

Expected human longevity

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ABSTRACT

In this paper we discuss the fall of ancient civilizations and possible future extinction causes for humans. Then we estimate the longevity of humans based on the absence of extraterrestrial civilizations and astronomical data using the Drake equation. If there are not many advanced civilizations in our galaxy, our longevity can be estimated at up to 10.000 years.

Keywords

Human extinction, Drake equation, Civilization collapse

1. INTRODUCTION

It seems that nothing in this world can last forever. While people are familiar with the fact that they are born and die, the process is less acceptable for nations and countries alike as the protests in media about dire prospects of the Slovenian nation and the European nations indicate [5]. But history teaches us that in the past there were many flourishing developed civilizations, yet none of them survived for a very long period of time. As people rise and fall, so do civilizations. The same is valid for human civilization - it will inevitably die out one day.

What are possible causes of the end of our civilization? Using the Drake equation, can we predict how much time we have left and how can we extend it?

Finally, are we like a child cognitively capable of accepting the incoming fate? Will we as civilization live healthy and long or perish at first major obstacle?

1.1 Fall of ancient civilizations

There are many different reasons why ancient civilizations went extinct. Here we mention a couple of civilizations and the reasons for their decline.

- **The Maya civilization**

There are several theories for the fall of Maya civilization but the prevalent is that climate changes and consequent drought were the main causes. Other causes include social disorder, over-population and warfare [2].

- **Minoan Civilization**

Minoans were one of the first civilizations in Europe. They were located in Crete, Greece and were wiped out by tsunamis following a volcanic eruption [4].

- **Roman Empire**

Roman civilization probably collapsed due to many reasons. Weak army, constant barbarian invasions, political instability, overpopulation and epidemics are only few of the causes that might have lead to downfall of this once powerful civilization [9].

- **Native Americans**

Decline of Native Americans happened when Europeans discovered America in 1492. They brought new diseases to the continent to which no Native American was immune. Furthermore, Europeans started with colonization and stone-age Native Americans had no proper weapons to resist them. One of huge problems in Indian communities is alcohol [11].

The stories of civilization declines are often presented as cautionary tales to frighten us into correcting the error of our ways - about the end of our own global civilization [7]. They focus on climate change, human-caused environmental impacts and overpopulation because these three factors are the major global concerns of our time. They have a strong appeal to us because of the ubiquity of disaster-based stories. There are also several positive components in these stories, e.g. they promote environmental responsibility, global concern and sustainable growth.

Cosmos or earth phenomena can cause extinction or at least significantly decline the number of humans, as the Toba supereruption around 70 000 years ago indicates. It is estimated that only around 10 000 people survived at some point afterwards. But these events might be less likely in the near future and in this paper we concentrate on the human-induced problems.

In recent theories, the downfall of all societies was accompanied with - if not caused by - "strange" ideologies, e.g. those that conflicted with the production process. Even though

it had to be clear at least to the visionaries at that times (equivalent of scientists today), the society did not want to abandon the obviously anti-productive orientations, but remained on the course - going down. For example consider American Indians who counted for 55 millions at the time Columbus first landed in Bahamas on October 12, 1492. Now there are only around 2 million of them. What is the cause - diseases, aggression of white settlers or inability to adapt to new circumstances in appropriate way?

While the doomsayers are a constant phenomenon in our life, and they come indeed in all forms and ideas, more often than not unsupported by data, serious analyses were able to predict the human-caused grim outcomes, e.g. before the second World War. Although in this particular case it was of no avail, it should not come as a pessimistic view - note that a zillion times more the collapse of civilization was averted due to the warnings of intellectuals. Whatever the case, it might be possible to scientifically correctly predict most likely current civilization dangers and at least some time-span of our civilization.

1.2 Possible causes of extinction of the human race

In this section we will discuss some of the possible causes for human extinction, based on an article by Bostrom [1].

- **Nuclear holocaust**

USA and Russia hold about 93 percent of all nuclear weapons, but other countries are starting to stockpile them as well. Even worse, the treaty preventing arms races has been called off.

There are various opinions whether an all out nuclear war could eradicate humankind. Some believe that it would be hard to reach all possible settlements. For example the ones that are isolated from other people like the mountains of Tibet or remote islands in the South Pacific [10]. Also, there are nuclear shelters preventing the chosen ones. But even if we survive the initial impact, the long term climatic effects will lead to nuclear winter and the number of people would decrease to drastic numbers. While humans as species would probably survive, the level of human civilization would decline dramatically, probably demanding several centuries to regain proper technological state - if ever.

