

ECONOPHYSICS AND ECONOMIC GROWTH RELATIONSHIP

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***Abstract.** All sciences taking their fact interpretation power from paramount modeling skills of physics. The mathematical modeling logic of Physics, for almost all the sciences has been a source. The technology of the modern world has pretty much benefited the experimental accumulation of physics. Indeed, the models and the mathematical methods, which are by such strong science, which is so effective in explanation and also creation of the modern world, created, was a science source for even economics and the economists thought that the economy through these methods could be explained. Nevertheless, our technology and civilization based on physic theories and these theories manages and shapes our world and the universe. According to objective science classification of Arthur Koestler, which by the science environment accepted, takes the physics the first place after math, because it provides a source for almost all sciences and internalized the math as its language. Because the most objective explanation of the scientific topics belongs to physics, and we are trying to explain the economy as objectively as possible, it is inevitable to create an interdisciplinary connection with this science.*

***Keywords:** thermodynamic entropy, social entropy, multipliers, crisis phases, Gross National Product, cyclical fluctuations.*

1. Introduction

Sir Isaac Newton, honored as one of the most important scientists of the history, enlightened by law of gravity not only a natural occurrence, but he invented also a new method of analysis. Newton, has defended that all the nature could be explained by this two-dimensional and inductive method of analysis with highest possible generalization. In fact, it is adopted one of the most important generalization of nature events by the human intelligence could create so far. This method anticipates that the results of the reaction examinations of small particles can be applied for larger particles, too. Economics has benefited like all other sciences this method of physics to able to be an independent science. It can be said that

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it is not a coincidence that economics has undergone the similar phases that the nature sciences, especially physics have undergone. We can see the effect of physics on economics from Adam Smith till the speech and publications of important classic and neo-classic economists. So that, after 1980's according to scientists of the dominant economics schools, is the only way to understand neo-classical economics is to understand physics.

This study tries to explain the economic development process with the help of physics theories. Particularly, it will be tried to explain development process over the concept of one of the thermodynamic laws "entropy".

2. Entropy of closed systems

Entropy is one of the most important and most solid physics law. In physics, it is the second law of thermodynamics and with the simplest definition represents the movement of all the physical systems towards "irreversibility untidiness". Entropy, validity was proved theoretically and also experimentally, says that the motion of the particle is initially on direction of balance, but after this balance point toward untidiness, while this movement is irreversible. This condition has been described as an inevitable feature of nature. Classical view approach that defends that a movement must be only towards equilibrium and this equilibrium situation will be maintained forever, lost its validity. Truly, the universe offers no proof that the orderliness and equilibrium situation neither been previously realized nor could achieve in the future. Therefore entropy is a so useful concept that it is used in several different disciplines with different functions like "Thermodynamics entropy", "Topological entropy", "Social Entropy".

Entropy is based upon logic of an autonomous and closed system. A thermodynamic system is always moving towards equilibrium. But in privacy according to entropy, after this equilibrium status more energy could not be converted into mechanical energy in an irreversible manner and begins to exhaust itself. The untidiness should increase more and more on yet. However, if this closed system, which was assumed as a constant, get energy from outside (with different explanation if energy is gave into system) lose the entropy its effectiveness. The largest physical unit, cosmos, is a closed system and receives theoretically no energy from outside. So its entropy multiplier increases, makes more energy irrevocably useless, thus exhaust itself. Likewise vanishing of the stars is explained by this theory and the observations are giving exact same results according to the theory. Finally, a closed system uses its internal energy and all the processes which in closed systems occur are irrevocable.

This paper will explore whether the closed economy model, which the dominant economics schools predicted, exactly causes the results that the entropy theory predicted. In this study, the economy is considered similar to the cosmos. It is true that the social systems and physical systems have very different structures, but it is presented here the methodology of nature sciences. The meaning of closed system for economy is not only a country economy, but the whole capital world economy. The method that will be pursued is to examine that the economy will reach to balance point but after this point the economy moves toward untidiness, the effects of this situation on the social reality and why it is possible to prevent this effects through the intervention to political and economic system. This is a representation of the irreversibility of the entropy in social systems like in theory predicted. Here the mean of “intervention” is not just the public or government interventions but even the intervention which is spontaneous occurring like institutional, social, demagogic, and ethic structure of a society. These effects should be accepted as the most important obstacles on the liberalization process.

