{8}$$

The condition $m > l$ can ensure $R'(\underline{\beta}) < 0$, which is compatible with the previous assumption.

Through the comparative static analysis, we obtain the third result.
Result 3: In a closed system under dictatorship:

$$\partial\underline{\beta}/\partial\rho < 0,\ \partial\underline{\beta}/\partial l < 0,\ \partial\underline{\beta}/\partial\theta > 0 \text{ and } \partial\underline{\beta}/\partial m > 0.$$

Proof: From equation (8), we get

$$\partial\underline{\beta}/\partial\rho = 1/R''(\underline{\beta}) < 0,\ \partial\underline{\beta}/\partial l = \rho/R''(\underline{\beta}) < 0,$$

$$\partial\underline{\beta}/\partial\theta = -m/R''(\underline{\beta}) > 0 \text{ and } \partial\underline{\beta}/\partial m = -(\theta - \underline{\theta})/R''(\underline{\beta}) > 0.$$

Result 3 implies that $\underline{\beta}$ is decreasing in ρ and l, respectively, while increasing in m and θ, respectively. The more ρ and l, the less $\underline{\beta}$, which is characteristic of the old dynastic China who was previously trapped in an involution. We can conclude that the more closed the system, the more possible it is locked in an involution. In fact, it shows that there are great path-dependence effects when the system is closed.

When the economic system is open, it can learn much from the outer world, and at the same time this exerts great competitive pressure on the autocrat. During the course of the evolution of the system, path dependence will play an insignificant role. In order to cope with challenges at a low cost, the autocrat has to trade off between profitability and controllability, which means that he must undertake a reform.

Competitive pressure is more important than path dependence, because the autocrat will adopt adaptive behavior according to his sufferings. In order to survive, the autocrat has to increase β to $\bar{\beta}$ at the cost of domestic instability. I suppose that survival gains, P, are the function of economic gains, EG, which are strictly increasing and concave ($P' > 0$, $P'' < 0$).

Economic gains will be:

$$EG = (\bar{\beta} - \beta)[(\bar{\theta} - \theta)M - \rho L]. \tag{9}$$

Survival gains, SG, will be[8]:

$$SG = P(EG). \tag{10}$$

Political losses, PL, will be:

$$PL = R(\beta) - R(\bar{\beta}). \tag{11}$$

The rational autocrat will make economic gains plus survival gains equal to political losses at the margin, which produces the following equation

$$R'(\bar{\beta}) = [1 + P'(EG)]\cdot[\rho L - (\bar{\theta} - \theta)M]. \tag{12}$$

Through the comparative static analysis, we have the fourth result:

Result 4: In an open system under dictatorship, the impacts of ρ, L, θ and M on $\bar{\beta}$ are all ambiguous.

Proof: From equation (8), we can get the related partial derivatives, and it is easy to find that their signs are all ambiguous.

Result 4 shows that path-dependence plays a trivial role when the system is open, just as we have anticipated. Great competitive pressure can easily break through path-dependence effects, as it produces additional benefits which are called survival gains. In order to increase S, the autocrat has to take effective measures to reform the economic system, such as raise β to $\bar{\beta}$. But when the autocrat chooses a market-supporting or market-augmenting development strategy under great competitive pressure, he will be overturned by a constitutional revolution when the middle class grows in strength to some critical degree. Dictatorship has a self-destruction mechanism in this sense, once it is on the track of market. This is the dictator's fatalism. Shen points out that a good dictator encourages private investment and the cost of this encouragement is that the ensuing higher growth rate will induce earlier democratization [4]. Zak and Feng's model also demonstrates that the economic position of the middle class determines the rate of transition from dictatorship to democracy [5]. Under this circumstance, accompanied by continuous high economic growth rate, China will have to undertake a series of political reforms which are oriented towards democratic process in order to reconcile the social and political conflicts.

CONCLUSION

In this paper, I mainly discuss the conditions of revolution, reform, and involution under dictatorship based on China's history. When the system is closed, path-dependence plays an important role, however, when the system is open, we should not attach much importance to path-dependence.

Certainly, we should not neglect the intergenerational negative externality of dictatorship, which has an important effect on the autocrat's choice and behavior. As Olson argues [6, p. 571]: "Many autocrats, at least at times, have had short time horizons: the examples of confiscations, repudiated loans, debased coinages, and inflated currencies perpetrated by monarchs and dictators over the course of history are almost beyond counting." Once the autocrat's predecessor has made wrong decisions, the successor has to bear their externalities. At the same time, the autocrat may form wrong expectations or make wrong judgment on ρ, θ and S. All of those will bring about different outcomes of revolution, reform, and involution.

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REMARKS

[1]This classification is obvious for developing economies, especially for China, but may be obscure for developed economies.

[2]This implies that the middle class faces more repression from the autocrat than the lower class. However, its number of population is too small to initiate a rebellious revolution, so it has to stand this kind of repression.

[3]The utility functions of the lower and the middle are $L = (1 - \rho)(1 - \alpha - \beta)l$ and $M = (1 - \theta)\beta m$, respectively.

[4]From this and note 3, we can obtain the social utility function $S + M + L = \alpha u + \beta m + (1 - \alpha - \beta)l$.

[6]It is easy for us to get the relation between $\bar{\theta}$ and $\bar{\rho}$, namely, $\bar{\theta} \geq 1 - (1 - \bar{\rho})l/m$.

[5]The so-called involution is a terminology which refers to being trapped in a stagnant state in which industrial revolution cannot come into being. This terminology is connected with the famous Needham puzzle (see [7, 8]), which is common sense for Chinese background scholars and coined as *neijuan* in Chinese language. Tullock's work [9] is conducive to understanding the nondemocratic system of the old empire of China.

[7]I assume that the middle class decreased will turn into the lower class, and that the middle class increased will be from the lower class.

[8]Survival gains are derived from external competitive pressure, which reflect a nation's quasi-natural selection process. So they are different from political gains.

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POLITIČKO-EKONOMSKI OBRAZAC KINESKE POVIJESTI: O REVOLUCIJI, REFORMI I INVOLUCIJI POD DIKTATUROM

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SAŽETAK

U ovom radu razvija se integrirani analitički okvir za revoluciju, reformu i involuciju u diktaturama, temeljen na povijesti Kine. Radi obuhvaćanja osnova političkih i ekonomskih međudjelovanja u kineskoj povijesti, u radu je izdvojeno nekoliko apstraktnih varijabli iz kineske povijesti. Na temelju njih je postavljen političko-ekonomski model. Autokrati su odigrali značajnu ulogu u određivanju oblika autoriteta i obrasca razvoja, što je kroz unutarnje procese dovodilo do revolucije, reforme i involucije. Kad je ekonomski sustav zatvoren, ovisnost o putu je značajna. Naprotiv, kad je sustav otvoren, ovisnosti o putu se ne smije dati veliko značenje.

KLJUČNE RIJEČI

revolucija, reforma, involucija, diktatura, ovisnost o putu, povijest Kine

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SCIENTIFIC OUTPUT OF CROATIAN UNIVERSITIES: COMPARISON WITH NEIGHBOURING COUNTRIES

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ABSTRACT

We compared the Croatian research output with the neighboring countries and the Croatian universities with the largest Slovenian, Hungarian, and Serbian universities. As far as papers listed by Social Science Citation Index are concerned, since 2000 the University of Zagreb exhibits best results in social sciences compared to the competing universities, that is not the case in "hard" sciences. For the last 12 years, only the University of Ljubljana has shown better results in total research output than the University of Zagreb. The difference in research output between the University of Zagreb and the rest of the Croatian universities has been constantly decreasing. As a case study we compare research output at Faculty of Civil Engeenering on different Croatian universities. By analyzing European countries, we show a functional dependence between the gross domestic product (GDP) and the research output. From this fit we conclude that the Croatian science exhibits research output as expected for the given level of GDP.

KEY WORDS

scientific production, universities, SCI-E, SSCI, A&HCI

CLASSIFICATION

JEL: Z19

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INTRODUCTION

Various analyses of scientific output have been performed in order to identify research excellence among universities and scientific institutions. In 2003, the academic ranking made by the Shangai Jiao Tong University yielded a list of the 500 most prestigious universities [1]. Several criteria of educational or research performance were used, including alumni and staff winning Nobel Prizes, highly cited researchers, papers published in highly ranked journals Nature and Science, papers listed in Science Citation Index – Expanded and per capita academic performance of an institution. In the 2003 ranking, there were no universities from Croatia, but there were some universities from South East Europe, namely, two Hungarian, the University of Szeged and the Eötvös Loránd University, and one Slovenian, the University of Ljubljana [1]. According to the 2005 ranking by the same University, both Hungarian universities maintained their positions among the best 500 universities, however the University of Ljubljana was not listed.

A few studies on the general productivity and citations of Croatian scientists have been published based both on national database and ISI databases [2-6]. These studies have revealed that the overall productivity of Croatian scientists were beyond the average productivity in the world. Also, it has been shown that the productivity of Croatian scientists in "soft" sciences was well below the productivity of their colleagues working in "hard" sciences [2]. By "hard" sciences we generally mean those sciences predominantly related to journals listed by the Science Citation Index - Expanded (SCI), while by "soft" sciences we mean all sciences related to journals listed by either the Social Science Citation Index (SSCI) or Arts & Humanities Citation Index (A&HCI).

METHODS

Motivated by the academic ranking performed on yearly basis by the Shangai Jiao Tong University where the University of Zagreb is constantly missing, in the paper we compare the research output of the University of Zagreb with the research output of the universities which were on the ranking list in 2003, namely, the University of Ljubljana, the University of Szeged, and the Eötvös Loránd University (Budapest). We also present the research output of the University of Belgrade, the University of Maribor, and the University of Trieste, as the closest Italian University. Two Hungarian and two Slovenian universities are chosen in order to assess whether the scientific policies in those countries go towards centralization or decentralization. In searching for the papers, we use the WoS (Web of Science), where journals are ascribed the Science Citation Index-Expanded (SCI), the Social Science Citation Index (SSCI), or Arts & Humanities Citation Index (A&HCI) depending whether they publish papers related to natural, biomedicine and technical discipline (SCI), sociology and economics (SSCI), or art and humanistic discipline (A&HCI).

For the period 1994-2005, we perform the analysis to assess the research output of scientists working at four Croatian universities (Zagreb, Rijeka, Split, and Osijek). Due to small scientific output at the University of Zadar and the University of Dubrovnik these two universities are not included in the analysis. In cases where a paper is written by many authors working on different universities, the paper is ascribed to each university. Generally, the numbers presented in the paper are something smaller than the real ones. That is because some authors use their own address and some use the name of the faculty in Croatian instead of English. Also, different names are used for the same university (the University of Osijek and J. J. Strossmayer University).

RESULTS

Recently, Jokić et al published a paper where, for the period 1996-2004, the authors analyzed the research output of Croatian scientists working in "hard" sciences [6]. Motivated by their result we raise the question whether Croatian science grows towards centralization or decentralization, how Croatian universities compare with those in the closest neighborhood, and how the Croatian science as the whole compares with the neighboring countries.

SCIENTIFIC OUTPUT OF CROATIAN UNIVERSITIES FROM 1994 TO 2005

In order to find some tendencies, precisely whether the difference between the University of Zagreb and the rest of Croatian universities is increasing or decreasing in time, for both "hard" and "soft" sciences, in Table 1 we report the total number of papers published by scientists at four largest Croatian universities, where in brackets we put the number of papers published in social sciences (according to SSCI) and humaninistic sciences (according to A&HCI). From the results exposed, we find that for the period analyzed the University of Zagreb increased the number of papers something more than two times, while the University of Split, the University of Rijeka, and the University of Osijek increased their research output for approximately five, six and ten times, respectively. In Table 1 and more clearly in Fig. 1, we see that the relative difference between the University of Zagreb compared to the rest of the Croatian universities analyzed is gradually decreasing. While in 1994 the total number of papers with address of the University of Zagreb was more than eight times larger than the total number of papers published by any of the other three mayor regional Croatian universities, in 2005 the University of Zagreb had about three times more papers than all regional univeristies together.

Table 1. Scientific output for four largest Croatian universities. We put the total number of papers published in journals listed by SCI-Expanded, SSCI, and A&HCI ("hard" and "soft" sciences together). In brackets are shown the number of papers published in journals listed in SSCI and A&HCI, respectively. The total number of papers with address of the University of Zagreb compared to the number of papers with the regional universities' addresses is gradually decreasing.

