Nierówności Społeczne a Wzrost Gospodarczy, nr 75 (3/2023)
Social Inequalities and Economic Growth, no. 75 (3/2023)
DOI: 10.15584/nsawg.2023.3.1 ISSN 1898-5084, eISSN 2658-0780

prof. dr hab. Mieczysław Dobija[1]
dr Jurij Renkas[2]
Department of Accounting
Kracow University of Economics

Thermodynamic relationships between time, capital, and labour[3]

Introduction

The first purpose of the paper is to theoretically illuminate and rigorously define the categories of capital, labour, and time. Thus, at the outset, we will present the achievements that have already occurred, and considerations based on thermodynamic fundamentals. We will present empirical calculations that confirm the theoretical findings. An important starting point is the argument about the nature of capital and its identity with the concept of energy in physics. This is not an analogy, but an identity, and this fundamentally changes the thinking about economics.

An important scientific source for considering capital is the work of L. Pacioli of 1494 called *Summa*[4] for short. In this guide to mathematics, the author presented a theory of dual accounting in the last section, the foundation of which is the principle of dualism, that is, the distinction between assets and capital in the form of basic identity. This work, not often overlooked by economists, contains profound statements without which economic thought will always be lame.

The identity is represented by the formula $A_0 = C_0$, where A and C represent the value of assets and capital, respectively, and the index marks a common

[1] Correspondence address: Kracow University of Economics, Department of Accounting, ul. Rakowicka, 27, 31-510 Kraków; e-mail: dobijam@uek.krakow.pl. ORCID: 0000-0003-0670-2313.

[2] Correspondence address: Kracow University of Economics, Department of Accounting, ul. Rakowicka, 27, 31-510 Kraków; e-mail: renkasj@uek.krakow.pl. ORCID: 0000-0001-7139-5458.

[3] The article presents the results of the Project ADN/WOFP/2023/000072 financed from the subsidy granted to the Krakow University of Economics.

[4] Pacioli L. (1494). *Summa de Arithmetica, Geometria, Proportioni et Proportionalita*. Wenecja.

moment in time. The formula therefore requires an understanding of the terms assets, capital, value and time. We treat assets as tangible and heterogeneous, while capital, understood by Pacioli as economic power, is an abstract and homogeneous category. It is embodied in assets. Thus, if assets are material, then according to the nature of philosophical dualism, capital is abstract energy, it represents the specific potential of the energy embodied in the assets.

The indisputable statement that capital is energy significantly enriches economic thought. Previously thought of as an analogy between capital and energy, we now have an identity, so a strong theoretical basis is emerging. These are the principles of thermodynamics that actually constitute the theory of energy, and therefore capital. The first principle of thermodynamics, indicating that capital cannot be created, undermines the foundations of the current financial system. Much is known about the second principle (usually capital letters are used out of respect for it). Albert Einstein said that it is a principle that no one will ever disprove.

Understanding capital and the role of thermodynamic knowledge provides a broader framework and avenues for the development of economic thought. A clear division is drawn; physics studies the world mainly at the micro and macro scales, while economic knowledge describes the earth's living system using physics, but as the history of capital shows, economic research leads to independent results. This is mainly evidenced by the discovery of the economic constant regarding capital and the passage of time.

R. Wright (2000, p. 11) states that the driving force of socioeconomic life is the pursuit of the benefits of playing with nature's positive, non-zero sum, i.e., everyone can win. The fact that many lose does not change this opinion. But let us consider the fact that this non-zero sum, as Wright calls it, must have some fixed measure. The rationale for this is the observation of the natural cyclic constant in the Solar System, as well as the constant of gravity, the electromagnetic field, solar and cosmic radiation, etc. The Earth's living system is stable, so the measure of potential capital growth should be constant. And this is, in fact, the case. Studies recognise the existence of the constant $a = 0.08$ [1/year]. This constant also determines the rate of passage of time.

There is a clear answer to the question: Why is capital, this abstract quantity, this important medium in non-zero summability? After all, what happens when an enterprise is unable to multiply capital or the capital embodied in a manufactured device disappears? The enterprise, after a failed restructuring attempt, becomes a bankrupt entity, while the device is scrap metal. So capital is the energy of existence; without it, an object loses its properties and name. For humans, it is the energy of life, the absence of which means the end of life. It is difficult to find something more important.

On the principles of thermodynamics as tools of cognition

Thermodynamics is fundamental knowledge, which means that without it, it is difficult to explain correctly the most important scientific questions. This opinion applies equally to economics and other scientific disciplines, which is now widely recognised. Organisations are emerging, such as IAISAE[5], whose statutory objectives are to create a platform for cooperation mainly in the field of thermodynamic knowledge[6]. 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 is realised via 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 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 increase. However, the buildup of disorder in the body is a fact, so the question becomes 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 (2002).

