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## ТЕОРЕТИЧЕСКИЕ И МЕТОДОЛОГИЧЕСКИЕ ПРОБЛЕМЫ

# The new theory of value



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**Abstract.** In this paper, by analogy with Newtonian mechanics, under the framework of mathematical economics paradigm, a new theory of value was constructed — compatible with the labor theory and the utility theory of value — to analyze the economic relationship between the force of labor, value and surplus value in the process of commodity production, and the economic relationship between the force of consumption and human demand, utility quantity and utility magnitude in the process of commodity consumption. This paper focuses on the basic concepts, basic dimensions, basic axioms, main conclusions and typical cases of the new theory of value. In the dimensional analysis, taking time, quantity and quality as the basic dimensions, this paper defines the derived dimensions of such basic economic concepts as demand, utility, labor force, value, currency, price, capital, surplus value, profit etc., which make all economic factors become commensurable objects. In particular, under the assumption of learning by doing and the factor of labor potential energy, this paper analyzes the internal logical relationship between the production of labor value and the creation of surplus value as time goes on, and further provides a solution to the problem of value transformation.

**Keywords:** Newtonian mechanics, new theory of value, value, value increment, value transformation.

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## 1. INTRODUCTION

The object of economic study is commodity. The core problem of these studies of commodities is how to measure value. The value of a commodity consists of two factors: one is the use value; the other is exchange value (Smith, 1994, p. 16). The use value is determined by the degree of satisfaction the subject gets in the process of consuming the commodity — the utility quantity. The exchange value is determined by the amount of labor that the subject consumes in producing the commodity (Smith, 1994, p. 16). Therefore, the key to solve the problem of value measurement is to give the measure of value of the utility quantity and the amount of labor.

In the history of economic theory, the labor value school first made a comprehensive analysis on the problem of the value measure. According to the labor theory of value, the use value of commodities was the premise and foundation of exchange value (Ricardo, 2001, p. 8). However, the amount of use value had nothing to do with value (Smith, 1994, p. 16; Marx, 1996, p. 3). Therefore, economic theory was concerned with how the amount of labor and the exchange value of commodities are measured, while commodity science was concerned with the utility quantity and the use value of commodities (Marx, 1996, p. 1).

Smith's historical contribution to economic theory was to systematically put forward three economic principles related to the labor value: 1) the natural wealth obtained without consuming labor had no value; 2) labor determines value; 3) man's labor had a gift of "increasing dexterity of workman" (Smith, 1994, p. 15, 16, 5). These axioms laid the foundation of the labor theory of value. However, Smith's understanding of the measure of value was insufficient. He gave three measures of value at the same time — the amount of labor expended in the production of commodities, labor dominated by capitalists and worker's wages, among which obviously there was a logical contradiction (Ricardo, 2001, p. 14; Marx, 1996, fn. 16).

Ricardo's progress was to point out that labor value and exchange value were two different concepts. The former was an absolute quantity, determined by the amount of labor expended in the production process. The latter was a relative quantity, which refers to the ratio of the labor values of different unit commodities (Ricardo, 2001, p. 10–11). Based on it, Ricardo further analyzed the theoretical problem of the measure of value. He tried to find a unified and unchangeable perfect measure of value under the condition that the labor productivity was constantly changing and the exchange values of various commodities were always changing (Ricardo, 2001, p. 32). But since Ricardo could never find an objective measure of the dynamic value of labor[1], his various solutions were questioned (Sraffa, 1951, p. 220–225).

On the theory of value, Marx's important contribution was based on Smith's labor theory of value; he further put forward the theoretical proposition that labor created surplus value (Marx, 1996, ch. 5–20). Marx's induction by empirical method that labor creates surplus value is convincing (Afanasyev, 1980, ch. 2). At the same time, Marx gave the division of constant capital and variable capital, which made a reasonable logical relationship between Smith's theoretical logic system of labor creating value and his theoretical proposition of labor creating surplus value[2]. However, there appeared many logical contradictions, when Marx used the abstract labor time as the measure of the value of commodities, and attempted to deduce the theoretical conclusion that labor created surplus value. For example, Marx's belief that lengthening labor hours and increasing labor intensity were the sole form of production of absolute surplus value (Marx, 1994), and the improvement of labor productivity of particular enterprises would create relative surplus value (Marx, 1996, ch. 14–17), was a clear logical contradiction. Because any particular quantity that actually occurred must affect the average of the aggregation. Therefore, if the theoretical proposition that the average labor time abstract and necessary determines the value of commodities is still true, then the labor costs deviating from the average value in the production process cannot lead to surplus value, whether absolute or relative. Clearly, there are other causes of surplus value, but Marx did not find them yet.

It can be seen that in the time of Marx, there were still several defects in conventional labor theory of value. The first was ignoring the analysis of the use value form of commodities, failing to realize that there is also an inevitable function relation between the "utility", use value and the value of commodities, so the exchange proportion of commodities can be expressed through substitutability of utility (Hicks, 1939). Second — the theory of value was unable to provide a convincing conclusion that labor creates surplus value from the internal logical relationship — the mathematical expression of labor, capital and surplus value under the theoretical proposition that labor determines value. And thirdly — holding one-sidedly — the labor time (socially abstract and necessary) was the only measure of value of commodities, ignoring the fact that product quantity and economic quality were also the basic factors affecting the value of commodities. Hence, when Marx further analyzed the problem of production price (Marx, 1998, ch. 9) in the process of total social production by theoretical proposition that abstract labor time determined value, so he came across some insurmountable theoretical difficulties.

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[1] In the history of science development, a theoretical conundrum was often completed by many people through a long time. As early as 1817, D. Ricardo was a genius to perceive that probably there was a dynamic measure of value, and stated to find a unified and unchangeable perfect measure of value (Ricardo, 2001, p. 32) for economics under the condition that the labor productivity was constantly changing.Aat that time there was only Euclidean geometry in flat space for the quantity theory. Therefore, Ricardo was been able to solve the problem of unified and dynamic measure of value. After Ricardo's death, in 1854, G.-F. Riemann gave the Riemannian measure defined by quadratic function in the "curved" space, which provided a mathematical theoretical basis for economics to solve the dynamic measure of value. In 2012, on the basis of Riemannian geometry, J. Wu proposed the Riemannian metric space of n types of commodity values with a 2n dimensional saddle Riemannian manifold as a base manifold for a dynamic measure of value, which enabled economics to use variable measure of value to calculate commodity values at a certain moment in the discrete state. (Wu, 2012, p. 32–70) However, Wu still has not given a dynamic measure of value under general continuous conditions. In 2020, Chen and Wang (Chen, Wang, 2020) published a paper on the convergence of high dimensional Kaehler–Ricci manifolds. One of the key research results was to solve the problem of convergent differential equations based on the metric tensor which changes with time parameter. We believe that the latest research results of differential geometry provide a solid mathematical theoretical basis for economics to solve the problem of Ricardo's perfect and unified measure of value.

[2] See Case 2 for a detailed description of this logical relationship.

E. von Böhm-Bawerk (Böhm-Bawerk, 1949, p. xiv) criticized severely that "a contradiction between volume I and volume III of "Capital" proved the uselessness of the labor theory of value". Therefore, the problem of value transformation in Marx's "Capital" caused a long-term academic debate.

After the Marginalist Revolution, neoclassical school also discussed the measurement for value of commodities. The marginalist economists Jevons, Menger and Walras proposed the law of diminishing marginal utility, deduced that the value of commodities was determined by marginal utility, and established the corresponding utility theory system of value. They believed that there was a function of diminishing marginal utility between the quantity of commodities and their utility, the utility of different commodities was related to the exchange rate — exchange value — between them. So, the reasonable proportion of commodities exchanged was the marginal utility substitution rate (Jevons, 1965, p. 79) between different commodities. The marginal rate of substitution was actually the choice between the pain caused by labor and the pleasure generated by utility enjoyment in the process of commodity production (Jevons, 1965, p. 63, 170). In the case of the founders of neoclassical economics, there was a continuous functional relationship between the quantity, utility and labor of commodities. They thought that the marginal utility of commodity could be measured and aggregated over the cardinal (Walras, 1965, app.).

