

**INNOVATION SNAIL, TRIPLE HELIX
AND OTHER CIRCULAR PROCESSES IN ECONOMICS**
Innovation Snail, Triple Helix, and Other Circular Processes in Economics
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The Triple Helix model of Innovation /1/ is gaining more and more supporters.

At the same time there remain 3 open questions which, if addressed, could help reinvent it from a visionary theory to practice theory:

- 1. Why is the triple helix model used to describe social progress?**
- 2. How does the triple helix model describe the current position and direction of a given society?**
- 3. What forecast can be made for a given society and its outlook?**

Quoting Henry Etzkowitz's Triple Helix /1, p.51/:

“... Triple Helix field theory (*hereinafter – the TH*) depicts helices with an internal core and external field space (see Figure 1). The model:

- helps explain why the three spheres keep a relatively independent and distinct status;
- shows where interactions take place;
- and explains why a dynamic triple helix can be formed with gradations between independence and interdependence, conflict and confluence of interest.

Conversely, the model can be used to help identify when a sphere is in danger of losing its identity.”

Figure 1. Interaction of the Triple Helix Fields: U – Universities, I – Industry, G – Government /1/.

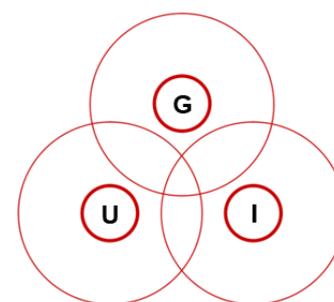
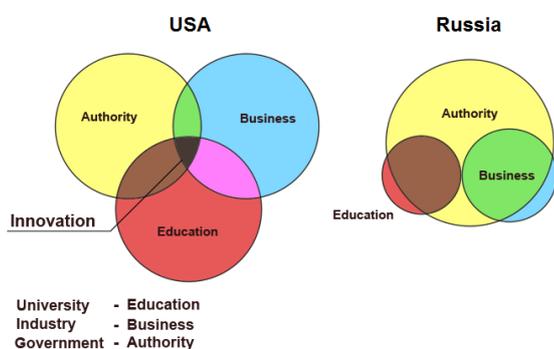


Figure 2. Interaction of institutional spheres in market (USA) and command (Russia) economies.

Our insight tells us that the author's arguments are correct, but how can they be substantiated? Reference /1/ offers a multitude of examples and documents, but gives no theoretical justification. The task is not too complex.

1. Why is the Triple Helix Model used to describe social progress?

1.1. The Triple Helix: Education, Business and Authority and how they interact

Why is it that these three elements – Education, Business and Authority – are singled out as the key elements of social progress?

To answer this question, our reasoning should be as follows:

Before discussing macro objects (global, national, regional economy), let's study the Triple Helix hypothesis at the micro object level – a typical household.

For this purpose let us note that China, for instance, has been using the sexagenary cycle system for millennia ($5 * 12$ -year period or $3 * 20$ -year cycles), the length of one cycle roughly matching the duration of a human life.

A typical human life cycle can be rendered in a typical S curve, not unlike the curves found in the Theory of Goods or Theory of Firm, Theory of Inventive Problem Solving (TIPS), Theory of Personnel, Theory of Civil Society /8-14/.

Evolution is usually described using the product life-cycle (PLC) model, a logistic S-curve adopted from biology.

The cycle is comprised of the four primary stages:

- market introduction of a product,
- exponential stage (growth),
- static stage (saturation/maturity) and
- decline (stagnation) /13/

The S-curve trajectory of development has been actively used by TIPS supporters for analysis of technological and social systems.

The S-curve has been repeatedly reinvented by economists, science theorists, patent experts and market analysts, which resulted in the multitude of names used to denote it: saturation, sigmoid, logistic curve, Foster's curve, product life-cycle curve, etc.

Figure 3 shows the three clearly defined segments.

- The first, flat segment – a new system's accustomization to the environment;
- The second, ascending segment – rapid growth and utilization of available resources;
- The third, flat segment – depletion of a system's resources.

Development of any system is determined by interaction of its opposing factors: those facilitating the development and those suppressing it. These factors are different for different stages of a system's life-cycle.

This law was first discovered in biology, then rediscovered in engineering and economics, and in late 1980s used to describe development of communities.

S-curves were first described in 1845 by Pierre François Verhulst. He was examining the development of yeast fungi colonies, and the result of his research was the S-curve. He found out that if less than 20 microorganisms were placed in the culture media, they wouldn't be able to survive. /15/

We can see that a great many authors utilized the S-curve for a variety of purposes. We can also see that the curve was sometimes segmented into 4 and sometimes into 3 parts.

