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A Critique of the Measure of Value

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Summary

Nearly three centuries after the writings of the founding fathers of political economy, this study rejects measuring value—created by labor and embodied in the product—by the number of labor hours expended in its production. Instead, it proposes a new standard: the socially necessary quantity of energy. Since Smith, through Ricardo, and to Marx, political economy has equated a product's value with the number of labor hours required to produce it. To say that a product's value is, for instance, three hours, is merely to indicate the duration of its production, not to disclose its actual value.

For the first time in the history of political economy, this study advances the correct standard of value: the socially necessary quantity of energy expended in production, measured in necessary kilocalories. This new standard allows to evaluate the value of all products created by labor—including those in the service sector, which classical political economy avoided due to the absence of a fixed standard for value in that domain.

Reaching this accurate measurement entails a rehabilitation of the law of value—the general law governing economic phenomena at the societal level. It restores political economy as a science concerned with the objective laws underlying production and distribution—laws structured around this central principle: the law of value.

The founding fathers—particularly Smith, Ricardo, and Marx—when faced with the problem of establishing a consistent standard of value, ultimately turned to the market to resolve the issue. This historical turn opened the floodgates to superficial theories and linear models that drifted away from science and from the discipline's original concern with objective laws. Subjective interpretations and impressionistic concepts replaced foundational insights, creating an epistemological rupture rather than building on the founding fathers' achievements.

As a result, generations of students—caught in this break—have been forced to swallow the bitter pill of theories presented as the only legitimate economic science, despite their repeated failure not only to solve successive economic crises, but even to explain or interpret them.

Keywords: Political Economy, Value Theory, Social Energy, Classical Economics

JEL Classification Codes: B14, B41, B51, D46, P16.

Introduction

Since the eighteenth century, political economy has sought to explain the mechanisms governing the production and distribution of wealth. At the center of these debates lies the concept of value, and more specifically, the problem of how value is measured. From Adam Smith and David Ricardo to Karl Marx, the prevailing view maintained that the value of commodities is determined by the quantity of human labor embodied in their production, measured in units of labor time. Yet this measure, which prevailed for nearly two centuries, raises serious theoretical and methodological difficulties. Can labor time serve as a rigorous and universal standard of value? Or does it merely reduce complex human effort to chronological duration?

This study begins from a simple premise: value is a real property that can be measured objectively, but labor time is an inadequate measure. By demonstrating the conceptual impasses that arise from using labor time, the study proposes an alternative: socially necessary energy, measured in kilocalories. Grounded in insights from the biological and physical sciences, this approach combines critique with reconstruction: it questions the epistemological foundations of classical value theory while offering a reformulation of the law of value adapted to the realities of contemporary capitalism.

Research Objective

The primary aim of this study is to propose a new unit of measurement for economic value — one that moves away from labor time and instead relies on the quantity of socially necessary energy (S.N.E.) expended in the production process. Drawing on rigorous scientific foundations from biology, physiology, and thermodynamics, this research seeks to address a longstanding conceptual and methodological flaw in the classical labor theory of value. The goal is to rehabilitate the law of value on empirically verifiable and conceptually consistent grounds, thereby reaffirming the aspiration of political economy to be a science rooted in objective laws.

Methodology

This research adopts both a critical and reconstructive approach. It begins with a conceptual and epistemological analysis of the notions of value, measurement, and human effort as they were developed in the tradition of classical political economy. This initial critical phase highlights the logical inconsistencies inherent in equating labor time with value.

The second, constructive phase draws on data from the biological sciences (nutrition, physiology) and established measurement tools (calorimeters, kilocalorie units) to propose an alternative metric: the actual caloric energy expended in the production of a good or service. The study also relies on standardized empirical data (e.g., WHO, 1974) to establish a quantitative framework applicable to different categories of productive activity.

1- The Conceptual Confusion between Value, Measurement, and Unit of Measurement

Value is an attribute of a thing, a characteristic that distinguishes and defines it. In this sense, it is like weight, length, volume, height, etc. If a thing has some heaviness (such as a hammer), we say that the thing has weight. If a thing has a certain distance between its ends (such as a road or a piece of fabric), we say that the thing has length. If a thing occupies a certain space (such as a table or a chair), we say that the thing has volume. If a thing has a vertical extent from its base to its top (such as a lecture hall), we say that the thing has height. The same applies to value: the thing/product that is the result of (whatever it may be: free, enslaved, coerced, contractual), and thus contains some degree of human effort embodied in this product, acquires value — it has value.

Value, in this sense, does not depend on its measurement or estimation for its existence; it is not rational to say that a thing has no value because we have not yet determined the quantity of human effort exerted in its production. This is because value, as an attribute, is conferred upon a thing as soon as a certain degree of human effort is embodied within it. Measuring or estimating its value by the quantity of something else only comes at a later stage after value itself has been established. Just as measuring length only follows the establishment of the attribute of distance between the ends of the thing.

When the abstract attribute is established from a qualitative perspective (weight, length, volume, height, value, etc.), all that remains is to recognize this attribute from a quantitative, tangible perspective by using the appropriate scale and unit of measurement suited to the nature of the thing being measured.

A measure is the tool or device by which the attribute to be measured quantitatively is measured. A measure of length is the tape divided into centimeters or the ruler, not the distance between the two ends of the object, while the unit of measurement is the centimeter. Therefore, when we say that the length of a piece of fabric is 12 meters, this means that we used the tape divided into centimeters or the ruler as a measure of length and used the centimeter as the unit of measurement.

However, clarity diminishes when addressing the measure and unit of measurement for value. Political economy recognizes that value stems from human labor embodied in a product. However, when measuring this value, it focuses on the time spent laboring rather than quantifying the labor itself. That is without measuring the value it essentially aims to measure! Not to mention the confusion between the measure and the unit of measurement. Adam Smith observed:

*"What is usually the produce of one day's labour, or one hour's labour, is usually worth a certain proportion of the produce of two days' labour, or two hours' labour (**The Wealth of Nations**, Book I, Chapter VI).(1)*

David Ricardo follows the same path as Smith, but he arrives at a slightly different measure, which is the average quantity of labor exerted in the production of gold:

*May not gold be considered as a commodity produced with such proportions of the two kinds of capital as approach nearest to the average quantity employed in the production of most commodities? May not these proportions be so nearly equally distant from the two extremes, the one where little capital is used, the other where little labour is employed, as to form a just mean between them? (**Principles**, Book I, Chapter VI).(2)*

As for Karl Marx he is the one who formulates the final version of the measure of value and its unit of measurement, stating that value is measured by the quantity of labor, and the quantity of labor is measured by the time spent (during which) the labor is exerted:

*"How shall we measure the quantity of value? The quantity of value is determined by the quantity of labour contained in it... As for the quantity of labour it is measured by the length of the work, by the time of labour, and the time of labour finds its standards in specific parts of time, such as the hour and day..." (**Capital**, Volume I, Chapter I).(3)*

Political economy, according to its doctrine in this way, when it says that the pen is worth 30 minutes, it means that the human effort embodied in the pen is worth 30 minutes. However, this doctrine in measuring value and its implications clashes with the fundamentals of the science of measurement, and even contradicts the very concept of value itself; it is scientifically incorrect to say that the human effort exerted in producing a thing equals (X) minutes or (Y) hours. While it may be permissible to say that the human effort exerted in producing a thing took (X) or (Y) minutes or hours, even then, when we say that the human effort was exerted over (X) minutes or (Y) hours, it does not mean that we have measured this human effort; on the contrary, it means that we have only known the time spent during which this effort occurred, without knowing the extent of that effort. We have known the time during which value was formed, but without knowing the quantity of value itself!

