Why is Algorithmic Theory a Necessary Basis of Economics?

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Abstract

This paper is a complementary explanation of the World Economics Association (WEA) 2019 "Going Online" conference paper "How Could Cognitive Revolution Happen To Economics? An Introduction to the Algorithm Framework Theory".

Key Words

Bounded Rationality; Instructions; Algorithm; Combinatorial Explosion; Subjectivity; Mental Distortion

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[1] This article, originally written in Chinese in 2017, has never been formally released before. The sites of Bin Li: https://binli.academia.edu/ https://www.researchgate.net/profile/Bin_Li197 http://blog.sina.com.cn/libinw (in Chinese) Email: libinw2011@163.com

Algorithmic Theory, or "Algorithm Framework Theory", has been around for more than eight years since the original Algorithmic book "A Theory for Unification of Social Sciences: Algorithm Framework Theory" (in Chinese, Bin Li, China Renmin University Press, 2009) was published. Many readers don't understand what I'm talking about. The difficulty of communication has been beyond my imagination. Bo far, I can say, no one has fully and accurately understood the Algorithmical principles and method. In fact, Algorithmic Theory itself shall be very simple. The difficulty, as Keynes put it, shall be that old ideas are so stubborn and so messy that when a coherent and unified system is given, each reader grasps only a part of it rather than the whole. Different readers' minds are locked in different errors. Only by cleaning up the errors one by one, and getting through the joints one by one, can we finally come to this simple and unified "Algorithmic World". Of course, another responsibility for poor communication lies with myself. The three published books are all too simplistic in language and a little too glib in expression. Limited to their lengths, the introductory papers are also uneasy, not as good as speaking in plain English! Therefore, I write this article again, in order to re-introduce Algorithmic Theory in the vernacular, and also to freely tell those that are not fit for formal writing, but actually must be said. "Algorithmic Economics" would be the beginning of a significant knowledge in the new century, thus, no matter how many words are said, they shall not be deemed "enough", but merely the preludes. Those who have mastered it first will start.

I. The Plight of Economics Comes from the Lack of a Thinking Theory

1.1 Microeconomics and Macroeconomics

The key obstacle to understanding the importance of Algorithmic Theory is that it has not been generally and deeply recognized that the plight that economics has been in is, in short, the lack of a proper theory of thinking. It is generally unknown how a person thinks. The thinking structure, manner, process, result, state, etc. are all specious in principle. Looking at the history of economic theory, as well as the whole economics circle composed of the mainstream and the non-mainstream, it can be realized that this is the root of the disputes, divisions and confusions thereof. Some scholars may agree with this view in part, but I am afraid it is far from comprehensive and in-depth understanding. Therefore, it is necessary to expand on this point first.

The core of mainstream economic theory is to describe or infer how people's decisions are made. In fact, it is to infer conscious activities and assume that people's actions are controlled completely by consciousness. In other words, its research objects are actually the human minds. Why is there a certain phenomenon in the economic society? The reason lies in the actors concerned to do a certain behavior. Why does the actor do a certain behavior? The reason is that s/he has a certain thoughtful activity. This's what mainstream theory means. When the mental activities reach the highest level (i.e. equilibrium) that it can reach, the decisions are made and the actions happen accordingly. This is well known. But the question is, why does the human brain make mistakes? Why are there "irrational" decisions? And, strikingly, why does innovation happen? "Innovation" in particular refers to a situation where what was thought to be the best practice in the past is no longer thought to be the best and the actors change their minds. To which the mainstream scholars respond: it's caused by new information, where less information used to produce lower levels of decision making, more information now produces higher levels of decision making. This answer seems plausible, for it has much to do with people's experiences. However, one of the functions of calculation is exactly to make predictions i.e. foreseeing new information, hence, why shall new information be anticipated for its arrival, or be collected, instead of being foreseen? This is a question that might get fewer meditations. Once it is raised, the mainstream will fall in big trouble. This causes further questions: If so, how far can it be foreseen? Is it possible to, based on limited information, predict all the information in the future, whatever near or far? If yes, what shall be the "limited information"? These questions may seem strange, but they are logically hard to avoid. The essence of mainstream theory is that it denies that the information processing methods (i.e., the "Algorithm") can be innovated solely; this denial is contrary to common sense and one-sided. For the purpose of decision making, the effectiveness of new information is obviously unstable, sometimes increasing, other times decreasing; sometimes people shall put aside their pen and paper and go outside to collect new

information, other times they shall immerse themselves in processing existing information at home. Clearly, economics needs a unified theoretical framework to be able to explain all these phenomena.

That's the problem with microeconomics. In the history of economic theory, macroeconomics emerged in different styles; it is not only popular, but also quite practical. However, it can be said that microeconomists have not yet understood the mystery of macroeconomics, and that the split between the macro and micro is only an external manifestation of this "incomprehension". To understand this disconnect, we need, in particular, to look at how macroeconomics differs from microeconomics.

The first is the difference in vision. Microeconomics looks inside an economy, whereas macroeconomics takes a step back and looks at the economy as a whole. Macroeconomics, in turn, draws on raw materials that are different from microeconomics, which starts with statistics rather than the information (such as prices) that can be obtained from micro-scenarios. What is the essential difference between these two ways of starting? It is difficult to see the difference from the angle of perfect rationality, for we can assume that the microscopic actors are capable of obtaining statistics, and that the macroscopic actors (such as the macro-control officials or macro-economists) are also capable of seeing or foreseeing the details in the microscopic world. Yet the fact that the macro and the micro don't integrate suggests that economists don't really understand things that way; Or, even if they assume perfect rationality, in fact they don't fully implement perfect rationality in specific studies. Macro and micro economists are consciously or unconsciously going along the line of bounded rationality. This needs to be emphasized. If we view them from this angle, it makes more senses. Respectively, doesn't macroeconomics emphasize the characteristics of human irrationality ("animal spirits"), the imperfection of the market, the necessity of government and macroeconomic policies, etc., just to illustrate the various consequences and manifestations of bounded rationality? The same is true of microeconomics, where the theoreticians always deduce from some easily available materials that are close to the reality, and the actors are required to calculate information by reasonable methods. In fact, microeconomics does not assume that the actors know everything. If knowing everything, why calculate? Also, it doesn't assume that the actors can solve anything. To get the actors to solve the equations, the economists themselves must first solve them in a way that every reader can agree on and carry out.

This leads to the argument that the agreement or conjunction between microeconomics and macroeconomics is to regard human reasoning as finite, to show how the thinking activities operate on a limited scale and intensity -- and thus the results can only be limited and imperfect. It is not enough to have limited sights (and thus limited access to information), but also limited computing power -- both are necessary. They have observed, analyzed and described different parts of the economy. "Macro" is also a "local". It is like looking at the ground from a high altitude, the range of view has been larger, but the details have become unclear. Because the objects are different, the conclusions cannot be completely consistent. Make this truth clear, macro and micro but consistent up.

1.2 Institution and Organization

The government was mentioned above. Government means the existence of institutions and organizations. Free markets need to coexist with institutions and organizations, which is traditionally a big issue. What exactly is an institution? Some people imagine it as very mysterious, but an institution is just an idea, something in the mind, not something physical or external to individuals. This category needs to be clarified first. For example, when we say the word "government", we might think of a governmental building. But "office building" is not the essence of a government. Without office buildings, can government officials exercise the governmental power? Do citizens recognize them as officials? The answer is clearly yes. The reason why a government becomes a government is that it is based on a contract between the officials and the public, and this "contract" is the idea in the mind. People's thoughts, or knowledges, take many forms. Some knowledges are cognitive. For example, "that is a mountain" is cognitive, making listeners know something. It may indirectly lead to decisions and actions, but not directly. However, the knowledge of "stop going ahead when the red light turns on" is decisive, telling people what to do if something is triggered -- although it does not represent the basis of the

cognitive knowledges to do so. Cognitive knowledges and decision knowledges are both interrelated and distinct from each other, and because of the finiteness of reasoning they are often disconnected, rather than coherent and matching one-to-one. The general idea of mainstream neoclassicism is that one can begin with cognitive knowledges and proceed all the way straightforwardly to decision making. As a result, we have been accustomed to not distinguish the types of knowledge and ignore the characteristics and independence of different kinds of knowledges, so that we finally ignore the categorial point of "institution is just a kind of thought or knowledge".

Since an institution is an idea, it is worth considering that institutions are included ontologically in the framework of economic analysis. Notice how institutions work in economic analysis. When theorists say that actors behave "within the framework of institutions", they are thinking of institutions as something like capital stocks, whereas the "behavior" as a flow. So, one idea that can be distilled from this is that the existence of institutions requires us to develop a theory about both thinking flows and thinking stocks. What to do? Naturally, it comes to mind the concept of "Roundabout Production Method" proposed by Böhm-Bawerk: due to the limited capacity of flow activities, the stocks of capital must be built up first in time, and then this capital can be used to support productive activities. That is to say, it is necessary to depict how the thinking activity is limited in capacity, and further, the finitude of this capacity needs to be depicted in the space-time environment -- because the issue of time sequence has happened thereon, and the word "stock" means "to store something somewhere", which contains the factor of space. Now, it can be said that a relatively important breakthrough has been made.

The situation that "the mind operates within the institutional framework while the institutions themselves remain unchanged" reminds us that there may be some conflicts between the stocked institutions and the thinking activities. Because, in the mainstream neoclassical analysis, whatever variables, as long as they are "thoughtful", must be fully flexible. Moreover, a change of one variable usually leads to the changes of other variables. The fact that some variables change while others remain the same shall be strange to those accustomed to mainstream thinking. Why is that? When we think about it, we find that the reason lies in "bounded rationality": the thinking power per unit of time is limited, so thinking takes time. It is difficult for the actors to control the situation that all variables change at the same time, hence only some variables are allowed to change, and the rest are assumed unchanged. The resulting conflicts are bound to cause the failure of neoclassical optimality.

The natures of institutions as thoughts and as thoughtful stocks, the conflicts and the "non-optimality" are all anti-mainstream findings. Only after these discoveries are made can we further understand what kind of thinking theory the institutional theory requires. Otherwise, the institutional puzzle will remain unsolvable and the importance of Algorithmic Theory will remain unknown.

