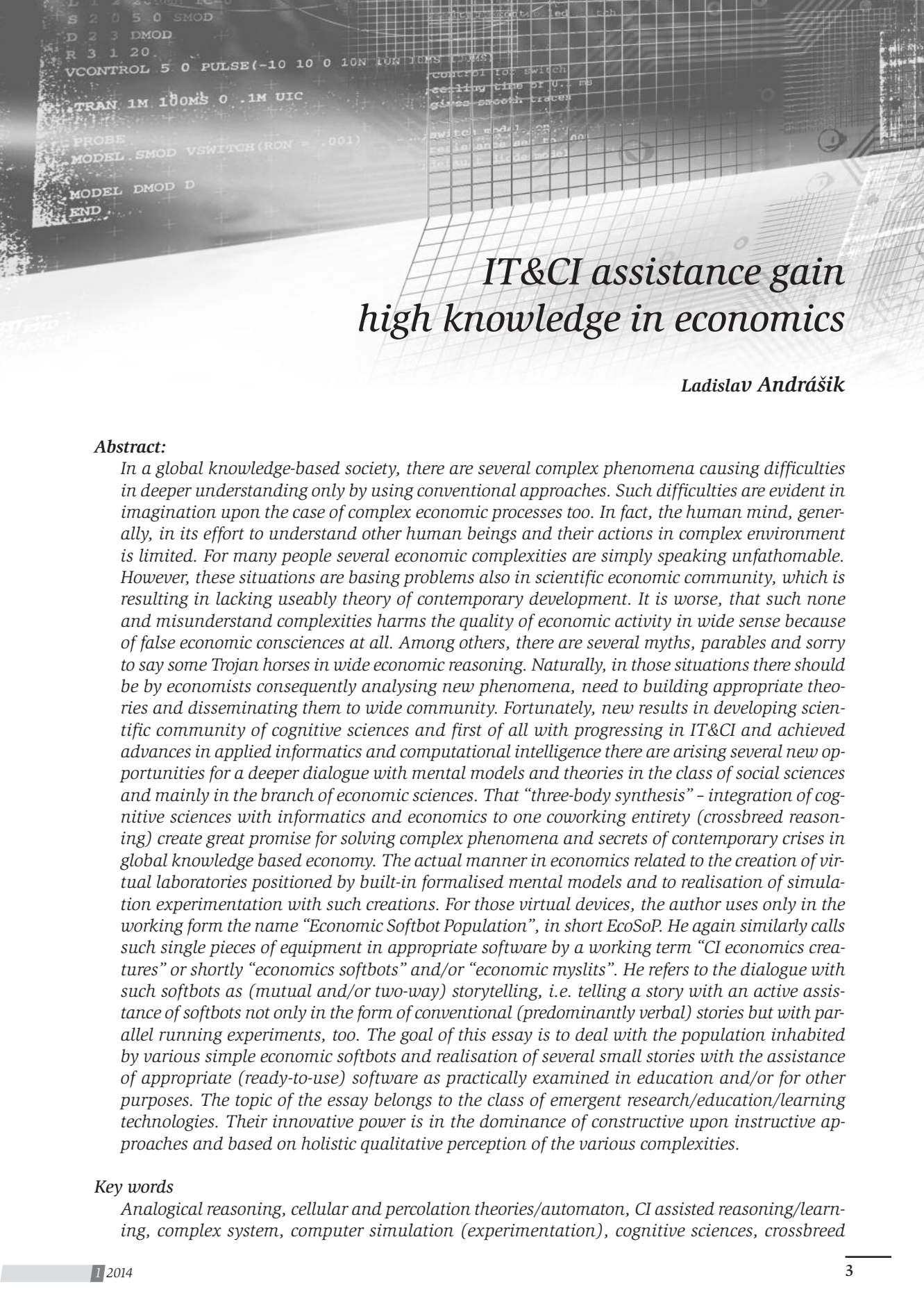




IT&CI assistance gain high knowledge in economics

Ladislav Andrášik

Abstract:

In a global knowledge-based society, there are several complex phenomena causing difficulties in deeper understanding only by using conventional approaches. Such difficulties are evident in imagination upon the case of complex economic processes too. In fact, the human mind, generally, in its effort to understand other human beings and their actions in complex environment is limited. For many people several economic complexities are simply speaking unfathomable. However, these situations are basing problems also in scientific economic community, which is resulting in lacking useably theory of contemporary development. It is worse, that such none and misunderstand complexities harms the quality of economic activity in wide sense because of false economic consciences at all. Among others, there are several myths, parables and sorry to say some Trojan horses in wide economic reasoning. Naturally, in those situations there should be by economists consequently analysing new phenomena, need to building appropriate theories and disseminating them to wide community. Fortunately, new results in developing scientific community of cognitive sciences and first of all with progressing in IT&CI and achieved advances in applied informatics and computational intelligence there are arising several new opportunities for a deeper dialogue with mental models and theories in the class of social sciences and mainly in the branch of economic sciences. That “three-body synthesis” – integration of cognitive sciences with informatics and economics to one coworking entirety (crossbreed reasoning) create great promise for solving complex phenomena and secrets of contemporary crises in global knowledge based economy. The actual manner in economics related to the creation of virtual laboratories positioned by built-in formalised mental models and to realisation of simulation experimentation with such creations. For those virtual devices, the author uses only in the working form the name “Economic Softbot Population”, in short EcoSoP. He again similarly calls such single pieces of equipment in appropriate software by a working term “CI economics creatures” or shortly “economics softbots” and/or “economic myslits”. He refers to the dialogue with such softbots as (mutual and/or two-way) storytelling, i.e. telling a story with an active assistance of softbots not only in the form of conventional (predominantly verbal) stories but with parallel running experiments, too. The goal of this essay is to deal with the population inhabited by various simple economic softbots and realisation of several small stories with the assistance of appropriate (ready-to-use) software as practically examined in education and/or for other purposes. The topic of the essay belongs to the class of emergent research/education/learning technologies. Their innovative power is in the dominance of constructive upon instructive approaches and based on holistic qualitative perception of the various complexities.

