CREATING NEW KNOWLEDGE ASSISTED BY COMPUTATIONAL DEVICES

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Abstract
In contemporary global knowledge based society there are scorching needs for new knowledge and unprecedented vision of future development. Author is focuses attention to new possibilities of fostering creative abilities and gaining new socio-economic knowledge by the assistance of ICT, Internet and mainly by using products and services of computational intelligence. His method used is prevalingly new knowledge creation by experimentation in virtual laboratories. In using conventional methods, he combines inductive and deductive methods as set up for developing mental models from up to down and bottom to up. Because in socio-economic branches it is very difficult and even almost wholly impossible to do experiments in objective reality the experimentation by the assistance of computational intelligence is promising advance in gaining new socio-economic knowledge in contemporary complex world. Using such new approaches, methods and tools is the main scientific aim of the author. He uses convicitive demonstration of successful using these unprecedented possibilities in gaining deeper knowledge about complex evolutionary phenomena. The distinction of such knowledge is against conventional one is consisting in very deep understanding of complex socio-economic dynamics. Using meant knowledge acquisition approaches is promising in quality and in abiding knowledge and skill of single individuals but the extraordinary progress of creative knowledge based society fostered by using them in advanced webs is useful for whole society.

Keywords: creative (activity, community, corporation, economy, firm, society), fostering creativity and knowledge gaining by computational methods,

JEL Classification: B52, C61, C62, C63, D41, M15, M21, R11, R58, R59,

Introduction
In the sense of Creative and Knowledge Society and in such real environment the new knowledge is emerging in different types of networks. New socio-economic knowledge may create single subject and/or groups of subjects, scientific team, and so forth united into different conventional network but in contemporary world, such knowledge creation is possible in advanced webs working in Internet. In this sense we have good experience and particular know-how that such knowledge creation in advanced webs are very useful for economics. We have in mind that traditional network (that is homogeneous economics network created only by human subjects) may precipitously improved by new achievements of ICT, internet and products and services of computational intelligence. To the group of people communicating in networks is entering new virtual subjects – digital creatures, in contemporary era. These are currently known under name notably as softbot and myslit. They “live” in certain domain comparatively is like such something as Kripke´s world. With them, we can as human subjects are in direct sensorial contact in different time passage and in different loci of planet surface. Different single subjects, or particular scientific groups, teams creates new knowledge by building models in virtual laboratories and experimenting in them, but if there are in live cooperation with other subject and this cooperation not must be intentional there is emerging extra ordinal creative environment for not individual but social imaging and reasoning. Truth of the matter there emerging not only Platonic by philosophy proclaiming social consciousness but growing consciousness physically anchored in Internet. From such point of view there may arise several serious misunderstanding within the reality labelled by words Creative and Knowledge Society. Unfortunately, those terms Creative and Knowledge, notably in the function of adjectives localised in front of the term Society is very blurred. Maybe nobody in wide population knows what exactly the notion of Creative Society is and how it emerges. The same is with notion of Knowledge Society. These are the reasons why it is indispensable to focus scientific attention on these distort problems. Despite of great scientific efforts in last year’s there all the time persisting’s a lot of misunderstanding in the notion of creative and knowledge

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Problems with creative and creativity are because these terms include a multitude of definitions, approaches and different using concerning several scientific branches: - in philosophy, - in cognitive sciences mainly in psychology, in social sciences (particularly in socio-economic theories), in informatics, in network science and others. Such is taking in the relationship between creativity and general intelligence, mental and neurological processes associated with creativity among others. There are also lack of intersubjectivity regarding opportunities for promotion and cultivate creativity through education and training, particularly as augmented by ICT and advanced webs in Internet, and the application of creative resources to improve the effectiveness of learning and teaching processes. Although meant problems are serious, we pay them attention only in necessary rate. Our dominant aspiration is the problems of new knowledge acquisition in economics. In this connection we concern attention of very interesting writing of J. Kloudova et al. on Creative Economy [18]. Our main objective is focused on economic knowledge acquisition by the assistance of computational intelligence and by help of cognitive sciences all imputed in advanced webs in Internet, which we consider as excellent new opportunity for fostering creative and knowledge society. For that purpose, we are using very suitable software environment such STELLA [28], iDMC [22 – 23] and partly Excel too.

