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Relativistic Economic Growth and Investment Decision

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Abstract

The research employed time series data sourced from the World Bank database, where time in years serves as a vital variable within the dataset. It analyzed the trends of the average global GDP as well as its present value concerning GDP growth rate over time. Discounting future value is crucial for effective financial planning, enabling the utilization of funds to create increased wealth over time. In both cases, the study determined that the growth rate of GDP is inversely associated with time itself. This relationship can further be elucidated by the inverse correlation between the average log transformation of global GDP and time. Time may be perceived differently depending on the observer's context. For a stationary observer, time seems to elapse more slowly in a rapidly growing economy, while it appears to progress more quickly in a slowly expanding economy. The values of GDP are affected by the expected output capacities of capital and labor inputs. In situations where labor productivity diminishes, a nation may aim for a higher capital-labor ratio, whereas it may pursue a lower capital-labor ratio when capital productivity declines. Over the long term, an increase in GDP is linked to a reduction in the time required for GDP generation.

Keywords: Relativity, Economic Growth, Investment

1. Introduction

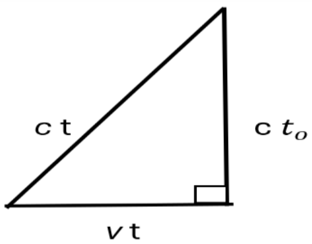
Time serves as the proof of the existence of matter. As the dynamics of matter evolve, so too does time. Indeed, when an object moves at a higher velocity, time appears to shrink (Einstein, 1916). This notion can be confusing, as time is typically viewed as a linear progression towards the future. Nevertheless, time is not constant; it varies for different observers based on their location within the gravitational field. The motion and direction of matter in space affect time. Since each nation employs mass and energy to transform divinely provided resources into finished goods, this research hypothesized that a specific type of time displacement must have taken place (Lee and Kuo, 2002). All essential elements, including space, time, GDP, and growth rate, are available for mathematical analysis, making the hypothesis verifiable. This study asserts that GDP movement aligns with Einstein's special theory of relativity. As the GDP growth rate increases, the passage of time contracts in a manner akin to energy consumption. This research integrates Einstein's theory of special relativity, using time as a measure for GDP growth rate. The study established several postulates, namely: 1) human action is based upon the hedonic concept of wealth, the more the better. 2) the productivity of inputs has a time metric measurement; 3) improvements in productivity enable companies to achieve a higher output with the same amount of input, resulting in increased revenues and, ultimately, a rise in Gross Domestic Product (Mehta et al 2011; Fagerlin and Ring et al., 2012); and 4) access to the global market for goods and services is time dependent. This research paper examines the suggested negative correlation between GDP growth rate and time. The core principle of time relativity influences productivity (Tinbergen, 1962), highlighting that GDP represents the sum of all economic activities with a time scale for evaluating labor and capital productivity and GDP growth rate. The results of the study provide valuable insights for academics, researchers, and policymakers.

Theoretical Framework

All matter in the universe is governed by the fundamental forces of nature, including electromagnetism, electricity, and gravitation. Indeed, the Cordus conjecture suggests that time, at its most basic level, consists of the frequency oscillations of matter particles. As a result, time is produced both locally and nonlocally as an intrinsic characteristic of matter (Pons et al., 2013). Based on this foundation, the research indicates that the process of GDP creation is inversely related to time, since the production process requires energy and mass, which are fundamental in Einstein's special theory of relativity (Fu and Kirschvink, 2019; Meyer, 1972). Consequently, the same principles apply and facilitate a connection between economics and contemporary physics. Although the study does not directly address the speed of light itself, the phenomenon of time dilation in economic activities is evident. Hence, log GDP and the time measurement annually, utilizing the time-GDP growth rate equation and the Lorentz factor γ as illustrated in Figure 1.

Before Einstein, the astronomer's understanding of the universe was based on Newton's three laws of motion. However, these three laws do not explain how gravity works between two distant masses like certain phenomena, such as light (for example, the light emitted by stars). Scientists who adopted Newton's physical theory assumed that light must pass through a medium they called "luminous ether". Scientists calculated how the motion of the Earth through the ether has affected the speed of light. The experiment concluded that there could be no ether and light must travel through a vacuum. But this contradicts the work of another scientist, James Clerk Maxwell (in Sarkar A, Tapan K.; Salazar-Palma, Magdalena; Sengupta, Dipak L, 2010), whose equations require that electromagnetic waves always travel with the same speed in vacuum. of about 186,282 miles per second (300,000 kilometers per second). Einstein's two postulates are as follows: 1) The laws of physics remain consistent across all frames of reference, and 2) The speed of light is constant in all frames of reference. The subject under discussion is time, and this can be confirmed as accurate by utilizing the Pythagorean theorem.

Figure 1



$$c^2 = a^2 + b^2$$

$$(ct)^2 = (vt)^2 + (ct_o)^2$$

$$c^2t^2 = v^2t^2 + c^2t_o^2$$

$$\frac{c^2t^2 - v^2t^2}{c^2} = t_o^2$$

$$t_o^2 = t^2 - \frac{v^2t^2}{c^2}$$

$$t_o^2 = t^2(1 - \frac{v^2}{c^2})$$

$$t_o = t\sqrt{1 - \frac{v^2}{c^2}}$$

$$t = \frac{t_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

It appears that time (t) as observed by stationary observer is not equivalent to the time of a moving object (t_o). The equation indicates that as the speed of an object (v) increases, the time (t_0) decreases. For the first time, it becomes clear that time is not linear progression with the future as depicted in Figure 1. Time changes for different observers depending on their position of the gravitational fields. The faster the object moves in space, the shorter is the time relative to the stationary observer. Hence, time is an important variable to understand the nature of the cosmos. It is inextricably linked to space, mass and energy (US Department of Energy). The combination of special and general relativity helps to explain the dilation of time and it is measured differently in different frames of reference. Consequently, time is a subjective value that relies on human actions occurring within it. Einstein's theory of relativity has an important application to daily life where time, it measures much of today's digital world in production, healthcare, trade and investment.