Year	University of …				
	Zagreb	Split	Rijeka	Osijek	Split, Rijeka and Osijek
1994	402 (32, 6)	23 (1, 0)	16 (1, 0)	8 (0, 0)	47 (2, 0)
1995	462 (38, 9)	28 (2, 0)	24 (0, 0)	14 (0, 0)	66 (2, 0)
1996	496 (39, 2)	28 (2, 0)	26 (6, 1)	12 (0, 0)	66 (8, 1)
1997	527 (51, 7)	10 (2, 0)	39 (5, 0)	16 (1, 0)	65 (6, 0)
1998	510 (39, 5)	40 (0, 0)	45 (5, 0)	25 (2, 0)	110 (7, 0)
1999	572 (61, 3)	38 (2, 0)	48 (6, 0)	31 (1, 0)	117 (9, 0)
2000	582 (68, 7)	57 (3, 0)	43 (7, 0)	39 (2, 0)	139 (12, 0)
2001	639 (65, 21)	58 (6, 0)	68 (12, 0)	32 (3, 0)	158 (21, 0)
2002	613 (47, 3)	59 (10, 0)	67 (14, 2)	29 (2, 1)	155 (26, 3)
2003	739 (87, 4)	71 (19, 0)	56 (15, 0)	56 (9, 0)	183 (43, 0)
2004	763 (86, 2)	79 (7, 0)	82 (19, 0)	61 (9, 0)	222 (35, 0)
2005	875 (98, 5)	112 (14, 0)	100 (18, 2)	80 (12, 0)	292 (44, 2)

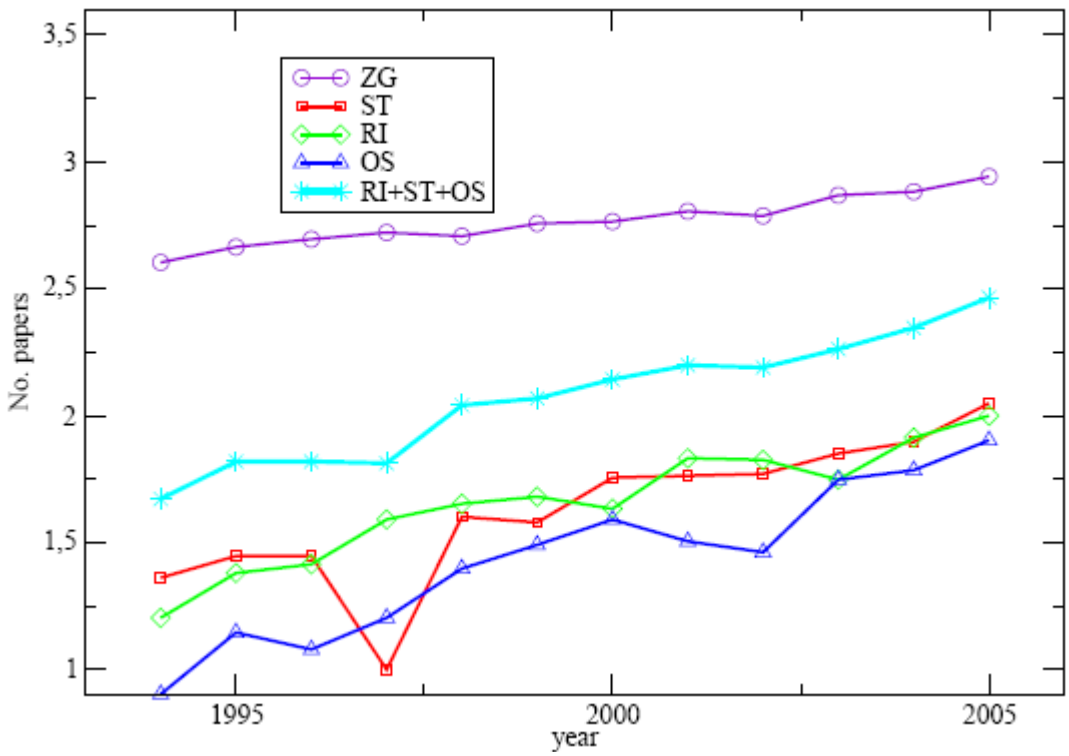

Figure 1. Ratio dened as reserach output of University of Zagreb vs. the rest of the Croatian universities varies from 8:1 to 3:1, with crossover after 1997. We show linear-log plot.

Table 1 shows that on average the difference between the University of Zagreb and the other Croatian universities has been decreasing in time if only "social" sciences are concerned (see the first numbers in the brackets). Table 1 reveals the crossover in the ratio of the research output between the University of Zagreb and all other regional universities in 1997, just after the Independence War taking place in Croatia till August of 1995. We find that from the total number of papers with address of the University of Zagreb approximately every ninth paper is published in "soft" sciences (results in brackets), where for the rest of Croatian universities, the percentage of papers published in "soft" sciences is even something higher. As a well-known result, from Table 1 is evident that the research output in "hard" sciences is much higher than in "soft" sciences. As a comparison Table 2 shows, for the year 2005, that even for the largest world universities the research output is much higher in "hard" sciences than in "soft" sciences.

Table 2. Scientific output for three famous world universities in the year 2005. We put the total number of papers listed by SCI-Expanded together with the number of papers published in journals listed in SSCI and A&HCI.

Harvard	Cambridge	Oxford
14569 (2328, 388)	7028 (1006, 817)	6628 (1008, 909)

COMPARISON WITH UNIVERSITIES IN NEIGHBORING COUNTRIES

Next we analyze how the research output of Croatian universities changes compared to those of universities in the neighboring countries. First, from Table 3 we note that if only total number of papers is relevant for evaluation of university ranking, on average the University of Zagreb exhibit worse results only from the University of Ljubljana and the University of Trieste. We find that for each year analyzed the Croatian major university published less papers than the major Slovenian university. That is partially due to the IndependenceWar. Nevertheless, if only social sciences are concerned, in comparison to the University of Ljubljana

Table 3. Scientific output of the University of Zagreb compared with two Hungarian, two Slovenian, one Italian and one Serbian university. Data for 2006 collected till 1 September.

Year	Univ. of Zagreb	Univ. of Szeged	Eötvös Loránd Univ.	Univ. of Ljubljana	Univ. of Maribor	Univ. of Trieste	Univ. of Belgrade
1994	402 (32, 6)		350	468	59	443	320
1995	462 (38, 9)		436	543	100	519	358
1996	496 (39, 2)	25	472	550	106	588	439
1997	527 (51, 7)	25	472	654	106	588	417
1998	510 (39, 5)	43	484	640	129	620	543
1999	572 (61, 3)	53	534	776	112	679	465
2000	582 (68, 7)	227 (3, 0)	542 (12, 12)	892 (39, 11)	162 (7, 1)	733 (49, 9)	420 (21, 5)
2001	639 (65, 21)	500 (13, 9)	567 (30, 14)	891 (62, 9)	181 (15, 3)	758 (53, 23)	389 (15, 6)
2002	613 (47, 3)	578 (16, 8)	586 (26, 13)	911 (53, 13)	228 (13, 1)	771 (52, 9)	428 (20, 5)
2003	739 (87, 4)	635 (14, 4)	594 (29, 9)	1045 (57, 16)	276 (20, 1)	856 (69, 7)	485 (16, 1)
2004	763 (86, 2)	690 (16, 7)	609 (25, 10)	973 (41, 10)	273 (26, 1)	784 (37, 10)	595 (28, 3)
2005	875 (98, 5)	783 (26, 10)	718 (34, 10)	1306 (98, 13)	346 (29, 1)	951 (67, 13)	730 (28, 1)
2006	610	451	448	743	187	566	534

the University of Zagreb exhibits better results. We also find that for the period from 2000 to 2005 the University of Zagreb published more papers in social sciences than any other university reported in Table 3.

Combining the results reported in Table 1 and Table 3, we find that in Slovenia the ratio between the total number of papers with address of the University of Ljubljana and the number of papers of the University of Maribor is approximately equal to the equivalent ratio calculated for the University of Zagreb in comparison to the rest of the Croatian universities. We note that in opposite to Croatia and Slovenia where the largest university is in the capital, in Hungary decentralization in science is more highlighted and the university with the largest research output is not located in Budapest but in Szeged [see Table 3 and Ref. 1].

Table 4. Scientific output for Croatia and three neighboring countries.Data for 2006 collected till 1 September.

Year	Croatia	Slovenia	Hungary	Serbia & Montenegr
1994	851	771	3308	850
1995	1060	917	3666	906
1996	1117	973	3755	1284
1997	1186	1182	4054	1081
1998	1211	1162	4630	1562
1999	1418	1385	4616	1344
2000	1412	1719	4856	1156
2001	1504	1745	5027	1222
2002	1407	1750	4796	1194
2003	1811	2045	5419	1456
2004	1793	1932	5279	1671
2005	2167	2523	6400	2248
2006	1538	1460	3951	1228

Now we raise the question how the total Croatian research output changes in time compared to the output of neighboring competing countries. From Table 4 and Fig. 2 we find that for the period of 12 years the total Croatian research output increased approximately 2,5 times, similarly as the Serbian research output. For the same period, Hungarian research output increased less than two times, while the Slovenian increased more than three times.

Note that Croatia, Slovenia and Serbia are similar countries as GDP is concerned. Approximately, Slovenia has two times larger GDP per capita than Croatia, but has two times smaller population. Similarly, Serbia has two times larger population than Croatia, but has two times smaller GDP per capita than Croatia. Note that the Croatian output according to Table 4 is currently higher than the Slovenian research output.

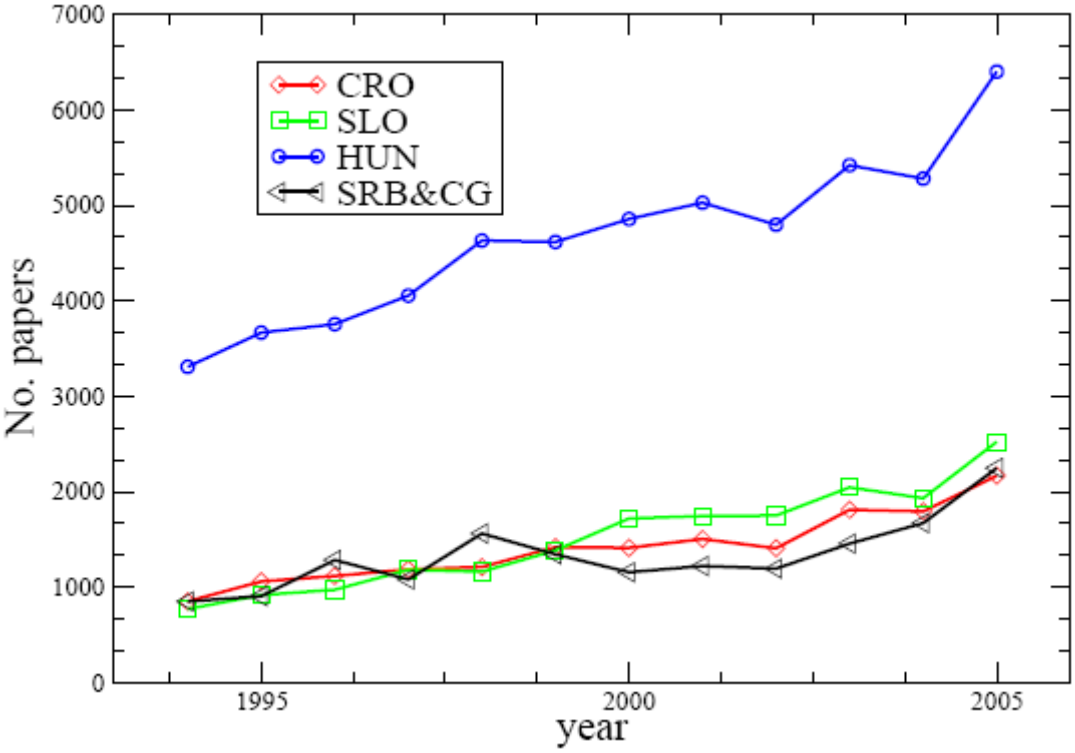

Figure 2. Scientific output of first neighbours.

RELATIONSHIP BETWEEN RESEARCH OUTPUT AND GDP

Globalization taking place worldwide after the fall of socialism in East Europe is followed by capital and industry transfer from developed countries to undeveloped countries mainly in East Europe and Asia. Due to competition, to maintain working places in developed countries, manufacturers in those countries have to constantly develop new technologies and create new products. Clearly, new technologies are closely related to science and education. For that reason, only countries with research output substantially larger than is expected for a given level of gross domestic product (GDP) have a nice perspective. Since research output is financed from the Government budget, clearly, the total research output must be related to the total money invested in research, where the latter is percentage of the GDP.

To test if there is a functional dependence between total number of papers published and money invested in research, In Figure3 we plot the total number of papers [7] versus GDP [9] for different European countries, and find a clear dependence that can be approximated by a power law. Power-law curve indicates what is the expected level of research output for a given level of GDP. Comparing total number of papers published in countries with similar GDP, such as Croatia, Slovenia, and Serbia & Montenegro, we may see that Croatian research

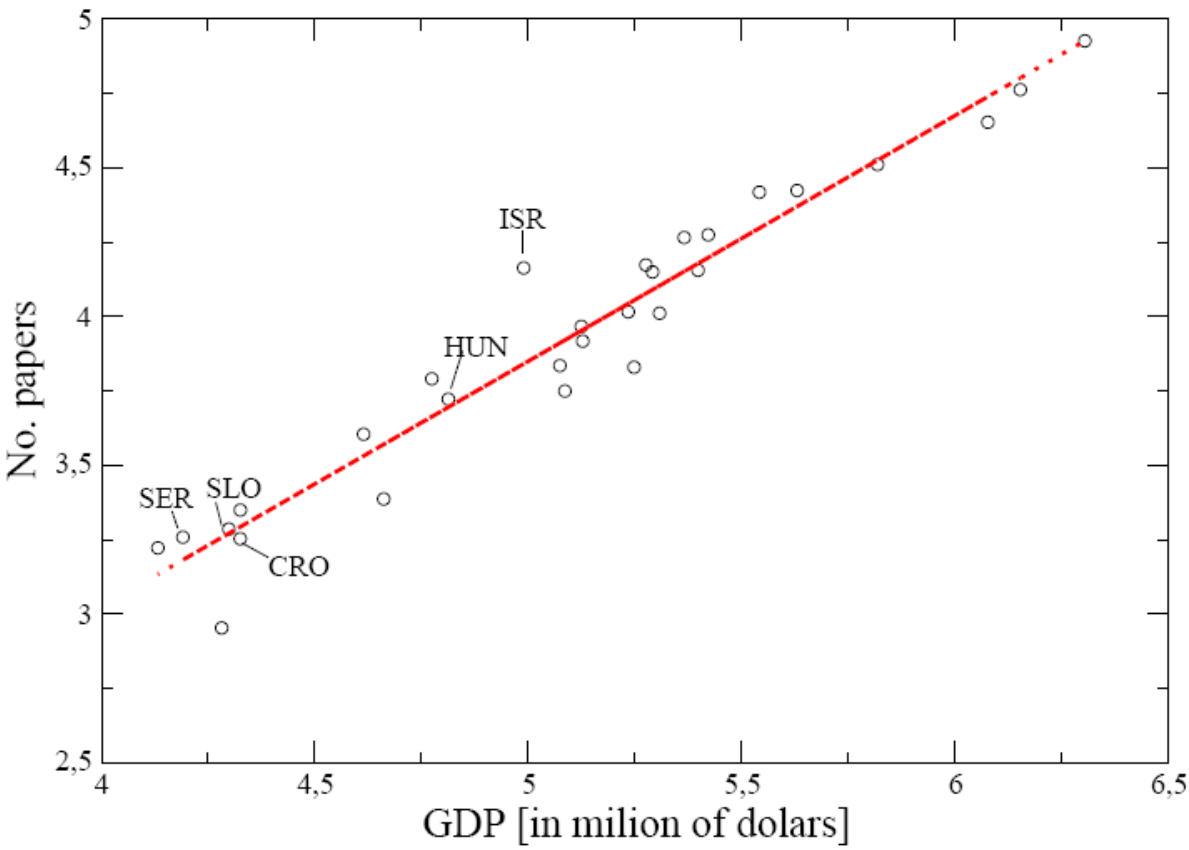

Figure 3. Log-log plot of total number of papers versus GDP calculated for European countries in 2004.

output is as expected for the Croatian level of GDP. Among countries exposed, Israel (well above the power-law curve) shows the best result with much more papers published than expected for a given level of GDP.