The second law of thermodynamics has at least three equivalent formulations:

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

[5] International Association for the Integration of Science and Engineering. Retrieved from: https://www.youtube.thermodynamics.nature.of.Time.Dobija.Renkas.2022 (2022.02.21).

[6] 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 the natural and social sciences.

- (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;
- (Entropic) The entropy of an isolated system cannot decrease (Greene, 2020, pp. 35–63).

The three versions of the SLT are equivalent. 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 tempo 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 and engineering sciences. J. Barbour (2021, pp. 359–399) describes the emergence of structure in the universe, pointing to the inalienable role of thermodynamics. The SLT is also fully applicable and inalienable in explaining biological processes on Earth.

Living entities are particularly subject to the SLT. 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 law of thermodynamics in Sir Kelvin's formulation. In addition, disorder, dysfunctionality of various organs and chronic diseases increase over time in the human body, and in general the ability to generate the necessary energy decreases. 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 behaviour 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 in 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 increases according to the constant a = 0.08 [1/year]. Therefore, it can be assumed 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 civilisation. 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).

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 that these three key scientific categories were passionately discussed, there was inadequate knowledge of thermodynamics. Moreover, as we shall see, time is closely related to man, so physicists had natural difficulties in recognising this category based on physics paradigms alone, as noted by D. Park, (1972, p. 111) 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 the 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 currently achieved state of knowledge regarding the constant 'a' and random variable 's' is synthetically summarised in Table 1. The contents of Table 1 are the subject of explanation of the presented study.

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

Natural constant 'a'	Random variable 's'
Rate of the passage of time and the metabolism of modern man	Human capital dissipation rate according to the second law of thermodynamics
Constant needed to calculate the value of personal human capital	Percentage of human capital value that determines fair salaries
Positive factor affecting capital growth in economics	Destructive factor affecting capital growth in the economy
Bottom line of growth rates in the plant kingdom	Magnitude underlying the 'uncertainty' category
Constant quantifying the impact of natural forces on economic development and growth	Basis of the 'risk premium' in finance and economics

Source: own elaboration.

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

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

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.

Update the definition of time and the constant that determines the rate of its passage

Many scholars are 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), the 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 recognised 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.

The original definition of time formulated by Isaac Newton and included in his work "Principia" is as follows (Newton, 1999, p. 54):

> 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 commonly used instead of true time.

Immanuel Kant (1724–1804), guided by well-known aphorisms such as (2021, pp. 59–60): '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', formulated an opinion about time and space. Time is a form of our sensuality; it is a form of the inner sense. He also recognised that time is empirically real. This opinion is largely confirmed by our definition of time. At that time, thermodynamics had not yet been developed, and yet Kant's understanding of the nature of time is extremely accurate, and also points to the inseparable connection between time and humanity.

The modified formulation of time takes into account the constant thermodynamic transformation taking place in the human body; that is, the ongoing transformation of the 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 and personal human capital.

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 (*E*) of modern man, personal human capital (*H*), 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, 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.

A formalised description of the transformation (T) that determines the course of time is as follows:

$$\text{T: } E_0 \times \mathrm{e}^{-\mathrm{at}} \text{ transforms into } H \times \mathrm{e}^{+\mathrm{at}} \tag{2}$$

where: constant $a = 0.08$ [1/year], t – number of years of the process.

Taking the maximum $E_0 = 1.0000$, we get that after one year, $E_1 = 0.9231$, after the second year, $E_2 = 0.8521$, after the third year, $E_3 = 0.7866$, …, while $E_{65} = 0.0055$, and so on. This transformation makes the infant look like a grown-up one-year-old child after one year, and the following years also show the rapid growth of a person's capital *H*, however slowing down. At the retirement age of 65, *E* is already very small, which is associated with certain effects in the physical body, as medic Ki Bo informed the Yellow Emperor (Maoshing, 2012, pp. 22–23). However, with this residual E, some people even reach an age close to 120 years, when $E_{120} = 0.000068$. This is because people still have at least two available sources of life energy; air and food. Thus, the indicated value of E with four zeros after the decimal point represents the biological end of life, so this is the biological zero for the function $E(t) = \mathrm{e}^{-0.08t}$ at $t = 120$ years.

The definition of time presented is a significant generalisation 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 civilisation, 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.