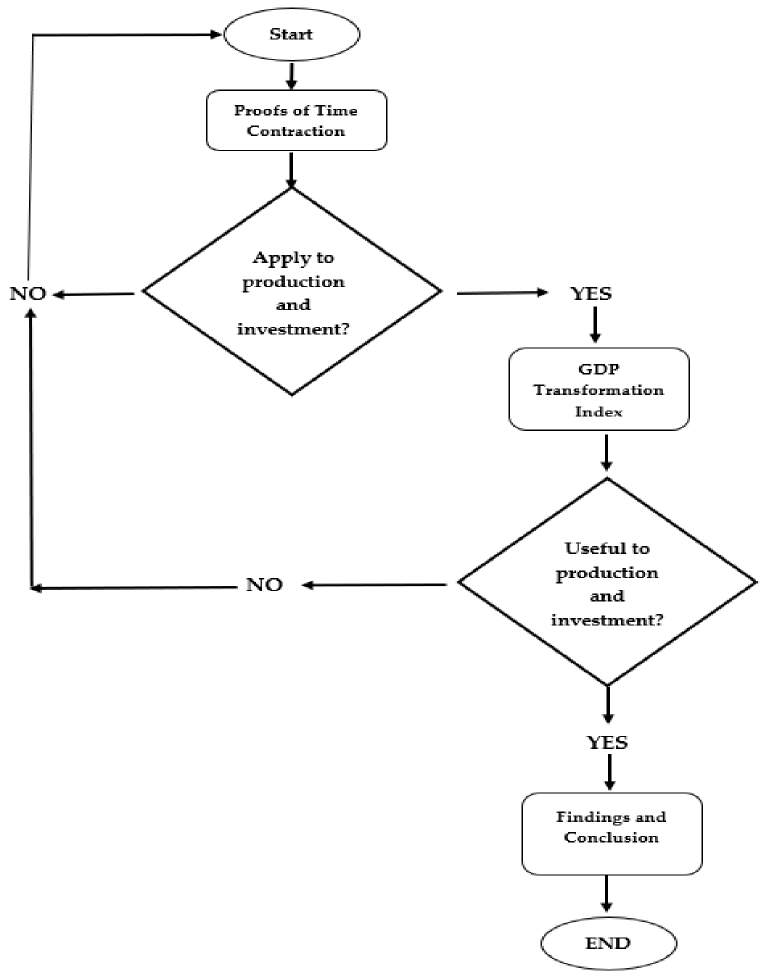
Undoubtedly, Einstein relativity theory is counterintuitive and need further reflection. He postulated that the laws of Physics and speed of light are the same regardless of frame of reference. Consequently, in an experiment, the perception of time and space differ from different time frames. The stationary observer experiences the same physical laws as a moving observer; however, they differ in their measurements of space and time. A stationary observer will observe length contraction and time dilation in fast-moving objects when compared to their own frame of reference. A fast-moving observer perceives time as normal, whereas for stationary and slow-moving observers, time appears dilated in relation to the fast-moving observer. On the other hand, scientific discoveries have revealed that the universe is expanding at a rate that exceeds the speed of light (Overbye, 2025). In any case, by thought experiment should be clear that as GDP growth rate rises, time decreases.

This research reveals a straightforward and significant finding regarding the presence of time contraction in economic activities. It is not so much of the Physics of time relativity per se, but also of the improvements in productivity enable companies to achieve a higher output with the same amount of input, resulting in increased revenues and, ultimately, a rise in Gross Domestic Product (Khan, Azizur Rahman, 2007; Kapos, Steven, 2005; Basnett, Yurendra and Ritwika Sen, 2013; Claire Melamed, Caire; Hartwig, Renate; and Grant, 2011; Gustavo, Crespi and Pluvia, Zuñiga, 2011; Eife, Benjamin, 2009). Thus, it hypothesized that the contraction of time is found in all economies, where time captures important realities of the movement GDP through time. According to this hypothesis, it is theoretically probable that a shorter duration would correlate with an increased GDP growth rate, improved health quality, enhanced education quality, greater productivity, and an elevated quality of life. Based on this premise, this research offers additional measurement and quantitative evaluation of a nation's capacity to produce GDP; which is especially significant when evaluating the productivity of labor and capital. Additionally, it serves as an effective method for monitoring GDP growth over time (Maynard and Stegemerten et al., 1948).

Conceptual Framework

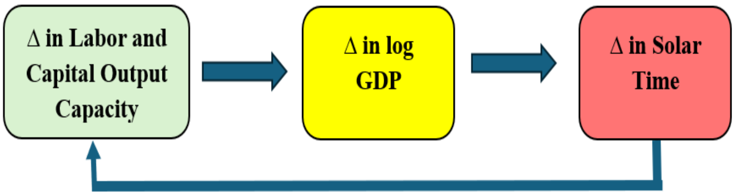
The study begins with the theory and some evidence of time contraction and goes on to explain its application to production and investment decisions. Below is the research process of the study.

Figure 2



In summary, the research establishes the subsequent framework shown in Figure 3

Figure 3



The framework delineates the approach for evidencing the occurrence of time dilation in the generation of GDP, functioning as a method to corroborate Einstein's theory of the universe, often known as the theory of special relativity. It begins with the evaluation of labor-capital productivity, which influences the yearly variations in average global GDP and, as a result, the fluctuations of time. In order to accomplish this goal, the study utilized non-discounted GDP alongside the compound annual growth rate (CAGR) to assess whether an inverse relationship exists between the GDP growth rate and the progression of time.

Problem Statement

The study seeks answers to the following problem:

1. What is the trend of the global average Gross Domestic Product (GDP) from 1960 to 2023?
2. How does the change in GDP relate with GDP growth rate?
3. How does the compound annual growth rate of GDP relate to time progression?
4. What conclusions can be made on the relationship between GDP growth rate and time?

Method

The researcher initiates the work with Einstein's theory of special relativity from previously established literature, and then applies this theory to the creation of GDP through careful observations and data collection. Therefore, the study employed a secondary research method. The objective is to assess the theory by utilizing it in the context of GDP fluctuations, and to derive precise and valid conclusions (Liu, 2016). This study hypothesized that a pattern of temporal contraction in the growth rate and movement of GDP can be found. Literally, GDP is the sum of all economic activities of the economy such the rate at which GDP grew can be likened to the speed of light. Although GDP is quantified in monetary terms per unit of time. The average global GDP from 1960 to 2023 (World Bank Open Data, 2025) increased consistently which translates to some velocity per second corresponding to certain percent of the speed of light in second, and so forth. This percentage is expected to increase in the future, as it has shown an upward trend. GDP experiences a transformation process where natural and human resources are converted into final goods. This transformation requires a certain amount of time. The study hypothesized that in a high-growth economy, this time is perceived as 'slower' because a greater output is generated in a shorter duration. Conversely, in a low-growth economy, the time taken is longer as it necessitates more time to achieve the same level of output. Therefore, from the viewpoint of a low-growth economy, time appears to be slower in a high-growth economy, while from the perspective of a high-growth economy, time seems to be faster in a low-growth economy. This observation holds true for a stationary observer. In this sense, intertemporal measures make GDP comparisons more relevant. The researcher will then formulate a theory of how time contraction will affect business and investment choices. To support this hypothesis, World Bank data will be used on the GDP growth rate from 1960 to 2023.