For over two centuries, political economy has axiomatically asserted that a commodity's value is measured by its production time. This approach, however, contradicts scientific principles and creates an epistemological crisis; for we must choose between two options: either to acknowledge, scientifically, that we are using an incorrect measure for value because we are measuring the human effort embodied in the product using the unit of time measurement! It is as if we are trying to measure length with the Richter scale, or height with the imperial gallon! Or we must openly admit that the political economy's understanding of value is incorrect and requires revision, because it says that value (human effort) is embodied, and then treats it (as time) spent!

Therefore, if the political economy's understanding of value is correct, the measure should be corrected. However, if the measure is correct, and thus the unit of measurement is also correct, the concept of value itself should be reconsidered.

In fact, the understanding of political economy regarding value is correct, at least based on the linguistic roots of the word "value," which will be used as a term to indicate that something contains a certain quantity of human effort. It is possible to attribute this flaw in the political economy's concept of value and its subsequent unit of measurement, to the underdevelopment of the science of measurement and the lack of measurement tools during the early stages of the development of political economy.

Hence, political economy resorted to the nearest known unit of measurement at the time, which was the unit of time—the time spent in producing something. It became established, albeit incorrectly, to say that the value of something is measured by the quantity of labor spent in producing it. And because the quantity of labor proved difficult to measure in the early stages of the development of political economy, the founders of the field had to define the quantity of labor expended using units of time (the time spent during this labor).

This ultimately meant considering time — the hour, the day, etc.— as the final measure of value. This approach not only confuses the measure with its unit but more crucially, it obscures the very essence of value itself.

2- The Instability of Labor Quantity as a Measure of Value

Well then, let's temporarily set aside what we've mentioned above, and let's assume, for the sake of argument, that we are wrong, and therefore consider political economy is correct in using the quantity of labor to measure value! Let us now align with the founders of the science in their measurement! We observe that the founding fathers of political economy agree that value is measured by the quantity of labor, and the quantity of labor is measured, as we mentioned, by the time spent (during) that labor. However, they differ on the nature of this labor:

Smith, who conflated value with exchange value, believed that the value of a commodity is determined by the quantity of labor expended in producing another commodity with which it is exchanged. In other words, he evaluates commodity (X) by the quantity of labor expended in producing commodity (Y) with which it is exchanged, rather than by the quantity of labor expended in producing commodity (X) itself:

"It is natural that the value of a commodity should be estimated by the quantity of another commodity which it can exchange for. The quantity of any commodity is generally estimated by the quantity of labor that it can purchase. The value of a commodity, therefore, depends upon the quantity of labor which it can command." (The Wealth of Nations, Chapter 5).(4)

As for David Ricardo, who tried, and perhaps claimed, to correct Smith, he argued that value is determined by the quantity of labor time expended in producing the commodity. As for the measure, it is, as we mentioned, the average quantity of labor spent in producing gold, which in turn is a commodity capable of serving as the exchange value for different commodities.

In the end, Marx returns to Adam Smith, but without measuring the value of a commodity by the quantity of labor expended in the production of the commodity exchanged for it. Instead, he measures it:

"By the quantity of labor contained in the commodity." (Capital, same source)(5)

Now, having considered the agreements and disagreements among the founding fathers as previously outlined, let us pose the following important question: what is the most essential characteristic of a measure? The direct and clear answer is: stability. That is, the measure—and therefore the unit of measure—must be stable in order to perform its function. It is not possible to measure value with a measure that is itself variable. In fact, the quantity of labor is a clear example of such a variable measure that cannot be relied upon to assess value; for different types of labor differ in terms of both effort and skill: the nature of a property guard's work differs from that of a builder in terms of effort, and thus one hour of the guard's labor differs from one hour of the builder's. Similarly, the nature of a barber's work differs from that of a surgeon in terms of skill, and thus one hour of the barber's labor differs from one hour of the surgeon's. In reality, this problem did indeed confront political economy, and after admitting that:

"The different degrees of hardship endured, and of ingenuity exercised, must likewise be taken into account. There may be more labour in an hour's work than in two hours' easy business; or in an hour's application to a trade which it cost ten years' labour to learn, than in a month's industry at an ordinary and obvious employment. But it is not easy to find any accurate measure either of hardship or ingenuity. In exchanging, indeed, the different productions of different sorts of labour for one another, some allowance is commonly made for both. (The Wealth of Nations, Book I, Chapter V)(6)

it is compelled to concede that:

It is adjusted, however, not by any accurate measure, but by the higgling and bargaining of the market, according to that sort of rough equality which though not exact, is sufficient for carrying on the business of common life. (Wealth of Nations, same source)(7)

And Ricardo, as usual, follows in Smith's path and agrees with the principle of the market's ability to equalize between different kinds of labor:

The estimation in which different qualities of labour are held, comes soon to be adjusted in the market with sufficient precision for all practical purposes and depends much on the comparative skill of the labourer, and intensity of the labour performed." (Principles, Chapter One).(8)

As for Marx—who ignored the existence of a real crisis resulting from the differences in labor in terms of intensity and skill—instead of reconsidering the measure of value and its unit of measurement, he too affirmed that:

"The different proportions in which different kinds of labor are reduced to simple labor as their unit of measurement are determined by a social process that takes place behind the backs of the producers." (Capital, Volume I, Chapter One).(9)

In reality, the market will not resolve the matter as the founders of our science believed. Rather, it will not only distance us from the origins of the science and the goal of revealing the objective law governing the phenomenon under study, but it will also increase the complexity of the issue. The market itself may make one hour of a blacksmith's labor (socially necessary) equal to one hour of a carpenter's labor (socially necessary) in one place, while it may make that same hour of the blacksmith's labor equal to ten times the hour of the carpenter's labor in another place. In both cases, neither the market nor political economy tells us the reason for this, that is, neither of them explains the reason for the equality between the two hours, nor the reason for the difference; they can do is point to the present situation, to momentary fluctuations, to what is immediate, without reaching the objective law that governs the natural exchange ratios between different kinds of labor.

