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ТЕОРЕТИЧЕСКИЕ И МЕТОДОЛОГИЧЕСКИЕ ПРОБЛЕМЫ

Analysis of marginalism. Part 1

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Abstract. In recent years, based on the traditional theory of value — the labor theory of value and the theory of surplus value, as well as the hypothesis of Jevons, Tesla and Foley, — Chinese and Russian scholars have further adopted the mathematical paradigm of theoretical mechanics for reference to establish a mathematical model system for economics, which is called the new theory of value. Compatible with the traditional theory of value, the new theory of value puts forward that the value depends on the force of labor expended in the process of commodity production. While the value appreciation depends on the labor gravitational force generated by the improving dexterity of workmen. That is to say, during the process of production, constant capital and variable capital as kinetic energy and potential energy of value, convert into each other under the value conservation theorem, playing a dominate role in generating value and surplus value of products. In addition, the law of diminishing marginal utility is not an axiom, but a special economic law under unbalanced supply and demand. Obviously, these theoretical conclusions are of great significance, which not only make the traditional theory of value a self-consistent logical system, but also complete the new theory of value by absorbing the rational components from both the classical economics based on the labor theory of value and the theory of surplus value, and neoclassical economics based on the law of diminishing marginal utility. In this paper, we will analyze this problem by investigating the origin of the law of diminishing marginal utility.

Keywords: new theory of value; force of labor; labor gravitational force; law of value equilibrium; law of diminishing marginal utility; self-consistency.

JEL Classification: C62, D46, D58.

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1. INTRODUCTION

In the history of economic theory, the marginal revolution is the watershed of mainstream economics from the traditional theory of value to neoclassical economics. The former refers to Smith's labor theory of value (Smith, 1776) and Marx's theory of surplus value (Marx, 1867), which proposed that the value of commodities is determined by the average amount of labor necessary consumed in the commodity production, and in capitalist society, the capital composed of living labor — variable capital — will create surplus value. The latter refers to the marginal utility theory of value founded by (Walras, 1874; Jevons, 1871; Menger, 1871), then supplemented and improved by (Wieser, 1889; Marshall, 1890; Hicks, 1939; Arrow,

1951; Debreu, 1959) and so on. These researches proposed that the value and price of commodities were determined by the marginal utility value under the supply and demand in the market.

Obviously, there are fundamental differences in almost all the basic theoretical problems between the traditional theory of value and neoclassical economics, including but not limited to:

– whether the value of commodities can be measured: the former is positive, while the latter is negative;

– how are the value and price of commodities reflected by the quantity: the former holds that the value and price of commodities are equivalent under the supply–demand balance, while the latter holds that the price of commodities is its marginal utility in any case, reflected by the law of diminishing marginal utility;

– how is the spontaneous adjustment mechanism of the market formed. The former believes that the value of commodities is determined by the labor amount consumed in the production process. The price of commodities deviates from its value due to the market supply and demand, and then enterprises will suffer loss in oversupply and earn extra profits in short supply. And the pursuit of profit maximization will lead to the spontaneous adjustment mechanism of the market. The latter believes that any kind of commodities have the equilibrium price, as long as the commodities in the market keep changing, there must be an equilibrium price that makes the supply equal to the demand, i.e. the difference between supply and demand of this type of commodities is zero.

Therefore, there are great differences in the basic axioms and corresponding theoretical conclusions between them, which divide the modern economics into polarized lineups. Especially, after the marginal revolution, the traditional theory of value were gradually marginalized, and the general equilibrium theory of neoclassical economics became the *mainstream economics*. The key reason is that marginalism has put forward a new basic axiom, and accordingly has established a new economic theoretical system that is different from the traditional theory of value, thus changing the historical process of economics around the world. Clearly, the theoretical conflict between the traditional theory of value and neoclassical economics starts from the divergence of basic axioms.

There is an old saying in China: a slight discrepancy leads to a great error. In the history of human science, if there are differences in axioms for the same problem by different groups, it must be an essential question of what is right or wrong. Like the difference in the assumptions that «the Earth rotates from West to East» by Kopernik's heliocentric theory and «the Sun rises from the East» by Ptolemy's geocentric theory, it turns out to be such a question. Obviously, the traditional theory of value and neoclassical economics face the same question in the history of economic theory.

In fact, the marginal revolution was caused by a theoretical misunderstanding, that is, the law of diminishing marginal utility is a theoretical conclusion rather than a basic axiom. To be specific, according to the traditional theory of value, the value of commodities is composed of the force of labor[1] expended in the production process, and due to human intelligence, the acting force of improving dexterity of workmen — labor gravitational force — creates the absolute value appreciation one after another in every period of producing the same kind of products without expending more force of labor (Wu et al., 2020). Then the value with appreciation makes the exchange value, which is the ratio of the unit value of this commodity to the unit value of other commodities, i.e. the general equivalent in value of commodities. The price is the monetary expression of the exchange value (Marx, 1867, ch. 1, sec. 3). In particular, according to the new theory of value, as long as the quality of any commodity is determined, there must be a rational demand in the market. In the process of commodity production, the market price of the commodity is equal to its exchange value under the supply–demand balance, and deviates from the exchange value when supply and demand are unbalanced — higher than the value in short supply and lower than the value in oversupply.

Here, the reasonable price of a commodity refers to its value. Thus, the reasonable price is not always same with the market price. If the unit value of commodities, i.e. the value per unit quantity commodity, refers to the value divided by the actual production quantity. In this case, we can define the market value function of a commodity: under the supply–demand balance the unit value is divided by the production quantity. Obviously, if the commodity quality remains unchanged, the rational demand for each commodity is limited. Also, if the labor productivity of the commodity remains unchanged, and the average force of labor necessary consumed in producing unit quantity commodity is a constant quantity, then the market value function of the commodity will be strictly decreasing (Wu J., Wu Z., 2021, Appendix, Fig. A3). Also,

[1] According to Marx's theory of surplus value, this is a process of producing absolute surplus value by the "living labor power" (Marx, 1867, ch. 10). Here, Marx did not regard the living labor power that constitutes variable capital as the "force of labor" (Wu et al., 2020), which can be analogous with "force" in theoretical mechanics.

the market price function, as the monetary expression of the market value, will be strictly decreasing (see Fig. 1 below). Clearly, the marginal decreasing property of commodity price function is not a basic axiom, but a special economic theorem based on labor theory of value, i.e. an inevitable law of motion of commodity market price under the imbalance of commodity supply and demand. Therefore, the law of diminishing marginal utility as a basic axiom is actually a misunderstanding, like the geocentric theory that the Sun rises from the East.

