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The Next Really Big Enormous Thing

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A postcard summary of life, the universe and everything might go as follows. The universe appeared and started expanding. Life appeared somewhere and then on Earth began making larger and smarter animals. Humans appeared and became smarter and more numerous, by inventing language, farming, industry, and computers.

The events in this summary are not evenly distributed over the history of the universe. The first events are relatively evenly distributed: the universe started fourteen billion years ago, life appeared by four billion years ago, and on Earth animals started growing larger and smarter about half a billion years ago. But the other events are very recent: our species appeared two million years ago, farming started ten thousand years ago, industry started two hundred years ago, and computers started a few decades ago.

Do we over-emphasize these recent events relative to their fundamental importance, because they are about our species and us? Are these events just arbitrary markers, chosen from thousands in a long history of relatively continuous change?

I think not, and here is why: most of these events separate a chain of distinct exponential growth modes. (Exponential growth is where a quantity doubles after some time duration, then continues to double again and again after similar durations.) The growth rates of these modes have varied enormously.

The slowest growth mode started first. Our fourteen billion year old universe is expanding, and that expansion is becoming exponential due to a mysterious "dark energy." The distance between the galaxies is predicted to double every ten billion years.

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We don't know enough about the history of non-animal life in the universe to identify its growth rates, but we can see that for the last half billion years the size of animals on Earth has grown exponentially. While the size of the typical animal is largely unchanged, the variation among animal size has greatly increased. Because of this, the mass of the largest animal has doubled about every seventy million years, and the mass of the largest brain has doubled about three times every hundred million years. So the largest brains have doubled about three hundred times faster than the distance between galaxies.

Humans (really "our human-like ancestors") began with some of the largest brains around, and then tripled their size. Those brains, and the innovations they embodied, seem to have enabled a huge growth in the human niche – it supported about ten thousand humans two million years ago, but about four million humans ten thousand years ago.

While data is scarce, this growth seems exponential, doubling about every two hundred and twenty five thousand years, or one hundred and fifty times faster than animal brains grew. (This growth rate for the human niche is consistent with faster growth for our ancestors – groups might kill off other groups to take over the niche.)

About ten thousand years ago, those four million humans began to settle and farm, instead of migrating to hunt and gather. The human population on Earth then began to double about every nine hundred years, or about two hundred and fifty times faster than hunting humans doubled.

Since the industrial revolution began a few hundred years ago, the human population has grown even faster. Before the industrial revolution total human wealth grew so slowly that population quickly caught up, keeping wealth per person at a near subsistence level. But in the last century or so wealth has grown faster than population, allowing for great increases in wealth per person.

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Economists' best estimates of total world product (average wealth per person times the number of people) show it to have been growing exponentially over the last century, doubling about every fifteen years, or about sixty times faster than under farming. And a model of the whole time series as a transition from a farming exponential mode to an industry exponential mode suggests that the transition is not over yet - we are slowly approaching a real industry doubling time of about six years, or one hundred and fifty times the farming growth rate.

A revised postcard summary of life, the universe, and everything, therefore, is that an exponentially growing universe gave life to a sequence of faster and faster exponential growth modes, first among the largest animal brains, then for the wealth of human hunters, then farmers, and then industry. It seems that each new growth mode starts when the previous mode reaches a certain enabling scale. That is, humans may not grow via culture until animal brains are large enough, farming may not be feasible until hunters are dense enough, and industry may not be possible until there are enough farmers.

Notice how many "important events" are left out of this postcard summary. Language, fire, writing, cities, sailing, printing presses, steam engines, electricity, assembly lines, radio, and hundreds of other "key" innovations are not listed separately here. You see, most big changes are just a part of some growth mode, and do not cause an increase in the growth rate. While we do not know what exactly has made growth rates change, we do see that the number of such causes so far can be counted on the fingers of one hand.