3. Economic Development and Crisis

The development level of countries is not dependent only on their economic mechanism. At the same time it depends on the physiological, anthropological, demagogic, sociological and especially political structure. It is quite difficult to quantitatively evaluate these effects. But it can be said that politics plays a more important role than the others because of its relation between economics. For example, the macroeconomic indicators which are accepted as crisis threshold are not valid for the U.S.A. USA shows a continuous and orderly growth trend. But JM Keynes has showed that the economies can reach to balance status even in underemployment situation and entropy means the confusion after balance point. So it will be helpful to obtain objective results to examine whether the existence of entropy over developing country economies which have less international political power.

In liberal economies, the continuing crises and immediately following growth oscillations, so cyclical fluctuations, are first introduced by especially W. Mitchell, J. Schumpeter, T. Veblen, and other several economists. According to cyclical fluctuations opinion, developing countries are in periodic crises and growth oscillations and these oscillations are placed on a trend line. This situation has several reasons. The most important one is that the economy doesn't have necessary constitutional rules or these

rules are not applied enough, so that the liberal economy can run correctly. This causes transferring of production instruments from productive to unproductive one. Therefore if there is no intervention to the economy in developing countries (as previously said, not only political but also social intervention), source distribution will be failed, the productivity will be decreased. As a subject, the necessity of external interventions to the economic system in the frame of entropy is the starting point of this study.

Basically, it is a macro-scaled issue whether the entropy can be applied to economies. It is about the general structure of the economy and the markets. Therefore, entropy for economic events will be investigated with the macroeconomic indicators. It is specified that the entropy means the movement tend to disorderliness of the system. Can be mentioned this case for the economies? To able to answer this question, at first some assumptions must be exposed. First assumption is: "In developing countries, if there are no interventions to the economy, the growth process is not continuous and orderly but this process occurs on a continuously increasing growth-crisis oscillation trend". This means each economic crisis is deeper than the previous crisis and each growth after crisis has a higher rate than the previous post-crisis growth. At this point, it will be examined the compliance of assumptions of some economies. The growth process of an economy which is analyzed in macro scale is measured by the production increase and decrease. In this case General National Product (*GNP*) will as a main indicator considered.

It's needed to present some assumptions to analyze entropy for economies. First of them is crisis and growth rates for an economy. Concretely how high is the positive or negative effect of crises and growth on an economy. This can be named as "amplitude" of the economy. Naturally developed countries have relative lower amplitude value than the developing countries. But this situation only implies that the crises in developed countries occurs in longer periods with lower rates and growth process takes longer with higher rates than the developing countries. Crises in developed countries can be less destructive than the developing countries because of the availability of the needed funding, institutionalization and isolation from internal political interventions. If it's analyzed the structural basis of the 1997 South East Asia and Russia, 1998 and 2000-2001 Turkey economic crisis, it can be clearly seen this situation. So, the "amplitude" of the economy is an important parameter for the investigation of growing period. In an economy, it's an important measure we should take, how often experiencing a crisis and growth processes, how

often entering to a new process. That's why the second parameter is the frequency growth and crisis periods, so period frequency.

Under these assumptions, some mathematical representations can be exposed. At first it was said that generally applicable knowledge source of economic growth is gross national product. Therefore it is the data source of the models which is here shown.

According to the Keynesian economic model, the growth of the economy is realized with the total demand and total production increases. This total demand is the sum of community consumption, total investments, government consumption and foreign trade. In this context, it can be said because foreign trade data depends on changes on world economy, the activities in other countries can increase or decrease the fragility of a country, so the count and rate of the growth and crisis periods of the country which is dependent to other countries. Government consumption or debts sometimes causes to irrational consumption like elections or future anxieties of politicians, and break the production or consumption balance. So, such as indicators like foreign trade, government consumption, are key indicators of the fragility for an economy. With a more general expression, if a country still grows in spite of the existence of factors that prevent the growth of a country under normal conditions, increases the fragility of the economy. That's why *GNP* is the main data source in this study.

4. The amplitude and frequency multipliers

If the amplitude of an economy is examining by the gross national product, then it can be examined by the proportional difference between growth and crisis phases. To able to this, the percentage change between top points of growth periods and deep points of previous and next crisis after growth must be calculated. The counts of growth-crisis periods are in the same way important to achieve the amplitude. It will be obtained certain number of data if the growth and crisis periods separated according to deep and top values of each period.