The above logics can also be applied to the organizational theory. An organization is, of course, an "institution-intensive" place. It is established according to certain institutions, and it runs its own institutions internally. However, besides those various activities supported by institutions in the organization, there are also a large number of temporary activities that cannot be completely supported by the institutions. These activities are usually carried out in a hierarchical structure. What is "hierarchy"? This is the heart of the organizational problem. In simple terms, hierarchy is a system in which one person controls others and makes them do what s/he wants them to do. According to the neoclassical idea, this shall be confusing: everyone consciously optimizes their behavior, and if the many optimizations match each other, why the interpersonal control and command is needed again? Thus, the first step to solve the organizational puzzle shall be to recognize that organizations are incompatible with mainstream theory and hence organizations have to be endogenized in a different way. Then we think of bounded rationality, and of the conflicts that would, according to the above logic, occur under the condition of bounded rationality: when people think and make decisions freely and consciously, their actions frequently do not match each other; mismatches lead to waste, so someone, through certain means (such as salary & wage payment), make others obey his/her orders, to build interpersonal coordination in a certain range. In this way, even if the commander's will changes frequently, and later commands are contradictive to earlier ones, the many subordinates can still operate orderly with each other. This coordination brings about additional benefits, and by sharing these benefits, the parties interested will be ready and positive to maintain an organization. In short, bounded rationality is

the cause of hierarchy and hence organization.

1.3 Money is an Entity of Thought

Money is another of the traditional puzzles in economics. What is money? It can be said that everyone has been in confusion, the textbooks are also evasive. There is no need for money in mainstream economic analysis. In the era of commodity money, money itself is a kind of commodity, so the question was covered up. In the age of credit money, money becomes only an abstract symbol, partly printed into paper money, so why is it still an important object and existence? Why do commodity transactions need a kind of general equivalent as the intermediary? Why is there the problem whether money is, like a common commodity, more or less, short or surplus? None of these questions have been answered convincingly before Algorithmic Theory. In desperation, the way economic analysis is performed is to "complete" the economic analysis on the assumption that there is no money, then "add on" money, and draw further conclusions. This "add-on method" (or "dichotomizing analysis") is well known among economists. Financial theory was thus separated from economic theory.

Now, let's say that money is a thought or an idea; In particular, it is the thought of "agreement", and the physical object in which the thought is recorded. That's the essence of money. The key is to recognize the thoughtful nature of money. As mentioned above, the thoughts in people's mind have been deemed cognitive generally, despite the decision-making, actional and engineering thoughts that institutions belong to, and money belongs to as well. What they have in common is that they tell people what to do (not what to think), thereby directly playing roles in actions.

One might ask: can't mainstream economics recognize that money is a thought? This brings us to another key implication of Algorithmic Theory, which is that thoughts are entities. What does this mean? In short, a thought is a "thing" like everything else. It can exist, move, and change just like an object (though different in some specific aspects); its presence also takes up space and position, and its motions and changes with speed limits. The bounded rationality, the thinking time, the invariability of one thought when others changing, and so on, can all be explained as the thoughts as entities, or the "substantiality" of thoughts. The words "entity" and "substantiality" are used not to play with philosophical terms, but to express these meanings concisely. The reason why mainstream economics cannot really accommodate money is that it denies the substantiality of thoughts. Why do I say that? This is because mainstream economics has a crucial feature that has been neglected for long time: it assumes infinite thinking speed, or zero thinking time. Ideas come and go instantly, calculations are done in a flash, and optimization is achieved as soon as it needs to be achieved. Not only do calculations not take time, but information transfer and communication do not take time, so social processes do not take time at all. Therefore, when we open our eyes to look at the economy, there will be no thoughts existing in it. The thoughts have gone up in smoke as if they had never stayed in the world, and all that is left is human body movements and other physical processes. Is this simple enough? Recall the famous joke that there must be no lost money on the ground, because if there were any, someone would have already picked it up. The joke is telling that mainstream theory assumes that the processes of information transmission, thinking and communication don't take time, and thus don't actually "exist" -- even though it puts the thinking and decision-making processes at the heart of theoretical analysis. In other words, it studies "nonexistent" objects!

Back to money. Since the mainstream theory excludes the thoughtful objects, it naturally cannot accommodate money. This is because money derives directly from the substantiality of thoughts. Take the general equivalent for example. In the absence of a general equivalent, a price is the exchange rate between two goods. If the exchange rate of the two targeted commodities is not known, it has to be converted according to the known exchange rates between other commodities. And because there are so many different kinds of goods, the conversion usually has to be done many even enormous times. So, how do you solve this problem? One obvious way would be that any commodity's price is stipulated to be represented by an agreed single item. This would save conversion times and costs, as well as speed up the conversion processes. This "single item" is the general equivalent. Thus it can be seen that the direct reason for the appearance of the general equivalent is to save the calculative costs and time; if the calculative costs and time were assumed to be zero, what would be saved? What's the point of pretending to introduce money?

In turn, when thoughts are deemed entities (this is a fact, we just need to admit it, rather than

assume it), not only can the general equivalent be naturally endogenized, and the equivalent must be taken in the hands of actors, under their control, such the actors will feel “safe” (the substantiality of thoughts will obviously cause the trust problem). And, only if a thought is an entity, it can wear the physical cloak such as printed matter or electronic data. Money is actually a combination of a particular idea and its physical cloak. On the basis of this understanding, other factors, properties and functions of money can be further endogenized. Not only can the problem of money be solved, but all the extant problems of economic theory can be solved at once.

1.4 Irrationality, Subjectivity, Uncertainty, Conflict, Plurality, Dynamics, etc.

The above text mentioned the Keynesian “animal spirits”. In behaviorist term, it is called “irrationality”. “Irrationality” is one of the great puzzles of economics, which means that people sometimes make “unreasonable” decisions – despite the “reasonable” solutions that economists have prepared for them. Behavioral economists are keen to collect and “prove” the “irrational” aspects of people in order to “explain” those deviations from the standard theory. A relevant issue is “subjectivity” that is emphasized by Austrian economics. The Austrian economists say that not only are values subjective, but knowledges, beliefs, expectations, and so on are largely subjective. The term “subjectivity” refers both to the lack of objective standards and to interpersonal differences of opinion. A Chicagoan similar concept is “uncertainty.” Some uncertainties can objectively show probabilities, others cannot. Another concept is Simon’s “bounded rationality” that has been mentioned above. It is sometimes interpreted as indicating existence of the boundary of human reason beyond which it is impossible to know or do anything. Finally, it is the turn to evolutionary economics. In contrast to the perfect rationality of mainstream economics, evolutionary economics does assume that human rationality is limited, but developing gradually; over time, smaller capabilities can produce larger results.

Among the senses mentioned above, the evolutionary idea shall be the most appropriate. In Algorithmic language, a theory of finite computational speed is the key to the synthesis of all these concepts. Finite computational speed means that in a given short period of time the thinking capacity is clearly limited, so that the easy questions can be answered while the difficult questions shall be not. Just as important, however, is the fact that, over time, the fruits of thinking are increasingly plentiful. Human knowledges, like crops, grow day by day and never end. This is what happens in the real world. To go further, as stated above, is to regard a thought as an entity or a substance, staying in a particular place, or moving in space, or developing or changing over time. On the other hand, any moving or changing thing in the course of time must always be finite, no matter how big or developed it has grown. In respect to thought, what does it mean to have a finite thought? It means “don’t know”; one must don’t know, or be not sure of, something at any point. This is exactly the “uncertainty” that usually refers to the “uncertain” nature of an object. However, “one palm cannot clap”, what cause “uncertainty” include the actor’s finite cognitive ability, besides the natures of the object, so “uncertainty” is just another word for “bounded rationality”. The same logic applies to “subjectivity” and “irrationality”. Since certain matters cannot be settled desirably and unanimously as scientific problems, “subjectivity” or “irrationality” shall be a forced method, and it may be better to guess subjectively or act irrationally than to do nothing at all. Moreover, “irrationality” is often a variant of human differences and hence subjectivities. It is common for one person (e.g. the economist as an observer) to think that the answer is reasonable, while another (e.g. the observed actor) does not; then the former would say that the latter is “irrational”. Therefore, “irrationality” is not the intentional choice of actors, but the intersubjective evaluation. Interpersonal differences of opinion will naturally cause “irrationality”, needless of other deliberate explanations. And, since knowledges need to grow, due to the many interpersonal differences in age, environment, etc., will everyone’s knowledge development keep pace with each other? Therefore, the interpersonal thoughtful differences are also an inevitable consequence of bounded rationality. Since the thoughtful differences are formed unintentionally as a consequence of time, it is impossible to coordinate neatly with each other in advance, then they are inevitably conflictive somewhat; thus, conflicts or contradictions are also the consequences or manifestations of bounded rationality. Some differences maybe not prominently conflictive, just lacking connections, so plurality or diversity, similarly, is another consequence -- temporarily or permanently.

The thread is almost here: we need a theory that depicts the spatiotemporal existence and

growth of thoughts. The theory will essentially bring together all of the above schools of economics. Unfortunately, evolutionary economics does not offer such a theory, and it is vague on this crucial point. So evolutionary economics, while plausible, has always impressed us with an empty or "phenomenon-on-phenomenon" feeling, rather than a theoretical one. Particularly, evolutionary economics has evaded confronting the assumption of "perfect rationality". The neoclassical framework implies a hypothesis of infinite calculative speed, which evolutionists have not focused on, and on this issue there was no clear disclosure, no refutation, and no alternative. In short, it's not to the point.

By the way, it is clear that this expected theory would also make economics truly dynamic. How cannot neoclassicism, which ontologically excludes the thinking processes, decisively lead to the static economics? The dynamics of thinking is apparently the gateway to the economic dynamics. I believe that this is a view that can be suddenly enlightening.

There are also some remaining questions (e.g. what the long-term prospects of mental activities are, and how equilibrium is reconciled with disequilibrium) to be answered. We'll do that after we give the Algorithm Framework Theory.

1.5 The Absence of Thinking Theory

To sum up, economics needs a thinking theory to explain how information is processed by the human brain, how ideas or knowledges are generated, and how they exist, move, change and develop in a spatiotemporal environment; and, why errors (including deviations, and any imperfect and paradoxical ideas) occur, why and how they are corrected; and, why the marginal benefits of information processing are fluctuating and even reversed; and, how Roundabout Production Method is applied to thinking activities and thereby causing knowledge stocks; and, why the knowledges in different individuals' brains are often different from each other; and, how conflicts arise and how they are eliminated; and, what is the "truth", the concrete meaning of subjectivity and irrationality, and how they develop and change, and so on. There are also some issues not highlighted above, such as the relationship between quantitative and qualitative analysis. Game theory is a demonstration of qualitative analysis, while microeconomics is primarily a demonstration of quantitative analysis. How do we combine them?