There is a long history of economic theory for discussion on the law of diminishing marginal utility. In 1776 A. Smith wrote: "The things which have the greatest value in use have frequently little or no value in exchange; and, on the contrary, those which have the greatest value in exchange have frequently little or no value in use. ... A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it. ... The value of any commodity, ... is equal to the quantity of labour which it enables him to purchase or command. Labour, therefore, is the real measure of the exchangeable value of all commodities" (Smith, 1776, p. 16). He observed the phenomenon that the scarcity assumption is easy to cause misunderstanding, because "scarcity" is not a factor that determines the exchange value. It is the amount of labor that determines the exchange value of commodities, which laid the foundation of labor theory of value. As for the relationship between the supply and demand and the market price, Smith noticed that there is an "effectual demand" (Smith, 1776, p. 30) in the market. When the supply exceeds the effectual demand, the market price will sink more or less below the natural price (reasonable price); when the supply falls short of the effectual demand, the market price will rise more or less above the natural price. However Smith did not explore further and more clearly — the reason, why the supply and demand *deviate the price from the value*.

On what determines the value, there was a heated debate between J.-B. Say and D. Ricardo. Say (Say, 1803, p. 290) believed that the price is in ratio to the supply and demand[2], while Ricardo (Ricardo, 1817, p. 207) believed that the price depends on the exchange value instead of the market supply and demand. Here, K. Marx supported Ricardo: "Whenever two forces operate equally in opposite directions, they balance one another, ... hence scientifically = 0, ... political economy assumes that supply and demand coincide with one another" (Marx, 1894, vol. III, ch. 10). Thus, the value is the average amount of labor necessary to produce the commodity under the supply-demand balance. If the supply and demand is unbalanced, the market price will deviate from its labor value (Marx, 1894, vol. III, ch. 9)[3]. We summarize Marx's above opinion as **Marx's first law**.

When the marginalism was first founded by L. Walras, W. Jevons and C. Menger, Smith's analysis on the «scarcity» of diamond was regarded as an important argument for the law of diminishing marginal utility (Walras, 1874, ch. 1–3). In fact, this law was originally raised by H. Gossen (Gossen, 1854), which once was overlooked but gradually recognized by economists. First in 1879, Jevons wrote about Gossen in the second edition of his celebrated "*Theory of Political Economy*" (Jevons, 1879), clarifying the originality of Gossen's law that provides a more accurate interpretation on the law of diminishing marginal utility. Later in 1885, Walras also wrote about Gossen, and recognized his work (Walras, 1885). Finally, F. Wieser, the successor of Menger, put forward the subjective utility theory of value (Wieser, 1889), and then mainstream economics acknowledged Gossen's law as the main expression of the law of diminishing marginal utility. According to Gossen's Law (Gossen, 1854), the want is of different strength varying according to the degree in which the want has been satisfied through the employment of goods. That is to say, as the quantity of every commodity brought to the market increases, its unit value decreases, so that the law of diminishing marginal utility is rooted at the strength of subjective want. Therefore, the marginal revolution broke out and deviated from the traditional theory of value due to their completely different basic axioms and corresponding theoretical conclusions. Henceforth, economics split into two irreconcilable lineups.

How to evaluate the "marginal revolution"? It is not only a question of right or wrong in the history of economic theory, but also a direction of right or left of the development of modern economics. In fact, there is always only one truth — traditional theory of value ***or*** marginalism? It is the principle question that should be answered in modern economics, by attaching more attention to value transformation, as well as

[2] Ricardo criticized that Say's "opinion that the price of commodities depends solely on the proportion of supply to demand, or demand to supply, has almost become almost an axiom in political economy, and has been the source of much error in this science" (Ricardo, 1817, p. 279).

[3] For specific mathematical analysis, see Theorems 1–3 (Wu, 1999a), Theorems 4–6 (Wu, 1999b) related to abstract algebra and category theory, and Theorems 5.1 and 5.2 (Wu J., Wu Z., 2021).

mathematizing the traditional theory of value. Then with such a scientific theoretical paradigm, the error of marginalism will be erased.

In this regard, based on the traditional theory of value, as well as the hypothesis of W. Jevons, N. Tesla and D. Foley[4], in recent years, some Chinese and Russian scholars have further adopted the mathematical paradigm of theoretical mechanics for reference to establish a mathematical model system for economics, which is called the new theory of value (Wu et al., 2020). Compatible with the traditional theory of value, there are five basic axioms:

Axiom 1. The natural wealth obtained without labor has no value.

Axiom 2. The force of labor determines the value of commodities.

Axiom 3. The force of labor is equivalent to the reaction force of labor.

Axiom 4. There must be a labor gravitational force in the labor process, which creates the value appreciation.

Axiom 5. On the premise that the quality of commodities remains unchanged, there is an upper limit (saturation or bliss point) for the demand amount for useful things required by people.

Based on the above, it is easy to further deduce the conclusion that in case of oversupply, the total value of products will be a constant, then, as the quantity of products increases, the unit value of commodities will be strictly decreasing. Obviously, the diminishing utility is a special law in oversupply, rather than a basic axiom. Marginalism mistakenly regards a part — the law of diminishing marginal utility — as a whole — a basic axiom for the entire neoclassical economic system, so that it can only prove theoretical rationality through the deductive analysis, which turns to be just a branch of the traditional theory of value. However, the traditional theory of value can accommodate neoclassical economics to promote modern economics a big step forward.

In this paper, based on the above discussion, we will adopt the paradigm of mathematical economics to objectively analyze the errors of marginalism, absorb its rational components and discard its dross.