Limitation of the Study

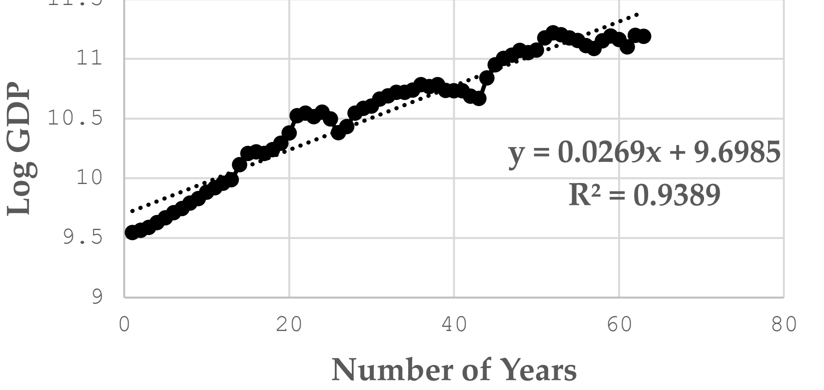
This research reinterprets GDP from the World Bank (World Bank Open Data, 2025) by utilizing the average GDP and transforms these figures into log values to enhance the analysis. There are two methods for identifying time relativity that are inherently non-probabilistic and probabilistic: non-discounting and discounting through the compound annual growth rate (CAGR). In this study, time is proposed as supporting metric for comparing GDP on a worldwide level that facilitates improved planning, goal establishment, and resource distribution, enhanced efficiency and effectiveness (Chad et al, 2016). While GDP is generally represented in the currency of the respective nation, t remains vulnerable to fluctuations in currency value. Lorentz factor also known as gamma factor s used to measure how much the measurement time change as average global GDP change. Given that the speed of light is a universal constant, and very large value100 percent GDP growth rate (1) may be employed instead.

Discussion of Results

Problem Statement 1

The study hypothesized that as GDP increases, the time to which GDP grows decreases. However, initially, the data shows that as GDP rises, time lengthens. Consider Figure 4, the global GDP (1960-2023) shows an upward trend, although, the Figure also marked by business cycles are characterized by the alternating phases of expansion and contraction in overall economic activity. In any case, the equation in Figure 4 demonstrates that values greater than .0269 (approximately 3%) signify a reduction in unemployment, while values lower than .0269 suggest an increase in unemployment, hence, business cycles. This implies that full employment is achieved when the unemployment rate is at least 2 – 3%. The best fit of the scatterplot is the regression line (log GDP = 9.6985 + 0.0269X) with an R squared of 0.9389. The predictive regression equation is significant (F = 912.158; ρ = 0.000). With a significance level of 0.05, there is a 5% chance that a difference between the variables (y, x) will be inferred when none actually exists. Put another way, if a variable's ρ -value is less than significance level, then the sample data offer sufficient evidence to reject the null hypothesis for the entire population. On the other hand, a ρ - value greater than 0.05 suggests that the evidence is poor and does not support the null hypothesis.