Key words

Analogical reasoning, cellular and percolation theories/automaton, CI assisted reasoning/learning, complex system, computer simulation (experimentation), cognitive sciences, crossbreed

knowledge processing, direct/circumlocutory connections/interactions, emergency, genetic algorithm, hybrid (human-softbot) networks, MAS, meta-analysis, myslits, neural networks, softbots, stigmergy, syntropy, three-body synthesis

ACM Computing Classification System

F.2, F.4.1, G.1.2, G.1.5, I.2, I.3.5, J.1, J.4, J.6, K.6

► Introduction

In a global knowledge-based society, there are coming up several complex phenomena and stories causing various difficulties in deeper understanding only by conventional approaches. Such difficulties are evident in the case of complex economic processes. Because of global knowledge-based economy is in permanent evolution in the form of double directed adaptation going temporarily to emerging qualitative successions the former stage of economic knowledge becoming obsolete. That obsolescence is not the result only of knowledge entropy but maybe dominantly is of some outstanding debt of economic research and common economic reasoning. In other word, economics has lost its ability to understand evolving objective reality which exposing existing knowledge to, as it were, secondary entropy. However, for “normal” economic life it is indispensable not entropic economics and common economic reasoning one, but is need to introduce syntropic¹⁾ economic science. This advanced form of economics has capability to inhibit entropy and allows coming excitants in the form of new knowledge into economic community. Those inhibitions – exhibitions process in economic reasoning robustly support the assistance of softbots and myslits. However, in common situations there are the needs for syntropic economic knowledge as the core of collective economic intelligence. That not only with explication of term economic science and/or economics there are problems with its vagueness, similar difficulties exists with term economic knowledge. Actually, the contemporary reality show the so called “main stream economics” is strongly entropic system of thinking. We are focusing attention to those problems in Part one of this essay. Fortunately, owing to the progress in IT, achieved advances in applied informatics and computational intelligence, and in cognitive sciences there arise several new opportunities for building virtual laboratories and by their assistance realise deeper dialogue with mental models and theories in the class of social sciences and mainly in the branch of economic sciences. Further strengthening of the quality and efficiency of investigation and learning process may promoted the neat using advanced result reached in the branches of cognitive sciences. However, achieving such deep level understanding by means those emergent technologies is not an easy task. There is necessitating serious and long-time preparatory activities in those integral scientific environments for achieving appropriate skills enabling to investigate and study such an advanced mode. In this relation, the economists and students of economics are again in a fortunate position thanks to the results achieved by scholars and software engineers working in the area of applied Computational Intelligence (CI). It has to note that from the point of view of economists and students of economics all such products one may generally perceived as software that is without commitment to differentiate among variety of CI products from the point of view of CI profession. Unfortunately, with these differences there may arise some misunderstandings between those two communities in general but more in the appropriate use of terms. Therefore, we pay some attention to clear up the matter of differences. Actually, the economists are staying in more simple, not a very exact platform, when they explaining particular new terms, in comparison with the platform using Applied Informatics (AI) and CI, than legitimate specialists of informatics regarded in more narrow sense. Naturally, the users in economic research and education tend to use more pragmatic and utilitarian approaches without analyzing a special character of those devices, methods and tools. We

1) We generally prefer the term *syntropy* against *negentropy* not only in our present essay. The last is naturally belongs to *physics* and *chemistry*, for social sciences is more appropriate the former one.

are partly in consensus with those approaches and handling with terms as softbot²⁾, CI products, and software more freely, that is as with devices directly serving results in investigation/learning. Accordingly, we have in mind typically something such as partially software-like assistant in research, education and individual learning in this essay. In another word, that *virtual assistant* is working under suitable computer software. In this sense, the term softbot we use to describe certain software or routine device able to realize some simple intelligence-required tasks better or faster than learning subject does. On the other hand, the creation named myslit is able realising more exacting intellectual tasks because of its self-creative potency to find convenient approach for solving. To tell that in common language, the softbots are able solving tasks based on before prepared routines³⁾. However, the myslit above that may self-create simple routines in the process of solving the task. The important constituent of economic softbot/myslit is its ability to create/produce virtual stories not only in a classical and/or conventional mode of storytelling but also as it contains several enriched parts in the form of running qualitative/quantitative and/or econometric experiments. We are focusing attentions for example to using product and serves existing in so-called ACE [1] (Agent-Based Computational Economics) and AE [28],[29],[36] (Artificial Economics) area. The more important character of those potentials is various possibilities for communication with the entirety of softbots population and/or with carefully chosen partial compilation of suitable softbots. The attribute “economic” in front of the word “softbot” may have a very rich content from the point of view of nominally chosen mental model. That comprehensive problem of economic mental models in the role of filling charge of softbots is the theme of Part two of this paper. In Part three, we show simple built economic softbots and in Part four, we are discussing problems connected with building and using computational stories for “ad hoc” talking between two different subjects, i.e. between human individual and computational creature.

1 *Economic Knowledge: The Entirety of Exosomatic Petrified Stocks and the Living Network of Endosomatic Intellectual Entities*

What is wrong with Economics notably in “Main stream” and why? Is that the question?

