ON VIRTUAL COMPLEX NETWORK OF ECONOMY CREATED IN STELLA: Critical discussion of parallels with Neoclassical Theory of economic growth

LADISLAV ANDRÁŠIK[1]

O virtuálnej komplexnej sieti ekonomiky vytvorenej softvérom STELLA: kritická diskusia v paralelách s neoklasickou teóriou hospodárskeho rastu

Abstract: *The orthodox economic science is evolving into contemporary form of mainstream economics based on imaginations that economies are similar entities as mechanical ones (in today's terms called – systems). However, in objective reality the economy is a complexly evolving social organism building oneself as complex network. Unfortunately, by contrast to mechanical system, the economy as a whole is not directly observable and susceptible to manipulation. Certain intervention into the economy in objective reality frequently is bringing unexpected results, because it is complexly answering social organism not mechanical mathematically processing able entity. There exist thanks to ICT and computational intelligence devices and tools possibilities to directly observe the result of evolution in virtual economy, more or less affected by interventions of its constructor. In this essay we are trying to imitate an economy in objective reality by virtual economy built in software STELLA as not very complex network. However, network approach is a relatively novel subject in economic theorizing, and there are several ─ different ways of understanding them. The main stress in this essay is laid on specific properties of holistic economic network in computer reality, which needs to be understood as common mathematical theory of complex networks, theories of neural networks, percolation theories and it is differing from applied economics of real networks in economies existing in the form of traffic, pipelines, etc.*

Keywords: *computational economy, complex network/systems, computational experimentations, mainstream economics, ontological/ methodological mistakes.*

JEL Classification: B4, C6, C53, C62, C69, C7, C90, D4, D5, D58, D6, D8, G12, L1.

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1 Introduction

A serious constructive approach to building economic theory it is permanently scarce phenomena among scholars in economics. However, without such approaches, methods, devices and tools we cannot seriously approach complex phenomena in wholeness of some economies in objective reality. Because it is impossible to directly observe the objective reality from outside, it is need some intermediary connecting link mediating better understanding of hidden phenomena and process or happenings ones. Such mediator may be possible a certain kind of virtual economy constructed in appropriate computer softwares. However, on the other hand mathematically astringent dressed mechanical model of economy (as it is used in neoclassical theory of economic growth) cannot serve as the correspondent entity to economy in objective reality. Such mathematical models not accomplished relevant scientific pretensions on correct description of objective reality, which is not mechanical system but a complexly evolving social organism in multilevel complex network[2]. In the last thirty years, there are several attitudes to focus attentions on complications with economies in objective reality from different side than in the mainstream economics namely from the side of theory of graphs and networks ones. The first approach to capture the global properties of such systems as complex network is to model them as graphs whose nodes represent the dynamical units, and whose links stand for the interactions between them. The author O. Gomes in his essay on *Complex Networks in Macroeconomics* published in 2014 is informing on using this new approach in different branches of contemporary science and main focus he put on economics. He shows that even at first sight the socio-economic entities look like *Complex Networks.* He has written that socio-economic phenomena might be approached, in many different contexts, through the construction of networks that highlight the local interaction among heterogeneous agents. We must to add to this assertion that every agent is authentic and inherently heterogeneous so in his roles, functions and activities too. Real-world networks concerning human relations in the society or in the economy involve a large number of nodes, and large numbers and qualitative varieties of links connecting them and an evolving structure where both nodes and links may be generated or may disappear

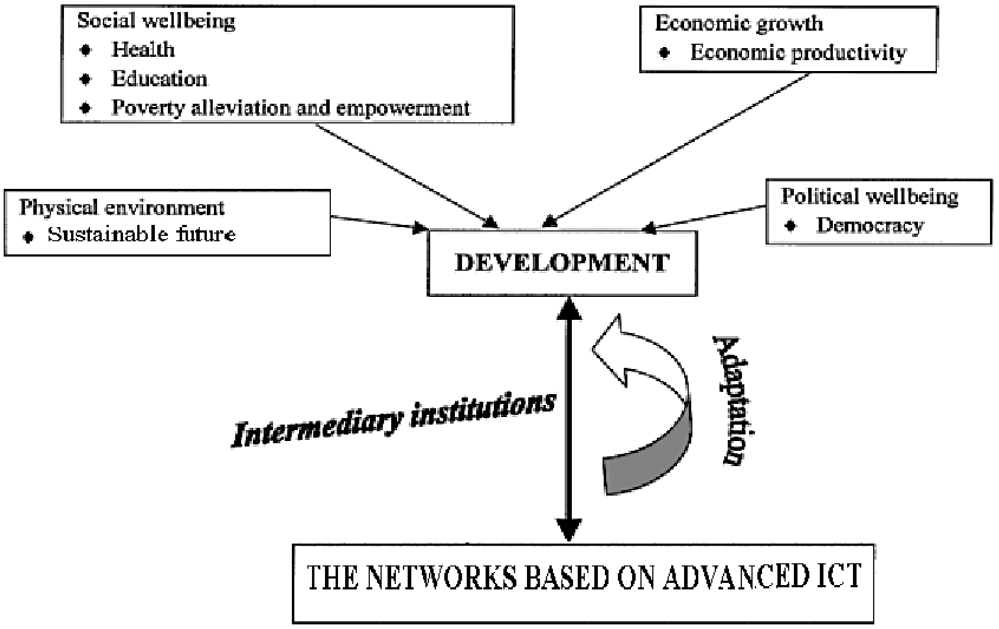
[2] The Complex networks in general are ubiquitous, as shown by many objective real world examples. They have non-trivial topological characteristics that traditional networks do not possess. Typical examples include the Internet, World Wide Web, wireless communication networks, power grids, and social, economic and biological networks. Nowadays several complex networks are emerging in virtual computational reality too as a result of complex evolution in simulation runs process from bottom up arising worlds.

at each time period. He emphasizes that the economies behave as a *Scale-Free Complex Network*[3]. A market for a given good, the financial system or the world economy, all display characteristics that allow to classify them as complex network structures and, more specifically, as having property of *Scale-Free Networks.* In otherimportant example A. Kirman discusses resourceful problems, which is from the subject of our virtual economy, certain economic models in which agents interact directly with each other rather than through the price system as in the standard general equilibrium model. Actually, in his chapter *Economies with Interacting Agents* (Kirman, 1998) among others as contributor to the book *The Economics of Networks* (Cohendet et al., 1998), he is suggested that the relationship between micro and macro behaviour is very different from that in the standard model and that the aggregate phenomena and process too that can arise are rich. The models considered by A. Kirman include ones with global interaction in which all agents can interact with each other which is by our opinion overambitious strong assumption and one in which agents can only interact with their immediate neighbours which is more realistic ones. The author is considered both static and dynamic models and the latter includes the class of evolutionary economic models. In the last part of his chapter, A. Kirman is discussed models in which communication networks evolve. Among others we are known that A. Kirman together with Oddou and Weber (1986) has applied stochastic graphs to simple decentralized pure exchanges economies. The Kirmans contribution into *introductory theory and methodology of complex networking economies* is very significant and useful. Other interesting for our investigations is the chapter in cited book is *Spatial Interactions in Dynamic Decentralized Economies:* a Review, due to the author G. Fagiolo (Cohendet et al., 1998). He describes in his chapter dynamic models of decentralized economies with imagination that agents in economies are spatially distributed and interacts directly and locally. He put more exactly that this means: (a) agents are located in a space as some graph or integer lattice that is seen in our essay perspective as network; (b) the current choice of each agent is influenced by past choices of their neighbour. In this way we are obtaining belief that this approach is very congenial with economic evolution in objective reality and it is also good inspiration for our work. We commit ourselves in this context to vigorously emphasize that there

[3] In recent literature, the *Scale-free Networks* are describes as a connected graph or network with the property that the number of links originating from a given node exhibits a power law distribution. A scale-free network can be constructed by progressively adding nodes to an existing network and introducing links to existing nodes with preferential attachment so that the probability of linking to a given node *i* is proportional to the number of existing links *ki* that node has.

