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# The Thermodynamic Nature of Time and Economic Income

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## Abstract

The definition of time formulated by Isaac Newton was created in the 17th century, so naturally it could not refer to thermodynamics, which significantly influences thinking about time. The essential content of the definition is the statement that time is absolute and flows uniformly independent of all events. This paper modifies this definition of time by pointing out that time is a manifestation of a thermodynamic process, it flows uniformly, at a rate determined by a suitable natural constant. The constant has a value of 0.08 [1/year] and indicates the natural, mathematical connection of the passage of time with the cyclic motion of the planet Earth, and therefore with the calendar. The thermodynamic process involves the transformation of the primary energy of modern man's life into his human capital, i.e., his ability to act and perform useful work. The term presented is conciliatory to the natural and economic sciences. The constant of the passage of time also plays an inalienable role in understanding capital and its periodic growth or profit. In considerations, entropy is consistently seen as a transformation of energy, so the constant discovered with the theory of measuring personal human capital turned out to be a measure of the passage of time.

## Keywords

Time, Economic Income, Thermodynamic, Fundamental Principles, Economic Constant, Primary Life Energy, Personal Human Capital

## 1. Introduction

The difficulties of precisely defining time and its passage, capital, profit and its sources are well known. The reason for this is that at the time when these three key scientific categories were passionately discussed, there was no adequate knowledge of thermodynamics. Moreover, as we shall see, time is closely related to man, so physicists had natural difficulties in recognizing this category on the basis of physics paradigms alone, as noted by D. Park, (1972) and R. Feynman (1963).

The authors of this article present the current definition of time and its passage. However, we have previously developed a theory for measuring human capital while stating the existence of a constant quantity, necessary in numerical calculations. This is the quantity $a = 0.08$ [1/year], which has various interpretations, in particular, it determines the rate at which the primary energy of human life decreases, and therefore determines the direction of the course of time. It is, however, a thermodynamic transformation that results in the accumulation of human capital at this rate.

Independently, the thermodynamic track in the study of human capital was indicated by viewing the human body as a heat engine. The second law of thermodynamics (SLT) in Kelvin's formulation, indicating that a heat engine cannot run without a cooler, directly relates to the human body. In the applications of this principle to the determination of fair wages, that is not allowing the depreciation of the human capital of the worker, the original said constant quantity was revealed. In fact, the application of SLT revealed the random variable ($s$) of human capital dissipation and empirical studies show that its mean value $E(s) \approx a = 0.08$ [1/year].

The current achieved state of knowledge regarding the constant "*a*" and random variable "*s*" is synthetically summarized in **Table 1**. The contents of **Table 1** are the subject of explanation of the presented study.

Research indicates that the relationship between the constant and the random variable is as follows:

$$E(s) \le a = 0.08 \text{ [1/year]} \quad (1)$$

The average magnitude of destruction $E(s)$ is minimally smaller than the constant of potential capital growth in farming, which guarantees the possibility of farming and generating profits.

**Table 1.** Natural constant "*a*" and random variable "*s*" shaping the economic environment.

| The natural constant "*a*" | Random variable "*s*" |
|---|---|
| The pace of the passage of time and the metabolism of modern man | PHC dissipation rate according to the second law of thermodynamics |
| Size needed to calculate the value of personal human capital (PHC) | The rate (percentage of PHC value) that determines the fair value of salaries |
| Positive factor affecting capital growth in management | Destructive factor affecting capital growth in the economy |
| Bottom line of growth rates in the plant kingdom | The magnitude underlying the "uncertainty" category |
| Constant quantifying the impact of natural forces on economic development and growth | The basis of the "risk premium" in finance and economics |

Source: own elaboration.

## 2. On the Principles of Thermodynamics as Tools of Cognition

Thermodynamics is fundamental knowledge, which means that without it it's difficult to explain correctly most important scientific questions. This opinion applies equally to economics and other scientific disciplines, which is now widely recognized. Organizations are emerging, such as IAISAE[1], whose statutory objectives are to create a platform for cooperation mainly in the field of thermodynamic knowledge[2]. Three fundamental principles are indeed manifested in the economic sciences: the principle of minimum action and the first and second principles of thermodynamics.

The first principle of thermodynamics expresses the idea that the sum of all types of energy in an isolated system is fixed, that is, energy cannot arise from nothing. This principle lies at the heart of accounting theory and the realization is made by the principle of duality and double entry (Dobija & Renkas, 2020). Thus, in accounting systems, it is possible to periodically measure profit, i.e. capital (energy) growth.

The second law of thermodynamics (SLT) accumulates extraordinary explanatory power. Each equivalent formulation of it reveals further areas of knowledge about reality. For example, Benjamin Thomson's (Sir Kelvin) natural formulation of this principle specifies that a heat engine cannot operate without a radiator, the latter not necessarily being a real object built for the purpose. There have been working cars without a radiator, and its role was fulfilled by the environment. The same is true of the organisms of living beings. Understanding that the human body can be seen as a heat engine and combining it with the necessary loss of energy has become a source of fruitfulness for human capital theory. Another example is related to the entropic formulation. The human body is not a closed and isolated system and therefore entropy does not need to grow. However, the buildup of disorder in the body is a fact, so the question is whether it can be counteracted. The positive answer is balanced nutrition, with food providing order and completeness to the elements. The principles of balanced nutrition are part of the knowledge from ancient, still prehistoric China, regarding the division of energy into elements. Note that preventing the growth of entropy is a common preoccupation of mankind. Entropy is associated with an increase in disorder, but it is actually a phenomenon of spontaneous and random dissipation of the potential of concentrated energy, as consistently pointed out by F. L. Lambert (1999, 2002).

The second law of thermodynamics (SLT) has at least three equivalent formulations[3]:

[1]International Association for the Integration of Science and Engineering (https://youtu.be/2rxA_pLNSGk).