- **Global warming**

Ever increasing releases of greenhouse gasses could start a feedback loop and the temperatures could increase to rise. Even more species would go extinct and we would be unable to produce crops. If a negative spiral would enhance heating up the planet, life would become unbearable outside with negative consequences similar to the nuclear winter.

- **Artificial intelligence**

The development of artificial intelligence will likely lead to superintelligence in the future. It is possible that in the case of a conflict between humans and superintelligence the entire human civilization could get annihilated [12].

- **Pandemic**

A new deadly disease could infect the entire world population. There could be an genetically engineered biological agent with long latency and high mortality. Those viruses could be released by a lunatic or spawned unintentionally [6].

- **Asteroid or comet impact**

This is a very small risk, but if an object 100 km wide would collide with Earth all advanced life could perish. There have been multiple extinctions on Earth and at least some were caused by impacts from space. The best known is the one eliminating dinosaurs around 65 million years ago when an object about 10 to 50 kilometers in diameter hit the Yucatan peninsula in Mexico. As a consequence, around 75 percent of all plant and animal species went extinct.

- **Accidental or deliberate misuse of nanotechnology**

It might be possible to construct bacterium-scale nanobots that are self replicating and can feed on organic matter. Such robots could ultimately eat or destroy entire biosphere. This is one of the examples where humans construct a new mechanism capable of destroying civilization.

Can we avoid extinction in the first place? Clearly, the answer is no, and the real question is how long will human civilization persist. In the next section we present a model that predicts the longevity of human civilization based on the Drake equation.

| Parameter | Distribution |
|-----------|--|
| R_* | log-uniform from 1 to 100 |
| f_p | log-uniform from 0.1 to 1 |
| n_e | log-uniform from 0.1 to 1 |
| f_l | log-normal rate, described in paper[8] |
| f_i | log-uniform from 0.001 to 1 |
| f_c | log-uniform from 0.01 to 1 |
| N | point values: 1 to 10 000 |

Table 1: Probability densities for the parameters in Equation (1)

2. THE DRAKE EQUATION AND ESTIMATING THE LONGEVITY OF HUMAN CIVILIZATION

In 1961 Frank Drake proposed an equation for calculating the number of detectable civilizations in our galaxy at any given moment. The equation consists of several parameters [3]:

$$N = R_* f_p n_e f_l f_i f_c L,$$

where R_* is the rate of star formation per year, f_p is the fraction of stars with planets, n_e is the number of Earth-like (or otherwise habitable) planets per star that has planets, f_l is the fraction of habitable planets with actual life, f_i is the fraction of life-bearing planets that develop intelligence, f_c is the fraction of intelligent civilizations that are detectable and L is the average longevity of such civilizations. Finally, N is the number of detectable civilizations. In the original

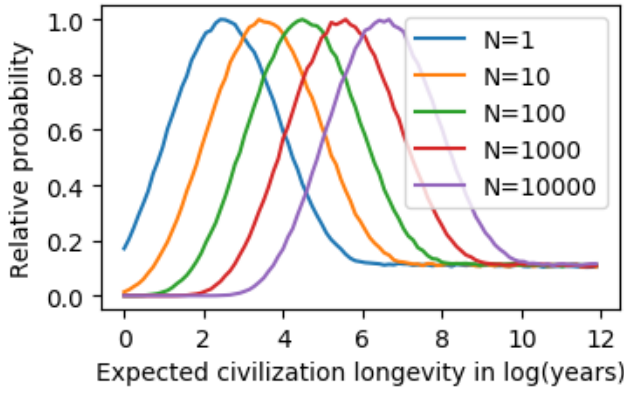


Figure 1: Graph for $\log(L)$, i.e. for expected human longevity based on the values of N - the number of civilizations in our galaxy.

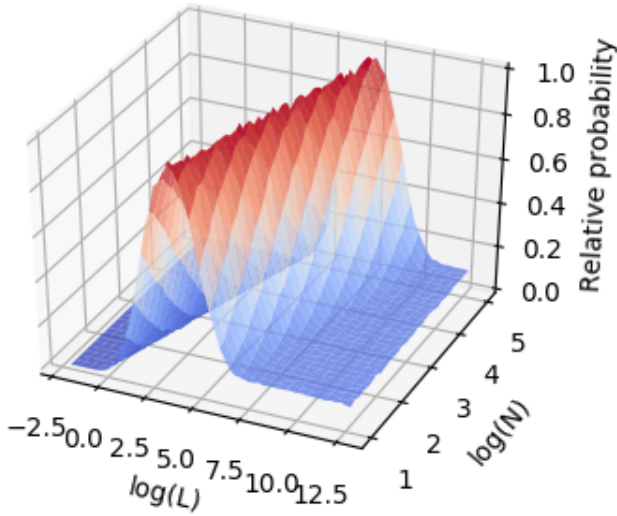


Figure 2: Longevity based on N , side view.

article the authors used point values to estimate each one of the parameters. Sandberg et al. used a different approach in [8] - instead of using point values they used probability distributions for the parameters.