1 Creating economic knowledge in society and socially: creative potency of network

The creativity is the spontaneously emergent product of complex living network originally consisting from human subjects that is the product of human society. On the other words, that is not only group of single living entities. It is because a lot of single creative subject present in the society are not enough for emerging quality in the sense of creative society. These are two independent entities in the sense that both are different quality. In society may exist in neighbour’s several very creative subjects but among them not must be connections of network quality, which is indispensible for creative actions. These are the traditional problems with emergency of creation of knowledge in society as a whole, accordingly with creation of new knowledge socially. There are two historically unprecedented happenings emerging in second part of former century which are progressing further. The first is ICT and the other one-advanced webs in Internet. The phenomena of fostering creativity in large and complex network and/or social network by assistance of ICT and computational intelligence are spontaneously emerging in contemporary global knowledge based society. Creative activity is ability of single and/or social subject to create and/or to make something new which have individual and social utility value in real historical context. To produce by society some new entities and qualitative events by creative activity is the ground for using term Creative and Knowledge Society although this seeming as pleonasm. Another understanding of creative society is that one as group of creative single individuals and/or society that is creative as a whole in the sense of creative activity in social connected mod: the holistic creative society. Computational creativity, computational intelligence is helping intensively in achieving new economic knowledge but it may note that computational creativity and creativity of single and/or social subject assisted by computational intelligence is not synonyms. Such software entities as softbots and myrls are conditioning and mediating easier connection among participants in network and doing their accession to achieving contents existing in network more efficient. These simple computation entities can regard as the first stage achieved in development of digitalised knowledge creating networks. More advanced software devices are allowing information and knowledge to reach directly in their process of emerging. Among others such primordial and/or simple entities but differentiated are applets for plotting dynamics of economic mental models as 2D and/or 3D nonlinear systems. These are useful for imagination upon behaviour of biological, ecological and social systems after their primordial mental models mathematically formalized. On the other hand, in up-to-date economies the people are challenging several new complex phenomena. In such new circumstances, it is not enough for deep understanding of economics phenomena to deal only with intended simple computational entities. They need more advanced devices and tools able helping them in understanding very confused and tangled evolutionary behaviour of national and global knowledge based economies. These may be realised as virtual parallel entity to objective economic reality and create in such path some base to compare one to other. The typical and in present day current yet is routine when investigator create own authentic mental model of objective economic reality, or use such one achieved from other investigator and transform it to mathematical formula. Such formalized mental models one can find in standard economics textbooks. That via textbook is conventional mode to sharing mental models in economics. The readers of actual textbook containing the group of models and
partial theories spontaneously creates network of such model among them with property of intersubjectivity. In such network, it expected that sharing idea is going to the quality of common sense. If such textbook contents are spreading not only personally among the economists in universities and research institutes but via internet, the dimension of network can be very large and the interconnections among participants even more, because the requirement of to be in same place and in same time is vanished. In such complex environment arises potencies for emerging new form and entities. A qualitative new situation may be emerging when the formalised mental model transformed to the form of digital virtual laboratory and experimentation with such devices is possible via internet. This is, in authors approach, the first stage of hybridisation of homogenous network for achieving new knowledge for economics, which is the mode to build network by populating it with computational models built from up to down [2 – 8]. The second one, and more advanced is local network but better the internet populated by virtual laboratories of type intelligent digital organism, which built by method from bottom to up. One type of such organism can be prepared for evolution in digital world by the aid of methods and tools of multi agent science.”

Going out from earlier conclusions there emerging enough to answer difficult question – what is economic knowledge mean in contemporary complex situation? Alternatively, seeing it in another facet – what is the very subject of Economics, and what presents a wide economic reasoning in society? It looks for the first sight that widespread economic knowledge is some pell-mell product of both regular scientific research and hereby emerging as spontaneous creations of every-day human activities, something such as “people’s daedal and/or folk creativity”, created similarly as folk proverb, myths, roundelays etc. However, in our opinion, the great impact on turbulent evolution of broad economic thinking has delivery time lag in creation scientific answers on new phenomena emerging in contemporary knowledge based society and the misinterpretation of former “holily truths” of mainstream economics. Unfortunately, maybe there is no one universally accepted answer to the question about very objects of economic science, also in today, as we noted beforehand. According of classics of 19th century, namely according to J. S. Mill, the object of economics (in earlier time political economy) is that sphere of man's action that is involved in the pursuit of wealth. However, in thirty years of last century Lionel Robbins replaced this definition of economic sciences in his famous book An Essay on the Nature and Significance of Economic Science [20] by asserting that, ”Economics is the science which studies human behavior as a relationship between given ends and scarce means which have alternative uses”, p.16. On the contrary, of those meanings, Carl Marx focuses explication of the object of economic investigation namely on economy as social phenomena. He emphasizes that behind relations between things, economic science should try to discover the specific relations between human beings that they cover. Actually, the object called economy is collective phenomena in the large population of people as a whole. That is, from synergetics point of view, these phenomena cannot understandable only on the base of summarized behavior of single performers. Behind every single player in economy, there stands authentic complex environment that forms his/her decisions and performance. Maybe,

Figure 1 Spontaneously evolving advanced story in human/software environment

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in every respect naturally, one can close up that major part of that environment creates by nominal subject appropriate part of the upper declared broad economic consciousness. However, that acquiring endosomatic knowledge from such broad offer is not simple process and much more difficult is its using in decision and real acts. That is the reason that the evolution of collective economic intelligence is such painful process.

