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ПРИМЕНЕННИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА К МОДЕЛИРОВАНИЮ КУРСА БИТКОЙНА

Искусственные нейросети – это современный метод, пригодный для решения задач аппроксимации нелинейной зависимости, который успешно применяется во многих сферах. В этой статье сравниваются возможности прогнозирования нейронных сетей обратного распространения, радиально-базисных функций, экстремальной машины обучения, долгой краткосрочной памяти, чтобы определить, какой алгоритм искусственного интеллекта лучший для моделирования цены биткойна. Критерием сравнения производительности сети было стандартное отклонение, среднее абсолютное отклонение и точность прогнозирования направления изменения курса. Вместе с тем, при изучении временных рядов рекомендуется проводить комплексный анализ данных, используя соответствующие сети в зависимости от длины ряда и специфики базы данных.

Ключевые слова: искусственный интеллект, обратное распространение, радиально-базисные функции, экстремальная машина обучения, долгая краткосрочная память, биткойн.

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THE FUTURE OF MACROECONOMICS: A CYBERNETIC VIEW

This paper outlines many weaknesses in macroeconomic theory today and suggests a way out of the dilemma is to use systems or cybernetic thinking. The paper uses a topical case study to illustrate the authors' views of economics, cybernetics and mathematics. It concludes with recommendations for the future of economics in the 21st century.

Key words Economics, Cybernetics, Mathematics, Knowledge.

1. Introduction

Economics is a young subject, often dated to the publication of "The Wealth of Nations" by Adam Smith in 1776. (Smith 2012) and was an attempt to understand economic reality. Recently, there has been a groundswell of opinions about the poor state of Economics, both in theory and in practice. (Romer 2016, Hoover 2016, Mason. 2016). Among other things, Economics is accused of not being a Science, of using wrong assumptions, misusing mathematics and not being a reliable predictor of events. Some pertinent questions are:

a) Is Economics fulfilling its original purpose?

Is it possible to understand reality? Various views are discussed in section three.

b) Are the tools used adequate?

The major economic tool is mathematics and a prominent methodology is the creation of models., These are discussed in section five.

c) Are the hypotheses (assumptions) used correct?

Hypotheses can be incorrect for many reasons, for example, known facts have been ignored, misunderstood or subject to cultural bias. Such situations can be rectified but what is difficult to handle is when there is no awareness of what is missing – Rumsfeld's "unknown unknowns." (Rumsfeld, 2002)

d) What is the current state of Economic Modelling?

Mason considers Economists more engineers ("homo faber") than scientists ("homo sapiens")? Is their quest to understand how the economy works rather than what it is? (Mason, 2012) There is a difference between theory and practice, Current Economic theory is not interdisciplinary and must involve more research into communication, linguistics, communication, culture, psychology and neuroscience.

2. What is meant by Cybernetics?

The science of Cybernetics arose in the 1940's from the conferences that were sponsored by the Joshua Macey Foundation and ran from 1941 – 1960. Their aims were to pursue meaningful communication across scientific thinking and to unite Science. The first conference, which was entitled "Feedback Mechanisms and Circular Causal Systems in Biological and Social Systems" was attended by an unprecedented network of great minds at the time including Norbert Weiner who coined the word "Cybernetics" (taken from the Greek word "kubernētikós" meaning steersman).(Boem, 2017) It has been applied in the social sciences by many practitioners.

Cybernetics is the science of effective organization (Beer, 1985)

Underlying principles in the science of cybernetics are now discussed:

2.1. Structure causes Behaviour

A basic cybernetic principle is that "structure determines behaviour" (Beer, 1993) Structure is a stable form of interactions that allow people to operate together as a whole In embodied systems, people are constituted as roles. These roles transform disembodied relationships (meaning) into embodied relationships (identity, content and structure) One function of an economist is to determine the prevalent economic structure. This requires knowledge, erudition and experience.

2.2. Ashby's law of Requisite Variety

In the mechanised world, complexity can be roughly equated with size i.e. the more parts there are, the more complex it is. In a systems world, the complexity resides in the connections between the parts. Thus, a very small system can be highly complex – an example would be a

marriage. It is between two people so has only two parts, but experience shows that because of the myriad factors connecting these parts with each other, it can be a very complex system indeed!