We used the Drake equation with the Sandberg's approach for the base of our calculations. Since the parameters in the equation are all estimates we can solve equation for L and take N as a variable. The estimation of N can be estimated from observations of our stellar neighbourhood. The equation for computing L is therefore as follows:

$$L = \frac{N}{R_* f_p n_e f_l f_i f_c} \quad (1)$$

2.1 Estimation of parameters

We used probability distributions to model each variable as in the paper presented by Sandberg [8]. For the distribution of the number of civilizations in our galaxy we set the lower bound at $N = 1$ and the upper bound at 10^4 . The reason for this estimate is as follows: If we assume that civilizations are

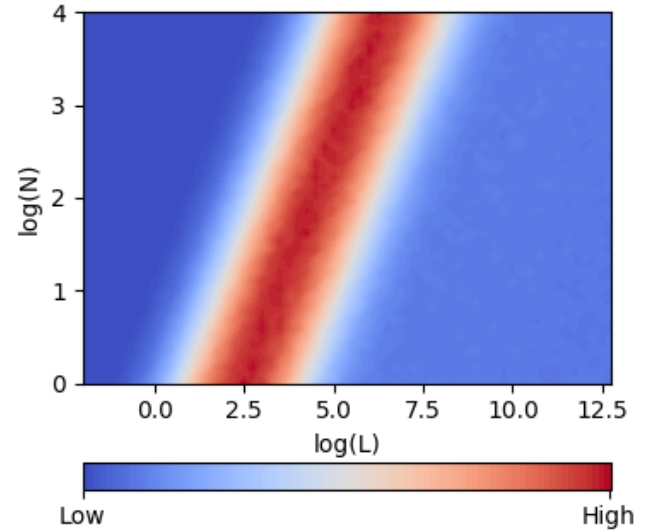


Figure 3: Longevity based on N , top view.

evenly distributed throughout the galaxy, then there are at most 10 000, since otherwise we would have already observed one (radius of the galaxy is 10^5 light years while we can detect signals as far as 10^3 light years). Consequently, the range of L is theoretically from 10^{-2} to 10^{13} , i.e. from 3 days to ten trillion years.

Please note that 10^4 is likely an upper limit for N since we have been trying in vain to get a signal from foreign civilizations even though quite extensive and expensive searches of the universe were performed. The search for extraterrestrial intelligence (SETI) is a collective term for scientific searches for intelligent extraterrestrial life. Various methods and approaches are used to detect signs of transmissions from civilizations on other planets, but most commonly monitoring of electromagnetic radiation is performed. The first scientific investigations began in the early 1900s, and focused international efforts have been going on since the 1980s. While some consider UFOs as a proof of foreign civilizations visiting us, there are no scientifically confirmed results so far. Regarding that some projects were distributed using huge resources and time, that is a rather disturbing indication. Furthermore, it should be noted that this paper relies purely on the known and generally accepted scientific knowledge and UFOs are not part of it.

To return to the parameters - to estimate the longevity of human civilization, we didn't model parameter N with distributions but we took multiple point-values as inputs to the equation. In other words, for example: Suppose there are 1, 10, 100, 1000, 10 000 civilizations in our galaxy now - what can we conclude about our longevity in that particular case?

Several hundreds of models either of different nature or of significantly different parameters were designed and tested, but here we present only one.

3. EXPERIMENTS

The computing was performed in a stochastic way: for a chosen N , a value of each parameter was randomly generated using the predefined probability density, and L was computed according to the Drake formula. The obtained probability distribution denotes the longevity of human civilization under chosen probability distribution for the given parameters and for the chosen N - the number of technologically advanced civilizations in our galaxy, i.e. the ones that transmit electromagnetic signals to space. From the obtained probability density, several derived graphs can be generated, e.g. the one in Figure 1. The same relations are also presented in side-view in Figure 2 and in 3D in Figure 3. Bigger N seemingly corresponds to better chances for longer human longevity, in positive correlation with N . In addition, our longevity is obviously limited, but the exact relations are somehow difficult to comprehend due to the non-linear scale.