Obviously, it was a historic progress that the marginalists introduced the influence factors of utility and use value in the measurement of commodity value. However, the marginalist theory of cardinal utility value also encountered the problem of unified measure of value. However, the marginalist theory of cardinal utility value also encountered the problem of unified measure of value. Since the early utility value theory believed that utility was determined by the subjective evaluation obtained by individuals in the process of consuming goods. Therefore, different individuals had special preferences, and it was difficult for people to measure the utility quantity of commodities with a uniform measure of utility value[3]. In order to solve this problem, neowelfarist economists of individual welfare choice theory constructed the ordinal utility theory of value based on partial order relations[4]. However, the partial order relation based on individual preference obviously cannot meet the needs of economic theory of global optimization. In this regard, social choice theory in welfarism (Sen, 1970a) tried to transform the personal preference relation into the social preference order relation, so as to provide the basis for the social decision-making. In spite of this, neoclassical economics still failed to find an ideal total-order relationship about utility value[5]. In order to solve this problem, J. Wu (Wu, 1999a) analyzed the order relation among the useful things, natural demand, subjective desire, utility quantity, utility grade, use value, labor value and so on, constructed a composite function of commodity value including use value and labor value with global optimization. He proved that under the constraint of value composite function, the space of commodity value with the utility quantity, utility magnitude, use value and labor value were algebraic structures with total order relation, that was a category based on the real number field and a K0 group[6].

Also, J. Wu analyzed the utility value mapping of $n \times m$ order that one object with multi-function and multiple objects for one function, and established a linear programming model system of the commodity production of means of subsistence and means of production, the commodity exchange and the input-output (Wu, 2012, ch. 11–12; Wu, Qin, 2008). Within the scope of limited capital elements, the model system takes the demand of everyone to meet the demand for utility quantity as the constraint condition, and the pursuit of maximizing the utility magnitude as the objective function, and focuses on solving the compatibility and total order structure of utility quantity, utility magnitude, using value and labor value in the value function. These research results of Wu and others are helpful to solve the logical contradictions between the "Leontief Paradox" (Leontief, 1953) in the input-output model and the "circular argumentation" (Eichner, 1983, p. 152) in the value aggregation of heterogeneous capital goods by the New Cambridge School. Unfortunately, at that time, J. Wu still followed Marx's theoretical proposition that abstract labor time determined value, so he was unable to eliminate the incompatible logical contradiction between labor value and surplus value in the conventional labor theory of value.

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[3] See Arrow's impossibility theorem (Arrow, 1970).

[4] See Pareto Principle and Kaldor–Hicks efficiency (Kaldor, 1939).

[5] "The impossibility of a Paretian liberal" has been questioned by many economists (Sen, 1970b; Ng, 1971; Austen-Smith, 1980; Wriglesworth, 1982).

[6] If Q is a category, then K0 group is formed under the direct sum operation. In J. Wu's paper (Wu, 1999a), with a 5n dimensional vector space composed of the quantity vector, the labor value vector, the utility quantity vector, the utility magnitude vector and the exchange value vector of n kinds of commodities as the definition domain, after the elements in the 5n dimensional vector space are projected to the one-dimensional real number set of commodity prices through the money function, an original image set of money function projection is formed and called "Price equivalence class category". On this basis, the algebraic properties of the direct sum operation in the category of price equivalence class are further analyzed, and the mathematical theoretical form of K0 group, which can transform the research objects of various economic attributes into homogeneous factors, and carry out commensuration and comparison is given.

In the above cases, there are still many difficulties in neoclassical economics.

1. The law of diminishing marginal utility does not satisfy axiom of completeness and cannot explain the economies of scale in common production processes (Samuelson, 2000).

2. "Diminishing marginal utility" is a special economic law when the supply exceeds the demand, but not an axiom (Wu, 1999b).

3. The general equilibrium conclusion deduced from the law of diminishing marginal effect is not compatible, and cannot explain various economic phenomena of overcapacity and involuntary unemployment deduced from the non-equilibrium assumption of "wage rigidity" (Keynes, 1936).

4. The partial order nature of utility relation leads to the fact that the combination of local optimal and global optimal is not equal to that of global optimization, so it is questioned by the "Fallacy of Composition" (Samuelson, 2000).

5. Neoclassical economic theory is unable to create a computer model that satisfies the conditions of the integration of equilibrium and non-equilibrium, and macro-economy and micro-economy (Makarov et al., 2019, 2020).

To sum up, regardless classical economics, Marxist economics, neoclassical economics, and Keynesian economics encountered insurmountable difficulties in their respective development, the basic reason that causes the theoretical development obstructed is that a scientific and reasonable measure of value in economics were not found.

## 2. BASIC CONCEPTS

### 2.1. Measure of value

We know that the value of a commodity consists of use value and labor value. Meanwhile, the use value is determined by the utility quantity obtained by the subject in the process of commodity consumption; the labor value is determined by the amount of labor consumed by the subject in the process of commodity production. Assuming that in the process of production, the amount of labor consumed by the subject is equal to the labor force consumed, then the factor determining the value of commodity is the labor force; while in the process of consumption, the utility quantity obtained by the subject is equal to the force of consumption expended[7], then the factor determining the use value of commodities is the force of consumption. Therefore, in the process of production and consumption of commodities, the force of labor and force of consumption are unites of the opposites: the former determines the form of labor value of commodities; the latter determines the form of use value of commodities.

From the external form of expression, the value and utility forms of commodities are kinds of mutually corresponding positive and negative relationships, i.e, the mathematical dual relationship. For example, in the process of consumption, consumption is equal to negative production; demand quantity is equal to negative labor productivity. Utility quantity is equal to the inverse of negative labor productivity; economic quality[8] is equal to

[7] From the external economic form, force of consumption is the market purchasing power. From the internal economic form, force of consumption is the ability of an independent individual's organic life to consume external useful things, which is determined by the human body's consumption activity ability and physiological function, including the individual's consumption activity ability for food and clothing, as well as within the human body the digestive function of the stomach, the respiratory function of the lung, and the blood supply function of the heart, etc. We believe that it is this force of consumption that acts on the external useful things and leads to the use value. In particular, from the form of quantity, force of consumption is related to the reaction of force of labor.

[8] The concept of economic quality can be derived from that of mass in physics — by analogy. The mass represents the physical quantity of the inertia of an object, numerically equal to the ratio of the external force on the object to the acceleration it obtains. In economics, we define economic quality as a measure of the economic inertia of labor products. It is in direct proportion to the socially necessary force of labor consumed by human beings in the production process. The more socially necessary force of labor it takes to produce a product, the higher its economic quality. In addition, there is a difference between economic quality and the standards of quality produced by man-made regulations, where the former is an absolute quality, and the latter is a relative quality. For instance, a certain industry has stipulated the quality standard for a type of products, then it is often said that the closer the product produced is to this quality standard, the better its quality. In addition, economic quality is a factor related to the process of consuming a product. In the field of consumption, the corresponding relation of economic quality is called economic quality. The higher the economic quality, the less force of consumption a person takes to consume the same amount of products; and on the contrary: the lower the economic quality, the more force of consumption a person takes to consume the same amount of products. For the specific connotation of economic quality and economic quality, see the dimensions in the second part below.

negative utility magnitude;[9] force of consumption is equal to negative force of labor[10]. At last, use value is equal to negative labor value; total amount of market sales is equal to total amount of market purchasing power etc.

From the internal relationship, there are essential differences between the labor value and use value forms of commodities, where the labor value form of commodities is an object influenced by human's subjective consciousness, i.e. the wisdom and talent of people make countless innovative technologies and new products emerge one after another during the production process. However, the use value form of commodities can only be an object controlled by the instinct of human body and organs. No one can change the function of his body and organs through subjective consciousness, just as human cannot control the process of stomach digestion through mind. In addition, the labor value form of commodities has other economic forms, including variable capital, labor gravitational force, surplus value, profit, interest and so on. And at last the dual relationship of these economic forms is not possessed by the use value form of commodities.

