# Evolution and Outlook of Resource Allocation Mechanism in the Age of Internet

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**Abstract:** In today's society, the Internet, big data and artificial intelligence are being integrated and the mechanisms of resource allocations are also evolving, mainly because of the changes in background factors, means, and processes that influence resource allocation. To analyze and study this evolution, we need to combine resource allocation, industrial organization, and industrial regulation theories to determine the driving and restricting factors new technologies bring to business-to-business and business-to-consumer interactions and how the combination of internet, big data and AI will impact productivity and pricing. We must also analyze the differences between today's supply-demand and pricing processes and those of the industrial age to discover whether there are special resource allocation mechanisms in this era and how to summarize them theoretically. This paper reviews the evolved resource allocation mechanisms at the present stage of the integration of the Internet, big data and AI based on resource allocation theories from classical Marxian, neoclassical, and modern western economics.

**Keywords:** Internet; resource allocation; big data; artificial intelligence; Internet-based resource allocation mechanism

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## Introduction

Resource allocation is a fundamental issue in the study of economic theories. Since classical economics based on cost and price theories was founded, economists[①] have studied resource allocation focusing on how product value and price fluctuations are influenced by the supply-demand relationship. Marxian economists have developed theories of resource allocation mainly in two ways. First, they founded the theory of socially necessary labor which has two aspects; analyzing the rational allocation of manpower, material and financial resources under the labor theory of value, [②] and resource allocation, driven simply by average rates of profit and production, a market mechanism commonly applied in the capitalist world, would lead to a huge waste of social labor. Although Marx built a preliminary skeleton of resource allocation theory in his *Economic and Philosophic Manuscripts of 1844*[③] and other early works, he did not negate the effect of the market mechanisms on resource allocation. However, he highlighted the significant role of the government's macro control in this regard and advocated a plan-based resource allocation mechanism. Setting aside the practice of Marxian economic theories in the past, these theories, in terms of their influence on the world of economics, have been a major ideological source for Western Economics with respect to resource allocation under government's macro control.

Alfred Marshall's Marginal Analysis presented a neoclassical perspective on resource allocation theories in economics. As an intermediary, neoclassical economics is the parent of modern mainstream economic theories. However, all neoclassical thoughts on resource allocation were derived from the age of Industrialization and were developed by taking technological factors into account as inherent variables. In fact, the changes in resource allocation is partially driven by technological development which impact not only manufacturer's strategies regarding what to make, how to make it and how much to make, but also the consumer's decisions on what to buy, how to buy and how much to buy. Thus, technological development, on some level and to a certain extent, are a function of market mechanisms and the government's macroeconomic control policies and therefore determine the output and price of goods and services. It is noticeable from the economic literature concerning resource allocation that economists tend to study this topic from the general and local equilibrium of economic operations. Centering on market mechanisms, their research was carried out on the grounds of rational choice theory and theoretically reflected people's choice behaviors in the age of industrialization with the assumption that technology remains static.

General equilibrium is a classical economic theory used to explain resource allocation. The general equilibrium of total supply and demand and quantitative composition of goods and services was first discussed by Gosson[④] and Jevons[⑤] and modeled by Walras.[⑥] Pareto,[⑦] on the other hand, demonstrated the well-known Pareto Optimality based on the inference that general equilibrium is achievable when budget constraint conditions for the market demand function are met. Economists have debated Walras' analysis and the Pareto

① Smith, 1988; Ricardo, 2009
② Marx, 1975
③ Central Compilation and Translation Bureau, 1998
④ Gosson, 1927
⑤ Jevons, 1957
⑥ Walras, 1954
⑦ Pareto, 1971

Optimality in their research by discussing either the equilibrium of productivity under the constant returns-to-scale model from the technological point of view, ① or the equilibrium of productivity under the constant returns-to-scale model,② or the constraints hindering the achievement of competitive equilibrium while focusing on the Pareto Optimality.③ Most of the aforesaid research were carried out on the assumption and inference of "economic man" or "rational economic man," where the preference, cognition, utility and other constraints are certain, featuring realistic basis and logics typical in the age of industrialization. In the era of the Internet, however, the resource allocation equilibrium should be further investigated as it is now possible to collect and process massive amounts of data with the help of technology.