Accordingly, it can be said that political economy, over the course of two centuries, has used an unstable measure for measuring value. When political economy recognizes that the quantity of labor cannot perform its function as a measure of value—because different kinds of labor differ in terms of both intensity and skill—it redirects us to the market, which means abandoning the science by halting at what is given.

This signifies the cessation of the search for the objective law governing the phenomenon under investigation. This necessitates us to correct the measure of value and its unit of measurement, beginning with a correct understanding of value, and consequently, a re-understanding of the fundamentals of political economy—a science concerned with the phenomena of the capitalist mode of production, which is structured around the law of value.

3- Towards a New Measure of Value Based on Socially Necessary Energy

Before we present our hypothesis regarding the correction of the measure of value, and consequently the correction of its unit of measurement, we must clearly emphasize that relying on the existence of a difference between value and its measure, as a justification for using the incorrect measure—which is a perennial argument that some may present to us—never justifies the use of the wrong measure and insisting that it is the correct one. Scientifically, and logically, it is not acceptable to attempt to use a thermometer, for example, to measure height. The first is a tool used to measure temperature, and the second is the vertical distance from the base of an object to its top.

The same judgment applies to value; it is neither scientifically nor logically acceptable—even if we are told that the term has its sacred, purified meaning: that value is human effort embodied in the product and then measure this embodied effort using the unit of time in which this effort is expended! The scientific truth is that the human effort exerted in the production of an object, which is embodied in the product, is actually measured by the caloric unit, which is the unit of thermal energy that the body requires, forms, and expends in order to perform, and during the performance of, its work, through the consumption of food, i.e., converting chemical energy (food) into mechanical energy (work). This energy, when embodied in the product, gives it value.

By using this unit of measurement, which is a stable unit of measurement(10), the quantity of energy that the body receives and expends can be known by measuring what the body needs under different conditions and when performing any type of work. We will symbolize the caloric unit by the letter (C). The quantity of energy is what our science has not yet reached when it stopped at measuring value by the unit of time. As for the measuring instrument, which is also stable and used for measurement, it is the calorimeter(11), through which the thermal energy emitted by the body during its exertion can be measured.

Energy consumption, in kilocalories, exerted by a standard man (65 kg).

Nature of the activity	Active, such as (Office work, lawyer, doctor, accountant, teacher, architect, store worker)	Moderate activity, such as (Construction workers, excluding heavy labor, most light industry workers, fishermen)"	Very active, such as (Some agricultural work, carpenter, unskilled labor, iron workers, miners, athletes)	Extremely active, such as (Woodcutter, blacksmith, cart pullers)
500	500	500	500	In bed (8 hours)
2400	1900	1400	1100	At work (8 hours)
1500 - 700	1500 - 700	1500 - 700	1500 - 700	Outside of work hours (8 hours)
4400 - 3600	3900 - 3100	3400 - 2600	3100 - 2300	Total energy expended (24 hours)
4000	3500	3000	2700	Average energy expended

Handbook on Human Nutritional Requirements (Geneva: W.H.O, 1974). P,70

Energy consumption, in kilocalories, exerted by a standard woman (55 kg)

Nature of the activity	Active, such as (office work, teacher, housewives, most other professions).	Moderately active, such as (workers in light industries, warehouse or store workers)	Very active, such as (some fieldwork, especially agricultural work).	Extremely active, such as (construction work, athletics).
420	420	420	420	In bed (8 hours)
1800	1400	1100	800	At work (8 hours)
980 - 580	980 - 580	980 - 580	980 - 580	Outside of work hours (8 hours)
3200 - 2800	2700 - 2400	2400 - 2000	2200 - 1800	Total energy expended (24 hours)
3000	2600	2200	2000	Average energy expended

Handbook on Human Nutritional Requirements (Geneva: W.H.O, 1974). P,70

Let us take a step forward. The worker who produces value, that is, the one who exerts the effort that becomes embodied in the product, requires essential means of livelihood, such as food, clothing, shelter, and so on. Let us start with the food that provides him with energy and enables him to perform work. More precisely, we begin with the actual expenditure of effort during which chemical energy is converted into mechanical energy. According to the science of nutrition, physics, biochemistry, and physiology, we now know, with scientific accuracy, the quantity of calories consumed during various types of human effort, which are in turn embodied in the product. For example, we now know (see the tables above) that a construction worker consumes 1400 (C) over 8 hours, meaning his product embodies 1400 (C). A worker in a steel factory, during the same period, consumes 1900 (C), and his product embodies 1900 (C); a blacksmith consumes 2400 (C), so his product embodies 2400 (C); a factory worker who consumes 1100 (C) will have her product embody 1100 (C), and a teacher consumes 800 (C), so the service she provides embodies 800 (C), and so on. What this means is that our understanding of the value of a pencil, consequently the value of any object, good, or service, is a result of labor. It is linked to our understanding of the quantity of energy expended in its production, not the time during which this energy is expended, as political economy has traditionally assumed for two centuries.

According to the two tables above, as we observe, the individual's specific caloric needs are not taken into account; this is because individuals vary in terms of height, weight, and so on. Therefore, the individual who requires a certain quantity of (C) may need more or less than another. Hence, the quantity of calories required is used as a reference, and from now on, we will symbolize this with the letters (N.C), which enable the ordinary worker to achieve three things: to work, to live as a worker, and to renew the production of their social class. Thus, wages not only secure the worker's survival for the next day, but also ensure the survival of the industrial army—i.e., the working class's descendants—so they can be pushed into the labor market.

Therefore, it is understandable that the architect's wage exceeds that of the blacksmith, despite the blacksmith consuming 2400 (N.C) while the architect only consumes 1100 (N.C). Wages, then, do not only cover the caloric needs socially required for a worker to work and live as a worker, but also include the quantity of calories necessary to become an architect or a blacksmith, making them fit for entry into the labor market. In other words, the capitalist class ensures through the wages it pays that the worker is able to reproduce themselves, thus guaranteeing the social reproduction of the working class and ensuring its continued existence.

Similarly to how the socially necessary quantity of energy is considered in relation to the producer (the worker), it is also considered in relation to the product, the commodity. When it comes to exchange, according to the Law of Value, we must take into account both the direct energy expended in the production of the thing (the direct effort embodied in the product) and the energy stored in the tools and materials used to produce that thing (the stored effort embodied in the means of production). The value of a coat, for example, is not determined solely by the quantity of direct energy expended in its production, but also by the quantity of energy stored in the materials and tools used in its production.

