
Journal of Religious Culture

Journal für Religionskultur

Ed. by / Hrsg. von

Edmund Weber

in Association with / in Zusammenarbeit mit

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in Kooperation mit dem Institut für Wissenschaftliche Irenik

ISSN 1434-5935 - © E.Weber – E-mail: e.weber@em.uni-frankfurt.de; info@irenik.org

<http://web.uni-frankfurt.de/irenik/religionskultur.htm>; <http://irenik.org/publikationen/jrc>;
<http://publikationen.ub.uni-frankfurt.de/solrsearch/index/search/searchtype/series/id/16137>;
<http://web.uni-frankfurt.de/irenik/ew.htm>; <http://irenik.org/>

No. 186 (2014)

Accelerating Scientific and Technological Progress and Forecasting Accuracy

By

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Abstract

In this article, the author shows that progress of info-communications is a key factor of society changes, as it radically changes the key aspects of human life. Studying the time of progress and comparing it with the most important anthropic characteristic - length of human life, he comes to the conclusion that our generation has witnessed the tipping point in the rate of development of human civilization. This showing up in the fact that the present stage of the scientific and technological advance lead to the transformation, perhaps on the same scale, what were the appearance of written language and publishing, but these multiple fundamental changes in the life of society occur within the life of a single generation.

In these circumstances, the task of forecasting, in its traditional setting, is becoming increasingly inaccurate. According to the author, the only possibility is to venture outside the framework of formal logic and technocratic approaches and try to find answers to these questions by generating new meanings of the realities surrounding us and in this context philosophy has a special role.

Keywords: progress, the dimensionless characteristic time of progress, speed of societal changes; time of one generation life, strategic planning, the area of incorrect forecasting, planning horizons

When you are riding a mountain bike or skiing down a mountain slope (especially if you gain more speed), you need to look forward. If you look under your feet, you see the day, belonging to the past, as this part of your path is almost over.

I. INTRODUCTION

Making an appeal to the subject of scientific and technological progress of mankind was always interesting in the first place, in terms of predicting the future. In this paper, we try to understand whether there is a possibility of a correct prediction in the circumstances of today. However, before turning to the issue, we will try to define a single trend of technological progress, speed, and also understand the situation in which we find ourselves in terms of the ever accelerating pace of its development.

The history of science and technology is a chain of epochal discoveries and technological breakthroughs that allowed human beings to stand out from the animal kingdom and, later, develop civilization. In that case, by virtue of the specific role that fixation and transmission of information played in the process of becoming homo-sapiens, the development of what we now call the info-communications was particularly important. The breakthrough events of the second half of the XX century began with the advent of computers and the invention of the microchip in 1971, making it possible to move towards miniaturization and simultaneously reduce the cost of computers. Then came the emergence of the Internet, which became the impetus for new discoveries and inventions: the web search engine, Wikipedia, Skype, Facebook, YouTube, Google Translate, PDA, e-government, the tablet computer, speech recognition and in consequence, significant changes in society. We have told in detail about the effects of all of these important discoveries and advances on mankind in previous articles [3, 4].

These events occurred with a pace new to this era. We will consider the average time between such events as the characteristic time of the progress – τ_{pr} . So, τ_{pr} (Tau of progress) - the typical time between events of progress in the period under review.

Attempts to structure the scientific and technological revolution have been made repeatedly [1; 2; 3]. Building on this well-known work, we have reduced to a single table those advances in technology of information exchange which are keys to the functioning and development of the society, stating the approximate time of occurrence. Based on the data, we see that the frequency with which there were important turning points in the development of info-communications, were significantly different in different periods. At the beginning, the typical interval between such events was tens of thousands of years, then a few thousand years, and then this interval gradually shrank to one century and less.

By the end of the twentieth century, revolutionary discoveries began to happen so often, that time intervals between them were reduced to a few years. Therefore, τ_{pr} , during the life of humanity, shortened a thousand times.

II. THE NUMBER OF EVENTS THAT OCCUR WITHIN THE LIFETIME OF GENERATION

Seeing this change of Tau of progress in human history, it is natural to *normalize the average lifetime of a generation to the characteristic time of progress.*

In this context, it is suitable to introduce the dimensionless unit

$$\gamma = \tau_{lf} / \tau_{pr}$$

Wherein:

- γ (gamma) – *the number of events that occur during the lifetime of a generation;*
- τ_{lf} (tau life) – *the average life of a generation.* For simplicity, we assume that τ_{lf} is a constant.
- τ_{pr} (tau of progress) – as has been said, is *the mean time between two consecutive events that determine the progress within the given time interval;*

Thus, the value of γ shows how many *radical changes took place during the lifetime of one generation.*

The following table illustrates the change in the characteristic dimensionless number γ in human history.