[2]Thermodynamics 2.0 is a platform where the natural sciences meet the social sciences. This biennial International Conference aims to identify and connect dots of scientific revolutions in natural and social sciences.

[3]Adamczyk Antoni (2008). Lectures and Animations in General Physics. Thermodynamics, http://www.if.pw.edu.pl/~anadam/WykLadyFO/FoWWW_27.html

1) (Kelvin) No such process is possible, the only result of which would be to do work equivalent to the heat received from the source;

2) (Clausius) No such process is possible, the only result of which would be the transfer of heat from a cold body to a hot one;

3) (Entropic) The entropy of an isolated system is not decreasing.

The three versions of SLT are equivalent. SLT version one, as mentioned, helped develop the theory of human capital measurement and the theory of fair compensation (Dobija & Renkas, 2021a, b). Understanding time and determining the pace of its passage is related to the third version of the SLT, but somewhat clarified. As (Bejan & Tsatsaronis, 2021) write, thermodynamics originated as the science of firepower. It developed in the 19th century about a century after the introduction of the first steam propulsion systems and is a pillar of physics, life sciences, life sciences and engineering sciences. J. Barbour (2018) describes the emergence of structure in the universe pointing to the inalienable role of thermodynamics. Additionally, SLT is fully applicable and inalienable in explaining biological processes on Earth.

Living entities are particularly subject to the second law of thermodynamics. Using the example of man, it is known that an organism acting like a heat engine must, in order to exist, lose some of the energy dissipated through heat. This is adjudicated by the second principle of thermodynamics in Sir Kelvin's formulation. In addition, disorder, dysfunctionality of various organs and chronic diseases are increasing in the human body, and in general the ability to generate the necessary energy is decreasing. This state of affairs also follows from the SLT, but in Boltzmann's formulation, i.e., increasing entropy as a measure of disorder. This undoubtedly impinges on human behavior and character.

One can get closer to answering the questions posed by focusing on the etymology of the word entropy, the essence of which is transformation. The rapid development of human beings in the first years of life indicates the existence of potential energy that transforms into energy of a different kind, namely personal human capital. We see this transformation all around; not only human offspring but also in the animal and plant world. Human capital, in turn, is naturally subject to the SLT and its potential also undergoes spontaneous, random dissipation.

Thus, reasoning leads to the conclusion of the existence of a resource (potential) of primary life energy. This potential of human life energy is transformed into personal human capital, which we know is increasing according to the constant $a = 0.08$ [1/year]. Therefore, it can be presumed that the potential of primary human life energy also decreases according to this constant. This thermodynamic process is common in the system of earthly life, but 8% as a dimension of the constant applies only to humans.

Another conclusion suggests that this transformation determines the nature of time and indicates that it is the constant $a = 0.08$ [1/year] that determines the pace of the course of time in human civilization. This is the discovery of an extremely important role for the constant, hitherto known as the constant of potential capital growth in economics (Dobija & Renkas, 2021c).

## 3. Update the Definition of Time and the Constant That Determines the Rate of Its Passage

Many scholars were deeply convinced of the existence of the phenomenon of the passage of time. According to (Holt, 2018: p. 19) A. Eddington declared that our intuitive sense of time's passage is so powerful that it must correspond to something in the objective world. If science cannot get purchase on it, one might say, well, so much the worse for science. In turn, J.T. Fraser (1979), founder of the International Society for Study of Time, expressed the belief that the sensation of the passage of time is perhaps more poignant, profound, and direct than any aspect of our existence. Moreover, time is profoundly related to the functions of the mind, and is the only dimension of our inner life. This is an extension of the opinion of Immanuel Kant, who recognized time and its passage as an inalienable tool of the human mind. Accepting these premises, it is justified that the human perception of time has its real basis, and for a human being time flows evenly, regardless of other events, so Newton's concept is essentially correct, only the feature of absoluteness can be disputed.

Acclaimed physicist and original thinker R. Feynman (2021: p. 61) begins his lecture on time with a speech:

> What is time? It would be nice if we could find a good definition of time. (…) Perhaps we should say: "Time is what happens when nothing else happens." Which also doesn't get us very far. Maybe it is just as well if we face the fact that time is one of the things we probably cannot define (in the dictionary sense), and just say that it is what we already know it to be: it is how long we wait!

This actually modern eminent scientist, not agreeing with the definition given by Isaac Newton, does not believe that defining time is possible. He must have experienced the frustration of being forced to wait idly, which caused him to feel that his time was being wasted. Like everyone else, he was not interested in the fact that something was always happening; namely, changes were constantly taking place in his body and in everything around him. We are talking about ubiquitous thermodynamic transformations in living and inanimate objects.

The original definition of time formulated by Isaac Newton included in his work "Principia" is as follows[4]:

> Absolute, true, and mathematical time, in and of itself and of its own nature, without reference to anything external, flows uniformly and by another name is called duration. Relative, apparent, and common time is any sensible and external measure (precise or imprecise) of duration by means of motion; such a measure—for example, an hour, a day, a month, a year—is common-

[4]Isaac Newton, The Principia. Mathematical Principles of Natural Philosophy, The Authoritative Translation by I. Bernard Cohen and Anne Whitman assisted by Julia Budenz, University of CaliforniaP ress, 1999, p. 54.

ly used instead of true time.

Wolfgang G. Leibniz (1646-1716) disagreed with the view of time as absolute, independent of anything. Leibniz was convinced that space and time were not real, but were relations between material objects and mathematical concepts. He considered time in the context of his philosophy and monadology.

Like Leibniz, Immanuel Kant (1724-1804) guided by well-known aphorisms such as: "without sensuality no object would be given to us, without intellect none would be conceived, concepts without sensory perceptions are empty, and perceptions without concepts are blind", he formulates an opinion about time and space. Time is a form of our sensuality, it is a form of the inner sense. He also recognized that time is empirically real (Kant, 2021). This opinion is largely confirmed by our definition of time. At that time thermodynamics had not yet developed, and yet Kant's understanding of the nature of time is extremely accurate, and additionally points to the inseparable connection between time and humanity.