Figure 4 Global Average Log GDP

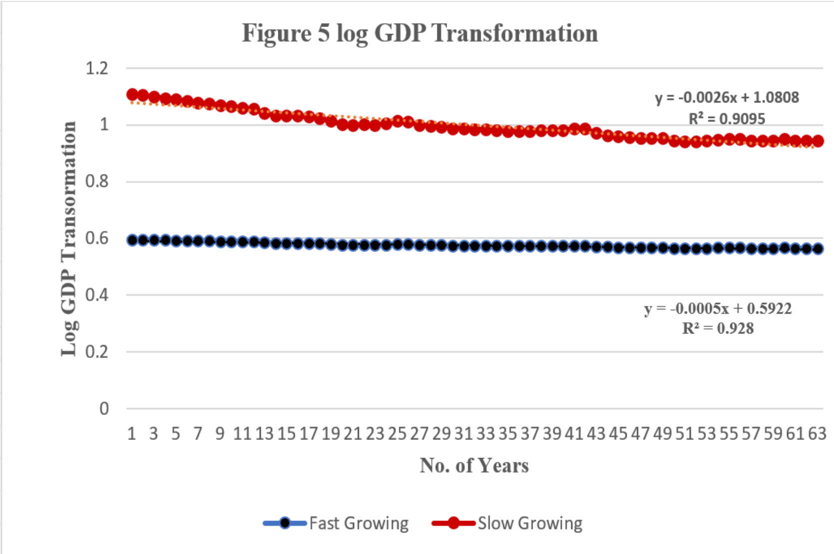


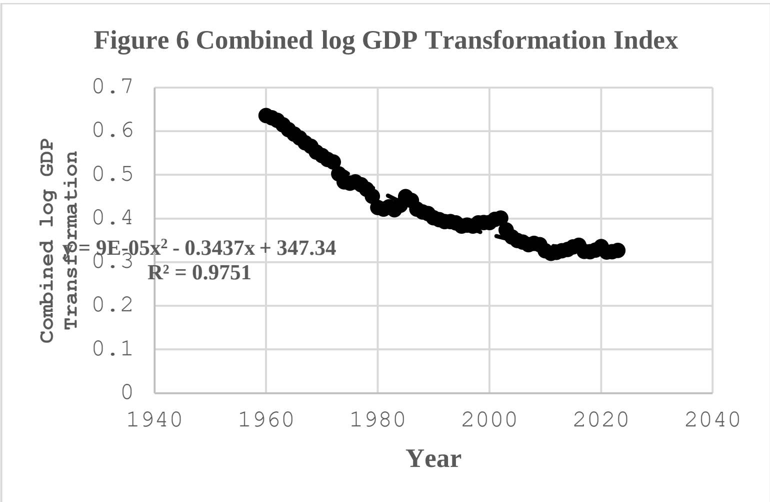
Problem Statement 2

It is more effective to convert the annual global GDP into average annual log values and subsequently transform these annual figures into a relativistic function. However, it is crucial to recognize that in determining the value of Lorentz transformation function can have a negative square root, say, $\sqrt{-.81119}$ equivalent to .81119i or $\sqrt{.81119}$ x $\sqrt{-1}$. The square root of -1 (i) is classified as an imaginary number; however, it is essential as it simplifies calculations and offers solutions to problems that would otherwise be challenging or unfeasible to resolve using solely real numbers. One alternative of making positive by squaring $y = \sqrt{-.8119}^2 x \sqrt{-1}^2$ = .8119 (1) = .8119. The equation depicted in Figure 4 represents the long-term log GDP trajectory or the predictive equation derived from the actual average annual log global GDP. The slope, which indicates the log GDP growth rate is .0269; however, this slope is not precise. A more accurate slopes with respect to time can be determined by transforming the data on GDP from the start to the finish via Lorentz transformation index is shown in Figure 5. The slopes are negative, indicating the negative relationship between transformation index and time. Figure 5 demonstrates that the log GDP transformation value is indeed decreasing by - .0026 and -.0005 for high-growth and low-growth economy respectively. These equations imply that time dilation occurs regardless of frame of reference. It appears to be normal for an observer within a high-growth economy; however, to a stationary or independent observer, the time in a high-growth economy seems to fall (black curve) in comparison to that of a low-growth economy (red curve). The correlation between log GDP growth rate and the change in log GDP is statistically significant (t = 17.087 $\rho =$ .000) and (t = 17.435 $\rho =$ .000) respectively. Generally, as time progresses, time contraction increases. The increase in time contraction is larger in high-growth economy and smaller for low growth-economy. as illustrated in Figure 5. Nevertheless, by subtracting the greater time contraction associated with a high-growth economy from that of a low-growth economy (which experiences a smaller time contraction), the resulting equation is = -.00018 + .3437 as illustrated in Figure 6. This indicates that time contraction diminishes by -.343 as time (in years) advances. In more straightforward terms, the observed decline in time contraction is attributable not only to the fundamental problem of scarcity but also supported by earlier research documented in the literature, which links this phenomenon to the inverse correlation between "potential" GDP and unemployment. According to its conventional definition, potential output denotes the maximum level of output attainable without triggering accelerating inflation (Fontanari, Palumbo, et al., 2022).

Consequently, the equation illustrated in Figure 4 meets the established definition. According to Okun's law which describes the relationship between unemployment and the country's productivity. It stipulates that for a 1% increase in unemployment, a country's GDP will fall by a greater percentage, usually double. A majority of studies which estimated Okun's law suggest that it is unemployment that responds to fluctuations in output (Boďa and Považanová, 2025). Okun's straightforward correlational relationship, further suggests a trade-off between unemployment and output, has undergone numerous evaluations with inconsistent results and conclusions. Despite that, this relationship has been characterized as "robust" (Blinder, 1997), and although there are some opposing perspectives (e.g. Gordon, 2010, International Monetary Fund, 2010, Meyer & Tasci, 2012), a general agreement exists that it typically persists, albeit with varying degrees of strength, asymmetries throughout the business cycle, structural breaks, or structural diversity (Ball et al., 2017, 2019, Nebot et al., 2019, Zanin, 2014).

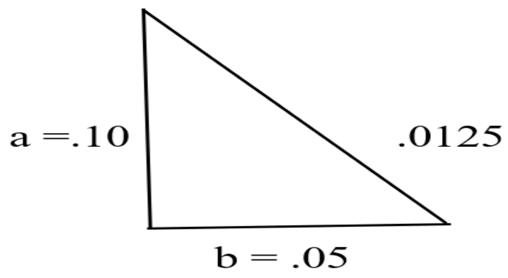
The findings also corroborate with the economic theory introduced by A. W. Phillips in 1958 which posits that there exists a consistent and inverse relationship between inflation and unemployment. According to this theory, economic growth is associated with inflation, which subsequently should result in an increase in job opportunities and a decrease in unemployment. However, the original concept of the Phillips curve has been somewhat disproven due to the occurrence of stagflation in the 1970s, when there were high levels of both inflation and unemployment (Barnichon and Geert, 2017; Ng and Wessel, 2018). Although, increase in log GDP may be viewed positively by all, it encompasses various dimensions of well-being. Typically, a rising GDP indicates an improved standard of living.





Evidently, the time appears to contract for an economy experiencing a 10 percent GDP growth rate, reducing to about 45 percent when compared to an economy with a 0.05 GDP growth rate as illustrated in Figure 7.