Nevertheless, the labor value and use value of commodities can be converted into each other. In order to survive, one must satisfy his needs by consuming external useful things. If there are not enough external useful things, we need to produce what we need by labor. For any one, production and consumption are a cyclical process[11]. The labor value and use value of commodities are mutually converted in this cycle. Therefore, economic theory needs to study not only labor theory of value, but also utility theory of value. It is the primary task of modern economic theory to construct the new value theory that unifies labor value and utility value.

Obviously, if the above theoretical conclusions can be held, then the new theory of value will obtain nearly the perfect form of theory[12]. Based on this theoretical form, the measure of value of various commodities can be reasonably explained by following the method of abstract analysis in Newton's mechanics. That is to say, before the human appears, all natural materials that emerge of themselves and perish of themselves have no value. After the emergence of humans, in order to meet the demand for external materials, these humans have to carry productive activities, where force of labor causes the displacement of particles in the commodity space to produce an acceleration, which determines the value of commodities. In particular, a rational human demand is limited. Force of labor creates value and surplus values only within the balance of supply and demand. Here the labor force is determined by time, product quantity, and economic quality. According to Newton's second law formula $f = ma$ helps us solve the measure of value of commodities. Since human have wisdom, labor force has an ability of "learning by doing" (Yang, Borland, 1991), that is "labor gravitational force". This special "gravitational force" is the cause of the gravitational acceleration and corresponding surplus value in the production of commodities. The Lagrange relation, $L = T - V$, or Hamilton relation, $H = -V + T$, can also help us accurately measure the surplus value in the process of commodity production. Finally, if the quantity of the produced products exceeds the scope of rational demand, then the force of labor consumed would create neither value, nor surplus value.

Therefore, the value of commodities exists within a bounded closed set, and the value function of commodities is guaranteed to have an extreme solution when the continuity assumption is satisfied. In this case, we can establish a complete economic axiomatic system, use scientific methods to deduce a variety of economic conclusions, and take mathematical methods of repeated verification to prove that the new theory of value has completeness, compatibility and independence[13].

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[9] C. Menger thought that there was an "order" (Menger, 1981, p. 18) structure about hierarchy of individual wants which enabled people to arrange the consumption of different commodities in order to satisfy their wants. Here, the economic quality refers to the attribute that the economic quality of commodities changes gradually by order in utility in the process of consumption.

[10] According to Jevons, labor value is a "disutility" (Jevons, 1965, p. 57).

[11] C. Jevons (Jevons, 1965, ch. 3–5) had analyzed these problems in details.

[12] In J. Wu's "On Wealth" (Wu, 2006, 2012), the author adopts Marx's axiom that abstract labor time necessary is the measure of value of the amount of labor, and constructs a mathematical economic model system of wealth differential value fiber cluster based on Riemannian manifold, which deeply and systematically analyzes the measure, calculation and law of value. Unfortunately, in the books of "On Wealth", J. Wu did not attribute the amount of labor to the force of labor, nor labor productivity with acceleration — to labor gravitational force. Therefore the theory of value in "On Wealth" has shortcomings. In this paper, we will correct the shortcomings and mistakes in "On Wealth" according to the new theory of value, which we believe will make theory of value more perfect.

[13] Based on new theory of value, the author has established a systems model for simulation of social economy dynamics integrating macro-economy and micro-economy — SED (Social Economic Dynamics) model. The model uses supercomputer to simulate the global economy realistically. A large number of simulation experiments show that the objective economic law is not changed by human subjective will. The choice of different economic systems will produce different results: the right choice will get miraculous harvest; the wrong choice will lead to disastrous consequences. In particular, the actual market economy is a dynamics steady-state system with strong adaptability, which can accommodate all kinds of extreme economic systems. An economic system that has stagnated for decades or even hundreds of years, an economic system with cyclical overcapacity of more than 30% and serious economic crisis, or an economic system with sustained development at an acceleration of more than 10% are acceptable. In the history of human

**2.2. Dimensions of value**

From the perspective of the new theory of value, the measure of value is actually the measure of labor force. Force of labor is divided into physical and mental. Physical strength is pure natural force, which is the ability of ordinary animals. Mental power has duality: one is the ability to control repetitive physical work, which is possessed by the central nervous system of vertebrates; the other is the intelligence, learning, creativity and subjective initiative of human central nervous system. It is the dual nature of human mental labor that gives human labor the ability of "learning by doing" — labor gravitational acceleration. In this case, the concepts of labor force and labor gravitational force in the new theory of value just correspond to that of force and gravity in Newtonian mechanics. Therefore, we can use the method of Newton's mechanics to express the dimensions of various economic concepts.

In Newtonian mechanics, the common basic dimensions are: time, distance and mass; the common derived dimensions are velocity, acceleration and gravitational acceleration. Here, the force of labor in new theory of value also has corresponding basic and derived dimensions, namely: time, product quantity, economic quality, labor productivity, labor production acceleration and labor gravitational acceleration. The understanding of these concepts in the new theory of value is analogous to that in Newtonian mechanics.

In the new theory of value, set $t$ for labor time, **b** — for product quantity, **m** — for economic quality, $v$ (related to product quantity) and $r$ (related to economic quality) — for labor productivity, $a$ (related to product quantity) and $u$ (related to economic quality) — for labor production acceleration, and **g** — for labor gravitational force[14]. Obviously, after giving the above definitions, we can further give various types of economic concepts and dimensions of economic theory.

**2.3. Basic dimensions**

So, $t$ is for labor time with dimension of [**T**]; **b** — for product quantity with dimension of [**L**]; **m** — for economic quality of commodities with dimension of [**M**];

labor productivity, **v** (related to product quantity): $v_\alpha = db_\alpha / dt$, or **r** (related to economic quality): $r_\alpha = dm_\alpha / dt$, where $\alpha = 1,\ldots,n$ represents n types of products; **v**'s dimension is [$\mathbf{LT}^{-1}$], **r**'s dimension is [$\mathbf{MT}^{-1}$];

acceleration of labor production, **a** (related to product quantity): $a_\alpha = d^2 b_\alpha / dt^2$; **u** (related to economic quality): $u_\alpha = d^2 m_\alpha / dt^2$; where $\alpha = 1,\ldots,n$ represents $n$ types of products; **a**'s dimension is [$\mathbf{LT}^{-2}$]; **u**'s dimension is [$\mathbf{MT}^{-2}$];

force of labor: $f_\alpha = f_{\alpha 1} + f_{\alpha 2} = m_\alpha a_\alpha + b_\alpha u_\alpha = m_\alpha (d^2 b_\alpha / dt^2) + b_\alpha (d^2 m_\alpha / dt^2)$, where $\alpha = 1,\ldots,n$ represents $n$ types of products, $f_\alpha$ represents the force of labor consumed in the production process of the $\alpha$-th type of products, $f_1$ represents the force of labor associated with the quantity of the $\alpha$-th type of products, $f_2$ represents the force of labor related to the economic quality of the $\alpha$ -th type of products, and $m_\alpha a_\alpha$, $b_\alpha u_\alpha$ are the multiplication of vectors, $\mathbf{f} = (f_1,\ldots,f_n) = (f_{11} + f_{12}, f_{21} + f_{22},\ldots, f_{n1} + f_{n2})$. The dimension is [$\mathbf{MLT}^{-2}$].

**2.4. Dimensions of labor value**

1. The labor value of commodities is the work done by the labor force, expressed as $\mathbf{W} = \mathbf{fb}$, which describes the work done by one unit labor force. The dimension is [$\mathbf{L}^2\mathbf{MT}^{-2}$].

2. The unit labor value refers to the labor value of any unit quantity of commodity, expressed as $\bar{w}_\alpha = w_\alpha / b_\alpha$, where $\bar{w}_\alpha$ represents the unit labor value of the $\alpha$-th type of commodities, $w_\alpha$ represents the total value of the $\alpha$-th type of commodities. The dimension is [$\mathbf{L}^2\mathbf{MT}^{-2}$].

3. The special equivalent form of commodities $(\bar{w}_1 : \bar{w}_2 : \ldots : \bar{w}_n) = (x_1 : x_2 : \ldots : x_n)$, $x_\alpha \in R$, $\alpha = 1,\ldots,n$ represents the relationship of exchange value among $n$ different commodities, where $R$ represents the set of real numbers. The dimension of the special exchange value coefficient $x_\alpha$ is [$\varsigma$].