## 1. A theoretical explanation to changes in investor's choice behaviors due to the latest technology

Investment choice behaviors, a factor that impacts or determines resource allocation in the human society, are changing in the age of the Internet. This can be briefly explained with fundamental theories: the neoclassical description of "preference consistency"④ which is completely helpless for explaining investor's preferences today. Ideas from modern mainstream economics related to information collection, integration, categorization and processing, as well as how perception is developed, are incapable of explaining the development of investor's perception in this era; ⑤ and the conclusions made by modern heterodox economics that the expected utility varies in the process of making investment choices⑥ also fails to effectively expound variations of investor's expected utility these days. The reason, is that how investors contemplate and make their choices is changing under the combined influence of the Internet, big data, machine learning/artificial intelligence (AI) and other cutting-edge technologies.

In the age of the Internet when time and space restrictions are released, channels synchronized, and real-time reviews are possible, motivation, preference, perception, utility and other factors affecting the decision-making process of investors all present in a scenario where "everything is connected." Choice behaviors of investors, be they individuals, businesses or government agencies, will be gradually influenced by the fusion of big data, the Internet and AI. As to the change, we should pay attention to these two aspects: (1) how big data, the Internet and AI technologies are fused, and (2) how such fusion interacts with the investor's choice preference, perception development, and adjustment of expected utility. For the first aspect, the facts are: the data acquired annually by society has increased beyond the limits of Moore's Law because of the deep penetration of the mobile Internet, the Internet of Things (IoT), sensors, social media and GPS devices; and the tremendous volume, multidimensionality and comprehensiveness of big data have enabled the generation, by machine leaning (AI), of accurate or even precisely targeted information, which in turn exerts influence on investment choices of individuals, businesses and government agencies. In this case, we could take big data

① Koopmans, 1951; Dantzig, 1951
② Hayek, 1945
③ Arrow, 1951
④ John & Oskar, 1947; Arrow & Debreu, 1954
⑤ Although modern mainstream economics does not indicate that people need to collect, integrate, categorize and process information to make rational choices, it does imply some related thoughts, according to studies of preference, perception and utility.
⑥ Kahneman & Tversky,1973; Kahneman & Tversky, 1974; Kahneman & Tversky, 1979

as the soul of such fusion, The Internet and IoT as the vector, and AI as the approach in order to clarify the relationships among the Internet, big data and machine leaning/AI.

Using AI actually represents an extended scope of analysis of the Internet and the IoT. Theoretically, the investor's choice preference is a function of utility. If investors were able to acquire accurate and/or precisely targeted information from the hybrid of the Internet, big data and AI, their choice preferences would neither be 'consistent,' as argued in neoclassical economics, or unpredictable, as indicated in modern mainstream or heterodox economics. Instead, the concept of preference similarity stands out, i.e. the investor's choice preference tends to be similar with that of smart brains that have acquired expertise from big data, the Internet, and AI and know how to combine them to maximize utility. Unlike the age of industrialization, the development of smart brains' perception will be gradually released from restrictions due to incomplete information as they gain insights by digging, collecting, integrating, categorizing and processing big data because the perceptions of smart brains allow utility to approach its maximum, while average brains generally follow smart perceptions when they are making investment choices. This is defined as investor perception simulation.

Apart from how exactly smart brains use big data to acquire accurate information and push utility toward the maximum, let's look solely at the influence of their preferences and perceptions on the investment choices of average brains, who make the majority of investment choices and whose simulation of investment preferences and perceptions therefore reflect changes in the investment choices in the age of the Internet. In addition, smart brains do not adjust their utility expectations as they develop their preferences and perceptions by fusing the Internet, big data and AI, and can acquire accurate information before they make investment decisions. On the contrary, average brains are unable to extract accurate information from big data. They simply follow suite. The average brains' utility expectations reflect their anticipation for the utility of investment choices made by the smart brains. Obviously, the classification of smart and average brains is a prerequisite for analyzing preference simulation, perception simulation and utility expectation.

Given the fact that average brains are a majority in the community of investors, we could describe the changes in investment choices today as preference simulation → perception simulation → utility expectation to align with fundamental theoretical analysis of preference, perception and utility in the rational choice theory. Certainly, the said description of change is derived from the thought that the integration of the Internet, big data and AI allows for grouping investors, and it stresses the assumption that the investment choice of average brains are guided by smart brains. If this description could reveal the truth of investment choices in the age of the Internet, we might explore this analytical approach further and carry out practical research about the evolution of resource allocation mechanisms.

## 2. Evolution of resource allocation mechanism in the age of Internet

Economic studies on resource allocation have evolved from focusing solely on market mechanisms to taking government control into account. Analytical approaches include: (1) the assumption of theoretical analysis has changed from complete information to incomplete information, and the reference system and analysis method of resource allocation theory are different; (2) determination of price and output, as well as formation of monopoly, are explained differently; and (3) the studies are always based on the grounds that the market or government goes out of control. Nonetheless, considering mechanism, majority, and behaviors, the resource allocation depends on the investment choices, which are limited by the sufficiency of information obtained.