Cybernetics defines the complexity of a system by how many different states it can take. This is called the VARIETY of the system. In general, if one considers n objects then there are a possible 2^n different states. Seven objects can generate a variety of 1024. All systems exist in an environment and this environment will generally have much higher variety than the system itself. Ross Asby insisted that only variety can absorb variety and formulated what is commonly known as Ashby's Law or requisite variety.

the variety of the controller must equal the variety of the controlled (Asby 1956)

To control a system, one needs to either increase the variety of the systems outputs or decrease the variety of the environment. These processes are known by "attenuation" and" amplification" This process is often known as "matching the requisite variety".

2.3. Synthesis

The classical philosophers understood the idea of synthesis but the scientific revolution in the seventeenth century, led by Descartes and Newton, introduced the idea of analysis. (Kaplan, 2018)). The notion of synthesis and its power as a tool was all but destroyed. One must turn to Hegel in the eighteenth century for the emergence of synthesis. Instead of analysing synthesis out of existence, he erected it as a higher outcome of the simultaneous existence of opposites – thesis and antithesis.(Baillie 1910)) Subsequently, systems became a means where terms are related and are an integral part of the whole. What were mutually exclusive opponents can now be collaborators Instead of breaking things apart, it is often advantageous to put them together. This posits the idea of a holistic approach to a situation rather than a reductionist one and can be regarded as a fundamental principle of Cybernetics.

2.4. Laws of Organisation

A key discovery of cybernetics is that all viable systems may be mapped onto each other under some transformation. That is a technical way of saying that every viable system obeys the same balancing law of information and energy flow, and that therefore all viable systems have structural commonalities. Five cybernetic processes that are common to all economic systems are Vision, Intelligence, Cohesion, Coordination and Implementation The title of Wiener's book (Cybernetics: or Control and Communication in the Animal and the Machine) emphasises this – the same laws apply to all – computers, servo-mechanisms, corporations, populations of animals. (Weiner, 1948). This is the essence of Cybernetics.

2.5. The Systems Paradigm

Many of the original Cyberneticians were excellent scientists brought up on the Scientific paradigm of Newton and Galileo. But they had come to realise the limitations of such thinking and initiated a new paradigm – The Systems Paradigm. To understand the Systems paradigm, the meaning of the word "system" must be established, the word is used in many contexts such as a set of rules and procedures (typified by the sayings "He is playing the system", "I have a system for making breakfast".) or as an object ("a sound system" or a "computing system.") In the cybernetic context, the word "system" has a precise meaning which is best summed by Russell Ackoff (Ackoff 1971)

A system is a set of parts where no single part has an independent effect on the whole. Thus, a system is a whole that cannot be divided into independent parts. One can say:

- *The essential properties of a system derive out of how its parts interact and not on how they act taken separately;*
- *The defining properties of any system are properties of the whole which none of its parts have;*
- *When the whole is disassembled, it loses its essential properties and so do all of its parts;*
- *In any system, when one improves the performance of the parts taken separately, then the performance of the whole does not necessarily improve and frequently gets worse;*
- *It's the way the parts fit together determine the performance of a system*

The Systems paradigm rests on this definition. It uses synthesis as opposed to analysis and holistic as opposed to reductionist thinking. It also replaces the traditional view of a static state in perfect harmony and/or balance (a mechanical concept) with the idea of homeostasis or dynamic equilibrium. The systems paradigm also encourages interdisciplinarity. Specialisation is regarded as the enemy of true knowledge. The more sub-groups there are in any branch of knowledge, the less chance there is of communication between the researchers. "This "specialised deafness" hinders the spread of knowledge. (Boulding 1956) One objective of Cybernetics is to develop "generalised ears" It can regarded as skeleton on which to hang the flesh and blood of particular disciplines.

3. What is knowledge?

To understand something, it first requires one to know what the thing really is? As Wittgenstein remarks "to know is to name." (Wittgenstein 2000).What actually exists?

3.1. The Realist (traditionalist) View

The traditional view of knowledge rests on the premise that there is an objective reality which exists independent of "homo sapiens". Things exist" and our perception has no influence on them. As Plato wrote in hisTheaetetus

"What is perceived must be there as perceivable beforehand" (McDowell 1973))

If this is so, then our intellectual efforts should be directed to discover what is already there. Knowledge consists of statements that accurately correspond to or match what exists in the real world. Model building is an attempt to produce replicas or copies of this reality. A model is deemed correct if it accurately reproduces what occurs and this results in knowledge. To model a situation, one needs assumptions, rules or procedures, inputs and outputs, all of which require considerable research. The model is adjudged to be "correct" if its outputs (from certain inputs) correspond to known outputs. If there is no such correspondence, several questions spring to mind:

a) Are the rules and procedures used in the model correct and complete?