When we imaging about general economic knowledge in contemporary society it have to get into account the unprecedented innovative impact of ICT, product and services of AI, CI and broad offer of specialized software including new web product and services. That is, at present we can differentiate among such entities: - stock of codified economic knowledge printed on conventional media (exosomatic knowledge), - individual endosomatic knowledge of single person and/or group of person in suddenly evaporating form and in highest level - network of endosomatic knowledge imprinted into live software entity with coworking virtual subjects that is in electronic form. In this sense, the petrified exosomatic knowledge is only potential economic force. Only if such knowledge fully adopts somebody for him/her it becoming of real forces to command and control the economic processes in his/her bounded environment. Collective economic intelligence, that is shared intelligence of whole members based on physically (by electronic means assisted and realized) based social networks that is on virtual intelligent devices in Internet only can serve to increasing the competitive ability of nominal group, community and/or national society in contemporary complex and turbulent world.

3 The family of introductory mental models in economics: role in new imagination

Despite of predominated inadequacies of contemporary economic reasoning declared in upper part of essay, that we are staying in the following platform. For understanding complex economic processes in contemporary global knowledge based society, it is as a first step, indispensable masterfully handling with a wide family of primordial models belonging to the class of economic science, at least to the branch of General Economics. That namely serves as alphabet ground for simple economic imagination. The second important step in the context of the purpose of this essay is, however, the higher-level skill in dealing with formal mathematical methods and tools. In addition, the third step as most important prerequisite for successful solving complex problems and percolating to the deepest roots of contemporary economic puzzles is the competence and high-level skill for self-evident use of advanced devices, tools, approaches, routines and methods from the area of IC-born products. That is, having the skill to command with them for gaining ability to create virtual metaphors upon conventional mental models and theories. These three steps are obligatory forward ordering process. It is necessary to start compulsory from the subjugation of the whole contain of the family of primordial mental models of General Economics. In the area of General Economics, there are collections of typical mental models in two divisions: i.e. the area of verbal and/or conventional of Microeconomic and of Macroeconomic mental models. Only as some examples, we bring small group of such mental models and a little more complex ones:

1. Relation between and among psychologically different, socio-economic groups:
   - Competition
   - Conflicts in different settings of aggression
   - Symbiosis
   - Cooperation and Collaboration
   - Commensalisms
   - Parasitism (Racketeering) and Parasitoizms (Tunneling, Asset stripping), and other black and/or shadow economic activities and so on
   - Dynamic (cobweb) game between producers and consumers in different type of markets

2. Further noticeable socio-economic topics constructed as mental models (used in textbooks, and/or in/of wider purposes):
   - Trade-Off possibility frontiers
   - Opportunity cost
   - Monopoly, Duopoly and Oligopoly
   - Cyclical economic and social growth
- Competitive scarcity
- Inconsistencies in resource depletion
- Renewable resources

3. Miscellaneous problems
- Preferences (social, economic and others)
- Conflicts between religion groups, communities
- Conflicts between ethnics, races, and so on

4. Evolution (that is development with emergent qualitative changes) of socioeconomic network

The higher stage is the advanced mental models coming near to complexities and turbulences of contemporary national, integrative and naturally to global economic processes too. However, our enthusiasm in that respect is not as high in this essay.

4 Possible Example of Using Primitive Model of Abstract Competitive Market

Let us exhibit as a simple example the single (free-competitive) market with one homogenous good. In long time in textbooks, that case is set free in the form of cobweb model or theorem introduced by Mordecai Ezekiel before World War II [12]. May be that is the simplest occurrence suitable for realization as softbot. Even it can be easily realized in Excel. Widespread spontaneous thoughts (fabula) on happenings in such market are that a recorded real market price is an independent signal for both populations of actors, i.e. for suppliers (producers) so as for demanders (consumers). If the price level is increasing, from the point of view of suppliers, it is a signal to bring more goods on the market and for demanders the opposite behavior is right, i.e. the customers are buying less. It is vice versa if the price is diminishing. On those verbal propositions, demand and supply functions of the price of the good works with the consideration that price adjustment equation depends on the price observed in the former period (or former step of iteration) and on the difference between demand and supply. The formalism is as follows

\[ D_t = a - bp_t \]

\[ S_t = -c + dp_{t-1} \]

\[ D_t - S_t = 0 \]