The community of economists are facing increasingly sharp attacks counter Economics and notably towards the so-called *Mainstream Economics* at present times. These phenomena are particularly understandable at least for two serious reasons: first, that is the unremitting tendencies to chaos and/or crises in national economies and global economy too; the second but parallel is the progressing global knowledge-based society with the world economy. Despite this hesitating consensus, it has clearly asserted that in general, those attacks directed against are not clearly defined subject. Actually, the target of attacks is at least two-legged object: the first is really the area of concrete state of economic reasoning and in more narrow sense the Economics, but the second is its derivative product, that is economic politics, the authentic political decisions, and its realisation in objective economy. The majority of motive of attacks laid in second mention objects. However, that not mean none ground for innocence of Economic and wide economic consciousness. Despite of mentioned two-legged character of the object of attacks we are focusing our attention exclusively only on economic consciousness, theories, mental models and Economics as branch of science. The economic policy and its results are verily itself catastrophe but our concern not going in that direction. Consequently, our endeavour is oriented to the field of economic imag-

2) The term “softbot” and/or “myslit” too, in these cases have the power implicitly to perform certain action. On the other hand, the term softbot, as semi-explicit performative is some agent not only able to perform certain actions but directly fulfils them, so it is in the half way between implicit to explicit performativity.

3) From the point of view of method of building and/or of architecture, the softbot as simple creature may be mastering from up to down, but in myslit creation process have to using methods from bottom to up, for example by the assistance of method and tools from area of MAS (Multi Agent System), ANN [11] (Artificial Neural Networks), etc.

ination/reasoning, economic mental models, theories, or Economics as codified knowledge and to economic reasoning as a whole shared in society.

Concerns about part of general attack directed on economics the misunderstanding have multi component character. The major reason of wrong interpretation is rest in the confusion of *positive* and *normative* functions of Economics and in imputing sins of politicians and of economic policy makers instead of them to Economics. In such confound sense; the Economics is obliged to take on, as it was executive responsibility for happenings in real economic life. However actually, Economics is responsible, in fulfilling its positive function, for the quality of economic reasoning. In its second function, i.e. fulfilling its normative function Economics may (is not directly responsible) serve, not obligatory, as theoretical foundations for economic policy. On the other hand, even in those associations Economics is not without blame and in other cases certainly, too. Economics as a whole or namely the Mainstream dominantly uses simplified *constructive approaches* to create mental models upon parts of objective economic reality on the basis of a few or in better cases on a wider group of observed facts but with the great inputs of subjective ideas imaginations (first line creators).

The worse thing is that the economists in the second line (narrators or verbal storytellers, teachers, etc.) achieve these defectively idealized results predominantly by instructive methods. In other cases, such mental models and/or their population (ideology, theory) often submitted as the “dinkum oil” for direct accrediting by recipients. Continuation of awful activities of different self-invited economists is malformation impact on wide economic consciousness of society via misunderstand economic theories. In these connections, it is very unhappy thing that economic science up to our time yet not has unit character. Nobody knows what the very object of economic science is. Actually, in the class of socio-economic sciences there is very narrow space for the verification in live objective reality. Some of it is possible only ex post. Nevertheless, this limitation is not establishing title to resign commitment of validation. One way is “validation” by “experimentation” in owns mind of recipient subjects and the other, more developed and helpful, is special examination by softbot assistants in virtual laboratories.

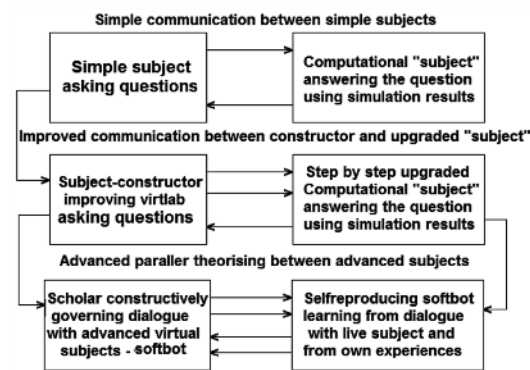


Fig. 1 Spontaneously evolving advanced story in human/software environment

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 everyday 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 thirties 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* [30] by asserting that, “Economics is the science which studies human behaviour as a rela-

tionship 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 behaviour of single performers. Behind every single player in economy, there stands authentic complex environment that forms his/her decisions and performance. Maybe, 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 are imaging about general economic knowledge in contemporary society it have to get into account the unprecedented innovative impact of IT, 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 realised) 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.

2 The Family of Introductory Mental Models in Economics and their Role in Advanced 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 are taking a small group of such and little more complex mental models:

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 Parasitoisms (Tunnelling, 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.

3 Possible Example of Using Primitive Model of Abstract Competitive Market

Let us exhibit as a simple example the single (free-competitive) market with one homogeneous 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 [18]. May be that is the simplest occurrence suitable for realisation as softbot. Even it can be easily realised 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 behaviour 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

$$\begin{aligned} D_t &= a - bp_t \\ S_t &= -c + dp_{t-1} \\ D_t - S_t &= 0, \end{aligned} \tag{1}$$

where the third equation is the requirement of the so called market clearing 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

$$\begin{aligned} p_t + 1 &= p_t + (a - bp_t) - c(-c + dp_t) = \\ &= a + c + (1 - b - d)p_t. \end{aligned} \tag{2}$$

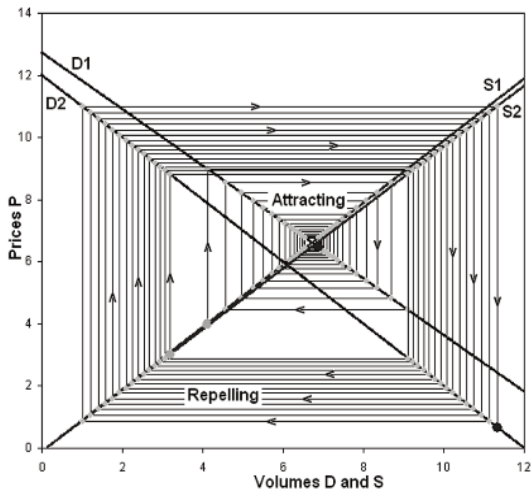


Fig. 2 Mutual position and slopes of two pair of curves is leading to E^* from every level of Price P or diverging

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 behaviour 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