| N | median | stabilization | volume |
|--------|------------|---------------|-----------|
| 1 | 2 200 | 13 600 | 2700 |
| 10 | 22 000 | 11 100 | 10 000 |
| 100 | 220 000 | 9 300 | 63 700 |
| 1000 | 2 200 000 | 5 800 | 545 600 |
| 10 000 | 22 000 000 | / | 1 000 800 |

Table 2: Median and stabilization values for different N .

| N | 0-1000 | 1000-2000 | 10 000-11 000 | 100 000-101 000 | 1 000 000-1 001 000 |
|--------|--------|-----------|---------------|-----------------|---------------------|
| 1 | 0.186 | 0.024 | 0.002 | 0.000 | 0.000 |
| 10 | 0.289 | 0.073 | 0.010 | 0.001 | 0.000 |
| 100 | 0.600 | 0.276 | 0.058 | 0.006 | 0.000 |
| 1000 | 0.871 | 0.789 | 0.298 | 0.053 | 0.005 |
| 10 000 | 0.275 | 0.749 | 0.843 | 0.299 | 0.048 |

Table 3: Probability densities of 1000 years for different N at 5 specific longevitys normalized to the highest value in 100 years.

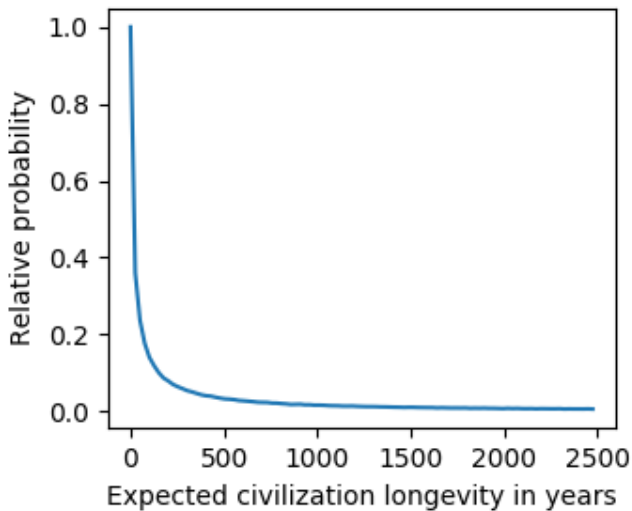


Figure 4: Graph for longevity, i.e. $\log(L)$ in linear scale for $N=1$.

If instead of logarithmic scale, the graph of probability densities is presented in a linear scale (Figure 4), the impression is now quite different. The "true" relation between N and L is as follows: majority of possibilities for smaller N are at the left part of the graph resulting in a bigger bump accompanied with a slower decline. The point of stabilization, i.e. when a decline is less than 1 percent in a corresponding 100 years is presented in Table 2 as "stabilization". One can also calculate median longevity by computing it for each graph, denoted as "median". The difference between "stabilization" and "median" is that median represents a point dividing all simulations into two equally frequent intervals, while stabilization indicates the end of steep, i.e. more than 1 percent decline in the probability densities. While median linearly grows with the number of civilizations, stabilization declines denotes where the peak in probability densities on the left is getting smaller than 1 percent. At N equal to 10 000, no decline is bigger than 1 percent. The right-most column "volume" denotes the percentage of the current integral of probability densities in a millennium decreases to less than 1 percent compared to the best 100 years (normalized). These relations are highlighted in Table 3 where the average over an interval 0..1000, 1000..2000, 10 000..11 000 etc. is divided by an average over best (i.e. usually the first) 100 years. These numbers denote how much more probable are the first 100 years compared to the first 1000 etc.

The reason why we present graphs in logarithmic scale is that the linear scale does not enable the reader to comprehend anything outside the relevant scope. For example, Figure 4 would consist of two lines if the max years would be 25 000 instead of 2 500 - one vertical on the left and one horizontal on the x axis.

4. CONCLUSION

The aim of this research was to establish probability densities of longevity of human civilization. In this paper we presented results of just one model while we have tested hundreds of them. The model analyzed here shows that if there are more civilizations, we have higher probability of living longer. Regardless of N and after initial fluctuations very close to the left, the curve of longevity is monotonic, decreasing. At N equal to 1, i.e. if we are the only ones in our galaxy, we will probably live only for approximately 2000 - 14 000 years. At N equal to 10, the expected high-probable longevity is from 11 600 to 22 000 years. At N equal to 10 000 there is no peak at the left and the probability density very slowly declines. In other words - there is not any explicit pattern and predictions are undecidable.

Our maximum survival time seems to be about 10 000 - 20 000 and maybe up to 100 000 years. This study is relevant because it clearly indicates that we need to start acting wisely sooner than later to prevent grim scenarios.

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