The understanding of time was formulated not as a result of the study of time, but of the categories of capital, labour and value and especially human capital, and thus in the minds of economists rather than physicists, leads to the view that physicists actually use the category of duration, a certain fragment of time that is fully present in economics. What is referred to by the letter '*t*' in the formulas of mechanics is the number of astronomical durations of an object or process. Of course, physicists, astronomers and other representatives of the natural sciences defined the arrows of time and introduced the principles of thermodynamics, so their orientation regarding the nature of reality prevails over others. Nevertheless, duration is present in their theories, not time, if the content of these concepts is taken into account. The connotation of time is associated with change, while permanence implies existence in an almost unchanging state. As we see it, the above statements are the reasons for constant discussions about time, but with no positive result or agreement on a common position.

Capital is a category that is closely related to time, and therefore, understanding capital is the first step in illuminating the nature of time and providing an appropriate definition; in particular, the need to come to an understanding of how to measure human capital, where the natural constant that turns out to be the constant of the passage of time is revealed. Thus, the category of profit, that is, the periodic growth of capital in economics, also naturally depends on the constant of the passage of time. Eventually it will become clear that there are two variables in the category of time: (i) t – which determines the number of unit periods (hours, months, years), and (ii) the natural constant that determines the rate of the passage of time. In physics formulas, time is represented only by the letter t; in economic formulas and calculations, time is represented by the pair (a, t), where $a = 0.08$ [1/year] and is the time lapse constant.

An important feature of the consideration of time presented here is that it is limited to the Earth System of Life (ESL), actually to the area of the solar system, treated as a virtually isolated part of the universe. Consideration of current socio-economic relations does not extend beyond the solar system and, moreover, we are not competent to share knowledge of the universe. This arrangement makes it easier to consider time in the ESL while relieving us from unfeasible studies of, for example, the metabolic rate of some extraterrestrial civilisation. As a result, there is no strong contradiction between our determination of time and J. Barbour's (2018) statements about the non-existence of time. Time in the ESL is inherently thermodynamic and related to the specific arrow of time of modern humans. The quoted author does not deny the existence of arrows of time. On the contrary, he emphasises and illuminates their importance.

Interpretation of the time lapse constant in terms of human capital measurement theory

According to the determination of time, the disappearance of *E* is accompanied by an increase in personal human capital. As is already known, the constant was discovered within the framework of the emergence of the theory of human capital measurement in the 1990s (Dobija, 1998, 2007). The idea of measuring H 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 capitalisation 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 *H*. This quantity undergoes spontaneous and random dissipation, so the minimum wage should be no less than $s \times H$, where (s) denotes the random dissipation of *H*.

The minimum wage formula emerged:

$$W = s \times H = s \times \mathrm{k} \times [(1 + \mathrm{r})^n - 1]/r \qquad (4)$$

where: *W* – annual fair minimum wage, *k* – annual cost of living, *r* – capitalisation rate of annual cost of living.

Taking into account the availability of data from the U.S. 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 *E* results in an increase in *H* according to the *T* – transformation. The formula for the disappearance of $E - Z(a,t) = exp[-at]$ – explains why human beings grow very quickly in the first years of life and why the changes are clearly visible. The growth of human capital is also explained: it is a composite of the cost of living and *E*, the proportion of which changes over time. Since the inflow of *E* is greatest in the first years of life, the growth of the child and all his or her abilities are very 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; Koziol, 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 accounting 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 their income to Social Security Tax and 1.45% 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 monthly[7].

According to formula (4), the theoretical minimum wage W(a) for a teenager (t = 17 years old) can be calculated: $W(a,t) = W(0.08, 17) = 0.08 \times (12 \times 585) \times [e^{0.08\times17} - 1] / 0.08$ = $1,694.00/month. On the other hand, the statutory monthly minimum wage is: $9.00 (average minimum wage per hour in 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) = 1,705 USD/month.

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: (i) the contribution to the pension fund is 20% of the salary, (ii) the contribution to health care coverage is 10% of the salary, (iii) the retirement age is 65, (iv) the family consists of 2 adults and 2 descendants, (v) the average number of life years is 85, (vi) the percentage of capitalisation 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.

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

1	Country	USA (USD)
2	Theoretical monthly minimum wage W(a) = a × H(a,t)	1,694.0
3	Statutory monthly minimum wage	1,705.0
4	Percentage of compliance (3) : (2)	100.7%
5	Total earning (2 persons × $1,694)	3,388.0

[7] Cost of living in the USA. Retrieved from: https://www.expatistan.com/cost-of-living (2022.02.21).