The modified formulation of time takes into account constant thermodynamic transformation taking place in the human organism, that is, the ongoing transformation of primal energy of life into personal human capital. The application of the SLT version of transformation requires the identification of objects; in this case, these objects are: primary life energy (PLE) and personal human capital (PHC).

In the proposed formulation, an explanation of time emerges that inalienably relates to thermodynamics, while also following the direction given by Newton. In this approach to the category of time, objects subject to the process of thermodynamic transformation are identified along with their quantitative characteristics. As a result, the category of time and the process that causes the passage of time are included in the following definition (Dobija & Renkas, 2021a, 2022).

> Time is the process of transformation of the stock of primary life energy of modern man into the ability to perform work, i.e. personal human capital. The rate of passage of time is constant and independent of anything. This rate is determined by the natural constant $a = 0.08$ [1/year].

In this term, concrete real elements appear, such as: the primary life energy (PLE) of modern man, personal human capital, the process of energy transformation and the uniformity of this process, the rate of which is determined by a natural constant. This term being in accordance with the idea of the even flow of time, it reveals the real objects mentioned by A. Eddington; the raw energy of life transforms into the energy of action. Thus, time passes evenly reflecting the decrease of the original stock of life forces and the increase of human capital. The course of these processes is controlled by a constant whose apriority value is 0.08 [1/year], and its unit of measurement refers to the astronomical calendar.

There is a thermodynamic transformation in each human unit; the disappearance of the PLE potential and the increase of the PHC potential, which can be put schematically:

$$T\text{: PLE} \times e^{-at} \rightarrow \text{PHC} \times e^{+at} \quad (2)$$

where: $t$—denotes the number of duration periods, constant $a = 0.08$ [1/year]. The PLE fading function is presented as follows $Z(a, t) = \exp[-at]$.

The definition of time presented is a significant generalization of the definition given by Isaac Newton. One can clearly see a barrier that could not be overcome in the 17th century. This was the lack of knowledge called thermodynamics, which also enabled the development of human capital theory. In addition, there was a lack of current results from gerontologists confirming that the end of a person's life is 120 years, which makes it possible to numerically estimate the rate at which time passes. Newton tied time to the calendar, in the updated definition this knowledge is complemented by a constant that has the astronomical year as the unit of measurement.

The given definition also meets all the characteristics of time described by I. Kant. It is the time of man, the representative of earthly civilization, for whom time and its passage is an immanent intellectual tool for learning about the reality in which he lives and acts. It also confirms the validity of beliefs about the uniform passage of time expressed by many prominent thinkers, with A. Eddington and J.T. Fraser in the lead. It also explains why physicists such as D. Park and R. Feynman doubted the possibility of defining time on the grounds of narrow physics paradigms. Time is integrally related to humans, so the life sciences, including the economic sciences, should make a significant contribution to the recognition of this abstract category.

## 4. Curves of Time Lapse and Human Capital Growth

The primordial resource of vital energy has been known since ancient times. In China it was and is known as qi energy. Huai-Chin-Nan (1984) writing about the essence of qi describes it as: "the primary energy of the body is like a hidden treasure that comes with life". This knowledge is clarified by P. Pitchford (2008), who points to three sources of qi energy. The first source called Yuan Qi is the primordial energy found in the determination of time. According to ancient knowledge, it is inherited from parents and passed on to offspring. The energy resource is limited and is used up over time. An unfavorable lifestyle leads to additional loss of this energy. The energy of life is known as: Qi—China, Prana—India, Mana—Polynesia, Ki—Japan, Fire of the spirit—Tibet.

Gerontologists (Vijg & Le Eric, 2017) clearly indicate that the end of human life is 120 years, so at that time PLE reaches biological zero. If one assumes that the initial energy of life is maximum and equal to 1.0, then based on this information and the knowledge that each potential undergoes spontaneous dissipation, one can write the equation:

$$1.0 \times e^{-120a} = 0.00005 \quad (3)$$

where $a$—denotes the annual rate of PLE loss. After 120 years of life the level of life energy is close to zero, so the value of 0.00005 is assumed, that is, 0.0000 supplemented by the number 5 at the 5th decimal place. This means that a person dies having still some quanta of life energy, but the level of this energy has reached biological zero, which is 0.00% of the initial energy. The solution to this equation is $a = 0.082529 \approx 0.083$ [1/year], or 8%. Note that the economic constant of potential growth, known from the PHC measurement theory, is also estimated at 8% per year, as found by many studies (Dobija & Renkas, 2021b). It is also known that $e^{0.08} - 1 \approx 0.083$. Thus, the constant as an a priori quantity is equal to 8%. This is another estimation of the constant, known early on from human capital measurement theory known and tested for at least two decades (Dobija & Renkas, 2021b).

In order to graphically illustrate the dynamics of modern man, **Figure 1** was drawn, where three curves characterize the changes of human energy over the time of its existence: the line of the disappearance of the initial stock of PLE (E), the line representing the changes of the organism's power (P) and the line of the increase of personal human capital (H). Line P is a graph of disposable power defined by M. Mazur (1976) as physiological power minus idle power. Line H illustrates the economic value of personal human capital and its relationship to the constant will be explained later. Line E is the natural graph of the Zt function. The P and H curves are adjusted to the scale of the figure and are shown as a percentage of the maximum magnitude.

The figure shows that initially the P line runs similarly to line 1 - E. Then the increasing idle power decreases the rate of increase of reachable power. The same reason causes the P-line to reach its flat maximum, to start a slow decline at more than 30 years. M. Mazur used physiological data to determine the maximum power of the average body, in period 27 - 35 years.