Thus, in exchange, the value of a coat that cost 100 (N.C) of living energy and 50 (N.C) of stored energy is equal to a piece of fabric that cost 80 (N.C) of living energy and 70 (N.C) of stored energy.

The consideration of necessary energy is based on the socially necessary quantity of energy, according to the prevailing productive technique. If, for instance, the production of quantity (X) of fabric originally required 200 (N.C) and a new machine or technique emerges that allows the same quantity produced using only 50 (N.C), the new social value will be determined according to the new production technique. Hence, 50 (N.C) per (X) of fabric will be recognized, and those who continue to produce the fabric with the old technique, requiring 200 (N.C), will bear the disadvantage of not utilizing the socially prevailing production technique. Therefore, when they take their fabric to the market for exchange, they will not exchange it for a product that was produced with 200 (N.C), but rather for a product that required only 50 (N.C) to produce.

4- Further Explanation

Let us assume that society begins the process of production with one billion Necessary Calories (N.C), represented by one billion units of colored paper certified to correspond to 1 (N.C). The bearer of any such note may exchange it for one unit of some foodstuff, whose production required the expenditure of 1 (N.C).

The capitalist now allocates 600 million notes—equivalent to 600 million (N.C)—to means of production (i.e. materials and instruments of labor) as follows: 300 million notes to purchase raw and auxiliary materials, handed over to their producers in exchange for what he requires of them; and another 300 million notes to purchase instruments of labor, likewise exchanged with their producers. Having thus secured the necessary materials and tools, the capitalist proceeds to purchase labor-power. He contracts workers to transform the materials, by means of the instruments, into finished products, paying them 400 million notes—equivalent to 400 million (N.C).

The workers, having just received 400 million notes, set about laboring so that the one billion notes return to the capitalist, but now embodied in commodities whose value is composed of: the value of materials (300) + instruments (300) + labor-power (400). That is, a total of one billion. Yet, to the capitalist, the process here would be utterly futile. He has advanced one billion in colored paper, and would merely receive back commodities valued at one billion. Such an outcome—had it been foreseen—would have deterred him from producing at all.

Therefore, the workers must generate, within his factory, a value exceeding that which they themselves received. They must produce surplus energy. The capitalist knows this in advance; indeed, the labor contract itself rests upon this fact.

Consider: with a single note, the worker can purchase a food item that embodies 1 (N.C) in production, but which yields 10 (N.C) when consumed—enabling him to labor for eight hours, or perhaps to sustain him for a full day of twenty-four hours. If we assume that each note yields 10 (N.C), and further assume (for simplicity) that these 10 (N.C) represent the bare minimum for survival, then the workers, having received 400 million (N.C), return to the capitalist only those 400 million embodied in the products, but also an additional 3,600 million (N.C) as surplus output. This surplus constitutes surplus value.

The capitalist pays the worker one note in exchange for eight hours of labor, but during those eight hours the worker expends not 1 (N.C) but 10 (N.C). The difference between what the capitalist pays and what he receives is surplus value. Without it, the capitalist would cease investing, and society would cease reproducing itself.

We note here that the materials and instruments of labor enter the process and reappear in the product only to the extent they were consumed—i.e., 600 million units. What is said of means of production also applies to taxes, advertising, etc.; none of these add more or less to the product than their own value.

Second Example: Suppose a worker in a light industry requires 1,400 (N.C). If this worker labors eight hours in a factory producing halva, turning out 100 pieces of 100 grams each, with every piece containing about 500 (N.C), then each piece embodies roughly 1 (N.C). Now, when a construction worker—who also requires 1,400 (N.C)—purchases and consumes three pieces, he obtains 1,500 (N.C). This sustains him through an eight-hour workday, energy which was expended in the building process and embodied in the product.

Yet the capitalist did not pay for the builder's 1,500 (N.C) of labor. He paid only for the 3 (N.C) required to produce the halva that supplies the builder with that energy. Thus, the capitalist advances 3 (N.C) but receives 1,500 (N.C) in return. The difference, as we have noted, accrues to the capitalist as surplus value, which he accumulates to expand reproduction on an enlarged scale.

A simpler and very real example in monetary terms: A factory worker who consumes a few grams of halva and a piece of bread costing no more than 3 pounds can work eight hours for the capitalist and generate hundreds of times the social value of that halva and bread. The difference accrues to the capitalist as surplus value. Workers, being typically remunerated at subsistence level, buy the cheapest foods that yield the highest energy return for sustaining their labor. Thus bread, beans, potatoes, aubergines, and inexpensive oils are staple foods of the working class. These provide, at relatively low cost, the highest caloric return, enabling the worker and his family to survive and reproduce surplus value—embodied in surplus product—which flows into the coffers of the capitalist, who in turn accumulates it to expand production.

If we now penetrate the depths of the capitalist production process and analyze the relations of productive forces at the highest level of abstraction, we find that the commodity, according to the above examples, is no longer merely the result of living labor (labor-power) and stored labor (materials and instruments), but of: living labor expended by workers + stored labor embodied in materials, instruments, and even the workers themselves + surplus labor (unpaid living labor).

Accordingly, the value of the commodity, and the law that regulates it, is the total necessary energy, i.e. social labor (living, stored, and surplus). Hence, the greater the total necessary energy, the greater the value; the lesser the total necessary energy, the lesser the value.

The constitution of value, and the principle regulating it, do not change; they merely develop—from (living labor) to (living labor + stored labor), and then to (living labor + stored labor + surplus labor).

In our first example above, we assumed that only a single capitalist existed in the market, thereby appropriating all the surplus value produced by the workers. Let us now suppose that the market contains four capitalists, with three new ones entering. Since the mass of profit—determined by the level of aggregate demand—remains unchanged (that is, no matter how many more capitalists enter the market and no matter how much the supply of the given commodity increases, society will not expand its consumption of it), the capitalists must divide among themselves the total profit mass of 3,600 million units. Each capitalist thus receives 900 million units, but only on one essential condition: that the prevailing productive technique allows—indeed compels—the capitalist to alter the composition of his productive capital from the combination (400 + 300 + 300)—namely, 400 million units for labor power, 300 million units for raw materials, and 300 million units for instruments of labor—into the combination (100 + 75 + 75), that is, 100 million units for labor power, 75 million for raw materials, and 75 million for instruments of labor. Only with this latter composition can he secure the profit of 900 million units.

In that case, the total value of each capitalist's output consists of living labor (100) + past labor (150) + surplus labor (900). Thus, the commodity leaves the capitalist's factory with its social value of 1,150 units and, in the market, begins its journey of price fluctuations above and below this social value.