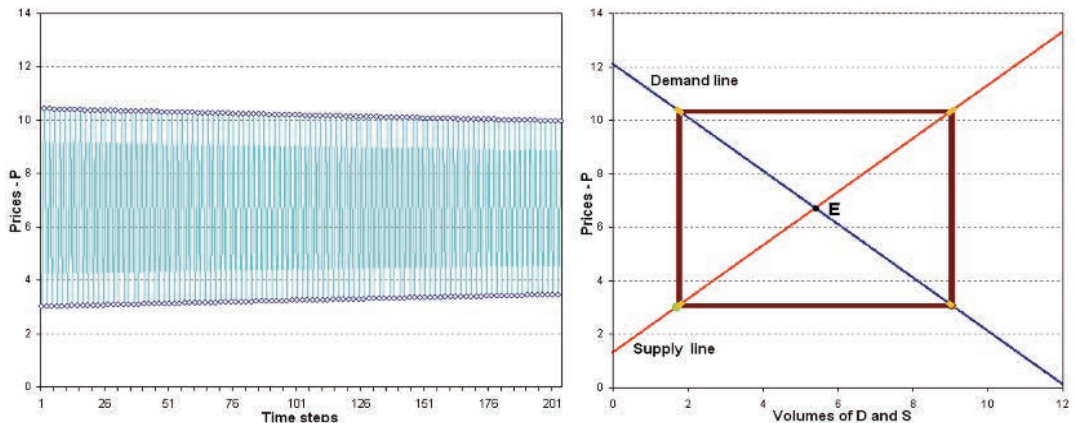


Fig. 3 Mutual position and slopes of demand and supply line produce very slow motion to Equilibrium

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. 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.

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

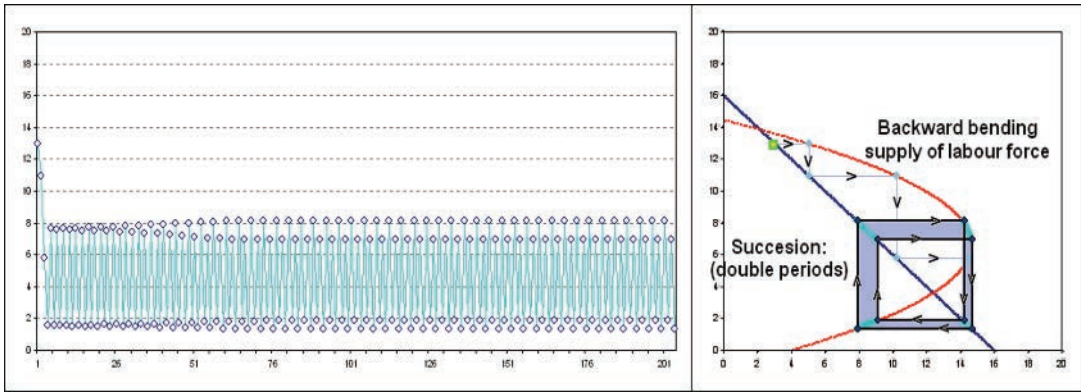


Fig. 4 Succession (adaptation) of price to double cycle

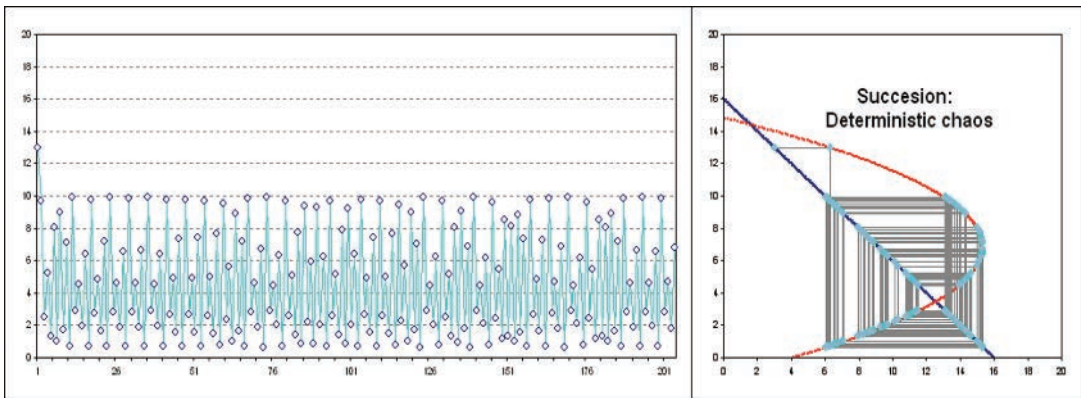


Fig. 5 Emerging some type of deterministic chaos

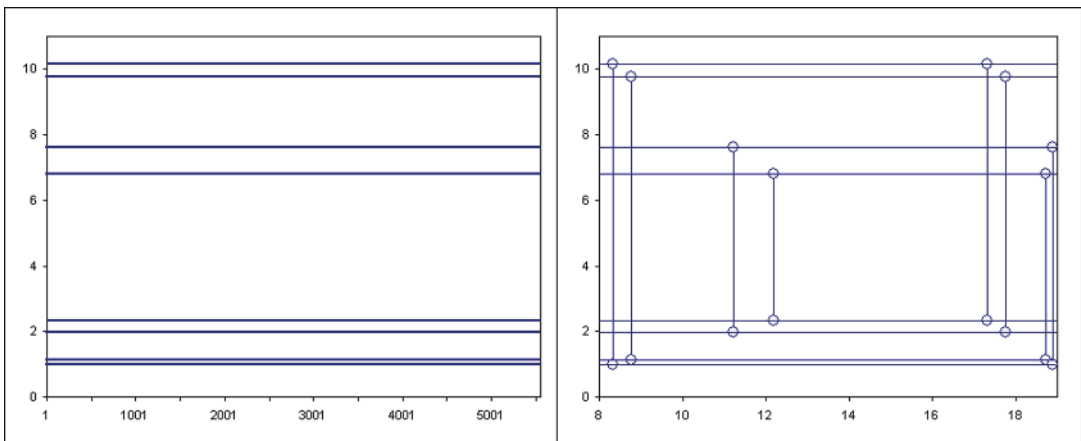


Fig. 6 Eight-periodic cycle: succession emerging after comparatively long transients

changes of positions and slopes of supply curve and demand line. Therefore, it is evident that very simple yet softbots demonstrated here can fulfil 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).