On the other hand we would have to use one criterion in order to develop a theory that would describe interaction of the three vastly different systems that are Education, Business and Authority. Another key parameter is understanding what factors are characteristic for each stage.

This criterion will be the time variation in CFi net cash flow, selected based on the "Money talks!" approach and the concept of money as the universal measure of value /16/. Using this criterion we shall draw up a business plan for the life cycle of one member of the community called Humankind.

Figure 3 shows the S-curve of the income-expenditure life-cycle for an average person, represented as the time variation of his/her CFi net cash flow and profit. We can see that normally

CFi graphs show differentiated phases (similar to the graphs of $-\sin(\alpha)$ and $-A*\cos(\alpha-\beta)$, where A , α and β correspond to amplitude, change in the tilt angle and deceleration).

Profit here is the time derivative of CFi at every i -time interval of the S-curve.

A typical household includes three generations of family members: children, parents and grandparents. The accumulative household S-curve will then have segments of each generation's S-curve intersect with segments of an older and a younger generation's curves.

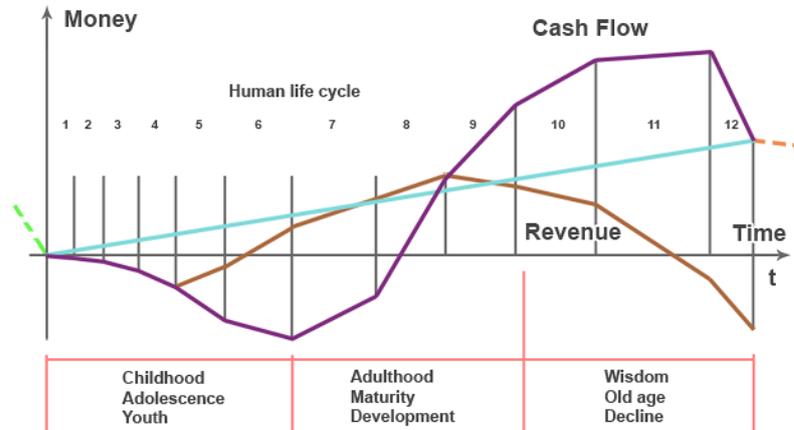


Figure 3. Typical human life-cycle (S-curve) represented by the time variation in his/her CFI net cash flow and profit.

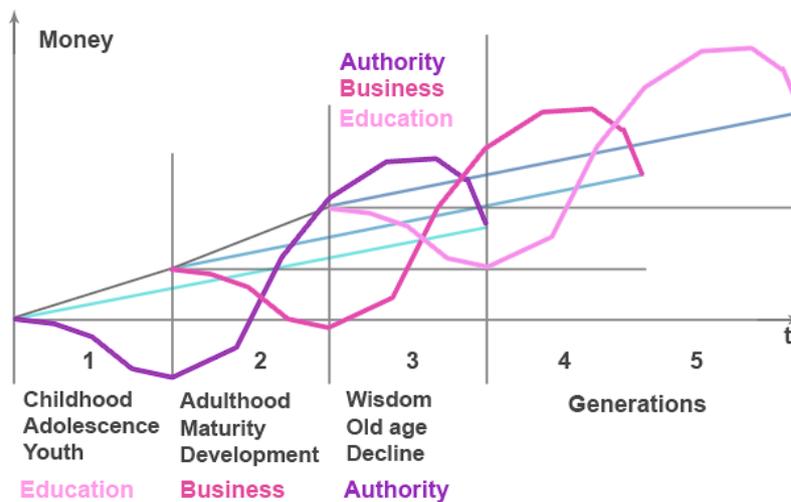


Figure 4. Typical household life-cycle represented by the time variation in its CFI net cash flow (Segment 3).

It's easy to find that a typical household is composed of three institutional spheres:

1. Education – the responsibility of children (20 years),
2. Business – the responsibility of parents (20 years),
3. Authority – the responsibility of grandparents (20 years).
4. Their intersection and summation produce the total net cash flow of the household.
5. Each generation's graph starts above the starting point of the graph of its preceding generation. This principle is key to a continuing dynasty.
6. These graphs however only show the opportunities that exist for every subsequent generation.

When combined, their highest points form an envelope S-curve for the whole family (Figure 5).

