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Science and the Future 2

To grow or not to grow: the dilemma of sustainability

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Abstract. The premises and conclusions of the Science and the Future conference held in 2013 are the basis for this paper. I shall describe the changes occurred in the world since 2013 to present both on the positive and on the negative side, together with the failures to change, that will be discussed during the present conference. I shall especially point out the failure to address the contradiction between material growth and sustainability. The limit posed by the growing complexity of the global economy will be demonstrated, showing its implications for the ungovernability of the system. I will stress the difficulty and urgency of a fully rational analysis and the discussion of some strongholds of the present social paradigm, which are intrinsically entangled with human and material unsustainability.

1 Foreword

Five years ago (October 2013) I had the privilege to open the first edition of Science and the Future. The purpose of that conference was to discuss the problems and contradictions implied in the then ongoing trends of the world economy. The starting point was the criticalities and inconsistencies pointed out forty-two years earlier in *The Limits to Growth*, promoted by the Club of Rome [1].

Science and the Future 2 will be held in the year of the fiftieth anniversary of the Club of Rome, founded in 1968 by Aurelio Peccei, David Rockefeller and Alexander King, and is an opportunity to examine the world's evolution in recent years. People's awareness of the problems humans are facing is probably higher now than it was fifty years ago. In 2015 the UN conference on climate change was held in Paris, and an important principle agreement was signed there (so far ratified by 197 states). The media often convey alarming messages to the general public regarding the disasters of the climate change, and climate change deniers have little evidence to support their position, and a small audience. At first sight, we are now in a better position to face the challenge of the consequences of our globally unsustainable way of life.

Despite all this, however, looking at global physical parameters suggests that little has changed or, in other words, that the global situation has considerably worsened in many respects. Nature is offering increasing evidence that we are going the wrong way. Floods in deserts, such as those in Petra (Jordan) in 2018, and recurring fires in California and other parts of the world can hardly be considered ordinary unlucky events.

2 State of the world

2.1 Energy

Considering the trends in world energy consumption (see Figure 1) the only evidence for a temporary decrease in demand is visibly a consequence of the recession, which originated with the so-called subprime mortgage crisis in the years after 2007. As soon as the engine of the old car offered signs of recovery, trends apparently resumed their old course.

The average consumption rate grew by 2.2% from 2016 to 2017, whereas the average yearly growth in the previous decade had been in the order of 1.7%. These numbers tells us that the world energy demand is not a consequence of conscious policies, but rather of the known mechanisms of the business-as-usual economy.

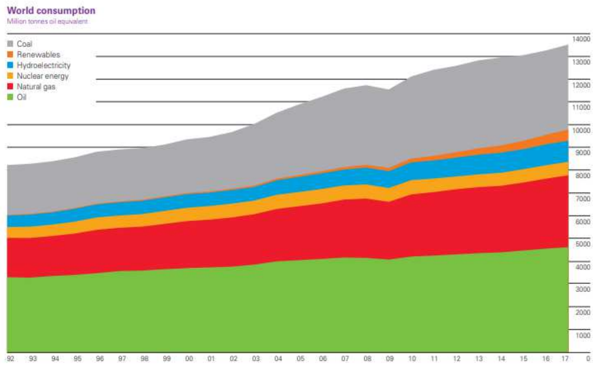

Fig. 1 World energy consumption trends.

Another remarkable figure is that 81% of energy is obtained from fossil sources and 10% from biomass: altogether 91% comes from combustion processes, even though, in the case of biomass, this could be in a circular and, in principle, sustainable way.

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2.2 CO_2 emissions

The trends in CO_2 emissions (Figure 2) are even more instructive: their connection with the ups and downs of the world economy is evident. Slowdowns in growth correspond to lower CO_2 emission rates. At the beginning of 2018 rating agencies and economical operators declared the world economy to be growing again after a few years of rickety evolution, and the 2017 carbon dioxide emission rate correspondingly turned out to be 2.2% higher than in 2015. There is no evidence for any effective containment policies anywhere in the world.