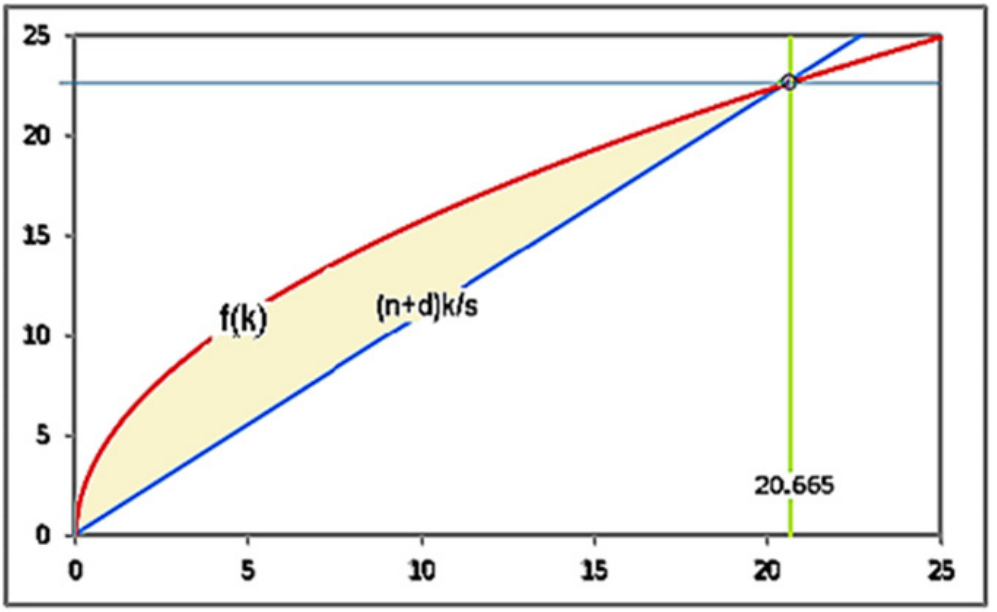
is cardinal difference between if on the one hand there is economics of such sectors of economies as are networks ones: networks of oil and other products pipelines, electrical networks, etc., that is, sectorial economics, and on the other side it is general economics of fullness economy having to treat as a complex network. The authors Newman, Watts and Strogatz, (2002) describe in theirs essay with name *Random graph models of social networks,* some new exactly solvable models of the structure of social networks, based on random graphs with arbitrary degree distributions. They give models both for simple unipartite networks, such as acquaintance networks, and bipartite networks, such as affiliation networks. The author compares the predictions of their models to data for a number of real-world social networks and find that in some cases, the models are in remarkable agreement with the data, whereas in others the agreement is poorer, perhaps indicating the presence of additional social structure in the network that is not captured by the random graph. Their works are also very inspirational in our endeavour to constructing virtual laboratories in STELLA in the form of complex networks. Among others we want to focus attention of readers to *Agent-based computational economics* (ACE) which is important further way, in the study of economies different from neoclassical approach. This approach is very congenial with our approach in this essay. ACE branch of economics is using agent-based modelling and simulation, in which an agent-based model is a one that comprising autonomous agents placed in an interactive social environment or network of socio-economic interaction among its nodes. Simulating these and similar models as model using appropriate software's in common computers is very useful and most practical way to understand evolution of economies by visualizing the process running in virtual environment, see for example Chen (2008) or Tesfatsion (2006). In these contexts worth mentioning the impact of theory and functional computational neural networks on reasoning in economics in direction to go to complex networks including such ones as Multilayer Perceptron Neural Networks and/or Auto-associative Neural Networks, (Chen, 2008). In contemporary era, the crucial role of development of socio-economic complex networks are playing the entirety of the Networks based on advanced ICT, and mainly the Internet among them, fig. 1.

Figure 1: The schema of complex development influenced by ICT networks



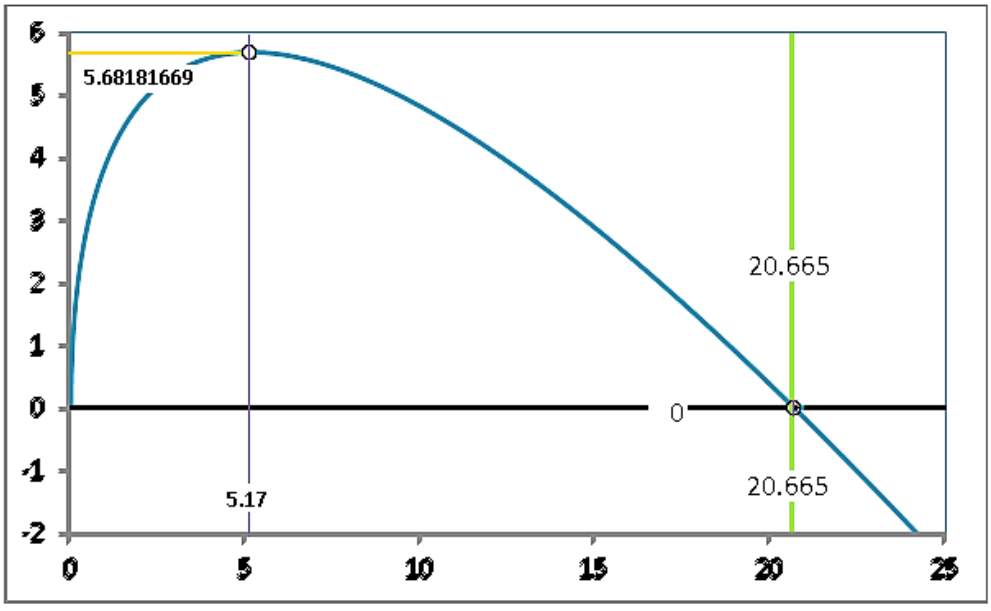
Source: The construction of this schema was inspired by Shirin Madon, LSE Research Online London

Figure 2: The Solow´s result: Steady state point achieved by us in Excel



We have chosen for demonstration Solow's model of economic growth because it is generally known in economic community, and it is easy to compare it with its alternative one created in STELLA. However before doing that we are realised, only to revitalize classroom imaginations about neoclassic economic growth based on reading common economic textbook, two graphs in Excel using Solow´s formulas. They can serve in looking for associations with imaginations on economic growth emerging from observation of process going in virtual economies living in software environment of STELLA, fig 2 and fig. 3. In the snapshot of fig. 2 we can see the graph of product per capita f(k) and the blue straight line of product of population growth n plus rate of depreciation of capital d multiplied by capital per capita k and divided by rate of saving s, that is (n+d)k/s. The pink area between curve f (k) and straight line is set of residual consumption per capita c emerging upon every vertical of values of capital per capita. Using Excel we have found the maximal value of consumption per capita c*, see fig. 3, similarly to Solow's one he finds by mathematic operations. It is clear even to first look at these graphs that used continual approach is not enable to show qualitative differences in dead capital stocks and living labour forces and in different time instances (years against months) in theirs payments. There are however several further failures and scientific mistakes with Solow´s approaches which shall be emerging in further part of this essay based on running of virtual economic models in STELLA.

Figure 3: Solow's result: maxima of c* achieved by us in Excel



2 Primordial in Stella constructed virtual Economy
(First attempt to constructing socio-economic complex network in STELLA)

Understanding the behaviour of a complex socio-economic organism requires more than an understanding of the individuals that comprise the system. It also requires understanding how individuals interact with each other, and how the achieved aggregated outcome can be more than the sum of contribution of individual's behaviour. The achieved final outcome of economy it is not plain sum of individual outcomes but it is synergetic result of economy as a whole, which is of complex economic network[4]. In this section of our essay we are trying to show based on simple STELLA model how such network can be functioning. In advance to step up to construction economic network in STELLA, we want to declare that such creatures are only metaphors rather than exact description of reality but such one which is more suitable for comparison with reality than neoclassical abstract formulas; furthermore neoclassical economists never declared that there models are only metaphors very distant from reality. In a complex evolving network, the nodes are:

First of all, authentic human subjects as decision makers and players of very different roles;

Secondly the different non-human entities as production facilities, stock-rooms, traffic devices, pipelines, banks, etc. The others composites of such networks are quantitatively and qualitatively different wide spectra of two directional interactions-links among nodes.