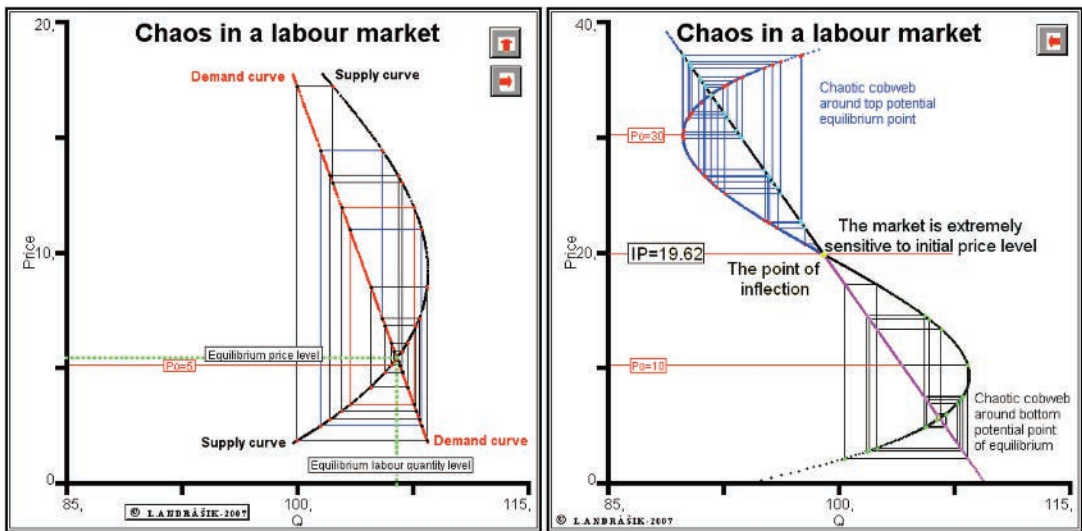


Fig. 7 Simulation experiment realised by author in software STELLA to demonstrate deterministic chaos

In mathematics, such work belongs to the branch of topology, i.e. we are dealing with topological map [14], [24], [26], [34]. 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 have 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 $p \times$ 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 [4] – [7], [18], [22]. 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], [11] – [13], [21], [22], [29].

4 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 in general

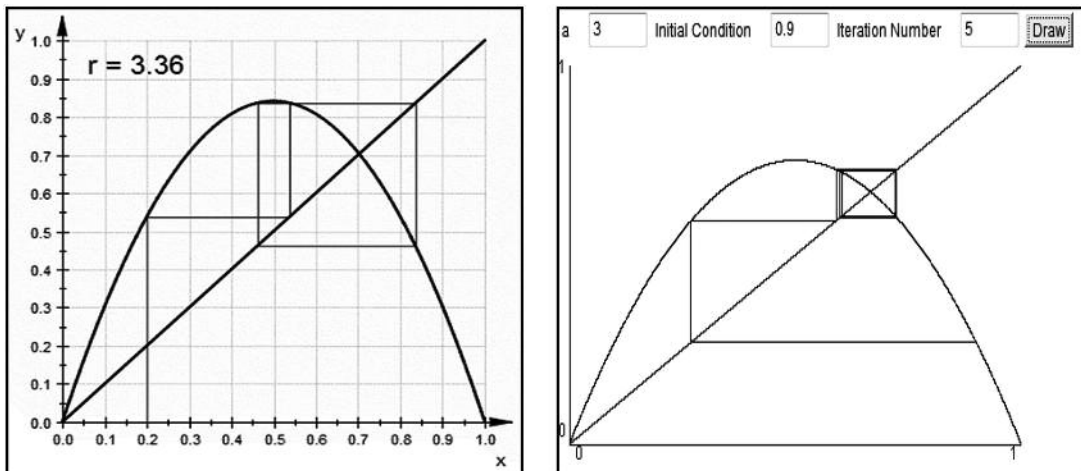


Fig. 8 A cobweb plotting Applet of Logistic map from Wikipedia (left); the same from: <http://math.la.asu.edu>

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, STELLA⁴⁾ [5], Vensim, iDMC [25], [26], SWARM [28] and other software too. On the other hand, for achieving advanced stories and for dancing with more sophisticated softbot [1], [11], [21] 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 indispensable. The same is valid for creation of complex virtual stories (self-creative stories).

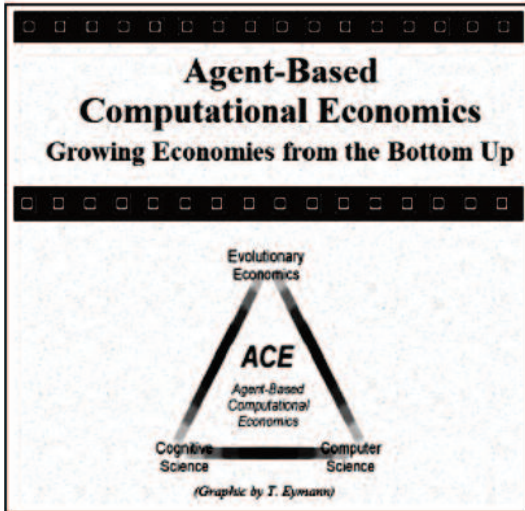


Fig. 9 The heading page of ACE website

ing with them 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” too⁵⁾. 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 nonmonotonic supply, the possibility for approaching more complex form of market mental model is the

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 be 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 (prevalingly a student) is only in the role of user non-intervening into mental model, map and architecture of virtual “subject” (virtual “triad”), i.e. he/she gives instructions for an experiment and is waiting for answers and working

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

5) It must note that he/her is still only economist not pretending on the role of (not act as if) PC programmer.