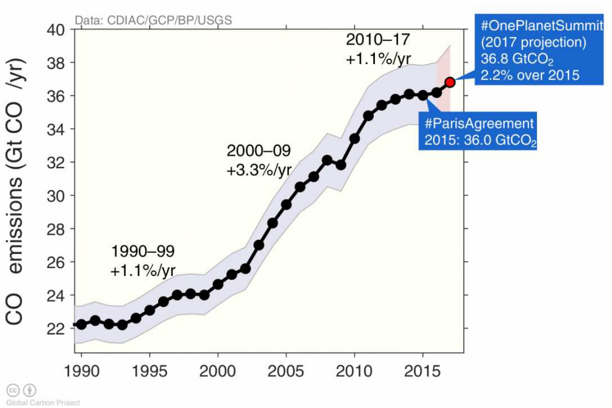

Fig. 2 Carbon dioxide emissions per year.

2.3 Mass migrations

Together with the physical aspects of global change we find also other human phenomena being monitored, and for which urgent actions are needed. These are conflicts and mass migrations; these topics will be discussed in other contributions to this conference. Here I simply draw attention to the trends and dynamics of migration fluxes.

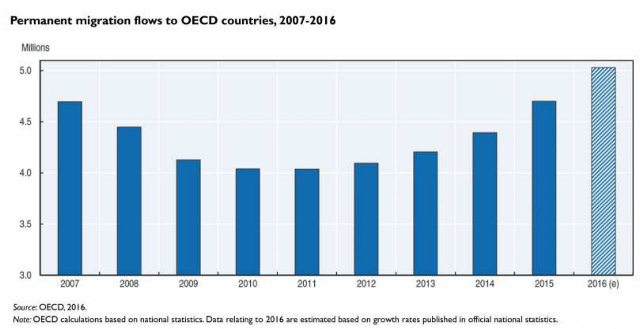

Fig. 3 Migration fluxes in the OECD area during a recent decennial.

Figure 3 presents the situation in the 36 countries that are part of the OECD (1.2 billion inhabitants altogether).

The number of permanent migrants has increased since 2011. There are multiple causes driving people to leave their home countries and seek their fortune elsewhere. Basically of course everybody aims to improve their condition, but most often people find they have to move due to immediate and dramatic pushes: war, disasters, or other causes of despair. Global climate changes are at the origin of many of these emergencies: water shortages, decreasing soil fertility, and recurrent extreme weather events. These emergencies all have more acute repercussions on poor peoples and nations, causing people to resort to flight and migration.

Conflicts and climate change will both be dealt with in this conference. I will focus on the differences that are inherent in the global economy and, coupled with other drivers, move desperate crowds to areas with narratives that have apparently led to more opportunities.

3 Inequalities

International observers know that income inequalities are indeed growing everywhere in the world with only local and limited exceptions. Figure 4 presents examples of a few developed countries, but the phenomenon is wider than this: the trends began at the end of the 1970s.

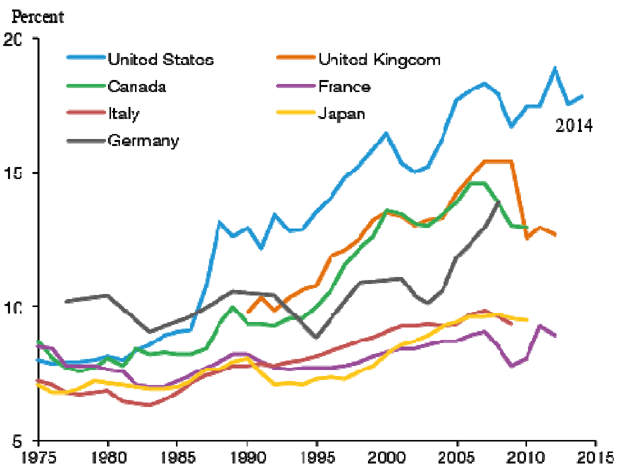

Fig. 4. Share of income earned by the richest 1% of the population in seven countries.

There are undoubtedly many irregularities and huge differences among countries, but the trend for all is towards growth. This is indeed a serious problem, and people are generally worried about how to cure this evident social disease, however, if we wish to cure an illness we must first identify its causes, and this means having a closer look at the very foundation of the present globalised economy. Unavoidably we have to come back to the sacred monster that has been at the centre of the scene for the last couple of centuries: growth.