The word (adverb) complex before word network is means that just as nodes as well as interactions are unforeseeably changing in time steps, because complex network are walking to future time instance in discrete steps. These phenomena may be understandable in such a way that in every *time-step loci* they can emerge different change in quantity and quality of nodes and interactions among them.

Maybe it is clearly understandable that if some economies have to be living as social organisms in objective and/or computer software reality (virtual reality) they must have at least three productive sectors that is *S1 producing fixed*

[4] A socio-economic complex network is a set of people or groups of people, (decision makers and actors of their decisions) and a set of containers for stocks and tubes for flows of economic entities with some pattern of interactions or "ties" between and among them (so called small world) and their interaction of different economic units (stocks and flows). In fact, the decision and its realisation may be and may be not the same in time and value.

capital Kfix, S2 producing circular capital Kcirc, S3 producing consumption goods CG and a sector of households H supplying labour forces L. Alongside to that, it is very important to take due note of the facts that any living entity cannot exists without some containers, tubes and other different links in its bodies. In this sense Solow's capital *K*, labour force L as stocks have to be set to containers, product *Q* or income *Y* as flows set in tubes and parameters and a in some converters. It must be for every economist clear understanding that real economic entities cannot exist and/or live in as it is sometimes called vacuum, as however Solow´s mathematical formulas can.

Let us suppose that appropriate sectors are cooperates with agriculture farms, mining, fishing and woodcutter's firms, so we they not to file into our network in an effort to keep good clarity of an arising graphs. In this case the virtual economy is created without government and is closed that is also for better clearness of graphs. The entities are performed as containers 

for states (capital, different goods, money etc.)[5], tubes 

for flows (capital, products, incomes, different goods, money etc.)[6], and converters 

with action connection. 

Using these building blocks, we are constructed a primordial part of our first virtual economy in STELLA only for two participants of future network; these are sectors of *Households and CG Producers ones*, see fig. 3. As it is obvious from snapshot tab. 1 in *RoomPforCG* there are disposable *130 units* of *CG* that balanced stock is enough for *13 months.* The producers purchases *10 units CG* in every months to *Household* and this volume is flowing via *Transfer CG* into *RoomHforCG.* In every month the *Households* are uses 10 units of *CG* for reproduction of labour forces *L* in size 10. The similar process but in backward direction is going between Households and CG Producers. After the exhaustion of containers fillings the process is stop. For the prolongation of behaviour of virtual economy in STELLA it is need to enter two other *Producers* into network and to build producing facilities. We perform this task in the next step of creating virtual economy in STELLA.

[5] In network and/or graph theory the container is node, or vertex.

[6] The tubes or pipelines in network and/or graph theory are links, connections, edge.

Figure 4: The minimal network consisted from Households and CG Producers

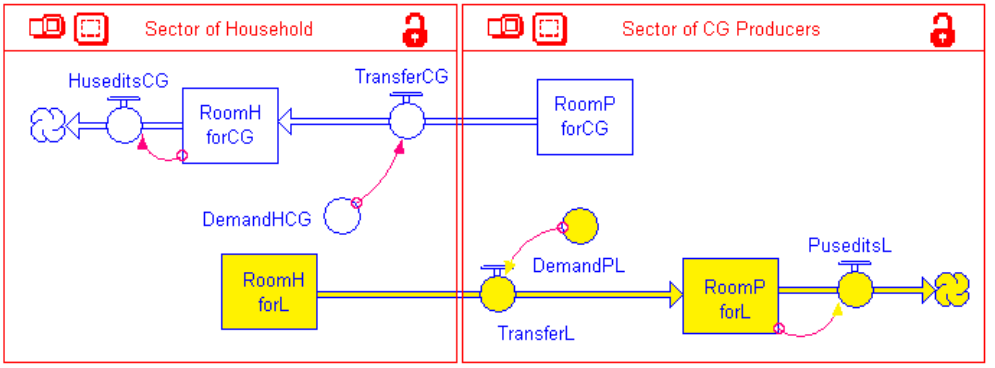


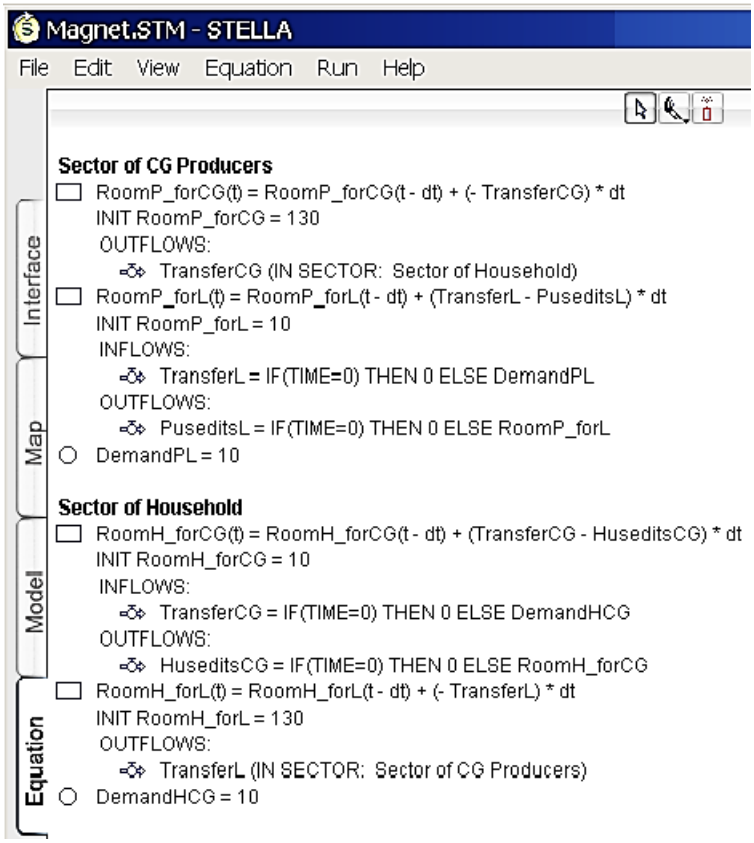
Table 1: The results of simulation-run in STELLA

1:56 PM 12/10/2019 — Table 1

Time	RoomP forC	DemandHCG	TransferCG	RoomH forC	HuseditsCG	RoomH forL	DemandPL	TransferL	RoomP forL	PuseditsL
0	130.00	10.00	0.00	10.00	0.00	130.00	10.00	0.00	10.00	0.00
1	130.00	10.00	10.00	10.00	10.00	130.00	10.00	10.00	10.00	10.00
2	120.00	10.00	10.00	10.00	10.00	120.00	10.00	10.00	10.00	10.00
3	110.00	10.00	10.00	10.00	10.00	110.00	10.00	10.00	10.00	10.00
4	100.00	10.00	10.00	10.00	10.00	100.00	10.00	10.00	10.00	10.00
5	90.00	10.00	10.00	10.00	10.00	90.00	10.00	10.00	10.00	10.00
6	80.00	10.00	10.00	10.00	10.00	80.00	10.00	10.00	10.00	10.00
7	70.00	10.00	10.00	10.00	10.00	70.00	10.00	10.00	10.00	10.00
8	60.00	10.00	10.00	10.00	10.00	60.00	10.00	10.00	10.00	10.00
9	50.00	10.00	10.00	10.00	10.00	50.00	10.00	10.00	10.00	10.00
10	40.00	10.00	10.00	10.00	10.00	40.00	10.00	10.00	10.00	10.00
11	30.00	10.00	10.00	10.00	10.00	30.00	10.00	10.00	10.00	10.00
12	20.00	10.00	10.00	10.00	10.00	20.00	10.00	10.00	10.00	10.00
13	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Final	0.00	10.00		10.00		0.00	10.00		10.00	