It is a common adage that "*a model is only as good as the assumptions it contains*." Assumptions are subjective, based on perceptions (both individual and communal) and should be continuously reviewed.

To deal with completeness is more difficult. Modelling is an iterative process which evolves. To immediately construct a model that contains every possible feature that could impact on behaviour is impossible. One must therefore prioritise the importance of features (again a subjective exercise) and build an initial model which is not expected to be accurate but only to serve as a foundation. One by one, features are added, or relaxed, and better models evolve. One is improving the model by adding (or shedding) extra

layers of understanding. At each stage, the model can be checked against known inputs and outputs. There is no end to this process. Isomorphisms seldom occur. Models are calibrated to the accuracy of match that is desired. No model can cover EVERY eventuality and therefore will never be complete.

b) Is the behaviour, that is being modelled, predictable? Research by Argyris into how people behave has shown certain anomalies. The explanation of behaviour (espoused theory) is often different to the "theory-in-use." (Argyris and Schon 1974). This can cause many problems. Argyris suggests two levels of behaviour: a single loop representing self-corrective processes (as exemplified by a thermostat) and a second loop which examines the underlying assumptions (or governing variables). (Argyris, 1991. When human activity is being modelled, roles may not be fully understood, An example is "bounded rationality" – the assumption that decision makers weigh up all actions before making the most rational choice. Recent work in neuroscience has confirmed that decisions are based on both rationality and emotion. (Damasio, 1994) which has resulted in alternative theories such as Behavioural Economics where decisions are taken heuristically. (Kahneman and Tversky, 2018) this may explain why many predicted economic results do not in fact occur. In an attempt to remedy this criticism, economists often add extra assumptions, but this is like moving the deckchairs on the Titanic. If the premise (bounded rationality) is incorrect, and people do not behave as they "should" then the model is incorrect.

c) Is it realistic to attempt to model the situation? Why should it be possible to model every situation? The question should be asking **why** we are modelling something as opposed to **why** we are modelling it, which introduces the idea of "purpose." The definition of a model can be modified to "*a simplified representation of reality* ***built for specific purpose***" The model may have a predictive purpose but how much confidence can be placed in the prediction? If the model is built for the purpose of control, then the outputs must be recognised as possible only if the parts being controlled behave as expected. This is achievable when machines or robots are modelled (excepting for wear and tear) but very difficult when humans are involved.

3.2. The Constructionist View

There is a tradition going back to Protagoras and then Hume and Kant leading to Piaget and von Foerster that defines knowledge as a process not a commodity. (Quine, 2004). Whatever knowledge is, it is not objective i.e. independent of the observer. As von Foerster remarked (1974) *"Objectivity is the delusion that observations could be made without an observer*"

Many cognitive scientists believe in a constructivist model of knowledge (Liu et al, 2005) that attempts to answer the primary question of epistemology, "How do we come to know what we know?" A constructionist reply is that Knowledge is constructed in the mind of the learner. There is a difference between knowledge and information. Information can be defined as the means by which knowledge is acquired. Piaget differentiated between physical, logico-mathematical, and social knowledge. The fact that a hall bounces or a glass breaks when dropped on the floor is an example of physical knowledge. Logico-mathematical knowledge consists of relationships between objects, such as comparing the way racquetballs and squash balls bounce. Social knowledge, such as the fact that soccer is played on days called "Saturday" and "Sunday", is based on social conventions. Learners construct understanding. They do not simply mirror and reflect what they are told or what they read. Learners look for meaning and look for regularity and order in the world even in the absence of full or complete information.

The acceptance of this view of knowledge results in a completely different view of modelling to the traditionalist one. Let us address the same three questions as for the realist case.

a) Are the rules and procedures used in the model correct and complete?

A constructionist does not know what the actual (real) rules and procedures are? There are "black boxes" where certain inputs seem to generate certain outputs. The workings inside the boxes are not known for certain. On this basis, any model is a subjective representation of the reality and it is difficult to conclude if they are complete or incorrect.

b) Is the behaviour, that is being modelled, predictable?