4. The general equivalent form of commodities is the general equivalent form in which the unit quantity of certain type of particular commodities has the same value as the quantity of all other commodities. For example, one gram of gold has the value of 50 kg of rice, 25 kg of cotton, 10 pieces of clothing, etc. Let the value

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economic development, maybe at least 50% of the energy is spent in the trial and error process of choosing different economic systems. All this can now be changed through the establishment of scientific computer simulation laboratory. More details about SED model see in (Wang et al., 2015; Makarov et al., 2019, 2020).

[14] In this paper, as for the mathematical symbols related to the new theory of value, the vector is represented by straight fonts and the scalar is represented by Italic fonts.

of precious metal unit be $\hat{w}^{\bullet}/\mathbf{b}^{\bullet}=\bar{w}^{\bullet}$, where $\mathbf{b}^{\bullet}$ represents the quantity of precious metal commodities, $\hat{w}^{\bullet}$ represents the total labor value of the precious metal commodities as the general equivalent, $\bar{w}^{\bullet}$represents the unit labor value of the precious metal commodities as the general equivalent. Therefore, $\sum_{\alpha}^{n-1}x_{\alpha}^{\bullet-1}\bar{w}_{\alpha}=\hat{w}^{\bullet}$, where $x_{\alpha}^{\bullet-1}$ represents the exchange value coefficient between precious metal commodities and the α-th type of commodities, then the general equivalent form of commodities will be $(x_1^{\bullet-1}\bar{w}_1,...,x_{n-1}^{\bullet-1}\bar{w}_{n-1})$, $x_{\alpha}^{\bullet}\in R$.

Here, the dimension of $\bar{w}^{\bullet}$ that $[\varsigma^{-1}\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$ represents the labor value of unit precious metal commodity, the dimension of $\bar{w}_{\alpha}$ that $[\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$ represents the labor value of unit commodity, and the dimension of coefficient $x_{\alpha}^{\bullet}$ is $[\varsigma]$.

5. Legal tender under the gold standard:

$$M^{\Delta}=\kappa\mathbf{b}^{\Delta}\Leftrightarrow\kappa(\sum\nolimits_{\alpha=1}^{n}\hat{w}_{\alpha}x_{\alpha}^{"})=\kappa(\sum\nolimits_{\alpha=1}^{n}\bar{w}_{\alpha}b_{\alpha}x_{\alpha}^{"}),$$

where $M^{\vartriangle}$ $M^{\Delta}$ represents the total amount of convertible precious metals under the gold standard issued by a country, and $\kappa^{\Delta}$ represents the conversion coefficient between the currency issued under the gold standard of a country and the value of precious metals. For example, the legal tender of a country is exchanged for one gram of gold at the rate of 380: 1. The dimension of legal tender under the gold standard is $[\kappa^{\Delta}\varsigma^{-1}\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

6. Commodity price under the gold standard: $p_{\alpha}^{\Delta}=(\bar{w}_{\alpha}/w)M^{\Delta}$, where $p_{\alpha}^{\Delta}$ stands for the price of the α-th type of commodities in a country under the gold standard, which indicates the convertibility of any commodity into gold through legal tender. The dimension of commodity price under the gold standard is $[\kappa^{\Delta}\varsigma^{-1}\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

7. Legal tender under non-gold standard:

$$M=\kappa\mathbf{w}=\kappa(\sum_{\alpha=1}^{n}w_{\alpha})=\kappa(\sum_{\alpha=1}^{n}\bar{w}_{\alpha}b_{\alpha}),$$

where $M$ represents the total amount of legal tender issued by a country under the non-gold standard, and $\kappa$ represents the conversion coefficient between the unit quantity of legal tender issued by a country under the non-gold standard and the total value of social commodities, namely price index. The dimension of legal tender under non-gold standard is $[\kappa\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

8. Commodity price under non-gold standard: $p_{\alpha}=(\bar{w}_{\alpha}/w)M$, where $p_{\alpha}$ is the price of the α-th type of commodities in a country. The dimension of commodity price under non-gold standard is $[\kappa\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

9. Kinetic energy of labor value $E=E_1+E_2=\sum\nolimits_{\alpha=1}^{n}\left(E_{\alpha1}+E_{\alpha2}\right)$,where $E_{\alpha1}=2^{-1}m_{\alpha1}v_{\alpha1}^2+2^{-1}b_{\alpha1}r_{\alpha1}^2$ is kinetic energy of labor value of means of production, $E_{\alpha2}=\left(2^{-1}m_{\alpha2}v_{\alpha2}^2+2^{-1}b_{\alpha2}r_{\alpha2}^2\right)$ is kinetic energy of labor value. The dimension is $[\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

10. Potential energy of labor gravitational force: $\varphi=\mathbf{mgb}=\sum_{\alpha=1}^{n}m_{\alpha}g_{\alpha}b_{\alpha}$ , which represents the work done by labor gravitational force. The dimension is $[\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

11. Surplus labor value under non-gold standard: $\varpi=\kappa(-E+\varphi)$[15], where $\kappa$ represents the conversion coefficient between the unit quantity of legal tender issued by a country under the non-gold standard and the total value of social commodities, namely price index. The dimension is $[\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

12. Constant capital under non-gold standard: $C=\sum\nolimits_{\alpha=1}^{n}C_{\alpha}=\sum\nolimits_{\alpha=1}^{n}\kappa E_{\alpha1}$ , where $C$ is kinetic energy of constant capital transformed in capital form. The dimension is $[\kappa\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

13. Variable capital under non-gold standard: $V=\sum\nolimits_{\alpha=1}^{n}V_{\alpha}=\sum\nolimits_{\alpha=1}^{n}\kappa E_{\alpha2}$, where $V$ is kinetic energy of labor transformed in capital form, that is the work done by the labor force driven by variable capital. The dimension is $[\kappa\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

14. Surplus value rate under non-gold standard: $\varpi/V$. The dimension is $[\kappa\varsigma]$.

15. Profit under non-gold standard: $\pi=\varpi$. The dimension is $[\kappa\mathbf{L}^2\mathbf{M}\mathbf{T}^{-2}]$.

16. Profit rate under non-gold standard: $\pi=\kappa\left[\varpi/(C+V)\right]$ indicates that profit rate is the monetary form of surplus value divided by the sum of constant capital and variable capital. The dimension is $[\kappa\varsigma]$.

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[15] Here, we use value Hamiltonian to express the surplus labor value of capital, because the labor wage corresponding to variable capital is prepared for purchasing consumption materials and conducting actual consumption, and human's living consumption is a process in which potential energy decreases and kinetic energy increases.

**2.5. Dimensions of exchange value**

1. Consumption quantity $-\mathbf{b} = -(b_1 : b_2 : \ldots : b_n)$ is a basic dimension. The dimension is $[\mathbf{L}]$.

2. Demand quantity[16]: $\hat{v}_{\alpha\beta} = -v_{\alpha\beta} = -db_{\alpha\beta}/dt$ (related to product quantity), $r_{\alpha\beta} = -r_{\alpha\beta} = -dm_{\alpha\beta}/dt$ (related to economic quality), where $\alpha = 1, \ldots, n$ represents $n$ types of products, and $\beta = 1, \ldots, m$ represents $m$ types of utility attributes within each of $n$ types of products. Therefore the demand quantity is the quantity of the $\alpha$-th type of commodities needed to satisfy one's demand for the $\beta$-th type of utility attribute per unit time, which actually is a negative labor productivity (analogous to velocity). The dimension of $\hat{\mathbf{v}}$ is $[\mathbf{LT}^{-1}]$, the dimension of $\mathbf{r}$ is $[\mathbf{MT}^{-1}]$.

3. Utility quantity[17]: $\hat{a}_{\alpha\beta 1} = -a_{\alpha\beta 1} = -1/v_{\alpha\beta} = -t/b_{\alpha\beta}$ (related to product quantity), $\hat{u}_{\alpha\beta 2} = -u_{\alpha\beta 2} = -1/r_{\alpha\beta} = -t/m_{\alpha\beta}$ (related to economic quality), where $\alpha = 1, \ldots, n$ represents $n$ types of products, and $\beta = 1, \ldots, m$ represents $m$ types of utility attributes within each of $n$ types of products. Therefore, the utility quantity is when a man uses the $\alpha$-th type of commodities to satisfy the man's $\beta$-th type of utility attribute, the time that can be satisfied for each unit of product consumed, which actually is reciprocal of quantity of demand. The dimension of $\hat{\mathbf{a}}$ is $[\mathbf{LT}^{-1}]$, the dimension of $\hat{\mathbf{u}}$ is $[\mathbf{MT}^{-1}]$.