First we just want to show is the building of model of virtual economy using operation from up to down until is the scheme for readers so-so transparent. We are forced to narrow correspondence with Solow's textbook theory of economic growth to use neoclassical production functions too, in the construction of our virtual economies. In them there arise similar problems as in economies in objective reality, for example discrepancy between times steps longitude of *S1* – one year and all other sectors where one month is. Other similar problems of discrepancy are existing incumbent on the fact that products of sector *S3* which is *CG* need only sector of households *H*. We can further find such several discrepancies in economies which neoclassical economists do not take into account in their theories and which have heavy influences on the final behaviour of economies. Let us begin investigations

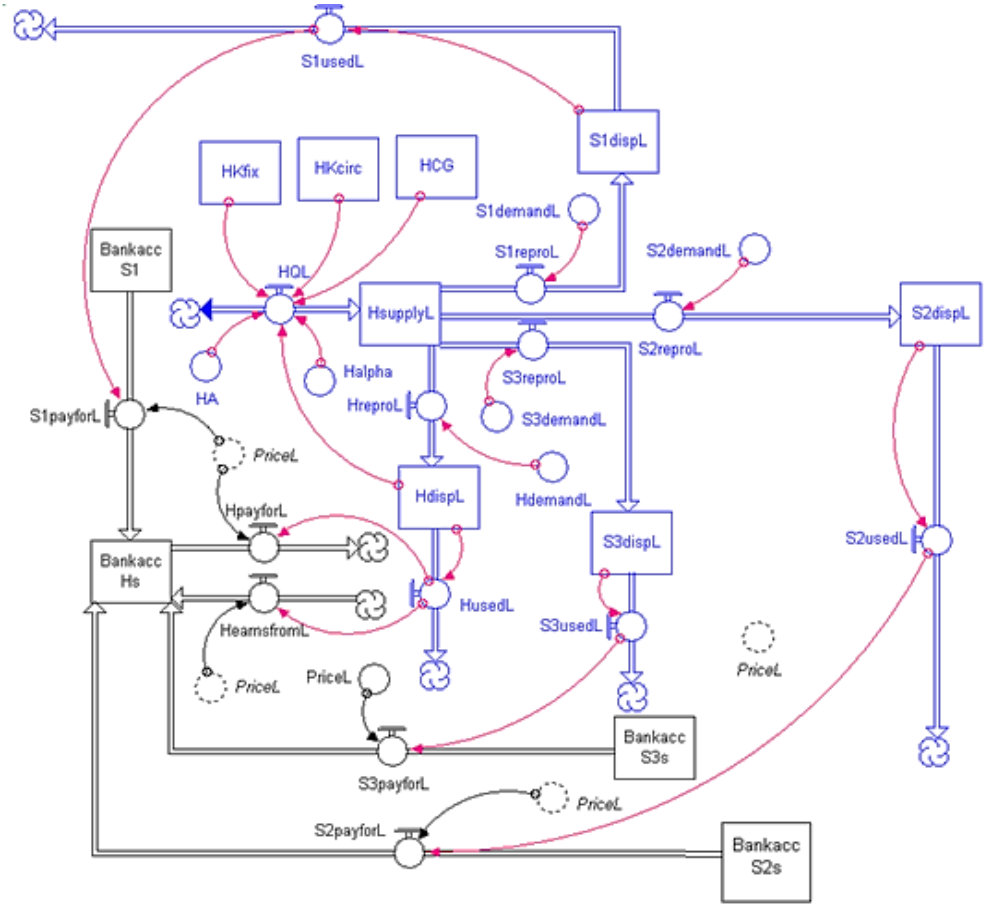
Table 2: The fillings of building block of scheme in fig. 5



with primordial case shoved in fig. 4. Before starting the run of simulation we have to be solving the tasks with singularity that is from where descendent the primal stock filled in containers the question which Solow fully ignores. To be simply getting somewhere, we must adapt the evasive manoeuvre (logical finesse) that they are the gifts of God. We do this because in reality these ones are the results of very long historical evolution, in so far we are confessing that we also do not have a scientifically adequate consistent attitude in this case. When looking at the graph in fig. 5 and its content in fig. 6a,b it must be clear that simple arithmetical averaging of present entities are removing all important qualitative and quantitative properties needed for the understanding of complex evolution in that network. It is fact that Solow's formulas are arithmetical average numbers stripped of real economic denotation because it is only ex post artificially glued to numbers, and as such they can anything/nothing say about economic growth but only about the growth of abstract

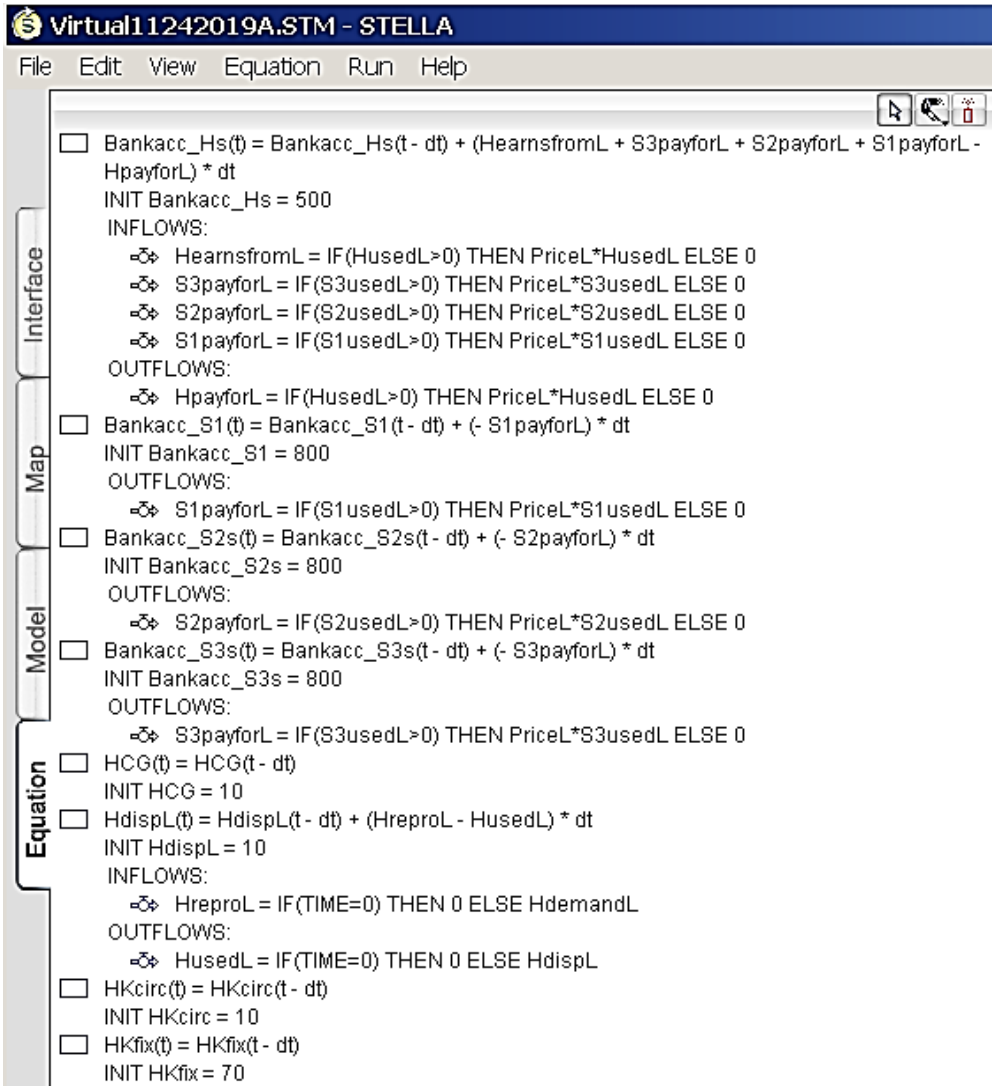
numbers. The Solow's theory of economic growth is very sophisticated scientific deceptions because using correct mathematical analysis of fully abstract formulas invoked the delusion that economies behave in the same way in objective reality. To understand these differences from neoclassical mathematical analysis it is needed to very consistently investigate not only snapshot in fig. 4 but together with fillings of building boxes in fig. 6a, b.