However, among all the subjects relevant, there is actually no proper theory on how a person thinks. Some theories are ambiguous, some are merely insinuating. None of them are convictive, clear, comprehensive, concise, or easy to grasp and use. The insight into this fact is startling. Take philosophy for example. Reading through the history of philosophy, we can find that this problem is actually the core problem that philosophers have been exploring since ancient times. Plato's famous idealism holds that knowledges are buried in people's hearts, and thinking or learning is to discover and reveal these "treasures" in one's heart. This view absolutizes knowledges, failing to explain why knowledges develop or change. Empiricism, on the other hand, holds that the human mind is only a "reflection" of external objects and circumstances. This view cannot explain why information does not interact with each other outside of people, but is "reflected" in the mind, nor does it explain why the same information can lead to different conclusions. More convictive in this respect is Kant's transcendental philosophy. Kant, in a very implicit and difficult way, expressed the idea that what were innate in the human minds were not knowledges, but the tools for processing information; these tools interacted with information to produce knowledges. This theory implies that the thinking tools are unique to the external objects and therefore independent of them, so it is a kind of pluralism. However, the mystery is that it can simultaneously accommodate any doctrine that insists on the subject-object consistency (whether the human mind is a reflection of external things or the external things are a reflection of the human mind); for the subject-object difference is only the starting point of thinking, even if they are really and ultimately consistent, the consistency can be reflected in the thinking results sooner or later. This idea of transcendentalism initiated a revolution in the history of philosophy, and roughly, most the subsequent philosophies have been following this approach ever since.

But what exactly are these "thinking tools"? No one seems to know. On the surface at least, modern and contemporary philosophy, psychology, social sciences, and humanities are all falling apart, each developing a vast body of literature, terminology and traditions that are difficult to communicate and integrate with each other. The same goes for economics. Each has its own circle. To publish, you must write according to the habit and style that prevail in your own circle.

Economic theory is becoming more and more diversified. The word “pluralism” has almost become a religion, a political correctness, a “normality” that shall be accepted without careful examination. On the other hand, some people have set their eyes on natural sciences such as biology and brain science, anticipating passively that a “shocking thunder” would happen one day, telling us the truth about human minds. What we fail to see is that, in terms of the purposes and needs of humanities and social sciences, we don’t need to expect the answers from natural sciences at all, which may be helpful in some trivia aspects, but inessential and unnecessary, because the existing accumulated knowledges have already been sufficient to achieve our goal.

II. The Introduction to Algorithmic Theory

2.1 What is the Secret of Algorithmic Theory?

The answer to the thinking theory, I think, is “Algorithm Framework Theory” (or “Algorithmic Theory”, or “Algorithmic Framework”). That is to say, Algorithmic Theory has answered all the above questions so well that it can be satisfactorily deemed a standard solution. I say this for a number of reasons that might have not been recognized by all readers.

Let’s recap Algorithmic Theory. The theory is so simple that it can be expressed in a single sentence: thinking, or computation, is to process the information from the outside world discretely, sequentially, alternately, and repetitively, using the finite Instructions that are innate in the human mind and equal to everybody. To be briefer, thinking means processing information by Instructions, or, thinking = computation = (Instruction + information) $\times$ speed $\times$ time.

This principle comes directly from computer science. It has long been ignored and is now being re-discovered and introduced by myself. Since I have narrated a lot about it earlier, I am going to re-state it here in a different way. Instead of introducing the principles of computers, I am going to talk about it outside of computers so that people who don’t know computer principles can understand it directly. Computers are no big deal, and ordinary readers of humanities and social sciences need not be mystified by them. Conversely, the computer is made by reference to the way the human brain thinks, so it is just an external, visual model of the human brain. For example, 2+4=6, which is the result of thinking by the human brain, or, it’s defined by the human brain. The idea behind the invention of the computer was to represent 2 and 4 by two different electronic signals, and then to combine the two signals into a new one that, according to the same rule as that representing 2 and 4, can be recognized as 6. Such devices shall not be everywhere, but need to be found or designed. When it is found or designed, a computer is thus invented, and all such additive calculations can be left to this device, and then the manual work can be saved. In fact, the way a computer works is mechanical, cumbersome, and unwieldy, it becomes useful only because the electronic signals it uses run so fast that it masks its unwieldiness.

Hence let’s go back to the human brain itself. We can imagine that there are many different organs inside the human brain, each with different functions, representing different Instruction; Or, there’s only one thinking organ, but it can do lots of different actions with information, and these different actions representing different Instructions. Since we traditionally like to find a physical basis for everything, the “organ” or “action” can be seen as the physical basis for an Instruction.

However, Instructions don’t really need this physicalist understanding. Instructions refer to the basic links, units or types of the micro thinking activities of mankind. For example, in the formula 1+2, the + is the Instruction, and 1 and 2 are the data to be processed by the Instruction. An Instruction is not an action of external substances, nor the ordinary action of limbs or biological organs, but the basic action of thinking. Because we’re thinking all the time, most of these Instructions are actually familiar to us. Even if you do not know the details, you must know them roughly. For example, in respect to the addition of mathematics, we all know what it means, and we can do additive calculations, and the same additive calculation usually leads to same result clearly. Do we need to think of addition as some physical organ or some action of that organ? Or do we need to interpret addition as some elementary particles, or some release of energy, or some state of matter? That would be, if any, the understanding of natural sciences, but we need not to. Indeed, Instructions or data are represented by electrons in a computer, and, perhaps, thinking tools or knowledges in the brain are, according to brain science, represented similarly to that in a computer, however, it doesn’t matter for any person to know it or not, because the human mind exists, moves, expresses, communicates and develops in its own unique and special way. Even if a

person does not understand what addition is at first, s/he can get to know it through the inspiration and training of others. The thoughts of different individuals communicate with each other in their own “thoughtful” way. Even if the basis of thinking is really atoms or molecules, the actors may be ignorant of this; the atoms and molecules may be working silently in the background, but the actors in the “foreground” can be completely unaware of this, and nothing will stand in the way of thinking.

This leads to a great concept called “software”. Software is a nickname for thought, but it reflects a breakthrough understanding of the nature of thought that allows us to re-examine our unique human “mind” in a different way – and, it is just the “mind” that re-examines the “mind”. In other words, what is mind or thought? What are Instructions? What is information? We don’t need to see the world, we just need to close our eyes and let the mind reflect on itself. Even if you were to show me the molecules and atoms that lead to thoughts, I would not be able to feel them. But when I close my eyes and think about it, I may know it immediately. For example, if person A disagrees with person B, it is impossible for us to know what it means if we leave the brain behind to understand it in the natural or physical world. It is only by turning round and looking for it in the human brain, and understanding it as a thought, that we know at once what it means. To understand, describe, analyze, and study minds, we shall be not in a “non-thinking” way, but directly in the way of thinking itself. It ought not to abandon the near and seek the far, but to give priority to myself, then from near to far, or from familiar to alien. Instead of using atoms and molecules to explain minds, the molecules and atoms that are used to “explain” minds themselves actually need minds to understand! Thinking is the original starting point for us to understand everything other, hence, we shall not get lost in the objective world we are trying to understand, and forget who we are, even requiring the objective world to tell us the answer. Correspondingly, when the mind wants to perform, it can do so in its own way, without the need to manipulate atoms, molecules, and the like to “think”; On the contrary, even if the manipulation of atoms and molecules (like what a computer does) can really take the place of thinking, this “manipulation” must have been carried out by the mind, and what is at the bottom and in the first place is always the mind or thought.

This is a very important principle for humanities and social scholars. When we study people and the society, if our core goal is to study the mind (or “software”) itself, we shall try to use the “mind’s own method” to solve it within the “mind’s own scope”. That is to say, a pen, a mouth, thinking, conversation, text, and so on should be the main means of study. We can walk into the real world, but we don’t have to walk into the lab of a natural scientist. Although this method is traditional, after the Algorithmical journey in this paper, the understanding of it will be deepened, and will be built in a new form and at a new height.

In the above sense, we can further realize that not only information needs Instructions, but “information” itself is the embodiment of the way in which thinking activities are carried out; it is Instruction that leads to the need for information, and that participates in the definition of information, otherwise we would not know what information is. “Instruction-information” constitutes an interdependent and relatively complete conceptual pair. We have been talking about information all the time when half of the conceptual pair is missing. In the same way, language, text and communication are all the ways that the mind expands itself; without understanding the unique nature of the mind, we cannot understand what these things are. We cannot separate ourselves from the mind to, in a one-sided way and in the absence of a thinking theory, study languages, nor can we equate the mind with languages. Thought is the entity, and language is the expression of thought as the entity. Like money, languages have the content of thought but wear physical clothes. They are all the combinations of the two entities of thought and physical materials.

2.2 How a Person Thinks

Now let’s look at the details of Instructions. Any thinking activity can be deemed the execution of an “Instruction”, such as “Deduce”, “Induce”, “Search”, “Compare”, “Imagine”, “Associate”, “Analogize”, “Abstract”, “Store”, “Recall”, “Imitate”, “Copy”, “Learn” and so on. We can go beyond the computer Instructions and extend the denotation of Instructions to any common verb referring to a mental activity, even despite whether the verb is a repeat of another. Since the number of words is finite, the number of verbs, and thus the number of the verbs referring to

thinking activities, is even more finite. There may be dozens or, at best, hundreds of these common verbs, even needless to list them clearly. Compared to the vast amount of information, even hundreds of Instructions are very small in number. We also don't need to know the details of how these Instructions process information for the moment, as this is what we have to face when we're programming a computer. Under the Algorithmic approach, especially when Algorithmically constructing theoretical principles, researchers think and express much the same as before, where the only difference is the introduction of the concepts such as Instruction, Algorithm – "Algorithm" means the method by which Instructions are used to process information. Algorithmic Theory ensures that we interpret thinking activity as a structure of "Instruction + information", which currently shall be enough to us. We don't pay attentions to the details of processing because we pay more attentions to the consequences of this operational structure. Of course, this ambiguity does not mean that we treat the processing details as a black box. An important source of acceptability for the concept of Instruction is that the meanings of Instructions actually have been familiar to us in the major and substantive terms, where the Instructions are simply pruned and rewritten in the format of the computer language. In other words, the concept is largely a "white box." For example, a syllogistic deductive reasoning has never lost its accuracy because it is not expressed in a computer language. Many aspects of non-computer languages (such as mathematical languages) are quite accurate. Algorithmic Theory, for its most part, is just the old wine in a new bottle.