(1)

where the third equation is the requirement of the so called market clearing, which is the result of which is synonymy of market equilibrium. After substituting the first and second equations to third and considering \( D - S \neq 0 \) we can receive the difference equation for evolving price

\[ p_{t+1} = p_t + (a - bp_t) - c (-c + dp_t) = a + c + (1 - b - d) p_t. \]

(2)

Equation (2) is implicitly performative and as such it is after setting it to algorithm (and/or routine) of virtual laboratory too, in this case we built it in Excel. Equation (2) turns into an explicit performative only after pushing the button of softbot “Run”. Therefore, in this sense the economic softbot as explicit performative is a functional constructive entirety of association of difference equation (2) transformed into appropriate routine and activated by pushing the button “Run”. For more obvious understanding of the behavior in the market described by (2) it is familiar with the majority of other disciplines of science to plot a graph. Naturally, the softbot intellectual outcome is simply execution of computation and plotting the graph, but it can do it more quickly and accomplishedly than any skilful man can. From snapshots in fig. 2 – 3 it can be also intuitively clear that with linear graph of Demand and Supply functions there can be only three quality of motion, that are attraction to \( E^* \), stable jumping up-down/down-up cycle of price (wage) rate . However, if one of the graphs is not line the result of motion is dramatically changes. The snapshots on fig.

Figure 2 Mutual position and slopes of two pair of curves is leading to \( E^* \) from every level of Price P or diverging

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4 – 6 are resulting by using so called *backward bending supply curve* of labour forces. In fig. 4 price is jumping in two cycle’s mode. The curvature of bow arc (supply curve) and chord (demand line) positions and slopes principally affect the resulting movement. After changing them deterministic chaos is emerging as seen in snapshot of fig. 5.

![Figure 3](image1.png) **Figure 3** Mutual position and slopes of demand and supply line produce very slow motion to Equilibrium

![Figure 4](image2.png) **Figure 4** Succession (adaptation) of price to double cycle

![Figure 5](image3.png) **Figure 5** Emerging some type of deterministic chaos
Some better possibilities for creation economic softbots that is available in Excel the author found in the software STELLA. In snapshot of fig. 7 the reader can see results of simulation experiments with softbot mimic of S-shaped supply curve of labour forces in competitive market. There are two chaotic regimes, one of them in upper branch of “S” curve and the other one on bottom part. We can see that the market is extremely sensitive to the level of initial wage rate but much more sensitive act in response to the changes of parameter values that is exactly said, to the changes of positions and slopes of supply curve and demand line. Therefore, it is evident that very simple yet softbots demonstrated here can fulfill narration function in understanding phenomena that are more complex better than in conventional form neither that in verbal declamation.