Figure 7 Pythagorean Theorem



$.0125 = a^2 + .0012$

$.0125 - .012 = a^2$

$.0005 = a^2$

$.22361 = a$

$.0125 - .0025 = b^2$

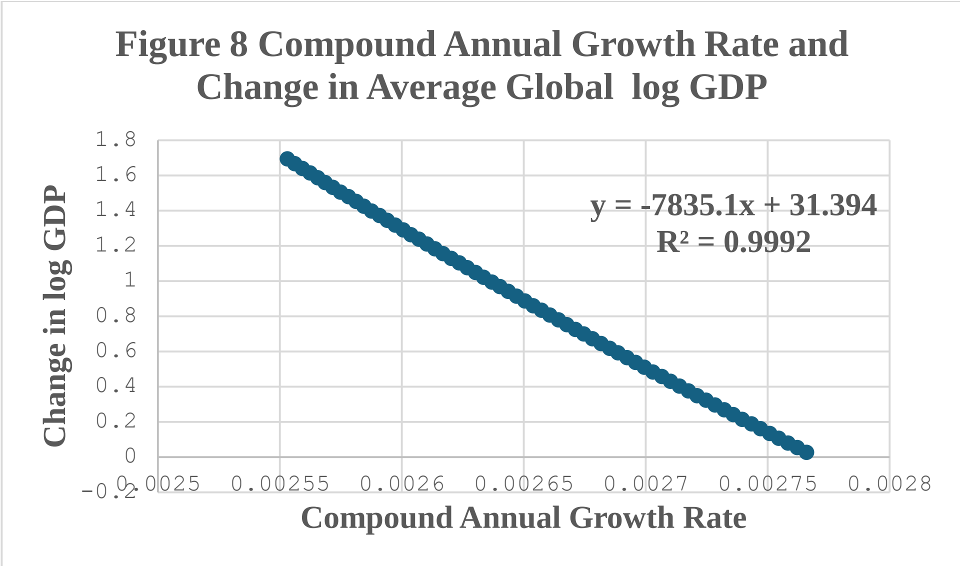
$.10 = b$

Lorentz Transformation

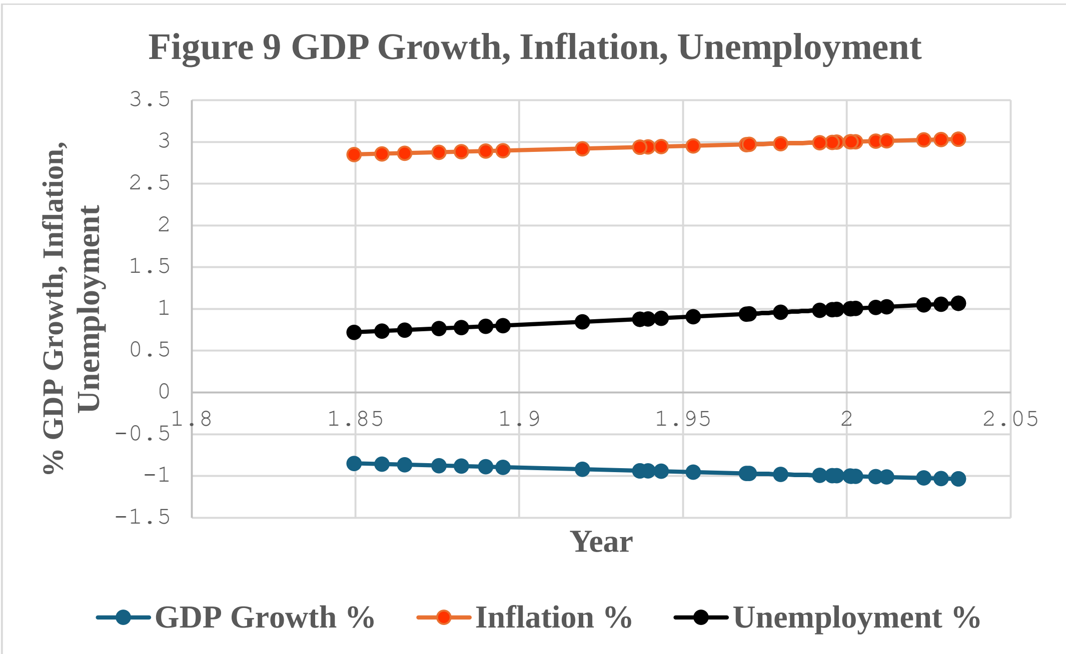
a = 1.0054093

b = 1.002497

Another alternative method for evaluating time contraction, albeit somewhat counterintuitive, involves transforming log GDP into present value (compound annual growth rate, CAGR) and constructing a regression line. Figure 8 also presents the transformation index (Lorentz, 1904). It is the relationship between compound log GDP growth rate and change in log GDP ($\Delta y = .0269\Delta x$). These two quantities may appear to convey the same idea, yet they are fundamentally different and possess unique meanings. The change in GDP measures the extent to which GDP has fluctuated as it progresses, whereas the GDP growth rate assesses the distance GDP has covered from its original point. Figure 8 demonstrates that with an increase in the compound annual growth rate, the change in log GDP declines.



Moreover, Figure 9 illustrates that the percentage of GDP growth is lower than that of inflation and unemployment. In contrast, unemployment shows the highest percentage from 1991 to 2018 (World Bank Open Data, 2025). the data appears to support Okun's law and the Phillips curve, which suggest an inverse relationship between inflation and unemployment—where an increase in inflation correlates with a decrease in unemployment, this is the reason that unemployment remains unchanged despite the ongoing decline in inflation. Evidently, an increase in GDP growth due to lower inflation correlates with higher unemployment - unemployment issue has not been fully eliminated.

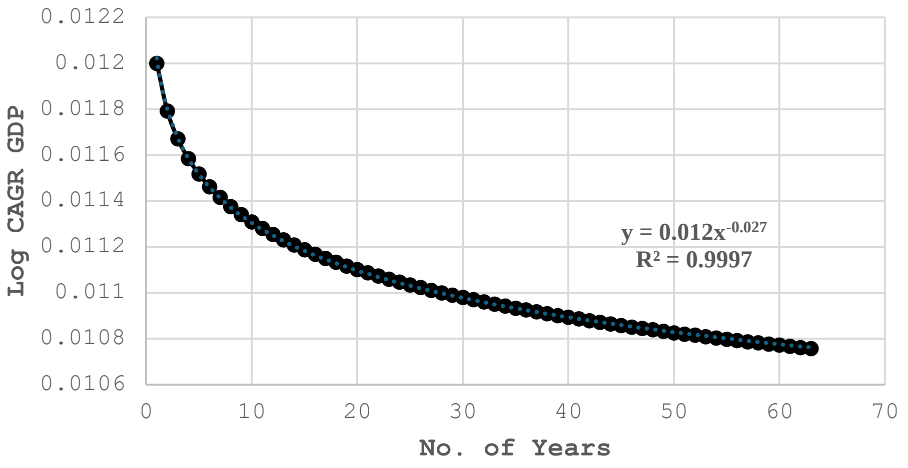


Problem Statement 3

It is essential to initially verify if the data points and their corresponding calculations are consistent with Einstein's theory of special relativity. One significant implication of Einstein's work in special relativity is that speed of light is a universal constant. An object that is in motion experiences time dilation, signifying that when it travels at high velocities, its passage of time occurs at a slower rate in comparison to when it is at rest. Hence, it is crucial to remind the readers that in 2023, worldwide energy consumption amounts to 740,000 terawatts (Ritchie, Rosado, Roser, 2020), equivalent to $7.4x10^{14}$ kilowatt-hours. This energy corresponds to a mass of $1.028x10^{11}$ kilogram-force per second. The connection between these two figures yields the speed or velocity, which is calculated to be $7.19x10^{3}$ or 7,190 per second approximately 3.86 percent of the speed of light. This velocity does not surpass the speed of light, which Einstein regarded as a universal constant. The data points, along with the corresponding calculations, are consistent with the theory of special relativity.

The research provides a brief examination of GDP estimates by utilizing the Compounded Annual Growth Rate (CAGR) method to analyze its behavior over time through the average annual change as illustrated in Figure 10. The equation in Figure 10 is significant ($t = 450 > t = 1.999$ at $df = 61$). The primary objective of the Compound Annual Growth Rate (CAGR) is to offer a smoothed, annualized perspective on the growth of an investment across a defined timeframe, facilitating the comparison of investment performance and setting realistic expectations for future returns. It effectively illustrates the annual growth rate required for an investment to increase from its initial value to its final value, under the assumption that profits are reinvested. This approach appears overly simplistic as it overlooks the actual discount rate and interest rate, along with their effects on inflation (excessive uptime) and unemployment (downtime). A positive CAGR may suggest a favorable economic outcome resulting from effective market entry, product innovation, or enhancements in operations, whereas a negative CAGR might indicate the necessity for strategic modifications. Consequently, Figure 10 illustrates, as compound GDP growth rate decreases, due perhaps to the market or any factor contracting as GDP grows, change in log GDP increases. However, this inverse relationship is not absolute and is contingent upon the relative perspective of the observer. For instance, in 1970, CAGR is .00327, while .000662 and .000182 in 1980 and 1990 respectively. CAGR diminishes over time. However, the effect of inflation on economic growth differs across nations and throughout different periods. This effect is influenced by specific characteristics of each country, the dataset utilized, and the methodology applied. Nevertheless, there is substantial evidence supporting a negative correlation between inflation and growth, particularly in developed economies (Akinsola and Odhiambo, 2017).

