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Forecasting human development noting knowledge factor

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The author considers laws of human development as a system; the work covers population growth during the demographic transition, knowledge enrichment, features of the sequence of global technology revolutions and their interrelation with knowledge enrichment. The author forecasts the growth of global GDP and dates of next technology revolutions. The revolutions are proved to come in pairs close in essence. The author develops tools for forecasting human development basing on intellectual capital analysis both of individual countries and worldwide.

The book is intended for researchers, economic lecturers and anybody who is interested in issues of human development, knowledge enrichment and forecasting.

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Content

Introduction

> It is developed consciousness, language and culture that distinguish us crucially from animals and that is why we outnumber comparable to us creatures hundred thousand times.[1].
>
> *Sergei Kapitsa*

What drives human development? Many famous scientists attempted this question, however outcomes of their investigations are still relatively modest despite impressive achievements of hard science.

We can split atom nuclear and produce nuclear energy. A man was launched into space, we investigate planets of Solar system, have landed on the Moon. We discovered thousands of planets in other solar systems and are searching for space brothers. Big aircrafts deliver hundred millions of people to have rest at seashore. We decoded human genetic code and can treat transmittable diseases. We produce computers which control large plants and domestic appliances, robots which replace people in industry. Annual steel output exceeds one and a half bln of tons and grain output exceeds two and a half bln. We cannot do without a notebook and a car. Billions of people connect each other via Internet and mobile communication means.

Meanwhile we were unable to anticipate the severe financial and economic crisis of 2008 and still fail to perceive its profound causes.

Scientists have been attempting computer-aided simulation of human development for about 40 years starting from works by Professor Jay Forrester[2]; Herbert Simon, the US economist and Nobel Prize Winner, summarized these attempts with the conclusion that forty-year experience of simulating complex systems on computers that became larger and speedier from year to year taught us that brute force would not lead us along the royal road to understanding these systems; instead simulation would require us to turn to basic principles and it is they that would lead us to resolution of this complexity paradox[3].

Humanity entered the ‘demographic transition’ epoch and it has been long now that developed countries fail just to sustain their population level, instead we are unable to control this process, unsure about its causes and cannot decide whether it is good or bad that population of these countries stopped growing.

It was a shocking revelation when PricewaterhouseCoopers[4] forecasted that in the near future (by 2017) seven major countries, G-7, will yield the economic palm to developing economies including BRIC and by 2050 their economic weight (purchasing power parity GDP) will be twice as small as of the latter.

Meanwhile achievements of ‘knowledge economy’ and importance of innovative development are widely promoted though practically none of the forecasts interrelates knowledge and global economic growth quantitatively.

So what role does knowledge play in the processes mentioned above? Noting S.P. Kapitsa’s statement that humanity is first an information society that ‘originated directly at the dawn of

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1 Капица С.П. Парадоксы роста: законы глобального развития человечества. – М., 2012. – С. 19.

2 Форрестер Дж. Мировая динамика. Пер. с англ. – М., 2003. (первое издание – 1978 год).

3 Cited from: Капица С.П. Парадоксы роста: законы глобального развития человечества. – С. 22.

4 Хоксворт Дж., Тивари А. Мир в 2050 году. Ускорение процесса изменения баланса экономических сил в мире: проблемы и возможности. – 2011. – С. 3, 7. http://www.pwc.ru/ru_RU/ru/globalisation/assets/World-in-2050-ru.pdf

human society millions of years ago rather than followed after computers and Gutenberg, hieroglyphs and language', the author investigates the role of knowledge in human development.

This investigation intends to discover and analyse main drivers of human development as a single system and the place of knowledge among these drivers.

Humanity as a subject of investigation is considered from its origin about 1.6 mln years ago up to about 2120, i.e. the time where relatively exact development parameters are still available. If developed tools allow, the investigation concerns not just humanity as a whole but major economies as well.

The investigation should discover quantitative interrelation between major parameters featuring humanity as a whole, in particular population figure, GDP, amount of knowledge, frequency and content of technology revolutions, as well as other parameters featuring industry, distribution and application of knowledge (number of scientists and engineers, number of publications and inventions, cost of these activities, the role of language, etc.).

The author applies various quantitative research tools and some elements of the systems approach. The investigation is prognostic in its nature so considered first are parameters responsible just for magnitude.