During the age of industrialization, people did not have access to adequate information. They could only make investment choices by collecting, integrating, categorizing and processing information from what had happened. In the era of the Internet when big data includes not only what has happened and what is happening, it can also reveals information of what will happen with the help of machine learning, ① i.e. big data, a combination of digital and non digital data (pictures, texts, drawings, videos, sounds, fingerprints, images…) contains the information necessary for making wiser, better informed investment choices. If we have managed to obtain massive data from the Internet, IoT, sensors, social media and GPS devices and, leveraging the comprehensiveness, multidimensionality and relevance of big data, acquired accurate and/or precisely targeted information by a range of machine learning technologies, then we can build the technological foundation for rational and accurate resource allocation. When companies try to obtain accurate information about supply and demand of goods and services and pricing through the analysis of big data, they operate under an Internet-based resource allocation mechanism, which has been upgraded from its predecessor, developed in the age of industrialization, and has evolved to include the choice modes of individuals, businesses, government agencies, technological development, markets and policies.

Evolution process 1: As the Internet, big data and AI are fused organically, behavioral interactions among investors will be a key part in the evolution of resource allocation mechanisms.

The investment choices of smart brains lead to the preference/perception simulation and utility expectation of average brains, which reflects the behavioral interactions between investors. Economics has long been an individualistic methodology taking ‘individual behavior’ as the basic analysis element and inter-individual behavioral interaction as the reference of analysis. The reason is that the age of industrialization lacked the technological base that triggers group behavioral interaction like it does in the age of the Internet. Yes, if we review the development of resource allocation mechanisms from a majority choice point of view, scattered individuals do interact with each other under the effect of price, supply and demand and other market signals, and somehow generate a collective force that affects resource allocation but, unfortunately, is not strong enough to consolidate itself in individual behaviors, and therefore cannot result in group behavioral interactions. In the era of the Internet, the preference and perception simulation and utility expectation of average brains impacted by the investment choices of smart brains obviously lead to a collective force ② that is strong enough to drive group behavioral interactions. It is because of this collective force that behavioral interactions among investors has become a key part in the evolution of resource allocation mechanisms.

① Current researches about how to use “algorithms” for data analysis by machine learning discuss how computers can acquire the ability to learn without specific programming, and what methods can be developed for AI–based data matching. The academia has classified machine learning, by the learning characteristics, into supervised/unsupervised, reinforcement and deep learning. However, researchers have only studied machine learning of past and on–going events so far, not touching the prediction of the future. This is discussed in the sections below.

② Economists tried to describe simulation behavior in individual choice under the framework of individual methodology. Some of the well–known concepts include Butterfly Effect, herd behavior, information overlaps, and framework dependency. For instance, in his analysis of financial market, Robert Shiller (2001) discussed simulation behavior induced by market mechanisms by applying catalytic factors, feedback loops, chain reactions and amplification mechanisms. But, the analysis, which targeted individual behavioral interactions, does not apply to group behaviors of average brains by simulating the smart brains in the age of the Internet.

While smart brains may collect, integrate, categorize and process market data to obtain complete and precisely targeted information, the investment choices of average brains made by simulating the smart brains can be seen as a choice behavior that indirectly benefits from big data analysis. Academically, can we take the "behavioral interactions" between smart and average brains as a basic analysis element and introduce collectivistic methodology into the study of economic theories? Clearly, this academic thought acknowledges the fact that the investments by average brains represent a large portion of the total investment volume of society, and the "behavioral interactions" between the two groups reflect the evolution of resource allocation mechanisms in the mode of choice. On the Internet, the behavioral interactions among investors is reflected in click-through rates, notability, real-time reviews, shares of experiences and other aspects of goods and services. Once becoming a key step in the evolution of resource allocation mechanisms, these interactions will have an extensive and deep influence on the evolution of the factors manufacturers consider when they are making investment or operational choices.

Evolution process 2: the application of big data and AI in microeconomic activities is reducing the dominant effect of price and supply and demand relationships on market resource allocation.