Figure 10 log CAGR GDP and Time



Briefly, change in GDP appears to decelerate when there is an increase in log GDP CAGR, and conversely, it accelerates when the growth rate decreases. The equation for CAGR below was utilized in the calculations for log GDP growth rates relative to the change in GDP. It is the average annual growth rate calculated over a defined time frame, considering solely the change in GDP along with the initial and final values of an investment or economy valuation. This equation was employed because annual growth rates can vary due to external influences, and merely comparing year-on-year growth rates does not provide a precise representation. The Compound Annual Growth Rate (CAGR) assists in mitigating these fluctuations by presuming a consistent growth rate throughout the entire period. This phenomenon can be ascribed to the diminishing variation in GDP, despite the increase in the GDP growth rate illustrated in Figure 10.

$$\text{GDP growth rate} = \left(\frac{\text{log GDP Ending}}{\text{log GDP Beginning}}\right)^{\frac{1}{t}} - 1$$

On average, the change in log GDP per Compound Annual Growth Rate (CAGR) decreases by -7,835 + 21.669 each year, even with the rise in input productivity. This situation seems counterintuitive, as the change log GDP growth is decreasing because the compound annual growth rate increases over time. In this context however, time becomes an essential resource as compound annual log GDP growth rate increases, the duration of time becomes shorter. Shorter time frames may encompass reduced workweeks or school days, increased productivity, better mental health, and a more balanced work-life situation (Office of Management and Budget, 2017 and Congressional Budget Office, USA, 2017). At any rate David Ricardo's theory of comparative advantage is true in the sense that nations gain from focusing on the production of goods for which they have a lower opportunity cost relative to other nations, even if another nation is more proficient in producing all goods (Staffa. 1073). This can be attributed to the tendency that profits and wages would exhibit an inverse relationship.

Consequently, as time progresses. log GDP CAGR diminishes, more rapidly as depicted in Figure 12. This indicates that as the economy expands at a quicker pace, the time required to achieve a specific growth rate level decrease. Assume that the highest compound annual growth rate (CAGR) of GDP is .00275, which corresponds to $5.1\text{x}10^8$ or 3,881 per second square, the ratio of this value to the speed of light (186,000) per second square is .0004. Consequently, Lorentz factor (γ), time dilation can be computed accordingly. In an economy exhibiting a CAGR of log GDP of .005, time dilation is .9995 times slower than in an economy with a CAGR of log GDP of .000275, which experiences a time dilation of 1.0004 times faster. Annually, time in a high-growth economy is slower by .08 % compared to a low-growth economy. Whilst GDP compound annual growth rate diminishes overtime, economic growth may still occur. This phenomenon is mathematically demonstrated through the definite integral of the corresponding equation $y = -.0003 \ln x + .0012$. This suggests that log GDP economic growth rate decreases by (7.1) times within a period of 5 to 10 years as detailed below. In 5 years, log GDP CAGR is .00362 while in 10 years log GDP CAGR is .00051.

$$-.0003 \text{ Ln } (10) + .0012 = -.00051$$

$$-.0003 \text{ Ln } (5) + .0012 = -.00362$$

$$-\frac{.00362}{.00051} = 7.1$$

Figure 11 presents the definite integral of log GDP CAGR along with the corresponding number of years. Ultimately, the log GDP CAGR tended to decline as time advances. To sustain a higher GDP growth rate, an economy must further minimize the time required to produce GDP through technological advances, as shown in Figure 10. It is sufficient to state that a high-growth economy will have ample time for other critical areas such as health, education, the environment, and income redistribution to ensure allocative efficiency. Time plays a crucial role in economic growth. The process called "invisible hand" (Berry, 2018) by classical economists indeed is the time dimension necessary for generating GDP both at local and global levels. Consequently, the law of comparative advantage (Sowell, 2006) is fundamentally a comparison not merely of cost (currency) - which is influenced by the fluctuations in investment and interest rates used for measurement - but rather, it is also primarily based on time.

Figure 11

$$-\int_1^5 .0003 \text{ Ln x} + .0012 \text{ dx}$$

$$-\int_1^5 .0003 \text{ Ln x dx} + \int_1^5 .0012 . \text{dx}$$

$$= -.00601$$

$$-\int_5^{10} .0003 \text{ Ln x} + .0012 \text{ dx}$$

$$-\int_5^{10} .0003 \text{ Ln x dx} + \int_5^{10} .0012 \text{ dx}$$

$$= -.00899$$

$$\frac{-.0899}{-.00601} = 1.481$$

When time dimension is incorporated in the measurement and assessment of GDP in the analysis of economic growth, it can enhance the monetary-based comparison of global GDP as illustrated in Table 4.

Table 4 Log GDP CAGR and Number of Years

Year	Log GDP CAGR
1	.0012
5	.00071
10	.000093
20	.0003
40	.000093

$$y = -.0003 \text{ Ln } x + .0012$$

$$y = -.0003\ (0) + .0012 = .0012$$

$$e^{0} = 1 \text{ year}$$

$$y = -.0003\ (1.6094) + .0012 = .00071$$

$$e^{1.6094} = 5 \text{ years}$$

$$y = -.0003 \ln(2.30258) + .0012 = .000093$$

$$e^{2.30258} = 10 \text{ years}$$

$$y = -.0003\ (2.99573) + .0012 = .00030$$

$$e^{2.99573} = 20 \text{ years}$$

$$y = -.0003\ (3.6888) + .0012 = .000093$$

$$e^{3.6888} = 40 \text{ years}$$

Meanwhile, for purposes of the study, a 100% (1) GDP growth rate is considered the maximum GDP growth that a country can achieve, making it a significant reference point. Using Lorents factor, Table 5 (assuming that GDP growth rate is CAGR) showed that India notably exhibits the highest time dilation of 0.1927 seconds, followed by China with a time reduction of 0.0801 seconds, and then the USA with a time dilation of 0.0163 seconds. Canada, UK, Brazil, Italy, France, Japan follow in descending order. This indicates that increased growth rates correlate with a more significant time dilation in relation to the gamma index, which is influenced by the GDP growth rate of the country.