3.1 Limits and constraints

The axioms at the base of the standard economic doctrine are essentially growth and competition. The standard conviction is that the remedy for income inequalities is global growth: if the economy overall grows then every player will receive an advantage.

Perennial growth is ideally described by an exponential curve. Calling W the wealth, t the time and assuming a stable growth rate per unit time α, it would be:

$$W = W_0 e^{\alpha t} \qquad (1)$$

If we apply (1) to the personal income of two subjects, *A* and *B*, starting at W_{0A} and W_{0B} and growing at the same rate, it is immediately clear that the ratio between the incomes W_A/W_B stays fixed while time passes, but the absolute value of the difference grows at the same rate as the incomes grow. In practice this kind of growth freezes the social pyramid, but the quantitative increase of the differences is likely to be increasingly troublesome.

A friendlier social version of economic growth advocates differential growth: lower incomes should increase faster than higher, and in this way the difference may be reduced. Such differential growth does not happen spontaneously, which means that the state must intervene in order to regulate and direct an economy towards this social rebalancing goal. The problem is: how long a state is in the condition to promote such a policy. The task is also difficult considering that those who have high income usually have also a stronger influence over public powers.

In any case the basic assumption for all the above approaches is the myth of perpetual growth. The real world, however, tells us a different story: perpetual material growth in a finite environment is *impossible*. This obvious fact has been known for a very long time and has been brought to the attention of the general public and of decision makers for fifty years, but the idea of a constraint like that is in fact, explicitly or implicitly, and in any case vehemently, rejected by the economic establishment.

In fact, in the best abstract conditions a finite growth process cannot develop along an exponential (as in Formula 1), but evolves following a trend described reasonably well by a *logistic* curve:

$$W = \frac{W_M}{1 + ae^{-\beta t}} \qquad (2)$$

W_M is the maximum attainable value (in an infinite time); the other parameters involve the assumed value at time t = 0 (a), and with the slope of the curve.

A typical logistic like (2) is shown in Figure 5. The units in the figure are arbitrary and the asymptotic maximum is normalised to 1; the initial (t = 0) value is a bit less than 20% of the asymptote. This type of evolution recalls the growth of trees: in principle it goes on forever but the growth rate diminishes continuously toward zero.

If we now add the other typical ingredient of the business-as-usual doctrine, i.e. *competition*, to the axiom of growth, then what happens to inequalities?

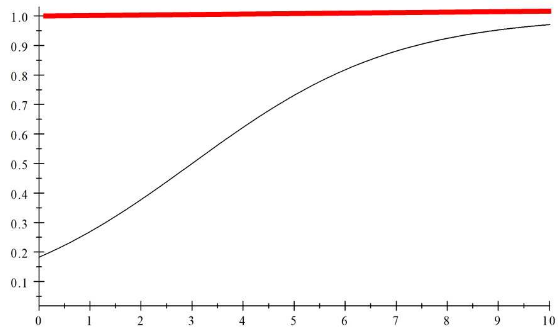

Fig. 5. Growth in a limited environment. The curve ideally tends to a constant value (the asymptote) with a continuously decreasing growth rate.

Consider two players, one of whom has an initial advantage. Each one tries to convert the available primary resources into personal wealth, but the stock of raw material is altogether finite. If, on a first optimistic approach, we suppose that both contenders act independently, but in any case working on what is freely available, the dynamics for everyone are similar to the logistic evolution, but the “roof” is not simply the physical asymptote: it is the finite physical provision diminished by what already belongs to the other competitor. If so, both players grow towards different asymptotic upper values and the same happens to the difference between them, which also follows a logistic-like evolution: continuous decelerated growth.

A more realistic approach sees that those at the top, while competing and winning, incorporate part of the wealth initially produced and owned by the lower competitor. In this way, the upper player faces the total amount of physically available resources, whilst the roof for the lower contender is the physical limit minus what is in hands of the stronger competitor. In this case the result is that shown in Figure 6: the weakest (lower curve), after a while, stops growing and its condition worsens, while the strongest continues to tend to the asymptote. We could call it the Monopoly Game Diagram.