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	2,371.6
9	Amount per person (2 adults + 2 children)	592.9
10	Average cost of living	585.0
11	Pension funds per one 333.8 x 12 x [(1 + 0.03)48 – 1)/0.03] =	418,218.0
12	Monthly pension after 65 years of work	1,742.0

Source: own elaboration.

As the calculations in Table 3 show, the amount remaining to cover the living costs per person 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 up two descendants 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 capitalisation rate of 3% is $418,218. Hence, the monthly pension amount can reach 1,742. The personal capital of the 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.

The considerations show the contribution of the constant to the solved cognitive problems of human capital measurement and the appropriate labour 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 in the U.S. This has been confirmed by calculations with repeated use of a constant that unambiguously indicates 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 disrupted 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. Economic crises happen because people do not respect the correct theories, as well as all kinds of negative political influences, which threaten pension funds.

SOURCES OF INCOME AS A PLAY BETWEEN CONSTANT, DISSIPATION AND LABOUR. THE RELATIONSHIP $E(s) < a$

Albert Einstein reportedly said that the compound interest formula is the greatest mathematical achievement of mankind[8]. Whether a joke or not, the formula $C_t = C_0e^{rt}$ is the nucleus of the general model of capital. Ch. Bliss (1975, p VII) expressed that we do not know what capital is and are unlikely to find out. We 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 of 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 recognise 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* – rate of disappearance of capital, and *m* – capital inflow by labour. Thus, the general model of capital after the period $\Delta t = 1$ is presented:

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

An example interpretation of model (5) 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 the 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 emphasised that the inflow of capital through the work of the 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. Labour does not increase capital; labour is merely a transfer of capital, but competent labour counteracts entropy.

The economic processes in which capital gains, or income, are sought are interpreted similarly. By definition, income = $\Delta C = C_1 - C_0 = C_0 \times e^{(a-s+m)t} - C_0$

[8] 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'. Retrieved from: http://www.ruleof72.net/rule-of-72-einstein.asp (2022.02.21).

$\approx C_0(a - s + m)\ \Delta t$, 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*), and 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 labour 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 labour that has coagulated. The source of labour is human capital, which, as the definition of time reveals, arises after the conversion of E. Thus, there are two sources of power to the economy: (i) the sun, which provides biomass growth at a rate typically exceeding 0.08 [1/year], (ii) the universe as the provider of *E* life energy. Economic processes generating GDP take place with the help of the 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 DZT. 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, pp. 394–399). 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 3 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 standardise 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 = 1,784.64 GBP. The monthly cost of living in the UK is estimated to be 568 GBP.

Therefore, s = 21,415.78/246,756 = 0.0867. In other selected European countries and the U.S. states, the estimation leads to similar results.

Table 3. 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)* [9]	$s = W_r/K(a,t)$
1	2	3	4	5
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

[9] Eurostat, Monthly minimum wages, https://ec.europa.eu/eurostat/databrowser/view/earn_mw_cur/default/table?lang=en (2022.02.21).

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 the percentage of Employer Social Security Tax[10] (UK – 13.8%, France – 45%, Germany – 19.98%, Belgium – 25%, Switzerland – 6.4%, Sweden – 31.42%).

Source: cost of living data was taken from (Cost of living, 2022).

The important relation suggested by Table 3 is the weak inequality $E(s) \leq a$. What does this mean? Using the definition of time, the constant can be looked at as the rate at which human labour resources are supplied from external sources: from nature. In turn, labour transfers human capital to labour objects, which then become products and assets, subject to entropy growth. Thus, if the random variable s, which determines the rate of dissipation of human capital, satisfies the indicated relationship, it can be expected that destruction does not necessarily prevail over construction. It should be emphasised that this opinion can be made under the natural assumption of openness of the system called a human.

Another general observation resulting from the calculations in Table 2 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 wages in the highly developed countries of Europe and the states of the U.S. are determined by the constant a = 0.08 [1/year]. This fact is associated with correspondingly high labour 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 labour; that is, transfers of human capital to products.

[10] *Employer Social Security Tax Rates*, https://home.kpmg/xx/en/home/services/tax/tax-tools-and-resources/tax-rates-online/social-security-employer-tax-rates-table.html (2022.02.21).

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 U.S., is a component of the CAMP model (Goetzmann, Ibbotson, 2006), which has strongly lost its values in current times. 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 recognise 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 4).

Table 4. 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, p. 35).

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 a priori: $a = 0.08$ [1/year].

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 1,500 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 1,000, Standard & Poor's 900, Standard & Poor's 600, Standard & Poor's 500, and 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%.

