Resour Environ Econ, 2024, 5(2): 420-425
DOI: 10.25082/REE.2023.02.001

COMMENTARY

A brief discussion on the coupling principle of positive and negative feedback in the economic system

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Received: July 8, 2024;
Accepted: September 25, 2024;
Published: October 5, 2024.

Citation: Gan R. A brief discussion on the coupling principle of positive and negative feedback in the economic system. *Resour Environ Econ*, 2024, **5**(2): 420-425. https://doi.org/10.25082/REE.2023.02.001

Abstract: This study clarifies the concepts of "feedback", "positive feedback", and "negative feedback" and explains the philosophy of the coupling principle of positive and negative feedback. The evolution process of the system is the organic coupling of positive and negative feedback, and only the reciprocating cycle of positive and negative feedback can ensure the occurrence and existence of heterogeneous new things. In the economic system, the law of increasing returns corresponds to the positive feedback mechanism, whereas the law of diminishing returns corresponds to the negative feedback mechanism. This study briefly expounds on the differences in understanding between the law of increasing returns and diminishing returns, and the equilibrium and disequilibrium of economic operation in the economics circle, based on the histories of economic thoughts and social and economic forms. This study emphasizes that instead of dividing and opposing each other, the idea of static partial equilibrium and dynamic general nonequilibrium in epistemology can be united to solve this difference. Finally, this paper explains the essential relationship and compatibility between the law of diminishing returns and increasing returns from the characteristics, nature, and proportional changes of tangible and intangible factors of production. Applying the positive and negative feedback coupling principle can clarify the essential relationship between the law of diminishing returns and increasing returns. From the philosophical level and epistemological significance, it can bridge the fundamental differences between equilibrium and nonequilibrium theories, which in turn, can help realize the creative synthesis of economic theory.

Keywords: economic system, positive and negative feedback, increasing and diminishing returns, tangible and intangible factors of production

1 Introduction

Mr. Longfei Niu [1], a Chinese cultural philosopher, has made a profound discussion from the philosophical aspect regarding the evolution mechanism of the material world. The basic principle of his idea is the coupling principle of positive and negative feedback in the system. The author introduces Longfei Niu's idea into the discourse of the mechanism of social system evolution to address the essential issue of the mechanism, thereby explaining the process of relative steady state and continuous change in social structure in a relatively reasonable way [2]. Moreover, this article applies this idea to the account of the evolutionary mechanism of the economic system, intending to bridge the fundamental divergence between equilibrium and disequilibrium theories in economics.

2 Basic concepts

Feedback is a fundamental concept in cybernetics. It refers to the process of regulating the function of a system by returning some or all of the system's output information to the system's input in the process of system–environment interaction. Feedback can be divided into positive and negative feedback. On the one hand, positive feedback is the process when regulating directions of the feedback and the input are the same, thereby promoting and enhancing the system's function. On the other hand, negative feedback is a process wherein the feedback information is regulated in the opposite direction of the input information, thereby inhibiting, and weakening the system's function. The meaning of positive feedback is to promote the changes in the system's internal environment, which in turn, causes structural instability of the system and, thus, drives it away from equilibrium. Alternatively, negative feedback means maintaining a stable environment

within the system, which keeps the system structure settled and consequently contributes to the system's balance.

The terms "positive" and "negative" here do not convey their literal meanings. For social systems, positive feedback can be either a revolutionary or destructive factor. For instance, positive feedback can lead to system innovation and collapse or annihilation. Again, negative feedback may be a conservative or constructive factor. For example, negative feedback can drive a system to maintain a steady state or cause the system to stagnate or to decay. The virtuous and vicious cycles of a system are both positive feedback mechanisms at work, whereas the system's steady state and equilibrium state are both negative feedback mechanisms in operation.