2. CRITICAL ASSESSMENT OF MARGINALISM

In order to develop further, the key for modern economics is to critically evaluate marginalism by digging out the theoretical roots and weakening the influence of such errors of marginalism.

2.1. The root of marginalism errors

1. The law of diminishing marginal utility originated from life experience that "scarcity makes things expensive", price rises or sinks due to short-supply or oversupply. These life experiences really happened, but not that convincing. Just as in the age of barbarism, superstitious explanations were given from life experience to many natural phenomena, it may be wrong for marginalism to regard the law of diminishing marginal utility as a principle axiom by subjective feelings.

2. Walras's general equilibrium theory is known as one of the main achievements of marginalism. In the general equilibrium equations, it is assumed that there are two men producing m consumer goods with n production factors, given the prices of m consumer goods and n production factors and mn technical coefficients, they produce goods and exchange equivalently in the market. In order to ensure the solution to the equilibrium price of the equations, we assume that this is a special case of linear equations; there are $(2m + 2n + mn)$ unknown variables. If one of the goods is selected as the standard and serves as the general equivalent, then its price is normalized to 1, and the price of all other commodities will be represented by it. (Walras, 1874, Appendix I, part III) Then, the unknown variables to be solved are $2m + 2n + mn - 1$, that is same with the number of independent equations. L. Walras believed that the equilibrium price of the equation has a unique solution, which is correct according to the Clem's law of linear programming. This is so called "Walras' law".

3. However, from the perspective of the general equilibrium linear equations, Walras' law is not original. After the exchange value defined by Smith and Ricardo (Smith, 1776, ch. 3; Ricardo, 1817, ch. 1, sec. 3; Marx, 1867, ch. 1, sec. 1–3) further provided a systematic and in-depth analysis on exchange value

[4] W. Jevons (Jevons, 1871, p. 21) proposed that the utility theory of value may be regarded as "the mechanics of utility and self-interest", and its research method is just as "that of kinematics or statics". Later, it was summarized by Tesla (Tesla, 1935): "the general laws governing movement in the realm of mechanics are applicable to humanity". More clearly, Foley said: "... the labor theory of value under the New Interpretation plays a role in political economy analogous to the role played by Newton's laws in mechanics. The definition of the monetary expression of labor time is analogous to the stipulation in Newtonian mechanics that force is equal to mass multiplied by acceleration" (Foley, 2000).

in particular the form of value. It is not difficult to prove that the exchange value is convex set if expressed in mathematical language according to Ricardo's and Marx's statements. Also, the continuous value function defined on the exchange value convex set must have a unique solution (Wu J., Wu Z., 2021, Theorem 3.1) Therefore, in a strict sense, Walras' general equilibrium theory originated from the study of exchange value by Ricardo and Marx, which had been ignored intentionally or unintentionally by Walras[5]. In addition, Walras took the law of diminishing marginal utility as the basic axiom of his general equilibrium theory, so that the according theoretical conclusions are quite different from those of the traditional theory of value. Obviously this is a major difference that the law of diminishing marginal utility is regarded as the source of Walras' law based on the general equilibrium theory, rather than a theorem deduced from the basic axiom based on the traditional theory of value.

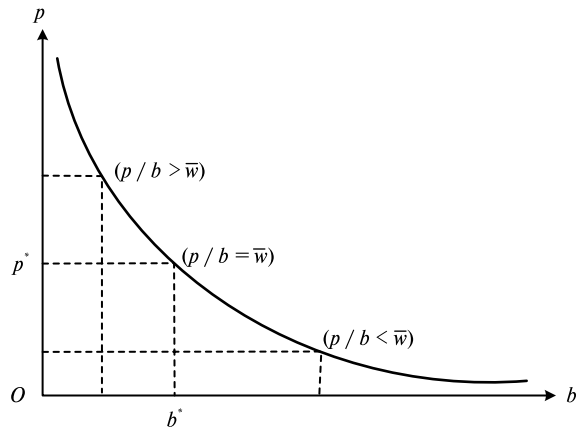

Fig. 1. Curve of market price under Marx's first law

Specifically, Marx's first law and Walras' law differs in understanding of the market equilibrium point of commodities. According to Marx (Marx, 1894, vol. III, ch. 10), the value of commodities is determined by the labor value — the average labor necessary consumed in production. If the supply and demand are unbalanced, the market price will deviate from the labor value[6]: lower in oversupply and higher in short supply (Marx, 1894, vol. III, ch. 9) (as shown in Fig. 1), where p is the market price, b is the market supply, b^* is the rational demand, and $\overline{w}$ is the unit value. According to Marx's first law, if the commodity price is a strictly decreasing function, the market supply and demand will not be in equilibrium. Also, Marx's first law shows that if and only if the supply and demand are in equilibrium, the market price will be the same with its value. That is, the equilibrium point of supply and demand is the fixed point of the market price function (Wu J., Wu Z., 2021, Theorems 3.1, 3.2).

Here, the market price depends on the exchange value. That is to say, according to Marx, the exchange value of any commodity is equal to the proportion of the unit value of that commodity in the total value of all commodities in the whole society. If there are n types of commodities, the unit value of any α-th type of commodity is recorded as $\overline{w}_\alpha$, so as to distinguish it from the total value of that type of commodity $w_\alpha = \overline{w}_\alpha b_\alpha$. If the n-th type of commodities is selected as the general equivalent, through which the exchange value of other commodities can be expressed[7]. In particular, under the gold standard, let the value of commodities w_n be the money supply, and then the exchange value of the commodity will be the reasonable price. Given the unit value of n types of commodities, the reasonable price of $n-1$ types of commodities will be

$$p_1 = \left(\overline{w}_1 / \sum\nolimits_{\alpha=1}^{n} \overline{w}_\alpha b_\alpha\right) w_n; \ldots; p_{n-1} = \left(\overline{w}_{n-1} / \sum\nolimits_{\alpha=1}^{n} \overline{w}_\alpha b_\alpha\right) w_n. \quad (1)$$

Therefore, according to Marx's first law, the value, exchange value and reasonable price of any commodity are generated under the supply–demand balance. If the supply and demand are unbalanced, the market price will deviate from the value. Here, the economic meaning of Marx's first law is clear and unambiguous. In particular, it is not difficult to prove that the reasonable price equation is equivalent to the simplified form of the finished product part of Walras' general equilibrium linear equations. That is to say, assuming that after production, the commodities are brought into the market circulation, since the equations of the supply and demand sides are equivalent, it only needs to examine the reasonable price of one side.