For the amplitude multiplier of the periodic motion (wave length):

g = sum of absolute *GNP* percentage change rates in growth-crisis periods;

n = count of growth-crisis phases;

$$h = \lim_{g \rightarrow 0} \frac{1}{n^{\sqrt[n]{g}}}. \quad (1)$$

The mathematical result is unknown if “ g ” takes zero. This means that measurement of amplitude doesn’t make a sense for a country that has no changes on total *GNP* change rate. Close to zero the number of “ h ” shows the resistance of a country against to the situations which caused a crisis. As long as the resistance increased, amplitude is reduced.

The other parameter is frequency multiplier which is needed like amplitude for the end-model. Under before specified assumptions and depending on “ h ” amplitude multiplier, it’s expected that the frequency value should continuously increase or decrease according to increase or decrease of count of growth-crisis periods; for a relative lower “ h ” value situation, growth-crisis periods takes longer time. In this case at first it must be defined that oscillation period, so frequency multiplier should be semi-logarithmic linear model.

In an economy, it prevents to achieve a general wave function to calculating each elapsed time from the lowest point of the crisis to the highest point of growth. That’s why it’s needed to calculate an average value for all of the growth-crisis times and it’s needed to achieve a general wave function value that expresses the process averagely for an economy that is examined according to this average value. This value can be calculated over the summation of the duration of each period and represents on average how often a new growth or crisis period experiencing. This must be the second assumption on examine of frequency multiplier. This average period duration must give a lower value for an economy which often experiences a new crisis and growth period but the frequency multiplier that will used in wave length function, should give a higher value. Therefore frequency multiplier must be a negative function of average duration of growth-crisis periods.

In summary here are the assumptions of frequency multiplier:

- 1 – Oscillation period multiplier should be semi-logarithmic linear model;
- 2 – In order to obtain general wave function, it must be investigated on average how often entering to a new phase instead each of phase durations;
- 3 – Frequency multiplier must be a negative function of average duration of growth-crisis periods.

According to these assumptions can be reached to the following forms.

x = Duration of each growth-crisis phase,
 n = sum of duration of the growth crisis periods;

$$k = \sum_{i=1}^n \frac{x_i}{n}.$$

This is simply the arithmetic average of the letters. The independent variable for the frequency multiplier which will be calculated, defined with “ k ”. If the change of proportion of gross national product of the first phase and the gross national product of the last phase is constant and if there is no scaling, under semi-logarithmic linear model assumption, while the value of independent variable “ k ” increases, it is expected that the value of the dependent variable frequency multiplier which is adversely affected as previously shown, should decrease. Consequently, the basic form of the frequency multiplier is:

$$k = e^{1/\delta}.$$

In this equation, if the natural logarithm of frequency multiplier is calculated, we obtain the following form.

$$\delta = \frac{1}{\ln k}. \quad (2)$$

So far, already required parameters for the final equation were obtained. As the growth crisis phase occurs periodically, the equation should be trigonometric. The next equation contains all of the previous parameters. So first it needs to be elucidated how these parameters will be included.

At first the data set must contain a variable for each economic phase. These phases has been token in seriatim and annual gross national product. For the annual series is used to “ t ”. This variable represents each economic phase. So this is simply:

n = count of analyzed data;
 $t = 1, 2, 3... n.$

Previously shown δ represents the frequency multiplier. We can internalize count of the growth-crisis periods by relating t variable which represents the location of each data in *GNP* data set. The main model was trigonometric and “ $t.\delta$ ” shows the amplitude of the model for growth-crisis

periods. This means, while “ t ” increases; it will be wandered away from the equilibrium point. Typically, the amplitude value of an economy which has experienced only one phase, will be lower than an economy which experiences relatively often crisis. This reduces the value of the frequency for a stable economy and increases in opposite situation. This can be shown as:

$$\cos(t\delta) + \sin(t\delta).$$

5. The “ h ” multiplier

The other parameter that must take a place in model is “ h ” multiplier. This multiplier describes how many deep and high are the rates of crisis and/or growth. Because the amplitude multiplier controls the frequency multiplier, this parameter should be a multiplier of the frequency period that is above described. But according to entropy law this parameter should to describe progressive increasing volatility.

The mathematical description:

“ h ” is to infinity converging exponential expression of the model and must be the control parameter of frequency.