For any complex system, the constructionist view is that the outputs are unpredictable as the cybernetic paradigm is not deterministic. Von Glasersfeld (1989) described the construction of knowledge as a search for a fit rather than a match with reality. This is this difference (between the concepts of "fit" and "match") between constructivist and the traditional view of knowledge. In the traditional view where knowledge corresponds to or "matches" reality, two or more individuals with the same knowledge must have similar copies or replicas of reality in their minds. If knowledge "fits" reality, then this introduces subjectivity. Each of us builds our own view of reality by trying to find order in the chaos of signals that impinge on our senses. What matters is whether the knowledge we construct functions satisfactorily in the context in which it arises

c) Is it realistic to attempt to model the situation? The question of purpose must be addressed. The model is a construct of what exists in one/s head. The constructivist purpose is to further understand, to increase knowledge and to make sense of the situation. This is always worthwhile.

4. A Case Study

The case study involves Brexit The following statement is from the BBC website.

Economic growth tumbled to its joint weakest in nine years at the end of 2018 as the UK joined the slump that has spread across much of the eurozone. GDP rose by 0.2% in the three months to December, slowing from 0.6% in the previous quarter. It takes growth for last year to 1.4%, the same level as 2012 and the joint-worst performance since the recession of 2009. The picture is not expected to improve into 2019.

It is chosen as to illustrate many of the points made so far in this paper.

4.1. Observations

1. Terminological Inexactitude

What is GDP? Is this the total value of goods and services (‘output') produced, aggregate income or aggregate expenditure? This confusion can be used to manipulate statements.

If one accepted an accuracy of half a percent in the UK GDP, then the uncertainty is £10 billion which is more than twice the quoted drop!!

2. Inflammatory remarks

"Economic growth tumbled. "Is there a need for the word "tumbled"? especially when it has been pointed out that this figure is highly questionable as it is dependent on incomplete statistics. Because of the Paris Accord, diesel cars are being phased out and sales are down. More hybrid and electric cars are coming to the market. Such behaviour will impact on GDP but is simply a reflection of changing markets.

3. Mathematical misuse

Growth, percentage growth and growth rate are often misused. This obfuscation between the three terms initiates many false conclusions

4 Questionable Assumptions

1. *"When GDP goes up, the economy is growing – people are spending more and businesses may be expanding. For this reason, GDP growth is a key measure of the overall strength of the economy."* This not necessarily true. If one takes the income measure, then one cannot draw this conclusion. Even taking the spending definition, a changing GDP could reflect levels of investment. Germany has a good GDP growth, but as the German people are naturally savers, spending did not increase.
2. *"… as the UK joined the slump that has spread across the Eurozone*" There is no justification for this remark. There is no proven relation that would correlate UK GDP to EU GDP. The EU have a different currency and many problems are caused by the management of this currency over 20 countries.
3. It is natural as the date for BREXIT grows close, that business are not investing. This is a political decision and not an economic one. Therefore, economic conclusions should not be drawn.
4. There is an assumption that there is some correspondence between GDP figures in previous years. Why should this be so. A major development in UK is the rise of technology and the uses of big data. This is exponentially growing from year to year. One would suppose that this should increase the GDP. but it takes time for new procedures to embed themselves and so the full impact of e technological change may not be reflected in present GDP figures.
5. Questionable Predictions

   The picture is not expected to improve in 2019. What justification is there for this statement? The term GDP is an aggregate of many interconnected parts. Its behaviour is thus not predictable but "emergent"

5. Economics for the 21st Century

The authors' opinion is that economics should be based on cybernetic principles and should involve a new ethics.

5.1. Cybernetic Principles

In 1968, the IS-LM model that Hicks (1937) had extracted from Keynes's *General Theory* had become the reigning paradigm of macroeconomics. Leijonhufvud (1968) proposed a radical reform of macroeconomic theory that would focus more clearly on the adjustment processes of actual economies Instead of a Walrasian approach, Leijonhufvud proposed what he called a "cybernetic" approach, one with no presumption that the system is in an equilibrium state. Such an approach would model the economy as an algorithm that determines how the state evolves from any given initial position. The "state" includes the transactors' initial information, beliefs, expectations, established trading relationships (especially in the labour market), endowments, debts and other contractual obligations, financial and real assets, and so forth. The approach would specify the set of possible actions that each transactor could undertake in a given situation, and behavioural rules for choosing among them. It would also specify the institutional framework within which exchange and production take place, and that framework would imply outcome functions determining what happens given any set of actions selected, in any given situation. Included among those outcomes would be changes in the variables defining the state of the system. It is indeed the start of a cybernetic approach which this paper is developing.