TABLE I. FUNDAMENTAL MILESTONES OF INFORMATION DEVELOPMENT

Fundamental Milestones of Information Development	Approximate time of appearance	τ_{pr} , years	$\gamma = \tau_{lf}/\tau_{pr}$
Speech	40 000 BC		
Written language	3300 BC	37000	0.00
Printing	1400	4700	0.01
Telegraph	1792	400	0.13
Radio	1895	100	0.50
Television	1950	55	0.91
Computer	1980	40	1.25
Mobile phone	1985	5	10
Internet	1991	6	8
Web search engine	1997	5	10
Wikipedia	2001	4	13
Skype	2003	2	25
Facebook	2004	1.5	33
YouTube	2005	1.5	33
Google Translate	2007	1.4	36
Communicator	2008	1.2	42
Tablet computer	2010	1.3	38
Speech recognition	2011	1	50
E-government	2012	0.5	100

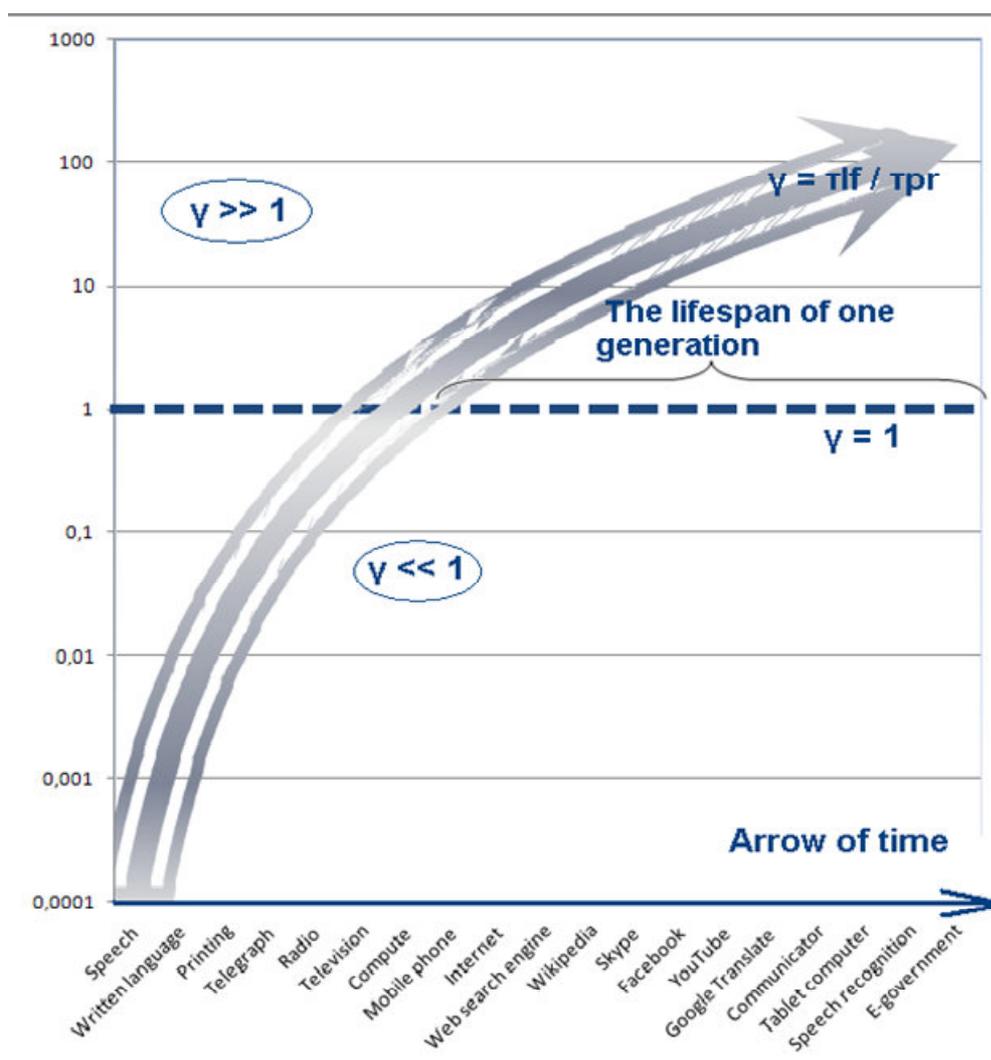
We see what fraction of the events is the share of the time of one generation in a particular era. Following the dynamics of the parameter γ , we note that at the beginning of the historical path of Homo sapiens, it was approximately zero. This shows that nothing changed in this historical era within the time of one generation. At the scale at which the issue is addressed,