The H line represents the growth of personal human capital, that visible effect of the transformation of life energy into the ability to do work in the material

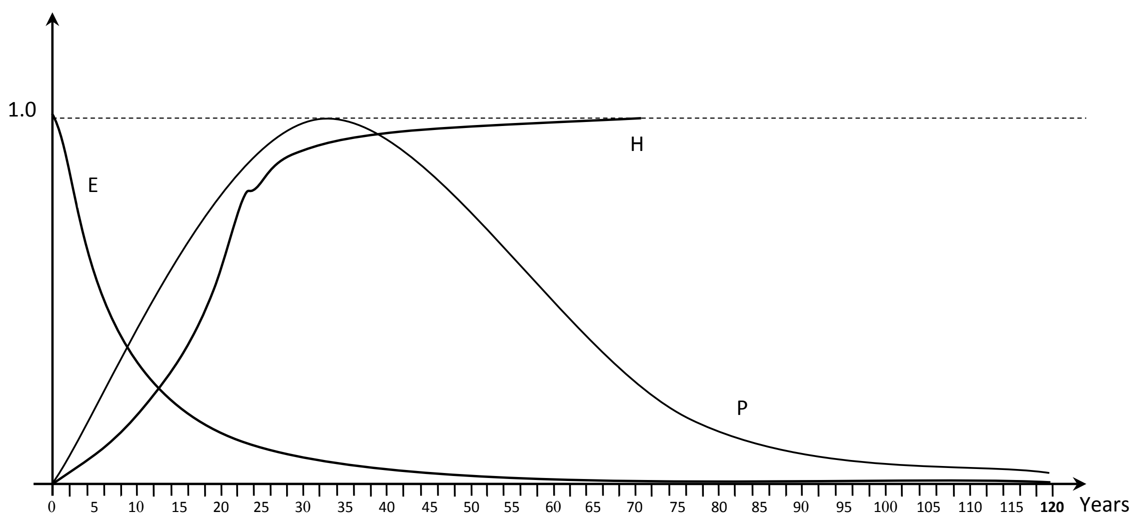


**Figure 1.** The disappearance of primary vital energy and the course of dispositional power in the human body. Source: (Dobija & Renkas, 2021b).

world. In a physically and mentally healthy person, personal human capital increases, despite the passage of time. People work, start families, settle homes, raise descendants and create various works. All this determines the development of the ability to perform work, the ability to do it, that is, transfers to the created objects. In the economic account of human capital, the constant $a = 0.08$ [1/year] plays the role of the rate of capitalization of the expenditures incurred in maintaining a descendant to adulthood and taking up work. This issue is subject to ongoing empirical research presented in the next section. Thus, the rate of decline in PLE affects the rate of increase in human capital growth expenditures.

From the course of the E-line it can be seen that at least from the age of 40, in order to prolong one's life, one should take conscious steps to obtain additional life energy from available sources. A human with knowledge and will to last can use two more sources of life energy other than PLE. Source two Gu Qi is energy extracted from consumed food, and source three Zong Qi is energy from the air, extracted through the lungs and skin. Maoshing Ni (2012) discusses the successive 8-year stages of human development in terms of kidney energy (synonymous with PLE) and states that by the sixty-fourth year of life, kidney exhaustion, fatigue, and weakness occur. This low state of PLE can be clearly seen in **Figure 1**. As we know, this is the period of reaching retirement age.

There are considerable possibilities for extending productive life. This issue was raised in the famous essay by E. Schrödinger (1944) asking a perverse question why man lives so long? He states that an organism can keep itself alive only by taking negative entropy from its environment, which is something positive for it. Thus, he pointed to the use of "order" existing in nature or consciously created by man in drugs, vitamins and various supplements. These products significantly benefit the elderly, whose organisms have to some extent lost the ability to absorb these compounds from food.

It should be noted, however, that this sipping of order, as described by E. Schrödinger, was reasonably practiced already in ancient times and to a greater extent than in the West today. Flavors were seen as types of energy and the main idea of correct nutrition was the balance, order and completeness of the elements in daily meals (Maoshing, 2012). There are many examples indicating that reaching an age close to 120 is not something absolutely extraordinary. For example, R. Taylor (1970) describes the long and happy lives of members of the Hunza tribe, where living to nearly 120 was common until recently. There is no shortage of examples of longevity.

## 5. Interpretation of the Time Lapse Constant in Terms of Human Capital Measurement Theory

According to the determination of time, the disappearance of PLE is accompanied by an increase in personal human capital. As is already known, the finding of a constant took place within the framework of the emergence of the theory of human capital measurement in the 1990s (Dobija, 1998, 2007). The idea of measuring PHC was to calculate the value of the stream of annual cost of living ($k$) from birth to employment after reaching at least 17 or 18 years of age. To calculate this value, a capitalization rate ($r$) equal to the real rate of return on the NYSE was used, which according to Ibbotson's research was estimated at 0.08 [1/year].

The second idea considered the thermodynamic nature of the calculated quantity referred to as PHC. This quantity undergoes spontaneous and random dissipation, so the minimum wage should be no less than $s \times$ PHC, where ($s$) denotes the random dissipation of PHC.

The minimum wage formula has been emerged:

$$W = s \times \text{PHC} = s \times k \times [(1 + r)^n - 1]/r \tag{4}$$

where: $W$—annual fair minimum wage, $k$—annual cost of living, $r$—capitalization rate of annual cost of living.

Taking into account the availability of data from the US and the fact that the minimum wage could be considered fair in that country, calculations were carried out, obtaining an estimate: $r = a = 0.08$ [1/year]. Then it turned out that at a minimum $s < r$. Thus, the constant $a = r$ was originally revealed in research on the value of human capital. Now we see the symmetry; the disappearance of PLE results in an increase in PHC according to the T-transformation. The formula for the disappearance of PLE: $Z(a, t) = \exp[-at]$, explains why human beings grow very fast in the first years of life and the changes are clearly visible. PHC growth factors are also explained, it is a composite of cost of living and PLE, the proportion of which changes over time. Since the inflow of PLE is greatest in the first years of life, the growth of the child and all his abilities is so pronounced.