5.2. Cybernetic Processes

There must be a shift from the underlying and dominant scientific paradigm to the systems paradigm (which includes cybernetics). The scientific paradigm used by economists gives the wrong priority and emphasis to mathematics. In the last few decades, there have been significant advances in mathematics that now allow stochastic data to be analysed and reasonably accurate trends to be discerned (Bayesian Analysis, Kalman Filters, VAR-regression techniques). Economics should continue to embrace these developments. And this is a good use of mathematics. What is now possible though is the inclusion of much more data. Instead of just economic data, the new Artificial Intelligence techniques can be applied to accurately analyse decision making under that involves political and social factors which can only help the economist. What is not correct and should be changed is the positivist thinking of mathematics. Mathematics is designed to give exact, precise answers and Economists should not attempt this (as in the case of Osborne above). Economics should move towards more qualitative analysis which is interdisciplinary and predicts trends and possible futures with appropriate health warnings. The reaction will be that governments, businesses and companies need figures in order to plan their investments. This is true but the figures that are calculated using the scientific paradigm are not correct and this has been shown time and time again. Plans can still be made on the basis of probable trends

A interesting paradox is that as economics begins to use mathematics more scientifically, it can become less of a science and more a useful body of knowledge.

Over the centuries many different interpretations of how economies work (Classical, Keynesian, neo-liberal) have been developed by great minds. It is not suggested that these are discarded but all recognised as interpretations of reality. The problem has been that these interpretations have become dogmas and attracted zealots. Thus, there is an unhealthy competition existing inside the economic community. This is in contrast to the stable and successful management accomplished by ants and bees i.e. cooperation rather than competition. This would be a major help to the advancement of economics.

5.3. Social Context

Economics does not exist in a vacuum. Decisions, investments, hire of labour, inequality, supply and demand, all have to be interpreted in the context of the times in which we live. In the last ten years, there has been revolutions in how homo sapiens sees itself in relation to each other and to the environment. There have been significant changes in the role and the status of woman. There is a seemingly unstoppable drive towards gender equality and diversity. The planet is now perceived as being in danger and many laws are being passed such as the one on the use of diesel fuel, recycling and resource exploitation. All these have significant effects on the economies of the world and can only be accommodated by Economic Theory by taking a more interdisciplinary, holistic approach. Because, many economic predictions have been wrong (by orders of magnitude), this has fed the general mistrust that the public is developing for the views of experts. This is a dangerous

development and must be discouraged but can only be done so by more judicious predictions which can be recognised as being in tune with current social mores.

5.4. Ethics

The whole idea of growth must be repackaged. Instead of Gross NATIONAL Product, emphasis should move to GLOBAL Natural Product i.e. an emphasis on sharing the wealth together. Economics must be seen as a way of achieving this goal even though it might never be reached at least in a short period of time. This fits with the holistic nature of systems thinking – looking at the big picture.

Also, the emphasis on growth has been used too indiscriminately. Different organisms should have different priorities. For businesses, creation of wealth is important, for governments it is important to manage deficits but there are organisms such as universities which need different definitions of growth. It is regrettable that concepts of treating them as businesses and all that entails have developed. One could argue that it is not the fault of economists that universities have adopted a questionable model and are using business economic theory, but economics does not do enough to prevent this. Economics has to lay out the ethical consequences of its theories. Economics is seen as a detached amoral science, but humans are moral creatures. To obtain the trust of the public, morality must be brought back into Economics. One purpose of economics is to provide plans for effective management but there should be an underlying message of prosperity for everyone. Unfortunately, as wealth inequality grows, economic theory is seen as complicit in this growth.

6. Conclusion

Problems concerning macroeconomics have become more apparent since the economic crisis of 2008 which was not predicted by econometric /forecasting models and was difficult to even explain using the new classical macroeconomics theories prevalent at the time. This illustrates a gap between what is being practised by governments and what is being taught in universities. It therefore goes to the heart of the problem with Economics – is it an explanatory tool of possible realities or, does it dictate economic policy making?

As an example of economic practice, to resolve the 2008 crisis, governments began to use economic policies that current academic theory rejected as incorrect. Mason(ref) argues cogently how leading New Keynesians (Stiglitz, 2017) resurrected previously rejected policy models relating to inflation, monetary policy, unemployment, liquidity traps and the effectiveness of fiscal policy to reinterpret the core of the 2008 global crisis. Stiglitz (ibid) argued that such a volte face was necessary as the modern new classical orthodoxy ignored behavioural economic issues and placed too much reliance on representative agent models (such as DSGE models) (Solow, 2008). Mason (ibid) showed that the USA moved from an ineffective balanced budget fiscal policy, to a policy that used deficit finance as a core lever in the alleviation of unemployment and GDP instability. So, within a 5-7-year gap, fiscal policy in the USA (so heavily criticised by previous Councils of Economic Advisors) was seen as vital for stabilisation policy. This was a U-turn on a major scale. The gist of Mason's case, behind this policy reversal is that the gulf between theoretical macroeconomics and its empirical / policy counterpart is so immense that they seem to two separate sub disciplines.