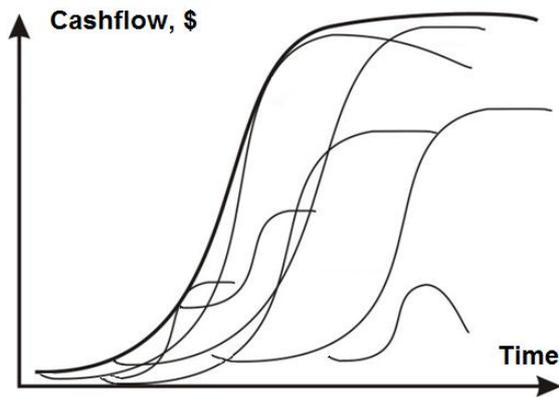


Figure 5. Life-cycle of a family represented by the time variation in the CFi of its members.

These are but intuitive conclusions, but they make it possible to rationalize that:

1. In the context of intergenerational continuity within a typical micro object of the economy (a household), we can single out 3 key institutional spheres: Education, Business and Authority;
2. The way these spheres interact both within a family, and within a state changes dynamically;
3. Different types of households (Western, Russian and Asian family patterns) will have these spheres interact differently, and so will the macro-economy in these parts of the world /2/.
4. If we sum up the enveloping curves for a city, region, country or the world, the result will be an integral value, in essence also an S-curve.

1.2. Cycles and waves in the global economy

Economic cycles, curves and waves

The economy is described by means of Kitchin and Juglar cycles, Kuznets curve and Kondratieff waves /17-20/. They all differ in nature /21/ and in the way they influence the economy and interact with each other (Table 1).

Table 1. Kitchin and Juglar cycles, Kuznets curve and Kondratieff waves.

#	Name	Time discovered	Standard period	Causes
1	Kitchin cycle	1920s	3—4 years	time lags in information movements affecting the decision making of commercial firms
2	Juglar cycle	1862	7—11 years	oscillations of the load level of existing production facilities, and oscillations of investments into fixed capital
3	Kuznets curve	1930	15—25 years	waves of demographic processes, in particular with immigrant inflows/outflows and the changes in construction intensity that they cause, “demographic” or “building” cycles/swings (infrastructural investment cycles)
4	Kondratieff waves	1930s	45—60 years	At the upward phase of a wave, expansion of economy results in social demand for changes. The opportunity for social change cannot keep up with economic demands, consequently a downward phase begins, with crisis causing the economy to restructure

What causes the formation of these S-curves in the economy? There is a multitude of factors, but in case of Kondratieff waves interacting with Juglar cycles the reason is clear: it is the level of development of the predominant technology model.

For instance, the following dating is given for the Kondratieff waves following industrial revolutions (see Table 2):

Table 2. Dating and causes of Kondratieff waves (1800—2060).

#	Dating	Duration	Causes (basic technology)
1	1803 till 1841-43	~ 40 years	textile mills, industrial use of coal
2	1844-51 till 1890-96	~ 45 years	coal mining and ferrous industry, railroad construction, steam engine
3	1891-96 till 1945-47	~ 53 years	heavy machine building, electric power industry, inorganic chemistry, steel and electric motor production
4	1945-47 till 1981-83	~ 36 years	car manufacture, chemical industry, petroleum refining, internal combustion engines, mass production
5	1981-83 till ~2018 г. (forecast)	~ 37 years	development of electronics and robotics industries, computing, laser and telecommunication technology
6	~2018 till ~2060 (forecast)	~ 42 years	possibly, <u>NBIC</u> convergence

* lowest economic indicators in the global economy /25/.

1.3. Changes if basic technology models

How do the basic models change? Genrich Altshuller has drawn the S-curves describing different technology models (technology systems), /23, p. 115/. They form the basis for the above cycles, waves and curves.

Accumulation of changes in a technology system will inevitably transform the nature of the economic system, thus starting a new cycle. Increase in production output and profitability of new technology will expel older technology, leaving their developers bankrupt. A recent example is the bankruptcy of Kodak, whose hesitation to adopt digital technology made it possible for newer players of the market to gain the upper hand /26/

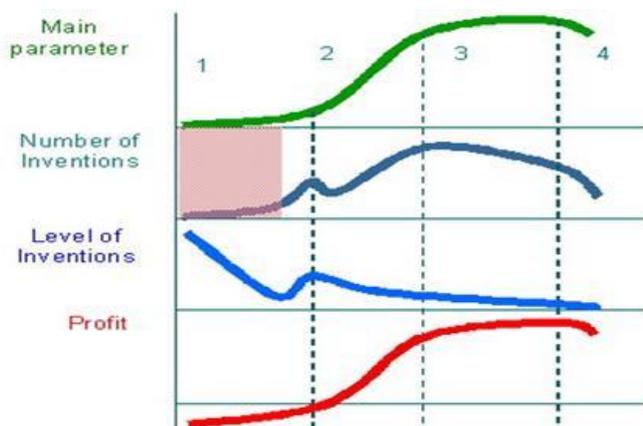


Figure 6. Correlation of the Main parameter, Number of inventions, Level of inventions and Profit of a technology system in various segments of its S-curve /23/.