MAJOR UNIVERSITY VS. REGIONALS': CASE OF CIVIL ENGINEERING

It is commonly believed that each faculty at the University of Zagreb has substantially larger research output than the corresponding faculty at any regional university. Here we choose the case of Faculty of Civil Engineering existing at each of four largest Croatian universities. In Table 5 for the period 1991-2005 we report their research output. Obviously, even with substantially smaller number of employees and projects, Faculties of Civil Engineering in Rijeka and Split are more productive than the corresponding Faculty at the University of Zagreb. Till 1 September 2006 we find 3 papers with Rijeka address, and one paper with Zagreb address.

Table 5.:Research output for the period 1991-2005 for four Faculties of Civil Engineering. In the parenthesis are shown number of teachers and teaching assistants. In the third row are given numbers of projects suported by the Croatian Ministry of Science, Education and Sport. In the last row we show the number of papers published which include the address of the Faculty.

	Zagreb	**Rijeka**	**Split**	**Osijek**
Teaching staff	68 (4, 37)	20 (11, 12)	36 (8, 26)	28 (14, 11)
No. of supported projects	30	5	18	9
No. of papers (1991-2005) with the address of the Faculty	10	14	17	3

CONCLUSIONS

In this paper we show that the relative difference between the major Croatian University and the rest of the Croatian universities has been gradually decreasing. This positive trend contributes to the decentralization of Croatian science. A good example of decentralization is Hungary, where the largest university is the University of Szeged, not the Eötvös Loránd University situated in Budapest. We hope the policy of decentralization in science will continue in years to come. The larger research output in regional universities may be easily achieved by increasing the number of scientists working in natural sciences, who are generally most productive.

The results obtained for the research output of universities in Table 3 should be put in correlation with the ranking of world's universities where, for the last three years, the none of Croatian universities was among the 500 most prestigious world universities. Even though the University of Zagreb published more papers than the Eötvös Loránd University and the University of Szeged, for each of the last three years, the two Hungarian universities were placed on the list of 500 most prestigeous universities.

As a future work, in evaluation of performance of each Croatian university it would be highly desirable to put in correlation the research output with the number of projects and money invested in each university. This might help in choosing the best strategy that could bring Croatian largest universities to the level of the best 500 world universities.

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ZNANSTVENI REZULTATI HRVATSKIH SVEUČILIŠTA: USPOREDBA SA SUSJEDNIM DRŽAVAMA

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SAŽETAK

Usporedili smo znanstvenu produkciju u Hrvatskoj s onom od susjednih zemalja, te Hrvatska sveučilišta s najvećim sveučilištima Slovenije, Madžarske i Srbije. Vezano uz radvoe uključene u indeks SSCI, od 2000. goine Sveučilište u Zagrebu pokazuje najbolji rezultat u društvenim znanostima u usporedbi s uspoređivanim sveučilištima, što nije slučaj za tzv. „čvrste" znanosti. U zadnjih 12 godina, samo Sveučilište u Ljubljani je pokazalo bolje rezultate u ukupnoj znanstvenoj produkciji od Sveučilišta u Zagrebu. Razlika u znanstvenoj produkciji između Sveučilišta u Zagrebu i ostalih hrvatskih sveučilišta stalno se smanjuje. Izdvojili smo usporedbu znanstvene produkcije građevinskih fakulteta različitih sveučilišta u Hrvatskoj. Analizirajući države Europe, pokazujemo funkcionalnu ovisnost između bruto domaćeg proizvoda i znanstvene produkcije. Iz funkcionalne ovisnosti zaključili smo kako je znanstvena produkcija Hrvatske u skladu s očekivanim iznosom obzirom na ostvareni bruto domaći proizvod.

KLJUČNE RIJEČI

znanstvena produkcija, sveučilišta, SCI-E, SSCI, A&HCI

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VIRTUAL COMMUNITIES AS COMMONS: CASE STUDY OF "CONNECT"

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ABSTRACT

In a world increasingly networked with the help of information technology, where face-to-face communities are more and more supported by computer-mediated communication, and some communities exist solely in virtual space, the perennial social dilemma of cooperation has resurged, intriguing social researchers' attention with new elements brought about by technological advances, such as software applications enabling simultaneous communication of community members through public and private channels, easy access to a variety of documents, anonymous messaging, forums for potentially unlimited number of members who may join or observe, and a number of other IT-enabled community-building tools. In this paper the authors discuss the cooperation problem in virtual communities through the case-study of "Connect", an online community of Croatian scientists. Starting point of the analysis is the observation that cooperation in virtual communities may be encouraged by implementing technological solutions that provide users with incentives to cooperate. With this in mind, the authors inspect the compliance of "Connect" to a set of design principles of robust common-pool resource institutions elaborated by Elinor Ostrom. The study demonstrates that the "Connect" satisfies the majority of Ostrom's principles, with some room for improvement, and fails to satisfy two of them, mainly due to non-existence of technical prerequisites and due to relatively small size of the community. The analysis lays ground for further work aimed at obtaining more prescriptive guidelines that would point to possible improvements in management of common pool resources in virtual communities.

KEY WORDS

commons, cooperation, management principles, virtual communities

CLASSIFICATION

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THE PROBLEM OF COOPERATION AND THE IMPACT OF TECHNOLOGY

COLLECTIVE ACTION, COORDINATION AND COOPERATION

Oftentimes in social life, situations arise when efforts of two or more individuals are needed to accomplish an outcome, i.e. when a collective action is needed [1]. Sometimes collective action requires merely aligning oneself with the others, as in choosing the side of the street to drive on. This is referred to as coordination problem, which is not particularly difficult to manage, as it is obvious that driving on the same side is beneficial for all individuals involved. The advantage of aligning oneself with others, as well as the disadvantage of not doing so, provides clear incentives for everyone to coordinate [2]. A person driving on the right side in the UK would be at a great loss because everyone else there drives on the left side.

Sometimes collective action situations give rise to cooperation problems, which are much more difficult to manage than coordination problems due to a different incentive structure. In such cases, for a given individual, aligning with others requires denying oneself a gain that could be obtained if everyone aligns and the individual shirks. While aligning oneself with others is still beneficial, it is even more so if everyone else aligns and the given individual does not. In other words, in cooperation problems each of the persons involved has an incentive to try to be a free-rider [2]. If everyone wipes off snow in front of her house, a person not doing this would be better-off, because he would not invest any effort and would nevertheless reap benefits from the work of others. Laws and regulations regarding wiping off snow usually exist in order to threaten potential free-riders by sanctions, cancelling thus the effects of negative incentives.

INFORMATION TECHNOLOGY – TECHNOLOGY OF COOPERATION?

Fortunately, even in cases of cooperation problems, there are social and/or technical arrangements which lower the costs of individual cooperation to levels acceptable to most people. Some authors termed such arrangements “technologies of cooperation” [3, p. 29].

Whether information technology belongs to technologies of cooperation is a subject of controversy. Authors who underline negative aspects of technology – threats that technology poses to human dignity, liberty and quality of life – are also extremely suspicious towards the role technology may play in furthering human cooperation. Techno-pessimists predict that, for example, as more people spend more time communicating electronically, time for face-to-face family and community life will diminish further [4]. More optimistic authors, however, come to very different conclusions. Howard Rheingold is of the opinion that “[t]he most profoundly transformative potential of connecting human social proclivities to the efficiency of information technologies is the chance to do new things together, the potential for cooperating on scales and in ways never before possible” [3, p. 114]. According to Jon Katz, “[t]he online world is home to some of the most participatory citizens we are ever likely to have” [5].

Both techno-pessimists and techno-optimists often overlook that incentive structures provided by a given technology are not predetermined by the technology itself but by human beings who envision, invent and implement particular technological solutions. Instead of taking the strategic setting of cooperation as given, we may always ask how one can promote cooperation by transforming the strategic setting itself [6]. Lawrence Lessig, writing on the architecture of cyberspace, points out that “[w]e can build, or architect, or code cyberspace to protect values that we believe are fundamental, or we can build, or architect, or code

cyberspace to allow those values to disappear" [1] [7]. If cooperation is prominent on our list of values, then we may design cyberspace to reflect such a value system.

We are often witnessing that ethical imperatives, however right we may perceive them, are not by themselves powerful enough to encourage people to put a certain value high on their agenda. However, in case of cooperation ethical imperatives are also backed by pragmatic considerations. If incentives to free-ride are overcome and cooperation is sustained, cooperating parties get better-off than they would have been had they not cooperated. The support of such pragmatic considerations may provide additional power to ethical imperatives, which may increase the incidence of cooperative outcomes in human social interactions. Unfortunately, pragmatic reasoning combined with human affinity to interact and cooperate with persons who are more similar to themselves rather than those who are less similar, also gives rise to many undesirable phenomena such as racism, ethnocentrism, sexism, nepotism and other discriminative forms of behaviour.

Information technology, as any other one, is a technology of cooperation whenever it provides the incentives to cooperate, and it is not a technology of cooperation whenever it does not provide such incentives. The choice of whether it will provide the desired incentives is in the hands of the members of society who participate in technological development, and that means all of us, at least to a certain extent [8].

VIRTUAL COMMUNITIES AS COMMONS

A virtual community or on-line community is a group of people who use computer networks as their primary mode of interaction [9, p. 55]. The members of virtual community have shared purposes and interact socially by adhering to tacit and explicit protocols, rituals, and roles using computer network technologies that support interaction [10]. Virtual communities emerge when enough people carry on public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace [11].

Virtual communities are a kind of commons, where commons is a general term referring to a resource shared by a group of people [12, p. 4]. The word originally denoted common pastureland of an English village where individual herders grazed their cattle [13]. Common resources that virtual communities provide are less tangible than pastureland, nevertheless, they are of importance to their members. Marc Smith identifies three kinds of collective goods that virtual communities provide: social network capital, knowledge capital and communion (cited in [11]). Social capital refers to the value of social networks and social contacts, as well as to the value of trust and reciprocity relations that arise from the networks and contacts [14]. Knowledge capital broadly includes all intelligible ideas, information, and data [12, p. 7] shared by community members. The members often "serve as information hunters and gatherers for each other" [3, p. 116]. Communion refers to various modes of emotional support, empathy and compassion among community members. Communion is closely related to social capital, as emotional ties arise from networks of social contacts.

THE TRAGEDY OF THE COMMONS

Sharing of a common resource leads to a variety of the cooperation problem known as the tragedy of the commons [15]. As common resource is always limited, each user should exploit only a certain share of it in order to avoid overexploitation. However, each one has an incentive to take more than her fair share, hoping that others will not take too much. If everyone succumbs to the temptation, the common resource ends depleted. In the original case of pastureland, it gets overgrazed and the grass ceases to grow. Such misfortunate endings present the tragedy of the commons. Today's social problems involving the tragedy

of the commons include pollution, over-fishing and excessive use of resources in general, traffic congestion problems, overpopulation and many others [13, 15].

As any other common resource, a virtual community is also susceptible to cooperation problems such as the tragedy of the commons. Collective goods provided by the community may be overused. Howard Rheingold, for example, points out that telling a newbie in a newsgroup to read the Frequently Asked Questions is a way for the community to constrain the over-consumption of its knowledge capital [3, p. 116]. If community experts were busy replying to newcomers all the time, their valuable time would be wasted.

Virtual communities, and particularly their discussion forums, are also susceptible to serial exchanges of deliberately hostile and insulting messages. Such exchanges in which emotional intensity often increases to extremely high levels are known as flame wars [16]. If video devices are not used, electronic communication is particularly conducive to flame wars because it is not easy to transmit facial expressions or voice intonations which may moderate the tone of a message[2]. The use of smileys and other emoticons may mitigate this problem to some extent. Pointing to the problems of flame wars and indulgence in ego-trips, Rheingold observes that "[t]he presence of flamers, bullies, bigots, charlatans, know-nothings, and nuts in online discourses poses a classic tragedy of the commons dilemma. If too many people take advantage of open access to seek other people's attention, the excesses of the free riders drive away the people who make the conversation valuable" [3, p. 121]. The most serious excesses may include the misuse of community's communication channels to spread spam e-mail or computer viruses, disseminate racist or xenophobic material, promote or incite hatred, discrimination or violence against particular individuals or groups, etc. [17-18].

OSTROM'S PRINCIPLES OF COMMONS MANAGEMENT

Problems like the tragedy of the commons point to the importance of commons management. Earlier authors writing on the management of commons mainly emphasised the leading role of a central authority in regulating commons. Such explanations, however, could not account for the observation that many local communities find ways of preventing overexploitation of the commons even in the absence of centralised governance. Such self-organised commons are characterised by strong and voluntary collective action, self-governing mechanisms, and a high degree of social capital on the part of the stakeholders [12, p. 5].

After conducting a large set of empirical studies on common-pool resource governance, Elinor Ostrom was able to identify eight design principles of self-organised, robust, long-enduring, common-pool resource institutions [19]:

1. Clearly defined boundaries should be in place.
2. Rules in use are well matched to local needs and conditions.
3. Individuals affected by rules can usually participate in modifying the rules.
4. The right of community members to devise their own rules is respected by external authorities.
5. A system for self-monitoring members' behaviour has been established.
6. A graduated system of sanctions is available.
7. Community members have access to low-cost conflict-resolution mechanisms.
8. Nested enterprises – appropriation, provision, monitoring and sanctioning, conflict resolution, and other governance activities – are organised in a nested structure with multiple layers of activities.

Ostrom has also found that an extremely rich variety of specific rules are used in practice, but no single set of specific rules can be clearly associated with successful management. For this reason principles are helpful to start an investigation, but they are not prescriptive.

APPLICATION TO VIRTUAL COMMUNITIES

Virtual communities are mainly self-organised. Their governance mechanisms often include administrator, moderator and/or editor roles, but their authorities are regularly limited. "Outright attempts to control online communities can kill them or send them underground." [9, p. 57]. As virtual communities are mainly self-governed, Ostrom's principles should apply to them as well.