Figure 5: The snapshot of primordial economy achieved from STELLA



We have to exclusively emphasize that in model it is assumed that the third sector produced homogenous consumption goods. These are usable only for the sector of households, so these articles will be directly bought only by households of this one for consume. On the other hand, the first and second sectors will buy these goods only for transaction function in special case using approach of the barter economy, which is as *barter general equivalent.* Let us follow up an evolutionary process in that virtual barter economy in more

Figure 6a: The fillings of building boxes of graph in fig. 3 first part



advanced scheme as it is shown in a snapshot of Fig. 6.. The households (*H* for after) permanently prepared labour forces *L* for the entire economy. The supply of *L* is collected in container *DispQL*. The third sector buys in every month *10 units* of *L* and pays for them by selling *20 units of consumption goods* (*CG* for after). That *CG* is coming into container *CGH*, flowing in product flow pipeline *reproCGH.*

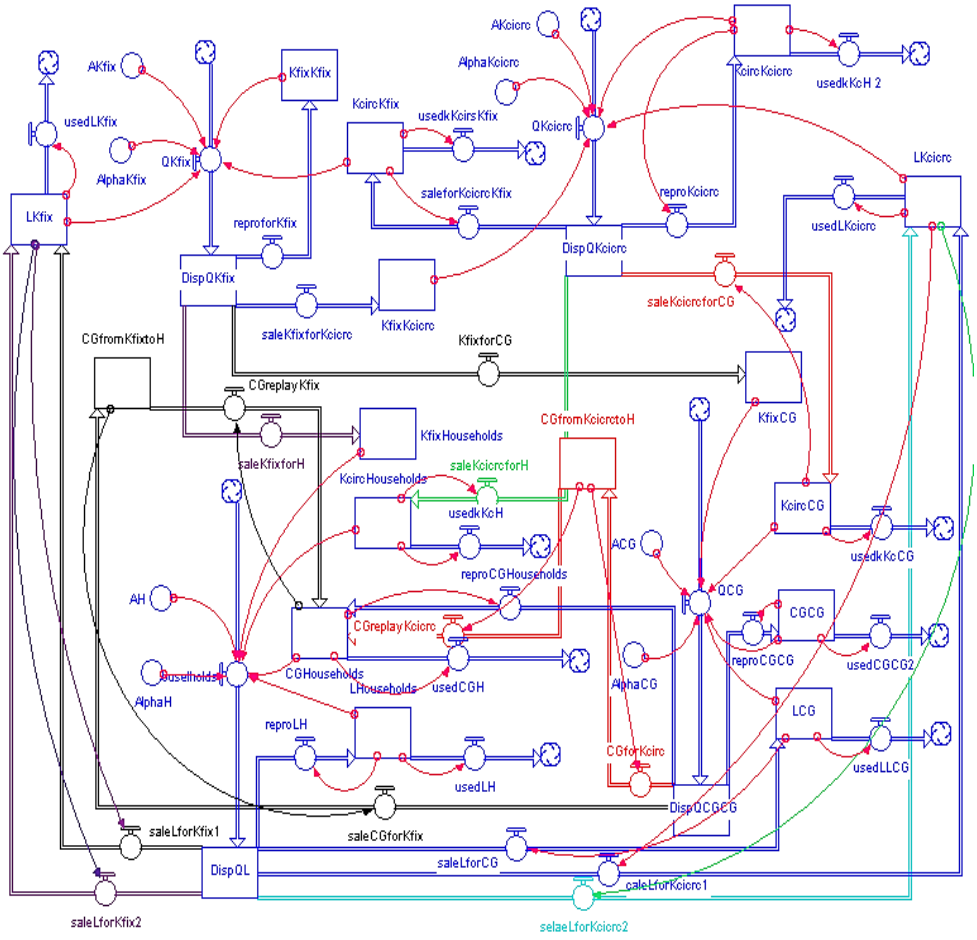
It is necessary to emphasize too that the original first volume of *CG* was consumed in the first month of the process. That amount was gone via pipeline

Figure 6b: The fillings of building boxes of graph in fig. 3 second part

HKfix(t) = HKfix(t - dt)
INIT HKfix = 70
HsupplyL(t) = HsupplyL(t - dt) + (HQL - HreproL - S1reproL - S3reproL - S2reproL) * dt
INIT HsupplyL = 0
INFLOWS:
HQL = HA*((HKfix+HKcirc)^Halpha)*(HCG+HdispL)^(1-Halpha) { Place right hand side of equation here... }
OUTFLOWS:
HreproL = IF(TIME=0) THEN 0 ELSE HdemandL
S1reproL = IF(TIME=0) THEN 0 ELSE S1demandL
S3reproL = IF(TIME=0) THEN 0 ELSE S3demandL
S2reproL = IF(TIME=0) THEN 0 ELSE S2demandL
S1dispL(t) = S1dispL(t - dt) + (S1reproL - S1usedL) * dt
INIT S1dispL = 10
INFLOWS:
S1reproL = IF(TIME=0) THEN 0 ELSE S1demandL
OUTFLOWS:
S1usedL = IF(TIME=0) THEN 0 ELSE S1dispL
S2dispL(t) = S2dispL(t - dt) + (S2reproL - S2usedL) * dt
INIT S2dispL = 10
INFLOWS:
S2reproL = IF(TIME=0) THEN 0 ELSE S2demandL
OUTFLOWS:
S2usedL = IF(TIME=0) THEN 0 ELSE S2dispL
S3dispL(t) = S3dispL(t - dt) + (S3reproL - S3usedL) * dt
INIT S3dispL = 10
INFLOWS:
S3reproL = IF(TIME=0) THEN 0 ELSE S3demandL
OUTFLOWS:
S3usedL = IF(TIME=0) THEN 0 ELSE S3dispL
HA = 1
Halpha = 0.5
HdemandL = 10
PriceL = 5
S1demandL = 10
S2demandL = 10
S3demandL = 10

usedCGH. In this way, the transaction between household and the third sector in first month was realized but we do not assume transaction costs, for an easier understanding of the process. The process cannot be going on in both sectors because the *Kcirc* was not reproduced. For that purpose, it is needed to buy new *Kcirc* from second sector. There emerges a problem for the third sector because the second sector cannot use *CG* directly only for itself. *CG* can be used only as an instrument of payment. In nominal case, it is used for the payment of wages of monthly hired labour forces *L*. Accordingly, here and there and in objective reality too, the process is not running so smoothly as in neoclassical models. Let us use common economic textbooks metaphor about demand and supply curves to show the process in v*irtual market* with *circular capital.* We constructed a little more complicated one in STELLA, which is

Figure 7 The schematic construction of simple virtual barter economy in environment STELLA