The "interaction" between Instructions and information can be understood in the way of a computer, or not, but directly from common sense. For example, if you compare 5 and 2, you get 5> 2. For this process, we now need to know that the Instruction used is "Compare", and the data processed are 5 and 2, and the other processes can be directly understood on a daily basis. Although "Compare", "5" and "2" are all entities, we do not need to imagine them as three kinds of physical objects and ask the questions such as "how much the weight and the volume of the total three kinds of objects are", otherwise, we will have set ourselves up for trouble. The mind itself knows that studying the mind does not require answering such questions. Let's emphasize that the substantive nature of thought can be understood with due reference to other types of entities, but it is unnecessarily confined in all respects to the concrete natures of other entities.

People know how to calculate and how to remember. For example, if an important piece of information generated during a computational process needs to be remembered, the actor will usually pay special attention to the information and try to "Store" (as an Instruction) it. The storing process (and the subsequent search for the memory) is actually complicated in computer science, where the relevant knowledges can constitute a specialized course. However, we need not such complication here, just as the actor need not to know exactly how his/her brain stores this information, where it is stored and how it can be searched and "read" when it is needed again -- thus it is successfully "recalled". Anyway, the human brain is able to execute the Instruction of "Store". The human brain can consciously decide whether to do it, know whether it is actually done, and know the result of this execution. This is the simplicity of Algorithmic Theory in comparison with computer science.

The general computational process can be summarized as follows: An Instruction processes 0, 1 or 2 pieces of information each time, which is called an "Operation"; Only one Instruction can be run at a time, so Instructions have to connect sequentially and process information respectively, selectively and repetitively; The results of processing are called knowledges that can be re-processed, stored, or discarded; The human brain can only run a limited number of Instructions in a unit of time, that is, carry out a limited number of computations.

One of the remaining questions that skeptics might ask is: Why is the "Instruction + information" structure only a formal assumption? What hasn't it essentially constrain the human thinking way? The answer to this question can be provided by artificial intelligence which, based largely on computer simulations, have been getting closer and closer to real people, and its news of progresses can be heard from daily news programs. According to the discussion in the previous section, the Instruction set of a computer is a subset of the Instruction set of a human brain, so we can think that at least the part of the human mind that is similar to that of a computer operates in the manner of "Instruction + information". Is there a part of the human mind that is substantially different from a computer? It seems that there are few; And, even if there are many, they are not necessarily inapplicable to the "Instruction + information" structure – as long as they can be expressed as "verb + information" (including the cases that an Instructions plus zero information,

known as an “empty Instruction”). Otherwise, if this structure cannot be satisfied, this would be a failure of Algorithmic Theory, and an Algorithmic crisis would happen.

III. The Implications and Consequences of this Thinking Manner

3.1 The Inferences: Part 1

Algorithmic Theory is naturally a theory of economics and social science hidden in computers. Its arrival has an immediate effect on curing the above diseases. Now let’s answer each of them one by one.

The first thing to emphasize is that the theory above introduces the complete concept of space and time into economics. Instructions, information, ideas, knowledges, and so on are entities, and are discrete, one by one. Any hypothesis about entities usually implies a discreteness (except in the extreme case where the whole world is treated as a single entity) that simultaneously acknowledges space, where relatively independent “things” (entities) are distributed, with gaps between them. The gaps allow one thing to move without “bumping” other things or requiring other things to change synchronously. Relations and interactions between entities may exist to a greater or lesser extent, but they generally do not go so far as to lead us to regard the different entities as one entity. This is obvious common sense in the physical world. Now, we need to bring this into humanities and social sciences, thereby treating the mind (or the spirit) this way. The extant economics and social sciences have sometimes done so unconsciously, but now it shall be necessary to bring this idea to the table explicitly and consciously (meanwhile, please do not forget that the concrete natures of a mental entity is different from those of a physical one).The importance of this approach can be by all means emphasized. Philosophical ideas have integrated with concrete theories here. If you forget this philosophical idea, it can also be naturally revived in the process of concrete theoretical analysis.

Information, Instructions, and knowledges are all distributed in different locations in space. The Instructions are located in the brain, and the different brains, following human bodies, are located in different spatial positions. It is exactly because of the different locations that the problems of information transmission, communication and computation arise. In other words, the problems of information supply, transmission, computation, interpersonal communication and so on are all the inevitable consequences of the substantiation of information; therefore, as long as the economic theory adopts Algorithmic Theory, it is unnecessary to introduce these issues again, and these issues will naturally emerge. The same goes for computing. Information is now no longer a “bachelor”, its counterpart is Instruction; They will seek each other in the space (through human behaviors) and then “interact” with each other. No space or the substantiation, no computations. Information transfer and computing are now also “traffic” problems. In the computational process, information goes into, or out of, specific areas of the brain respectively (such as “Central Processing Area”, “Temporary Storage Area”, “Permanent Storage Area”, etc., which are also necessary according to the above thinking manner), leading to the occurrence of computing. Since traffic takes time, the concepts of computing time, computing speed, and information transfer time are all naturally generated.

The weakness of an Operation (i.e. no more than two data are processed in an Operation) can be used to visualize and concretely interpret the concept of bounded rationality. The finitude of rationality is so evident here that it need not be deliberately emphasized as a dogma. But since computing is now an “act” that can be performed continuously over time, it is clear that human knowledges will grow indefinitely. It may not be possible to know something at a moment, but no one can guarantee that it will not be known in the long course of history. Therefore, there is no such thing as “absolute ignorance” or “pure uncertainty”.

A variety of Instructions process a variety of information, which means that Algorithm Theory has started from plurality. This may seem absolute, but it is distinct from the pluralism assumed by mainstream theory (e.g., the assumption of multiple values of actors in microeconomics). Why do I say that? This is because, for a theory containing thinking processes, the world shall be naturally pluralistic before the theory is developed, otherwise it shall be needless to develop the theory about thinking. Plurality entails inconsistency and problems, and thinking is all about solving problems and thus aligning information (through knowledges). In other words, where there is a thinking or analytical process, there must be plurality in advance, and, if there is plurality, there

will be thinking processes; They are not independent of each other. In this sense, plurality is not even a “hypothesis”, but a synonym of computation. This effect is different from that of the mainstream, as the mainstream analysis, being perfectly rational, shall be incompatible with plurality which, therefore, can only be attached to the analytical process as an abrupt and exogenous “hypothesis”. This view also applies to the plurality of Instructions. An Instruction that computes on information does not necessarily know itself. It takes time for the human mind to get to know itself, just as to know external things. We only know that the human brain has so many Instructions, but we do not know how they relate to each other or whether they can be reduced to a single Instruction.

Just as the tiny body of an individual moves in the vast natural and social environment, the human mind moves as a “dot” on the “plane” of data and knowledges. This is how the thinking flows and the stocks are comparatively coexisting. It is believed that this description can be consistent with people’s common understanding of consciousness. We often imagine our mind moving like a mouse across a much larger screen. The light of consciousness is so faint that it has to use the roundabout method of production to produce its thoughts. This means that, because its ability is limited, it has to pick up a little bit of information at a time to process, and put aside the result, and then pick up another little bit of information to process... thus the resultant stocks of knowledge pile up more and more around it. At a certain time in the future, the stored knowledges might be picked up again, and continue to be processed. The so-called “roundabout” refers to the repeated or cyclical processes between the stocks and the flows. This is like when a factory using raw materials to make consumer goods, it often increases the stock of capital goods and semi-finished products, hence the size of the factory will become larger and larger, and the productive steps will become more and more. In the past, we did not know what the stocks of knowledge were used for in economics, whereas the original information was deduced quickly and directly into the optimal decisions, and any intermediate result was assumed to be discarded at the end of the analysis – because the relevant calculations were assumed to be redone easily to reproduce theses intermediate results in the future. Now that we know that the knowledge stocks come from the limitation of the thinking ability (or the computing speed), we have to build and maintain the knowledge stocks. This shall be economically desirable.

Is it possible that all information will one day be “counted out”? Is it possible that all knowledges will one day be discovered? This is a matter which we must consider at this moment. Nevertheless, Algorithmically, this seemingly complex question is easy to answer. The answer is the “Combinatorial Explosion” principle. This mathematical concept means that as the number of the elements increases, the number of “combinations” that some of the elements can constitute will grow so rapidly that it will soon approach infinity. Thinking is to create permutations or combinations between Instructions and information. Considering that the processed information can be processed again, and that the original information itself is vast and inexhaustible, it is mathematically easy, and quite rigorous, to prove that the knowledges available to mankind shall be endless, and that there is no ultimate, static system of truth! This is probably one of the most important discoveries that Algorithmic Theory can make.

In the light of all the above, let’s look at the natures and states of knowledges. Because of the weak capacity of the computations (“Current or Spot Computations or Operations”) that are made temporarily when facing an urgent problem, the computations shall resort mainly to the stocks of knowledge. This is like, in order to compute, installing programs in a computer. Computer programs are made mainly by other people, while the “programs” in the human brain are made by themselves or others. The greater the quantity and quality of the knowledge stocks, the stronger the ability of computation and problem solving -- and vice versa. There is no any guarantee that computations will be undertaken in the most orderly and efficient manner, or that all problems will be solved correctly and entirely, or that the potentials of all obtained information will be fully explored. In this respect the human mind is the same as a computer. It is conceivable that some knowledge stocks may have been developed deliberately in advance for a specific problem and played (fortunately) a proper and timely role in solving the problem. However, other (probably more) knowledges cannot be expected to work in this desirable manner. Whether or not the actor realizes that the possibilities of knowledge are endless, s/he can only do so for the time being, even reluctantly. Some knowledge stocks may be formed in the process of solving other problems, and be saved only from wastes, and re-used to solve the problems that are different from their origins. Some knowledges are formed in place A and time A, and are forced to apply in place B

and time B. Some knowledges are gained by hearsay, or by mistake, or by accident. Since the calculations that can be performed in any period are limited in number, the knowledges produced and thus available at any point cannot be expected to be complete, they shall not be a well-integrated and rigorous system, but a mixture of good and bad, and of mistakes, lapses and disappointments. What is right and what is wrong? Since the function of each Instruction is assumed to be specific and immutable, when it is used for processing specific information, the problem of matching occurs -- either the Instruction does not match the information, or the information to be processed does not match another information to be processed, and so on. This is a necessary effect. If certain processing methods are defined as “right”, the different or opposite methods can be deemed wrong. In this way, the concepts of “right” and “wrong” endogenously come into being.