Taking into account Ostrom's advice that the principles are helpful to start an investigation, we have analysed compliance of a particular virtual community to the eight principles. The choice of the sample virtual community was rather arbitrary. We have chosen "Connect" – a virtual community of Croatian scientists, educators, students, and other science-related staff – mainly owing to our familiarity with its self-governing mechanisms and to our high regard for the role this community plays in Croatian scientific public sphere.

When collecting information, we have been observing the online activities of the community for several months by playing the role of an invisible researcher[3]. This simple method naturally supported our strivings to be present in the setting, to see what is going on without being observed, and to capture the essence of the setting and participants without influencing them [20]. The "invisible researcher's method" is rooted in the tradition of ethnographic studies, and it was originally developed to facilitate the research of traditional communities, but its application easily extends to virtual community settings. After completing the observation stage we have presented a review of main results to the editor of the "Connect::Portal", who gave consent to our publication intentions.

The analysis presented here is mainly descriptive and it attempts to provide preliminary assessment of factors influencing cooperative potential of the community. We shall first review general findings related to cooperation within the "Connect" community. Motivated by the previously mentioned susceptibility of virtual communities to a particular kind of cooperation problems known as the tragedy of the commons, we shall later focus on the community's potential to commons management. We shall attempt to assess this potential by investigating the community's compliance to Ostrom's principles. As the review of general findings will demonstrate, the "Connect" community indeed possesses characteristics of self-organised commons, including strong and voluntary collective action, self-governing mechanisms, and a high degree of social capital on stakeholders' part. This finding supports the plausibility of application of Ostrom's principles to the "Connect" community.

The analysis will also lay ground for further work aimed at obtaining more prescriptive guidelines that would point to possible improvements in management of common pool resources in virtual communities.

"CONNECT" VIRTUAL COMMUNITY

The "Connect" virtual community [21] started in 2004 as an enterprise of a group of enthusiastic young researchers with the vision of creating a virtual meeting place of Croatian scientists and of all those whose work is in any way related to Croatian science. Since 2004 heretofore the community has grown to more than 1300 members[4].

"Connect" is formally structured as a programme of the "Society znanost.org" NGO. The programme consists of several related on-line activities or projects, which include web portal, members' database, virtual sub-communities with the accompanying e-newsletters and mailing lists, focus forum, science initiatives, as well as a section dedicated to on-line management of community's off-line activities. The metaphor used in describing the programme and its projects is the one of a "virtual city" consisting of several "virtual squares" [22].

Prior to analysing the incidence of cooperation and the compliance of "Connect" to Ostrom's principles, we shall briefly review each of the projects with a view to provide contextual information about the range of the community's activities.

CONNECT::PORTAL

"Connect::Portal" [23] occupies a place of a "central virtual square" of the community, where most on-line interactions among community members occur. The portal is a place of numerous on-line discussions, which are organised in thematic threads. Community members freely open new threads and post comments to already existing ones.

Postings to discussion threads are signed and the authors bear full responsibility for what they have written. Signatures on postings are public to community members and invisible to outsiders. The only exceptions are initial postings in discussion threads, where signatures of authors are visible to all. The increased visibility for authors of initial postings is hoped to provide additional incentive to open new threads.

The choice of a discussion topic is entirely free. According to topics, threads are loosely grouped into several wider thematic sections, such as Education, Science, Croatia, World, Jobs, etc. Sections are further divided into subsections, but again the division is not strict as threads freely flow from topic to topic, relate one to another, overlap, and weave in unpredictable ways as lively human discussions often do.

Portal's public discussion space is augmented with a service that enables the exchange of private messages. Members are encouraged to use this service whenever their public discussions meander into private or off topic areas.

CONNECT::DATABASE

"Connect::Database" contains members' short personal data: basic personal information, contact information, area of expertise, and special interests. Some of these data are accessible to members only.

E-CONNECT

"E-connect" [24] encompasses e-newsletters and mailing lists aimed at informing visitors and members about the community's activities. "E-connect" also furthers the growth of professional special-interest groups, which develop as "Connect" sub-communities with their own web-pages, professional discussion forums, newsletters, and mailing lists.

CONNECT::WIKIFF

"Connect::WikiFF" [25] stands for Wiki Focus Forum and denotes an area of community's virtual space set apart for members' collaborative work on various topics of interest. Forum is technically based on the Wiki collaborative technology for organizing information on Web sites that allows visitors to add, remove, and edit content [26]. Members freely open new topics and contribute to already existing ones.

CONNECT::SCIENCE INITIATIVES

"Connect::Science Initiatives" [27] is the most recent of the community's projects. It started in 2006 with the aim to encourage dialogue on various issues related to science and technology. The first undertaken initiative was the organisation of a video-conference on problems and possibilities surrounding the start-up of a modern science institute in developing countries.

CONNECT::PARTY AND CONNECT::GALLERY

"Connect::Party" [28] and "Connect::Gallery" [29] are sections dedicated to on-line management of "Connect" community's off-line activities. Members of community gather annually at a Christmas party. However, this tradition has been somewhat neglected in recent two years.

COOPERATION IN THE "CONNECT" COMMUNITY

The main achievements of "Connect" have so far been related to democratisation of the Croatian scientific public sphere. Approximately 2500 discussion threads have been opened at the community's portal. As one member observed, "Connect", and particularly public discussions at its portal, contributed to bringing many important issues related to science in Croatia from backdoors to public sight [30]. In doing this, "Connect" both provided help to and received help from other media through a kind of mutually reinforcing feedback loop. In one direction, portal discussions have often served as sources of interesting and fresh topics for media coverage, and in the other direction, extensive media coverage has helped the community to attract attention of prospective new members.

The main achievement of "E-connect" has been the establishment of four special-interest sub-communities: astronomers' "Astro Connect" forum, "HR in CH" – a mailing list of Croatian young scientists in Switzerland, the "Kognet" network connecting Croatian scientists and students whose primary scientific interest lies in cognitive neuroscience, and "Geo Connect" – a similar network of those with primary interest in geosciences.

Fourteen topics have been opened so far at the Wiki Focus Forum. Most of them have been related to various issues of professional interest to scientists. Focused collaborative work on preparation of document proposals for the Second Congress of Croatian Scientists presents a recent example of successful cooperation among community members [31].

Another case of successful cooperation involved public nomination of the community's candidates for the vacancies in the National Council for Science [32]. Regular public announcements of job opportunities in science and of vacancies in science-related administrative bodies contribute to the transparency of the related selection and election procedures [33].

An example of cooperative public interviewing is provided by the Guests section of the community's portal, which is devoted to bringing prominent scientists and science officials closer to the "Connect" community [34]. Members themselves propose prospective guests and arrange for their "visits". Over a certain period of a guest's visit members freely ask questions on-line. At the end of the visit, guest provides answers also in an on-line form. Seven guests have visited the portal so far, including the distinguished late professor Ivan Supek.

Finally, cooperation almost certainly occurs through members' direct communication by means of various community services. Cooperative arrangements that emerge in such a way are less publicly visible and their assessment would entail members to answer a research questionnaire, which was not envisioned in this stage of our research.

COOPERATION PROBLEMS IN THE "CONNECT" COMMUNITY

Unfortunately, discussions at the community's portal occasionally get also so highly charged with emotions that civil debate becomes close to impossible. Contrasting opinions and opposing arguments then give way to angry disputes and flame wars. Examples of deliberate flaming include direct exchanges of insults; attacks *ad hominem*; using titles, official and other positions of authority to impress or even threaten members with different opinions; using authoritative or patronising tone and various other methods of disparaging discussion of

participants with different opinions. Various sorts of insinuations and intentional biased portrayal of individuals, groups, events, and situations, known as spins [35], have also been used as weapons of flame wars.

Although these flame wars are not as frequent and intensive as in many other non-scientific forums, their consequences are still destructive to the community's commons. Focus of such heated discussions gradually shifts from the original issues to the trading of insults. Some participants, who find themselves hurt, tend to retreat from the community, while others tend to continue disputes indefinitely, sometimes even through other media. Although this may not be true in general, personal experience of the authors tells that the incidence of flame wars discourages prospective members from entering the community and current members from entering discussions. Fortunately, excesses more serious than occasional flame wars have not been noticed so far.

COMPLIANCE OF "CONNECT" TO OSTROM'S PRINCIPLES

PRINCIPLE 1: BOUNDARIES

The boundaries of "Connect" are drawn by the rules regulating membership in the community. The membership is open to researchers, educators, students, as well as to other professionals if they hold at least a bachelor's degree. Members need not be Croatian citizens, although they have to be related to Croatia in some way. For some of them Croatia may simply be a place of living, education, scientific research, or other science-related activities.

Although membership in "Connect" is open to all practitioners of sciences, social sciences, and humanities, in reality only a fraction of Croatian scientific community uses the opportunity of membership. Members from sciences prevail. One of the reasons for that may be traced to the community's beginnings, when most of the initiators of "Connect" were junior researchers with background in sciences. Another reason may be that practitioners of sciences are usually more proficient in using information technology tools, so that they get used to the community's electronic services more easily than practitioners of other disciplines. In any case, prevalence of members from sciences causes bias in choice of discussion topics towards issues primarily relevant to sciences. These topics attract, in turn, more new members from sciences, and such self-selection mechanism establishes a sort of additional boundary around the community.

PRINCIPLE 2: RULES MATCHED TO LOCAL NEEDS

Membership in "Connect" assumes acceptance of a set of fundamental rules. The rules regulate procedures and mechanisms necessary for the community's existence. Registration procedure, personal data reliability, and data protection are among the main subjects of these rather general and not overly restrictive rules.

Projects such as WikiFF add to these basic rules some more specific rules that are tailored to project-specific needs. Each of the "E-connect" sub-communities maintains a set of rules specifically matched to its needs, as well. These more specific rules are regularly also slightly more restrictive than the general-level rules.

The example of rules that govern public discussions at "Connect::Portal" will illustrate how more specific rules are matched to the needs of ongoing activities, as Ostrom's principle number 2 requires. The portal's rules may be roughly divided into three distinct groups. Firstly, there are technical rules of the "know-how" character. They determine how to format text of a posting, how to post own contribution, how to comment or rate another person's contribution, etc.

The second group consists of the rules regulating content of discussions. These rules primarily prohibit publishing of undesirable content, such as advertisements, messages of political marketing, and public defamation messages. Publishing of copyrighted material is forbidden as well.

The third group of rules is comprised of the netiquette rules, which prescribe manners of public discussion in virtual space. The explicit purpose of these rules is to prevent flame wars. Netiquette rules are, therefore, specially emphasised and links to additional netiquette sources on the web are provided. However, as responsibility for public expression rests on individuals, the netiquette rules have only advisory and not mandatory status.

PRINCIPLE 3: PARTICIPATION IN MODIFYING THE RULES

Rules governing internal workings of the "Connect" community are open to discussion and revision. For instance, rules of "Connect::Portal" are stated in a separate discussion thread and are subject to comments as any other posting. Intentions of modifying the rules are publicly announced by the editor. Modifications of rules are often topics of vigorous public discussions. Rules concerning rating of postings have been particularly contested on several occasions. The controversy surrounding the rating rules will be given more attention when we discuss the system of sanctions.

PRINCIPLE 4: RESPECT OF RIGHTS AND RULES BY AUTHORITIES

There is no point in discussing the role of external authorities, as they have no direct influence over the community.

The role of editor assumes certain internal authority at the "Connect::Portal" and similar roles of moderators exist in "E-connect" sub-communities. Editor is appointed by the "Connect::Portal" project coordinator. Editorial board consisting of three members has been recently established in order to provide support to the editor [36].

The editor's main task is to supervise compliance with the portal's rules. Editor has the right to intervene in cases of severe breach of rules. However, in exercising this right, editor mainly acts as a benevolent, non-intrusive supervisor, who generally refrains from modifying or deleting postings and only issues warnings to participants when discussions erupt into flame wars. Editor also has the last word in discussions concerning rule modifications and changes.

PRINCIPLE 5: SELF-MONITORING SYSTEM

The community's self-monitoring system is implemented as a system of ratings. Members can rate postings of discussions in which they do not participate. They can choose among three positive, two neutral and four negative ratings. The positive ratings are the following: "Insightful", "Informative", and "Interesting". Each of the positive ratings holds one positive point. The neutral ratings are "Neutral" and "Funny". They hold zero points. The negative ratings are as follows: "Off topic", "Superfluous", "Improper", and "Provocative". Each of the negative ratings holds one negative point.

Total rating of a posting is calculated only if at least 3 ratings have been cast. Numerical part or magnitude of the total rating is a sum of all ratings. Textual part of the total rating is a textual label of the most frequent rating of the same sign as the calculated sum. As an example, suppose that a rating got three "Informative" ratings, one "Interesting" rating, and one "Off topic" rating. The numerical part of the total rating of this posting is then calculated as in expression (1):

$$3*(+1) + 1*(+1) + 1*(-1) = +3. \quad (1)$$

The textual part of the total rating is "Informative", because this is the textual label of the most frequent positive rating of this posting.

Ratings are anonymous. The total rating and the distribution of all ratings are public and they are visible to members and to visitors as well.

The primary intention of the rating system is to provide feedback to authors as to how their contributions are perceived by the rest of the community. Ratings are designed with the purpose to rate the manner and tone in which a posting has been written, and not to rate the opinion expressed in the posting. Flaming messages are supposed to receive mostly negative ratings, which should encourage their authors to adjust the manner of expression and the tone of discussion accordingly. Such sanctioning effects of ratings are expected to decrease the incidence of flame wars.

Some members also use ratings for the purpose of filtering, assuming that negatively rated postings hold less valuable content and hence are not worthy of being read.

PRINCIPLE 6: GRADUATED SANCTIONS

Ratings cast by community members provide the first level of the community's system of sanctions. As all members are free to rate postings, this level of sanctions is decentralised.

However, flame wars sometimes continue, without being impeded by negative ratings assigned to flaming postings, and then the second level of sanctions must be activated. This sanctioning level is centralised and mainly consists of warnings issued by the portal's editor. As mentioned previously, the editor also holds the right to delete exceedingly offensive postings, but he uses this privilege only as an instrument of last resort.