However, Walras did not admit that his general equilibrium linear equations originated from Marx's general equivalent form, instead, he attributed to that the price is proportional to scarcity (Walras, 1874, ch. 3).

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[5] Walras' definition of exchange value (Walras, 1874, ch. 5) is completely consistent with those by Ricardo and Marx. However, for unknown reasons, Walras did not explain this in his works.

[6] For specific mathematical analysis, see Theorems 1–3 (Wu, 1999a), Theorem 4–6 (Wu, 1999b) where the mathematical analysis related to abstract algebra and category theory is given by Hao Zhifeng (Vice Secretary of the Party Committee and President of Shantou University, China, http://english.stu.edu.cn/info/1024/1192.htm), and Theorems 5.1 and 5.2 (Wu J., Wu Z., 2021).

[7] This conclusion can be obtained from Marx's analysis of the form of value (Marx, 1867, vol. I). For specific mathematical expressions see (Wu J., Wu Z., 2021, Theorem 4.1; Wu, Qin, 2008).

Thus, Walras denied that the value is determined by the amount of labor consumed in the production process, and defined the commodity utility function with the supply price (or sales price) as the independent variable, the market commodity supply (or demand) as the dependent variable, and the strictly decreasing marginal utility as the corresponding law. Therefore, if Walras' Law holds, the sum of the market prices multiplied by the quantity, including supply and demand, must be constant at zero (Walras, 1874, preface). Further, from the utility function, the conclusion will be that as the price declines, the supply will increase; as the price increases, the supply will decline. That is, no matter how the market commodity price changes, the sum of supply and demand will be always zero counted by the total supply and sales. This is the so-called Walras' law, which can be represented by Hicks indifference curve (Hicks, 1939): where $u(\cdot)$ is the utility function (Fig. 2). When there are n types of commodities, for the equilibrium point solution $b^* = (b_1^*, \ldots, b_n^*)$, when $b_i^* > 0$, there is $\partial u(b^*) / \partial b_i = \lambda p_i$. The slope of the equivalent utility curve $u(b_1, b_2) = u(b_1^*, b_2^*)$ at $b^* = (b_1^*, b_2^*)$ is

$$db_2 / db_1 = \left(\partial u(b^*) / \partial b_1\right) / \left(\partial u(b^*) / \partial b_2\right) = -MRS_{12}(b^*) < p_1 / p_2.$$

Therefore, according to Walras' law, as long as the Hicks indifference curve is a continuous function, or the market price can adjust spontaneously, there will not be any disequilibrium.

Clearly, for the same economic phenomenon expressed as a function of declining commodity price, Marx's first law and Walras' law have completely different interpretations:

According to marginalism and Walras' law, the commodity demand can be expressed as a function with the first derivative less than zero and the second derivative greater than zero; the supply as a function of utility value with the first derivative greater than zero and the second derivative less than zero (see Appendix, Fig. A1). The supply and demand functions satisfying the law of diminishing marginal utility and Walras' law are simple, clear and easy to understand.

According to the new theory of value and Marx's first law, the phenomenon of declining commodity price hides complex economic laws. Specifically, under the gold standard and while the quality maintains unchanged, the factors affecting the market price include: the force of labor consumed in the production process, the functional relationship between the consumed force of labor and production quantity, and the relationship between production quantity and rational demand. All this will determine the following concepts of a commodity:

- the reasonable price (or equilibrium price) is the proportion of the exchange value of commodities to the total amount of money (see Formula (1));
- the market price is the reasonable price of a commodity divided by the quantity (see Fig. 1);
- the value is a piece-wise function, which is strictly increasing linear when the production quantity is less than the rational demand, then a constant when the production quantity is the same with or larger than the rational demand (see Appendix, Fig. A2);
- the unit value is the value divided by the production quantity, which is a strictly decreasing function (see Appendix, Fig. A3);

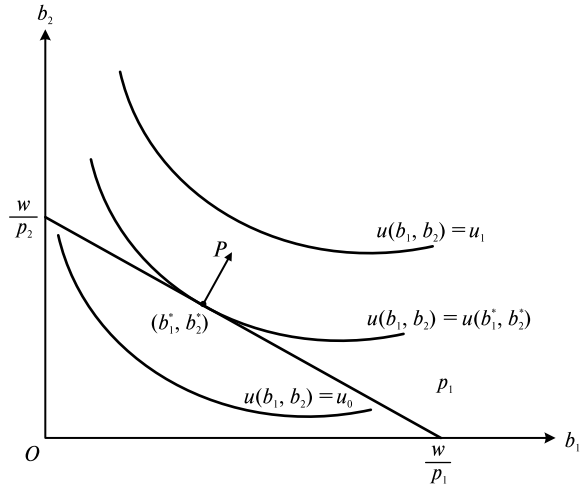

Fig. 2. Curve of market price under Walras' law

- the excess surplus-value of commercial capital in the commodity circulation is also a strictly decreasing function, which is equal to the market value minus the unit value under the unbalanced supply and demand (see Appendix, Fig. A4);
- the production cost is equal to the quantity multiplied by the average social force of labor necessary consumed for per unit product, which is a linear function of quantity (see Appendix, Fig. A5);
- the surplus value of capital is equal to the kinetic energy minus the potential energy of capital value, that is, the Lagrange function of capital, which can be converted into the Brachistochrone line of capital by the Lagrange function of capital (Wu et al., 2020; see Fig. A.6), or can be shown as the length of the optimal projection curve of capital minus the length of the production cost curve of commodities (see Appendix, Fig. A7).

As interpreted above, it seems simple by marginalism and Walras' law, but complex by the new theory of value and Marx's first law. In fact, there are abstract and complex economic laws behind the seemingly simple phenomenon. Generally, there are at least two laws for the decline of marginal value function: one is hidden in the decline of function caused by the supply and demand in the commodity market (see Fig. 1 above and Appendix, Fig. A2–A4). The other is under the joint impact of capital kinetic energy and potential energy (see Appendix, Fig. A5–A7).