In short, the knowledge system (including book knowledges and practical knowledges) is an imperfect mixture, and this “imperfection” and “mixedness” may exist in any dimension, link, or category of knowledges. Where there is more computing energy invested, the knowledges produced may be more developed; Conversely, the knowledges will be poorer where less energy is invested. The knowledges, like the grasses in the desert, grow flush or sparse around different sources of water. For example, some are cognitive knowledges (including sciences) and some are actional knowledges (including engineering); They are not completely consistent with each other and may be at different levels of development.

3.2 The Inferences: Part 2

If Algorithmic Theory is like a piece of music, now coming its climax. The climax is to be brought about by mainstream theory. The mainstream “maximization” (or “optimization”) entails that calculations should not be carried out in a muddled or passive way, but deliberately. This reminds us to conceive, design, compare and select computational plans. The finiteness of computing resources (including the time and other conditions) is no excuse for forsaking optimization; conversely, because these recourses are exactly limited, actors needed to make good use of them, hence need to conceive, design, compare and select.

The efforts will have multiple consequences. The first consequence is that the actors will prioritize the development of those deterministic or universal knowledges. A term related to plurality is called “heterogeneity”, which indicates that an object or many objects are not homogeneous. The world in the eyes of actors is pluralistic and heterogeneous, which shall be the case before processing; Because the strength of processing is limited, the world after processing will remain so to a large extent. Particularly, a misleading mainstream concept of heterogeneity, known as “division of labor”, needs to be clarified. The division of labor impressively hints that things of different qualities can be in harmony with one another, so that they are equal in value. This shall be a fallacy of composition, or an overgeneralization. More broadly, there are gaps in value; that is to say, when we discuss the differentiation of the world and the differences of things to carry out qualitative analyses, we shall not generally, automatically, and indiscriminately assume that equilibria have been existed between all the objects. Only in this way can the world be restored to its original vivid forms.

This means that different persons are less likely to synchronously understand everything in the world, and irregularity will occur widely. At a certain time, the cognitive difficulty of different objects shall be different to actors, and the actors’ cognitive depth shall also be different from each other. One strategy is to exploit certainty first, and ignore uncertainty. And, the discreteness between things to some extent allows people to independently identify some certainties while other uncertainties can stay elsewhere. The actors can first make clear what they can be sure of, and then, on this basis, they seek knowledge of other things and the solutions to practical problems. The same is true of universality. Universality indicates the features common to many things, so the treatment of universality means that the same treatment can apply to a large number of objects of the same kind, thereby gaining huge economies.

On the other hand, however, this strategy has its limits. It is impossible for the actors to be totally free to swim in the ocean of information, where the key restraint is that the decision is time-limited, requiring the resolution to a specified variable (and hence some other variables relevant) within a limited time. With recognizing the computing time, it is important to remember that most demands need to be satisfied on time, and that many resources will fail if they are not

utilized in a timely manner. In fact, people make decisions in the halfway of cognition, they have no any general or ultimate purpose, and hence no any neoclassical one-off or lump-sum "solution"; the purposes, resources, and the pertinent means have all been torn into pieces and re-combined into daily series in the time order. This is the real problem of human life and humankind, which Neoclassical economics does not properly understand.

In this case, what shall the actors do? This leads to the second consequence, the emergence of subjectivity (or "irrationality"). In a limited time, only a limited amount of certainties can be discovered, and only a limited amount of deductive inferences (as mainstream theory prefers) can be undertaken, and, the questions that can be answered definitively cannot always happen to be the ones that require answers. At this time, the actors have another choice, that is, use induction, analogy, imitation, imagination and other non-deductive Instructions or Algorithms (collectively as "Heterodox Algorithms") to compute. Even if the actors know it is shoddy, they have to select among them. Various Heterodox Algorithms are actually familiar to us, as long as we pay a little attention to their details and procedures, we will realize that the conclusions drawn from these Algorithms are not likely to be accurate or even far from those "theoretically correct" answers. However, Heterodox Algorithms can be fast, direct and easy to operate, so they have significant comparative advantages over the deductive method. We call this consequence the "Subjective Turn" of computing, or the "Mental Distortions". The mainstream deductive process is like a straight line from the premises to the conclusion, while Heterodox Algorithms distort the straight line to bend and deviate from the original intended destination.

What we are trying to prove is that a thinking activity, or a computational process, is in fact often a mixture of multifarious Instructions and Algorithms (orthodox or heterodox), and hence a mixture of subjectivity and objectivity. This is like the input in the production of goods, due to the change of its marginal return, the variety and quantity of input must be constantly adjusted, which further leads to the change of the computational results. The proof of this almost common-sense view actually requires a widely roundabout preparation, particularly an optimization in the spatiotemporal conditions. This shall be both the subversion and application of mainstream and traditional economic methods. For readers accustomed to the mainstream equilibrium paradigm, in particular, it is important to note that although the whole world is important and unavoidable, under Algorithmic Framework, the wholeness can be considered in its own unique way. That is, the actors at a given time-space point may perceive the existence of the distant and the whole to varying degrees, and may realize that they cannot certify their details for the time being, so they will ponder how to deal with the whole. They may no longer compute the information around him passively and methodically in the given order, instead, they will "jump" through the ocean of information, trying to selectively generalize, guess, imagine, and so on. As a result, each actor will develop his or her own (subjective and objective) view of the whole world, and this view may evolve over time. This means the individualization, contextualization, subjectization and historicization of general equilibrium. I'd like to rename it the "Algorithmic Equilibrium". We have mainstream economics to thank for injecting the optimal, and thus the comparable and arguable possibilities into Algorithmic Framework that avoids the simplistic description and the trap of naturalism.

3.3 The Inferences: Part 3

The vivid concept of "Mental Distortion" leads us to live and in-depth understanding of the natures of any existing human thought and its differences from, and conflicts with, other thoughts. Algorithm Theory can easily explain the thoughtful differences, that is, as the same Instruction processes the same information to get the same result, different Instructions process different information in different order, thereby getting different thoughts. The implications of this statement are significant in themselves. Considering that the number of computations in a computer is often counted in units of "hundreds of millions", it can be assumed analogically that the amount of computations normally carried out in the human brain is also very large. Since computations are quite free, independent and autonomous, and the knowledges (including the knowledges of how to compute) of the actors involved are limited, how can it be supposed that all computations are performed with exactly the same Instructions, same information and same order? Therefore, a primary and basic inference of Algorithm Theory is the generation of individuality, differences, plurality and conflicts of thoughts. This conclusion applies not only to the minds of

different individuals, but also, inevitably, to those “dressed up” in the same brain at the same time or at different times. On the other hand, the thoughtful differences and conflicts are unnecessarily absolute, because when two people have a conflict of opinion, as long as one person agrees to compute in the same way as the other, s/he is bound to come to the same conclusion. This provides the possibility of the development of interpersonal consensus. It can be agreed that a theory to achieve these effects shall be necessary for the whole intelligentsia (not only for economists), however, it has not begotten until the birth of Algorithmic Theory.

“Mental Distortion” deepens this perspective. Now, we know that the differences and conflicts of ideas are not merely caused passively and mechanically. The thinking thread goes, bends, and then “knots” somewhere. After some arduous marches, computations must end up and the computed world must be “concluded”. The actor shall have wanted to speculate riskily. In other words, “Mental Distortion” may be done intentionally, or be “constructed” boldly, which adds (perhaps a great deal of) new differences and conflicts to the knowledge systems. Therefore, it is easy to understand that you look at the problem in this way but I do in that way. The computational results are accumulated into knowledge stocks, which will tend to be used repetitively unless they are deliberately updated (the tests on the knowledge stocks usually must be insufficient, because the knowledge stocks would become useless when the tests are costly). Also, we now realize that although the history runs on and on, generations of people have, in the midway of history, respectively made up their own conclusive minds on the whole history, therefore, it is reasonable that the views of different generations (or even of the same person) contradict each other, and that the earlier is often corrected by the later. Another effect is that while knowledge stocks direct future computations, they also confine or mislead them, as they may tell the descendants: don’t go there, it is dangerous! In the jargon, this is “path dependence”.

The above is the case between thoughts, and so it is between individuals. An individual is an “accumulation” of many thoughts in a certain space (i.e. within the human brain). From this perspective, we can get an ideal concept of “individual”, where homogeneity, heterogeneity, cooperation, conflict, competition, imitation and so on coexist with each other. Again, this clear and comprehensive view shall be unprecedented. Enormous information and ideas gather into the brain of the same person, and moving with the person through space. By convenient and hence frequent computations over time, its internal interaction and integration will take place, and its internal parts will be much closer to each other than they are to the ideas located outside the person and in the external world. Ideas within the brain communicate with each other by biological means more frequently and quickly than they do with the thoughts of other persons, and hence, the differences of thoughts within the brain are bound to be smaller than those between people, the latter may be relatively vast and gulf-like. As a result, communication, an important concept whose importance has never really been recognized, will once again protrude at the heart of economic theory. Communication is first based on interpersonal differences in thinking, otherwise there would be no need for communication -- perhaps this is the reason why mainstream economics ignores the problem of communication. Secondly, communication shall be not limited to the exchange of what is often called “information”, but also include the exchange of ideas and opinions, hence the minds of others are themselves a source of information. Thirdly, since neural networks do not exist between people, a premise of communication is to encode information and ideas into physical symbols. Thus, spoken and writing languages will be introduced naturally. Social sciences shall not focus on the technical means of communication, but they need to study the social and human aspects of communication, including languages, expressional skills and methods. Communications not only require significant resource investment, but also inevitably distort information to a greater or lesser extent. Finally, a comparison between the means of interpersonal communication and the means of communication within the human brain will show why the concept of the individual is more reliable, while the connection between people is relatively loose, and the individual and the society will be in a relativistic framework, both competing and cooperating. In turn, we can easily clarify the pros and cons of the concept of “economic man”. This series of theoretical problems can be broken through at one go.

From the perspective of “Mental Distortion”, we can also understand development in depth. Development is mainly caused by the progress of knowledges, which is a consensus of economists. However, knowledge development shall not be limited to incremental or marginal expansion, but also include destructive innovations. That is, the existing stock of knowledges can be negated, destroyed, and replaced with new and allegedly more correct knowledges. Why does these

"destructive innovations" happen? A reason is that the past knowledges were largely generated by "Mental Distortions", which hence were judged to be wrong later. Such "Algorithm-improving innovation" and "information-driven innovation" occur alternately, indicating the fluctuations of the marginal benefits both of information mining and of information processing. This shall be a relatively complete theoretical framework for innovation analysis, and a necessary and basic stance that economic theory shall adopt.