PRINCIPLE 7: LOW-COST CONFLICT RESOLUTION

Conflict resolution mechanisms have not been implemented. One of the reasons probably lies in the lack of adequate technical prerequisites. It remains a challenge for social computing practitioners to develop low-cost e-versions of various conflict resolution procedures such as negotiation, mediation, conciliation, adjudication, arbitration, etc. [37].

PRINCIPLE 8: NESTED GOVERNANCE STRUCTURE

Ostrom's principle no. 8 posits that community's governance activities are organised in a nested structure with multiple layers of activities. This principle puts forth the most demanding requirement, which cannot be fulfilled before the governance structure of considerable complexity exists.

The "Connect" community is still too small to afford multi-layered self-governance. However, the "E-connect" sub-community structure testifies that "Connect" is envisioned as a nested self-governing community with multiple layers of special-interest sub-communities, each of them possessing its own governance structure.

COMPLIANCE REVISITED: A DISCUSSION

We may summarize the results of the analysis of compliance to Ostrom's principles by concluding that the principles 1-6 have been implemented, while the principles 7-8 have not been implemented. As an explanation of the failure to satisfy the principles 7-8, we have found that technical prerequisites for the implementation of the principle 7 still do not exist, and that the community is still too small for the implementation of the principle 8. In particular, the first steps towards development of a multi-layered, nested self-governance structure within the community have been made in accordance with the principle 8.

As to the effectiveness of the implemented principles, we have found that the principles 1-4 have been implemented effectively, while the current implementation of the principles 5-6 still leaves room for improvements.

The sanctioning system, and particularly the system of ratings, has been a subject of lengthy discussions at the community's portal, and several weaknesses of the system have been pointed out. Firstly, there is a problem of sample size, because usually only a small number of ratings are cast. Secondly, there is a problem with sample quality because ratings may come from author's "friends" or "enemies" only, and not represent "the silent majority". Thirdly, the effects of ratings are not easily observable or measurable. Fourthly, meaningfulness of the total rating may be called into question.

Unfortunately, there are no ready-made solutions to any of these problems. Mitigating the problem of a small sample size would require introducing additional incentives to rate postings. This could be done, in principle, through some kind of "meta-moderation" or "meta-rating system", where frequent and quality raters would be endowed with more "karma points" [3, pp. 122-123; 38]. More karma points carry more opportunities to rate as a reward. This kind of reward would, however, have no purpose if all members are free to rate any time they want, as they currently are. If only members "with good enough karma" had the privilege to rate and meta-rate, this would exacerbate the problem of ratings' sample quality. In a relatively small community like "Connect", where most of the members know each other, a significant portion of ratings and meta-ratings inevitably concerns (meta-)rater's "friends" or "enemies". If the (meta-)rating ability depended on "good enough karma", this would provide additional incentive to unfairly (meta-)rate "enemies" and eliminate them from the (meta-)rating pool [39].

The problem of ratings' sample quality is rooted in the asymmetry between publicly signed postings and anonymous ratings. This asymmetry, however, cannot be easily removed. On the one hand, abolishing anonymity of raters would discourage negative ratings and diminish the intended sanctioning effect. On the other hand, abolishing publicity of signatures on contributions would diminish both responsibility for written content and incentives to post genuinely valuable content. Moreover, anonymity of contributions to public discussions is utterly at odds with the spirit of scientific community.

Those members who oppose the current system of anonymous ratings, often call into question moderating effects of ratings on the one side, and stress excessively restrictive effects that ratings have on discussions, on the other side. Verifying such arguments, however, is a difficult task. It is hard to measure both whether the frequency and intensity of flame wars has declined, as well as whether the total amount of postings has declined, since and due to the introduction of ratings.

The asymmetry between publicly signed postings and anonymous ratings may be regarded as a reflection of a broader dilemma between freedom of public expression through postings and freedom of anonymous expression of disagreement by means of ratings. If one is more concerned with the freedom of expression, one will typically attach less priority to the rating system. If one is, however, more concerned with the freedom to express disagreement without a possibility of retaliation, one will assign greater priority to anonymous ratings. In scientific communities hierarchy of authorities is typically strong [40]. Those who occupy higher positions in the hierarchy are obviously favoured by publicity of signatures on contributions. As we have already mentioned, positions of authority have been used in flame wars to impress or even threaten members with less authority and different opinions. Therefore, it may indeed be reasonable to assign greater priority to the anonymity of ratings, as is currently the case in the "Connect" community. The fact that certain individuals did not

hesitate to exert pressures on editors to disclose the identity of raters who negatively rated their contributions [41] lends additional support to the stated conclusion.

The community gatherings like "Connect::Party" provide a way to compensate for the lack of trust that anonymous ratings may accidentally instil in some members. Generally, both on-line and off-line events are important for sustaining virtual communities since they strengthen members' identification within the community and with one another [42]. Face-to-face meetings present the most effective way to build personal relationships because they provide opportunities to understand individual communication styles and personal and professional motivations, and allow deeper kind of rapport, or trust to develop [43]. Referring to the three kinds of collective goods provided by virtual communities, we may say that face-to-face meetings facilitate transformation of social network capital into communion.

Concerning meaningfulness of total ratings, objections have been raised that the total rating need not be the most frequent of all ratings, and that postings with starkly different rating distributions may end with an identical total rating. However, as there is no perfect mechanism for extracting a single, summary rating from a multitude of individual raters' preferences [44], any total rating would represent only an approximation of the overall ratings distribution. The implemented total rating approximates the "magnitude" of positive, or negative, majority judgment by the numerical part and the qualitative nature of the majority judgment by the textual part.

FURTHER WORK

Literature on virtual communities is replete with warnings to community developers of how much effort and commitment is needed in order to maintain a viable community. This effort is almost always greater than the effort required to launch a community [9, p. 58].

Notwithstanding any of the previously mentioned problems, the "Connect" community is strikingly self-sustainable. New discussion threads open daily and comments to the existing threads arrive continuously. Debates become hotter from time to time, but in most cases civility is preserved without the editor's interventions.

Yet, from time to time, flame wars erupt and suddenly all the discouraging incentives implemented to contain the flame wars seem in vain. Signed contributions, netiquette rules, the two-level sanctioning system – all of these are not strong enough. What else is required?

The work presented in this paper will hopefully continue and enable us to approach the answer to the stated question more closely. In our further work we aim to increase the sample size of virtual communities being analysed, and to compare the various on-line communities regarding their compliance to Ostrom's principles, as well as regarding the incidence of both cooperative and non-cooperative outcomes. We also plan to increase the sample size of guidelines being taken into consideration. Beside the Ostrom's principles there exist other sets of guidelines for the management of commons, some of which have been specifically adjusted for application to virtual communities [42, 45-47].

By continuing investigations we hope to obtain further insight into factors influencing cooperative potential of virtual communities, better understand specific rules of commons management and the underlying systems of incentives in virtual communities, better explain incidence of successful cooperation and cooperation breakdowns, and perhaps provide advice to social software designers on promising directions of their further work. We hope that our work will provide at least a glimpse at possible ways of using information technology for further lowering the costs of human cooperation.

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REMARKS

[1]The broad meaning of "we" includes our elected representatives in legislative bodies, government, courts, etc.

[2]Referring to our previous discussion of information technology as a technology of cooperation, we stress that susceptibility to flame wars may generally be attributed to certain human characterictics such as conceit and vanity more than to some innate characteristics of the information technology itself. The crucial question again is the one of finding ways in which those human characteristics will be encouraged, or discouraged, by particular technological solutions.

[3]One of the authors is a member of the "Connect" community, which enabled her to collect first-hand information on members' services during preparation of this article. However, none of the authors participated in online discussions. Except for the mentioned membership in "Connect", the authors have not been associated to the "Connect" community, nor to its parental NGO.

[4]All numerical data related to the "Connect" virtual community were collected on 4. June 2008.

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VIRTUALNE ZAJEDNICE KAO ZAJEDNIČKA DOBRA: STUDIJA SLUČAJA ZAJEDNICE "CONNECT"

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SAŽETAK

U sve umreženijem svijetu, gdje se zajednice sve više koriste informacijskom tehnologijom, a mnoge zajednice postoje isključivo u virtualnom prostoru, iznova se javlja vječna društvena dilema suradnje, privlačeći pozornost društvenih istraživača novim elementima koje donose tehnološke inovacije, kao što su softverska rješenja koja omogućuju istodobnu komunikaciju članova zajednice putem javnih i privatnih kanala, laka dostupnost mnoštva različitih dokumenata, anonimnost poruka, forumi za potencijalno neograničen broj sudionika ili promatrača, i brojni drugi alati za izgradnju zajednice temeljeni na dostignućima informacijske tehnologije. U ovom članku autori razmatraju problem suradnje u virtualnim zajednicama putem studije slučaja online zajednice hrvatskih znanstvenika "Connect". Analiza polazi od opažanja da je suradnju unutar virtualnih zajednica moguće poticati primjenom tehnoloških rješenja koja korisnicima umnogome olakšavaju suradnju. Autori provjeravaju usklađenost zajednice "Connect" sa skupom načela izgradnje institucija temeljenih na zajedničkim resursima, koje je formulirala Elinor Ostrom. Studija pokazuje da "Connect" zadovoljava glavninu navedenih načela, uz mogućnosti manjih poboljšanja, te da ne zadovoljava dva načela, uglavnom zbog nepostojanja tehničkih preduvjeta i zbog relativno malog broja članova zajednice. Analiza postavlja temelje daljnjih istraživanja, usmjerenih ka nalaženju smjernica i preporuka za moguća daljnja unaprjeđenja sustava upravljanja zajedničkim resursima u virtualnim zajednicama.

KLJUČNE RIJEČI

zajednička dobra, suradnja, načela upravljanja, virtualne zajednice

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APPLICATION OF GAME THEORY IN DESCRIBING EFFICACY OF DECISION MAKING IN SPORTSMAN'S TACTICAL PERFORMANCE IN TEAM SPORTS

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ABSTRACT

A mathematical method of decision-making in which a competitive or cooperative situation is analyzed to determine the optimal course of action for an interested "player" is often called game theory. Game theory has very broad application in different sciences. Team sports tactical performance is considered from the aspects of data processing theory and the phenomenon of selective attention, as well as from the game theory. Team sports tactical performance is an asymmetric, sequential (of imperfect information), non-zero-sum game. In decision making, predictability in team sports is in fact bargaining, and the player has to use a mixed strategy for choosing option with highest expected utility. Player could choose a trembling hand equilibrium, to eliminate imperfect equilibrium. Strategic dominance conceipt can explain that a player could choose strategy which dominates between other possible strategies, and/or could be led by "team reasoning", too. In this article, the level of predictability of the most frequent tactical performance of one player in a team sport game is considered, reflecting outcomes both for the same team's tactical performance (co-players in one player's team), as well as for the opponent team's tactical performance. Four different possible situations during team sport competition could lead to considering utilities of one player's specific decisions.

KEY WORDS

game theory, team sport, tactics

CLASSIFICATION

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INTRODUCTION

A mathematical method of decision-making in which a competitive or cooperative situation is analyzed to determine the optimal course of action for an interested "player" is often called game theory [1]. A game is any situation in which the outcomes ('pay-offs') are the product of interaction of more than one rational player. The term includes not only games in the ordinary sense, but a wide range of human interactions. Game theory studies situations where multiple players make decisions in an attempt to maximize their returns. The essential feature is that it provides a formal modelling approach to social situations in which decision makers interact with other agents.

Game theory has played, and continues to play a large role in the social sciences. Beginning in the 1970s, game theory has been applied to animal behaviour, including evolutionary theory [2]. Many games, especially the prisoner's dilemma [3], are used to illustrate ideas in political science and ethics. Game theory has recently drawn attention from computer scientists because of its use in artificial intelligence and cybernetics. The first known discussion of game theory was written by James Waldegrave in 1713. In 1838, Cournot considers a duopoly and presents a solution that is a restricted version of the Nash equilibrium [4]. But, game theory really exists as a unique field since John von Neumann published a series of papers in 1928 (he can rightfully be called the inventor of game theory). Von Neumann's work in game theory culminated in the book "The Theory of Games and Economic Behaviour" by von Neumann and Oskar Morgenstern [5]. This work contains the method for finding optimal solutions for two-person zero-sum games. During this time period, work on game theory was primarily focused on cooperative game theory, which analyzes optimal strategies for groups of individuals, presuming that they can enforce agreements between them about proper strategies.

In 1950, the first discussion of the prisoner's dilemma appeared, and around this same time, John Nash developed a definition of an "optimum" strategy for multiplayer games where no such optimum was previously defined, known as Nash equilibrium [6-8]. This equilibrium allowed the analysis of non-cooperative games as well as cooperative ones. Nash mathematically clarified the distinction between cooperative and noncooperative games [8]. In noncooperative games, unlike cooperative ones, no outside authority assures that players stick to the same predetermined rules, and binding agreements are not feasible. Further, he recognized that in noncooperative games there exist sets of optimal strategies (so-called Nash equilibrium) used by the players in a game so that no player can benefit by unilaterally changing his or her strategy if the strategies of the other players remain unchanged [1]. Because noncooperative games are common in the real world, the discovery revolutionized game theory. Nash also recognized that such an equilibrium solution would also be optimal in cooperative games. Nash also introduced the concept of bargaining [2, 3], in which two or more players collude to produce a situation where failure to collude would make each of them worse off. Reinhard Selten [9] introduced his solution concept of subgame perfect equilibrium, which further refined the Nash equilibrium. In 1967, John Harsanyi developed the concepts of complete information and Bayesian games [10]. In the 1970s, game theory was extensively applied in biology, largely as a result of the work of John Maynard Smith and his evolutionary stable strategy. In addition, the concepts of correlated equilibrium, trembling hand perfection, and common knowledge were introduced and analyzed. Schelling worked on dynamic models, early examples of evolutionary game theory. Aumann contributed more to the equilibrium school, developing an equilibrium coarsening correlated equilibrium and developing extensive analysis of the assumption of common knowledge [2].