Technical analysis of a technology system S-curve (Figure 8.1)

Definition of a technology system

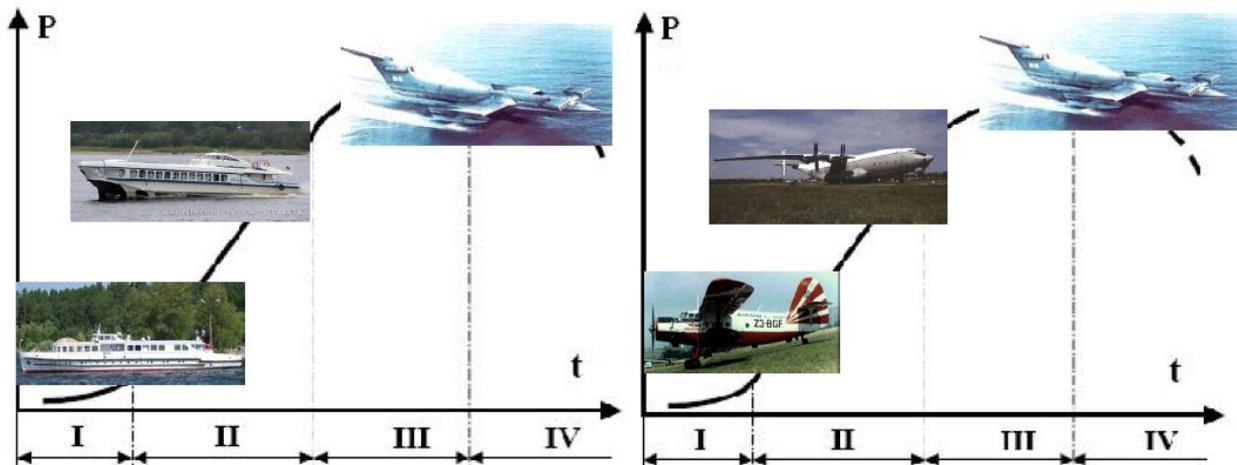
Choosing a definition can be a challenge.

For example: a ground effect vehicle can be regarded either as a part of a technology system (*the fastest*) ship or (*the most economic*) plane, see Figure 7. There can be a componential and functional approach to defining an evolving technology system.

Componential approach: what the system is made of, how the system works. The approach can be represented by a single S-curve.

Example: gasoline internal combustion engine, clearly belonging in the 4th stage.

Functional approach: what is the system intended for, what is the function of the system.



Ekranoplan KM (A ground effect vehicle, 1966, R.Alekseev, N.Novgorod, USSR)

- Flight weight: 540 tons;
- Max Velocity: 500 km/h.

<http://airboat.fatal.ru/ens/ens.htm>

Hydrofoil boat «Rocket» (1959, R.Alekseev, N.Novgorod, USSR)

- Deadweight: 25 tons;
- Max Velocity: 70 km/h.

AN-24 Antei (1965, O.Antonov's Bureau, Ukraine, USSR)

- Flight weight: 225 tons;
- Max Velocity: 600 km/h.

Figure 7. Transition from one technology system to another can be due to a series of changes /24/:

- **Ekranoplan KM**, A ground effect vehicle, 1966, R.Alekseev's Bureau, N.Novgorod, Flight weight: 540 tons; Max Velocity: 500 km/h.
<http://airboat.fatal.ru/ens/ens.htm> .
- **Hydrofoil boat «Rocket»** (1959, R.Alekseev's Bureau, N.Novgorod, USSR), Deadweight: 25 tons; Max Velocity: 70 km/h.
- **AN-24 Antei** (1965, O.Antonov's Bureau, Ukraine, USSR), Flight weight: 225 tons; Max Velocity: 600 km/h.

This approach is better described as “transition to a new S-curve” and “envelope curve”, see figure 8.

Example: the development of vehicle engine (including gasoline, injection, diesel engines, turbine, hybrid, etc.) will be described by an envelope curve of a series of S-curves.