Table 5 GDP Growth Rate and Gamma Index

Countries	GDP Growth Rate*	(γ) Gamma Index	Rank
USA	.018	.000163	3
China	.04	.000801	2
India	.062	.001927	1
Japan	.0006	.000000	8
UK	.011	.000061	5
France	.0006	.00000018	7
Italy	.0004	.00000008	7
Canada	.014	.00009801	4
Brazil	.002	.000002	6

***Source: IMF, 2025**

Time Relativity in Business, Banking and Investment Decision

Numerous measurements encountered in daily life can be further analyzed by utilizing time as a metric. For instance, time serves as a metric in most sports games. Additionally, various measurements in business, investment, and banking also employ time as a metric. The subsequent examples illustrate this. $I = Prt$, where $t = \frac{I}{Pr}$, $r = \frac{I}{Pt}$. In this context, both time and the rate of interest are inversely related to the interest itself. Time serves as the inverse of interest concerning the principal and the interest rate, whereas the interest rate acts as the inverse of interest in relation to the principal and time. Interest rate can equate into time vis-a-vis by the following equation:

$r = \frac{I}{Pt} = \frac{I}{\frac{1}{t}} = t$. Where t and r are equal.

Moreover, the projected future GDP values are determined by the anticipated productivity of capital and labor inputs (Cobb and Douglas, 1928) which is the ratio (A) between output and input (output/input). Hence GDP experiences growth based on the sum of production elasticity associated with capital and labor inputs as illustrated in equation 1 to equation 4. In instances where labor productivity diminishes, a nation may strive for a reduced labor-to-capital ratio, whereas it may seek a higher labor-to-capital ratio when capital productivity declines (note that GDP follows the variation of labor-capital ratio). Hence, GDP can either be lesser or greater than 1 or equal to 1. This indicates that increased GDP growth rates correlate with enhanced labor-capital productivity and extended time dilation. Nevertheless, the Cobb-Douglas production function, while a valuable instrument, presents several limitations: 1) the elasticity of substitution is fixed at one, whereas in practice, the elasticity of labor and capital fluctuates with variations in the levels of labor and capital employed. 2) It assumes that technology is constant and predetermined, whereas in reality, technology is continuously evolving. 3) It fails to consider the dynamics of market conditions and their impact on output. 4) It treats labor and capital as identical and interchangeable, which does not accurately reflect how industries adjust their output in response to market changes. For instance, a study conducted by Onalan and Basegmez (2018) revealed that the contribution rate of capital is 0.403, while that of labor is 1.094 towards economic growth. The total contributions of these factors amount to 1.497, exceeding one. The findings of the study indicated that the rate of GDP increase surpasses that of the growth in capital stock and labor. Over time, GDP is expected to exhibit a rising trend, even with the fluctuations in labor and capital utilization that alternate between increases and decreases.

The Cobb-Douglas production function represents the technological relationship between one or two factor inputs (such as labor and capital) and the total output (GDP) generated by these inputs. It is mathematically formulated as $y = AL^{\beta}K^{\alpha}$, where y denotes total output, A signifies total factor productivity ($\frac{y}{L^{\beta}K^{\alpha}}$), and β and α represent output elasticities for labor and capital respectively. This study introduces a simplifying assumption that total factor productivity (equation 4) is the aggregate of output elasticities. If the sum equals 1 (validated in various studies as false), the production system exhibits constant returns to scale (equation 1); if it exceeds 1, it indicates increasing returns to scale (equation 2). Constant returns to scale imply that doubling each input results in a doubling of output, while increasing returns to scale suggest that any additional input leads to more than double the output. For instance, constant return to scale illustrates the following:

$$y = A\,(100)^{.50}(100)^{.50} = 100 \quad \textbf{(eq. 1)}$$

$$A = \frac{100}{100} = 1.00$$

Since productivity (A) is simplified to be the sum of output elasticities. In reality, it may encompass additional factors that lead to increased output. Therefore:

$$y = A\,(100)^{.50}(100)^{.80} = 517.5 \quad \textbf{(eq.2)}$$

$$A = \frac{517.5}{398.11} = 1.30$$

$$A = .50 + .8 = 1.3 \text{ Total factor productivity} \quad \textbf{(eq. 3)}$$

Strictly speaking, total factor productivity is jointly determined by the output generated by each input of labor and capital (output/input). However, GDP is reported on an annual basis, allowing it to be assessed over time (for example, by summing the productivity of each input to represent the time during which GDP is produced). Therefore, *the sum of productivity of each input is essentially the total factor productivity which is essentially the time during which GDP is generated*. For instance, as demonstrated in equation 4 to equation 5.

Productivity of labor = .50, Productivity of capital = .80. Total factor productivity = 1.3

$$x^a x^b = (x)^{a+b} \quad \textbf{(eq. 4)}$$

$$100^{.50}100^{.80} = 100^{1.3}$$

$$398.1071 = 398.1071$$

$$100^{t} = 398.1071$$

$$t\log(100) = \log(398.1071)$$

$$t = \frac{2.6}{2}$$

$$t = 1.3 \text{ years}$$

Note that the 398.1071 output does not separately reflect the changing quantity of labor and capital respectively but the total factor productivity is known. This can be assessed in the following manner:

$$x^a y^b = 398.1071 \qquad \textbf{(eq. 5)}$$

$$8^{1.3} 12.5^{1.3} = 398.1071$$

$$(14.9285)(26.6675) = 398.1071 \text{ or}$$

$$(100)^{1.3} = 398.1071$$

Consequently, GDP is derived from the product of the inputs raised to the sum of the productivity associated with each input (for instance, the duration in years) during which the inputs have evolved.

$$100^t = 398.1071 \qquad \text{(eq.6)}$$

$$t \log(100) = \log(398.1071)$$

$$2t = 2.6$$

$$t = 1.3 \text{ Years}$$

If x is unknown

$$x^{1.3} = 398.10$$

$$1.3 \log(x) = \log 398.1071$$

$$\log(x) = \frac{2.6}{1.3} = 2.0$$

$$\text{anti} \log x = 100$$

Figure 7 demonstrates the inverse correlation between the GDP growth rate and the time duration measured in years. Utilizing the equation presented in Figure 5 suggests that a growth rate of five percent, the maximum 100 percent growth rate can be attained in 122.7 years, whereas a ten percent growth rate, it can be achieved in 62.8 years. This implies that elevated growth rates can be accomplished more rapidly through a substantial increase in productivity. The Solow-Swan model, introduced by Robert Solow and Trevor Swan in 1956, provides the most comprehensive understanding of economic growth. It is articulated through the capital-labor ratio and output per worker as follows:

$$\frac{Y}{L} = \frac{(L,K)}{L} \qquad \text{(eq. 6)}$$

Where: Y = output per worker
L = Labor

K = Capital or capital per worker

$$\text{Let } y = \frac{Y}{L} \text{ and } k = \frac{K}{L}$$

Assuming the economy is on the verge of achieving an output of 398.1071, with a saving rate of s = 0.10 and a depreciation rate of 0.05, calculate the steady-state capital per worker, output per worker, investment per worker, and consumption per worker.