The investigation comprises three parts. The first analyses the foundation of human development including a review of works accomplished in this area, provides analysis from the systems approach perspective and clarifies some issues investigated in details earlier: population figures and cyclic mode of its development.

The second part investigates the role of knowledge in human development. It analyses laws of knowledge enrichment in time and methods for forecasting global GDP growth related to knowledge enrichment. Also considered are the issue of how thinking originated and stages of the past world development.

The third part considers actualization of knowledge recourse via intelligence. Since different countries are developed to a high degree inhomogeneously, this part analyses different countries and groups of them additionally to the world as a whole. Note that this part is prognostic in its nature.

Conclusions

1. Differential equation for population growth (N) as function of time (T) is the following

$$dN/ dT = (1/C)\cdot N^2 \cdot(1 - N/N_{max}),$$

and its analytical solution that fits statistic data well is

$$T = T_1 - C/N - (C/N_{max})\cdot Ln(N/(N_{max} - N)).$$

2. Technology revolutions come in pairs close in the essence, for example, the First and the Second Industrial Revolutions. The time period between major technology revolutions fits geometric progression with the ratio of 0.5 and dates of these revolutions are represented by

$$T_n = 630 + 1392\cdot(1 - 2^{-n}).$$

3. Prognostic revolutions precede major revolutions and the total sequence of revolutions fits geometric progression which gives the following expression for dates of revolutions

$$T_n = 52 + 1970\cdot(1 - 2^{-n/2}).$$

4. The amount of knowledge (Z) in the period of hyperbolic population growth is expressed as

$$Z \approx 2.25\cdot 10^9 / (2050 - T)^{1.25}.$$

In the demographic transition period, the amount of knowledge may be calculated as follows

$$Z \approx 20\cdot(N/N_0)^{1.25}.$$

5. Publications, including patents, registered in Scopus reference database ensure about one third part of the knowledge enrichment.
6. In between revolutions, knowledge enriches by about half and global population grows by 40% that causes crisis events and renovation of economy worldwide.
7. The key factor responsible for the cyclic mode of economy development is the trigger effect when knowledge exceeds the threshold level fixed by the previous technology revolution.
8. The crisis started in 2008 prognoses a biotechnology revolution. Dates of next technology revolutions: 2026 – biotechnology revolution, 2059 – prognostic knowledge revolution, 2118 – knowledge revolution.
9. In modern world, global GDP is directly proportional to the total amount of knowledge

$$G = k\cdot N\cdot Z.$$

10. In the next century, global gross domestic product may be represented as follows

$$G = k\cdot N(T-25)^{2.25}.$$

11. In the period from 2010 to 2100, global GDP will grow quasilinear due to demographic transition and according to the following equation (by PPP in trn GK dollars as in 2010):

$$G = 4.4\cdot(T - 1993).$$

12. Currently the USA and EU are the largest economies by their intellectual capital indicator ($И_{ИК}$). China's $И_{ИК}$ is 10% less. Russia, Japan and India with $И_{ИК}$ 2.5 times less than it of the leaders take places from the fourth to the sixth.
13. Russian GDP is 41% less than its intellectual capital is able to provide. Japan loses 26% of its GDP, South Korea and Canada – 37% each, Israel – 52% and Ukraine – 70%.
14. Evaluating GDP by the intellectual capital indicator allows forecasting GDP growth of countries in future and fits well forecasts made by PwC and other forecasting institutions.
15. By 2100, global GDP will equal by PPP around 470 trn GK dollars as in 2010. By that time, China and India will be the largest economies in the world with GDP around US$100 trn each whereas GDP of the US and EU will be twice as less.

16. By 2050, Russia may join to the most successful large countries as to GDP per capita (more than US$70,000 per capita per annum) and predictably be the ninth in the world and will achieve this due mainly its intellectual capital.
17. In 21 century, main strategic aim of Russia will be to raise its GDP to $И_{ИК}$ ratio to the international standard by eliminating barriers to acquiring and applying global knowledge and by using immigration and other factors purposefully to avoid depopulation.
18. Specialists' contribution to GDP depends on their educational level exponentially

$$G_E = 125 \cdot 10^{E/5},$$

where E is the accumulated years of learning; G_E is contribution to GDP in GK dollars as in 2011.
19. The key factor of economy development will be intellectual capital of countries the amount of which depends on the number of engineers and scientists.