This paper takes a slightly different view. At the heart of the Mason's paradox lies the perception of what economics is. If it is regarded as a positivist theory (with definite and well-defined economic reasoning) that uses Newtonian scientific thinking, then problems will escalate. The academics are seen as presenting the practitioners with a set of rules and procedures for solving their problems and when they fail to work, their names and sub discipline area are besmirched. A negative feedback loop develops where the reputation of Economics declines and, if not corrected, result in its death. (Omerod, 2001)

The paper proposes and justifies a change in perception. Economics should use the systems paradigm, which is interdisciplinary, holistic, more qualitative and abductive rather than inductive. Typical of this approach is the Santa Fe Institute who recognise the complexity of social phenomena which can produce unintelligibility and the unpredictability in the behaviour of socio-economic systems i.e. there is no one answer to a problem and the task of academics is to explore and present alternatives. The new perception should encompass:

- A new approach to growth – cooperation AND competition;
- A redefinition of inclusion – the global economy;
- New labour relationships – algorithmic management;
- Impact of technology especially analysis of data;
- Cybernetic models of regulation and control.

The new economic thinking must unleash the potential of regenerative design in order to create a circular, not linear, economy – and to restore ourselves as full participants in Earth's cyclical processes of life.

Economics is currently regarded as a detached amoral science, but we are moral beings. Morality must be at the centre of economics in order for people to relate to and trust it. Cybernetics shows that deeply ingrained, reciprocal moral behaviours are the glue that holds society together. Understanding the economy as not just an amoral machine that provides incentives and distributes resources, but rather as a human moral construct is essential, not just for creating a more just economy, but also for understanding how the economy actually creates prosperity.

Mathematicians can disagree about the results of their theories and indeed this is how mathematics develops but Economic disagreements are ultimately unresolvable. There is no reality to test them against. There is a danger that Economics becomes self-indulgent and seen as clever people playing in a vacuum. It should not be forgotten that economic decisions play a very important part in our lives. Should economics keep with its utilitarian stance where it is about maximising the common good or is there a deontological aspect where duty, obligation play a role? Until recently, moral actions by agents played no part in Economic theory. Perhaps it is time that this changed. Economics should not be seen as "competencies without comprehension" (Dennett 2016)

Economics should be regarded as an intelligent attempt by intelligent people to interpret social behaviour. It does not recognise that there are definitive economic models and thus rejects the determinism inherent in Mason's case. Practice is a consequence of theories not theory. Economics should offer practitioners of economic policy-making, a raft of different models, each with its own assumptions and constraints and none of them presented as the undisputed cause of events. The practitioners will use their judgement to select the theory that harmonises with their weltauunschaum. As history unfolds, circumstances change, and different economic models will be needed. Economics as a subject evolves and develops. When practitioners change their economic models. it is seen as a natural consequence of systemic behaviour. It will reflect on the advantages of Economics and be to its benefit not detriment as an academic subject.

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МАЙБУТНЄ МАКРОЕКОНОМІКИ: КІБЕРНЕТИЧНА ОЦІНКА

Окреслено багато слабких сторін у сучасній макроекономічної теорії і запропоновано як рішення використання систем або кібернетичного мислення. За допомогою актуального дослідження проілюстровано погляди авторів на економіку, кібернетику і математику. На закінчення наведено рекомендації щодо майбутнього економіки у 21 столітті.

Ключові слова: економіка, кібернетика, математика, знання.

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БУДУЩЕЕ МАКРОЭКОНОМИКИ: КИБЕРНЕТИЧЕСКАЯ ОЦЕНКА

Очерчены многие слабые стороны в современной макроэкономической теории и предложено в качестве решения использование систем или кибернетического мышления. При помощи актуального исследования проиллюстрированы взгляды авторов на экономику, кибернетику и математику. В заключение приведены рекомендации относительно будущего экономики в 21 веке.

Ключевые слова: экономика, кибернетика, математика, знания.