During the industrialization age, manufacturers made decisions on what to invest and what/when/how much to produce mainly according to supply and demand relationships and price fluctuations if the government did not intervene in economic activities or did not implement industrial regulations. This resource allocation theory, which is regarded as a classic in neoclassical economics and modern mainstream economics, has never got rid of the predicament of market failure, hence it is difficult to achieve Pareto optimality. This is essentially because manufacturers only obtained partial information from limited data in their operations, and the digging, collection, integration, categorization and processing of necessary information, as well as the development of their perceptions based on such information, were bridled by their bounded rationality and limited technical means. The major reason for the bounded rationality was that the manufacturer was unable to figure out the possible results of their investment/operational decisions since they couldn't gather complete information; as to technical means, it was mainly because of the lack of technical capabilities necessary for the manufacturer to make market signal-based investment/operational decisions that met the effective demands. We can see that optimal resource allocation mechanisms lead to Walras' general equilibrium and guarantee proper allocations and quantitative compositions based on effective demand, providing that manufacturers can acquire complete and accurate information, break the constraint of bounded rationality, and are using new technology to deal with the totality of supply and demand and its quantitative composition in the market clearing sense as an algorithm.

In today's world where the Internet, big data and machine learning/AI integrate organically, the exponential growth of big data will eventually contain all market information including price fluctuations and supply-demand relationships. According to mainstream economic theory, the supply-demand relationship determines price volatility, which determines manufacturers' investments and operations, and that is how the resource allocation mechanisms works. The truth is, however, that the supply and demand relationships between goods and services are determined, considering certain factors such as employment and income distribution, mainly by the choice preferences and perceptions that reflect the consumption trend, the manufacturer's perception of investment choices, and the utility expectations of both consumers and manufacturers. Smart manufacturers do not tie their investments directly to price fluctuations and supply and demand relationships; instead, they study and categorize the big data reflecting people's preferences, perceptions, and utility expectations on the cloud platform, do match-making by using cloud computing and AI, and acquire clear and true information of price fluctuations and supply and demand relationships before making investment/operational decisions. Although price and supply and demand relationships still play a role in the Internet-based resource allocation mechanisms, their dominant effect has been largely weakened.

Evolution process 3: a vital way for establishing the Internet-based resource allocation mechanisms is that smart brains make investment/operational choices through machine learning of big data and AI-based matching of big data.

Machine learning means to analyze the data with algorithms. At present, all types of machine learning deals with historical or current data, be it supervised learning with sample identification, unsupervised learning without sample identification, reinforcement learning functioning in a trial-and-error mode in a dynamic environment, or deep learning that combines low-level and high-level data. If future data is not included in machine learning for AI-based matching of big data, then it is difficult to really establish Internet-based resource allocation mechanisms. Current discussions on how computers can acquire the ability to learn without specific programming highlight how to enable big data matching with artificial intelligence,① but this will only be using historical and current data supported by real events. As to the methods for machine learning of future data, we should first figure out how to do data mining and then find a proper way to learn. A possible option is that we can leverage the completeness and relevance of historical and current data for the mining of future data, i.e. we can, based on the reinforcement and deep learning of these two types of data, utilize their multidimensionality and relevance to predict future data. This machine learning of future data may be referred to as "predictive reinforcement learning."②

Considering the determination of supply and demand for goods and services, "predictive reinforcement learning" is a crucial process for establishing Internet-based resource allocation mechanisms. To determine the exact supply and demand, manufacturers must use intensive cloud computing methods for mining, collection, integration, categorization and processing of historical, current and future data, and acquire machine learning capabilities for handling them. Machine learning is vital to the transformation of resource allocation mechanisms as it forecasts real economic operations. Since the future supply and demand relationships of goods and services are uncertain in the economic world, it is impossible for economists to solve uncertain challenges through models developed with definite programming conditions. This will lead to failures of the market and the government. Machine learning will function as an important intermediary in the fusion of the Internet, big data and AI, largely because it can transform manufacturer's investments and operations into an algorithm, and the utility function of the Internet-based resource allocation mechanisms will be greatly compromised without such an algorithm or if it is unscientifically engineered.

Evolution process 4: As the supply and demand relationships of goods and services are transformed into

① Taddy, 2017

② In fact, it's not so important as to what kind of concept is developed to describe machine learning of future data. What really matters is how to mine future data and bring such machine learning into reality. For example, Alibaba Group's "new retail" investment strategy, which combines online and offline sectors, is an attempt to obtain future data by mining and processing the multi–dimensionally correlated historical and current data, in order to explore the algorithm for future data through the "predictive reinforcement learning" defined in this paper to eventually develop a thorough understanding of the supply and demand relationships.

an algorithm, industrial organizations will change from a vertically integrated architecture to a networked collaborative architecture, which will enable the Internet-based resource allocation mechanisms.