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.

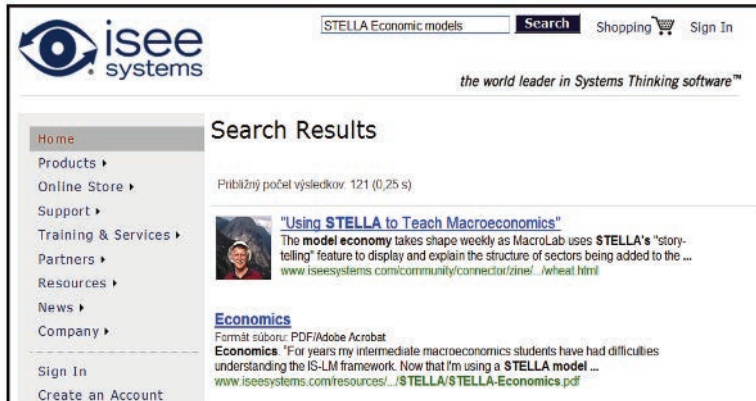


Fig. 10 Search realised on the Internet front page of ISEE Systems

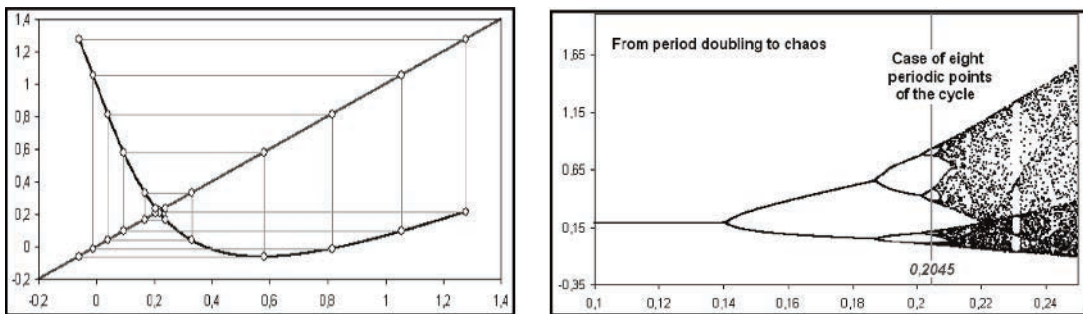


Fig. 11 Visualizing chaos (left) by connecting of dots on diagonal and on curve(cobweb graph made in Excel); Bifurcation portrait (right) with chosen bifurcation value of w generating cycle with eight periodic points

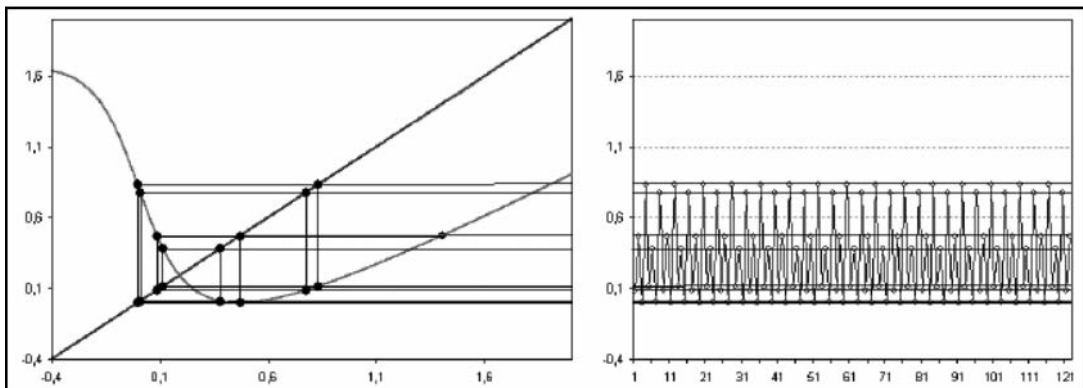


Fig. 12 Comparison of two possible exposition of same event

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 use 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 [25], [26].

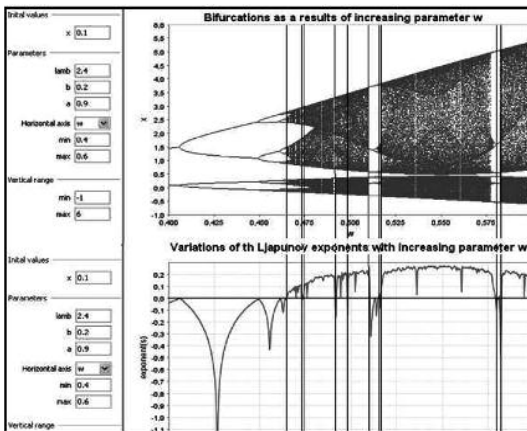


Fig. 13 The corresponding of periods in bifurcation portrait with Lyapunov exponents

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 some 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 data, but there is left room for autonomous self-creation. In iDMC software there are several other suitable routines allowing

deeper analyses of the nature of mental model constructed via up-down method as it is shoving by fig. 14. Seen from other side, using method of building computation economy from bottom-up are bringing wholly new situation, qualitatively unprecedented. 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 MABS⁶, [12], [13], [21], [28], [29]. Other very interesting direction producing topics appropriate for the imputation to the advanced

6) The proceedings of first workshop published in 1998 [35].