Human knowledge thesaurus is like a sketch of the world, which reflects the situation of the objective world as well as the painter's feelings and views. The sketches are different from day to day. However, these different paintings are not arranged randomly, but in a neat order, that is, the paintings are getting bigger and better historically. This is what development means. Knowledge grows from the simplest single computation to the infinite future, showing a compelling picture of dynamic expansion. Each person inherits the knowledges of the past, or of predecessors, or of others, and on this basis updates and develops them. As long as the cost of copying knowledges is in most cases lower than the cost of developing knowledges, the knowledge system as a whole shall be progressive. As long as the objective world changes at a slower rate than the evolution of knowledges, the knowledge system will also progress. These suggest the conditions for progress or development. Therefore, Algorithm Theory shall be a concise, vivid and eloquent theory to explain the evolution of ideas, and hence to explain the economic and social progresses.

Does mainstream economics have no value? No. It can be argued that mainstream theory reveals a great deal about intellectual progresses and even describes the progressive processes -- though not completely. The thoughtful development is a process from raw materials to something that can no longer be advanced, and thus the "optimality" or "equilibrium". A sole computational process is an evolutionary process, as is a group interaction until it reaches a certain static state. By convention, such a process of reaching equilibrium (now called "Algorithmic Equilibrium") is called "Convergence". In short, the mainstream theory reveals the convergent processes. However, this kind of process is selected from the diverse and discrete world, and the discreteness ensures that such existence and process can exist and expand relatively independently without being disturbed by the surrounding things, and hence ensures that this kind of theoretical description is real to a certain extent. However, the same logic can be extended to the fact that after the actors complete a convergent process, they usually only needs to act pursuant to the equilibrated knowledge as a fixed pattern, thus their research resources are saved, so that they can turn to compute on the other unexplored "virgin lands" located beside the equilibrium. The old problem has been solved, then the new one can be studied again, hence their minds will return active. Neoclassical equilibrium is an ultimate state of idleness, which the Algorithmic economics will avoid. Accordingly, we call this re-activated process "Divergence".

It can be believed that the mainstream theory reveals only a half of the world: the positive, harmonious and successful half, while Algorithmic Theory, on the basis of synthesis of various non-mainstream economics, complements and reveals the other half of the world: the negative, the conflictive and the failing half. A complete economic and social theory needs to combine these two aspects.

IV. What Principles and Methods does Economics Need?

4.1 Ontology

The above series of inferences are clearly and highly true -- even if they are kind of ambiguous. With these inferences in hand, we can now advance the idea that the real world shall be, in principle, formed according to the logic described above; therefore, we can say in principle that we have roughly and fuzzily explained (or "endogenized") the entire economy and society. All we have to do now is to continue the deduction to get closer to the reality and the details.

The stocks of personal and social knowledges have been accumulated and grown up historically, so human intelligence is constantly developing, and the range of human activities in nature is constantly expanding. That is, economic and social theory needs to acknowledge the limited scope of society and the fact that man-made things coexist with the natural world. The scope and depth of economic activity are more limited, and markets and commodity trading are a smaller component of economic activity.

The first thing to explain is the emergence of government. The logic of government is rooted in

knowledge stocks that provide simple and direct parameters or answers for Current Operations. In this sense, all knowledge stocks are similar, and “rules” are not something unique or mysterious. For example, the rule that “damages must be repaid” is similar to the knowledge that “there is a river on the north of the village”, both of which are used to make decisions without re-examination. Because of plurality, it is natural to believe that the coexistence of some behaviors with less interpersonal influence and others with greater influence is a normal phenomenon. The interpersonal influences, as externalities, justify (cautiously) the adoption of holistic thinking. We can imagine that a “society”, as a virtual “actor”, needs to build some “holistic” stocks of knowledge. This wholeness is bred from both interpersonal homogeneity and individual independence, the latter can cause intentional irresponsibility. For example, people who damage property can flee the site and refuse to repay. For a variety of reasons from information transfers and computations, it is not enough to rely on the spontaneous mechanisms of punishment that has existed in the free society -- the punishment may not be implemented, or done not in time, or done not strong enough, and so on. That is to say, some mechanisms (such as legal systems) ought to be designed from the perspective of the whole society and enforced under a unified arrangement. The implementation of such a system, even if costly on a case-by-case basis (e.g. using state power only for a minor case), has better results from the point of view of the whole society, and is therefore economical and worthwhile. This is only one theory for governments, and other relevant doctrines (public goods, coercion, organization, power, etc.) can all be derived similarly from our unified framework, where most of the factors emphasized in these doctrines are actually the inferences of bounded rationality. We will not detail them here.

Government is an institution that enforces certain social knowledges. However, the disadvantage of enforcement is that it is not flexible enough to respond to specific and changing situations to a higher degree, hence, it is generally limited to smaller areas, with much of the rest regulated by morality, custom and the free market. This shall be the result of the combination of plurality, irregularity and bounded rationality. Society tries to maintain a balance between enforcement and freedom, but, due to bounded rationality, no society can achieve this balance perfectly.

Society is interlinked, but because of the difficulty of holding people accountable, the society allows people to speak and act quite freely, and their responsibilities are limited only to certain areas. Therefore, freedom itself is a product of Mental Distortions. The limitation of the ability to think and act leads to the finitude of the nature and scale of microscopic behaviors, and the behaviors we see every day have been formed under the limitation and finitude. Individuals use various information (not only prices) and Algorithms (objective or subjective) to compute and make decisions, and then take various actions (not only transactions), with changing roles in the society. Everything and every action have their own contents or meanings that cannot be completely contained by others. Things are different not only qualitatively, but often in value. The opportunities to arbitrage do not always exist everywhere, but need to be searched and even developed. Commodity transactions occur occasionally, the resultant price information is referential limitedly, and the price mechanism adjusts the economy also limitedly. As a means to facilitate transactions, money is endogenous and plays a variety of functions, including the store of value. The issue of cash flow is of importance independent of other economic issues. All kinds of flows and stocks coexist. Individual heterogeneities, or asynchronous behaviors, offset or interact with each other extensively. Given the limitation of attentions, people often consciously or unconsciously confirm or deny, encourage or inhibit each other’s behaviors (meaning “Invisible Hand”), which to some extent mitigates the negative consequences of freedom. Similar effects could happen to organizations, because the problems such as communication and negotiation delimit the organizational sizes. Large and small enterprises and other organizations coexist and compete with independent individuals. The advantage of the free society is that the existence of huge numbers of independent actors leads to the rapid growth of diverse ideas that compete each other, the superior survived and the inferior eliminated, therefore, it is relatively conducive to the development, dissemination and inheritance of knowledges. Freedom also allows physical products to be enriched quite quickly -- although shortages, surpluses, conflicts, and other lapses might happen from time to time. Micro actors will bear most of the consequences of these failures, and after they are offset with each other, the macro performance of the economy and the society shall be generally and relatively stable, and the remaining problems requiring governmental intervention are usually few or individual.

Viewed Algorithmically, development (i.e. the situation today is better than yesterday) is an unstoppable phenomenon; whatever kind of socio-economic system will inevitably lead to development. But backsliding is also real, and crises come up ever and again. Comparatively, we can explore the macro causes of development: the first is the accumulation and dissemination of knowledges; Secondly, the coercive force is monopolized by the state and used moderately, thus avoiding the damages that otherwise might be incurred by armed struggles; the third is to maintain a certain balance between the radical and conservative strategies. As mentioned above, the social order shall be kind of fragile, where people usually only remember how to do things routinely, not fully aware of the reasons thereunder. As a result, when facing drastic changes, people may suddenly become blind and hence the earlier cooperative relationships break down. Thus, not all innovations are benign, some of them (including institutional changes) can cause damages, and hence ought to be inhibited. This is the origin of conservatism, which prefers the marginal and incremental innovations so that the positive consequences of innovation can outweigh the negative ones in a timely manner, thus achieving the monotonous aggregate growth. Knowledge stocks can never be completely changed in a short period of time, because they are the crystallization of all the thinking activities of predecessors. The impossibility is endogenized by the constant capacity of Current Operations.

4.2 The Thought about Thought: Higher Order

From the above brief discussion, we can realize that economic and social theory shall reveal not only the traditional things such as regularity and certainty, but also their opposite, namely irregularity, uncertainty, plurality, conflict, chaos, and so on, as well as the combination (or mixture) of them. The latter shall also be regarded as a kind of "laws". This is not idle nonsense. Although these "laws" may be imprecise, they are useful and meaningful, which even can be seen in applied theories or practices. For example, in order to predict commodity prices, you first need to recognize that prices are volatile in principle, and limited in guiding behaviors, and that some information may not be conductive to prices, or the conduction is very slow, and the specific price to be forecast depends on the situation of information conducted and the specific "Algorithms" used by the actors, etc., and on this basis the specific forecast can proceed. Even if the researcher has a firm grasp of the actor's Algorithm (including the supply or demand function), s/he must understand that the Algorithm might change with the change of knowledges, and that in another situation the actor may adopt another Algorithm that somewhat contradicts it. Only on such premises can the price forecast be made correctly and properly, and the forecast made can be properly comprehended and used – provided that the forecaster will explain the nature and meaning of his/her forecast.

For a practitioner, these laws are also significant. For example, when one is planning to go into business, one turns to economics for help. Is it enough for economists just tell him the equilibrium theory? The answer is: not only insufficient, but misleading, because it's like telling him that it's the same thing to do any business, and that it's the same thing to do or not to do -- because you're only a minuscule quantity. We need not say much about the absurdity. A proper economic theory, at least, shall tell the actors: As your individual rationality is limited, be cautious, but efforts will generally be rewarded; The opportunities for profit are existent somewhere in the market, but not everywhere, so you need to search and identify them; You shall choose a business that suits with your personality and resources; The success of business involves a large number of known or unknown factors, so please do not be complacent with any existing knowledges and skills, and do not believe in any single law; The source of profit is inexhaustible, so don't despair; The strategy of "be rational" doesn't always work, please get ready for "fighting" when necessary, and so on. Aren't these suggestions important? Especially, when we have been able to theorize about them, can we be deterred? Isn't this the theoretical advance that we have been seeking all along?