Now let us assume that a new capitalist—a fifth one—enters the market with a new technique and therefore a new composition, say (45 + 25 + 30). This capitalist's share of the profit mass will be $(3,600 \div 5)$, i.e. 720 million units. Yet he will outcompete his peers because he secures his average profit by expending a smaller quantity of value. Meanwhile, the four older enterprises, using the old technique and the old composition, see their profits fall from million units to 720 million, due to the redistribution of the total profit mass across five enterprises instead of four. The fifth enterprise, newly arrived, expends only 100 million units and obtains 720 million units. At the same time, he sells his commodity at the prevailing social value—970 million units (composed of 250 million units representing the value of the productive forces + 720 million units as the profit share of each enterprise). He therefore has an additional (differential) profit of 150 million units, since he expends only 100 million rather than 250 million units, yet still receives 720 million units. In contrast, each of the four older enterprises expends 250 million units in order to receive the same 720 million units.

This situation will persist only temporarily, until the new technique and its new composition are gradually adopted by all factories. At that point, the compositions of all five enterprises become identical, and the social value is formed by the combination: $45 \text{ Lp} + 25 \text{ Mp} + 30 \text{ Ip} + 720 \text{ Sv} = 820$ million units. Consequently, the “circulating” social value declines from 4,600 million units to only 4,100 million units.

5- Incorporating Time into the Analysis

To continue our discussion on the role played by time in the formation of value, we must revisit the issue that political economy has faced and that Ricardo and later Marx addressed. The issue is as follows: there are three goods: wooden molds, wine, and pottery. Each of the three goods requires 120 hours of labor (12) (live, stored, and surplus). Up to this point, there is no issue with exchange according to the law of value; the exchange between the three goods will occur at a 1:1 ratio. However, the difficulty arises when political economy faces the problem of time:

- The owner of the wooden molds, who spent 120 hours of labor, must wait 240 days before the molds can be offered for exchange, and thus the capital will return with profit.
- The owner of the wine, who also spent 120 hours of labor, must wait 120 days before the wine can be offered for exchange.
- The owner of the pottery, who also spent 120 hours of labor, needs to wait only 60 days before the pottery can be offered for exchange, and then the capital will return with profit.

So how can we conduct an exchange naturally between goods that have equal production costs (120 hours of labor) but different production times (13) days for the wooden molds, 120 days for the wine, and 60 days for the pottery)?

For Ricardo, the solution, in the end, is to provide a reward for waiting! He estimated this, in the third edition of his principles, at 10%. But Ricardo never told us why 10%, not 9% or 11%.

As for Marx (who distinguished, starting from the use of labor power, between the working day (14) and the period of labor, (15) and likewise distinguished beginning with the use of capital, between Labour-time (16) and production time) he considered the tendency of profit rates to equalize across sectors playing a decisive role in explaining the role of time in the formation of value. However, relying solely on the ability of this tendency—as Marx believed—direct producers toward branches of production through the advance or withdrawal of capitals according to the “average rate of profit,” (17) necessarily leads to the conclusion that the owner of wooden molds and the owner of wine would both turn to pottery! But this does not, did not, and will not happen. We know that political economy—at least according to Ricardo's contribution—reached, at a relatively early stage, the determination of a commodity's value by the quantity of socially necessary labor expended to produce it. This value is not limited to the living labor expended in production alone; it also includes the necessary labor embodied in the construction of buildings, machines, and equipment essential to production—in other words, stored labor.

Therefore, the value of the coat, which required 100 hours of live labor and 50 hours of stored labor for its production, is equal to the value of the fabric which required 80 hours of live labor and 70 hours of stored labor for its production. When Marx came along, he completed the components of value, and we came to know that the value of the coat is not only composed of live labor and stored labor but also includes surplus labor. This was his initial line of thought (18) before he deviated in his second stage, adopting the concept of average surplus labor. (19) However, the political economy as it stands does not, and will not, assist us scientifically in identifying the reason why our three friends remain in the market without any of them, either the owner of the wooden molds or the owner of the wine, shifting to the pottery production branch. This is because each of them, as we mentioned earlier, spends 120 hours of labor (live, stored, and surplus), but no capital returns laden with profit, since we have neglected the time spent in trading. This is only after 240 days in the wooden mold production branch, 120 days in the wine production branch, and only 60 days in the pottery production branch.

The hypothesis we propose is that the reason the three of them remain in the market is that the social value of the commodity, through its development determined by the quantity of live, stored, and surplus energy (valued in necessary calories) divided by its production time. The relative social value of the commodity is determined by its social value divided by its production time, compared to the social value of the other commodity with which it is exchanged also divided by its production time.

When commodities meet naturally, they exchange according to this law. And when their prices fluctuate in the market, they oscillate around this social value. In applying this law, we encounter three hypotheses: either the production times differ while the social values are equal, or the social values differ while the production times are equal, or both the production times and the social values differ. In all cases, the law of relative social value applies, meaning the social value of the commodity divided by its production time, relative to the social value of the commodity with which it is exchanged, divided by its production time.

Based on this, and having applied our methodology in measuring value by replacing the labor hour with the necessary quantity of energy, we assumed that each of the three—namely the owner of the wooden molds, the owner of the wine, and the owner of the pottery—spends 12,000 necessary calories (live + stored labor + surplus labor). However, as mentioned, the capital does not return with profit except after 240 days in the wooden molds production branch, 120 days in the wine production branch, and only 60 days in the pottery production branch. Therefore:

- The value of one unit in the wooden molds production branch equals the value of half a unit in the wine production branch.
- The value of one unit in the wine production branch equals the value of half a unit in the pottery production branch.
- The value of one unit in the pottery production branch equals the value of 2 units of wine and 4 units of wooden molds.

However, achieving 50 (value/time) (20) as in the wooden molds production branch, which is done by: 12,000 production cost and 240 production time can also be achieved by:

- 6,000 production cost and 120 production time (as in the wine production branch).
- It can also be achieved by: 3,000 production cost and 60 production time (as in the pottery production branch).

Therefore, the two capitalists—the producer of wooden molds and the producer of wine—will adjust the (value/time) combination to 3,000/60. This is response to the development in the degree of social struggle for control over new technology, without being compelled, with the ongoing revolution in the forces of social production, to transition from one branch of production to another. Let us observe:

First: The adjustment of the production combinations (value/time) in the factories of wooden molds, wine, and pottery occurs as a result of the law of relative social value, governed by the degree of social struggle in the field of technology, not as a result of an assumed waiting reward as Ricardo imagined nor due to the tendency of profit rates to equalize as Marx believed.

Second: The adjustment in combinations using new production techniques to achieve 50 (value/time) at the lowest production cost (3000 N.C.) and the shortest production time (60 days) will lead to a general decrease in relative social values on a social level, within a framework of intense competition to control new developments in the field of technology, with the aim of achieving the lowest (value/time). This may raise the question of whether the phenomenon of value itself could fade away as a result of the continuous development in the field of technology. Let us defer addressing this question until after discussing the first observation related to the ability of the tendency of profit rates to equalize in explaining the role of time in the formation of value.