To sum up, the fundamental differences between Marx's first law and Walras' law lies in:

1) according to Marx, at the point of supply–demand balance can the price of commodities be determined by the exchange value. However, according to Walras, the equilibrium price always exists no matter in what ratio of supply and demand;

2) according to Marx, as the supply and demand are in balance, the total supply and sales of commodities are equal. However, the equal total supply and sales will not indicate the supply-demand balance (Wu J., Wu Z., 2021, Theorems 5.1, 5.2), like the balance sheet (which is always in balance), but there are still product backlog and losses. However, according to Walras, the supply and demand will be always in balance as long as the price can adjust spontaneously;

3) according to Marx, the market price of commodities is a strict monotone decreasing function under unbalanced supply and demand (Wu J., Wu Z., 2021, Theorems 5.1, 5.2), which is a theorem deduced from the axiomatic system. However, the marginalism regarded the law of diminishing marginal utility as an axiom, which is taking one part as the whole.

2.2. Influence of marginalism errors

The objective economic laws are not transferred by human will, as Engels (Engels, 1878, ch. 10) said: "Social forces are completely like natural forces. They play a blind, coercive and destructive role when we have not yet recognized and considered them". There is only one truth, if the traditional theory of value is correct, the prevalence of the wrong marginalism will bring serious harms to the development of modern economy.

2.2.1. Resulting in the split of neoclassical economics

After Walras' law came into being, a puzzling problem arose: the law of diminishing marginal utility is a nonlinear function. Although A. Cournot (Cournot, 1838) and L. Walras (Walras, 1874) proved the existence and stability of equilibrium in the single market, yet the strict proof of which can only be completed under the linear condition, instead of the nonlinear condition (Arrow, Intriligator, 1981, p. 3).

In order to justify itself, the general equilibrium school has made great efforts. Early in the 1930s and 1940s, J. Hicks (Hicks, 1939) and P. Samuelson (Samuelson, 1941) used a special ordinal theory to prove the existence of solutions to general equilibrium equations under nonlinear conditions. Later by 1959, G. Debreu (Debreu, 1959) who is the first economist in the history of economic theory to use the standard mathematical paradigm for economic research successfully gave an accurate proof in his book *The Theory of Value*. In the study of the general equilibrium theory, Debreu first gave the mathematical definitions for the basic economic concepts, including quantity, time, velocity, commodity vector space, Euclidean metric of value in commodity vector space, topological manifold in commodity Euclidean metric space, and based on which defined the price, value, utility function, individual preference order structure, commodity utility convex set and etc. Second, in addition to the law of diminishing marginal utility, Debreu added rigid theoretical assumptions, including: the continuity of utility value; information symmetry; market clearing; constant or decreasing returns to scale; no externality in production and consumption; strict convex of consumer preference and enterprise production set; complete substitution and etc., which give the necessary and sufficient conditions for the existence and stability of solutions to general equilibrium equations under nonlinear conditions. Finally, Debreu introduced Kakutani theorem to prove the existence of the "fixed point" — the existence and stability of the solution to general equilibrium equations under general conditions, including nonlinear conditions.

Obviously, as for methodology, Debreu made great contributions to the mathematization of neoclassical economics. However, in the history of scientific development, Debreu has therefore brought neoclassical economics into a difficult predicament. To be specific, Debreu's new axiomatic system restricted the general equilibrium theory to a special and narrow field, so that the general equilibrium theory has been still not complete — unable to explain all economic phenomena with one same axiomatic system. Hence Arrow and Debreu further constructed a logically rigorous model (Arrow, Debreu, 1954). So afterwards neoclassical economics involuntarily entered an era of disintegration when various schools (in addition to the mainstream general equilibrium theory, like Keynesian economics, monetarist economics, institutional economics, econometrics, system dynamics and so on) emerged being incompatible with each other. It shows that

the marginalism has neither completeness nor compatibility, leading to conflicts, debates and repeated trials and errors within various schools of neoclassical economics.

2.2.2. Triggering incurable cyclical economic crisis

According to the new theory of value, from Axiom 2 comes theorem of inverse ratio between product quality and labor productivity. From Axiom 5, when the quality is constant, there is always an upper bound of demand for any commodity. Also under the acting force of improving dexterity of workmen, as the time for producing the same commodity goes, the labor productivity will always keep growing. In this case, there are the following economic laws:

– when there is overproduction, under the theorem of inverse ratio between product quality and labor productivity by enlarging the production of high-quality products, it will help to avoid overcapacity and rebalance the supply and demand at a higher quality level. If not, it will lead to overcapacity, and as this situation goes, product surplus will become more and more serious and eventually lead to economic crisis. (Wu J., Wu Z., 2021, Theorem 4.1);

– when demand exceeds supply, under the theorem of inverse ratio between product quality and labor productivity by reducing the production of high-quality products and shifting the improving labor productivity to increase the production of lower quality of products, so as to help rebalancing the supply and demand at a lower quality level. This is effective particularly in severe natural disasters and wartime;

– among countries with different comparative advantages, reasonable international trade or capital transfer will help the balanced development of different countries. That is, if developed countries are in a state of overcapacity, then transferring overcapacity to developing countries through international trade or capital export will help to eliminate its overcapacity and improve the living standards of developing countries[8].

The above three are the general economic laws of realizing the supply–demand balance of both quantity and quality in the commodity production, expressed by the total differential equations. Actually they are different manifestations of the theorem of inverse ratio between quality and labor productivity.

Obviously, various schools of neoclassical economics have not recognized the above "laws of supply–demand balance of both quantity and quality", so that they were helpless to deal with overcapacity and resorted to various wrong solutions. For example, by Liberalism, based on general equilibrium theory, the spontaneous price adjustment mechanism was proposed, leading to disorderly competition and continuous overproduction, then more vicious competition, wider gap between the rich and the poor, and more frequent periodic economic crises. By Keynesianism, mistakenly the quantitative easing policy was implemented with hope to create demand, stimulate consumption and regain market equilibrium, yet leading to more excess capacity, over-consumption, and repeated trials and errors. By Welfarism, Sismondi's leisure strategy[9] was advocated to reduce working hours, leading to slackness and slow economic development; and etc. Clearly, these were all caused by the errors of marginalism.