The natural development of theories for measuring personal human capital has led to the development of models suitable for employees with varying degrees of professional education and experience (Dobija, 2011; Renkas, 2022) and others.

In order to provide independent evidence that the estimated wages are fair and to give scientific weight to this category, **Table 2** is presented, which contains an account made on average cost of living and minimum wages in the United States. For the calculations, it is assumed that two parents receive earnings at the theoretical minimum wage. Also those working contribute 6.2% of Social Security Tax and 1.45% of Medicare Tax, which is the basis for the respective funds. The remaining income is compared with the cost of living. The average cost of living in the United States is estimated to be $585.00[5].

According to formula (3), the theoretical minimum wage $W(a)$ for a teenager ($t$ = 17 years old) is calculated: $W(a, t) = W(0.08, 17) = 0.08 \times (12 \times 585) \times [e^{0.08\times17} - 1]/0.08$ = $1694.00/month. On the other hand, the statutory monthly minimum wage is: $9.00 (average minimum wage per hour from all states) × 176 hours (number of hours worked per month) × 1.0765 (6.2% Social Security Tax and 1.45% Medicare Tax paid by the employer) = 1705 USD/month.

[5]Cost of living in USA. https://www.expatistan.com/cost-of-living (access date: 24.02.2022 r.).

**Table 2.** Proof that the theoretically calculated wage $W(a)$ is fair

| 1 | Country | USA (USD) |
|---|---|---|
| 2 | Theoretical monthly minimum wage $W(a) = a \times H(a, t)$ | 1694.0 |
| 3 | Statutory monthly minimum wage | 1705.0 |
| 4 | Percentage of compliance (3): (2) | 100.7% |
| 5 | Total earning (2 persons × $1694) | 3388.0 |
| 6 | Pension fund contribution including Social Security Tax paid by the employee (20%) | 677.6 |
| 7 | Health care contribution including Medicare Tax paid by the employee (10%) | 338.8 |
| 8 | Amount remaining for cost of living disbursement | 2371.6 |
| 9 | Amount per person (2 adults + 2 children) | 592.9 |
| 10 | Average cost of living | 585.0 |
| 11 | Pension funds per one $333.8 \times 12 \times [(1 + 0.03)^{48} - 1)/0.03] =$ | 418218.0 |
| 12 | Monthly pension after 65 year of work | 1742.0 |

Source: own elaboration.

The key role of the constant $a = 0.08$ [1/year] in determining wages that preserve workers' personal capital (are fair) is shown by the calculations in **Table 3**. Assumptions are made that: 1) the contribution to the pension fund is 20% of the salary, 2) the contribution to health care coverage is 10% of the salary, 3) the retirement age is 65, 4) the family consists of 2 adults and 2 descendants, 5) the average number of life years is 85, 6) the percentage of capitalization of the pension contribution is 3%. Under these natural assumptions and a given constant value, the theoretical wage $W(a, t)$ ensures that the worker's personal capital does not depreciate, that is, it is a fair wage.

As the calculations in **Table 2** show, the amount to cover of living costs per person remaining in the family ($592.9) exceeds the value of the average cost of living of $585. This means that the standard of living is preserved and the earnings of two working parents in the U.S. make it possible to bring two descendants up to the level of human capital they have achieved, i.e., this wage guarantees the preservation of human capital. In addition, after 48 years of work, the pension fund calculated at a capitalization rate of 3% is $418,218. Hence, the monthly pension amount can reach 1742. Personal capital of worker is preserved over a lifetime of 85 years, so the wage under study can be considered fair. The condition for this is the value of the constant 0.08 [1/year].

Note that the remuneration adopted in the calculation represents the minimum. However, in reality, earnings increase over time due to the increase in capital from experience, so the amount left in the family per person will also be higher. It should also be added that empirical studies show that the earnings of employees are at the level of 10% of the value of personal capital (Koziol, 2011). This allows for a slow, steady progress in the welfare of the employed.

**Table 3.** Descriptive statistics for constant and the average percentage of agreement between expected and set wages based on human capital theory

| Statistical quantities | Obtained values |
|---|---|
| Sample size (number of surveys) | 3920 |
| Average value of the percentage of congruence between expected and theoretical wages | 100.3% |
| The average value of dispersion $E(s)$ | 0.0799 |
| Standard deviation | 0.0052 |
| $Q_1$ | 0.0780 |
| Median | 0.0797 |
| $Q_3$ | 0.0814 |
| Kurtosis | 208.49 |

Source: own elaboration.

The considerations show the contribution of the constant to the solved cognitive problems of human capital measurement and the appropriate labor compensation that preserves this capital. The constant [0.08 1/year] is clearly a steady invariable theoretical and computational factor that leads to original economic knowledge. The formulas and calculations confirm the known fact that minimum wages are at a fair level in the countries studied, especially the US. This has been confirmed by calculations with repeated use of a constant, unambiguously indicating that the minimum wage at the level of 8% of the value of the personal capital of the employed person makes it possible for a family to bring up 2 descendants, to work out pension funds for the next 25 years of life. Unfortunately, this positive theoretical picture is disturbed by various factors occurring in social and economic reality. People have their own characters and are not always industrious, thrifty and reasonable, there are serious illnesses. There are economic crises caused by not respecting the correct theories, as well as all kinds of negative political influences, which threaten pension funds.

## 6. The Manifestation of a Constant in Wage Expectations

The general model for measuring the personal capital of the employed includes several more variables. These are: the cost of professional education; the number of years of professional work; the learning parameter, which allows using a modified learning curve to measure capital gains through experience. Empirical studies conducted over the last two decades (Dobija, 2004, 2015; Jedrzejczyk, Koziol, & Renkas, 2021; Koziol, 2011; Koziol & Mikos, 2020; Koziol & Renkas, 2021; Kurek & Gorowski, 2020a, 2020b, 2020c; Kurek, 2021; Renkas, 2018, 2021) using the general model confirm all the conclusions obtained in the previous section on teenage minimum wages. One application of the general model is to study wage expectations and verify the hypothesis of whether there reveals a constant. An example research was done on data from Ukraine, which does not belong to a country with a decent minimum wage.