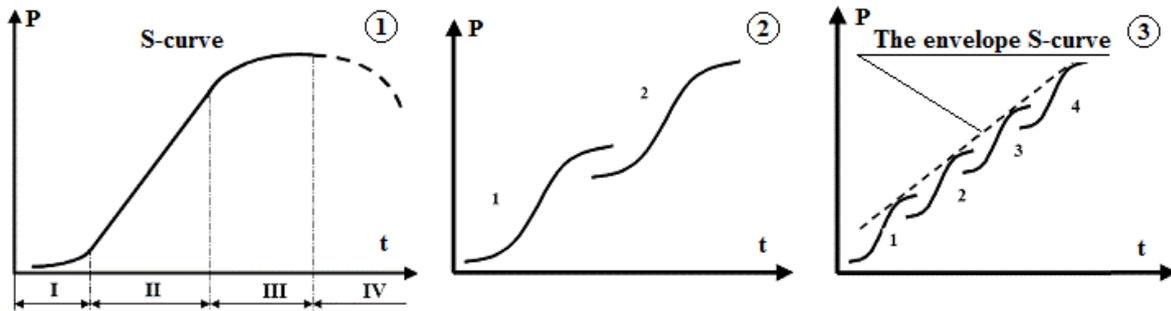


Figure 8. Classic S-curve (1), transition from one technology system to another (2) and formation of the resultant curve enveloping the S-curves of individual technology systems (3) /24/.

Figure 8.1. shows the development of the properties of one technology system:

- I: formation of the system (idea and test models);
- II: commercial manufacture of the system and its finalization;
- III: minor improvement of the system. Its key parameters normally remain unchanged;
- IV: degradation of certain parameters of the system /24/.

It should be noted that there are many limitations to development of a technology system: physical, technical, economic, legal, etc. They all have their own impact on development of both the technology system and the business based on that system.

2. How does the triple helix model describe the current position and direction of a given society?

In order to see how the spheres of the triple helix interact, we shall assume the following.

1. There are three primary spheres – Education, Business, Authority – which never cease to interact;
2. The position of each sphere in relation to that of the other two depends on its vector, which is the overall vector of the sphere factor distribution over the envelope curve;
3. Distribution of the factor has to be defined by means of a polar coordinate system.

This is the central problem of the whole TH theory. Only by solving it, only by defining the notion of the “sphere factor” and the overall vector for each of the TH components (Education, Business, Authority) can we draw the diagram given in Figure 1 /1, p. 53, Fig. 1.5/. Otherwise we cannot regard the TH as an instrument that can be used to describe the system of interaction of the spheres, let alone to define the current status of society and determine any corrections necessary, which would be the real life application of the TH theory.

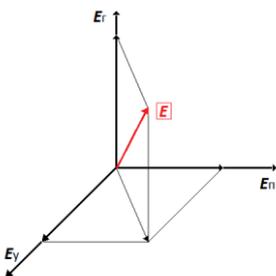


Figure 9. Synthetic interaction (of sphere factors) within the Triple Helix /1/.

What is this “factor distribution over the sphere”? If we are to discuss the Business sphere, the concept is more or less clear. We have adopted money as our criterion (the Business sphere factor),

which we all know to be the universal equivalent of value. To be more exact, we have selected capital gain or net cash flow CF as the factor of the Business sphere.

We will draw the Business sphere distribution using the result of our *Innovation Snail* research /3—5/ as set forth in the GACEBT (**General applied cost estimation business theory in FaceBook.com epoch**) theory publication.

Let us review the fundamental theses of the GACEBT theory:

1. Any society has **4 key resources** for its development:
 - 1.1. **Human resources** as the productive force;
 - 1.2. **Technology** as skills and practices that have been recorded and are repeatable;
 - 1.3. **Capital** as the funds accumulated as a result of exploitation of factors 1.1 and 1.2.
 - 1.4. **People** as the consumer society forming market demand for the goods, information and knowledge produced by 1.1—1.3.

These resources constantly interact throughout the whole life cycle of business, and *one of the resources is dominant* at a given point of the cycle, with the rest being only secondary.

2. Any community incorporates 3 spheres (clusters) where it develops by different principles /1/:
 - 2.1. **Education;**
 - 2.2. **Business;**
 - 2.3. **Authority.**

These spheres constantly interact with each other and with the spheres of other communities, thus ensuring their progress. But where there is a discrepancy between the levels of development of these spheres, a community suffers regress, with the cycle returning to the starting point upon failure.

3. We need the primary factor that would make it possible to place the resources against each other at every stage of the triple helix.