A prominent feature of industrial organizations in the era of industrialization was the joint effects of pricing mechanisms, product attributes, supply and demand relationships, and geographic locations, which resulted in an industrial cluster that demonstrated the interactions between businesses. Such a industrial cluster corresponded to industrial chain that formed a market structure where businesses were linked by upstream and downstream relations with quantitative ratios for different industries. The integration of resources was vertically associated in this market structure. In the age of the Internet, new competition and monopolization methods and approaches have changed the industrial organization as businesses are not relying fully on market signals any longer, but are mining, collecting, integrating, classifying and processing big data for intensive cloud computing, and using AI to analyze big data in order to determine outputs and prices. Futurists have interpreted this new technology as an algorithm[①] when they talk about the economic, political, cultural, and ideological impact of AI-based analyses of big data. When it comes to the application of this new technology, economists explain it as data intelligence, and imply that data intelligence will change resource allocation mechanisms and industrial organizations.

The process of new technology reshaping resource allocation mechanisms is reflected not only in production but also in distribution. Aiming at market scenarios featuring the fusion of big data, the Internet, IoT and machine learning/AI, some scholars have attached more importance to the research of network synergy, an Internet-based collaboration that, on the basis of data intelligence, moves investments, production, operations and other inter-business activities to operating platforms such as the Internet or IoT through big data processing. Network synergy is a way of leading to competition and monopoly in the Internet era, and it co-functions with data intelligence in the process of driving the establishment of the Internet-based resource allocation mechanisms and reshaping industrial organizations. If data intelligence is a necessary condition for establishing Internet-based resource allocation mechanisms, then network synergy is a sufficient condition for that purpose. It is of great significance to understand the connection between the two, which will help us develop a clearer vision for the future of Internet-based resource allocation mechanisms.

## 3. Presence and prospects of the internet-based resource allocation mechanisms

**3.1 Data intelligence is a fundamental factor that makes the Internet-based resource allocation mechanisms possible. Determining the output and price based on intelligent data is a specific reflection of the function of the Internet-based resource allocation mechanisms.**

A large part of the current theoretical analyses of companies determining output and price based on big data focus on abstract theories in which it is taken as an algorithm, rather than specifically analyzing how the Internet-based resource allocation mechanisms operate from company-level data intelligence. When determining output and price based on data intelligence, companies must be capable of processing big data, in addition to mining, collection, integration and categorization of big data. The former requires the capability of

① Noah, 2017; Kelly, 2014

intensive cloud computing; the latter requires machine learning and decision-making by AI-based analysis of big data. Only when companies reach a necessary level of data intelligence can they accurately forecast market demands and set a price leading to market clearing. Given the deep integration of the Internet, big data, IoT and machine learning/AI, it is reasonable to envision, as a prediction of the future resource allocation pattern, that the Internet-based resource allocation mechanisms will be fully functional when most or all companies can apply data intelligence to determine output and price.

The theoretical basis is that the exponentially growing big data contains all the information that is needed to make decisions. Before mining, control and utilization of big data is possible, all the information that affects the company's investments and operations is merely something in existence objectively. In the age of the Internet, big data or AI, companies are able to mine and collect big data with the Internet, IoT, mobile devices, sensors, social media, GPS, etc. However, it is one thing to acquire big data containing all the information but another thing to extract all the information the data may contain to further derive precisely targeted information. To achieve market-clearing results, the Internet-based resource allocation mechanisms must enable an overall balance between total supply and demand through company-level data intelligence. This requires companies to gain the capabilities to attain data intelligence when determining output and price.

When a company's capabilities to mine, collect, integrate and categorize big data are not considered, its strength of data intelligence depends on how well it can process big data, which directly determines the extent and scale of the Internet-based resource allocation mechanisms. In the future, companies will expand the scope of parameters, replace a single well-engineered model with many simple models, and intelligently handle the supply and demand relationships and pricing through various machine learning methods. This "data-driven method" will be the main approach for companies to achieve data intelligence in the future.[①] Investigation of companies using historical and current data for the purpose of data intelligence indicates that the "data-driven method" has gained some progress in determining outputs and prices. Whether this method will be applicable to processing future data or will we need to develop the "predictive reinforcement learning," a machine learning method dedicated to future data, we will need to wait for considerable advances in the research of artificial intelligence.