In poorer countries, such as Ukraine, minimum wages are usually far from decent. However, it is possible to study wage expectations in relation to their possible dependence on the constant. This type of research was conducted using data provided by questionnaires from Labour Offices in five different regions of Ukraine. 3920 job seekers were surveyed asking for the data necessary to calculate the value of their human capital (age, education, work experience, etc.) and their expected wage if hired. The choice of the survey location is dictated by the fact that the job seeker does not manifest excessive expectations, but counts the cost of living for the whole family. By comparing the theoretical wages with the expected wages indicated by the respondents, the percentage of compliance of these wages and the value of the constant were estimated. Basic statistics of the set of determined values for the constant and the obtained average value of the compliance percentage for 3920 respondents are presented in **Table 3**.

The statistics presented in **Table 3** indicate a very high level of agreement between the wages expected and those determined on the basis of the theoretical model, which includes in the calculations the constant $a = 0.08$ [1/year]. Thus, it is shown that job seekers' wage expectations are a function of the economic constant, confirming its value and at the same time indicating its economic significance. This demonstrates the profound impact of this constant on the economic reality of human capital growth and equivalent wages. Among 3920 respondents, the mean value of "*a*" in light of salary expectations, with a very small standard deviation (0.005237), is close to the magnitude of 0.08 which confirms the hypothetical value. Additionally, the probability distribution is leptokurtic, indicating a high clustering of the magnitude "*a*" around the value of 8%. Thus, the study of expected wages as a percentage of the human capital value of job seekers, confirmed the presence of a constant size "*a*" at a level significantly close to 0.08 [1/year].

Another study example concerns the wage expectations of economics graduates in Poland. B. Kurek and I. Gorowski (2020a, 2020b, 2020c; Kurek, 2021) presented a cross-sectional study of wage expectations in terms of a constant a = 0.08 [1/year] and the impact of various variables on its magnitude. The empirical study confirmed the hypothesis that a constant "*a*" is manifested in wage expectations of graduates.

## 7. Sources of Profit as a Play between Constant, Dissipation and Labor. The Relationship $E(s) < a$

Albert Einstein reportedly said that the compound interest formula is the greatest mathematical achievement of mankind[6]. Whether a joke or not, the formula $C_t = C_0 e^{rt}$ is the nucleus of the general model of capital. Ch. Bliss (1975) has expressed that we do not know what capital is and are unlikely to find out. We

[6]Albert Einstein is credited with discovering the compound interest rule of 72. Referring to compound interest, Albert Einstein is quoted as saying: "It is the greatest mathematical discovery of all time". https://howmoneyworks.com/danblanchard/blog/the-rule-of-72-explained

certainly will not find out without knowledge of thermodynamics. Thermodynamics is already manifested in the simple model of compound interest through the variable of initial capital $C_0$, its necessity for existence, since nothing will arise from nothing. Einstein introduced the rule 72 indicating after how many years the initial capital will double, at a given interest rate $r$, which shows that he was toying with it. It is a fact that the compound interest formula is important, after all, it is the main mathematical tool in this study.

To create a general model of capital it is necessary to recognize the structure of the rate determining the changes in initial capital $C_0$, that is, the structure of the variable $r$. The discovery of the constant in economic research made it possible to determine the structure of the rate $r$ as a function of the constant $a$, as presented in the work (Dobija & Kurek, 2013). Theoretical analysis led to the model $r = a - s + m$, where: $s$—the rate of disappearance of capital, $m$—capital inflow by labor. Thus, the general model of capital after the period $\Delta t = 1$ is presented:

$$C_t = C_0 \times e^{-st} \times e^{mt} \times e^{at} = C_0 \times e^{(a-s+m)t,a} \geq E(s) = 0.08\ [1/\text{year}] \quad (4)$$

An example interpretation of model (4) with respect to human capital is as follows. An infant is born (variable $C_0$). This infant subject only to the influences of the forces of nature (the second principle) could die (variable $e^{-st}$). The work of parents and society offsets the negative influences of the forces of nature (variable $e^{mt}$), so the infant develops and grows due to changes of PLE, which is quantified by the constant (variable $e^{at}$). It should be emphasized that the inflow of capital through the work of parents can only level the destructive influences, it is not possible to create a stock of life energy, or to accelerate its transformation into human capital, that is, to accelerate the course of time. The child will develop at a natural rate regardless of the surplus efforts of the parents. Labor does not increase capital; labor is merely a transfer of capital, but competent labor counteracts entropy.

The economic processes in which capital gains, or income, are sought are interpreted similarly. By definition, income = $\Delta C = C_1 - C_0 = C_0 \times e^{(a-s+m)t} - C_0 \approx C_0(a - s + m)\Delta t$, where $\Delta t = 1$. A company must have initial capital $C_0$ (the first principle), which is affected by forces that dissipate equity capital ($-s$), the work of the staff tries to offset the impacts of the second principle ($m$), if successful, return on assets ROA ≈ $a$. In some cases, it is possible that ROA > $a$, which happens at the expense of other firms or this is the result of the emergence of creative intellectual capital.

Concluding this topic, let us note that the economy is powered by Nature. We are not talking about raw material resources, which in economics are not valued in monetary terms, they are measured in natural units. The size of GDP is mainly created by labor and management, this can be seen as the sum of: wages and salaries, annual depreciation amounts of fixed assets, and profits and some taxes. The value of fixed assets is determined by the work done in previous periods, i.e., the labor that has coagulated. The source of labor is human capital, which, as the definition of time reveals arises after the PLE conversion. Thus, there are two sources of power to the economy: 1) the Sun, which provides biomass growth at a rate typically exceeding 0.08 [1/year], 2) the Universe as the provider of PLE. Economic processes generating GDP take place with the help of a constant a, which also determines the rate of passage of time. One can say that this constant imbues the saying "time is money" with content.