The visualization of formalized mental model by softbots luckily has further impact and merits, bringing several arrangements, such as, for example, revealing former inconsistencies and mistakes in reasoning. In the upper examples, there are several such inconsistencies and mistakes even though the chosen mental models are seemingly very simple. In addition, thank to assistance of softbots much more mistakes become reveal because of living experimentation with that mental model after putting them to more advanced virtual laboratory. It is right that some of misleading connected with such approaches as upper used cobweb theorem of competitive market is obvious also if it is the result intuitive observation. Among such belongs the lack of meaningful origin of the history of evolving to equilibrium, i.e. the lack of singular point and together with this the lack of trajectory from past to present time, too. From mathematical point of view, this problem is not very heavy, because in some actual case may be evident, that may be present continuous sets of starting points for price independent from Supply and Demand quantities (the set is a straight line identical with positive part of price axis in the first quadrant of Cartesian coordinate system, i.e. with ordinate). From every point of the continuous set in question, there can start an authentic trajectory; consequently, we have again a continuous set not points but trajectories, in agreement with formulae (2).
In mathematics, such work belongs to the branch of topology, i.e. we are dealing with topological map [1], [2 – 8], and [23]. Nevertheless, from the point of view of economics as science, the situation described brings nil knowledge or any answers to the question: “Why does it behave in such modes?”, but in the MSE there is a prevailing belief that the answer rests in bringing meaningful knowledge. Actually, from the abstract viewpoint, there can be several answers, and they depend on the above-described economic presumptions. Because the nature of first and second rows of formulae (1) both graphs has straight-line form. In addition they has mutually opposite slopes (parameters $b$, and $d$) and they are located one to the other in relations of parameters $a$, and $c$. The possible abstract behaviour is trivial, i.e. there may be only three behaviour modes, (two modes of them, it is of attracting and repelling, like exhibits the snapshot of fig. 2, and the third, that is the periodic cycle is in fig. 3): 1. Convergence to fixed, i.e. equilibrium point $E^*$ ($E$ has an attractive character). 2. Divergence from fixed point and/or from any other chosen starting point of continuous rectangular $p \times q$ amounts of $D$ and $S$ goods (the character of those points is repelling). 3. The last case is (period two) cyclical behaviour with one minimum and one maximum of price and of amount. Unfortunately, the behaviour on the economically relevant market is not such trivial. On the other hand, these inadequacies do not mean that any dealing with such trivial cases is the loss of time. Just reversal, the mistakes and inadequacies of trivial cases calling sequences of looking after better approaches and methods. Actually, the construction of, even though simple softbots and dancing with them are among such approaches that are capable of going ahead in solving difficult problems in the way of repairing primitive mental models. On the state of snapshot from Excel construction on fig. 2, one can conclude even on intuitive looking at Supply and Demand lines that the level of starting price has an impact only on the longitude of cobweb trajectory. Line shapes of graphs, their slopes and their mutual positions assign the (three possible mode) qualities of evolution. From this, it is only a step to a discovery that the decisive factors conjoined with qualitatively divers of market behaviour are economic-subjective nuances staying behind the actual shape, slope and positioning of graphs. The conclusion is that the mental model of competitive market in the described form is wholly unrealistic and has to upgrade. The effective way to improving that mental model is a construction of a virtual laboratory with changed graphs, for example, using the so called backward bending or better yet using “S” shaped supply curve, exhibited in snapshots of fig. 4 – 7. Paradoxically, the situation also in a seemingly simple market is so complex that imaging the behaviour by continuous curves is not concise. Although the conventional print to paper, do not allow continual observation such processes, which is possible only in direct experimentation in virtual laboratory, it is no doubt that “reading”, though merely the simple particular snapshot is sometimes more effective for deep understanding than classical reading of verbal texts with hand-drawn pictures [2 – 8], [9 – 10], [23]. Luckily, the above is only trivial illustration of possibilities of dancing with softbots for introductory familiarization, because there are several emergently effective software devices for such dancing with advanced creatures [1], [22–24], and [28], [22].
5 The Economic Mental Models Built in Softbots

There are several suitable software enabling realization of various, more or less complex economic softbot in our time. However, in Internet everyone can find several ready to use applets. Those we can regard as the class of the simplest softbots, snapshots in fig. 8. They are

![Figure 8 A cobweb plotting Applet of Logistic map from Wikipedia (left); the same from: http://math.la.asu.edu (right)](image)

in general very useful but from our point of view their main drawback is the impossibility for reconstruction by user, he/her can only realise experiment by variation of values of parameters or coordinates of chosen origin loci. In contrast to such simple devices for advance imagination and deeper economic reasoning, we need software allowing users independently from any programmer to construct own softbot and/or virtual laboratories. Such procedure free of programmer assistance allows for example Simulink in Matlab, STELLA\(^1\) [28], Vensim, iDMC [22 – 23], and SWARM [24] and other software too. On the other hand, for achieving advanced stories and for dancing with more sophisticate softbot [1], [2], and [8] notably myslit for a wider use in economic community, the assistance of scholars from the community of branch of computational intelligence and/or skilful programmers are indispensible. The same is valid for creation of complex virtual stories (self-creative stories).

In running simple communication between simple subjects (top layer of scheme in fig. 1) the story spontaneously moves on governed by asking questions with human subjects. This story automatically saved in the memory of human subject and the other story, i.e. digitalized topological map, by human subject settings of starting point’s coordinates, chosen values of parameter and simulation runs saved in the software. That top layer can perceived as based on phenomenological approach, i.e. by another subject predisposed built “top-down” research and/or learning system (CI “subject”) serve as assistant of investigating subject. In this case, the human subject (prevailingly a student) is only in the role of user non-intervening into mental model, map and architecture of virtual “subject” (vir-

\(^1\) The author published in these journal essays where he demonstrates among other the possibilities of using software STELLA for purposes in economics.