these generations lived at the same level of civilization, passing traditional skills from father to son, with almost nothing changing in their existence. Then we see a continuous increase of the number of changes in a single generation. In our generation, it is more than one (with an explicit tendency to become many more).

Fig.1 shows the changing number of events that have occurred within a generation over the time of mankind's existence. Figure I. The number of events that occur within the lifetime of a generation

On this graph, the dimensionless parameter γ is represented on the vertical axis in a logarithmic scale. The X-axis represents the arrow of time, where the most important milestones in the development of the information are noted.

In accordance with our formal definition, the dimensionless parameter γ is equal to 1 when, within the lifetime of one generation, the one event of critical importance, in terms of scientific and technological progress, takes place. Thereby, the *dotted line* on the graph



corresponding to $\gamma = 1$, is the *boundary* between the area of human existence in the predominantly *traditional lifestyle* and the area where fundamental *changes in lifestyle*, caused by scientific-technical progress, occur within the lifetime of one generation repeatedly.

When the speed of technological progress has reached such a level that the *frontier* ($\gamma = 1$) is *crossed*, humanity is entering an era when, in the style of life of human communities and

individuals, there is a *qualitative change*: the most *traditional way of life* is replaced by the tide of life, where *rapid changes occur in real time* to the eyes of people living in this era (as *active participants* in this process, and as *unwitting witnesses*).

Based on the above, Figure 1 distinguishes **three areas**:

III. THE AREA $\gamma \ll 1$. ZONE OF ACCURATE PREDICTIONS

The graph below the $\gamma = 1$ shows that, on the one hand, in the historical scale technological change occurs, and is accelerated, but, on the other hand, it is so slow that to most people the change goes unnoticed. According to the table and graph, we see that in this area, hundreds or even thousands of generations of people were living in a conservative world outside the reach of technological revolutions. They lived in a world where the mode of existence for generations was almost unchanged. Of course, milestones of progress could come within the life of a random generation, but such events were epochal only in terms of priority of discovery, as they did not lead to a radical change in lifestyle. Life was changed a few centuries later.

The generations, whose life fell in this area, mentally felt certainty and predictability about their future. In that time, not only the specific lifecycles or the fates of some people were predictable, but the style and way of life, infrastructure, urban and rural landscapes, and, most importantly, ways to share information were predictable. In this area, people perceived the world as invariable, so in this period there was no understanding of life as progress.

Accordingly, in the area that is above the named boundary $\gamma = 1$, prognostication and strategic planning or long-term planning were possible. In this area, the task of prediction was accurate.

IV. THE AREA $\gamma \approx 1$. AREA OF TRANSITION

As one can see from the graph, the continuous, but very slow acceleration of scientific and technical advance was occurring throughout the history of mankind. However, since the XIX century, scientific and technical advances have lead to a rate of change at which the dimensionless parameter γ , which characterizes this rate, becomes commensurate to unity.

Crossing the boundary $\gamma = 1$ did not occur at one time. It was not an intersection point; it was a transitional period - a time when the number of key events becomes commensurate to the length of human life.

Accordingly, in the area $\gamma \approx 1$, prognostication and strategic planning are still possible. In that time, forecasting remained reasonably accurate. The case is recalled of the Soviet Union, where Gosplan implemented national development planning as a special state agency.

Thus, the rapid development of science and technology, which at this point in history was determined mainly by the development of information and communication technologies, continues, and the area is entered in which the achievements of scientific and technological progress, dramatically affecting the most important aspects of people's lives, are happening now. That is, happening many times over the lifetime of one generation (of our generation). *For the first time in human history, we are in the zone where $\gamma \gg 1$.*

V. THE AREA $\gamma \gg 1$. REALM OF FALSE PREDICTIONS

As we can see from the data, a *turning point* came at the end of the twentieth century. [Change is in the fact *that when $\gamma \gg 1$, people live in a world that is changing before their eyes. For the first time in human history, we are in an area where $\gamma \gg 1$.*]

Qualitative changes have taken place in recent years, despite the *great conservatism of many aspects of material life* (housing, transport, energy), where the pace of change has not been achieved to the degree that is seen in info-communications. The events of recent decades

show that progress in the information field is the most important driver of change of society, *radically changing key aspects of human life*.