Since 2017, the Chinese government proposed a strategy for high-quality development to consume excess capacity and strengthen economic internal circulation, which is in line with the theorem of inverse ratio between quality and labor productivity[10]. China accomplished remarkable fruits in the past five years, and expects to achieve a rapid development in the next five years. Compared with various macroeconomic policies by neoclassic economics, it is more scientific and beneficial by China's strategy for high-quality development, which shows great significance of correct theoretical guidance to the development of various economies.

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[8] When analyzing the international capital export according to Ricardo's theory of comparative advantage based on the labor theory of value, it can reasonably explain the transfer of global capital from North to South in the modern global economy. Here the theory of comparative advantage can also be explained by the theorem of inverse ratio between quality and labor productivity: the decline of quality leads to the release of energy, which transforms the excess capacity of developed countries to the wealth value of developing countries. The two theories are compatible with each other.

[9] According to J. Sismondi (Sismondi, 1819), wants are not insatiable, so it is not that the more products are supplied, the better. In overcapacity, man should reduce labor time for more leisure activities, so as to rebalance the supply and demand of commodities in the market.

[10] In 2010 T. Wang, J. Wu (Wang, Wu, 2014) and other researchers put forward a proposal for quality-oriented development during overcapacity in the age of globalization, supported by a special project of the Ministry of Science and Technology of the People's Republic of China, "Analysis of the Effect of Applying the SED Model on China's Four Trillion Fiscal Investment under the International Financial Crisis" (Wang, Wu, 2015; Wang et al., 2022), based on the theorem of inverse ratio between quality and labor productivity. In the past decade, the Chinese government has regarded high-quality development as one of the major macroeconomic policies.

APPENDIX

Utility value functions based on the law of diminishing marginal utility and the new theory of value

In order to make it easier for understanding the difference between the utility theory of value under the law of diminishing marginal utility and the new theory of value, we compare their main functional relationships. To be consistent with the law of diminishing marginal utility, we exchange the order of independent and dependent variables — supply and demand — of the equilibrium price function defined by Walras' theory of general equilibrium, shown as Fig. A1 where b is the quantity of products, b^* is the equilibrium quantity, p is the market price, S is the supply, D is the demand. Walras (1874) first proved that under first-order homogeneous quasilinear conditions there is a solution of equilibrium price for the function of commodity utility value. However, the solution is unsatisfactory since that the commodity utility value function is not linear if it satisfies the law of diminishing marginal utility, also there are individual preferences according to subjective utility theory of value, therefore the values cannot "furnish any data for absolute calculations" (Say, 1803, p. xxvi), that is, there cannot be a unified measure of value.

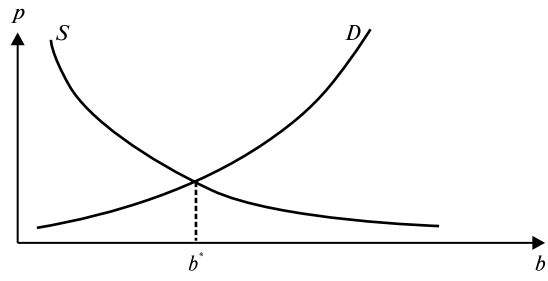

Fig. A1. General supply and demand curve

Then according to Hicks (Hicks, 1939), the utility value function cannot obtain the extremum solution of the continuous function based on the cardinal theory with the total order in the real number domain, but can only use the ordinal theory for value calculation. Latter, Debreu (Debreu, 1959, ch. 5–7) proved the existence and stability of the extremum solutions of the continuous function based on the ordinal theory under special upper semicontinuous or lower semicontinuous conditions with the partial order in the real number domain. Also, Arrow and Debreu (Arrow, Debreu, 1954) proved the impossibility theorem that a measure of value for commodity utility value based on global optimum does not exist, that is, the value cannot be measured.

According to the new theory of value and the traditional labor theory of value and the theory of surplus-value, we make a comprehensive study on the utility theory of value under the law of diminishing marginal utility. In our opinion, the law of diminishing marginal utility in fact is only a special theorem of the use value function within the commodity value function under non-equilibrium supply and demand. That is to say, the value is composed of labor value and use value, which are determined by the function of the force of labor composed of the basic quantities of value — time, quantity and quality. In this case, with time as the dependent variable, and the forces of labor for both quality and quantity as unknown functions, the commodity value is a complex variable function, where the labor value function is the real part, and the value function is the imaginary part (Wu J., Wu Z., 2021). If considering only the labor value function, i.e. the process of realizing the labor value of commodities in production, we will find that when the quality and use value in the commodity value function are constant quantities, then the commodity value function of a commodity is linear in the real number domain with production quantity as the independent variable and the labor value of the commodity as the dependent variable. If considering comprehensively the commodity value function under supply and demand balance, oversupply and short-supply, there will be a series of corresponding functional relationships and relevant theoretical conclusions.

1. The total value function of a commodity

According to the new theory of value, there is Axiom 2 that force of labor determines value and Axiom 5 that in the case of quality is constant, the rational demand of any commodity has an upper bound point. Also, according to Marx's first law, it's assumed that the value of a commodity is determined by the average labor necessary consumed per unit quantity in the production process, the total value of any commodity will be a price-wise function. That is, the total value is a strictly monotonically increasing linear function when production quantity is smaller than the rational demand, then when production quantity is beyond the rational demand, the total value is a constant.