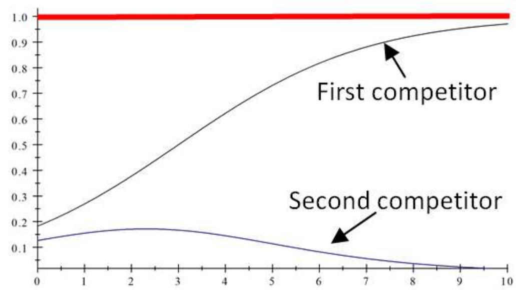

Fig. 6. Effect of growth combined with competition in a finite environment. The weakest (lower curve), after a while, stops growing and its condition worsens, while the strongest continues to tend to the asymptote.

Of course reality is much more complicated than a simple two-player scheme, but the essential mechanisms are the same and the expected evolution is reasonably well represented in Figure 6.

4 Costs

The situation described in the previous section is indeed abstract and idealised because it assumes the effect of costs, or in general of negative feedback that cannot, in any case, be eliminated (second principle of thermodynamics), is exactly calibrated in order not to stop but simply to slow down the growth process more and more effectively.

The real world can be represented by two simple examples borrowed from physics. The first involves Ohm's and Joule's laws. Ohm's law tells us that an "advantage", in the form of an electric current I, is directly proportional to its cause, the potential difference V between the ends of a conductive wire:

$$I = \frac{V}{R} \tag{3}$$

Joule's law warns us that the side effect of the flowing current W (the heating of the conducting cable) is proportional to the square of the voltage:

$$W = \frac{V^2}{R} \tag{4}$$

The same also holds true for material flows and for the movement of an object. The momentum p is proportional to the speed v (**$p = mv$**), but the kinetic energy is proportional to the square of v: $T = mv^2/2$. The effort needed to increase the speed grows faster than the speed, and if a crash occurs then the energy to be dissipated, the damage to deal with, increases quadratically with the velocity.

These trivial, but at the same time universal, remarks have to be added to the fact that the economic system is a complex network and that the complexity grows quadratically when the number of knots in the net grows.

This issue was discussed in the first edition of Science and the Future (2013) and in [2]. Summarising everything in one sentence and starting from the optimal logistic trend for gross benefits (Figure 5), costs (whatever they are) grow faster than advantages. Consequently, the net gain in the growing system evolves as in Figure 7 rather than Figure 5.

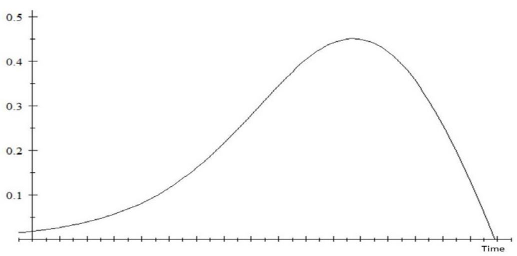

Fig. 7. Evolution of "net gains" in time, for a growing system.

This trend also has to be taken into account when discussing income inequalities, and the result is a further worsening of the situation.

5 Conclusion

In summary, we have seen that the physical clues we clearly read around us indicate that, despite the ongoing debate on global changes induced by human behaviour, the business as usual philosophy continues to prevail, and at the same time the consequences of the changes become more and more compelling. Furthermore, they are more heavily felt by the poorest of the world.

Applying simple rational arguments based on physical properties and constraints we saw that the troubles humanity has to face are the *necessary* consequences of the paradigm of growth and competition. Of course technology and science can help in mitigating the impact of global change and bringing the situation under control, but we should avoid attributing magical powers to science. Irrationality is still very strong and, especially on the side of the decreasing number of human beings who have the biggest advantages, all attempts to renegotiate the conditions of the social pact have been violently and stubbornly rejected. Unfortunately, however, we are all on the same and unique planet and we should strive for the best for everybody.

Science shows that irrational egoism is not the right engine of progress for humans.

References

1. Meadows, D. H., Meadows D. L., Randers J., Behrens W. W. III, *The limits to growth*, Potomac Associates, 1972. Now freely accessible on line at http://donellameadows.org/the-limits-to-growth-now-available-to-read-online/.
2. Tartaglia, A., *Limits for a growing complexity system,* in "Physical Limits to Economic Growth", R. Burlando and A. Tartaglia ed.s, Routledge, London and New York (2018).