**3.2 Data intelligence and network synergy of companies are correlated and jointly maintain the existence and development of the Internet-based resource allocation mechanisms.**

The relationship between data intelligence and network synergy is both sides of a copper plate. Intelligent data reflects how big data is matched by supply-related AI capabilities, and it is an operational process to determine the output and price through machine learning. Network synergy represents a multi-party interaction (between businesses, or businesses and consumers) on the Internet or IoT; it reflects the application of demand-related big data and verifies whether the output and price related big data processing is accurate in the operation of data intelligence. Network synergy is the market spillover of data intelligence mainly because the effect of network synergy is generated when companies analyze big data with algorithms and then make investment/operational decisions by utilizing data intelligence. This spillover, featuring the effect of network synergy, allows verification of the data intelligence quality through network synergy. The effect of network

① Wu, 2016

synergy is embedded in the Internet-based resource allocation mechanisms.

Theoretically, the effect of network synergy is a utility function of big data, the Internet, and AI, which integrate and demonstrate the effect of the Internet-based resource allocation mechanisms. In the era of the Internet, companies have begun to pay attention to the network synergy between businesses and between businesses and consumers when they are intelligently processing historical output and price data while trying to explore the current and future data that reflect supply and demand relationships through such network synergy. For example, companies will pay attention to click-through rates, notability and real-time reviews of goods and services on the Internet or IoT, and even promotions by influencers. Some Chinese researchers have analyzed these phenomena from the perspective of resource aggregation, pointing out a trend that companies aggregate market resources through the Internet platform, production resources through the IoT/industrial chain platform, and fragmented resources through the Internet-based platforms of the sharing economy.① This means that they have virtually identified the existence of the Internet-based resource allocation mechanisms and observed that network synergy is a specific manifestation of such mechanisms.

Research of economic theory needs a future-oriented perspective for development of the Internet-based resource allocation mechanisms. As to the future of big data and AI, futurists tend to believe that the composition and movement of all matters, organic and inorganic, will become an algorithm. Regardless of the feasibility of this vision, we can look at the basis of the analysis by futurists, which at least includes the following conditions: (1) We have made considerable progress in developing the technologies for mining and collecting big data and are now at a level high enough for us to probe for accurate information; (2) Big data processing technologies have also reached to a very high level and the mining and processing of historical, current and future data can be done through machine learning; and (3) the Internet and IoT platforms are sufficiently extensive to cover all areas of human activities, and the interpersonal behavioral interactions are fully released from the limits of space and time and synchronized in a way that the relationships between all behavioral interactions are clearly revealed by analyzing big data concerning perceptions, experiences and evaluations of real behaviors.

It can be easily noted that when analyzed as economic activities, the first and second conditions are the technologies required for data intelligence of the Internet-based resource allocation mechanisms, while the third condition is for the platforms required for network synergy of the Internet-based resource allocation mechanisms. Given that balanced macroeconomic operation relies on the rational allocation of resources, macroeconomic benefits in the era of the Internet are therefore mainly dependent on interpersonal behavioral interactions, i.e. the effect of network synergy, providing that data intelligence technology is fully developed. In this sense, the effect of network synergy can be regarded as a utility function of the Internet-based resource allocation mechanisms. Unlike the relatively specific utility functions of the manufacturer's investments and operations, this is an abstract utility function for the macroeconomic benefits caused by the Internet-based resource allocation mechanisms and is difficult to express with a specific formula. Nevertheless, as a macro-level utility function, the effect of network synergy is always connected with the two explanatory variables, i.e. data intelligence and network synergy. Is it reasonable to indirectly transform our vision for the Internet-based

① Jiang, 2017

resource allocation mechanisms to a vision for the network synergy?① If yes, will this vision involve more macroeconomic issues?

**3.3 When the best effect of network synergy is achievable based on the economic operations of high-level data intelligence, we may draw a theoretical inference about implementation of a planned economy.**

The prospect for the Internet-based resource allocation mechanisms is actually for the data intelligence, network synergy and corresponding effects of network synergy. Data intelligence and network synergy can be fully realized and analyzed by taking the Internet-based resource allocation mechanisms as an algorithm. When society-wide data intelligence is fully realized, it means that: first, we will be able to mine and collect the encompassing big data with the Internet, IoT, mobile devices, sensors, social media, GPS, etc.; second, with the help of artificial intelligence, we can obtain near-complete information necessary for decision-making from the encompassing big data; third, people can identify real information and even acquire accurate information through data intelligence and know the outcomes of investments or operational decisions. On the other hand, when society-wide network synergy is fully realized, it signifies the maximum macroeconomic benefit (optimal effect of network synergy). For this fascinating vision, supporters believe that it is possible to implement a planned economy in the future, while opponents argue that the planned economy is not an option even if this vision is correct. ② We can interpret this debate about the implementation of a planned economy as an argument about the existence and role of the Internet-based resource allocation mechanisms. Whether plan-based socio-economic operations are acceptable depends on whether we can obtain accurate information about total supply and demand, and the quantitative composition of the data.