3 Philosophical thought of the coupling principle of positive and negative feedback

The basic idea of the positive and negative feedback coupling principle stems from cybernetics. First-generation cybernetics focused on the issues of the system's negative feedback. At that point Cybernetics emphasized that an open system could maintain its steady state only when a circular negative feedback loop is formed in its internal environment. Meanwhile, second-generation cybernetics dealt with both negative and positive feedback issues and combined the two to study their interaction mechanisms. Moreover, the cybernetics at that time indicated that under the combined actions of positive and negative feedback, the system could operate in three states: dynamic equilibrium (steady state), deviation from equilibrium (unstable state), and abrupt bifurcation (in multiple steady states). For a system, positive feedback amplifies the input. Additionally, the positive feedback effect of the system occurs when the negative feedback effect decays [3]. Niu Long-Fei, a cultural philosopher, summarised the philosophical idea of positive feedback, self-generation and negative feedback, and selfstabilization coupling principle based on the outcomes of systems science in combination with the classical Chinese philosophy in Zhou Yi (the Earliest Book on Systems Science in the World and among the oldest of the Chinese classics) and Taoism's idea of Tai Chi (a Chinese cosmological term for the Supreme Ultimate).

The evolution of a system contains both positive and negative feedback effects. Moreover, it is an organic coupling of positive and negative feedback. As Longfei Niu noted, "The former is to change, the latter is to not unchanged. The former is the proliferation of information, and the latter is the maintenance of information. The former is positive feedback selfgeneration, and the latter is negative feedback selfstability." He further stated, "Neither positive feedback self-generation alone nor negative feedback selfstabilization alone, is a sufficient condition for the evolution of things. However, the reciprocal cycle of the two is what ensures the occurrence and existence of heterogeneous new things" [4]. A system in a stable state will be destabilized and self-organized due to a positive feedback mechanism. The result of self-organization is to create a new structed system on a new level, which will maintain a relatively stable state due to a negative feedback mechanism.

4 Positive and negative feedback in law of economic

Both positive and negative feedback phenomena exist in real economic activities. By way of illustration, "the rich get richer, and the poor get poorer" is a positive feedback phenomenon in wealth distribution. Simultaneously, the balance of supply and demand is a negative feedback appearance in market exchange. Moreover, positive and negative feedback precepts exist among the economic laws that people have concluded. As proof, the laws of increasing returns and diminishing returns are postulated, where the former corresponds to a positive feedback mechanism and the latter corresponds to a negative feedback mechanism. The law of increasing returns means that as the input factors continue to grow in an economic system, the output will increase; accordingly, that is, the marginal revenue is on the rise. Meanwhile, the law of diminishing returns refers to the fact that as input factors continue to increase in an economic system, the system's output will first increase and then decrease; that is, the marginal revenue shows a downward trend. These laws are two basic propositions in economic theory. From a superficial point of view, they are contradictory and opposed to each other, which have led to a long dispute in the economics community. Can they be organically integrated and unified?

5 Unification of two different types of understanding

In terms of premises, period, and method of observation of propositions, the law of diminishing returns is the result of a static study of local, short-term phenomena in the economic field.

Alternatively, the law of increasing returns is the insight derived from dynamic research of overall, long-term events in the economic area. Arguments in the economic community are more reflected in the differences between the understanding of these two aspects. To essentially identify the differences, the histories of economic thought and socioeconomic formations can be examined.

5.1 An investigation into the history of economic thought

If tracing the economic thought back to the initiation of classical economic theory, it will be noticed that there is no such divergence in Adam Smith's The Wealth of Nations. Since the 1930s, the static equilibrium framework has been continuously refined in the mainstream economics community, dominated by neoclassical economic thought, whereas dynamic economic development has long been neglected. It was not until the 1980s that economic theories emphasizing disequilibrium and the law of increasing returns attracted attention.

In The Wealth of Nations, Adam Smith proposed two different theories of economic equilibrium and economic evolution. His idea of equilibrium was mainly reflected in the section "On the natural and market prices of commodities." Since Adam Smith proposed the theory of economic equilibrium, from Léon Walras (1834–1910) and Alfred Marshall (1842–1924) to Kenneth J. Arrow (1921–2017) and Gérard Debreu (1921–2004), the general equilibrium theories were in the same vein. The core of general equilibrium theory was the analysis of the conditions for reaching various equilibria in an economic system. To build mathematical models, economists had to make extremely strict assumptions about the theory's premises, from which increasing returns and the nature of technological and institutional changes were excluded [5].

In 1890, Alfred Marshall applied partial equilibrium analysis in his masterpiece Principles of Economics [6] to detail the existence of increasing and diminishing returns in the economic system and the interrelationship between them. From the characteristics of diminishing returns in agriculture and mining sections, he inferred that the universal law governing the economic system was the law of diminishing returns. Moreover, he attributed the cause of increasing returns to the expansion of firms or industries' size. When the size of the representative firms increased, individual firms experienced increasing returns to scale, which he termed as an "internal economy." Meanwhile, when the size of the representative firms remained the same but the size of the industry increased, individual firms also experienced increasing returns to scale, which he termed as the "external economy."