The same is true for policymakers. The market cannot live without the government, and the government needs the market as well. A proper bounded rationalism can not only explain the meaning of the governmental existence, but also explain that the government only exists in the cooperation and competition with the market. This theory leads to the obvious conclusion that it is impossible for an authority or a center to do everything, and the impossibility is endogenous. Any policy must be made at some sacrifice, and its effects are inevitably kind of diverse and unpredictable. Thus, caution and restraint on the part of those in power are necessary. This is what

the theory itself will tell those in power automatically, without the need to inculcate them the ideological dogma of freedom. Similarly, the market is by no means perfect. It is the result of "Exclusive Algorithm" (that is, except those that are explicitly authorized to the government, everything whatever is clearly recognized or not depends on the market). Therefore, instead of fighting an ideological battle in vain, we shall always keep an eye on the operation of the market and carefully identify and adjust the boundary between the government and the market at any time.

The usefulness of such "laws" in theory and practice seems obvious, but the nature of them needs further discussion. These laws are actually claiming "no law", we can call them "Higher Order Laws", that is, the actors as the objects of our study often think that their objects lack law, and such "thinking" is discovered by our researchers. These laws are ex post, that is, the actors' thoughts and deeds, as facts or entities, have already happened, and then we researchers can observe and study them. The researchers are no longer able to intervene and change them, and their findings can only be used in the future. This is a consequence of the substantiality of thought. What's the point of emphasizing this? It pertains significantly to the reform of mainstream theory. One meaning of the ultra-rationalist style of neoclassicism is that at any point in time, whether recalling the past or foreseeing the future, the actors can fully analyze, predict and interact with objects so that they will not regret their past behaviors in the future, and researchers will not complain about the actors. This is the core idea of the term of "rational expectation". In other words, conditioned with zero thinking time, the complete fluidity of thought quenches the locality and individuality of any thought. So how do we study the thoughts? You study it, but you are also studied by it; you intervene with it, but you are intervened with by it; finally, all thoughts will become coherent with one another, no substantive division between them. It is like looking at an object, if it moves very fast and keeps always above your eyelids, you will never see it. Or, if it transforms so rapidly that it can instantly turn into whatever you want, you will not know what it is. Such a "thought" cannot be objectified.

On the other hand, if a thought has the nature of a substance, it exists and moves in a particular space, changing at a certain but not so fast rate, and is relatively independent from the thoughts of our researchers, and can be separated from each other, we researchers will grasp it and apply our thoughts to its study. Therefore, the concept of "minimum thinking activity" (Meta Computation) is indispensable, and so are the space and discreteness. It sounds complicated, but it's really that simple. Once these conditions are satisfied in Algorithm Framework, the objects will be partially interrelated, partially conflictive and partially irrelevant in our eyes, and in a single and whole picture, and the symbiosis means another kind of consistency between them; And, as the computations keep deepening over time, they are possible to turn more consistent or consistent again in the future. This possibility, together with the symbiosis, can be called "Higher-Order Consistency" -- although they are not so consistent now at the "first-order" level. This "Higher-Order Consistency" is a necessary part of the Grand Synthesis. This shall be a simple and reasonable thinking that is distinct from traditional ideas.

4.3 The Grand Synthesis

The economic society is mixed and chaotic to some extent, where the connections and consistencies exist only locally. Even the first-order consistency established by Algorithm Theory (such as the consistency between thinking time, stock, conflict and innovation, collectively called "thinking-knowledge-conflict-innovation quaternity") can only be regarded as a local one that cannot be used to explain everything. The establishment of the unitive principle does not eliminate the independence of specific theories, nor can it completely eliminate the conflicts between different specific theories. However, conflict and plurality cannot be seen as absolute, otherwise we would fall in another mistake. The most important thing is to realize that both the actors and the researchers are all in the historical process of thinking, and it is this "process" that creates the state of the world and the minds of ours. As for the ultimate truth about the objected world, it is impossible to know. This is the scientific element that we shall extract first. Science is primarily to discover the most reliable things, and this strategy distinguishes science from metaphysics. Metaphysics is of course still useful in scientific research, as reflected in the fact that hypotheses are needed from time to time, but it cannot be completely proved or falsified. In my opinion, economics and social science need to adopt the composite method of "first order + high order" to

integrate. Without this method, the “complete unification” that was supposed only pursuant to the methods of natural science would probably be wrong.

This bizarre logic is actually and reasonably based on a simple ontology of how the human mind works -- Algorithm Framework Theory. In fact, the basic methods and principles of science (both natural science and social science) have not changed, and the new things are generated just by combination of the basic scientific methods and the Algorithmic theory. The combination causes the replacement of some old things with the new products.

However, this can be regarded as a “relatively complete” new system. The new system is so complete that instead of piecing together the existing schools of thought one by one to form the whole, we first portray the whole, and then we only need to mark or highlight some parts of the whole so that they correspond to the schools respectively. To this kind of correspondence relation, now again we make a summary and emphasis.

The core elements of mainstream neoclassical economics include deduction, equilibrium, statics, quantitativeness (price centrism), etc., while macroeconomics is characterized by disequilibrium, subjectivity, empiricism, and money. Macroeconomics, in particular, uses the real economy as the theoretical prototype on which all analyses, including statistics, is based. This approach will be explained in the next sections. The historical school, guided by time, emphasized most of those elements ignored by classical economics. This tradition continued in Austrian economics. While continuing to deeply analyze various mainstream and non-mainstream elements, Austrian economics fell into further fragmentation due to the lack of an overall theoretical framework. The same is true of the Chicago school. After the introduction of transaction costs, the new institutional economics pitifully failed to materialize thoughts, but on the contrary, attempted to combine with mainstream economics. Marxist economics uniquely emphasized the precious element of contradiction (or conflict) and attempted to establish a comprehensive and dynamic social science, but simultaneously put forward the extremely rationalistic and deterministic propositions (such as the labor theory of value), thus adhering to its rival, the classical economics. Game theory, which inherited the Marxist tradition of conflict theory, focuses on demonstrating structural (i.e. “qualitative” rather than mainstream quantitative) computations. The last one is behavioral economics. In Algorithmic language, behavioral economics mainly describes various kinds of “Mental Distortion” phenomena, namely, the deviations of realities from the neoclassical conclusions, which behavioral economics tries to explain as the consequences of certain inherent “human natures” (emotions, instincts, psychologies, impulses, etc.); this is redundant and unnecessary; this error reflects the common misunderstanding of “rational thinking” in the intellectual circles since modern times. People have mistakenly believed that the “correct” and “rational” knowledges, represented by sciences, would eventually dominate the whole knowledge system, while “irrationality” should be the secondary, pathological and temporary existence. In fact, the “rational thinking” itself is distortive, even without the interference of innate human natures. We can literally think (or assume) that something “irrational” is innate in the human brain, but it shall be essentially similar to, rather than different from, acquired knowledges. Even if these innate “knowledges” from biological inheritance evolve more slowly than ordinary knowledges, so that the gap between the two has been widening (which may be why behavioral economists pay special attention to innate inheritance), it is needless to introduce new hypotheses. Moreover, given the explosive growth of knowledge, it is hard to believe that the proportion of “irrational knowledges” will continuously decline, because the divergent effect will thwart the decline. Thus, what Algorithmic Theory reveals shall be the big discoveries that are enough to reverse those traditional ideas of the intelligentsia. It generates new theoretical principles in a batch (rather than a single one), corrects traditional errors in a batch, or resolves batched traditional problems.

4.4 The Methodology

For the above comprehensive system, such a question also needs to ask: how to carry out economic research thereon? Some people may ask: since the actors can be subjective, sometimes unwise, “irrational”, contradictory or regretful, is such a synthesis meaningful or useful? In a specific study, should the researcher prove that the actor will do the right thing or the wrong thing? Is it still necessary for economic theory to infer any phenomenon? Should economists henceforth

only depict the reality as novelists do?

These are good questions. However, in Algorithmic Framework, these questions are not only easy to answer, but also natural and very meaningful. From ontology to methodology, the Algorithmic discussion can be done at one go. Furthermore, without the Algorithmic methodology, the Algorithmic ontological discourse would be incomplete. It is only after elaborating on the Algorithmic methodology that we have an entire understanding of the principles on which the social sciences, including economics, should be based, and why these fields have struggled with strife and ineptitude over the past centuries.

In order to answer the methodological questions, we first need to think about the natures of research activities and their results. An ontology of human minds shall differ from the general ontology, and it will bring many surprising consequences. One of the "surprises" is that the world we study contains everything including the other humans of our own kind, our own existence, the consequences of our past actions, and so on -- though the "present self" is external to the objected world. Researchers are human beings, and we must assume that researchers also think in the manner described by Algorithmic Theory. Therefore, a basic conclusion comes into being, that is, the methods of researchers to study the world cannot be essentially different from the methods of actors to study the world, hence "social science methodology $\approx$ social science ontology". In other words, as for any of the various Algorithms that actors use, our researchers are likely to adopt.

However, this is not all true. For the inevitable question is: "is social science a retelling of the actors' minds?" Nevertheless, the answer to this question is the same as above: while the actors are learning from each other and referring to each other's ideas, they are also developing their own personalized and stylized thoughts, which is of course the same between the researchers and the actors. Researchers must also develop their own distinctive ideas. A researcher is not a god, his/her thinking is also Algorithmically restrained. The difference between the two is that the actors are often faced with urgent situations in specific affairs, while the researchers, though limited by the computational speed, are not as urgent as the actors and their tasks are not so specific. Researchers are either professional or focus on certain (essentially local) problems in their relatively "free" time. For this reason, academic activities usually give priority to the general and long-term problems from the object world, and selectively ignore the particular or temporary problems. In other words, the scope of research activities is generally narrowed and the depth deepened in comparison with the daily thinking activities of actors (Combination Explosion ensures that the research depth can be generally unlimited). One might ask again: why are the actors often in a hurry, but the researchers' schedules so relaxed? The answer, of course, lies in division of labor and trade. The researchers peddle their specialized knowledges to the actors, and then use the proceeds to sustain themselves in the esoteric, systematic, and long-term research activities. Scientists often ignore many aspects of the object world and focus only on issues such as "logical self-consistency". If a conclusion cannot be reached with certainty, it is better for scientists not to reach it than to force it, as the actors often have to do, even when they know they are not sure. This forms the unique character of scientific knowledges. Through such an approach, we can fully reveal and demonstrate the characteristics and methods of science, as well as the collaborative, competitive, complementary and interactive relationships between sciences and common knowledges.