In this article a review of decision making 'logic' has been given, in accordance with mathematical game theory hypotheses (Section 1.1.). Consequently, the issues of unstable equilibrium have been considered (Section 1.2.), as defined by Nash, describing a number of cases lacking the universal rational solution for the decision maker. As a specific case of necessarily unstable equilibrium the team resoning has been explained (Section 1.3.), where the decision maker attempts to maximize the collective and not the individual payoff. In this article, externally competitive (sport game is s competition between two teams) but internally (inside the same team) cooperative team sports were analyzed, which include interaction between players [31]. These are so-called sport games (football, soccer, basketball, volleyball, ice hockey, handball, water-polo, etc.).

Game theory has been applied in analysis of consequences of making a decision on tactical performance of an individual in team sport, for the players in both the player's and opponent team (Section 2). Beyond the game theory, psychological theoretic frames for describing efficacy of tactical sportsman's performance in competition are: data processing theory and phenomenon of the selective attention. Both "psychological frames" explain why a player might choose less rational decisions (unpredictable performance, for example) in sport situations.

The reasons why an individual may bring more or less rational decisions in tactical performance have been given within data processing model (Section 2.1.) and selective attention phenomenon (Section 2.2.). Predictibility of an individual player's behaviour may have an excitatory or inhibitory effect onto his co-players and players of the opponent team (Section 2.3.). The central part of the article (Section 2.4.) describes hypothetical situations in relation to predictability of a player's tactical performance during a game, and the effect onto the tactical performance efficacy of the players of his own or opponent team.

TYPES OF GAMES

In a symmetric game, payoffs for playing a particular strategy depend only on the other strategies employed, not on who is playing them. If identities of players can be changed without changing the payoff to the strategies, then a game is symmetric. In asymmetric games, there are no identical strategy sets for both players. It is possible, however, for a game to have identical strategies for both players, yet be asymmetric [11]. Zero sum games are a special case of constant sum games, in which choices by players can neither increase nor decrease the available resources. In zero-sum games the total benefit to all players in the game, for every combination of strategies, always adds to zero (a player benefits only at the expense of others). Many games studied by game theorists (including the Prisoner's Dilemma) are non-zero-sum games, because some outcomes have net results greater or less than zero. Informally, in non-zero-sum games, a gain by one player does not necessarily correspond with a loss by another. In simultaneous games, either both players move simultaneously, or the later players are unaware of the earlier players' actions (making them effectively simultaneous). Sequential (dynamic) games are games where later players have some knowledge about earlier actions. This need not be perfect knowledge about every action of earlier players; it might be very little information. For instance, a player may know that an earlier player did not perform one particular action, while he does not know which of the other available actions the first player actually performed. A subset of sequential games consists of games of perfect information. A game is one of perfect information if all players know the moves previously made by all other players. Thus, only sequential games can be games of perfect information, since in simultaneous games not every player knows the actions of the others. Most games studied in game theory are imperfect information games.

DECISION MAKING

Game theory is concerned with rational choice in decisions involving two or more interdependent decision makers. Its range of applicability is broad, including all decisions in which an outcome depends on the actions of two or more decision makers, called players, each having two or more ways of acting, called strategies, and sufficiently well-defined preferences among the possible outcomes to enable numerical payoffs reflecting these preferences to be assigned [12-14].

Decision theory has a certain logical primacy in psychology, because decision making drives all deliberate behaviour, and game theory is the portion of decision theory dealing with decisions involving strategic interdependence. The notion of rationality underlying game theory is instrumental rationality, according to which rational agents choose the best means to achieve their most preferred outcomes [13]. A person's reasons for acting in a particular way are invariably internal, hence an action is instrumentally rational, relative to the agent's knowledge and beliefs at the time of acting, if it is the best means to achieve the most preferred outcome, provided only that the knowledge and beliefs are not inconsistent or incoherent [13, 15]. Instrumental rationality is formalized in expected utility theory, introduced as an axiomatic system by von Neumann and Morgenstern [1], in which utilities are represented by payoffs, and the theory (presented by von Neumann and Morgenstern) is primarily normative, in as much as its basic aim is to determine what strategies rational players should choose to maximize their payoffs. It is not primarily a positive or descriptive theory that predicts what strategies human players are likely to choose in practice.

The starting point for modeling any decision problem must be an understanding of the problem as it is seen by the decision-maker, a definition of the objectives of the decision-maker, the identification of alternative solutions to the problem, and the formulation of means for representing the objectives in a way that can be used to select among the alternative answers [13]. A utility function is a means for representing the objectives in a way that can be used to select among the alternative answers. To represent the objectives, two aspects must be recognized. One is the relative importance of the objectives and the second is the scale for assessment individually for each of them. In this respect, it is important to note that an unweighted mix of criteria, such as "the greatest good for the greatest number," is irrational; one cannot in general optimize two objectives simultaneously. To do so, there must be a single criterion, and if there are two or more objectives, that criterion must suitably represent their relative importance. It is that requirement that makes the utility function necessary [13]. The process of modelling a decision-making problem has three steps. First is to translate the problem of comparison among objectives into "quantitative/qualitative" ratios. Second is to translate, to the extent possible, the qualitative objectives into quantitative ones. For example, this might be accomplished by translating "effectiveness" into a combination of measurable characteristics. Third, and most fundamental, is to translate the process of assessment into relative comparisons of alternative options [2].

The usual frame of reference for a game theoretic model is a competitive game, in which the contexts represent the opponent's strategies for play, and the utilities (if positive) are payments to the decision-maker from the opponent (or, if negative, from the decision-maker to the opponent).

As a principle, game theory assumes that the players in a game are "rational," in the sense that they will each make decisions that are best for their individual interests, as expressed by their respective utility functions. That implies, in particular, that the relative frequencies of the options and contexts will be determined by the optimal strategy of the player whose plays they represent.

It is further assumed that both players have complete knowledge of the utility functions for each.

In particular, there are applications of game theory for which the assumption of maximizing individual interests, with max-min as the resulting criterion for choice and with the use of randomization as the means for creating mixed strategies, may be changed. The means for doing so is called "bargaining" and the resulting games are called "cooperative games".

Bargaining is a process of making offers and demands with the objective of achieving total, joint results that are better than can be obtained from simply the competitive game [7, 8, 16].

In non-cooperative games, the players act independently, whereas in cooperative games they are free to negotiate coalitions based binding and enforceable agreements. The leading solution concept for non-cooperative games is Nash equilibrium. This is a profile of strategy choices, one for each of the n players in a game, such that each player's strategy is a best reply to the $n - 1$ others. The best reply is a strategy that maximizes a player's payoff, in case of strategies chosen by the others. An important psychological property of an equilibrium point is that it gives the players no cause to regret their strategy choices when those of their co-players are revealed. Nash [7, 8] gave two separate proofs that every game with a finite number of players (each having a finite number of strategies) has at least one equilibrium point, provided that mixed strategies are brought into consideration. A mixed strategy is a probability distribution over a player's (pure) strategies. In the popular Bayesian interpretation of game theory, a mixed strategy is viewed construed as uncertainty in the mind of a co-player about which pure strategy will be chosen [16].

The fundamental problem in an attempt to determine rational play in games is that individual players have incomplete control over the outcomes of their actions. A rational decision maker chooses the option with the highest expected utility or one of the options with the highest expected utility. But a game does not generally have a strategy that is best in this straightforward sense, because a player's preferences range over outcomes, not strategies, and outcomes are determined partly by the choices of other players.

Deviations from perfect rationality are inevitable, because human decision makers have restricted rationality. Bridging hypothesis provides game theory with a secondary objective, that of making testable predictions, thus justifying the otherwise inexplicable enterprise of experimental gaming [17-20].

UNSTABLE EQUILIBRIUM

The specification of the game and the players' rationality are common knowledge in the game. Any uniquely rational solution must be an equilibrium point, and any conclusion that a player validly deduces about a game will be deduced by the co-player(s) and will be common knowledge in the game. This logical implication is called the transparency of reason [21]. A Nash equilibrium, even if unique, is not necessarily a rational solution, because a game may have no uniquely rational solution.

If a particular outcome is a Nash equilibrium, that is not a sufficient reason for a rational player to choose the corresponding equilibrium strategy. It implies that neither player has any reason to expect the other to choose a mixed equilibrium strategy. In the mixed-strategy case, not only does the fact that a particular outcome is a Nash equilibrium fail to provide a player with a sufficient reason for choosing the corresponding equilibrium strategy, but, on the contrary, it appears to vitiate any reason that a player might have for choosing it.

Harsanyi [16] suggested that a player should always be assumed to have a small amount of uncertainty about a co-player's payoffs. If games with solutions in mixed strategies are modelled by disturbed games with randomly fluctuating payoffs, deviating slightly from the

values in the payoff matrix, then mixed-strategy equilibrium becomes replaced by pure-strategy equilibrium points, and the fluctuating payoffs interact in such a way that rational players choose strategies with the probabilities prescribed by the original mixed-strategy solution. Thus, although rational players will simply choose their best pure strategies without making any attempt to randomize, they will choose them with the probabilities of the classical mixed-strategy solution.

Some equilibrium points require players to choose strategies that are arguably irrational. This anomaly was discovered by Selten [9, 22], who developed a refinement of Nash equilibrium, called the subgame-perfect equilibrium. This equilibrium is one that induces payoff-maximizing choices in every branch or subgame of its extensive form. Selten [22] introduced the concept of trembling-hand equilibrium to identify and eliminate imperfect equilibrium. At every decision node in the extensive form of a game there is assumed to be a small probability ε (epsilon) that the player's rationality will break down for some unspecified reason, resulting in a mistake or unintended move. Selten presupposes whenever a player's hand 'trembles', the erroneous move is assumed to be determined by a random process, and every move that could possibly be made at every decision node therefore has some positive probability of being played. Assuming that the players' trembling hands are common knowledge in a game, Selten proved that only the subgame-perfect equilibrium of the original game remain equilibrium points in the perturbed game, and they continue to be equilibrium points as the probability ε tends to zero. According to this widely accepted refinement of the equilibrium concept, the standard game-theoretic assumption of rationality is reinterpreted as a limiting case of incomplete rationality.

TEAM REASONING

Team reasoning [23-26] is based on the idea that, under certain circumstances, players act to maximize their collective payoff, relative to their knowledge and beliefs, rather than their individual payoffs. A team-reasoning player first identifies a profile of strategy choices that maximizes the collective payoff of the players, and if this profile is unique, plays the corresponding individual strategy that is a component of it. This involves a radical revision of the standard assumptions, according to which decision makers maximize individual payoffs. But examples of joint enterprises abound in which people appear to be motivated by collective rather than individual interests. In some circumstances de-individuation may even occur, with people tending to lose their sense of personal identity and accountability [27, 28]. Experimental research has confirmed the intuition that there are circumstances in which decision makers prefer outcomes that maximize collective payoffs [29].

A second suggestion for explaining the payoff-dominance phenomenon is Stackelberg reasoning, suggested by Colman and Stirk [30]. The assumption here is that players choose strategies that maximize their individual payoffs on the assumption that any choice will invariably be met by the co-player's best reply, as if players could read each others' minds.

In spite of strategic dominance, experimental evidence [18] has shown that players frequently cooperate, to their mutual advantage. Strategic dominance describes a situation when dominance is strong, when a strategy yields a strictly better payoff than any alternative against all possible counter-strategies, as in the Prisoner's Dilemma Game. In those circumstances, it seems obvious that it is the uniquely rational way of acting. Even if a strategy only weakly dominates all other strategies, that seems to be a strong argument for choosing it.

The most compelling solution concept of all is strategic dominance. Nothing seems more obvious than the rationality of choosing a strategy that yields a higher payoff than any other against every possible counter-strategy or combination of counter-strategies. If one course of

action is unconditionally best in all circumstances that might arise, then it seems obvious that a rational player will invariably choose it.

GAME THEORY AND TACTICAL SPORT PERFORMANCE IN TEAM SPORTS

It's important to emphasize that games are commonly defined as sets of players, actions and preferences over the outcomes. In this article, "players" are sport teams (opponents and co-players) and predictability/unpredictability of individual player's actions.

Szymanski [32] used game theory in a sport economy, describing an influence of increasing gate revenue sharing among teams in one league, which reduces competitive balance. The same author [33] used game theory in describing the economy of the sport contests. Sindik et al. [34] used the model of non-zero-sum games to describe some problems in working circles, between the leader and employees.

In this article, game theory is used in an attempt to explain payoffs linked with predictability of individual player's actions, for co-players in his own team, as well as for the opponent team players. It is assumed that predictability in team sports could be explained as an asymmetric, sequential, non-zero-sum game. Individuals do not have the same importance in team performances (that is the reason for explaining them as asymmetric), payoff results are always greater or less than zero (non-zero-sum is caused by different "fatal" choices in various sport game's situations, but also in sometimes unpredictable positive payoffs, even in moderate negative payoffs). Moreover, predictability in team sports is a sequential game of imperfect information, because all players have some knowledge about the moves previously made by all other players, but not all their moves in all typical sport situations. From the decision making point of view, predictability in team sports is in fact bargaining, because a player can't make decisions only depending on opponent team tactical performance (rules of the competitive game). He must simultaneously consider the tactical performance of his co-players in the same team (rules of the cooperative game), and make some mixed strategy for choosing option with highest expected utility. So, a player could choose a trembling hand equilibrium, to eliminate imperfect equilibrium, which comes out from subgame-perfect equilibrium (complexity of the teams sport's performance can induce player's partial analysis of some aspects of sport tactical performance). Besides, team reasoning could lead to identifying a profile of strategy choices that maximizes collective payoff of the players. Finally, strategic dominance can explain that a player when making decision about tactical performance under certain circumstances could choose strategy which dominates among other possible strategies.

DATA PROCESSING AS A QUALITY LIMITING FACTOR IN ACTIONABLE PLAYER'S PERFORMANCE IN COMPETITION

Data processing capacity of each sportsman is limited. If one of the tasks requires total available data processing capacity 'space', it will result with other tasks being performed with less efficacy. Fast data processing determines correct and duly motor action, and that motor action induces the performance in sport competition.

That is the reason why the data processing model is of great importance for describing quality of the player's tactical performance, hence the sport result of the whole individual's sport team.