If we proceed from the notion of money as the universal equivalent of value /16/, our primary factor will be either revenue, net cash flow, profit or something else.

The author stems from the assumption that only two factors can be primary factors:

1. net cash flow in the I time period ΣCF_i .
2. profit, the first derivative of ΣCF_i .

If we outline distribution of first primary factor (CF_i) in the polar system of coordinates, its point positioned at 0 and 360 degrees will have a **singularity** – the so-called *paradigmatic rupture* defining the new stage of business development based on conceptually new knowledge of the society. The rupture can be either positive (the value at 360 degrees being higher than the value at 0 degrees), thus representing progress, or negative (the value at 360 degrees being lower than the value at 0 degrees), representing regress.

Our analysis of various business processes as homogenous revenue generation processes makes it possible to claim that in the course of its development (from generation of a new idea to its exhaustion) any Business will go through 12 stages, with resources 1.1—1.4 constantly interacting throughout all of them. Each stage has its typical revenue generation process and essentially unique, yet typical expenses.

These stages are (typical investment models given in brackets):

Business stages according to the Innovation Snail
Zero-profit stages:

1. Business idea (educational grants, self investment, i.e. the Founder);
2. Reflection on the business idea (the Family);
3. Primary business model (the Friends);
4. Establishment of a business entity (the Fools – people investing in venture projects, fund grants);

Profitable stages of a growing Business:

5. First sales (Business Angel);
6. Stabilized operation of a business entity (Venture Capital, VC);
7. Expansion to adjacent markets (direct investor, Private Equity);
8. The highest point of the extensive growth (Initial Public Offering, IPO);

Profitable stages of a mature Business:

9. The highest point of the production efficiency (Second Public Offering, SPO);
10. The highest point of the product trade efficiency (Stock Exchange);
11. The highest point of the information trade efficiency (Multiple Stock Exchanges);
12. Development of social orientation in the Business, its degradation or transition to the next stage (Soap Bubble).



Figure 10. Innovation Snail of a typical Business.

Education stages according to the Innovation Snail

If the primary factor for Business is net cash flow CF_i , what are the primary factors for Education and Authority?

The answer may vary between countries at different stages of their development. I assume that the primary factor for these two spheres is still the same, i.e. net cash flow CF_i , due to the fact that money acts as the universal equivalent of value.

For example, there can be radically different ways to generate revenue CF_i in the

educational system:

Zero-profit stages:

1. Self-education, family education;
2. Elementary education;
3. Secondary education;
4. Higher education (state-financing, grants);

Profitable stages of growing Education:

1. Post graduate education, master's degree, second higher education, MBA;
2. Doctor's degree or establishment of own educational institution;
3. Mentorship for post-graduates or formation of branches of an educational institution;
4. Scientific following or a celebrated educational institution with branches;

Profitable stages of mature Education:

1. Educational monopolies (500 largest universities, Moscow State University in Russia);
2. Education for ambition (Stanford University, trainings);
3. Distance learning (TUSUR with over 300 branches, former Jiangsu Radio and TV University, www.jstvu.edu.cn/);
4. Education as a social network (www.wikipedia.com, www.skillopedia.com, etc.), forums, cults, missions.

Peculiarities of the Education sphere:

Most people involved in the Education sphere in developed and developing countries go up to stages 3—5 before moving to either Business or Authority, causing Education to have an overall negative cash flow CFI at the global level.

Where a person continues in the Education sphere, there are two scenarios for development past stages 5—8:

Profitable – formation of their own educational business, possible cooperation with the other two spheres in pursuit of demand for educational services;

Zero-profit – scientific work which, if successful, evolves from a means to support one's family into a scientific following, generating high profit.

Any further development in Education is only possible at stages 9—11 with integration with stages given in 2.1—2.2, as market monopolization in Education (stage 9), maximum demand satisfaction (stage 10) and generation of profit from intellection property and proprietary rights (stage 11) can only result from constant interaction of scientific and educational aspects of the Education sphere.

At stage 12 the cash flow is reduced to minimum due to its negative value to the system, but keeping the cash flow positive will allow the system to move forward to the 1 stage of a new Innovation Snail.

Science and innovation dwell at the junction of Education and Education, Business and Authority, and even at the junction of Business and Authority. That said, scientific creativity is still primarily the prerogative of Education, as it complements the latter. After all, the purpose of scientific creativity is generation of conceptually new knowledge, and that purpose is closest to Education, as it is Education where young people seek to challenge the authorities.