Summary

What are the drivers of human development, what laws govern them and what results will be achieved by following these laws? To investigate these issues was the main task set by the author in this work.

Global demographic issues and solution of singularity and demographic transition paradoxes are considered in the initial part of the work. The differential equation for the global population growth suggested by the author does not require introduction of new entities in order to explain features of demographic transition. Higher productivity leads to 'hyperbolic' fertility, however at a definite stage it allows women to choose between childbirth and career, i.e. new social perspectives. And it is hard to withstand this choice…

Direct interrelation between the utmost global population and the highest possible productivity determines essentially human development in the post-demographic transition period. Moderated population growth may lead to the human development stagnation so it is important to understand the situation when population stops growing and what threats this implies for humanity. The forecasted GDP growth, content and dates of technology revolutions in 21 century clarify these issues to some extent.

Knowledge is the second to demography force that drives human development. But how to measure so different knowledge, how to weight ideas of geniuses and thoughts of ordinary scientists? How to orient oneself in endless information flows? Estimations of magnitudes helped identify basic laws of knowledge enrichment, do 'first steps' in this direction. The results achieved in 'measuring knowledge" are rather interesting and help evaluate opportunities to use other knowledge databases.

For example, knowledge appears to enrich by half in between technology revolutions and it is this enrichment that seems to cause the so called 'long waves'. The author proves also that frequency of knowledge waves shortens and they come in pairs of close content like the First and the Second Industrial Revolutions. However the knowledge waves frequency elongates during the demographic transition.

An important conclusion derived from the adopted approach is that in modern age global GDP is directly proportional to the total amount of knowledge accumulated by mankind. So we can forecast the global GDP growth and identify the content of next technology revolutions.

Analysis underpinned with knowledge measurements provides the base for considering how humanity developed in previous epochs, what happened to knowledge when humanity passed the ‘bottlenecks’ hundred of thousands years ago, what helped homo sapience to survive and how far humanity was cast back.

Intelligence of people is the third force which comprises both people and knowledge and serves directly to transform reality. The Intellectual Capital Indicator (ИИК) model suggested by the author helps measure intellectual power of countries, specialist groups and the world as a whole; estimate their contribution to the global GDP and forecast elements of global development.

Estimations achieved with this tool prove higher education and science are the key recourses of country development and their effects may be estimated quantitatively quite precisely.

The author estimates quantitatively contribution of specialists of different qualifications to GDP and proves this contribution depends exponentially on the years of learning, so this highlights significance of the intellectual component.

Applicability of the results obtained is broad; because of their numerical nature they may form the robust base for strategic forecasting and planning both worldwide and by individual countries. And the Intellectual Capital Indicator tool seems to be most fruitful.

Suggestions concerning strategic development of Russia are worth special attention. Essential is the conclusion that intellectual resource of Russia dominates its natural wealth and this resource should have opportunities to be applied. The most persistent is the task to eliminate the gap between available intellectual capital and GDP, destroy barriers for engaging global knowledge. Should this task be accomplished, Russia might become one of the most successful countries as to its GDP per capita and this success would be achieved due to mainly its intellectual capital.

This work allows considering human development perspectives as far as next 100 years. The first half of 21 century will witness significant achievements in biotechnology. Afterwards there will be revolutionary changes in knowledge production. Global GDP will increase by about five times over that period and the quality of life will jump including developing economies. Previous opportunities to raise intellectual capital will be exhausted and demand for artificial intellectual systems will intensify so that new complex problems will require solutions.

In this book, the author did not consider problems of exhausting natural resources and transition to totally renewable resource base and environmentally perfect industry. Are modern science and technology capable to resolve these problems and how quickly?

Noting that aggravating ethic contradictions between the existing culture and scientific approach may imply a serious threat for further development within the knowledge enrichment paradigm, the author intends to consider a block of these challenging problems in future.

Development and raise of living standards in poor countries is considered in parvo though the author’s findings prove this problem to be of key significance for demographic survival of mankind.

Quite limited is the block of education problems that are essential for human development. The law of educational exponent opens vast perspectives that imply opportunities for multiplying efficiency of intellectual activity. The author intends to research these problems next.