4. Force of consumption[18] $\hat{f}_{\alpha\beta} = -f_{\alpha\beta}$. Its dimension, the same as that of labor force, is $[\mathbf{MLT}^{-2}]$.

5. Utility magnitude $\hat{m}_\alpha = -m_\alpha = \sum_{\beta=1}^{m} -m_{\alpha\beta}$, where $\alpha = 1, \ldots, n$ represents $n$ types of products, and $\beta = 1, \ldots, m$ represents $m$ types of utility attributes within each of $n$ types of products, the utility magnitude $\hat{m}_\alpha$ in fact is the economic quality $-m_\alpha$ realized in the consumption of the $\alpha$-th type of commodities. That is to say, utility magnitude is a negative economic quality, which is a dual relationship of economic quality appeared in the commodity consumption process. To be specific, the utility magnitude refers to the force of consumption that one consumes every single unit of the $\alpha$-th type of commodities to satisfy one's demand for the $\beta$-th type of utility attribute. The higher the utility magnitude, the less force of consumption a person has to consume the same amount of commodities. And on the contrary: the lower the utility magnitude, the more the force of consumption a person needs to possess in order to consume the same amount of commodities. Due to $m$ types of utility attributes of each type of commodities, the total utility magnitude of the $\alpha$-th type of commodities is the sum of the utility magnitude realized in each usage. The dimension is $[\mathbf{M}]$.

6. Use value $\hat{\mathbf{w}} = -\mathbf{w} = \hat{\mathbf{f}}\mathbf{b} = -\mathbf{f}\mathbf{b}$. Use value and labor value are in a dual relationship. The former is represented by the wealth form of commodity in the process of consumption, while the latter is the wealth form of commodity in the process of production. Its dimension, the same as the dimension of value, is $[\mathbf{L}^2\mathbf{MT}^{-2}]$.

7. Total social market sales $\hat{M} = -M = \sum_{\alpha=1}^{n} -M_\alpha = -\hat{w}_\alpha = -\bar{w}_\alpha b_\alpha$, where $\hat{M}_\alpha$ represents the total legal tender flow or market sales of the $\alpha$-th type of commodities in circulation, and $\hat{M}$ represents the total legal tender flow or total social market sales. The market sales corresponds to the marketing purchasing power, that is $M_\alpha$ represents the total legal tender flow or market purchasing power of the $\alpha$-th type of commodities in circulation, and $M$ represents the total market purchasing power that total legal tender flow has in the circulation of social commodities. The dimension of total social market sales is $[\kappa\mathbf{L}^2\mathbf{MT}^{-2}]$.

In the preceded analysis, we defined the basic concepts of economics, and gave the corresponding dimensions. On this basis, we can further define more advanced and complex economic concepts and dimensions — such as stock, price earnings ratio, stock market index, futures, futures index etc.

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[16] Here, human demand refers to the general term — "human demand" — for means of subsistence, means of production and means of development in various economic fields based on the natural demand of human beings. In the economic field, people's demand object, whether pure materials, or spiritual consumer goods containing views, culture, art and ideology, must be a type of commodities that are expressed by a certain quantity and economic quality. Therefore, we believe that human demands are objective. An individual has subjective demand preferences; however, in the objective demand of the whole society, individual preference is only a special form of deviation from the average, which does not affect the supply–demand relationship and commodity prices. In accordance with the general market rules, all commodity prices are fair to all customers.

[17] The utility, we understand, is an objective utility. According to K. Marx (Marx, 1996, ch. 24, fn. 50): "To know what is useful for a dog, one must study dog's nature. This nature itself is not to be deduced from the principle of utility. Applying this to man, one would criticize all human acts, movements, relations etc., by the principle of utility, and must first deal with human nature in general, and then — with human nature as modified in each historical epoch." For the mathematical calculation method of objective utility value, please, refer to (Wu "On Wealth", vol. 1, p. 115–464).

[18] K. Marx may be the first economist to find out the dual relationship between production and consumption, which was stated in his 1857–1858 economic manuscripts from a qualitative point of view: "Production, then, is also immediately consumption, consumption is also immediately production." "The identities between consumption and production thus appear threefold: 1) Immediate identity... 2) [In the sense] that one appears as a means for the other ... 3) ...each supplies the other with its object" (Marx, 1973 (Grundrisse, 1857–1858), p. 77–79).

Therefore, all economic concepts can be further defined by the basic concepts and corresponding dimensions. Meanwhile, we have also given the measure of value of commodities.

## 3. BASIC AXIOMS

In the second half of the 17th century, Bacon, Hobbes, Locke, Feuerbach and other materialists tried to use Newton mechanics straightly to explain the economic problems of human society. Their theory is called mechanical materialism. After the mid-18th century, such economists as Smith, Ricardo and Marx established the theoretical system of labor value. In a sense, conventional labor theory of value has already used the analogy method of Newton's mechanics to study economic problems[19]. Now, according to the basic economic principles in labor theory of value, combined with the axiomatic system of Newtonian mechanics, we further propose the following basic axiomatic system of the new theory of value[20].

**Axiom 1**. *Natural wealth has no value.*

In the motion of natural wealth without labor, there is no action of any labor force during the displacement by the uniform linear motion of a point $(\mathbf{b}_1,...,\mathbf{b}_n)\in\mathbf{B}^n$ in the quantity vector space $\mathbf{B}^n$ constructed by the quantities of $n$ kinds of natural wealth nor a point $(\mathbf{m}_1,...,\mathbf{m}_n)\in\mathbf{M}^n$ in the quality vector space $\mathbf{M}^n$ constructed by the economic qualities of n kinds of natural wealth, i.e.,

$$\mathbf{f}=0\Leftrightarrow\frac{d\mathbf{m}}{dt}=\text{const},\ \frac{d\mathbf{b}}{dt}=\text{const}, \tag{1}$$

**Axiom 2**. *The force of labor is determined by the acceleration in the production of wealth*.

In the production process of wealth, with the means of production, one uses his own labor force acting on a point $(\mathbf{b}_1,...,\mathbf{b}_n)\in\mathbf{B}^n$ in the quantity vector space $\mathbf{B}^n$ and a point $(\mathbf{m}_1,...,\mathbf{m}_n)\in\mathbf{M}^n$ in the quality vector space $\mathbf{M}^n$ so that the points takes displacements, therefore the labor force can be expressed as

$$f=f_1+f_2=m\,a+b\,u=m\frac{d^2b}{dt^2}+b\frac{d^2m}{dt^2}, \tag{2}$$

where $a$ presents the acceleration related to production, i.e. the changing rate of labor productivity, $u$ represents the acceleration related to economic quality

**Axiom 3.** *The sum of the labor force and force of consumption is zero*[21].

Analogous to Newton's third law, in economic theory there is

$$f=-\bar{f}, \tag{3}$$

where $-\bar{f}$ is a reacting force, being a force of consumption.

**Axiom 4**. *In labor process, there must be labor gravitational force, which is only a natural force*.

In the labor production process, human wisdom produces gravitational potential energy that causes the gravitational acceleration to exert a force on the displacement acceleration of a point in the vector space of products. Generally speaking, it is an ability of "learning by doing", which is a special talent of human,

[19] D. Foley (Foley, 2000) said that, "... 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 equaled to mass multiplied by acceleration." Maybe Jevons would agree with this assumption. Because he stated, that utility theory of value was actually a kind of "mechanism of utility and self-interest", and its method was as "that of kinematics or statics" (Jevons, 1965, p. 22).