Authority stages according to the Innovation Snail

I believe that Authority is the most complex sphere to describe and to form a graph for, as Authority today is a hierarchy that starting from stage 4 is withdrawn from the object it manages – the population, be it the authority in a household, a city, a country or the world.

We know that the primary characteristic of any authority is the economy it originates from and which the authority tries to regulate. Therefore, the two spheres are tightly intertwined with short time lags between the points of direct interactions:

- tax, tariff, regulatory, administrative, etc.
- financing of political campaigns, reinvestment or flight of capital, social responsibility of business, charity work, etc.

Interconnection of Education and Authority, on the other hand, although intrinsic, has much longer time lags. People move to the Authority and Business spheres after completing their cycle in Education as fully formed individuals. Formation of an individual takes decades. Education therefore has delayed impact on the other two spheres, while the impact of Business and Authority on Education is relatively immediate.

These peculiarities must be taken into account if we are to analyze the structure of the Authority graph.

Net cash flow CF_i can be determined by analyzing the business processes involved in generation of GDP on the territory of the Authority. The best way to demonstrate this is to draw the graph for a situation where Authority forms fast.

History shows that fast-forming Authority is often a dictatorship. Many cultures go through this stage repeatedly throughout their history, each time having a different ideology as the platform (Imperial Russia rested on monarchy, USSR – on communism, Russian Federation – on federacy, Union State of Russia and Belarus – on pro-Slavic sentiment, Customs Union – on post-USSR consolidation).

All the above considered, we can make the following conclusions.

Peculiarities of the Authority sphere:

1. Most people begin interacting with Authority earlier than with any other sphere (children are registered upon birth). At the same time, actual participation in its business processes and generation of its CF_i generally begins later than with other spheres, i.e. when an individual makes a choice to go into politics.

2. Business processes of Authority involve more participants than the other spheres do. Authority has the highest impact on the other two TH spheres.

3. Therefore Authority has the largest number of stages – 12 – engaged in generation of its principal factor, the GDP.

4. Many developed countries (Japan, Sweden, Switzerland, Luxembourg, Greece) are socially oriented countries with distinctively stagnant business processes from the point of view of the Innovation Snail of the humankind. That is the pathway to degradation of economy, resulting in recession, stagnation, deflation and regress.

5. Therefore, the more countries evolve from stage 11 (Information focus) to stage 12 (Society focus), the more generally unstable the development of the humankind will be, the more likely it is to move to a new level of the Innovation Snail.

And the humankind will only have two directions for further development:

- 5.1. Downward, as a result of a technological or natural cataclysm;
- 5.2. Upward, to “nanohumanity”.