$$\text{Since } L^{.50}K^{.80} \text{ or } (100)^{1.3} = 398.1071 \qquad \textbf{(eq. 7)}$$

$$\frac{398{,}1071}{10} = K^{.80}$$

$$.10K^{.80} = .05k$$

$$2 = K^{.20}$$

K = 32 capital per worker

$$Y = 32^{.80}$$

Y = 16 output per worker

I = sy

I = 1.6 i = .10 (16) Investment per worker

C = y – i

C = 16 – 1.6

C = 14.4

C = 14.4 Consumption per worker

Due to the fact that the output capacity of each necessary input is represented in t years, through mathematical reasoning that savings, depreciation, capital per worker, output per worker, investment per worker, and consumption per worker can also be articulated in t years. This indicates that all calculations will be conducted on a per worker and per year basis. For example, in a steady state, it is typically assumed that investment (i) should equal saving, while investment (i) is considered a fraction of output. The following holds true for saving (s) and depreciation (d):

$$s^t = dk \qquad \text{(eq.8)}$$

$$\log(1.6) = .05\,(32)$$

$$t\log(1.6) = \log(1.6)$$

$$t = \frac{\log(1.6)}{\log(1.6)} = 1 \text{ year (this indicates steady state where saving = depreciation)}$$

For capital per worker

$$.20\,t\log(k) = \log 2$$
$$.20t\,(1.5051499) = .30102999$$
$$.20t = \frac{.30102999}{1.5051499}$$
$$.20t = .20$$
$$t = 1 \text{ year (this indicates steady state where: } \Delta k = 0)$$

For output per worker

$$.80\,k\log 32 = \log 16$$
$$.80t\,(1.5051499) = 1.204119$$
$$.80\,t = \frac{1.204119}{1.5051499}$$
$$.80t = .80$$

t = 1 year(this indicates steady state: capital per worker = output per worker) (Note 1 indicates that any number multiplied by 1, it retains its original value). If the saving rate decreases to .05, then capital per worker is 1.0, output per worker is 1.0, investment equals .05, and consumption per worker amounts to .95. Conversely, if the saving rate increases to .20, capital per worker becomes 1,024, output per worker reaches 256, investment per worker is 51.2, and consumption per worker totals 204.8. Therefore, changes in saving results in the changes in capital per worker, output per worker, investment per worker, and consumption per worker. Personal savings play a vital role not only in an individual's financial health but also at the national level, where a high personal savings rate often correlates with a quicker economic recovery. With credit readily accessible, it can be argued that many individuals will begin to utilize their credit as though it were a savings account. Regrettably, this trend has resulted in a significant number of credit defaults; a notable instance of this is the chain reaction of defaults that triggered the economic decline known as the recession.

Consequently, increased productivity signifies a greater level of output (GDP), as the duration of time diminishes, discussed in the preceding section. It can be concluded that output (GDP) is directly related to total productivity while being inversely related to the duration of time. The process of making an investment decision adheres to a similar principle, where the duration of time is inversely related to the return on investment. As the return on investment increases, the time duration correspondingly decreases. By mathematical deduction, the following is true:

$$(1 + r)^t = P \qquad \textbf{(eq 7)}$$

$$t\log(1 + r) = \frac{\log P}{\log(1 + r)}$$

If the logarithm of return on investment (log r) rises, then the time (t) must diminish while keeping the logarithm of GDP growth rate (log P) constant. In simpler terms, time is directly proportional to the logarithm of GDP growth rate and inversely proportional to the logarithm of return on investment (r). In this context, negative values of t indicate a negative increase in time.

Conclusion

Economic growth experiences consistent transformations, with time serving as the metric for its assessment. Time is the most precisely quantified physical entity, providing a distinct numerical value for measuring GDP. It delineates the precise moment at which instantaneous GDP is recorded, as well as indicating a time span that represents the duration of GDP as an ongoing occurrence. A nation's GDP is evaluated in comparison to another by utilizing solar time. This evaluation is performed through direct observation of the global GDP. Average solar time denotes the time that would be recorded through observation if the GDPs were to increase at a steady apparent speed throughout the year, rather than at a slightly variable apparent speed, as it actually occurs, influenced by various factors (including meteorological and economic factors). The difference between the average log global GDP and a country's log GDP CAGR is known as the equation of time as illustrated in Figure 5. This is generally represented as a correction, approximately 1.0 second if measured in seconds, 1.0 minute if measured in minutes, 1.0 hour if measured in hours, and so forth, either added to or subtracted from a nation's GDP solar time to determine its average GDP growth rate.

When the GDP remains unchanged, the importance of time diminishes, as time stops its progression when GDP ceases to fluctuate. This indicates that the time is zero when the growth rate is zero. The growth rate of GDP depends on the frame of reference. The length of time in one frame of reference can be viewed as either longer or shorter than in another frame of reference. In this study, time appears longer for economy with low growth rate and shorter for an economy with higher growth rate. The global positioning of GDP growth rates and the enhancement of access to international trade can leverage the relativistic effect of a change in production time. The sustainability of GDP can be assessed by observing the changes in GDP per capita, as this reflects variations in the potential for future growth, unfortunately this is beyond the purview of this research.

There exists a potential inverse correlation between GDP growth and time to produce it. This arises on the inverse relationship between unemployment and productivity. As unemployment increase, GDP will fall by a greater percentage. At any rate, increasing productivity of inputs particularly increase in capital formation, along with advancements in human capital, leads to a reduction in the time required to generate a larger output. The opposite is true, prolonged periods of slower growth may result in diminished economic development, lower living standards, and heightened unemployment. This situation can also influence fiscal stability, possibly resulting in increased deficits and debt obligations. Furthermore, it may have repercussions on inflation, potentially causing deflationary pressures or, in certain instances, stagflation. Currently, it remains challenging to identify practical applications for the discovery, however, it is evident that time progresses at a slower pace for a nation experiencing a high GDP growth rate compared to one with a low growth rate. With advancements in technology, culture, and society, GDP growth can significantly increase in a shorter period. There exists a considerable likelihood of revolutionary innovations, medical breakthroughs, and new scientific discoveries among nations. All of these factors may enhance social norms, art, and language, provide enrichment and education, as well as offer solutions to current challenges for a potentially improved world. Achieving a GDP growth rate equivalent to 100% of the speed of light is unattainable. If we assume it were to reach this speed, time would cease to progress. While GDP would be expanding at its maximum capacity, there would be no awareness of this growth, as everything would have transformed as well. Life teaches us to make good use of time, but time teaches us the value of life…. anonymous.

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