While growth rates have varied widely, growth rate changes have been remarkably consistent -- each mode grew from one hundred and fifty to three hundred times faster than its predecessor. Also, the recent modes have made a similar number of doublings. While the universe has barely completed one doubling time, and the largest animals grew through sixteen doublings, hunting grew through nine doublings, farming grew through seven and a half doublings, and industry has so far done a bit over nine doublings.

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This pattern explains event clustering – transitions between faster growth modes that double a similar number of times must cluster closer and closer in time. But looking at this pattern, I cannot help but wonder: are we in the last mode, or will there be more?

If a new growth transition were to be similar to the last few, in terms of the number of doublings and the increase in the growth rate, then the remarkable consistency in the previous transitions allows a remarkably precise prediction. A new growth mode should arise sometime within about the next seven industry mode doublings (i.e., the next seventy years) and give a new wealth doubling time of between seven and sixteen days. Such a new mode would surely count as "the next really big enormous thing."

The suggestion that the world economy will soon double every week or two seems so far from ordinary experience as to be, well, "crazy." Of course similar predictions made before the previous transitions would have seemed similarly crazy. Nevertheless, it is hard to take this seriously without at least some account of how it could be possible.

Now we cannot expect to get a very detailed account. After all, most economics has been designed to explain the actual social worlds that we have seen so far, and not all the possible social worlds that might exist. Even then we are still pretty ignorant about the causes of the previous transitions. But we do want at least a sketchy account.

It turns out to be hard to create such an account using things like space colonization or new energy sources, mainly because we now pay only a small fraction of our budget on things like land and energy. But we pay seventy percent of world income for human labor, so anything that can lower this cost can have a huge impact. I am thus drawn to consider scenarios involving robotics or artificial intelligence.

While machines have sometimes displaced human workers, they have much more often helped humans be more productive at tasks that machines cannot do. Machines have thus on net raised the value, and hence the cost, of human labor. And because people are essential, the

limited rate of human population growth has limited the economic growth rate.

Once we have machines that can do almost all the tasks that people can do, however, this picture changes dramatically. Since the number of machines can grow as fast as the economy needs them, human population growth no longer limits economic growth. In fact, simple growth models which assume no other changes can easily allow a new doubling time of a month, a week, or even less.

Now admittedly, progress in robotics and artificial intelligence has been slow over the decades, primarily because it is so hard to write the software. And at these rates it could be centuries before we have software that can do almost all tasks that people do. The "upload" approach, however, of scanning human brains then simulating them in detail in computers, seems likely to succeed within the next half century or so.

The transition from farming to industry seems to have been more gradual than the transition from hunting to farming. Even such a "gradual" transition, however, would be very dramatic. Assume that a new transition was as gradual as the one to industry, and that the world economic growth rate was six percent in both 2039 and 2040, plus or minus a typical yearly fluctuation of half a percent.

If so, then in 2041, the increase in the growth rate might be the size of a typical fluctuation, and then in 2042 the growth rate would be a noticeably different eight percent. Growth would then be 14% in 2043, 50% in 2044, 150% in 2045, and 500% in 2046. Within five years the change would go from barely noticeable to overwhelming.

This is disturbing because human wages should fall quickly with the falling price of machines. So while humans who owned shares in the firms that made machines would get very rich, those whose only source of income was their labor could die of starvation. And if people wait to see the transition happen before they believe it is real, they might not have time to arrange for other sources of income.

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If we stand back from all the big events and innovations we have seen in the last century and look at the overall world economic growth rate, it seems surprisingly steady. All those events and innovations contribute to growth, but have not much changed the overall growth rate. From this, one might expect such steady growth to continue for a long time.

Looking further back in time, however, we see that once in a while something has changed the growth rate by enormous factors in a relatively short time. We might do well to not ignore such a speeding freight train until it actually hits us.

For more information see my papers:

Long-Term Growth As A Sequence of Exponential Modes

Economic Growth Given Machine Intelligence

If Uploads Come First

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