According to all of these assumptions, the model can be described like this:

$$y = f(t, h, \delta) = t + e^{ht} (\cos(t\delta) + \sin(t\delta)). \quad (3)$$

This trigonometric function expresses periodic and continuous progressively increasing volatility. “ h ” is the amplitude multiplier, “ t ” is the iteration value and “ δ ” is the frequency multiplier of the model. These values are the model constants which should be calculated for each country. “ h ” and “ δ ” are directly proportional. Because both of growth and crisis effects in the same direction.

Then, if ε is the untidiness multiplier for an economy:

$$\varepsilon = h \cdot \delta. \quad (4)$$

This equation represents the tendency of industry to untidiness, clearly said, measures the force of liberalism in an economy according to the previously presented assumptions of entropy. In this way the features of “ h ” and “ δ ” are valid for this ε equation, too.

6. The Analysis of Gross National Product (GNP) for Turkey

The data packet which will be investigated, is 1981-2005 *GNP* figures (in billion dollars) of Turkey (see Table 1).

Table 1
Gross National Product of Turkey (1980-2005)

Year	GNP (billion dollars)	Year	GNP (billion dollars)
1980	68	1993	179
1981	72	1994	132
1982	64	1995	170
1983	60	1996	184
1984	59	1997	192
1985	67	1998	207
1986	75	1999	185
1987	86	2000	200
1988	90	2001	146
1989	108	2002	181
1990	151	2003	239
1991	150	2004	299
1992	158	2005	361

Source: <http://www.tuik.gov.tr>.

The *GNP* values should be separated to the phases. These phases consists maximum growth points and lowest crisis points. It can be achieved such as a table, according to the *GNP* figures for 1981-2005 (see Table 2).

Table 2

Phase		GNP (billion dollars)	Change rate
1981-1984	Growth-crisis period	:72-59	-%18,06
1984-1993	Crisis-growth period	:59-179	% 203,38
1993-1994	Growth-crisis period	:179-132	-%26,26
1994-1998	Crisis-growth period	:132-207	%56,82
1998-2001	Growth-crisis period	:207-146	-%29,47
2001-2005	Crisis-growth period	:146-361	%147,26

For Turkey, there are 6 pieces of growth crisis stage and that is why the “*n*” variable for this example is 6.

$$g = -18,06 + 203,39 - 26,26 + 56,82 - 29,47 + 147,26 = 333,69.$$

According to the source data and equation (1):

$$h \cong 0,0633.$$

Also, the duration of each growth – crisis periods can be shown like in table 3.

Table 3

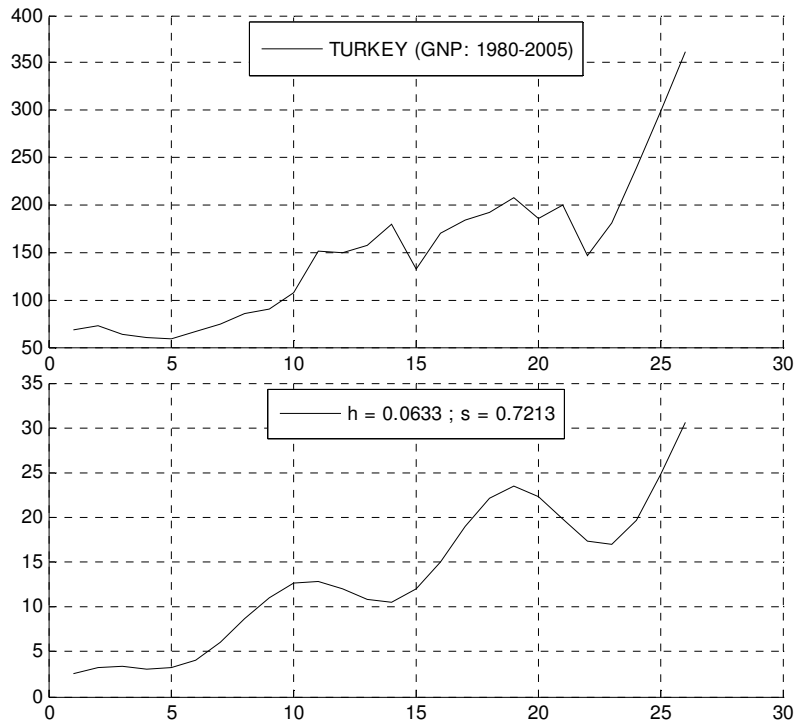
<i>Phase</i>		<i>Duration (years)</i>
1981–1984	<i>Growth-crisis</i>	3
1984–1993	<i>Crisis-growth</i>	9
1993–1994	<i>Growth-crisis</i>	1
1994–1998	<i>Crisis-growth</i>	4
1998–2001	<i>Growth-crisis</i>	3
2001–2005	<i>Crisis-growth</i>	4