The quantity of the transferred information in a problem situation, could be quantified in terms of number of questions needed for solving that problem (number of information bits), or in the terms of the mathematical formulas [31]. The idea about limited capacity of the data

processing helps in making difference between a very skilful sportsman and less skilful sportsman [31], which is measurable by testing the response time. Namely, it has been proven that by increased learning (training) the attention requirements needed for the motor action decrease, leaving more space for processing of other data, i.e. for acquiring new technical or tactical knowledge. If some task occupies all space for data processing of an individual, there is no more space for the other tasks which also need attention and data processing. That's the reason why well trained sportsmen have faster data processing. But, the situation is not so simple, good technical and tactical training is not enough. Even if a player is very skilful in performing particular technical and tactical elements, there is a possibility that he could perform slowly, while confronting an unpredictable situation in sport competition.

From the aspect of possibility of fast data processing in the team sports, synchronized cooperation between players is a factor which sometimes extremely contributes to the team success, much more than a fictive «sum» of individual qualities in individual players, respectively individual's motor and functional abilities, technical skills. Untrained or unforeseeable tactical performance of an individual within a team in sporting events necessarily influences the need for data processing capacity space enlargement, thus slowing down the 'team' reaction time and reflecting onto poorer team performance.

SELECTIVE ATTENTION AND SPORT PERFORMANCE

Selective attention is ability for suppressing entrance of irrelevant information, simultaneously focusing attention on relevant information.

Easterbrook's "theory of using signs" [31] describes the phenomenon of reducing the extent of attention. With a growing level of activation (arousal), player's attention latitude can be tight. This process of reducing attention latitude has some desirable «optimum» (optimal level of the arousal), when entrance of the irrelevant signs is reduced. However, further process of reducing, which grows along with the level of arousal, leads to reducing perception of irrelevant, and even some relevant signs, which will have non-desirable influence on action sport player's efficacy (performance in competition). Over-aroused player will make faults during sport performance, because he sub-optimally uses less processed information. Very probably, he gets less information and makes bad selections. Similar assumption may be made on team level, when contemplating unforeseeable tactical performance of an individual player in relation to agreed team tactics during a sporting event: it results in 'distraction' and over-arousal of other players in the team, who are required to put some extra effort to understand tactical moves of an individual player, instead of being focused onto team tactics. Consequently, their tactical performance is necessarily poorer.

INFLUENCE OF PREDICTABILITY OF ACTIONS OF PLAYERS IN THE SAME TEAM ON THE FINAL RESULT IN COMPETITION

Cooperation between players appears as an specially important factor, if we consider cooperation quality from the point of view of predictability for individual competitor, who interacts with his co-players (players in the same team) and opponents (players in the opponent team).

Analyzing theoretic assumptions, from the aspect of the team action in sport, it's probable that an individual player, exhibiting frequent unpredictable sport tactical performance for the players in the same team, is not highly responsible, consequent, disciplined, self-critical. But, if his unpredictability is expected by the players in the same team, and not expected by the opponent team, an individual will not damage group cohesion in his team. When co-players imply his unpredictability, they could perform more carefully in team tactical actions.

From the data processing point of view, it could be argued that data processing for unpredictable individual player's performance could last longer, for the players in the same team.

From the aspect of the arousal level (Easterbrook [31]), it is probable that in the situation of less predictable individual's performance, arousal level could be beyond optimal level, what could result in poorer sport performance in both teams (player's and opponent's), but more in the opponent team (the same explanation as in the situation of group action rules). "Expected" individual's unpredictable performance could result with less excited (calm) team performance of the co-players in the same team.

HYPOTHETICAL SITUATIONS: PREDICTABILITY/UNPREDICTABILITY FOR CO-PLAYERS/OPPONENTS AND THE PAYOFFS

Actions are defined as "average" or the most frequently used individual player's tactical performance, viewed from it's predictability level (predictable/unpredictable). Outcomes are considered from the aspect of utility of the sport performance: either for an individual player or for the co-team or opponent team.

In team sports, cooperation between players is the factor which sometimes extremely contributes to team success, much more than fictive "sum" of the team members individual qualities, such as individual motor and functional abilities, technical skills, etc. This model's main assumption describes consequences of the individual's tactical decisions during sport competition in relation with a plan for own team tactical acting (co-players), but also in relations with a plan for opponent team tactical acting. But in order to consider individual's tactical performance predictability, it is necessary to consider his motor activity during sport competition.

Observing this problem from the aspect of game theory, establishing different possible situations during sport competition could lead to considering advantages for specific decisions (outcomes). The dichotomy in this article considers:

- predictability or non-predictability (for the individual's technical and tactical action during sport competition), in relation with
- co-players (in the same team) or opponents (players in the opponent's team).

In practical experiment, an "isolated" situation of the sport competition, or a sample of the individual's performance during sport competition, is considered. Nevertheless, the individual's tactical performance is a 'mediator' in relation to which utility for players of the same or opponent team is being considered. In following tables, first number in the cell OUTCOME ADVANTAGE always represents utility for the same team, in which individual plays (co-players); second number represents the utility for opponent team (opponents).

Accordingly, following main situations are possible:

- predictability for the co-players and unpredictability for the opponents,
- predictability for co-players and predictability for the opponents,
- unpredictability for co-players and unpredictability for the opponents,
- unpredictability for co-players and predictability for the opponents.

Predictability for the co-players and unpredictability for the opponents

That is hypothetically the best possible outcome for player's (individual's) team (co-players): the player whose performance is predictable to players in the same team, could enable their systematic individual and team action. Preciselly, assumed predictability is an idealisation, as

in reality thereis always some contribution of unpredictable actions, or they could be assumed. All trained tactical variations could be performed.

On the other hand, unpredictability of his motor activity could have a "confusing" effect on opponents, who become disabled to currently recognize the pattern of tactical opponent's performance. In this situation, opponent's team could hardly apply adequate "contra – tactical" plan. That situation is the most rational option which player could choose, although in practice it is very hard to predict what pattern of player's tactical performance is really unpredictable for the opponent team. But, that's the option with the best utility, a number -10 (for opponent team), 10 (for his team) is added to this situation.

Table 1. Outcomes from the situation when a player's tactical performance is predictable for players in the same team and unpredictable for players in the opponent team.

PREDICTABLE	UNPREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	10, 10

Predictability for co-players and predictability for the opponents

That's hypothetically a very advantageous possible outcome. The player with predictable performance for the players in the same team, could enable a systematic individual and team acting to the team (same as in situation a). However, in this situation co-players include the possibility that the opponent could recognize a pattern of tactical individual's performance. Consequently, all players in the individual's team have to choose "the safer" tactical patterns of the motor performance.

On the other hand, unpredictability of his tactical performance cannot have any "confusing" effect onto the opponent team, who could currently recognize a pattern of tactical opponent's performance. In this situation, opponent's team could currently apply an adequate "contra – tactical" plan. However, this plan cannot be a surprise for co-players (who may expect counter-tactics of the opponent team), and consequently such situation cannot be considered as particularly convenient for the opponent team. That's why numbers 0 (for opponent team) and 10 (for the co-players, in player's team) are added to this hypothetic situation.

Table 2. Outcomes from the situation when a player's tactical performance is predictable both for players in same team and for players in the opponent team

PREDICTABLE	PREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	10, 0

Unpredictability for co-players and unpredictability for the opponents

That's hypothetically a relatively disadvantageous possible outcome. The player whose tactical performance is unpredictable for the players in the same team, could disable any systematic individual and team acting (in his team), especially when applying "risky" tactical patterns. Applying such patterns could be "suicidal" for the individual's team, if his tactical performance is unpredictable. On the other hand, although unpredictability of his action performance could have some "confusing" effect on the opponent (so the opponent couldn't apply adequate "contra-tactics"), this tactical pattern is disadvantageous for the opponent team, too. Namely, neither player's team nor opponent team could include "the safest" or "risky" tactical patterns of tactical performance. That is the only option which brings absolute doubt, total unpredictability. However, possible favourable outcome of the individual "improvisation" could bring some "positive" outcome (mostly by "confusing" the opponent team). That's why number –10 (for co-players in player's team), and -10 (for opponent team) is added to this hypothetic situation.

Table 3. Outcomes from the situation when a player's tactical performance is unpredictable both for players in same team and for players in the opponent team

UNPREDICTABLE	UNPREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	-10, -10

Unpredictability for co-players and predictability for the opponents

That's hypothetically the most disadvantageous possible outcome. The player whose tactical performance is unpredictable for the players in the same team, could disable them in any systematic individual and team acting, especially while applying "risky" tactical patterns (same as in the situation c.). On the other hand, his action performance doesn't have "confusing" effect on the opponent, so the opponent could apply adequate "contra-tactics".

In described situation co-players wouldn't be able to include "the safest" or "risky" tactical patterns of tactical performance. Therefore, that is a completely "suicidal" possibility, which would most probably bring a negative outcome for the co-players and individual's team success, but positive outcome for the opponent team.

Consequently, numbers –10 (for player's team), 10 (for opponent team) are added to this hypothetic situation.

Table 4. Outcomes from the situation when a player's tactical performance is unpredictable for players in the same team and predictable for players in the opponent team

UNPREDICTABLE	PREDICTABLE	OUTCOME AVANTAGE
CO-PLAYERS	OPPONENTS	-10, 10

Accordingly, below is shown the table which summarizes all these hypothetic options simultaneously.

Table 5. Outcomes from all situations when a player's tactical performance is predictable or unpredictable for players in the same team and for players in the opponent team

PLAYER / TEAM	CO-PLAYER(S)	OPPONENTS	Σ
PREDICTABLE	10	0	10
UNPREDICTABLE	-10	-10	-20
Σ	0	-10	-10

From these hypotheses made by the author, predictability could in general be better than unpredictability, whether for the players in the same team or for the opponent's team players.

Although the model shows only a very simplified option of describing individual's tactical action in competitive situations in collective sports, this description possible outcomes of the tactical individual's actions, could be a starting point for the individual tactical training.

Because it offers a relatively clear numeric description of different situations during sport competition, this model could be relatively easily tested, by systematic comparison of given tactical tasks (by trainer), the performance of these tasks by individual player (and all other players in the same team) during sport competition, and team statistics.

A more complex model could include the "net" of similar possible situations for all players in the same team, and a more complex situation could include all players from the opponent team. However, multiplying the number of interactive situations in the same game, the model could hypothetically predict more differentiated outcomes and utilities. Consequently, consideration of tactical predictability of an individual player during a sporting event could be the first step in the trainer's approach in the tactical training process.

CONCLUSIONS

In this article, the level of predictability of the most frequent tactical performance of one player in a team sport game is considered, reflecting outcomes both on the same team's tactical performance (co-players in one player's team), as well as for the opponent team's tactical performance. In this situation, the problem of cooperation between the players in the same team, during sport competition (between two teams) is simultaneously considered, explained by conjectures derived from the game theory and from psychological theories. Four different possible situations during team sport competition could lead to considering utilities of a player's specific decisions.

The model could be relatively easily tested, in specific team sports. According to the hypotheses offered by the author, predictability is in general better than unpredictability, both for the players in the same team and for the opponent's team players. Such an approach could be the first step in finding practical solutions in individual and team tactical training, for any team sport.

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PRIMJENA TEORIJE IGARA ZA OPISIVANJE UČINKOVITOSTI ODLUČIVANJA U TAKTIČKOM DJELOVANJU SPORTAŠA U TIMSKIM SPORTOVIMA

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SAŽETAK

Matematička metoda odlučivanja u kojoj se analizira kompetitivna ili kooperativna situacija radi određivanja optimalnog djelovanja zainteresiranog „igrača" uobičajeno se naziva teorijom igara. Teorija igara široke je primjene u različitim znanstvenim područjima. Taktičko djelovanje u timskim sportovima razmatrano je sa stajališta teorije procesiranja podataka i pojave selektivne pažnje, kao i sa stajališta teorije igara. Taktičko djelovanje u timskim sportovima je asimetrična, sekvencijalna (nepotpune informacije) igra s ishodom različitim od nule. U odlučivanju, predvidljivost u timskim sportovima je zapravo razmjena, a igrač mora koristiti mješovite strategije za odabir varijante najveće očekivane korisnosti. Igrač može odabrati *trembling hand* ravnotežu radi uklanjanja nesavršene ravnoteže. Koncept strateške dominacije može objasniti kako igrač može odabrati strategiju koja dominira ostalim mogućim strategijama, ili može također biti vođen „timskim pristupom". U ovom radu razmatra se razina predvidljivosti najčešćih taktičkih djelovanja jednog igrača u timskom sportu. Pritom se razmatraju ishodi za taktičko djelovanje kako tima suigrača tako i protivničkog tima. Četiri moguće, različite situacije koje se javljaju tijekom natjecanja u timskim sportovima mogu dovesti do razmatranja korisnosti specifičnih odluka jednog igrača.

KLJUČNE RIJEČI

teorija igara, timski sportovi, taktike

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PRINCIPLES OF COMPUTER MODELLING OF THE SOLID PRODUCTS LEARNING

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ABSTRACT

The key condition for the realization of successful product's development and technological excellence is creation of a simple access to transition from the domain of designing to the domain of product's manufacturing. Nowadays, there are a lot of possibilities for this condition to be fulfilled and they depend on the level of organizational contemporariness which has to possess tools and skills in order to fulfill the demands of a superb production.

KEY WORDS

modelling, solid, CAD, computer aided design, 3D/2D, constructive element, parent/child relationships, drawing, part, assembly

CLASSIFICATION

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INTRODUCTION

The beginnings of computer designing in applications of CAD (Computer Aided Design) were based on 2D modelling of solids: machine-made elements, constructions, standard and non standard elements. 2D projections of a model are directly suitable for making the technical documentation: working and assembling drawings. However the main difficulties of such approach of designing aided by a computer were caused by a procedure of making 3D model out of already existing 2D projection in full display. Because of such difficulties, we were often obliged to hide or suspend certain displays on 2D models (such as dimensions and specific details) in order to do a process of third dimension extrusion. Such approaches were often the cause of technical mistakes and making of an unforeseeable time for their noticing, correction, removing, or at the worst case working out the existence of such a model.

When a new approach of solid products modelling appeared in CAD/CAM/CAE software family, a reversed procedure of modelling was created. First you create 3D model (which is a model that can be physically accomplished) out of which 2D projection is automatically created for the needs of technical documentation where there is no possibility for a mistake to appear and unnecessary losing of time and at the same time each change in 3D model is automatically reflected on all the applications derived from the model and there is no need for data interpretation. Therefore, when there is a need for certain modification of a project, for example an assembly (Figure 1) it is possible to make corrections without returning to the beginning and to each model (part) individually, but one can directly make the corrections on the assembly itself [1].