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tual “triad”), i.e. he/she gives instructions for an experiment and is waiting for answers and working with

**Figure 9 The heading page of ACE website**

those in his/her own mind. There can, however, arise a situation that authentic subject (he/she may be student too, but mainly is a researcher) is not satisfied with achieved information and decides to make some improvement of the “triad”. After such a step, the second (middle) layer is coming into action. In this situation, the human subject is not only in the role of a person who asks questions, but he/her becoming a creator and constructor of the “triad” too. Based on these improvements he/she can create more suitable environment for problems investigated and naturally, the story is richer, but still spontaneous. In new birth possibilities, because of the human subject activation, there arises also a platform not only for writing down a verbal story, but for building a story on technologies used for improving the “triad”. We are introducing one of possible primitive forms of such passing from the top to middle layer by means of two types of perplexing the “linear” market by introducing the nonmonotonic supply function. In the first case, we are dealing with another than before used “S” shaped supply curve based on squared and cubed price and in the second case, we base the supply on the arctan function of price with weighing the impact of price expectation on process of adjusting supplied amount of goods to market. For this purpose, we used price function for nonmonotonic supply and linear demand but in struggle to save area leaving out mathematical formulas of the model. The exhibitions of result of the first case of qualitative experiments are in the snapshots of fig. 11 – fig. 13. Concerning the other type of non monotonous supply, the possibility for approaching more complex form of market mental model is the consideration lying on the S-shaped supply curve (relation between quantities of good and the levels of price) not created by the help of cubed price but by arctan trigonometric function.

**Figure 10 Search realised on the Internet front page of ISEE Systems**

![Search Results](image)

**Figure 11 Visualizing chaos (left) by connecting of dots on diagonal and on curve (cobweb graph made in Excel); Bifurcation portrait (right) with chosen bifurcation value of w generating cycle with eight periodic points**

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2 It must note that he/her is still only economist not pretending on the role of (not act as if) PC programmer.
Because of a famous special shape of arctan function graph (it enables sigmoid learning), the (two-key) economic considerations (EC) are easy (naturally follow from the shape of graph) for subsequent formulations. First EC: If price levels are low then supply increases slowly, because of start-up costs and fixed production costs. Second EC: If price levels are high then supply increases slowly, because of supply and capacity constraints. These two EC lead to strong bounding of possible extreme behaviour in comparison with using cubed price. Based on these considerations it is possible to create a second kind of a non-linear, increasing supply curve. By choosing the inflection-point of the supply curve to be the new origin is one of possibilities of simplifying the imagination. In such a way the coordinates change and the graph splits to upper (signed plus) and bottom (signed minus) parts. In left snapshot of fig. 11, there is a section of the supply curve against diagonal and the cobweb. The shape of the curve causes deterministic chaos. The right snapshot exposes the series of bifurcations causing different qualitative events, after increasing the value of weight parameter $w$, i.e. period doubling bifurcations, deterministic chaos, odd periods and their folds. We choose the value $w = 0.2045$ only for the demonstration of eight period event. It was also used for the exhibition of transient to succession in cobweb graph (left) and time step trajectory (right) snapshots of fig. 12. By these results of experiments, we showed that some simple mental model could investigate also by means of Excel, i.e. by a device popular among economists. Nevertheless, such job is too complicated and the construction of such triad takes a great part of memory even in the simplest cases. For it is more favourable to use better devices for such jobs. We are successfully using iDMC, which is, in subjected cases very friendly to a constructor and economical to PC [22 – 23].

In snapshot of fig. 13 we combine the bifurcation portrait (upper snapshot) with the graph of Lyapunov exponents (bottom) for a clear presentation of coincidence of bifurcation values with Lyapunov coefficients lying on zero level. The third (bottom) layer of the scheme in fig. 1 is an entirely different case. There are two decisive innovations against two upper levels. The first is the change of method creating mental models and the second is the construction of computational environment. In the first innovation, the top-down method changes its form from bottom upwards, i.e. in this approach the mental model not created by the mental reconstruction of objective reality with using of former perceptions and empirical net
data, but there is left room for autonomous self-creation. For these purposes, there used among other such methods as MAS, ANN, also cellular automaton, percolation theory, classification theory, genetic and evolutionary algorithms and similar methods and approaches. In the second innovation they used for the construction of virtual subject methods and tools of “computational life” and “computational intelligence” in *sensu stricto*. As for the potential content of advanced softbots, we can focus our attention on the products of community of socio-economics scholars working in the area of Multi-Agent-Based Simulation organizing workshops under label MABS\(^3\), [9 – 10], [14], [16], [26], [28]. Other very interesting direction producing topics appropriate for the imputation to the advanced softbot bodies is the community of scholars collaborating under the title Artificial Economics. Similar and very successful ensemble cooperates with L. Tesfatsion. That community is facing the problems of Agent-Based Computational Economics (ACE) [1]. Special economic entities may create using means of theory, approaches, methods and tools of ANN. In economic and financial modelling based on ANN, the seminal work in this area was the publication of Beltratti, Margarita and Terna [31]. There is a wide collection of models in scientific literature and pragmatic too, usable after a suitable adjustment as contents blocks to building bodies of variable economic softbots. Therefore, in such a way there are opening entries to very heterogeneous softbot population occupied with comparable simple to highly advanced computational creatures. That circumstance is very beneficial for heterogeneous users ranging from students to researchers, teachers and economists in real practice too, for talking/dancing. Obviously, the students have the greatest utility from talking with softbot population, because they can penetrate into deep tangled coves of complex economic entities by this nonconventional method. The mutual conversation between researchers and softbots forced by a two-sided improvement of the mental model of research subject is going ahead not only in the quality of knowing complex economic phenomena but also in involving their new brainwaves.