To discuss this alleged ability, which is rooted deep in the science of political economy, of the tendency of profit rates to equalize in explaining the role of time in forming value, we will analyze the role of social value in adjusting the (value/time) ratio, starting from analyzing the components of the product price itself. We neglected this above and merely assumed that its value (in total) is 12,000 units, without examining the quantity of each of its components specifically: the stored labor and surplus labor. In other words, without examining the fixed capital (means of production) and the profit (surplus labor). Now, let's assume that the production price of the wooden mold producer, which is 12,000 (N.C), consists of 3,000 means of production, denoted by (M) and 9,000 surplus labor, which is the profit, denoted by (P). We will also assume that the production price of the wine producer, also 12,000 (N.C), consists of 9,000 (M.P) and 3,000 (P). As for the production price of the pottery producer, also 12,000 (N.C), let's assume it consists of 11,000 (M.P) and 1,000 (P).

According to Marx's hypothesis, it is now necessary, before analyzing the components of the production price, to reverse his theory. The wine producer and the pottery producer should now move to the field of wooden mold production, where the latter obtains the highest possible profit, which quantities to 9,000 units. They will continue to earn the highest profit even if the capital of the pottery producer undergoes four cycles for every one cycle of the wooden mold producer's capital. If the capital of the former undergoes four cycles, it will only earn 4,000 units in 240 days. The same applies to the wine producer: two cycles of his capital will only yield him 6,000 units in 240 days. Therefore, the capitals of the wine sector and the pottery sector, despite the uncertainty surrounding the issue, will tend toward the wooden mold production sector. The rush of capital in this manner toward the wooden mold production sector will be a result of the tendency of profit rates to equalize, exactly as Marx stated!

However, it is essential here, immediately, not only to discard the relationship between time and the dormant forces of production without labor, but also to ensure that the analysis, as we have just done, is carried out by entirely excluding the means of production from the calculations! Our calculations were as follows: 9,000/240 in the wooden mold production sector, 3,000/120 in the wine production sector, and 1,000/60 in the pottery production sector.

In other words, we ignored, following Marx's theory which, without any clear reason, disregarded the value of the means of production in each sector, as we only calculated the profit-to-production-time ratio! It is well known that profit can only be realized during time through the forces of production. Therefore, it is not acceptable to neglect them when calculating (value/time).

Hence, if we want to understand the role that time plays in the formation of value, we cannot rely on that excessive and scientifically unjustified confidence in the ability of profit rates to equalize! Instead, the calculation must be done as follows: 12,000/240 in the wooden mold production sector, 12,000/120 in the wine production sector, and 12,000/60 in the pottery production sector.

In this regard, Marx's theory of the tendency of profit rates to equalize (which intentionally overlooks the value of dormant means of production as a component of the cost of production) stops short of explaining the capital flows in and out, without considering time! Marx's theory of the tendency of profit rates to equalize cannot, therefore, fulfill its purpose when used to understand the role that time plays in the formation of value! Only the law of relative social value can explain the role of time in the formation of value on a social level.

If we return to the example above, and apply the law of relative social value, which takes time into account and does not neglect the value of dormant means of production, we will find that the capitals, whether active in the production of wooden molds, wine, or pottery, will not leave one sector for another. Instead, adjustments will only be made in the production combinations (value/time) using available technologies to achieve 50 (value/time) with the lowest production cost of 3000 (N.C) and the lowest production time of 15 days.

So far, we have discussed adjustments in production combinations within different branches in a particular sector, such as the industrial sector. Now, in order to deepen the analysis, we must shift the level of discussion from branches to sectors. Let's assume there are three agricultural products: wheat, rice, and corn. Each of these products costs 24,000 (N.C). However, the wheat producer must wait 480 days, the rice producer must wait 240 days, and the corn producer must wait 120 days. According to the law of relative social value, we will have different (value/time) here, where 50 (value/time) is achieved with 6,000 (N.C) in a production time of 30 days.

This means that the economy, at the sector level, has (value/time) in the industrial sector that differs from (value/time) in the agricultural sector. This natural difference in (value/time) across sectors is due to, and organized by, the size of the capitals on the one hand and the production time on the other. This difference in (value/time) across sectors, which arises from the law of relative social value, governed, as mentioned, by the degree of social struggle in the field of technology, rather than by the tendency of profit rates to equalize, gives us, at least, three hypotheses, or rather methodological explanations, where it can:

- And it must be the case that there is no equalization of wages across sectors.
- Also, it can, and must, be the case that there is no equalization of profits across sectors.
- It can also, and must, be the case that there is no equalization of the prices of means of production on the social level.

Let us now, for further analysis, shift the level of discussion to the field of foreign trade. This time, let's take a homogeneous commodity as an example to see, from another perspective, how social value is determined over time, according to the prevailing production technique. Let us assume that the production of cheese in France, England, and the Netherlands costs 48,000 (N.C). However, it is only released into the market after 960 days in France, 480 days in England, and 240 days in the Netherlands. In this case, we will be dealing with a (value/time) that is also determined by the law of relative social value, composed of a production price of 12,000 (N.C) and a production time of 60 days. Therefore, capitals will make adjustments to their production combinations (value/time) in order to achieve the lowest production price of "12,000" in the shortest production time of "60" on a global scale.

Because these adjustments in the production combinations, whether in the industrial or agricultural sector within national economies, or even on a global scale, to achieve the lowest (value/time), depend primarily on the developments occurring in the field of technology. And since value, as we know, is the quantity of labor (living, stored, and surplus) embodied in the product, the introduction of technology, in this sense, particularly affects the quantity of labor as one of the components of value, potentially reducing its quantity within value to zero. This might suggest the disappearance and obliteration of value; thus, we must dispel this illusion, the illusion of the machine curse, which might eliminate the phenomenon of value and abolish it historically!

It is clear that the contemporary capitalist world in the past twenty, and perhaps thirty, years has witnessed a rapid development in the social forces of production. It has become easy, with the mere press of a button on a keyboard, to transfer billions of dollars from one country to another, thousands of miles apart, in an instant. The situation might even reach the point where an entire nation could be erased from the face of the Earth, simply by pressing that same button on the keyboard!

Humankind has finally, through the power of machinery, achieved some victories over two stubborn adversaries: time and distance. With the exhilaration of this triumph, the human mind continued to affirm its success with further innovation, invention, and development in the field of technology. This victory, however, brought with it the bitter struggle between the historically victorious machine, driven by the continuous progress in technology, and the human hand, which had distinguished humanity from the animal kingdom. It has become common to replace dozens, and perhaps hundreds, of workers with a single machine—one that may even be operated remotely!