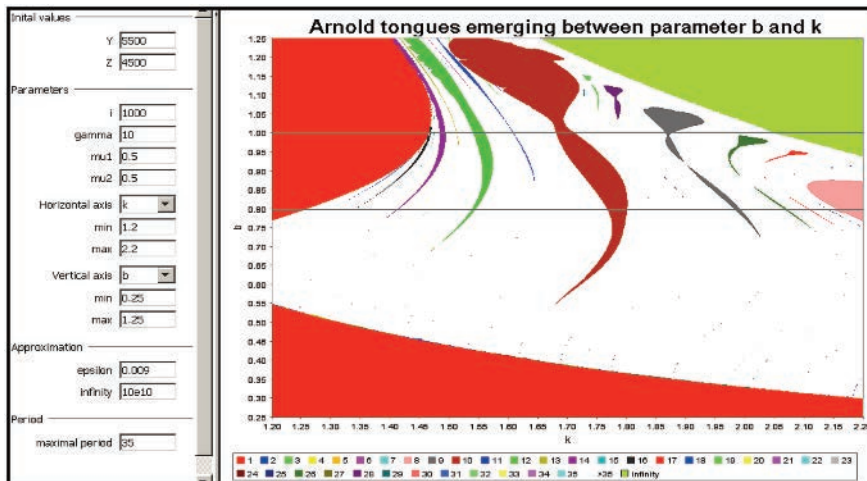


Fig. 14 Deeper insight into Samuelson's model of business cycle with added accelerator/multiplier

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, the seminal work in this area was the publication of Beltratti, Margarita and Terna [11]. 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.

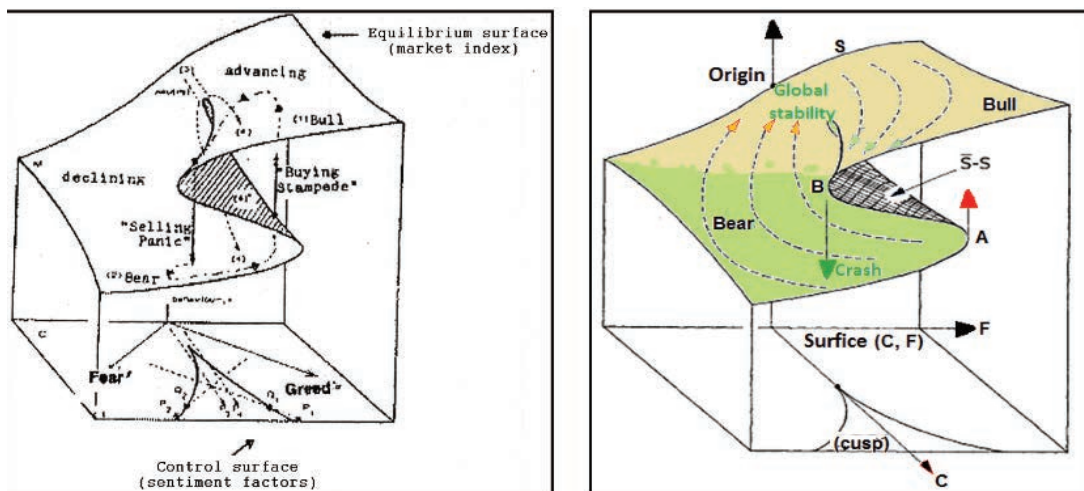


Fig. 15 Depictions of cusp catastrophe in stock market

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

The new technologies of learning and investigation of complex economic phenomena assisted by IT, 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 (exosomatisation) 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 communities⁷⁾. 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 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, “rheostats” 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 transfor-

7) 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.

mation 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 accomplishes 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.

▀ Conclusions

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 IT 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 myslits) 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 applets 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 IT, 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 *myslits* 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 IT, 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 IT’s are intensively use to codify and transmit the new knowledge.