Capital and labour – complementary notion

The economic sciences are known to have difficulties in understanding capital, even though it is a major scientific concept. It is a strange one. The measurement of the periodic growth of capital, or income (profit), is dealt with in the theory and practice of accounting. And this measurement largely forms the basis for budgeting and steering the state economy. Understanding and defining capital stems from a basic principle of accounting theory, the principle of dualism. According to this principle, a distinction is made between heterogeneous tangible assets and homogeneous abstract capital embodied in these assets. In doing so, it is worth noting that the natural sciences and economics share at least one common paradigm, that is, the *matter-energy* dualism in physics and the *asset-capital* dualism in economics.

This dualism found in the economic sciences is aptly characterised by Y. Ijiri (1995, p. 55). According to that author, capital is abstract, aggregate and homogeneous, while resources are concrete and heterogeneous. The double-entry accounting system, which has been the foundation of accounting for more than five centuries, has been based on a dual view of resources and capital since its inception. Let us add that the category of resources differs from assets, in that assets have an explicitly measured capital value, while resources do not. Therefore, resources are estimated in natural units. For example: coal resources in a given layer are estimated at 10 million tons.

What, then, is this abstract medium called capital, and why is its periodic growth viewed so positively? How can this be explained using the example of cars, which is a vivid example of tangible assets? Well, the car has the ability to drive, to do work. This abstract property of the car is known to fade over time, the car loses its ability to drive. When it fades completely, the car is gone, only scrap remains. Similarly, the disappearance of the energy of life causes a person to cease to exist. It is also clear why a company with initial capital seeks to achieve periodic increments of capital; this is a condition for survival.

These are two fundamental scientific concepts and from them arise derived categories. Capital is the ability to do work and, from this term, it follows that work is a complementary category. At the same time, capital is a potential category. A dynamic category, on the other hand, is labour, which can be performed as long as there is the potential to perform it, i.e. capital. Labour is defined as the transfer of capital to the object of labour. A given object, such as a car, may have a greater or lesser concentration of capital obtained from transfers called labour. Those modern, perfectly constructed and equipped cars having a high concentration of capital are characterised by high value. Thus, we have a natural sequence of major economic concepts: capital, labour, value.

Work is done by machines but also by people with adequate human capital, the concentration of which may be higher or lower. It is natural that a worker with a higher value of capital receives a higher proportional salary. When dealing with the issues of measuring human capital and adequate compensation for labour, a natural constant analogous to known quantities of this kind was revealed (Dobija, Renkas, 2021b). As is known, there is this constant $a = 0.08$ [1/year], which is also related to the category of time.

Capital is thermodynamic in nature; it does not arise from nothing and is subject to natural spontaneous dissipation. It cannot be created out of nothing; it appears with the birth of a human being, grows as human capital and is further transferred through labour processes. Similarly, capital grows through other living organisms. In these processes, the sun plays an inalienable role by providing energy for the processes of life. The measurement of the periodic growth of capital in economics, which is provided by accounting systems, has as its basis the double entry of economic operations resulting from the principle of dualism, which precludes that capital can arise from nothing (the first principle of thermodynamics).

In addition, the capital embodied in an object disperses spontaneously and its potential is reduced; entropy increases in an isolated object. In the case of a car, knowing its value at the end of its useful life (the level of concentration of capital), it is possible to determine the theoretically reasonable rate of capital dispersion, i.e. depreciation of the car. The general formula for determining the annual rate of depreciation (entropy increase) of the object under consideration is as follows: $Vp \times e^{-d \times t} = Vk$, where: Vp – initial value of the object, Vk –value at the end of the useful life, t – number of years of operation, and d – annual rate of depreciation of the asset.

In a consistent thermodynamic approach, the issue of capital is presented clearly and simply. The discernment of capital in economic thought, in which there was no lack of reference to physics, but there is still a lack of distinction between abstract capital with material resources or assets, is presented differently. A recent work by T. Piketty (2015) is an example of an economic work in which the author defines capital as he sees fit, with no connection to scientific achievements or accounting theory.

R.M. Solow (1963, p. 8) expressed his opinion on capital: "…It seems that certain issues that were debated in the 19th century, for example, how capital should be measured, remain contentious to this day…". R.M. Solow (1963, p. 10) goes on to emphasise that these debates were inconsistent and still are, although he himself participates in them. He states that it is highly significant that if a theoretical issue remains debatable and unresolved after 80 years, the suspicion arises that it is either misplaced or very deep indeed.