The image painted above, undoubtedly drawn from the daily reality that we all observe, has led some to imagine a new historical revolution akin to the Agricultural and Industrial Revolutions! (Without considering these as one of the intellectual products of the European mind and its conception of world history, beginning with Europe's own history!) The absurdity surrounding this supposed revolution has turned it into an unquestioned assumption, treated as a given, and has become the starting point for imagining the new relationship between the machine and the worker. No longer based on "contradiction," this relationship is now founded on "exclusion"—perpetual exclusion leading to the tragic end of human labor and even of humanity itself, when the machine declares its eternal victory! This outcome has caused those who believe in the illusions of this new historical revolution to attempt to draw a picture of the catastrophic end of the contemporary world, in the manner of biblical prophecies!

The issue of the conflict between the machine and humanity, which leads to the end of value, and the analysis of the fate of humanity through the promise of a new revolution, a revolution coming from the West, only appear as manifestations of a crisis of consciousness. This crisis appears both at the structural and operational levels: Since humans descended from the trees, they have not ceased creating. Through the heroic movement of history, they have discovered all the technologies that helped them subdue nature to their will, compensating for their weaknesses. They surpassed wild animals in strength, speed, ferocity, and destruction, challenging nature with grandeur and fortitude, overcoming their frailty; they soared higher than birds without fear, dived into the depths of the seas without hesitation, and walked on water, carrying their burdens to the furthest limits. In this way, from the very beginning, humans never stopped discovering, innovating, and developing. They never ceased striving, by nature, to discover the means that would make them more productive and prosperous, constantly working to develop those means. Therefore, no new structural insights can be offered. Perhaps the form has changed—the form of the tool, the form of the machine, the form of society, and the form of political organization. But the essence remains the same, unchanged and unaltered. The development is formal, not substantive. It is this "formal" aspect that has misled those who believe in the new revolution; they imagined change in the "substance"! For perhaps the easy communication between people thousands of miles apart, and the smooth transition from the north of the planet to the south, and the most advanced machines performing the most complex production processes and the most destructive means have led these believers in the new revolution—whom I do not share belief with—to claim victory for what they believe in! However, historical truth confirms that the world, through the slow and grand movement of history, with the shifting of civilization's centers of gravity from east to west, then from west to east, and again from east to west, has always known, just as it does now, the same forms of development, the same level of amazement, and the same degree of awe. The difference has only been in the "form." Just as mobile phones, computers, and luxury vehicles with advanced technology have dazzled people's eyes and even captivated their souls, in our contemporary world, mechanical devices, valves, perfumed oils combined with sodium hydroxide, crystal glasses, mirrors, wires, lenses, cameras, surgical tools (around 150 tools, still used today), threads used in surgeries that dissolve in the body after the procedure, thermometers, analog computers, astrolabes, distillation, filtration, evaporation, sterilization, oxidation devices, insulating materials, geometric arches, mathematical numbering systems—all these, and certainly this is just an example, have played the same magical role. Just as factories spread in Europe in the nineteenth century, factories and workshops using hundreds, perhaps thousands, of workers producing for the market, even the international market for profit, spread in Baghdad, Nishapur, Seville, and Tanis.

Just as scholars from Europe and the United States have excelled in our contemporary world, so too did, for example, Al-Kindi, Ibn Bajjah, Ibn al-Baita, Idrisi, Al-Biruni, Ibn Sina, Al-Khawarizmi, Al-Zahawi, Al-Majriti, Al-Jazari, Ibn Hayyan, Ibn al-Haytham, and Al-Dinuri. Promoting a new revolution, a revolution coming from the West that claims to be superior, can only succeed by first distorting consciousness and erasing humanity's memory!

If, at the structural level, it is about erasing humanity's memory, at the analytical level, it is about preventing the formation of memory altogether! This prevention requires disabling understanding and obliterating critical awareness to the extent of creating false consciousness that denies the phenomenon of value, imagining its decline and eventual historical disappearance as a final result of the machine's victory! Can we, in reality, at the performance level, that value can wither away and disappear? The answer to this question, though simple and clear, and the related critical questions, is not what we should focus on. Rather, we should focus on the path the mind takes to provide that answer. For it is in this path that all the shortcomings of the contemporary economic mind appear, the one that has been raised on mechanical visions and linear methodologies, or the one that grew up with generalizations and absorbed the principles of initial summaries. Therefore, assume that the path the mind takes to answer the above question is defined by critical awareness and the following ideas:

1. The social value, in its simplest form, consists of living labor, stored labor, and surplus labor. The introduction of machines, due to advancements in technology, which reduces living labor and, by extension, surplus labor in a certain sector to zero, does not mean the historical disappearance of value. The machine itself is a quantity of human labor embodied in the product.
2. If we assume, according to the prevailing view, that a particular machine has been invented which causes the displacement of a number of workers in a certain sector, the question arises: Didn't this new and innovative machine, which replaced the dismissed workers, require the effort of other workers in different sectors to produce it? From the inventive mind to the hands that cast, shaped, and manufactured it... and so on, including the extensive activities of supporting and accompanying economic activities such as construction, supply, transportation, security, and financial operations... etc. Therefore, technological development, which leads to the substitution of machines for labor in a particular branch or sector, inevitably brings about a modification of the employment structure, both in depth and extent. As a result, the use of machines does not solely lead to the exclusion of workers in the branch or sector.

in question; it also, at the same time, leads to the creation of new productive fields that require a different, qualitative, and specific workforce. Thus, the machine, which causes unemployment for workers in one sector, creates numerous jobs in another sector, unless, with the freedom of economic activity new productive sectors are created.

3. And if we stretch our imagination further and suppose that machines, on the widest possible scale and in all fields of economic activity, begin to produce themselves entirely, rendering humans completely obsolete in the production process, then capitalism will inevitably correct its course and abandon the machine—either directly or indirectly, willingly or unwillingly. For capitalism has never allowed, nor will it ever allow, the kind of impoverishment that would lead to its own demise. It has never permitted the extinction of exchange values that would bring its movement to a halt. Whenever the capitalist economy ceases to function, capitalism—defined as the subjugation of production and distribution in society to the laws of capital's motion (21)—interacts to revive it, even if that means temporarily sacrificing some of its own achievements.

4. Imagine, for example, an agricultural society consisting of 1,000 individuals, 990 of whom are wage laborers working for 10 landowners. If those 10 landowners, in obedience to technological development, decide to replace their laborers with machines, they will soon find themselves bankrupt—perhaps even transformed into potential wage laborers themselves—since their products will find no buyers. The laborers, now unemployed, hold no exchange values. At that point, capitalism will not simply stand by and watch its own collapse; it will intervene, according to its own laws of motion, to correct the trajectory—even if that means rejecting the very machine which, by then, will also find no one to purchase it, having become ineffective in generating profits.