[20] The economic problems discussed in this paper are limited to category of classical and neoclassical economic theory. In our opinion, the vast majority of economic activities in human society are carried out at low speed and in balance. Therefore, we should adopt the method of Newtonian mechanics to analyze. However, we think that the new theory of value can also study the economic phenomenon of high-speed movement and non-equilibrium state. For example, if the validity of Moore's law continues for decades, then labor productivity would be close to the speed of light. At this point, if relativity is still valid, the energy of products will tend to infinity. J. Wu (Wu, 2012, p. 830–833) had already analyzed this phenomenon. Since the 20th century, different economic schools, — such as system dynamics, economic cybernetics, financial physics, dissipative economic theory and complex system theory, have carried out corresponding economic research by using various research methods of physics. We believe that these new research methods, including micro physics and non-equilibrium state, are necessary. In particular, the discovery of Higgs boson in 2013 made great progress in the study of unified field theory. Therefore, it could be expected that more physics research methods are introduced into economic theory in the future. At the same time, the development of economic theory will also get a qualitative leap.

[21] The third law of the new theory of value can also be expressed as: Assets + Liabilities = Zero, where assets are equal to the acting force of labor value, and liabilities are equal to the reacting force of labor value. In the history of economic theory, double-entry bookkeeping — balance sheet — is the most widely used mathematical economic model.

so that with the extension of time, the labor productivity of a certain type of products is bound to increase, leading to acceleration of labor gravitational force generated in the labor production process

$$g_\alpha = \bar{b}_\alpha \frac{d^2\bar{m}_\alpha}{dt^2} + \bar{m}_\alpha \frac{d^2\bar{b}_\alpha}{dt^2} > 0. \tag{4}$$

Here, in the labor production process, different people produce the same products of labor because of the differences in personal wisdom and expertise; the personal labor gravitational force will be different. That is to say, there are many different forms of labor gravitational force, including constant acceleration, incremental acceleration and decreased acceleration. Meanwhile, any kind of labor gravitational force is a natural force, not the labor force, that is

$$g_1, g_2 \notin \mathbf{F},\ g_1, g_2 \in \mathbf{G}, \mathbf{F} \subset \mathbf{G}, \mathbf{G} \neq \varnothing, \tag{5}$$

these are called the expressions of labor gravitational force, where $\bar{\mathbf{m}}$ is a point in the quality vector space of products of labor under the natural force — labor gravitational force $\mathbf{g}$, $\bar{\mathbf{b}}$ is a point in the quantity vector space of products of labor under the natural force — labor gravitational force $\mathbf{g}$, $\mathbf{F}$ is the set of the force of labor, and $\mathbf{G}$ is the set of natural force, and $\mathbf{F}$ is the true subset of $\mathbf{G}$. The expression above indicates that labor gravitational force determined by labor acceleration is a natural force, but not a force of labor[22].

**Axiom 5.** *Force of labor determines the value of commodities.*

The commodity economy is a social economic system that carries out wealth production through the division of labor and the exchange of commodities. In the commodity economic system, when people exchange commodities in the market, the value of commodities of both parties is evaluated by the average necessary labor force expended in the production. Specifically, the value of commodities is equal to the work done by the labor force, that is

$$\mathbf{w} = \mathbf{f}_1\mathbf{b} + \mathbf{f}_2\mathbf{m}. \tag{6}$$

**Axiom 6.** *There is an upper bound for the demand quantity of useful things*[23].

The rational demand for useful things is $\mathbf{b}^* = (b_1^*, \ldots, b_n^*)$. Then according to this axiom, we have the following mathematical expression of one's demand quantity:

$$\begin{cases} v_{\alpha\beta} = -v_{\alpha\beta} = -db_{\alpha\beta}/dt;\ r_{\alpha\beta} = -r_{\alpha\beta} = -dm_{\alpha\beta}/dt;\ b_\alpha \le b_\alpha^*; \\ v_{\alpha\beta}^* = -v_{\alpha\beta}^* = -db_{\alpha\beta}/dt;\ r_{\alpha\beta}^* = -r_{\alpha\beta}^* = -dm_{\alpha\beta}/dt;\ b_\alpha > b_\alpha^*; \end{cases} \tag{7}$$

where $\alpha = 1, \ldots, n$ represents $n$ types of products, and $\beta = 1, \ldots, m$ represents $m$ types of utility attributes within each of $n$ types of products, and $v^*, r^*$ respectively means that in the case of oversupply, the rational demand related to prod-uct quantity and quality is a constant.

## 4. MAIN ECONOMICS CONCLUSIONS

According to the basic axioms of the new theory of value, we can further deduce various theoretical conclusions[24] and ensure that all theoretical conclusions meet the requirements of completeness, compatibility and independence.

**Theorem 1**. *A product has no value when its supply exceeds the rational demand.*

According to Axiom 6, a product beyond the rational demand can not meet people's needs, so it has no utility and use value, as well as no labor value and exchange value[25].

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[22] Some readers might think that, artificial intelligence of machines should also be able to create surplus value. We disagree with this for two reasons: 1) there is no intelligence in the machine itself. Artificial intelligence is a kind of ability given by human beings to the machine; 2) once the artificial intelligence is owned by machines, the power is just a kind of ability of the machine itself, which will be converted into a pure natural force, just like the general machine — constant capital — creating only the labor value, but not the surplus value.

[23] According to Gossen's first law (Gossen, 1983) and real life experience, the real consumption quantity is saturated in a limited time. Therefore, the rational demand of human beings has an upper bound, which is the bliss point.

[24] There are many related economic theorems, including the one, where the labor gravitational force does not create value, the quantity and economic quality of products produced with the equivalent labor force are equal under the condition of supply and demand balance, the market general equilibrium based on labor value, the existence of maximum value of multivariate value differential equation, and so on. All these ideas are not discussed here due to the limit of space.

[25] This was proposed by D. Ricardo (Ricardo, 2001, p. 8), Say (Say, 2006, p. 26) and Marx (Marx, 1996, ch. 1).

Therefore, we have the theorem of commodity value as the following:

$$\begin{cases} f_\alpha = m_\alpha u_\alpha + b_\alpha a_\alpha = m_\alpha (d^2 b_\alpha / dt^2) + b_\alpha (d^2 m_\alpha / dt^2), & b_\alpha \le b_\alpha^*; \\ f_\alpha^* = m_\alpha u_\alpha^* + b_\alpha^* a_\alpha^* = m_\alpha (d^2 b_\alpha^* / dt^2) + b_\alpha^* (d^2 m_\alpha / dt^2), & b_\alpha > b_\alpha^*, \end{cases} \tag{8}$$

where $b_\alpha$ is the quantity of the α-th type of commodities; $b_\alpha^*$ is the rational demand of the α-th type of commodities; $u_\alpha^*$ is the acceleration of labor force expended in the production for the rational demand $b_\alpha^*$ of the α-th type of commodities; $a_\alpha^*$ is the acceleration of labor force expended in the production for the rational demand $b_\alpha^*$ of the α-th type of commodities; $f_\alpha$ is the labor force expended in the production of the α-th type of commodities; $f_\alpha^* = \mathrm{C}$ indicates that the labor force expended in the production that create the use value of the α-th type of commodities is a constant, when its product quantity exceeds the rational demand. Therefore, the work done by the force of labor that can create use value — the value of commodities — is also a constant.

P r o o f. Omitted. The conclusion is clear.

**Theorem 2.** *In the process of commodity production, as the labor time extends, the labor productivity will inevitably increase, which will also lead to the increase of surplus value per product unit, that is*

$$\left( \frac{\partial^2 \mathbf{b}(\mathbf{f}, t, \mathbf{m})_{[t_0, t_1]}}{\partial t^2} \mathbf{b}^* \mathbf{m} \right)_{[t_0, t_1]} \Big/ \mathbf{b}_{[t_0, t_1]} = \frac{\mathbf{w}^*_{[t_0, t_1]}}{\mathbf{b}_{[t_0, t_1]}} = \left( \frac{\partial^2 \mathbf{b}(\mathbf{f}, t, \mathbf{m})_{[t_1, t_2]}}{\partial t^2} \mathbf{b}^* \mathbf{m} \right)_{[t_1, t_2]} \Big/ \mathbf{b}_{[t_1, t_2]} = \frac{\mathbf{w}^*_{[t_1, t_2]}}{\mathbf{b}_{[t_1, t_2]}}, \tag{9}$$

*and*

$$\left( \frac{\partial^2 \mathbf{b}(\mathbf{g}, t, \mathbf{m})_{[t_0, t_1]}}{\partial t^2} \mathbf{b}^* \mathbf{m} \right)_{[t_0, t_1]} \Big/ \mathbf{b}_{[t_0, t_1]} = \frac{\varpi^*_{[t_0, t_1]}}{\mathbf{b}_{[t_0, t_1]}} < \left( \frac{\partial^2 \mathbf{b}(\mathbf{g}, t, \mathbf{m})_{[t_1, t_2]}}{\partial t^2} \mathbf{b}^* \mathbf{m} \right)_{[t_1, t_2]} \Big/ \mathbf{b}_{[t_1, t_2]} = \frac{\varpi^*_{[t_1, t_2]}}{\mathbf{b}_{[t_1, t_2]}}. \tag{10}$$

Proof see Appendix.