“*k*” variable is the arithmetic average of the oscillation phase duration according to Table 3; δ is the frequency multiplier. If the equation 2 is applied to these data:

$$k = 24/6 = 4;$$

$$\delta \cong 0,7213.$$

The from figure 1 graphs is the representation of the function “*y*” that is obtained using equations (1), (2), (3).



The above graph from figure 1 represents the gross national product figures for Turkey in the billion dollars between the years 1980-2005, and lying down is the graphical representation of equation 3. If the values are interpreted for Turkey, it can be obtained similar results with the model. The result of this function for 2001 is the local minimum. After this point began a process of growth and it increases continuously until 2006. The value of the function on 2006 is the local maximum.

If the gross national product and the graph of the equation are studied, it is not expected that the movement time to be exact equal because the figures has been calculated on average. Thus it is possible that the anticipatory disorderliness of growth or crisis could be together at the same time or only one of them exists. So, sometimes there may be either only progressive increasing growth or only progressive reducing crises. Then it can be said that this economy in another specific structural condition which cannot be described with the indicators here explained, or could be as previously presented, relatively weaker or stronger political or social structural dynamics. But that obviously can be seen that the economic process overlapping with the equation.

This equation indicates that the economic process is not on the way equilibrium but rather on the way of disequilibrium. The *GNP* figures prove these assumptions. Truly the crisis in 2001 caused even deeper than 1994's crisis, and the 1994 is still lower than 1984's crisis. Similarly, the growth between years 2001-2006 is still higher than 1994-1998 and this growth is also higher than 1993-1994's growth.

For some countries has been calculated “ ε ” values according to gross national product in the context of the above functions are given on table 4.

Table 4

Country	h	δ	ε
India	0,0043	0,3235	0,0014
Spain	0,0122	0,3235	0,0039
South Korea	0,0501	0,5020	0,0252
Turkey	0,0633	0,7213	0,0456
Hungary	0,1020	0,5020	0,0512
Brazil	0,0921	0,5866	0,0540
South Africa	0,0736	0,8839	0,0650
Russia	0,1500	0,5020	0,0753
Greece	0,1109	0,7643	0,0848
Argentina	0,0872	1,1422	0,0982

According to ε variable, first striking countries are India and Greece which belongs to the developing countries group. For India variable “ ε ”, which is relatively low, means that the crisis are occurring in low rates and long periods than the other countries. Thus the opposite states can be applied to Greece and Argentina. But there is an important point that should be defined: While the values are calculated, the political and economic transformations should be taking into consideration. Therefore, if the political, economic transformations or structural evolutions of the countries considered while the periods are separated, function could distribute more consistent results. This separating process depends on the observer. For example, the economic and political evolution of Russia in 1989 or Hungary in 1993 should be studied in two forms as before and after evolution. Secondly “ h ” and “ δ ” values should be carefully analyzed. “ h ” value refers to the amplitude of growth and crisis periods but if two countries have approximately same “ δ ” value, then “ h ” describes only the progressive increasing growth or decreasing crisis. But it can be so interpreted if two countries have approximately same “ h ” value, then “ δ ” refers both progressive increasing growth and progressive decreasing crisis.

7. Conclusions

Consequently, this study shows that for developing countries could be mentioned the existence of cyclical fluctuation which is suitable with entropy law. It means that generally the growth-crisis and crisis-growth periods have higher rates than the previous growth-crisis and crisis-growth periods for an economy. But such as ever-increasing cyclical fluctuation causes a source distribution problem in economies and its negative social effects causes to converting more and more source unusable, reduces the productivity and finally the social welfare level. Therefore full liberalization of markets of developing countries causes economic problems and because of this the previously presented “external interferences” will be legalized.

Finally, it is not possible that volatility can sociological so continue, because the economic contraction means the reduction of production and employment. Community may come to a point so that the crisis will not to be cope. This situation causes for a society not only economic but also sociological crisis. So the social problems which are sourced from economic problems can be prevented, not through full liberalization, but through external interferences to the economy.

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