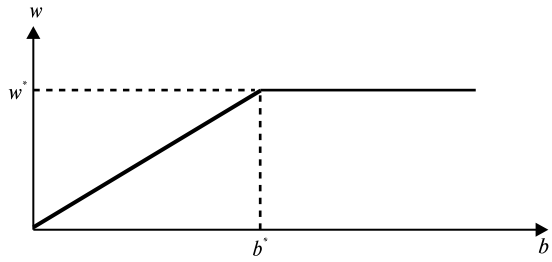

Fig. A2. Total value of a commodity

In Fig. A2 b is the production quantity, b^* is the rational demand and w is the total value. Then, let $\bar{f}$ be the force of labor consumed for unit quantity, b be the independent variable, w be the dependent variable, b^* be the exogenous parameter, and $\bar{f}$ as the corresponding rule, the value function of a commodity will be piecewise:

$$w = \bar{f}(b) = \begin{cases} \bar{f} \times b, & b \le b^* \\ \bar{f} \times b^*, & b > b^*. \end{cases}$$

2. The unit value function of a commodity

The unit value of a commodity refers to the total value of the commodity divided by its production quantity. Let $\bar{w}$ be the unit value of the commodity, then $\bar{w} = w / b$. Obviously, under the balance of supply and demand, the unit value is $\bar{w}^* = w / b^*$, and the total value is $w^* = \bar{w}^*$. While under unbalanced supply and demand, the unit value $\bar{w}$ of a commodity is shown as below Fig. A3 which is also the market value of the commodity, i.e. the value of the commodity per unit quantity is $\bar{w} = w / b$.

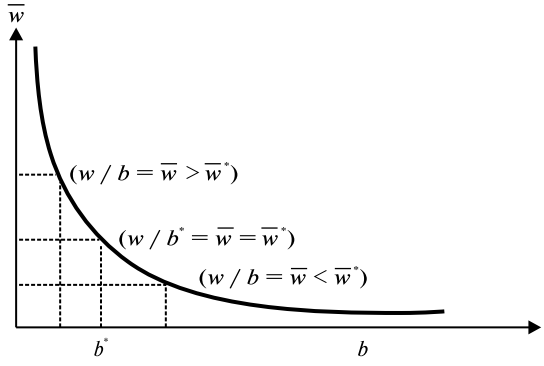

Fig. A3. Unit value of a commodity

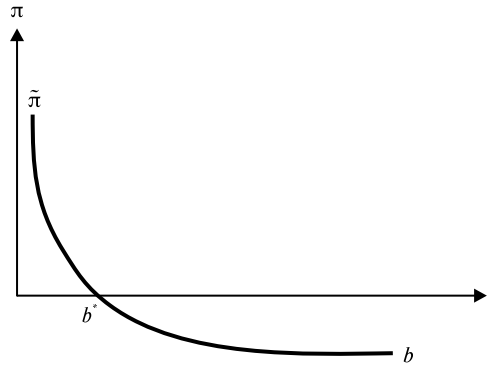

Fig. A4. Surplus-value of a commodity

Apparently, it is a strictly monotonic decreasing function. When the production quantity of the commodity is smaller than the rational demand, its market value is greater than its unit value and total value in the equilibrium state, i.e. $\bar{w} > \bar{w}^* > w^*$. When the production quantity exceeds the rational demand, the market value is greater than the unit value in the equilibrium state, i.e. $\bar{w} < \bar{w}^* < w^*$. Obviously, the market value function of the commodity has the same property as the market price function, yet differs only in the form of expression. The former indicates the unit value of the commodity in relation to the production quantity (Fig. A3), and the latter shows the monetary expression of the market value of the commodity (see Fig. 1).

3. The market excess surplus-value function of a commodity

This function refers to the excess surplus value of commercial capital related to the circulation of a commodity in the market. Here, the market excess surplus value of a commercial capital refers to the difference between the market value caused by the non-equilibrium state and the unit value in the equilibrium state, which is equal to the product of the unit value in the equilibrium state of supply and demand and the rational demand minus the product of the unit value in the equilibrium state

and the actual production quantity. Then, the function of the market excess surplus value of commercial capital can be expressed as $\tilde{\pi} = F(\bar{w}^*, b) = \bar{w}^* \times b^* - \bar{w}^* \times b$ (see Fig. A3) [11]: where π is the surplus value of commercial capital, and $\tilde{\pi}$ is the change curve of the dependent variable of the surplus value function of commercial capital.

4. The cost function of a commodity

According to Marx's first law, the commodity cost refers to the average force of labor necessary consumed in the process of commodity production. Then, the function of commodity cost indicates the force of labor consumed for products per unit quantity. Let f be the force of labor, d be the cost, $\bar{f}$ be the force of labor consumed per unit product, and then the cost function is $d = \bar{f} \times b$ (Fig. A5).

Note that the cost curve Z is an effective cost before reaching the point (b^*, f^*) equal to the value of the commodity. However, after the point (b^*, f^*) it is the ineffective cost, and the force of labor consumed is doing extra work.

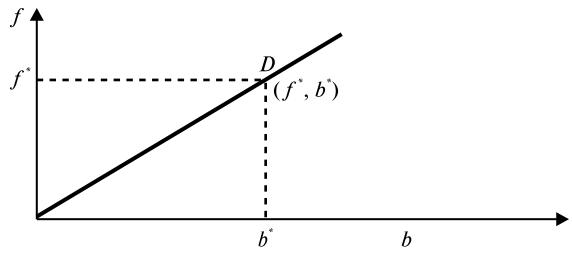

Fig. A5. Cost of a commodity

5. The optimal trajectory function of industrial capital related to the production process of a commodity [12]

The optimal trajectory of industrial capital is an economic phenomenon that considers the joint action of the force of labor and the labor gravitational force. Here, the greatest difficulty is to understand the value conservation theorem. For example, under the influence of labor gravitational force, skilled workers and unskilled workers expend the same force of labor but achieve different labor effects, which do not change the value of commodities.

Assuming that producing unit quantity and unit quality spend the same force of labor, it can deduce the capital Brachistochrone line B based on the quality acceleration surplus value and the capital optimal ejection curve M based on the quantity acceleration surplus value. It is a complicated deduction, which will be discussed in another paper.