References

- [1] ACE website is in Internet <http://www2.econ.iastate.edu/tesfatsi/ace.htm>.
- [2] Agliari, A., Bischi, G-I., Dieci, R., Gardini, L., (2005), Global Bifurcations of Closed Invariant Curves in Two-Dimensional Maps: a Computer Assisted Study, *International Journal of Bifurcation and Chaos* 15, p. 1285-1328.
- [3] Agliari, A., Dieci, R., Gardini, L. (2007), Homoclinic Tangles in a Kaldor-like Business Cycle Model, *Journal of Economic Behaviour & Organization*, 62, pp. 324-347, available at www.elsevier.com/locate/econbase, for similar articles see Internet page of Laura Gardini, see also:
- [4] Agliari, A., (2006), Homoclinic Connections and Subcritical Neimark Bifurcation in a Duopoly Model with Adaptively Adjusted Productions, *Chaos, Solitons & Fractals*, Volume 29, Issue 3, August 2006, p. 739-755.
- [5] Andrásik, L., (2004), The Theory of Computer-aided Experimentation in an Artificial Economy - Some Unconventional Approaches to Simulation of Models of Economical Evolution and to Experimentation in Successive Environment, *Economic Journal/Ekonomický časopis*, 52, No. 8, p. 996.
- [6] Andrásik, L., (2008), Digital Stories in Non-Linear Dynamical Economies in Discrete Time, *Economic Journal/Ekonomický časopis*, 56, No. 3, p. 239.
- [7] Andrásik, L., (1998), Virtual Life and Perpetualogics (Self-Preservation of Virtual Entities in Computational Intelligent Technology), *Philosophy/Filozofia*, 53, 1, pp. 15-26.
- [8] Andrásik, L., (1998) Learning by Evolution - in an Artificial Economy, *Economic Journal/Ekonomický časopis*, 46, 1, pp. 72-98.
- [10] Bal, F., and Nijkamp, P., (1998), In Search of Valid Results in a Complex Economic Environment: the Potential of Meta-analysis and Value Transfer, *Tinbergen Institute Discussion Paper TI 98-005/3*, Tinbergen Institute, Amsterdam.
- [11] Bal, F., and Nijkamp, P., (1998), Winners and Losers in Spatial Duopoly Markets; the Relevance of a Value Transfer Approach", *Tinbergen Institute Discussion Paper TI 98-00#/3*, Tinbergen Institute, Amsterdam.
- [12] Bal, F., and Nijkamp, P., (1999), The Ceteris Paribus Clause in the Context of Meta-analysis and Value Transfer", in: *Comparative Environmental Economic Assessment: Meta-analysis and Benefit Transfer*, R.J.G.M. Florax, P. Nijkamp and K. Willis (eds.), Forthcoming.
- [13] Beltratti, A., Margarita, S., And Terna, P., (1996), *Neural Networks for Economic and Financial Modeling*, International Thomson Publishing Inc.
- [14] Bosse, T., Geller, A., Jonker, C. M., (Eds.): *Multi-Agent-Based Simulation XI*, 6532, *Lecture Notes in Computer Science*, Springer, 2011.
- [15] Bruun, CH.: *Advances in Artificial Economics, The Economy as a Complex Dynamic System*, 584, *Lecture Notes in Economics and Mathematical Systems*, Springer, Berlin, Heidelberg, 2006.
- [16] Cathala, J. C., *On the Boundaries of Absorbing and Chaotic Areas in Second-Order Endomorphism, Non-linear Analysis, Theory, Methods & Applications*, Vol. 29, No. 1, pp. 77-119, 1997.
- [17] David, P. A., and Foray, D., *An Introduction to the Economy of Knowledge Society*, Department of Economics, Oxford University, Manor Road Building, Oxford OX1 3UQ, Discussion Paper Series, Number 84, December 2001.
- [18] Dieci, R., *Critical Curves and Bifurcations of Absorbing Areas in a Financial Model*, *Nonlinear Analysis*, Vol., 47, pp. 5265-5276, 2001, (also in the Internet: <http://www.elsevier.nl/locate/na>)
- [19] Dopher, K., (Eds.): *The Evolutionary Foundation of Economics*, Cambridge University Press, 2005.
- [20] Ezekiel M., *The Cobweb Theorem*, *The Quarterly Journal of Economics*, Vol. 52, No. 2 (Feb., 1938), pp. 255-280, Oxford University Press, 1938.
- [21] Ferber, J.: *Multi-Agent System, An Introduction to Distributed Artificial Intelligence*. Addison-Wesley Longman, 1999.
- [22] Foray, D., *The Economics of Knowledge*, The MIT Press, Cambridge, Massachusetts, London, England, 2004.
- [23] Hales, D., Edmonds, B., Norling, E., (Eds.), 2581: *Multi-Agent-Based Simulation III*, 2927, *Lecture Notes in Computer Science*, Springer, 2003.
- [24] Chiarella, C., Dieci, R., Gardini, L., *Speculative Behaviour and Complex Asset Price Dynamics: a Global Analysis*, *Journal of Economic Behaviour & Organization*, Vol. 49, 2002, s. 173-197, (the paper is avail-

- able on Internet: <http://www.elsevier.com/locate/econbase>).
- [25] Guckenheimer, J., Oster, G. F. & Ipaktchi, A., The Dynamics of Density Dependent Population Models, *Journal of Mathematical Biology*, Vol. 4, pp. 101–147, 1977.
 - [26] Gumowski, I. & Mira, Ch., "Recurrences and Discrete Dynamic Systems – An introduction". Lecture notes in mathematics, No. 809, Springer-Verlag, Berlin, 1980.
 - [27] Lines, M., Medio, A.: iDMC (interactive Dynamical Model Calculator), user's guide, 2005, (<http://www.dss.uniud.it/nonlinear>)
 - [28] Lines, M., Medio, A.: *Nonlinear Dynamics: A Primer*, Cambridge University Press, 2001.
 - [29] Lorenz, H-W.: *Nonlinear Dynamical Economics and Chaotic Motions*, Springer-Verlag, Berlin-Heidelberg-Budapest, 1993.
 - [30] Moss, S., Davidsson, P. (Eds.): *Multi-Agent-Based Simulation*, 1979, *Lecture Notes in Artificial Intelligence*, Subseries of *Lecture Notes in Computer Science*. Springer, Berlin, 2001.
 - [31] Robbins, L., *An Essay on the Nature and Significance of Economic Science*. London: Macmillan. 1932.
 - [32] Prigogin, I., Time, Dynamics and Chaos: Integrating Poincare's 'Non-Integrable Systems', report: <http://www.osti.gov/accomplishments/documents/fullText/ACC0300.pdf>, 1990.
 - [33] Prigogin, I., (1991), The Behavior of Matter Under Nonequilibrium Conditions: Fundamental Aspects and Applications: Progress Report for Period April 15, 1990 – April 14, report: <http://www.osti.gov/accomplishments/documents/fullText/ACC0299.pdf>.
 - [34] Puu, T. (1997), *Nonlinear Economic Dynamics*, Springer-Verlag, Berlin-Heidelberg.
 - [35] Puu, T. (2000), *Attractors, Bifurcations and Chaos*, Springer-Verlag, Berlin- Heidelberg-New York.
 - [36] Sichman, J. S., Conte, R., Gilbert, N., (Eds.), (1998), *Multi-Agent Systems and Agent-Based Simulation*, 1534, *Lecture Notes in Computer Science*, Springer.
 - [37] Smale, S., (1967), Differentiable Dynamical Systems, *Bulletin of American Mathematical Society*, Vol. 73, pp. 747–817.
 - [38] Von Neumann, J., Morgenstern, O., (1944), *Theory of Games and Economic Behavior*. Princeton University Press.
 - [39] Vosvrda, M., Barunik, J., (2009), Can a stochastic cusp catastrophe model explain stock market crashes? *Journal of Economic Dynamics & Control*, vol. 33, pp. 1824–1836.
 - [40] Zeeman, E. C., (1974), On the Unstable Behaviour of Stock Exchanges. *Journal of Mathematical Economics* 1, p. 39–49.

prof. Ing. Ladislav Andrášik, DrSc.

Rektorát Ekonomickej univerzity v Bratislave, Bratislava, Dolnozemska cesta 1,
ladislav.andrasik@euba.sk