Recall also that Ch. Bliss, A.J. Cohen and G.C. Harcourt (2005), in a three-volume work entitled: 'Capital Theory', collected 71 scientific articles, chapters of monographs, and letters from the 19th, 20th and 21st centuries, the authors of which presented their own views on capital theory. The differences in views were so great that they justified the authors formulating the opinion that capital theory is an infamous subject precisely because of the notoriously recurring controversies surrounding it. This controversy is the result of the continuing tension between the two concepts of capital: physical and value. This is because economists view capital both as a collection of heterogeneous resources used in the process of producing goods and as a homogeneous fund of value that flows between alternative uses to establish a uniform rate of return.

Current economic theory suffers many failures when confronted with practice, which many authors have written about. N. Roubini and S. Mihm (2011, p. 59) describe the prevailing discrepancies that exist among economists on almost every important issue. As they write:

'Such divergence of views may embarrass non-economists. After all, economics aspires to be a science that obeys laws, performs equations, creates mathematical models and uses other tools used in objective research. But beyond the façade of a single scientific truth lies a huge variety of mutually contradictory opinions, especially on the contentious issue of financial crises. This was the case in the 19th and 20th centuries, and it is still the case today.'

To be fair, many economists associated capital as an abstract category. Physical theories, the epistemological views of physical theorists, were the model to which scientists working in the field of economic sciences referred. As (Mirowski, 1989, pp. 224–225) writes, many scholars viewed value and utility through the prism of the physical understanding of energy and considered mechanics as a model for economic science. (The latter opinion ultimately proved wrong.) W.S. Jevons (1905, p. 219), for example, wrote explicitly that the concept of value is to our science what energy is to mechanics. In 1926, I. Fisher presented a table containing analogies of physical and economic categories (Mirowski, 1989, pp. 224–225); energy in his understanding was the equivalent of utility.

However, the aforementioned economists could not sufficiently clarify this issue. By associating value with energy, they did not clearly state that it is capital, as the ability to do work, that has all the characteristics of energy, and that value should be understood as the concentration of capital in an object. They also failed to find the right analogies between the laws governing energy in physics and capital in economics and correctly interpret the laws of thermodynamics in relation to economics. We should add that the issue of capital creation from nothing, related to the actions of the current banking system, negatively weighs on the theory of political economy and its possibilities for development.

Ending words

The role of the knowledge of thermodynamics is, as can be seen from the presented research, 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. Through 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 the 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 labour, which nullifies entropy and allows the inflow of energy offered by nature.

Modifying the definition of time to include the thermodynamic transformation of life energy into human capital has naturally enriched the understanding of the potential constant of capital growth, which opens up avenues for further scientific research. A deeper understanding of the structure of the discount factor naturally emerges. In this quantity, time appears fully as a pair (t, a). At the same time, it is an example of an important economic theory (capital budgeting), in which there are scientific categories of present and future value (PV and FV), rather than mere divagations about the past and future.

It can be expected that economists who do not respect the principle of dualism in their writings and consider capital as a type of asset will find that they oppose the theory based on the foundation of the unassailable capital-labour-time triad. The chutzpah called the 'Cambridge controversy' will stop poisoning the clarity of economic thought. And without this ethically dubious achievement, it is astonishing to ignore the theory of double-entry accounting, the theoretical and practical importance of which is indisputable in terms of creating information for maintaining the financial balance of an organisation. And maintaining balance is a condition of existence. It can also be expected that it will be established that the texts of creative economic works will take into account the languages of mathematics and physics necessary to describe abstract but real categories, as well as the natural language in which the author conducts a clear narrative presenting achievements.

Bibliography

Atkins, P. (2007). *Four Laws that Drive the Universe*. New York: Oxford University Press.

Barbour, J. (2018). *The End of Time: The Next Revolution in Our Understanding of the Universe*. Cracow: Copernicus Center Press.

Barbour, J. (2021). *The Janus Point: A New Theory of Time* (Polish language: Nowa teoria czasu. Punkt Janusa). Cracow: Copernicus Center Press.

Bejan, A., Tsatsaronis, G. (2021). Purpose in Thermodynamics. *Energies, 14*, 408. DOI: 10.3390/en14020408.

Bliss, C., Cohen, A. J., Harcourt, G. C. (2005). *Capital Theory*, Vol. I–III. Massachusetts: Edward Elgar Publishing Limited, Northampton.

Bliss, J. Ch. (1975). *Capital Theory and the Distribution of Income*. Oxford: North-Holland, California Institute of Technology, Michael A. Gottlieb and Rudolf Pfeiffer.

Cost of living in USA. Retrieved from: https://www.expatistan.com/cost-of-living (2022.02.24).