In 1928, Allyn Abbott Young (1876–1929) expounded Adam Smith's economic thoughts. He attributed the cause for increasing returns to the interaction and mutual promotion between the division of labor among industries and the extent of the market. Simultaneously, he highlighted the conditions of departure from equilibrium in economic operations [7].

The ideas of Alfred Marshall and Allyn Young have a significant influence on later economists. Since then, two significantly different thought lines have been formed in the development of economic theories: the neoclassical and structuralist economic theories. The neoclassical economic theory incorporates the external economy into the equilibrium framework. Meanwhile, a structuralist economic theory initiated by economist Allyn Young and refined by Karl Gunnar Myrdal (1898–1987) and Nicholas Kaldor (1908–1986) emphasizes the importance of imbalanced characteristics of the economic operating process and the importance of historical conditions. Its most recent representative is W. Brian Arthur.

Rethinking the basic assumptions and research paradigms of neoclassical economic theory, Brian Arthur constructed a new framework of complexity economics by applying the positive feedback thought in cybernetics and the probability theory method in mathematics to analyze the disequilibrium process and increasing returns in the economic system [8]. His series of papers published since the 1980s (1987, 1988, 1989, 1990, *etc.* [9–12]) have advanced the theory of increasing returns to a new stage and made significant contributions to the development of economic theory. Brian Arthur stressed that the law governing the modern economic system was the law of increasing rather than diminishing returns. Moreover, the evolution of the economic system was characterized by positive feedback and path dependence. He highlighted that, under the premise of increasing returns, multiple equilibria would occur in the operation of the economic system. That is, increasing returns could lead to a variety of possible outcomes, and the exact outcome bound to happen was not certain but mediated by a series of random events in history. A result selected by random events might be inefficient; in other words, it might not be necessarily optimal but suboptimal or inferior. However, once the economic system determined such an outcome, the economic operator would step into that specific path and be locked in it. The result of the positive feedback effect of increasing returns would magnify this outcome, eventually leading to the "the superior gets better, and the inferior gets worse" result. From this, he precisely

explained the "vicious circle of poverty" phenomenon in underdeveloped countries and the economic growth differences of "poor countries get poorer, and rich countries get richer." Brian Arthur focused more on studying the evolution of technologies, and his framework needs to be considered in a broader domain.

If neoclassical economic theory is representative of emphasizing the law of diminishing returns, structuralist economic theory is the representative of underlining the law of increasing returns. The former emphasizes the equilibrium characteristics of the economic operation process and the law of diminishing returns. It is based on the concept of the optimal, unique outcome, predictable, and history-independent equilibrium. Conversely, the latter underlines the nonequilibrium characteristics of the economic operating process and the law of increasing returns. It is founded on the concept of nonoptimal, multi-results, unpredictable, and history-dependent evolution. Obviously, these are two very different economic theories.

In the economic field, the neoclassical economic theory emphasizes statics, negative feedback, and equilibrium more, but ignores long-run unbalanced growth. It even tries to integrate long-term economic improvement into the equilibrium framework. Meanwhile, structuralist economic theory emphasizes the dynamics, positive feedback, and disequilibrium while ignoring the partial short-term economic equilibrium in the economic domain. The long-standing debate in the economics circle about economic equilibrium and disequilibrium reflects the divergence of understanding of the relationship between positive and negative feedback. This disagreement may be settled by unifying the local static equilibrium idea and the overall dynamic nonequilibrium idea in epistemology. The two ideas cannot be separated or opposed to each other, nor can either of them be abandoned.

5.2 A study in the history of socio-economic formations

In the history of socioeconomic formations, human society has experienced the eras of the gathering and hunting economy, agricultural economy, industrial economy, service economy, and information economy. In the long historical process, on one hand, more factors of production have been involved in the economic system, and the connotation of the economic system has been enriched. On the other hand, among the total factors of production, the relative weight and revenue contribution of tangible factors have tended to decrease gradually, whereas the relative weight and revenue contribution of intangible factors have tended to increase progressively.