## 5. CALCULATION CASES[26]

**Case 1. Value Calculation**

According to the calculation formula of value of commodities in Axioms 2, 5 and 6, given that the growth rate of natural wealth and the acceleration of force of labor are known, assuming that the growth amount of natural wealth and the product quantity of labor production determined by the growth rate of natural wealth are just equal to the rational demand, this paper studies how to calculate the value of the total products produced.

In a process of wealth growth influenced by natural environmental factors, the function of the growth amount of wealth is $\mathbf{b}(t) = 2^{-1}t + 4^{-1}t^2 + 1$, where $2^{-1}t + 1$ is the product quantity part influenced by natural state factors and $1/4t^2$ is the product part influenced by human labor factors, then the growth rate of wealth is $\dot{\mathbf{b}}(t) = d\mathbf{b}(t)/dt = 2^{-1} + 2^{-1}t$.

Acceleration of growth is $\ddot{\mathbf{b}}(t) = \mathrm{d}\dot{\mathbf{b}}(t)/dt = d^2\mathbf{b}(t)/dt^2 = 2^{-1}$.

Let $\mathbf{m}(t) = 1$, the labor force consumed in the production process is $\mathbf{f}(t) = \mathbf{m}(t)\ddot{\mathbf{b}}(t) = 2^{-1}$. Average labor force consumed per unit product is

$$\mathbf{f}(t) = \left[ \int_{\mathrm{b}(0)}^{\mathrm{b}(t)} \mathbf{f}(\mathbf{b}^{-1}(\tau)) \right] d\tau / \mathbf{b}(t) = \left[ \int_0^t 2^{-1}(2^{-1} + 2^{-1}\tau) d\tau \right) / (2^{-1}t + 4^{-1}t^2 + 1) \Big] d\tau / (2^{-1}t + 4^{-1}t^2 + 1) =$$

$$= (2^{-1}(2^{-1}\tau + 4^{-1}\tau^2)\big|_0^t) / (2^{-1}t + 4^{-1}t^2 + 1) = (4^{-1}t + 8^{-1}t^2) / (2^{-1}t + 4^{-1}t^2 + 1) = (t^2 + 2t) / (4t^2 + 2t + 8).$$

According to the above mathematical expression, readers can calculate the commodity value under various conditions by substituting the specific value.

This case indicates that: 1) the amount of oil and minerals, for instance provided by nature, cannot meet the needs of all people. When human beings producing this kind of natural wealth with labor, those products

[26] There are many calculation cases based on the new theory of value, including the calculation of absolute surplus value and relative surplus value, the calculation of value under the Brachistochrone constraint, value equivalence and value transformation between different countries, and so on. These are interesting cases, which will not be discussed here due to the limit of space.

have value, though they make the natural wealth not originally processed by labor; 2) the total value of all products is equal to the work done by the labor force. Here, all the products include products made up of pure natural wealth and products produced in the course of labor production.

**Case 2. Calculation of Average Profit Rate**

This case further studies the relationships in between surplus value, profit, surplus value rate and profit rate of capital in different industries in the same period of time in the process of total social production. It will focus on the analysis of "value transformation" problem, that is — how to unify the surplus value rate with the profit rate in the process of total social production, when the organic composition of capital in different industries is different.

According to the above axioms and the definitions of value dimension (without considering monetary factors), there are the following relations: surplus value — $\varpi = -E + \varphi$; constant capital — $C = \sum_{\alpha=1}^{n} C_\alpha$; variable capital — $V = \sum_{\alpha=1}^{n} V_\alpha$; surplus value rate — $\varpi / V$; profit — $\pi = \varpi$; and profit rate — $\tau = \varpi / (C + V)$.

To study the influence of constant capital and variable capital of different industries on surplus value of the β-th period in total social production process, the total advance capital in any production process can be divided into constant capital $C$, variable capital $V$ and value potential energy $\vartheta$, then the surplus value of industry α under non-gold standard in period β is

$$\varpi_\alpha^t = \varphi_\alpha^t - C_\alpha^t - V_\alpha^t = \mathbf{m}_\alpha^t \mathbf{g} \mathbf{b}_\alpha^t - (2^{-1}\mathbf{m}_{\alpha 1}^t \mathbf{v}_{\alpha 1}^{2t} + 2^{-1}\mathbf{b}_{\alpha 1}^t \mathbf{r}_{\alpha 1}^{2t} + 2^{-1}\mathbf{m}_{\alpha 2}^t \mathbf{v}_{\alpha 2}^{2t} + 2^{-1}\mathbf{b}_{\alpha 2}^t \mathbf{r}_{\alpha 2}^{2t}). \tag{11}$$

In order to simplify the discussion, the above formula can be expressed as

$$\varpi_\alpha^t = \varphi_\alpha^t - C_\alpha^t - V_\alpha^t = \mathbf{m}_\alpha^t \mathbf{g}_\alpha^t \mathbf{b}_\alpha^t - (2^{-1}\mathbf{m}_{\alpha 1}^t \mathbf{v}_{\alpha 1}^{2t} + 2^{-1}\mathbf{m}_{\alpha 2}^t \mathbf{v}_{\alpha 2}^{2t}) \tag{12}$$

Based on Marx's theory of surplus value, for industry α in the period β in any simple reproduction process: 1) constant capital is a constant and does not create surplus value; 2) variable capital creates surplus value; 3) the same force of labor creates the same surplus value in any different industry with different organic composition of capital. So the surplus value rate is the same there; 4) in different industries with the same total advanced capital, no matter how different the organic composition of capital is; the profit rate of capital is the same; 5) the total profit created in the total social production process of capital is equal to the total surplus value, and the total price of all commodities is equal to the total value. Therefore, Marx's theory of surplus value can be shown by the following relations under the regulation of value with Lagrange function:

$$d\varphi / dt = 0,\ dC / dt = 0,\ \varpi_\alpha + \varphi_\alpha - V_\alpha = \mathbb{C}_\alpha.$$

Under the axiom of "learning by doing" $dg / dt > 0$ and Marx's corollary that variable capital creates surplus value, we can give the following relation:

$$\varpi_\alpha^t = \pi_\alpha^t = C_\alpha^t + V_\alpha^t - \varphi_\alpha^t \Rightarrow \pi_\alpha^t = \tau_\alpha^t / \varphi_\alpha^t - C_\alpha^t - V_\alpha^t (1 + \tau_\alpha^t), \tag{13}$$

which is called the profit function of capital, only if it satisfies three constraints proposed by Marx:

1) surplus value is equal to profit: $\varpi_\alpha^t = \pi_\alpha^t = V_\alpha^t \tau_\alpha^t$;

2) total advance capital is constant: $C_\alpha^t + V_\alpha^t = \mathbb{C}$;

3) the ratio of capital is $0 < C_\alpha^t / (C_\alpha^t + V_\alpha^t),\ \ V_\alpha^t / (C_\alpha^t + V_\alpha^t) < 1$,

and which is also called value transformation relation after introducing value potential energy factors. Therefore, required by value transformation, in any α-th industry at the β-th period we can through Formula (13) figure out the surplus value and profit of capital satisfying Marx's theory of surplus value. Especially, based on Marx's theory of surplus value, if Formula (13) satisfies the above three constraints, then