4.5 Methodology (continued)

Now turn to a brief discussion of research methods.

First, any scientific theory needs to be aware of its own limitations, and it is best to, in advance, state those limitations for its audience, as well as its uses and usages for the actors. Economics textbooks should do just that -- and, such statements should be logically justified by the contents of the textbooks themselves, so as not to become dogma.

Second, for the social science, in particular, it is necessary to recognize that conscious ideas of real actors have the significance of a "theoretical benchmark". The real actors themselves construct theories about the real world day by day, hour by hour, and in large quantities. These knowledges have been tested, revised, refined and passed on from generation to generation, and thus have high reliability. In addition, the theories that scholars put forward in the past have been infiltrated into the minds of ordinary actors through education and dissemination. On this basis,

the common actors' understandings and treatments of the world have been roughly proved to be feasible. The goal of the researchers' work is simply to create marginal and better ideas and knowledges. Neoclassical theory negates the possibility of such improvement and thus negates the theory itself, whereas the Algorithmic perspective both affirms this possibility and limits it: how can researchers, only with small investments, expect to change the minds of real people with such strong backgrounds all at once? It's impossible. It is also impossible for the researchers to envisage a completely different set of lifestyles (such as Arrow-Debreu General Equilibrium Model) to replace them. This scenario is either a myth or has little chance of success. Therefore, it would be wiser to take the real world, and thus the set of ideas of all the real actors, as the benchmark for theoretical research, replacing the position of Arrow-Debreu General Equilibrium Model in mainstream economics. The real persons are not much less intelligent than the academicians. They may not be as good at the problems that scientists focus on, but they are probably good at the areas that scientists don't. In other words, the conscious ideas of real actors have a kind of intelligent equality or equipollence in front of scholars. Researchers can now work around this new benchmark, taking materials from it, putting them into a closed-door study, and returning the results of the study for testing and application -- and so on and so forth. Real society also means the synthesis of theories, because those different and conflictive theories often describe only different areas and aspects of the real society. The core criterion to evaluate a theory is whether it is useful for the common actors to understand and reform the world. Whether the theory conforms to the norms within the scientific community is only a reference standard. Because, the scientist community is possible to fall into collective errors. An unorthodox theory cannot be expected to be accepted by the scientific community immediately, but this does not necessarily mean that they will not be accepted by future scientific communities.

In addition, the methods of actors are diverse and comprehensive, and so must the researchers. Any method (theoretical or empirical; subjective or objective; structural or quantitative; proving or falsifying; or, "conscious", statistical, historical, exemplary, experimental, simulative, constructive, policy-oriented, etc.) has its place, but even the cooperation of them all may not work well. Algorithmically, a core feature of a theory is its formal simplicity. A theory is established by summing up a large number of empirical facts and then jumping into the relatively simple form; Since then, people generally, and economically, just need to remember the theory and apply it, instead of going back to the tedious materials that produced it. However, due to the existence of heterogeneity, such a good thing happens not everywhere, the marginal benefits of theoretical work will eventually decline, and researchers will have to put aside the theory and directly face the empirical facts. Therefore, Algorithmic Theory can naturally lead economics to the observation and emphasis of the real society. The Algorithmic principles only in principle endogenize the whole world, and various specific economic theories only roughly explain the world from different aspects, whereas the specific details of socio-economic operations need us further to observe and study deeply from inside. In the past, mainstream economics abstracted the real economy into something like geometric models, now the Algorithmic principles can further make them colorful, dynamic and complicated. However, this is not enough. We also need to start from the other end, and to scan the social realities entirely and continuously. This is somewhat analogous to the work of historians. The collation, collection and restatement of real materials is in itself an academic contribution, which, together with theoretical analyses, constitute a wholesome discipline. The restatement of materials is always narrative but containing a large number of diverse, irregular and even subliminal theoretical elements. The link-up of theory and experience means that the marginal benefits of the theoretical method and the empirical method have reached an equilibrium, and that the two methods become kind of coherent. The conscious ideas of real actors can be viewed not only as the competitors of theories, but also as the phenomena and facts with the same status as other visible social phenomena, which can be studied by means of inquiry, detection, experiment, etc.. For the observers with limited rationality, any object has a certain mystique, so the necessity of the experimental method as an emergent approach is obvious.

Algorithmically, researchers can have two attitudes toward reality: one is to explain it, and the other is to reform it. Since the "optimal" behaviors of actors in fact are not necessarily optimal objectively, the second attitude can exist as a choice even at the beginning of the research work. And because the optimal part and the part that can be improved in the object world often coexist, these two attitudes are not only competitive, but complementary. As humans, the major objects of

study in social science belong to the same species as the researchers, it is crucial that the researchers can, by communication, directly influence the thoughts and behaviors of the subjects. This has led to any social science work being more or less "social engineering", that is, giving advice to actors (common actors or governments), which is actually another motivation for the development of social science. As a kind of knowledges, science can influence the cognition of actors and hence indirectly influence their decisions and actions. Moreover, the guidance can be explicit. The distinction between engineering and science is similar to that among any other kinds of knowledges. The abundant literature derived from the question of "how to do" has a long history and a strong tradition. However, in the context of equilibrium theory, we cannot clarify the distinction and reasonably discuss them respectively. Now, social engineering or policy science can formally be an integral part of "Algorithmic Social Science". Algorithmic policy science can have very broad conclusions. For examples, it can illustrate the comparative advantages of centralization and decentralization at the same time, so as to seek to establish their appropriate proportion and combination in an institutional construction, rather than simply and dogmatically favoring one side or the other; Monetary regulators shall be alert to the limitations of quantitative adjustment, and shall pay more attentions to structural indicators and structural measures, especially the structural consequences of sustained monetary injection into the market; Asset markets and speculative activities have a tendency to cause instability, hence need special regulation, and so on. Limited to the space, these cannot be detailed here.

A rising branch of research today is the computer-program-based simulation. Under the guidance of Algorithmic Theory, and after the systematic economic principles have been re-established by using traditional manual methods, the simulative programming methods can be used additionally to the applied and concrete studies. The latter job shall be suitable for those scholars interested in "formalization". They used to be immersed in mathematical methods, but now they can turn to computer programming. Most existing computer simulations are conducted under the guidance of equilibrium theory, which have been misled. By reconstructing the methodological principles, programming experts can now reorient themselves and start again. The "human society" in the computer must also go through an "evolutionary" process from small to large, from simple to complex. But because computers run so fast, they will evolve much faster than real human societies. Scientists around the world can work together to build a giant system about human society. The acquisition, collation and filling of real data can improve the fidelity of the system. Real people as experimenters can also participate in the games on computer platform, in order to constantly improve the system. What practical use would such a giant system have? One obvious use is in policy design, which can improve policy solutions by showing the consequences of policies in the virtual world in advance.

V. Conclusion

According to the scientific methodology, a theory is highly acceptable when it explains the widest range of phenomena in the simplest form. Some readers have misunderstood that Algorithmic Theory does not explain real phenomena, which is quite wrong. The phenomena explained Algorithmically so widespread that it is all around us now and then that we almost neglect their existence. Is life diverse? Is it dynamic? Is there any conflicts? Is there innovations? Is there any developments? Does dynamics and statics exist side by side? Are trading opportunities local? Are prices variable? Is the government symbiotic with the market? Does the real regime oppose monopoly? If the answers to these questions are all "yes", Algorithmic Theory can be deemed verified basically and preliminarily. A principle can be verified in this way. The readers can value principle propositions only from ordinary experiences, common sense and general knowledges. In solving existing theoretical puzzles, the power of Algorithmic Theory can be clearly "all-in-one" (though we don't necessarily see it as the ultimate and absolute "truth"). Economics and social science used to lack such "framework" theory. They just start from common sense, directly into the applied or concrete theories, devoid of such a platform to cover everything. Now we need to make up for this platform. Without it, there would be no unified economics or social science. The unified economics and social science will not begin until they come back here to re-start. For others, the theory's broad range of explanations and relatively vague implications may be viewed as a disadvantage. I think this is a negative effect of the long-term use of mathematical methods. Of course, framing theory is only for those who are willing to accept and use it, and it cannot prove itself "strictly enough".

The slogan "get economics started again" may seem depressing, but the fruits of natural sciences shall be not surprising when comparing their physical objects with the complex humans as the objects of social science. Instead of starting from scratch, the current rich harvest of social sciences will be selectively absorbed (as the grand synthesis should be) and the march will be brisk and smooth. Although some technical terms are used for the time being, the Algorithmic study is interesting and not mechanically boring like the mainstream economics of mathematics. It can be easily and smoothly extended to other areas of social sciences, philosophy, and humanities, which I will discuss elsewhere. Even if the author does not do so, anyone who has mastered these principles and methods can do it as well. Algorithmical research is also exciting, especially as the unfolding picture of Big Bang of knowledges draws our attentions to the future. There has been a serious asymmetry between the study of the future and the study of history, mainly because in the past we lacked a theory that could naturally "endogenize" the future. The prospective researches will greatly enhance the practicability of economics and social science. Social science is by no means confined to windy chat, it will, like natural sciences, demonstrate its value to mankind by serving the creation of institutions, the formulation of policies, and the guidance of behaviors.

References

Li, Bin (2006). *The Algorithmic Economics: A General Theory on Bounded Rationality* (in Chinese), Economic Research Information, No.6. pp3–14.

Li, Bin (2009). *A Theory for Unification of Social Sciences: Algorithm Framework Theory* (in Chinese). Beijing: China Renmin University Press. English translation available here: https://www.researchgate.net/profile/Bin_Li197

Li, Bin (2011). *The Synthesis of Various Economics: An All-in-One Solution*, Paper presented at the annual conference of Association for Heterodox Economics (AHE), Nottingham, UK. https://www.hetecon.net/wp-content/uploads/2019/12/Li_AHE2011061R.pdf

Li, Bin (2012). *A Preliminary Inquiry into Principles of the General Social Science: The Algorithmic Approach* (in Chinese). Beijing: China Renmin University Press.

Li, Bin (2019). *How Could The Cognitive Revolution Happen To Economics? An Introd uction to the Algorithm Framework Theory*, World Economics Association (WEA) online c onference "Going Digital". https://goingdigital2019.weaconferences.net/papers/how-could-the-cognitive-revolution-happen-to-economics-an-introduction-to-the-algorithm-framework-theory/

Li, Bin (2019). *Foundations of Algorithmic Economics: The Cognitive Revolution and the Grand Synthesis of Economics* (in Chinese). Beijing: Economic Daily Press.