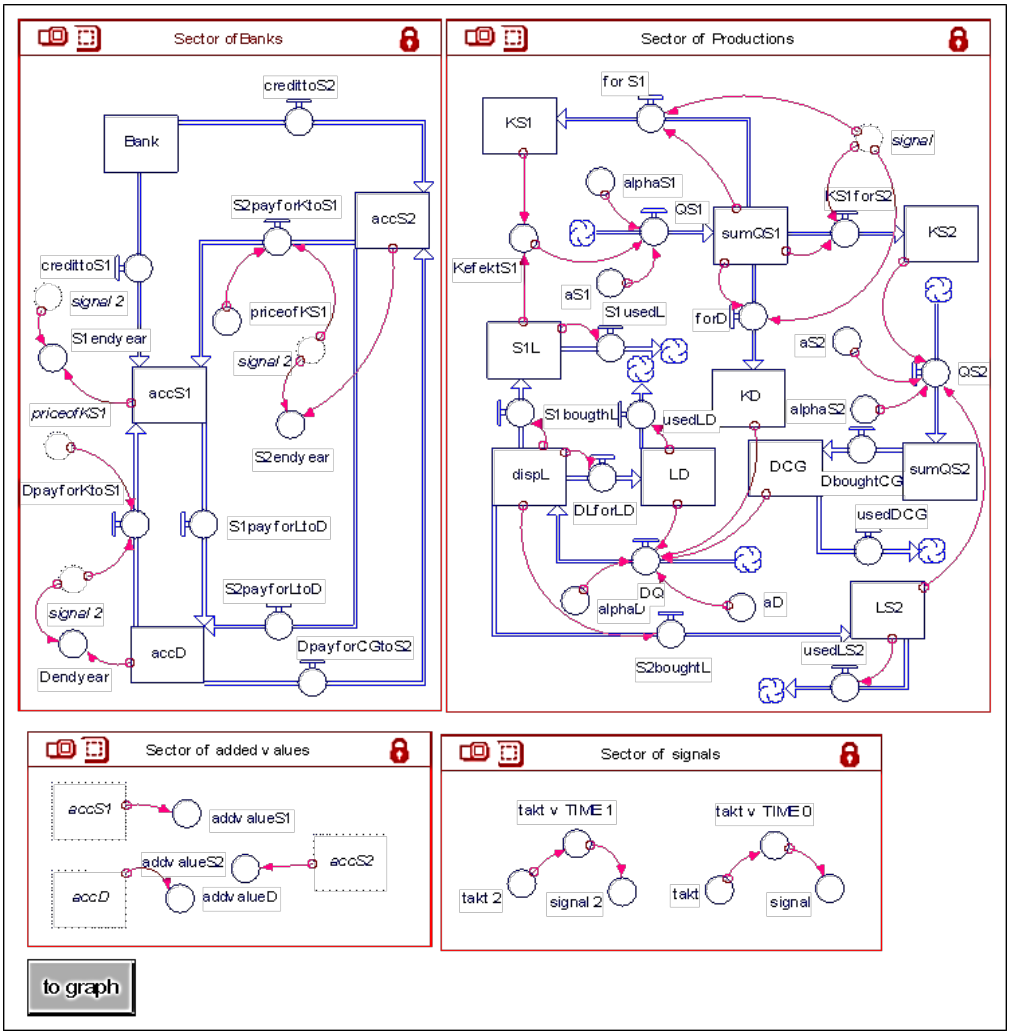
not a complex in sensu stricto[7] model for these purposes, see fig 8.

As we can see in graphs of fig. 10, the distance between *Demand and Supply* is comparatively large so it can be expected that fatal quantitative and qualitative events may be emerging, too (great over/ under production in sectors, unemployment etc.). Economists, of course, are know that demand and supply curves play only the role of figurative tool for creating primeval imaginations

[7] The image of scheme or other drawings may be only complicating not complex as scientific category. The scheme for example in snapshot of fig. 6 begins complex only after we are regarding that in those networks there exist subjects as decision makers and as actors of those decisions. In other words, the complex network are evolving in an unforeseeable way, because of free will of present subjects in the network, that is one can make a rational decision and bad one, too.

of process in the market. Everybody knows that in market in objective reality any such curves exist and the market subject must detect needed information by other subtle devices, methods and tools. *Sector 2* immediately displays that their products are storing up in the finished stock rooms in rising levels. That is a new event in discrete time (one month). In the new situations CEO-s of *S2* enterprises (having no information on demand/supply curves) one after another individually decide to lower their production which results in volume of *Kcirc* supply *66.56* units, not based on artificially created M. Ezekiel's Cobweb theorem (Ezekiel, 1938).

Figure 8: The production part of economy with bank sector added



These decisions of CEOs result again in discrete time events emerging not only in *Kcirc* market but in all markets. In *Kcirc* market emerging not only new price level equal to *30.85* but in further month higher level of entire demand equals to *44.4* too. After reactions in other markets, the wholeness of STELLA *virtual economical network* begins to behave in the view of outside observer as if it was *random complex network* similar to *Erdős–Rényi* model one (1959, 1960). These phenomena are emerging because CEOs in *S2* are individually diminishing the outputs of their enterprises and consequently along with that diminishing their demands resulting in entirety of *S2* demand for *DL, S1Kfix, S2Kcirc* and *S3CG.* Only for evocation of certain needed associations between STELLA process and Ezekiel's cobweb, we haveconstructed in Excel the very case in point cobweb evolution between *straight line Demand dash* and *backward bending Supply curve*, see fig. 12 and fig. 13. The scheme in fig. 9 constructed for drawing demand and supply curves is complicated but not complex in narrow sense.

Figure 9: The construction for drawing curves in STELLA

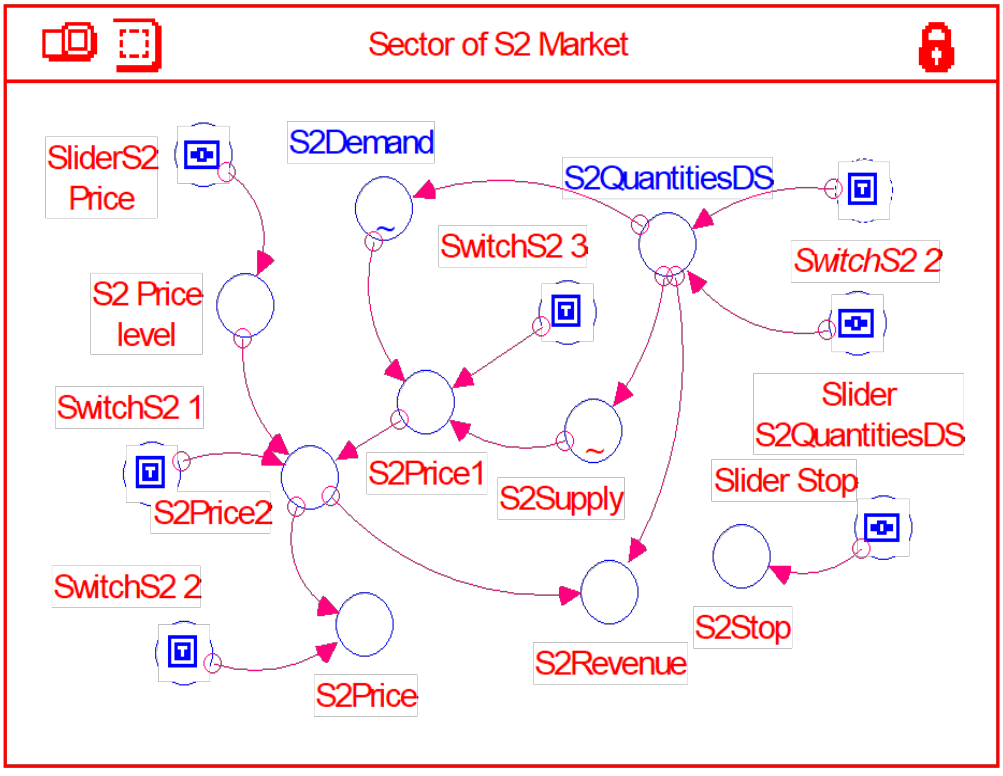


Figure 10: A long distance between Demand and Supply in price level = 50

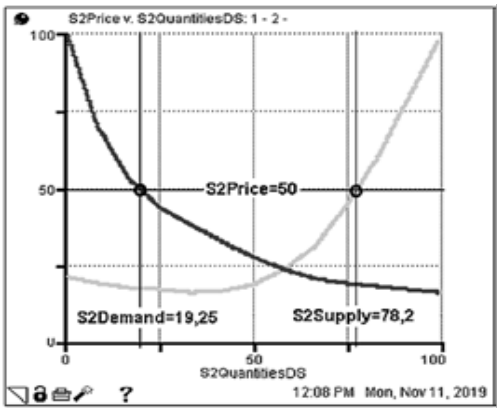
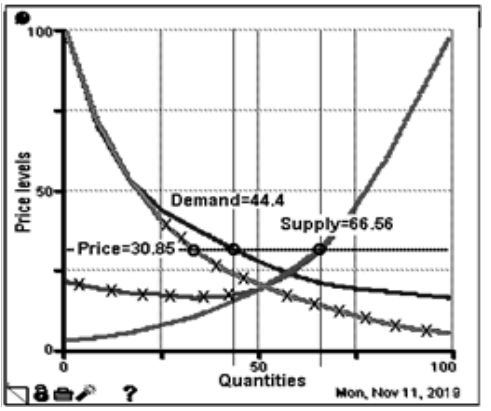