$\because\ \pi_\alpha^t = \varpi_\alpha^t = V_\alpha^t \tau_\alpha^t,\ C_\alpha^t + V_\alpha^t = \mathbb{C}$;

$\therefore$ 1) $\pi_\alpha^t / V_\alpha^t = k_{\alpha 2}^t \in \mathbb{C},\ \pi_\alpha^t = k_\alpha^t V_\alpha^t,\ \tau_\alpha^t = k_\alpha^t \in \mathbb{C}$;

2) $\pi_\alpha^t = \tau_\alpha^t / \varphi_\alpha^t - C_\alpha^t - V_\alpha^t - \varpi_\alpha^t,\ 2\pi_\alpha^t = \tau_\alpha^t / \varphi_\alpha^t - C_\alpha^t - V_\alpha^t,\ 2k_\alpha^t V_\alpha^t = \tau_\alpha^t / \varphi_\alpha^t - C_\alpha^t - V_\alpha^t$;

3) $\left(2k_\alpha^t + 1\right) V_\alpha^t = \tau_\alpha^t / \varphi_\alpha^t - C_\alpha^t,\ \tau_\alpha^t = k_\alpha^t,\ \left(2\tau_\alpha^t + 1\right) V_\alpha^t = \tau_\alpha^t / \varphi_\alpha^t - C_\alpha^t$.

Obviously, this is a linear Formula with two unknowns. Under the constraints of Formula (13), there must be infinite solutions. Here, the general economic law is that the greater the constant capital $C$ is, the greater the potential energy of labor gravitational force is $\varphi$[27]. Suppose, the organic composition of capital

[27] It seems that our conclusions in this case are similar to those of F. Seton. When Seton (Seton, 1957) studied the problem of value transformation, he believed that technological progress could lead to the creation of more surplus value in the labor materials, and

in the first industry is 80: 20; in the second industry is 70: 30; and in the third industry is 60: 40, then we can calculate by solving Formula (13) and substituting Formula (14).

It is not difficult for readers to calculate that, and draw the following conclusions: in the case of different organic compositions of capital in the first, second and third industries, the surplus value = profit is 20%, the profit rate is 20%, the surplus value rate are 100%, and the price and value of commodities are 120% with the dimension of ($k\mathbf{L}^2\,\mathbf{MT}^{-2}$). Obviously, the above case can be applied to all industries that meet the constraints.

This case shows that under the axiom that labor force determines value and labor gravitational force determines surplus value, Marx's production price theory has a self-consistent logical relationship.

## *APPENDIX*

Proof of Theorem 2

According to Axiom 2: $f = ma$ and Axiom 5: $w = fb$, the force of labor consumed in the process of labor production determines the value of commodities. Also according to Axiom 4, the labor gravitational force $\varphi = mgb$ is a natural force, not a force of labor. Therefore, labor gravitational force can improve labor productivity, that is, as labor time increases, an increase in the quantity of products or economic quality by consuming the same labor force, however the labor value of the products will not increase. That is to say, in the means of production industry, the economic relationship between value and surplus value is Hamiltonian, $\omega = w - \varphi = fb - mgb$. In the process of labor production, surplus value must exist. Set $[t_0,t_1],[t_1,t_2],\ldots,[t_{n-1},t_n]$ for the time period of the social reproduction process. It is assumed that the economic quality of a product is a constant, $m_{t_0} = m_{t_1} = \ldots = m_{t_n}$. The quantity of products in each cycle is always increasing under the role of "learning by doing". Therefore, the quantity of products of labor and the product quantity with labor gravitational force in each period will increase compared to that in the previous period, that is

$$\frac{\partial \mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_0,t_1]}}{\partial t} + \frac{\partial \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_0,t_1]}}{\partial t} > 0 \tag{A1}$$

and the quantity of products produced by the labor force and the product quantity increased by the labor gravitational force in each period will be greater than that in the previous period; that is

$$\frac{\partial \mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_0,t_1]}}{\partial t} + \frac{\partial \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_0,t_1]}}{\partial t} < \frac{\partial \mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_1,t_2]}}{\partial t} + \frac{\partial \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_1,t_2]}}{\partial t}. \tag{A2}$$

Also, according to Axiom 2, in different time periods, the labor force consumed is constant, thus the value of commodities is constant, that is

$$\left[\frac{\partial^2 \mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_0,t_1]}}{\partial t^2}\mathbf{b}^*\mathbf{m}\right]_{[t_0,t_1]} = w^*_{[t_0,t_1]} = \left[\frac{\partial^2 \mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_1,t_2]}}{\partial t^2}\mathbf{b}^*\mathbf{m}\right]_{[t_1,t_2]} = w^*_{[t_1,t_2]} \tag{A3}$$

and according to Axiom 4, in the production process, the surplus value created by labor gravitational potential energy is constantly increasing; that is

$$\left[\frac{\partial^2 \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_0,t_1]}}{\partial t^2}\mathbf{b}^*\mathbf{m}\right]_{[t_0,t_1]} = \varpi^*_{[t_0,t_1]} < \left[\frac{\partial^2 \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_1,t_2]}}{\partial t^2}\mathbf{b}^*\mathbf{m}\right]_{[t_1,t_2]} = \varpi^*_{[t_1,t_2]}. \tag{A4}$$

Therefore, the combination (9)–(12) implies that there must be a value increment — surplus value — in each unit product in every new labor production process, that is

$$\frac{\left(\frac{\partial^2 \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_0,t_1]}}{\partial t^2}\mathbf{b}^*\mathbf{m}\right)_{[t_0,t_1]}}{\mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_0,t_1]} + \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_0,t_1]}} = \frac{\varpi^*_{[t_0,t_1]}}{\mathrm{b}_{[t_0,t_1]}} < \frac{\left(\frac{\partial^2 \mathbf{b}(\mathbf{g},t,\mathbf{m})_{[t_1,t_2]}}{\partial t^2}\mathbf{b}^*\mathbf{m}\right)_{[t_1,t_2]}}{\mathbf{b}(\mathbf{f},t,\mathbf{m})_{[t_1,t_2]} + \mathbf{b}(\mathbf{g},t,\mathrm{m})_{[t_1,t_2]}} = \frac{\varpi^*_{[t_1,t_2]}}{\mathbf{b}_{[t_1,t_2]}}.$$

Obviously, in any new period of production, there must be new added surplus value.

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the constant capital defined by Marx. Therefore, Marx's theory of surplus value is wrong. In fact, this is not the case. Because, in this case, the factors that affect the potential energy of force of labor — surplus value rate — are endogenous factors determined by the acceleration of labor force. Its generation is determined by variable capital and has nothing to do with constant capital. That is to say, although the mass of any substance is positively correlated with the inertial potential energy. However, if this mass inertial potential energy is not generated by the potential energy of labor gravitational force, it can only be a pure mass inertial potential energy of natural substance, which has nothing to do with commodity value and surplus value. Understanding this is the key for us to be able to reasonably explain Marx's theory of surplus value.

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## Новая теория стоимости



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*Специальная программа прикладных исследований по высокопроизводительным вычислениям Совместного фонда «NSFC-Guangdong», грант № U1501501.*

**Аннотация.** В этом исследовании с использованием законов ньютоновой механики и различных методов математического моделирования экономики была разработана новая теория стоимости, совместимая с трудовой теорией стоимости и теорией полезности. Эта теория используется для анализа экономической взаимосвязи между трудом и добавленной стоимостью, создаваемой в процессе товарного производства, а также для исследования взаимосвязи между спросом и предложением и меняющейся полезностью потребляемых товаров. В статье особое внимание уделяется понятиям, аксиомам, способам измерения основных показателей, а также примерам, соотнесенным к новой теории стоимости. При соответствующем анализе, учитывая такие параметры, как время, количество и качество, в работе определяются производные основных экономических концепций: спрос, полезность, труд, цена, капитал, добавленная стоимость, прибыль и т.д. Исходя из предположения о потенциальной энергии фактора труда, в статье анализируется взаимосвязь между стоимостью труда и созданной с течением времени добавленной стоимостью, а также предлагается решение проблемы трансформации полезности потребляемых товаров.

**Ключевые слова:** Ньютонова механика, новая теория стоимости, стоимость, добавленная стоимость, преобразование полезности.

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