**Talking with Softbot alone and with Structured Computational Story**

The new technologies of learning and investigation of complex economic phenomena assisted by ICT, applied informatics, computational intelligence and cognitive science bring at least three levels of conducting a dialogue with softbots as we showed in scheme of fig. 1. From another viewpoint, it ought to emphasize that such process in all cases begins with endosomatic investigation and/or learning by authentic subject. Only after mastering all the knowledge and skill potentials of such device, there arise possibilities for the some form of codification of achieved knowledge. It is clear that without the codification (exosomatization) of newly achieved (endosomatic) knowledge their required intersubjectivity cannot effectively reach. On the other hand, it is interesting that a great cohort of independent discussants with similar or same computational entity reach a higher level of intersubjectivity than the group of readers of some textbook or monograph.

Reaching a similar level of intersubjectivity and equal understanding among book readers as in the above-mentioned cohort requires a wide mutual face-to-face and collective discussions after reading. Upon that experience, it is clear that discourse with not a bit accomplished computational story device is more than listening to or reading a conventional storytelling. Fortunately, the above mentioned devices, methods and tools also offer new technologies and methods for the creation of deep structured computational stories built-in with not only conventional verbal stories, pictures, graphs, and tables and so on, but populating them with a variety of softbot communities\(^4\). In this sense, the talking with a virtual discussant can have several levels from very simple talking (in the form of asking questions) with single softbots at the bottom level, to exceedingly advanced one with a deeply structured computational story at the top level which we intituled somewhat allegorically dancing. At preliminary level of being contiguous with computational entities are prevailing the form of passive observation of

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3 The proceedings of first workshop published in 1998 [9].

4 Of course, the creation of a structured computational story in economics is not an isolated job only for economic scholar. Such job is need for an integrative collaboration between an economist and software engineers at least.
events provoked by pushing the desired buttons localised on the main command board (interface) of computational story or at least of particular applet. Admittedly, this activity is not the same as observation by listing in a textbook and/or in a scientific monograph. The important difference against print on essay consists in the possibility to contemplate evolution of the experiment running in PC with adjustable singular point, values of parameters, time and speed by buttons, sliders, tables, “rhéostats” and/or “potentiometers”. However, saying it more exactly, the observer can use the whole scale of routines built in computational entity. In this context, it is interesting that in past years there have been emerging on the Internet several computational stories that are appropriate for social sciences and economics. Only for the creation of clear imagination about the matter, we focuses the reader attention include a few simple and semi-advanced stories made in software STELA by Pontifex Consulting. However, if he/she changes his/her activity from the passive observer and enters the process of modification of softbot, or moreover tries to build a new one for one’s own purpose, the situation is going to change dramatically. Such activity becomes more constructive and/or more creative because the subject has to look for anonymous or hidden approaches, methods and tools. The benefit from this is a higher form of verifying achieved investigation results because the subject is push to this activity by curiosity and pull to the process by the desire to achieve effectively functioning device. This desire is directing the subject to reflecting and creative activity in the form of building entities from the bottom upwards (third level of the diagram, Fig. 1). In order to create such a very advanced story, it is necessary to use special requirements and routines in creating relevant softbot and, maybe in the future appropriate myslit. In such case, as a rule, there has to be used another methodological approach than phenomenological. Mostly, the constructor in this case uses a building approach from bottom upwards, or quite implicitly, he/she uses multi-agent approach with specific aspirations. However, the constructive approach and/or doing something constructively has, at least may have, a deeper sense. Implementing the process of mental model creation, its transformation into topological or into another mathematical construct, moreover the construction of the creature capable of functioning in appropriate software can be perceived as some kind of learning-by-doing but not in manual work sense. The creature, of course is made by hands, but is clearly an intellectual process running not only in vigilance but also in deeper layers of mind (in brain structure is not under direct control of subject). As an example of such process, we refer to the case of spontaneous scrabbling by oneself subject of an essay in the process of intensive reasoning. However, the building the block and principal block diagram, the programming and so on is another “scrabbling”. Among other important requirement is, so called Principle of Minimum Prejudices. A little simpler saying – if the purpose of using bottom-to-up modelling and suitable multi-agent simulation in economics is accomplishment wholly, at least partially, independent authentic evolutionary story, it is need to carefully considering what and how much existing knowledge to implement and what commands and routines to embed.