Figure 11: The new situations with shifted Demand and Supply curves



3 A little more advanced virtual Economy in Stella

Self-organizing economy: No external disturbances, not even highly diverse interventions in economic policy from the centre can completely suppress *Adam Smith's invisible hand* but they can cause serious damage to economic development.

Let us construct a little more advanced virtual economy which better corresponds to the idea of *complex network*. However, in this new case we are going out from the same neoclassical theoretical positions and our methods and tools as before, too. We have created virtual economy consisting from four sectors: *S1- Kfix; S2-Kcirc; S3-CG* and *Households-L.*

Figure 12: The dense cobweb (deterministic chaos) on the left; the time evolution on the right

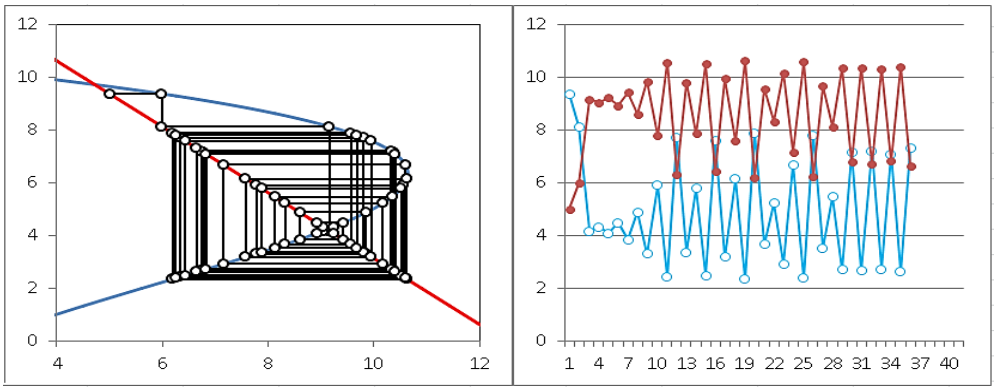


Figure 13: The conventional cobweb – evolution to equilibrium – created in Excel

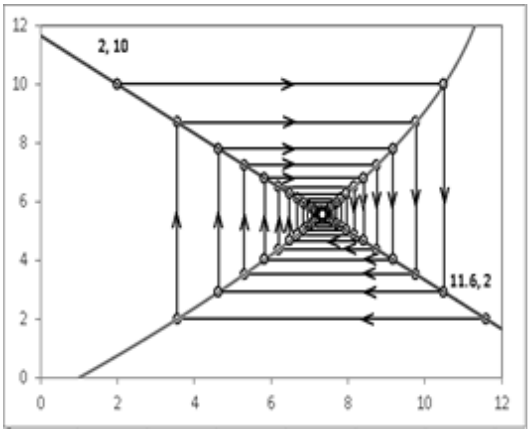


Figure 14: Price=5; Demand=? Supply=? in STELLA

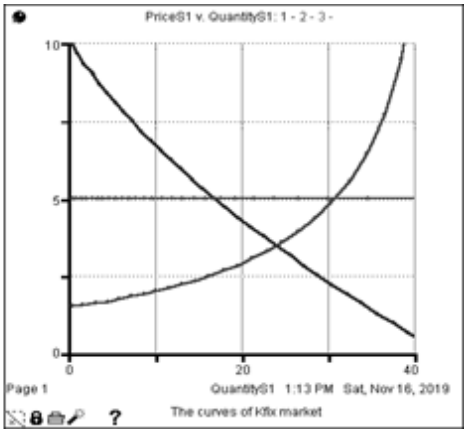


Figure15: Price=5; Demand=9.1; Supply=28.3 in STELLA[8]

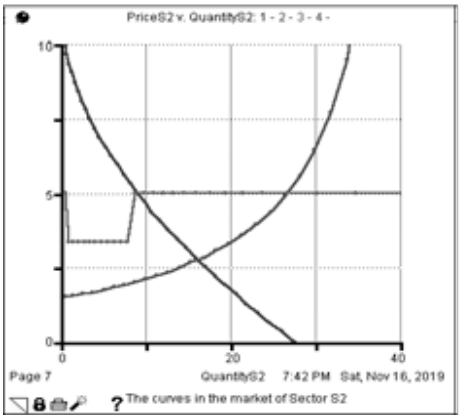
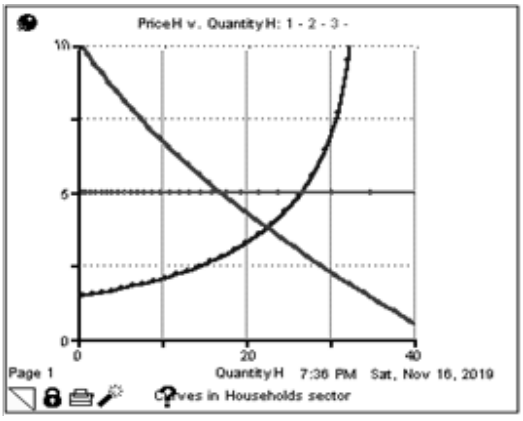


Figure 16: Price=5; Demand=9.1; Supply=28.3 in STELLA



The price of *Kcirc* in the *S2* market reacts to changes in *Kcirc* supplies after some CEO´s remedial measures in production (in this case diminishing of production accompanied by diminishing of demand for *L, Kfix* and *Kcirc*). It is not surprising that the prices will be delayed after realized quantity decisions of CEOs by several time steps, (maybe or maybe not). Even depending on these primal measures, all markets are react because all CEOs and *Households* are taking own related measures based on those changes. These initiates some

[8] Only for smoothed plotting the curves in STELLA, fig. 13 - 16 we need to choose Run Specs DT = 0.0625 (small longitude of steps) and for Virtual economy DT = 1. On the other hand if we need to visualise evolution of price we need to adjust DT = 1 too, see fig. 17. Let you compare the different graphs!

chain reaction in the whole virtual economy. Not at all! In every sector there arise similar events and the chain reaction become multiplicative process with the markets nature being similar to a sea vexing. There is emerging blank right that such complex behaviour in complex network cannot be properly described by the mechanical model of economic growth in the mathematical formalism. Unfortunately, even such simple model of economic growth created by us in STELLA cannot be solved correctly with the help of mathematics, because there are unpredictable of subjects' decisions on volume and in time. As we noted earlier that and other similar STELLA network is similar to random graph due to Erdős-Rényi and in our opinion, that kind of tasks is a too great challenge for mathematics under contemporary theory.