Figure 1. Assembly of a diesel engine.

SOLID PRODUCTS MODELLING

Parametric solid modelling by means of constructive elements implicates that parts and assemblies are created by defining of the elements of a higher level with clear physical meanings. The term clear physical meaning implicates defining of the elements suitable for the third dimension extrusion, extrusion along the curve or some other trajectory, for defining of the cuttings, orifices, incisions, roundness and the like [2, 3].

Using this approach to modelling a designer observes his model with a high level of abstraction. Elements are defined by determining of a corresponding values and references for different kinds of constructions such as referential surfaces, planes, directions, parameters of similar elements series, shapes, dimensions, etc. At element modelling a material is added or subtracted to the parts, whereas such elements can be geometrical forms such as referential axes or planes.

Changing or defining of dimensions and other attributes of an element can be done at any moment but one should keep in mind that such changes are automatically transmitted to the whole model.

Solid modelling of a created computer model contains all the information of a real object. Those are models with cubic capacity which can have mass and inertia if specific solidity of the material is defined in advance. The important difference of this kind of modelling in relation to surface modelling is that orifices and holes in the model of solid automatically create new surface so that one can precisely determine which side of surface represents solid material.

PRINCIPLES OF REALIZATION AND MODELLING ACCOMPLISHMENT OF SOLID PRODUCTS

At the very access to software for 3D modelling of solids such as: ProENGINEER WILDFIRE (which is applied in this work); Solid Works; Solid Edge; CATIA; Autodesk Inventor, etc. in which one wants to create a model by means of constructive elements [5] he or she has to keep in mind that a model which cannot be physically accomplished also cannot be projected in the applications mentioned above or some of them can be projected but one should pay attention to estimation of its probability to be manufactured in machine made process.

The displayed model in Figure 2 represents an object which resembles three-sided spatial object but on the occasion of solid modelling it is not possible to create such a model which is ambiguous and cannot exist physically [4]. However such a model is very simply suitable for creation in 2D, wire and surface models.

Let us observe the part of a model in figure 3 which can be physically accomplished and can be modelled by means of computer as a solid product but there is a question imposed whether the machines can make such orifices inside the displayed model the estimation of which is the authority of a person who designed this model [1].

THE PRINCIPLES OF CONSTRUCTIVE ELEMENTS' RELATION

Constructive elements represent basis for solid products modelling and they possess reciprocal relations which are practically called Parent/Child relationship.

Constructive element "parent" is the element that represents the base, that is to say a reference for the creation of a new element which will have the characteristic "child" because of the subordination which is created by its existence. Parents and children can be surfaces of some models, planes, angles, axes, points, and the like, which are reciprocally subordinated in such a way that if, for example one deletes the element "parent", its elements "children" will also disappear.

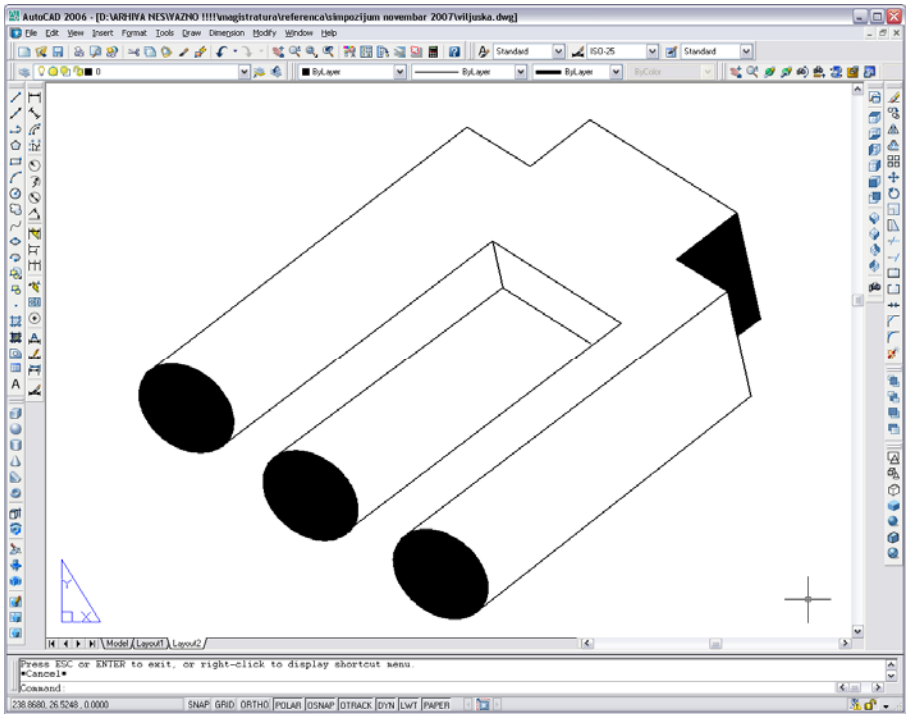

Figure 2. Unusual three-sided spatial object created in AutoCAD.

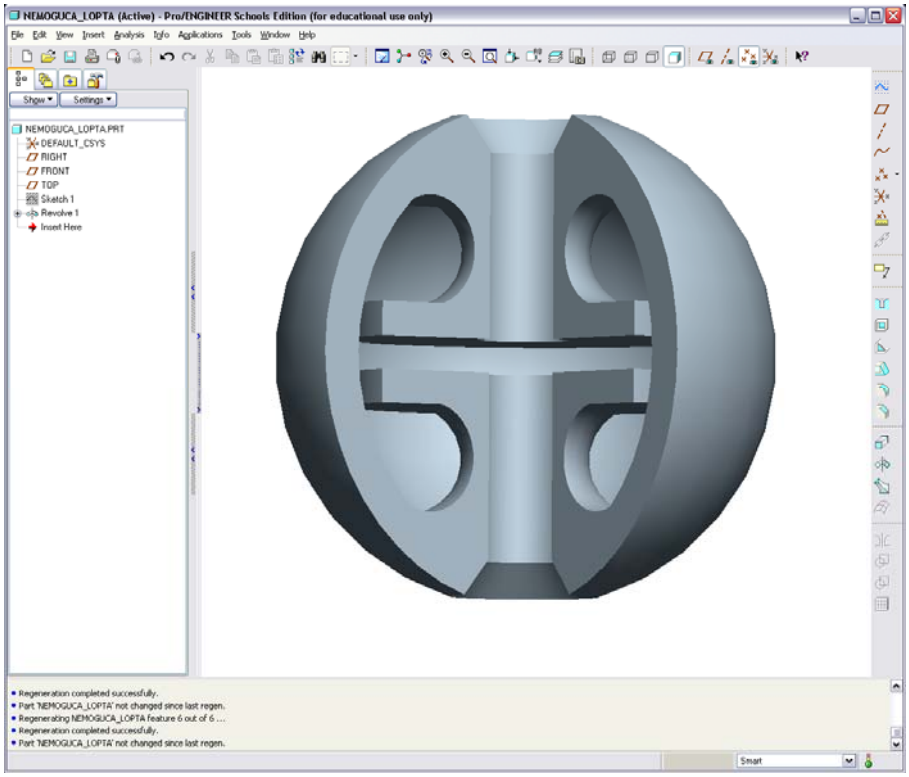

Figure 3. Part of a solid model created in ProENGINEER.

At solid product modelling it is very important to be careful about these relationships and principles for their creation because on the contrary a seemingly simple constructive problem can turn into an extremely complicated one especially at the moments when one changes or deletes some elements which possess parent/child relationship.

The applications mentioned above for 3D modelling mainly possess special functions for the work with parent/child relationships which have to be studied well before engaging in modification of a project.

In Figure 4 one can observe the relation of referential surface of prismatic part which represents the element "parent" on which there is a constructive element created of the circle "child" for the extrusion of cylindrical part.

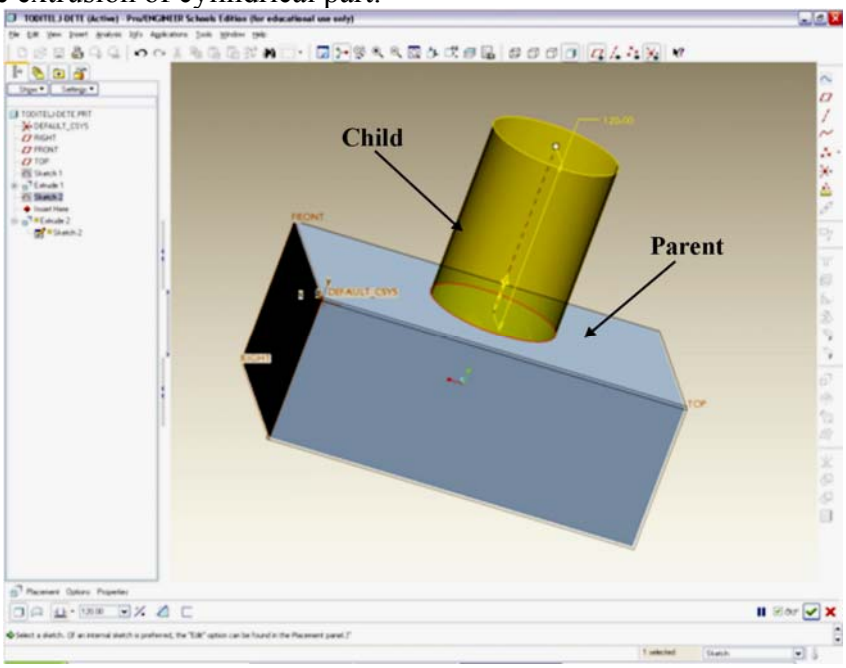

Figure 4. Parent/Child relationships.

THE PRINCIPLE OF PRACTICAL OBSERVATION OF A CONSTRUCTIVE ELEMENT

In this part of the work there will be described the principle of observation (recording) of a solid product's constructive element which is suitable for the creation in 3D applications on the basis of which a real model is reached.

The transition from 2D to 3D modelling can cause certain difficulties especially because of the practical speculation over the elements out of which the third dimension should evolve. In 3D modelling the creation of constructive element is done in the sketching part (2D projection) and the problems often appear on the occasion of sketch's confirmation and the impossibility of 3D projection creation. Here one should think of the difference between 2D technical drawing in display and the sketch for 3D modelling which resembles that drawing but without certain segments which would prevent forming of 3D dimension (diagonal lines, lines with an interval, axes, details, etc.).

That means that recording of constructive element of a geometrical form which has to be worked out in 3D is not as same as the recording of the view and looks of the form in technical drawing in 2D projection. Constructive elements should be regarded as a reflection of shadow's contour, for example the shadow of our profile (Figure 5) on the wall of a certain object on which one can see only the silhouette, that is to say outward lines of his or her looks where one cannot see the features of the face, eyes, mouth, ears, and other parts inside the shadow. So, on the basis of this example the other details (holes, orifices, grooves, roundness and the like) inside the observed geometrical form should be separately created in the same

way when we make a model according to a certain technological procedure and use clay or wood (from a sample to a completed part).

Figure 5. The example of shadow's contour.

While working with applications for 3D modelling of solid elements at some moments one can come across conclusion that can refute the claims mentioned above especially with extrusion but the possible problems appear with an effort to change of delete certain displays (orifices, holes, grooves, roundness, prostrated angles, and the like) which did not evolve separately but they were created inside the main constructive element.

When one finishes with model making according to the mentioned principle he or she can begin with making 2D technical drawing in standard format which is performed almost automatically and on which there are all necessary views, details, and looks displayed. The model and the drawing are connected with two-direction association so that each change of dimension on the technical drawing will automatically be reflected onto the model and reversely which proves the presence of parent/child relationship.

CONCLUSION

Everything that is described in this work represents the decadal experience of engaging in this problem as a teacher of a subject modelling of machine made elements and constructions in technical school. With an intention to present the simplest access to computer modelling to students and the beginners of the course by means of this kind of lecturing I managed to explain to students and people who had foreknowledge about this matter the relations which are present and make an important basis in further work.

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[5] -, *AutoCAD, Autodesk VIZ Architectural Desktop, 3D Studio VIZ, Autodesk Inventor, CATIA, I-DEAS, IronCAD, Mechanical Desktop, SolidWorks, Solid Edge, Land Development, MicroStation, Revit, Silverscreen, Thinkdesign, Unigraphics NX*,
Catalogues at Internet sites.

PRINCIPI UČENJA RAČUNALNOG MODELIRANJA ČVRSTIH TIJELA

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SAŽETAK

Ključni uvjet za realizaciju uspješnog razvoja proizvoda i tehnološku izvrsnost je stvaranje jednostavnog pristupa prijelazu iz domene dizajniranja u domenu proizvodnje proizvoda. U današnje vrijeme mnogo je mogućnosti za ispunjavanje tog uvjeta. Oni ovise o razini organizacijske suvremenosti koja uključuje i alate i vještine potrebne za ispunjavanje zahtjeva vrhunske proizvodnje.

KLJUČNE RIJEČI

modeliranje, čvrsto tijelo, CAD, *computer aided design*, 3D/2D, konstruktivni element, relacija roditeljstva, dio, sklop

MANUSCRIPT PREPARATION GUIDELINES

Manuscript sent should contain these elements in the following order: title, name(s) and surname(s) of author(s), affiliation(s), summary, key words, classification, manuscript text, references. Sections acknowledgments and remarks are optional. If present, position them right before the references.

SUMMARY Concisely and clearly written, approx. 250 words.

KEY WORDS Not more than 5 key words, as accurate and precise as possible.

CLASSIFICATION Suggest at least one classification using documented schemes, e.g., ACM, APA, JEL, PACS.

TEXT Write using UK spelling of English. Preferred file format is Microsoft Word. Provide manuscripts in grey tone. For online and CD-ROM versions, manuscripts with coloured textual and graphic material are admissible. Consult editors for details.

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Include figures and tables in the preferred position in text. Alternatively, put them in different locations, but state where a particular figure or table should be included. Enumerate them separately using Arabic numerals, strictly following the order they are introduced in the text. Reference figures and tables completely, e.g., "as is shown on Figure 1, *y* depends on x …", or in shortened form using parentheses, e.g., "the *y* dependence on *x* shows (Fig. 1) that…".

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