Cost of living, 2022. Retrieved from: https://www.numbeo.com/cost-of-living/rankings_by_country.jsp (2022.02.21).

Cost of living in USA. Retrieved from: https://www.expatistan.com/cost-of-living (2022.02.24).

Dobija, M. (2007). Abstract Nature of Capital and Money. In: M. Linda Cornwall (eds.), *New Developments in Banking and Finance* (pp. 89–114). New York, Inc.: Nova Science Publishers.

Dobija, M. (1998). How to place human resources into the balance sheet. *Journal of Human Resource Costing & Accounting*, *3*(1), 83–92. 2. DOI: 10.1108/eb029044.

Dobija, M. (2011). Labor Productivity vs. Minimum Wage Level. *Modern Economy*, *2*(5), 780–787. DOI: 10.4236/me.2011.25086.

Dobija, M., Kurek, B. (2013). Towards Scientific Economics. *Modern Economy*, *4*(4), 293–304. DOI: 10.4236/me.2013.44033.

Dobija, M., Renkas, J. (2020). Accounting among the Natural Sciences. *Modern Economy*,*11*(12), 2081–2100. DOI: 10.4236/me.2020.1112138.

Dobija, M., Renkas, J. (2021a). How the inclusion of thermodynamic principles recovers economic sciences. *International Journal of Accounting and Economics Studies*, *9*(2), 21–31. DOI: 10.14419/ijaes.v9i2.31608.

Dobija, M., Renkas, J. (2021b). The thermodynamic principles as the theoretical basis of fair remuneration. *International Journal of Physical Research*, *9*(1), 1–6. DOI: 10.14419/ijpr.v9i1.31247.

Dobija, M., Renkas, J. (2021c). Thermodynamic constant of time passage. *International Journal of Physical Research*, *9*(2), 92–97. DOI: 10.14419/ijpr.v9i2.31823.

Dobija, M., Renkas, J. (2022). Study on Thermodynamic Constant of Time Passage. *Research Trends and Challenges in Physical Science, 6*, 57–68. DOI: 10.9734/bpi/rtcps/v6/15220D.

Employer Social Security Tax Rates. Retrieved from: https://home.kpmg/xx/en/home/services/tax/tax-tools-and-resources/tax-rates-online/social-security-employer-tax-rates-table.html (2022.02.21).

Eurostat, Monthly minimum wages. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/earn_mw_cur/default/table?lang=en (2022.02.21).

Feynman, R. (1963). Time and Distance, The Feynman Lectures on Physics, Vol. I, Ch. 5. Retrieved from: https://www.feynmanlectures.caltech.edu/I_toc.html (2022.02.21).

Fraser, I. T. (1979). Wyjście z jaskini Platona: naturalna historia czasu. *Zagadnienia filozoficzne w nauce*, II/1979/80, 18–39.

Goetzmann, W. N., Ibbotson, R. G. (2006). History and the Equity Risk Premium. In: W. N. Goetzmann, R. G. Ibbotson (eds.), *The Equity Risk Premium: Essays and Explorations*. Oxford: Yale School of Management, Oxford University Press.

Greene, B. (2020). *Until the end of time. Polish edition*. Warszawa: Prószyński Media Sp. z o.o.

Holt, J. (2018). *When Einstein Walked with Gödel: Excursions to the Edge of Thought*. New York: Farrar, Straus and Giroux.

Ijiri, Y. (1995). Segment Statements and Informativeness of Measures: Managing Capital vs. Managing Resources. *Accounting Horizons, 9*(3), 55–67.

International Association for the Integration of Science and Engineering. Retrieved from: https://www.youtube.thermodynamics.nature.of.Time.Dobija.Renkas.2022 (2022.02.21).

Jevons, W. S. (1905). *Principles of Economics*. London: Macmillan.

Kant, I. (2021). *The Critique Of Pure Reason*, Translation and Comments by Philip McPherson Rudisill, Completed on October 17, 2019, with editing on-going as of, November 5, 2021, 59–60. Retrieved from: https://chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://kantwesley.com/Kant/CritiqueOfPureReason.pdf (2022.02.21).

Koziol, W. (2011). Constant of potential growth in the calculation of human capital (Polish language: Stała potencjalnego wzrostu w rachunku kapitału ludzkiego). *Nierówności Społeczne w Wzrost Gospodarczy*, *19*, 252–260.

Kurek, B. (2012). An estimation of the capital growth rate in business activities. *Modern Economy, 3*(4), 364–372. DOI: 10.4236/me.2012.34047.