All previous events can be regarded as *revolutionary*, but between them *centuries passed*. Now we are seeing huge changes in technology that lead to *changes* that may be *on the same scale* as the appearance of written language and publishing. Now multiple radical changes in society, caused by scientific and technological revolution, occur *within the life of a single generation*. [3].

According to different estimates, depending on the starting point, this event can be dated differently, but in any event, it happened recently, just before our generation. That is, *we are witnessing or are unwitting participants in this turning point and the historical changes in the rate of development of human civilization* [4].

VI. CROSSING THE LINE $\gamma = 1$ AND THE PROBLEM OF ACCURATE FORECASTING

The fact that the rate of technological progress has reached such a level that fundamental changes occur many times in a generation, has influenced many aspects of real life. One of the important points is that, the *problem of forecasting the ways of further development* appears in a very different light.

We can see that, so far, in the area $\gamma \ll 1$, where people lived conservative lives in an unchanging world, *planning* could be conducted with a high probability of success. Now we are in the area where the very formulation of *the problem of long-term prognoses of development is fallacious*.

From the time of entering the zone where $\gamma \gg 1$ the success of any prediction obviously narrowed. However, it is this unpredictability that makes any reasonably reliable predictions particularly popular. Therefore, in this new situation, even *minimally correct prediction becomes critically important*.

Here is a partial list of issues in all areas that are on the agenda today:

- Education. How to develop the human capital and, therefore, what kind of education should we have?
- Politics. Which factors will dominate in politics? For example, now we see such a strong, unpredictable and uncontrolled growth of the Internet and social networks, that society is being structured on entirely new principles (horizontal communication, the influence of the blogosphere et cetera).
- Economics. In which directions should we invest? This is an important issue, in particular, when it comes to investments in the long term, such as pension funds, state development funds, etc.

For Russia, especially, of obvious importance is the diversification of the economy, id est., the replacement of the current raw material economy with the development of innovative technologies and the manufacture of high-tech products.

Here again the question arises: what technology and what products?

The issue is that any such development is a process that requires planning for a period of not less than five years and, as a rule, more. This is the time it takes from the stage of scientific and technical invention to the stage of commercial production.

- Infrastructure. Is it reasonable to maintain the concept of urban planning or transport development at a time of changing distribution of labor resources, due to the rapid development of IT and robotics, which give us the opportunity of full participation in the work process without employees being present in a specific workplace?

For example, how can we make a forecast of development of transport infrastructure for the next 20 years if, because of the further development of info-communications and robotics, it may be that in 5-10 years, much of the population will discharge their duties without leaving home?

- The Defence industry. How to construct the concept of development of the defense-industrial complex in the realities of rapidly developing info-communications and robotics?
- Culture. The development of the concept of national identity and its preservation, in the new context of globalization, which is a consequence of IT development.

Thus, the process of rapid progress gives rise to new questions that were not even on the old agenda.

CONCLUSION. PROBLEM OF THE STATUS OF THE PHILOSOPHER

Thus, at the turn of the XX - XXI centuries, scientific and technical progress in the field of info-communications, the important area of social development, reached the critical speed. This is reflected in the fact that the present generation has to live with the reality of revolutionary transformations occurring many times during their lives.

In these circumstances, the task of forecasting, in its traditional setting, is becoming increasingly inaccurate. The only possibility is to venture outside the framework of formal logic and technocratic approaches and try to find answers to these questions by generating new meanings of the realities surrounding us.

In this context, public inquiry concerning the basic comprehension of the current situation is becoming more common. Arising out of this discussion is a greater understanding about alternative ways of development in the areas of investment strategy; working out adequate educational concepts; prediction of the transformation of domestic-policy landscape caused by radical changes of management tools, and comprehending specific external challenges and threats to be faced by the Russian Federation, and the answers to these challenges, including approaches to the development of the military-industrial complex.

In consequence, Philosophy, the 'Science of Science', will likely find new life. Previously shunned by the scientific and technological community, it promises to flourish again, because tomorrow's issues are now unlikely to be resolved within the framework of the exact sciences, including not only science and technology, but also economics and sociology.

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