6. The surplus-value function of industrial capital related to the production process of a commodity

First, according to Marx's second law, "the value created by living labor" exceeds "the value of the force of labor", then the difference of these two is the so-called surplus value. Second, according to Marx's first law, the value of commodities is determined by the average force of labor necessary consumed under the balance of supply and demand, and the production cost of commodities is a linear function. Finally, according to the new theory of value, the optimal trajectory of capital is a projection equation. Therefore, we can further define the surplus-value function of industrial capital that refers to the total income of industrial capital minus its cost. It is shown in Fig. A6 that the optimal trajectory of industrial capital is the Brachistochrone line of industrial capital or the optimal ejection curve of industrial capital. Therefore, the value change in the operation process of industrial capital can be expressed as the integral of the value function of industrial capital, or the length of the optimal trajectory of industrial capital. In this case, the surplus value

[11] There was a heated debate between J.-B. Say and D. Ricardo over the determination of value. Say denied Smith's labor theory of value, and believed that the value of commodities is determined by supply and demand, because supply creates its own demand, and "the rise of price is in direct ratio to the demand, and inverse ratio to the supply" (Say, 1803, p. 290). Ricardo analyzed in detail all kinds of logical errors of Say's opinion, and pointed out that the root of Say's error was to confuse different concepts of value, wealth and utility, and he "constantly overlooks the essential difference that there is between value in use, and value in exchange" (Ricardo, 1817, p. 207). Following D. Ricardo, K. Marx further explained that, when supply and demand are in balance, labor determines value, otherwise the relationship between supply and demand will cause the market price of commodities to deviate from the value. Unfortunately, marginalism has followed Say's opinion and continued this error to today. In this regard, this figure reproduces Marx's law as a function of the excess surplus value of commercial capital, with hope to help economics recognize the error of Say and marginalism.

[12] According to the new theory of value (Wu et al., 2020), the optimal trajectory of capital motion can be expressed as a Lagrangian function, from which the Brachistochrone line of a particle can be deduced with theoretical mechanics background.

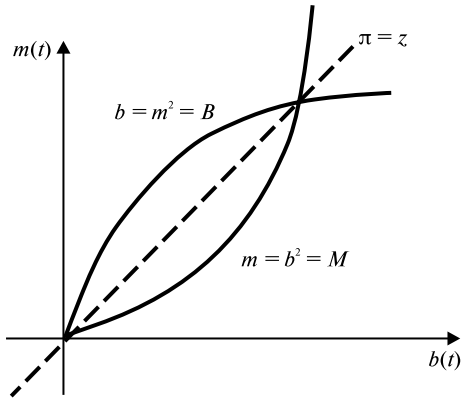

Fig. A6. Optimal trajectories of industrial capital

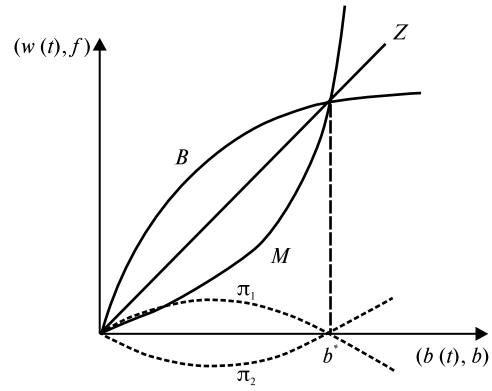

Fig. A7. Surplus values of industrial capital

of industrial capital is the length of optimal trajectory of industrial capital minus the length of the curve of production cost, shown as below Fig. A7, which is obtained by merging Fig. A5 and A6.

According to the new theory of value and Marx's first and second laws, we can draw a conclusion that the surplus value of industrial capital is the lengths of industrial capital B and M minus the length of cost curve Z. Assuming that producing the quantity per unit and the quality per unit expend the same force of labor, π is the surplus value of industrial capital, then $\pi_1 = K_1 - Z$ and $\pi_2 = K_2 - Z$, the trajectories of which are shown as the dotted lines in Fig. A6. Here, the trajectories of π_1 and π_2 prove the theorem that quality is inversely proportional to labor productivity. To be specific, π_1 shows that as the force of labor increases production quantity, industrial capital surplus-value per unit quantity (hereafter unit quantity of surplus value) is a parabola, which is positive when the quantity is smaller than the rational demand, and turns to be negative when the quantity goes larger than the rational demand; π_2 shows that as the force of labor improves the quality, capital surplus value per unit quality (hereafter unit quality of surplus value) is a negative parabola, which decreases although it expends more force of labor and increases the quantity, then turns to be positive when the quantity excesses the rational demand. That is to say, under oversupply, the improvement of quality will help the excess capacity convert into commodity value, and increase the surplus value of industrial capital per unit quantity (Wu J., Wu Z., 2021, Theorem 5.1, 5.2).

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Анализ маржинализма. Часть 1

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Аннотация. В последние годы китайские и российские ученые, сохраняя в качестве основы традиционную теорию стоимости, — трудовую теории стоимости и теорию прибавочной стоимости, а также гипотезу Джевонса, Теслы и Фоули — использовали математическую парадигму теоретической механики для создания системы математических моделей экономики, которую назвали новой теорией стоимости. Совместимая с традиционной теорией, новая теория стоимости выдвигает идею о том, что потребляемая в процессе производства рабочая сила определяет стоимость товара, а сила притяжения рабочей силы определяет оценку ее самой. В то же время оценка стоимости зависит от гравитационной силы, созданной путем усовершенствования навыков работников. В процессе производства постоянный и переменный виды капитала и потенциальная энергия стоимости, переходящая одна в другую, согласно теореме преобразования стоимости, играет ведущую роль в создании стоимости и прибавочной стоимости. Кроме того, закон убывающей предельной полезности не является аксиомой, а специальным экономическим законом при дисбалансе спроса и предложения. Эти теоретические положения имеют большое значение, поскольку превращают традиционную теорию стоимости в самодостаточную логическую систему в виде новой теории стоимости, которая вобрала рациональные элементы как из классической экономики, основанной на трудовой теории стоимости и теории прибавочной стоимости, так и из неоклассической экономики с ее законом убывающей предельной полезности. В первой части статьи мы обращаемся к этой проблематике, исследуя происхождение закона убывающей предельной полезности.

Ключевые слова: новая теория стоимости, рабочая сила, гравитационный параметр рабочей силы, закон равновесия стоимости, закон убывающей маржинальной полезности, непротиворечивость.

Классификация JEL: C62, D46, D58.

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