Lambert, F. L. (2002). Disorder – A Cracked Crutch for Supporting Entropy Discussions. *The Journal of Chemical Education*, *79*(2), 79–187. DOI: 10.1021/ed079p187.

Maoshing, Ni. (2012). *The Yellow Emperor's Classic of Medicine* (Polish edition), Łódź: Wydawnictwo Galaktyka.

Mirowski, P. (1989). *More Heat than Light, Economics as social physics: Physics as nature's economics*. Cambrodge: Cambridge University Press.

Newton, I. (1999). *The Principia. Mathematical Principles of Natural Philosophy.* The Authoritative Translation by I. B. Cohen and A. Whitman assisted by J. Budenz. California: University of California Press.

Park, D. (1972). The myth of the passage of time. In: J. T. Fraser, F. Haber, G. Muller (eds.), *The Study of Time* (pp. 110–121). Berlin: Springer Verlag.
Piketty, T. (2015). *Kapitał w XXI wieku*. Warszawa: Wydawnictwo Krytyki Politycznej.
Pikulska-Robaszkiewicz, A. (1999). *Usury in the State and Law of Republican Rome* (Polish language: Lichwa w państwie i prawie republikańskiego Rzymu). Łódź: Wydawnictwo Uniwersytetu Łódzkiego.
Renkas, J. (2022). *Thermodynamic model of human capital measurement in applications to employee compensation formation* (Polish language: Termodynamiczny model pomiaru kapitału ludzkiego w zastosowaniach do kształtowania wynagrodzeń za pracę). Warszawa: Wydawnictwo Difin.
Roubini, N., Mihm, S. (2011). *Ekonomia kryzysu*. Warszawa: OficynaWolter Kluwers.
Solow, R. (1963). *Capital Theory and the Rate of Return*. Amsterdam: North-Holland Publishing Company.
Wright, R. (2000). *Nonzero. The Logic of Human Destiny*. New York: Pantheon Books (Polish edition).

Summary

In the theoretical achievements of economics, the past has left many insinuations, not always accurate terms and also controversies. This does not burden the scholars whose diligent efforts fell on the immature ground of general knowledge, in particular the lack of thermodynamics. The categories of capital, profit, labour are basic examples. There was also a lack of understanding of the nature of time. This issue was as if left to physicists, despite the fact that the use of present and future value was and is a significant achievement in economics and accounting. On the other hand, among those engaged in physics, there are divergences about time travel. The great idea of the economy as a game with nature with a non-zero positive sum has also not spread in economic theory, reinforcing the aspiration to belong to the natural sciences. Therefore, we take up the consideration of the *capital-labour-time* triad as an important basic element of economic knowledge. In our view, this correctly understood triad will correctly illuminate many economic issues and can form the hard core of a scientific program for improving economic and accounting theory. Thus, the epistemology of I. Lakatos defines the methodology of ongoing research, in which positive heuristics and empirical verification are the engine of scientific action.

Keywords: time, capital, labour, thermodynamics, economic constant.

Termodynamiczne relacje między czasem, kapitałem i pracą

Streszczenie

W teoretycznych dokonaniach ekonomii przeszłość pozostawiła wiele niedomówień, nie zawsze trafnych określeń, a także kontrowersji. Nie obciąża to uczonych, których rzetelne wysiłki padały na niedojrzały grunt wiedzy ogólnej, w szczególności na brak termodynamiki. Kategorie kapitału, zysku, pracy to podstawowe przykłady. Brakowało też zrozumienia natury czasu, ta kwestia została jakby zostawiona fizykom, mimo że posługiwanie się wartością teraźniejszą i przyszłą było i jest znaczącym osiągnięciem ekonomii i rachunkowości. Natomiast wśród zajmujących się fizyką mają miejsce dywagacje o podróżach w czasie. Wielka idea gospodarki jako gry z naturą o sumie niezerowej dodatniej także nie upowszechniła się w teorii ekonomii wzmacniając dążenia do przynależności do nauk naturalnych. Dlatego podejmujemy rozważania o triadzie *kapitał-praca-czas* jako istotnym podstawowym elemencie wiedzy ekonomicznej. W naszym przekonaniu ta poprawnie rozumiana triada poprawnie naświetli wiele kwestii ekonomicznych i może stanowić twarde jądro naukowego programu doskonalenia teorii ekonomii i rachunkowości. Zatem epistemologia I. Lakatosa określa metodologię prowadzonych badań, w których pozytywna heurystyka i empiryczna weryfikacja stanowią motor naukowych działań.

Słowa kluczowe: czas, kapitał, praca, termodynamika, stała ekonomiczna.

JEL: A12, E24, J24, O15.