Is the mean value of the random variable s representing the forces that dissipate energy and increase entropy smaller or equal to the constant *a*? Common sense indicates that the relation $E(s) < a$ is true, with the difference being very small. After all, economic units generate periodic profits, while paying decent wages to employees, so they overcome the destruction from SLT. On the other hand, there are accepted opinions that the actions determined by the SLT are overwhelming and lead to the "heat death of the Universe", which was recently challenged by J. Barbour (2021). There is also a well-known opinion (Atkins, 2007), which states that "where something is built up, something elsewhere falls into ruin, but at an even faster rate". These are opinions concerning the Universe or large-scale structures of, for example, the entire Solar System. However, they are not subjects of economic considerations. The question posed is about the Earth's living system and the question of whether the beneficial impact of nature, as defined by a constant, outweighs the somewhat destructive impact of the SLT. Research in human capital seems to confirm expectations.

**Table 4** presents the results of estimating the random variable "*s*" from the actual minimum wage in the indicated European countries and selected U.S. states (workers were assumed to be 17 years old to standardize the results). For example, in the UK the statutory minimum wage is set at 8.91 GBP/hour. Adding the 13.8% Employer Social Security Tax to this amount results in the total cost of employing a worker. On a monthly basis this is: 176 hours × 10.14 GBP/ hour = 1784.64 GBP. The monthly cost of living in the UK is estimated to be 568 GBP. Therefore: $s = 21415.78/246{,}756 = 0.0867$. In other selected European countries or the US states the estimation leads to similar results.

The important relation suggested by **Table 4** is the weak inequality $E(s) \leq a$. What does this mean? By the definition of time the constant can be looked at as the rate at which human labor resources are supplied from external sources; from Nature. In turn, labor transfers human capital to labor objects, which then become products and assets, subject to entropy growth. Thus, if the random variable s that determines the rate of dissipation of human capital satisfies the indicated relationship $E(s) \leq a$, it can be expected that destruction does not necessarily prevail over construction. It should be emphasized that this opinion can be made under the natural assumption of openness of the system called human individual.

A similar inequality is observed in the case of wage expectations (**Table 3**), where the value of "*s*" = 0.0799. Although there may naturally be an increase in the expectations of those surveyed relative to the human capital represented, the value of "*s*" is below 0.08, confirming the conclusions formulated above.

Table 4. Calculation of "s" values for selected European countries and U.S. states.

| Country or State of U.S. | Monthly cost of living per person ($k$/12) | The value of human capital $K(a, t)$ | Statutory annual minimum wage ($W_r$)*[7] | $s = W_r/K(a, t)$ |
|---|---|---|---|---|
| Belgium, [EUR] | 898 | 390,117 | 24,879 | 0.0638 |
| France, [EUR] | 932 | 404,888 | 27,900 | 0.0689 |
| Germany, [EUR] | 954 | 414,445 | 32,567 | 0.0786 |
| Great Britain, [GBP] | 568 | 246,756 | 21,416 | 0.0868 |
| Switzerland, [CHF] | 1.617 | 702,472 | 47,182 | 0.0672 |
| Sweden, [SEK] | 9.696 | 4,212,224 | 283,874 | 0.0674 |
| Alaska (USA), [USD] | 696 | 302,363 | 22,493 | 0.0744 |
| California (USA), [USD] | 790 | 343,199 | 29,547 | 0.0861 |
| Colorado (USA), [USD] | 725 | 314,961 | 27,287 | 0.0866 |
| Florida (USA), [USD] | 638 | 277,166 | 19,452 | 0.0702 |
| Hawaii (USA), [USD] | 770 | 334,510 | 22,957 | 0.0686 |
| Idaho (USA), [USD] | 531 | 230,682 | 16,474 | 0.0714 |
| Indiana (USA), [USD] | 572 | 248,493 | 16,474 | 0.0663 |
| Kentucky (USA), [USD] | 527 | 228,944 | 16,474 | 0.0720 |
| Louisiana (USA), [USD] | 585 | 254,141 | 16,474 | 0.0648 |
| Maryland (USA), [USD] | 630 | 273,690 | 25,006 | 0.0914 |
| Massachusetts (USA), [USD] | 807 | 350,584 | 28,998 | 0.0827 |
| Michigan (USA), [USD] | 560 | 243,280 | 21,944 | 0.0902 |
| Minnesota (USA), [USD] | 638 | 277,166 | 22,746 | 0.0821 |
| Nebraska (USA), [USD] | 577 | 250,666 | 20,465 | 0.0816 |
| New Jersey (USA), [USD] | 885 | 384,470 | 25,006 | 0.0650 |
| New Mexico (USA), [USD] | 498 | 216,346 | 20,465 | 0.0946 |
| North Carolina (USA), [USD] | 572 | 248,493 | 16,474 | 0.0663 |
| Ohio (USA), [USD] | 523 | 227,206 | 19,789 | 0.0871 |
| Oklahoma (USA), [USD] | 506 | 219,821 | 16,474 | 0.0749 |
| Oregon (USA), [USD] | 725 | 314,961 | 25,576 | 0.0812 |
| Rhode Island (USA), [USD] | 613 | 266,305 | 23,866 | 0.0896 |
| Tennessee (USA), [USD] | 490 | 212,870 | 16,474 | 0.0774 |
| Texas (USA), [USD] | 543 | 235,895 | 16,474 | 0.0698 |
| Vermont (USA), [USD] | 626 | 271,953 | 24,922 | 0.0916 |
| Washington (USA), [USD] | 770 | 334,510 | 30,687 | 0.0917 |
| Wisconsin (USA), [USD] | 556 | 241,543 | 16,474 | 0.0682 |
| | | | **Mean value $E(s)$** | **0.0775** |
| | | | **Minimum value** | **0.0638** |
| | | | **Maximum value** | **0.0946** |
| | | | **Median value** | **0.0762** |
| | | | **Standard deviation** | **0.0099** |

*The statutory hourly wage was increased by a percentage of Employer Social Security Tax (UK—13.8%, France—45%, Germany—19.98%, Belgium—25%, Switzerland—6.4%, Sweden—31.42%). Cost of living data was taken from (Cost of living, 2022). Source: own elaboration.

