2.4 The exponential growth trap

Many of the complex problems that the world is faced with today are related to growth. Economic growth and growing populations induce shortages of space, energy, raw materials and food, and an increase of such seemingly unrelated variables as the cost of living, pollution and the crime rate.

These processes usually start with an exponentially growing phase before eventually slowing down and then leveling off. An intuitive understanding of exponential growth is important to improve our understanding of complex growth related problems.

Reinforcing feedback generates exponential growth: the growing action increases the performance variable, the performance variable then amplifies the growing action and the compounding fraction determines how strong this amplification is. At each successive cycle of the loop, the performance variable grows at an increasing rate. We can see this reinforcing, “exponential” growth from the hockey stick shape of the performance variable curve over time. By comparison, the dotted line shows how the performance variable would have grown at a constant, linear rate. The cycle of amplification continues until the loop is stopped or slowed down.

The danger with reinforcing feedback and exponential growth is that we rarely notice before it is too late. The reinforcing nature of positive feedback can really create havoc if it goes unchecked. In the beginning we don’t notice the small increases in the variables. When we do, the exponential growth is often in full swing and sometimes it’s too late. This is what we call “boiling frogs”. Do you know how to boil a frog? You can’t just drop it into a pot of boiling water as it will jump straight out. You have to put it into a pot of cold water and gently turn on the heat. As the water gets warmer and warmer the frog gets a little groggy and by the time he realizes that the water is too hot, he is too tired to jump out. The same thing happens with reinforcing feedback driven growth. Small causes slowly snowball into big effects but by the time we see the result of reinforcing feedback it is often too late to do anything about it.

Throughout cultures and time we have been warned of the dangers of exponential growth.

There is a French riddle for children about water lilies growing in a pond. Suppose you own a pond on which one water lily is growing. The lily plant doubles in size each day. If the lily were allowed to grow unchecked, it would completely cover the pond in 30 days, choking off the other forms of life in the water. For a long time the lily plant seems small, and so you decide not to worry about cutting it back until it covers half the pond. On what day will that be? On the twenty-ninth day, of course. You have only one day left to save your pond!

The Chinese have a similar fable about a boy who planted some duckweed in a pond and in India they tell a story of a prince who foolishly accepted to pay for the game of chess with a number of grains of rice that doubled on every square of the chess board.

Despite its ubiquity, we have trouble appreciating exponential growth. “Exponential growth bias” is the tendency to linearize exponential functions. Rather than imagining them growing in a reinforcing manner, we tend to see them increasing as a straight line.

Suppose you invest 100 euros at an interest rate of 7 percent per year. If you don’t withdraw any money, how much do you think you will have in your account after 30 years?

Don’t calculate the answer but simply make a guess regarding the future value. What do you think?

The correct answer is 761 euros. Was your answer lower of higher? People with exponential growth bias would tend to underestimate the future value. When researchers from Sweden asked this exact question to 1300 randomly selected adults, 62% underestimated the value with a median answer of 410.

We can anticipate exponential growth by calculating the “doubling time”: the time it takes for the performance variable to double in size. The doubling time is calculated by dividing 70 by the compounding rate. In the previous exercise, a sum growing at 7% per year would double in 10 years. At the end of 10 years it would be 200 and would double again to 400 after 20 years. After 30 years, the sum would be 800. This is pretty close to the exact answer of 761. It is not perfectly accurate but it does give us a ball park estimate.

Of course, nothing can grow forever. All growth will reach a limit at some point. Population growth for example will be slowed down by limits to food, water and space. These limits are one of the roles of balancing feedback that we explore in our next unit.