In the era of the gathering and hunting economy, the geographical distribution and abundance of natural resources on the land, for example, water, plants, and animals, directly influenced the economic life of different ethnic groups in human society. Meanwhile, in the age of the agricultural economy, production factors, such as land and labor, had a leading role in the development of social productivity. In the industrial economy era, factors such as land, labor, and monetary capital played a leading role in the development of social productivity. Since the 20th century, human society has entered the era of the service economy. In terms of improving social productivity, the role played by tangible factors of production (i.e., land, labor, and monetary capital) has been reaching its limit. Alternatively, the role played by intangible factors (e.g.,human capital, management knowledge, and production technology) has become increasingly important. Since the 1950s, human society has entered the era of the information economy. In this era, the proportion of tangible production factors in the economic system, such as natural resources, land, labor, and monetary capital, has declined. Meanwhile, the proportion of intangible production factors in the economic system (e.g., human capital, education and training, knowledge, technology, institution, and information) is increasing daily.

For a specific society or country, the quantity of tangible factors, for instance, natural resources, land, labor, and monetary capital, is limited in the short term (less than a year). These factors generally have characteristics and properties such as scarcity, slow regeneration, and difficulty in sharing, which determine the features of diminishing returns in an economic system dominated by tangible factors of production. Moreover, the quantity and quality of intangible factors are growing and improving in the long term (more than one year). These factors usually have characteristics and properties, opposite to the aforementioned ones, such as non-scarcity, faster regeneration, and the ability to be shared, which determine the features of an economic system led by intangible factors of production with increasing returns. At present, human society has entered the era of the knowledge economy. Various kinds of knowledge and technologies are nonexpendable and can be easily spread and shared as factors of production. Furthermore, they can be integrated with other knowledge and technologies to derive new ones, that is, creating new knowledge through the existing knowledge and inventing new technologies through existing technologies, thus enabling continuous innovation and value appreciation of the economic system.

It is apparent that equilibrium theory and disequilibrium theory are not in absolute opposition and contradiction but can be compatible and unified. The analysis of economic systems lends itself to the application of equilibrium theory in the short term and disequilibrium theory in the long term.

Regarding the relationship and compatibility between the law of diminishing returns and that of increasing returns, Tao Shi and Aiping Tao (2007) gave a better explanation [13]: changes in the relative weight of tangible and intangible factors of production in total factors directly determine the direction of changes in returns. Increasing returns may appear in a certain industry or a certain section of an industry in a traditional economy. However, under the predominance of tangible factors, the increasing returns as particularity are often submerged in the generality of decreasing returns in many economic fields. With the continuous enrichment of the economy, the proportion of intangible factors in the total increases. Thus, the increasing trend of total marginal returns becomes more apparent, and the law of increasing returns extends from one or a few fields to many other fields and thus becomes increasingly general.

From the above discussion, the understanding of the theory of equilibrium and the theory of disequilibrium, and that of the law of diminishing returns and the law of increasing returns, are in fact compatible with each other and can be unified, despite the long-standing disputes between them in economics.

6 Conclusion

The human social system is a super-complex giant system. It is easy to fall into misunderstandings and draw one-sided conclusions from partial and short-term observations. Only observation and thinking from the overall and long-term historical process can help us witness the trend of social development clearly and truly grasp its essence. In the long evolution of the social system, both positive and negative feedback effects are alternate in predominance, thereby making the system both relatively stable and in a constant state of evolutionary change. From a long-term historical perspective, after a social system has accumulated abundant practices, some individuals will generate innovations in knowledge, technology, institutions, and so on. When these innovations are disseminated and diffused through social selection, the positive feedback mechanism of evolution in the social system is activated. Furthermore, when the positive feedback effect develops to a critical point, the social system will suddenly bifurcate, it may either jump to a higher or fall to a lower level. The leap or fall of the social system depends on the influence of contingent factors at that point. Once the social system enters a certain level, it will remain relatively stable for a certain period due to the effect of the negative feedback mechanism. The long-term evolution of the social system is a process of organic coupling, alternating dominance, and reciprocating cycles of the effects of positive and negative feedback.

Applying the coupling principle of positive and negative feedback can clarify the essential relationship and compatibility between the law of diminishing returns and the law of increasing returns, this can bridge the fundamental differences between the theories of equilibrium and disequilibrium in economics in a philosophical and epistemological sense, and thus, help effectuate the creative synthesis of economic theories.

Conflicts of interest

The author declares that there is no conflict of interest.

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