[7] *Eurostat, Monthly minimum wages*, https://ec.europa.eu/eurostat/databrowser/view/earn_mw_cur/default/table?lang=en (access date: 21.02.2022 r.)

Another general observation resulting from the calculations in **Table 4** is the conclusion that the constant determines the growth rate of human capital which leads to the formulation of the theory of remuneration as a function of this capital. Moreover, the results of calculations confirm that the minimum wage in highly developed countries of Europe and states of the USA is determined by the constant $a = 0.08$ [1/year]. This fact is associated with correspondingly high labor productivity, as highlighted in (Dobija, 2011).

In contrast, the pure influence of nature quantified by a constant is presented in the following empirical study. It can be shown further that the constant also reveals itself in the study of business profit rates and stock returns. This is because profits are created by human labor, that is, transfers of human capital to products.

Research in this field has long been conducted on the assessment of the "risk premium". This quantity defined as the difference between the real rate of return and the return on Treasury Bills in the US is a component of the CAMP model (Goetzmann & Ibbotson, 2006), which has strongly lost its values in the current time. Our approach to the study of the "risk premium" is marked by an awareness of the economic constant with which this "risk premium" is associated. We recognize that in an efficient market, periodic profits are partly the result of natural forces. After all, employees receive fair wages, depreciation of fixed assets increases costs, so it is also the forces of nature that are the source of the periodic increase in invested capital. Therefore, the magnitude of the constant, under the hypothesis $a = 0.08$ [1/year], is estimated as the real rate of return earned in an efficient market (**Table 5**).

To calculate the rate of return based on the data in **Table 5**, the percentage of inflation was subtracted from the stock return, resulting in the value: 12.39% − 3.12% = 9.27%, calculated according to the arithmetic mean. However, according to the geometric mean, it is 10.43% − 3.04% = 7.39%. Within this range (7.39% - 9.27%) is the average multi-year return achieved in the U.S. equity market. To arrive at a point estimate, the arithmetic average of these two numbers was calculated and a value of 8.285% was obtained. In the case of stock market information and corporate earnings reporting, the data determines the value at the end of the calculation year. Thus, if capital multiplies at a rate of 8% (*ex ante*), then at the end of the year (*ex post*) it reaches a multiplication of $e^{0.08} - 1$, or about 8.33%. Thus, the estimation determines that apriori: $a = 0.08$ [1/year].

**Table 5.** Summary statistics for returns on U.S. stocks, bonds, and Treasury Bills (1926-2004).

| Specification | Stocks | Long-term government bonds | Treasury Bills | Inflation | Real rate of return |
|---|---|---|---|---|---|
| Arithmetic mean | 12.39% | 5.82% | 3.76% | 3.12% | 9.27% |
| Geometric mean | 10.43% | 5.44% | 3.72% | 3.04% | 7.39% |
| Standard deviation | 20.31% | 9.30% | 3.14% | 4.32% | 8.33% |

Source: own elaboration based on (Goetzmann & Ibbotson, 2006).

Rates of return on invested capital in economic entities were examined, among others, by B. Kurek (2012). The research was conducted on a sample of financial statements of companies belonging to the Standard & Poor's 1500 index over a period of 20 years. The components of the index were taken into account, i.e. companies grouped in the Standard & Poor's 1000, Standard & Poor's 900, Standard & Poor's 600, Standard & Poor's 500, Standard & Poor's 400 indices. The total number of observations in the sample reached 22,952 financial reports. The results of B. Kurek's statistical tests confirmed the hypothesis of a mean ex post risk premium of 8.33%, which corresponds to an 8% ex ante risk premium. The test was performed at a confidence level of 0.999, yielding a confidence interval of 8.25% - 8.89%, with a mean of 8.57%. Statistical inference was considered completely safe due to the low relative random error (3.75%). The research of B. Kurek concerned the rate of capital multiplication in real economic entities.

The constant under consideration is also found in the interest rates set by the loan agreements of the old days. This was especially true for farms. Indeed, A. Pikulska-Robaszkiewicz (1999) indicates that in Republican Rome, the law specified an interest rate on loans not exceeding 8%.

## 8. Ending Words

The role of the knowledge of thermodynamics is, as can be seen from the presented investigations, very helpful in explaining the issues of time and the effects of economic processes taking place in time. An extremely constructive feature of the second principle is that it forces living organisms to act to contain entropy in order to prolong duration. In the case of humans, it compels logical thinking and productive, purposeful work. The synthesis of the principles of thermodynamics, knowledge of the primordial energy of life, human consciousness including the knowledge of the astronomical calendar emerges an understanding of time on planet Earth. Periodic economic profit is revealed as a result of the existence of initial capital and the result of the game between the inflow of capital with the stream of labor, which nullifies entropy and allows the inflow of energy offered by nature.

The considerations presented have shown that doubts about the final definition of time by those representing narrow physics paradigms are correct. According to the given definition, time appears as a product of two factors $a \times t$, where $t$ is the number of periods. This becomes evident in economic formulas. For example, the basic formula for measuring human capital is $H(a, t) = N \times [e^{at} - 1]/a$, where $H(a, t)$—the value of capital, $N$—the annual value of the cost of living, $t$—the number of years until the beginning of working life. Interpretation of the presented formula, applied to the calculations in **Table 2**, shows that the value of capital is affected by two factors: 1) the cost of living, 2) the energy supply, determined by the constant "$a$". In this formula, the full concept of time is revealed. In contrast, the simplest formula $S = v \times t$ only involves the number of astronomical periods.

So the only information is the distance traveled. No information about the depreciation of the car and the change in the driver's life force.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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