Figure 17: The virtual economy in STELLA with four sectors

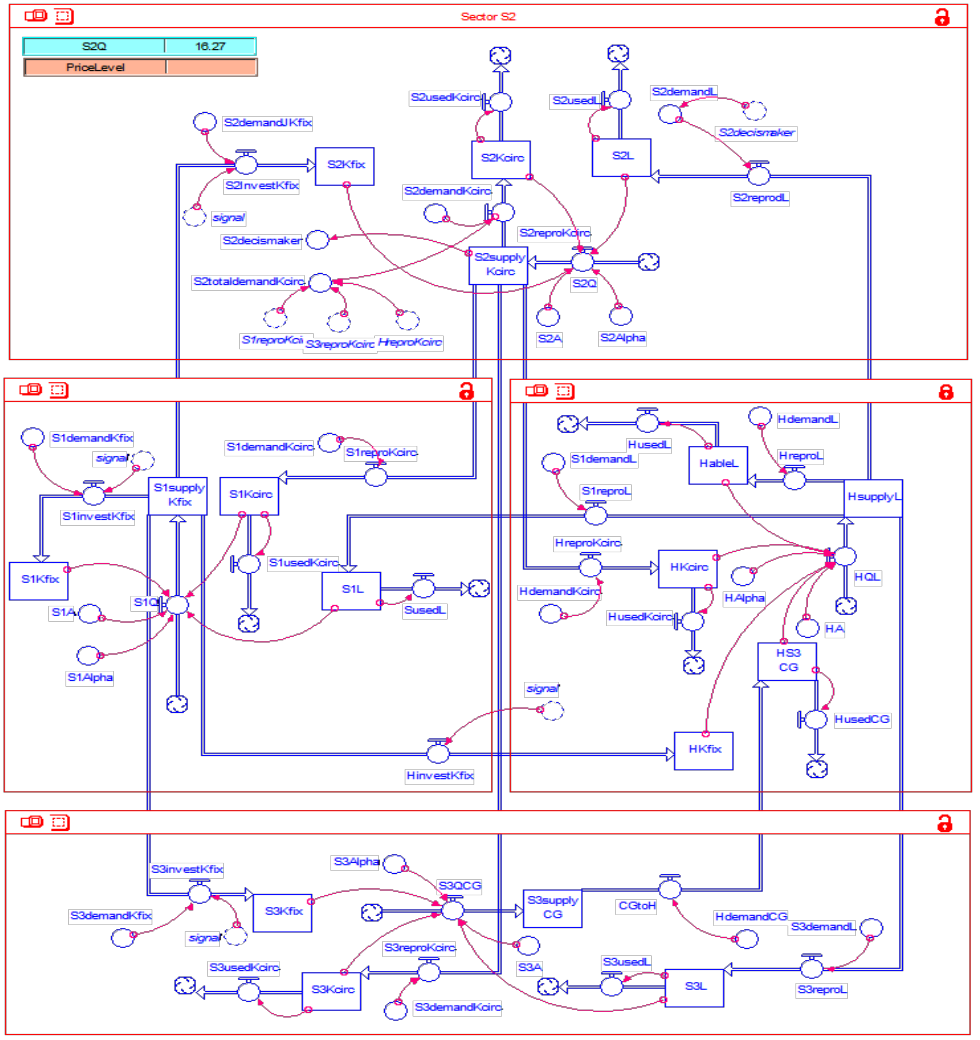


Figure 18: The price fluctuation in two cycles created in STELLA

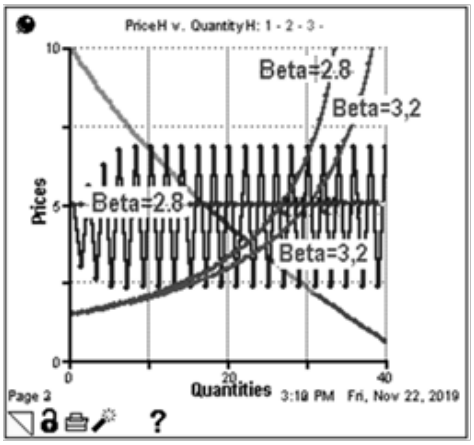
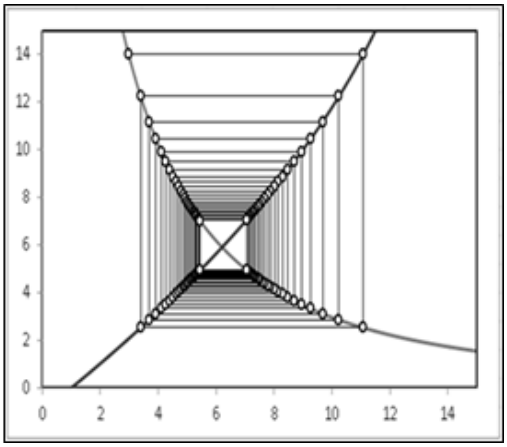


Figure 19: The change of Supply curve because the value perturbation of Beta



Truth of the matter, STELLA network is a little more complex then Erdős-Rényi (1959), (1960) graph because of by subjects (decision makers and actors of theirs decisions) bringing peculiar random perturbation into network, which is furthermore changing in time instants and volumes (different random sequences of random perturbations).

We need to note that there is great difference between cases in which prices are changing based on CEO's decisions and the other case when they are changing upon perturbation of supply curve fashion and/or loci. Let us think about conventional cobweb process and compare it with the process in complex network economy created by us in STELLA again. It is evident that the process cannot evolve as originally imaged by Ezekiel in his fairy-tale world (Ezekiel, 1938). If, for example the situation depicted in Fig. 17 is the case of labour force *L*, in this high level of wage rate the supply of *L* is adequately high; however, firms cannot employ all supplied labour forces (workers), that is, maybe only a small portion of them. In this long distance between demand and supply there occurs very high unemployment in virtual economy. The receipts of households are indeed high resulting from the high level of wages but the gains spread very unevenly among members of households and a lot of people must drastically diminish theirs demand for *CG.* In the consequence, inside the *CG*'s market there are emerging some disturbances and disequilibrium very much like in the labour force market. Even a more complex situation is emerging in all markets if we imagine the case of *backword banding supply curve* of labour forces.

4 Conclusions

In this paper, we were trying to shed some light on ontological, theoretical and methodological imperfections in neoclassical economics and/or mainstream economics by using simple and available computational devices. For easy and good understanding of the situations, we have chosen a relatively simple and in economic community very known theories; namely we focused attention on using for attestation of unconformity with objective reality example of R. M. Solow's theory of economic growth. For that purpose, we use construction of virtual economy in the environment of software STELLA in the form of complex economic network. We have even chosen relatively simple models for the construction in STELLA. The simulation runs clearly show that the emergence complexities in these mode constructed network do not allow us to describe economic growth with simple abstract formulas as Solow did in his theory. Actually, the mathematically astringent dressed mechanical model of economy (as it is used in neoclassical theory of economic growth) cannot serve as the correspondent entity to the economy in objective reality. We are emphasize again that such mathematical models did not accomplish relevant scientific pretensions on correct description of economies in objective reality, which is not a mechanical system but complexly evolving social organism in a multilevel complex network. In this paper we offer another approach to investigation of events, but in virtual economies constructed in STELLA environment. In general, the ontological problems of neoclassical and contemporary mainstream economics is based on the facts that economy is not a mechanical system similar to Newtonian mechanics, not to thermodynamics according to R. Clausius, but a complexly evolving social organism network. In fact, it is known that the economies in objective reality are not directly observable and so cannot be efficiently controlled from one centre. On the other hand, the virtual economy running in computers or supercomputers is fully observable in its motions and on this basis it enables us to draw comparative studies between the virtual and the objective reality. However, the construction of models that allow us to deeper understand how socio-economic networks of interconnections emerge and really behave, and how closely they correspond to objective reality is an area that still needs to be developed. It is true that our paper is nothing more than a poor introductory base for reasoning on suggested complex economic problems. We are aware that several parts of this paper can pose some difficulties for readers because these subjects force them to "read" very strange schemes, graphs and tables with an enormous collection of numbers. On the other hand, if the reader is to master them and

become skilled in deeper understanding of economic behaviour, then they can achieve it only with verbal and formal mathematical fittings.

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