Here are a few questions to discuss: (1) If we can collect the big data containing complete information; (2) If we can acquire complete and accurate information from big data; and (3) If we can achieve network synergy. One of the key indicators of top-level data intelligence is the ability to mine big data for behavioral interactions and to coordinate behavioral interactions through artificial intelligence. Another important indicator is the ability to mine and process big data for future events. If this is the case, the "plan" is market-oriented. For that reason, we can assume that if we can obtain accurate and precisely targeted information through the mining and processing of historical, current and future data, then it is possible for us to implement a market-oriented planned economy under the effects of the Internet-based resource allocation mechanisms.

**3.4 In the age of Internet when AI and automation impact employment and income distributions, we can forecast and control the impacts as a vision for the effects of the Internet-based resource allocation mechanisms.**

① It's necessary to note that network synergy includes two aspects: first, the micro-level behavioral interactions between a single business and its customers generated by the business matching big data on the Internet platform using artificial intelligence for investments and operations (data intelligence); second, the macro-level behavioral interactions between all businesses and their customers. When we consider the effect of network synergy as a utility function of the Internet-based resource allocation mechanism, such an effect refers particularly to the results from the macro-level behavioral interactions.

② For this issue, Ma Jack and Qian Yingyi (2017) had a typical debate on Sina.com. Mr. Ma believed that a planned economy is feasible in the future based on the vision of data intelligence that everything can be rendered as an algorithm, while Mr. Qian, by referring to the economic practice before the reform and opening-up policy, negated the viability of a planned economy. Zhang Xukun (2017) asserted that a planned economy is not feasible by taking the lessons learned from the failure of the European Utopia Commune as an example.Xu Chenggang (2017) based his arguments on the general mechanism of economic operation and believed that big data and AI cannot enable a planned economy. Anyway most economists stand against a planned economy, leaving Mr. Ma alone in an unsupported position. The truth is, however, the debate between the two sides had not completely probed into the key points of data intelligence, and this issue remains to be studied.

The Internet-based resource allocation mechanisms will have an impact on employment, mainly due to AI and AI-enabled automation. According to analytical models which classify low-skilled, repetitive, highly-skilled and non-repetitive production activities,① our vision of the impact of the Internet-based resource allocation mechanisms on jobs should take into account the impact of AI on low-skilled and highly-skilled jobs caused by differences in repetitive and non-repetitive production. Benzell et al. ② believed that while artificial intelligence replaces low-skilled jobs to a large extent, it also replaces some high-skilled jobs as well. Acemoglu③ argued that the cost of labor and capital, under equilibrium conditions, will result in a reduction of low-skilled jobs due to artificial intelligence while creating some highly skilled jobs. By scrutinizing these latest viewpoints, it is easy to note that they, while demonstrating the role of factors and the correlation of their cost and artificial intelligence, certainly imply that the Internet-based resource allocation mechanisms will affect employment.

At present, most mainstream views on the impact of AI on employment hold that the impacts on low-skilled and highly-skilled jobs are complementary. Diving deeper into this point of view, it also involves the issue of income distribution for jobs at different levels or even the same level. In fact, AI has different influences on GDP, employment, income distribution and social welfare in different countries. When investigating AI and analyzing the impact of the Internet-based resource allocation mechanisms on income distribution, in a purely theoretical sense, we should base our analysis on the algorithm. However, as an algorithm is scenario-related, it is difficult to accurately implement an algorithm for analyzing employment and income distributions, where multiple variables and complicated scenarios are involved. Therefore, without strong capabilities of machine learning and AI-based matching of big data, it is challenging to accurately predict the impact of AI and AI-enabled automation on employment and income distributions when the Internet-based resource allocation mechanisms take effect.

Our society is about to embrace the era of the Internet-based resource allocation mechanisms with big data as its soul. Data intelligence, network synergy and the corresponding effects of network synergy will adjust resource allocation which is an issue focusing on the totality of supply and demand. For the objectively existing Internet-based resource allocation mechanisms, economists need to carry out in-depth analyses and forecasts within the context of developing of new technologies.

## REFERENCES

Acemoglu, D., & Restrepo, P. (2016). The race between machine and man: Implications of technology for growth, factor shares and employment. *NBER Working Paper*.

Alfred Marshall. (1965). *Principles of economics*. In Liangbi Chen(Trans.). Beijing: The Commercial Press.