7 Discussions

No secret is that the topics of knowledge creation in contemporary creative and knowledge society is very problematic, full of misunderstanding and difficult area of research.

It is important to take into account the differences between virtual world emerging in individual consciousness and other one mastering by man out of authentic mind. Logically those ones are both parallel to objective world but every in different form. The so called “evolutionary mastering” of human mind (bricolage, tinkering) going on in objective reality for thousands years is fortified by adding to former one rapid bricolage assisted by softbots and myslits in electronic virtual reality in our days. This someone has to understand in such form that new meme need not come through very long distressful way of phylogeny. The advances in ICT, CI and in cognitive sciences allow constructing and/or “creating” artificial world for dual experiments to objective ones. In artificial world constructed by method from bottom to up using so called minimum principle of embedding in prejudices of creator may spontaneously emerging entities living in that virtual environment. Such experimentalizations can help in slipping out of diverse myths, misbeliefs, fata morgana, dogma, mirages, etc. surviving in hu-

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man consciousness, in sciences as a whole, and in economics obviously too\textsuperscript{5}. This products and assistance of ICT, CI and cognitive sciences union is very important potency of advanced economic reasoning in runaway evolving contemporary world. If economics has to be the self-same science it must strive for experimentation because only experimentation makes possible falsification of theory. For the reason that economics has bounded opportunities for experimentation in objective reality, moreover experimentation in economy at large is impossible at all. In that inappropriate situation the sole way is “experimentation” with economic models and or theories after their formalization to mathematical entities in mind of authentic economist, or further advancing that method by using products and services of ICT and CI, what we regards as promising opportunity for more plausible falsification of economic theories. By famous molecular chemist, biologist and philosopher L. Kováč, “Aristotle’s barrier is a boundary in human species-specific reality separating the space that can be captured by sheer contemplation and reasoning from an additional space that can only be reached by experimental falsification of hypotheses. The reality circumscribed by Aristotle’s barrier is simple and easy to human comprehension, often familiar if not self-evident. It is also related to the Lebenswelt, the natural world or life world, of phenomenology [20] (see also Kováč, 1992)”.

**Conclusion**

At present, it is clear that the unprecedented technological revolution happens and new products and services are taking place in common life as we enter to the era of ICT and global knowledge age. It is a revolution of crucial importance in that it involves technologies for knowledge and information production and dissemination via the variety networks of excellence and virtual agents (softbots and mysllits) setting to Internet. These new technologies and outstandingly the product and services of CI in coworking with scholars in branches of cognitive sciences and using their result and services have breath-taking potential also for cultivation ideas and imaginations in the field of collective economic consciousness. They enable remote access to information and offer wholly new means of acquiring knowledge. In addition to transmitting written texts and other items to be digitalized, they also allow users to access and work upon knowledge systems, among other with such devices like apples and virtual laboratories from a distance (e.g. distant experimentation), to take new economic knowledge. Among others these new tools allows creating excellence environments for distance-learning courses. As examples, such realised within the framework of interactive relations among teachers and students (Tele-Bridge education). Other forms have unbelievable quantities of information – a sort of universal library – available on their desktops, and so on. The ICT, AI and CI enhance creative interaction not only among scholars, scientists and students but, similarly, among product designers, suppliers and the end customers. The creation of virtual objects such as softbots and mysllits that can be farther modified in large dimension and are instantly accessible to everyone, namely softbots specialized for economists serves to facilitate collective work and learning and as a result may increases the level of collective economic consciousness. In that respect, the new possibilities that computers have opened up for qualitative understanding of complex economic processes via numerical simulation represent extraordinary significant departure from prior experiences and from conventional economic knowledge. Higher level of collective economic intelligence and wisdom emerging when people are using more intensively knowledge-based activities, supported by ICT, AI, IC and using specialised software, interacting for achieving knowledge suitable for understanding changes reality in global knowledge based society. As expected, such activities involve several aspects. Among them play important role three subsequent elements: 1. the significant number of collective members via coworking via not only coworking not only with ourselves but using assistance of softbot creating new economic knowledge (diffuse sources of innovation); 2. the community creates a “public” space for exchanging and circulating the knowledge in hybrid networks; 3. The new ICT are intensively used to codify and transmit the new knowledge.

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\textsuperscript{5} It is evident fact that not only conventional science but contemporary one too is contaminated by not clear outcomes and maybe myths – clearly social sciences, inclusive economics, more than natural and technical sciences.
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