5. Technological development is not, as commonly claimed in the discourse of official educational institutions, linked to the level of societal advancement; rather, it is determined by the intensity of conflict among social forces competing to impose their dominance over innovations in the field of social productive forces.

6. This struggle to acquire the new in the field of technology leads to a reduction in the social value of the commodity to its lowest (value/time) ratio. Consequently, the lowered value of a given commodity reduces the values of the products that contribute to its final production. The same applies to the value of labor power: for the value of labor power to decline, increased productivity must also affect other branches of industry whose products determine the value of labor power.

7. The contradiction between the general rise in prices at the social level and the long-term downward tendency of value is what explains the stagflation that plagues the contemporary capitalist economy. When value—and especially surplus value—declines due to the degree of social struggle in the technological field, capitalists raise the prices of their products to compensate for the continuous shrinkage in profits. At the same time, capitalism, no longer functioning naturally, casts more and more victims out of the labor market. The result: a steady increase in the money supply, rising prices to absorb the excess of monetary units, increasing unemployment, stagnant markets, and piled-up goods. Then capitalism, as usual, intervenes to manage its crisis—albeit only to the extent that the laws of its motion are allowed freedom by the political system.

Conclusion

This study has argued that labor time, long treated as the standard measure of value, is conceptually inadequate. By contrast, socially necessary energy—measured in kilocalories—offers a concrete, empirical, and scientifically grounded alternative. Recasting the law of value in these materialist terms not only resolves a long-standing theoretical impasse but also reaffirms the original ambition of political economy: to explain the real processes of social reproduction.

The proposal of an energy-based measure of value invites further inquiry, both theoretical and empirical, into how value is created, compared, and distributed in contemporary economies. In this sense, the study lays the foundation for a renewed science of value—one that builds upon abstraction while extending it into measurable, physical reality.

Muhammad Adel Zaky is an Egyptian researcher specializing in the history of economic thought. He is the author of *Critique of Political Economy*, a book that has gone through six editions. His research explores the evolution of economic ideas in relation to social and historical change.

Footnotes

1. Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Edited by R. H. Campbell and A. S. Skinner. 2 vols. Glasgow Edition of the Works and Correspondence of Adam Smith. Oxford: Oxford University Press, 1976. P. 47.

2. Ricardo, David. *On the Principles of Political Economy and Taxation*. Edited by Piero Sraffa, with the collaboration of M. H. Dobb. The Works and Correspondence of David Ricardo, Vol. I. Cambridge: Cambridge University Press, 1951. P.52.

3. Marx, Karl. *Capital: A Critique of Political Economy*. Volume I: The Process of Capitalist Production. Translated by Ben Fowkes. Introduced by Ernest Mandel. London: Penguin Classics in association with New Left Review, 1990. P. 126.

4. Smith, A. (1976). *An Inquiry into the Nature and Causes of the Wealth of Nations*, p. 59.

5. Marx, K. (1990). *Capital: A Critique of Political Economy*. Volume I: The Process of Capitalist Production, p. 133.

6. Smith, A. (1976). *An Inquiry into the Nature and Causes of the Wealth of Nations*, p. 69.

7. Smith, A. (1976). *An Inquiry into the Nature and Causes of the Wealth of Nations*, p. 69.

8. Ricardo, David. *On the Principles of Political Economy and Taxation*. P.59.

9. Marx, K. (1990). *Capital*, p. 153.

10. When the body converts food into movement, heat is generated, which is energy, and its unit of measurement is the calorie. Therefore, energy is the ability (force) that enables the body to perform the processes that maintain life. It is not a nutritional element but the result of the metabolism of food components. Scientifically, the calorie is defined as the quantity of heat required to raise the temperature of 1 gram of water by 1 degree Celsius. The large calorie, or kilocalorie, is the quantity of heat required to raise the temperature of 1 kilogram of water by 1 degree Celsius.

11. Calorimeter: A device with various types used to measure the quantity of heat produced by chemical reactions. Readers can find detailed scientific information in textbooks on food science, nature, and chemistry. See for example:

Marion Bennion, *Introductory Foods*, 7th ed. (New York: Macmillan Publishing Co., 1974), pp. 123 ff;.

Allan Camron and Yvonne Collymore, *The Science of Food and Cooking* (London: Edward Arnold, 1979), pp. 6543–7654;

Robert Weber, *Heat and Temperature Measurement* (New York: Prentice-Hall, 1950), Chapter 10: “Calorimetry,” pp. 171–189;

D. Fenna, *Elsevier's Encyclopedic Dictionary of Measures* (Amsterdam: Elsevier Science B.V., 1998), p. 72;

Handbook on Human Nutritional Requirements (Geneva: W.H.O., 1974);

See also the encyclopedic work whose research remains scientifically valuable despite its early date: *Temperature: Its Measurement and Control in Science and Industry*, Papers presented at the Symposium held in New York City, November 1939, under the auspices of the American Institute of Physics (New York: Reinhold Publishing Corporation, 1941), Chapter 6: “*Temperature and its Regulation in Man*,” pp. 525–575.

12. As a temporary measure, we will retain here the error in political economy regarding the measurement of value.

13. The time of production is the total duration required to complete a given product, which implies the possibility that capital remains tied up in the production without actual use, that is, lying dormant without labour. Consequently, the price of the product, according to Marx, will generally rise; for he maintains that the transfer of value to the product is not calculated according to the time during which fixed capital performs its functions, but rather according to the time during which it loses its value.

14. The working day is: the period during which the worker must expend their labour power daily.

15. The period of labour is: the total period of time required to complete a specific product, meaning the possibility of capital remaining tied in the production field without actual use, i.e., it remains dormant without work. Therefore, the price of the product, according to Marx, will generally rise because he believes that the transfer of value to the product is not calculated according to the time during which fixed capital performs its functions but according to the time during which it loses its value!

16. The labour time is: the time during which capital is actually used productively.

17. That is, the total of surplus values in the branch ÷ the total active capitals in the same branch.

18. Karl Marx, *Capital: A Critique of Political Economy*, Vol. 1. Book I, chap. VII.

19. Marx, *Capital*, Vol. 3, Book III, chap. IX.

20. By dividing the value by time in each branch and the ratio of the products of the division in each branch to each other.

21. For my critique of the common concept of capitalism and my explanation of its laws of motion, see: Zaky, Muhammad, *Critique of Political Economy*, (Cairo: Hindawi Foundation, 2021), Chapter I, Chapter VII, and Chapter III, Chapter V.

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