① Autor & Dorn, 2013.
② Benzell, Kotlikoef, Lagarda & Sachs, 2015.
③ Acemoglu, & Restrepo, 2016

Arrow, K.& G. Debreu. (1954). Existence of equilibrium for a competitive economy. *Econometrica* (22).

Autor, D., H. & Dorn, D. (2013). The Growth of Low-Skill Service Jobs and the Polarization of the U.S. Labor Market. *American Economic Review*,103(5).

Benzell, S., Kotlikoef, L., Lagarda, G. & Sachs, J. (2015). Robots are us: Some economics of human replacement. *NBER Working Paper.*

Central Compilation and Translation Bureau. (1998). *Marx & Engels collected works.(Volume I)*. Beijing: People's Publishing House.

Dantzig, G.B. (1951). The programming of interdependent activities. In activity analysis of Production and allocation(ed). T. Koopmans, Cowles Commission Monograph No.13, New York: Wiley, 2.

Gosson, H. (1927). Entwicklung der Gesetze des menschlichen Verkehrs.(3rd edn). Berlin: Prager.

Harari Yuval Noah. (2017). *Homo Deus: A brief history of tomorrow.* In Lin Junhong. (Trans.). Beijing: CITIC Press Group.

Hayek, F, Von. (1945). The use of knowledge in society. *American Economics Review*, (35), 519-553. Reprinted in F. von Hayek, (1949). *Individualism and Economic Order*, Chicago: University of Chicago Press. Arrow, K.J. (1951). An extension of the basic theorems of classical welfare economics. *Proceedings of the Second Berkeley Symposium*, Berkeley: University of California Press.

He Da'an. (2016). Expanded boundary and limitation of individualistic methodology in western economics. *Social Sciences in China*, (2).

Jevons, W.S. (1957). *The theory of political economy.* London: Macmillan; Sth edn, New York: Kelley and Millman.

Jiang Xiaojuan. (2017). Resource reorganization and the growth of the service industry in an interconnected society. *Economic*

*Kahneman, D & Tversky,A*. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, vol. 47,(2).

Kahneman, D & Tversky, A. (1973). On the psychology of prediction. *Psychological Review* (80).

Kahneman, D & Tversky, A. (1974). Judgement under uncertainty-Heuristics and biases. *Science*, 185(3).

Karl Marx. (1975). *Capital (Volume I)*. In Central Compilation and Translation Bureau(Trans.). Beijing: People's Publishing House.

Karl Marx. (1975). *Capital(Volume III)*. In Central Compilation and Translation Bureau. (Trans.) Beijing: People's Publishing House.

Kevin Kelly. (2014).*New rules for the new economy.* In Liu Zhongtao et al. (Trans.). Beijing: Publishing House of Electronics Industry.

Koopmans, T.C. (1951). Analysis of production as an efficient combination of activities. In Activity Analysis of Production and allocation, (ed). T.C. Koopmans, Wiley: New York.

Lecun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature.* 521(7553).

Pareto, V. (1971). Manuel d'économie politique. Paris. Trans. from 1927 edn as Manual of Political Economy, New York. Kelley,

Peilin, W. (2016, December 7). *Ma Jack vs QianYingyi : can big data, cloud computing and AI revitalize planned economy?* Retrieved from https://www.yicai.com/news/5177196.html

Ricardo David. (2009). *On the principles of political economy and taxation*. In Jungong Feng(Trans.). Beijing: Guangming Daily Publishing House.

Robert, J. Shiller. (2001). *Irrational exuberance.* Beijing: China Renmin University Press.

Smith Adam. (1988). *An inquiry into the nature and causes of the wealth of nations*. In Dali Guo & Yanan Wang (Trans.). Beijing: The Commercial Press.

Taddy, M. (2017). The technological elements of artificial intelligence. *Working Paper.*

V. L. Smith. (1994). Economics in the laboratory. *Journal of economic perspectives.*

Von neumann, John & Oskar morgenstern. (1947). *Theory of games and economic behavior.* (2d ed). Princeton: Princeton University Press.

Walras, L. (1954). Elements d'économie politique Pure. Lausanne: Cobaz. In W.Jaffé. (Trans). *As elements of economics*. London: George Allen & Unwin, from the 1926 definitive edition.

Wu Jun. (2016). *Smart age: big data and intelligent revolution redefine the future*. Beijing: CITIC Press Group.

Xu Chenggang. (2017, September 25). *Why it is impossible to build planned economy with big data and AI*. Retrieved from https://economy.china.com/domestic/11173294/20170925/31510309.html

Zhang Xukun. (2017). The utopia of planned economy in the age of big data. *Exploration and Free Views*, (10).

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