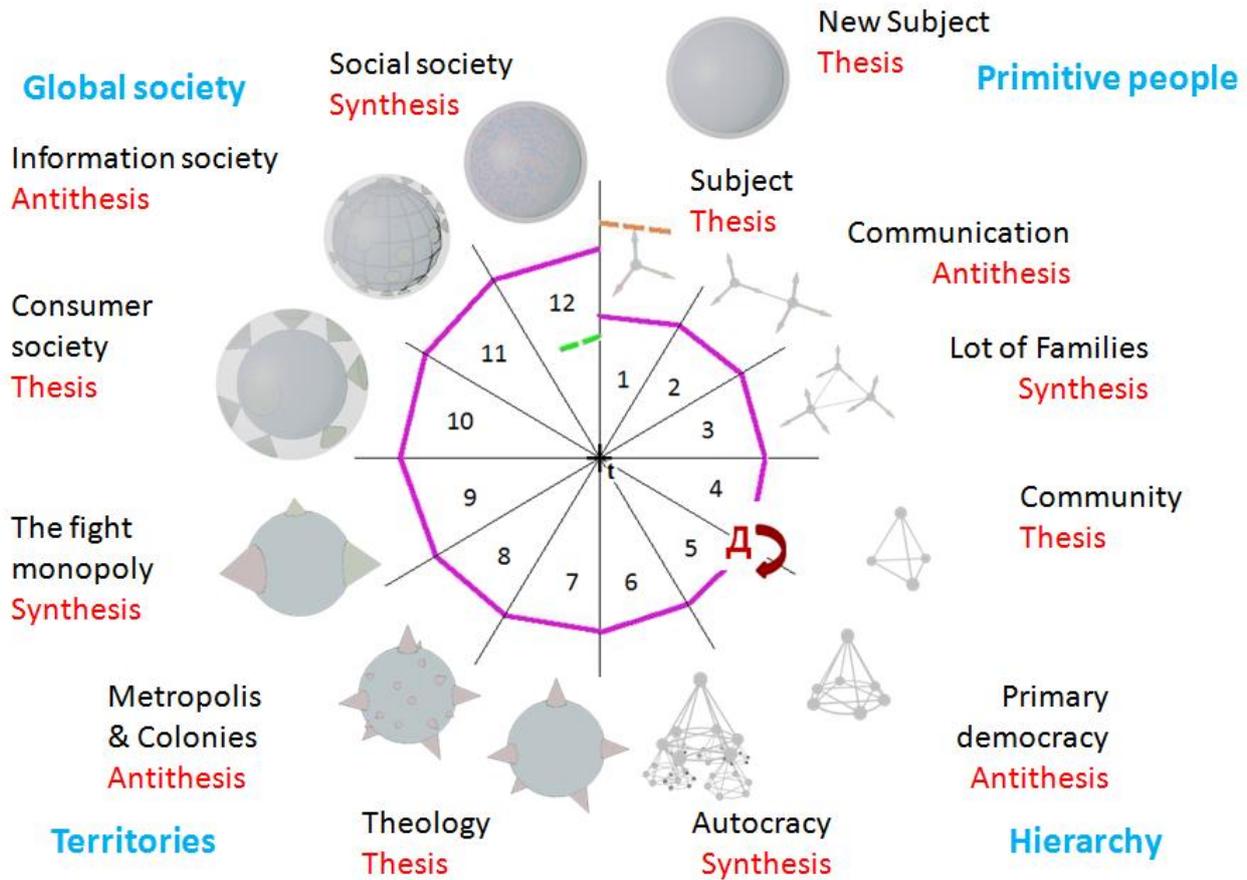


Figure.11. Helix of the humankind, upward development - from Eva&Adam family to Navy&Avatar family.

We shall also mention an alternative direction of development as described by Kapitsa in /27/, i.e. stabilization of the Earth's population due to sharp drop in the birth rate of developed countries and moderate growth of developing countries. This can automatically result in transition to a new, essentially regressive stage of the Helix where the reducing population of developed countries reaches the point when it can no longer exist independently.

A nuclear conflict in this event will be possible to avoid by democratically passing the authority to the new national majority (as is the case with the US President Barack Obama who is of Kenyan origin, only with someone focused on their national roots). That would stimulate the less developed countries invade the more developed ones, just as the Huns invaded the Roman Empire. The outcome of such invasion will inevitably be devastating, causing the other two spheres of the Innovation Snail to degrade.

On the other hand, it is possible that the very Innovation Snail can evolve. After all, it is based of the CFi factor. Should money be abolished as the universal equivalent of cost (which is a possible scenario today, when commodity and monetary markets grow apart further and further), the Innovation Snail can experience a development of its own without having losing its primary element, a human. So in the end, we may find that Karl Marx was right and the humankind will live in communism.

Triple Helix as a whole and as the result of interaction of its spheres.

It is evident that the Triple Helix system is unique for each territory in the way its spheres interact.

The very nature of the TH is based on the natural human life cycle, and its structure is unique for every person, both in terms of timing and in distribution of net cash flow CFi.

All TH S-curves are similar, whether it is individual curves for participants of each sphere, or their aggregated curves.

We shall note that universal adoption of ISO /28/ makes it easier to see this distribution, as these standards break the process into separate stages with definite types of business processes. This makes it possible to determine CFi for every stage of the process, placing it in the Innovation Snail graph.

Business is the most rapidly changing sphere of the TH. For instance, it took only 1.2 years for Yahoo.com to progress from stages 1 to 8, from idea and company registration by Jerry Yang and David Filo (March 1995) to IPO (April 12, 1996) /7/!

Authority has the widest scatter of co-existing stages with different business-processes. Any developed country will have type 1 business processes (generation of political ideas by society and formation of leaders) concurrent with type 12 business processes (religion, advertising, social networks).

Education is the most conservative and low-profit sphere. Its development pattern is remarkable in that past stage 4 it takes two separate ways, education proper and science, which inevitably merge upon reaching stage 9, forming a new synergy.

Global and local coordinates of the Triple Helix

Analysis of interaction and mutual impact of the TH:

1. Identify the direction of the vector of each sphere: Education, Business and Authority;
2. Place the spheres and their vectors against global coordinates;
3. Determine the extent of interaction between the spheres via projection of their vectors on each other.

The task is obviously a challenge, but should the human civilization be described and proved in this manner, the Innovation Snail may find practical application as an efficient tool for strategy development.

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