We are living in exponential times...
...but what does it really mean?

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Why a physicist at CERN would want to lecture business people about this topic?

Exponential ~ hugely accelerated

At our LHC we accelerate “stuff” pretty fast and study what happens when this “stuff” collides.
Why would you be interested in “exponential”?

Because you maybe interested in “sustainability”

Let’s briefly explore together.
I will not use equations…because Editors always warn that for every equation in a book, the readership is halved. So I don’t want to end up this presentation talking to myself.

I am not the kind of physicist that likes equations too much except when they really tell something (..I say it here at CERN only to very good friends).
Let’s understand “exponential”… two stories and a quiz for you
First story: The legend of the invention of Chess.
The legend of the invention of Chess.

- 460 billion metric tons (rice grain weight ~ 25 mg);
- 630 years of worldwide rice production;
- 10 light years of rice laid end to end (rice grain size ~ 5 mm long);
- A tower of rice 40 x 40 m² base rising all the way to the Moon.

Please, $2^{63}$ rice grains here!!
Second story: What is the cheapest way to get to the Moon?
What is the cheapest way to get to the Moon?

1. Take a piece of paper.
2. Start folding it in half each time.
What is the cheapest way to get to the Moon?

25 folds ~ Empire State Building

30 folds ~ Altitude of planes

40 folds ~ GPS satellite orbit

45 folds ~ Congratulations, you have reached the Moon!

Folding increases thickness exponentially
And now the quiz...
I am an evil physicist.

Disguised in a business suit I kidnap you.

I tie you to the highest seat in the Yankee stadium (NY).

At 15:00 h I set up a device that releases a first drop.

I set up my device so water accumulates doubling in size every minute…

… How much time do you have for escaping before you drown?

(assume the stadium is water tight)

Any guesses????
You have until 15:50 h.

...ok that’s bad news...

Can things get worse?
When will the stadium be 93% filled up so it gets you really nervous?

Again, any guesses?
At 15:45 h...

...yes, things can get worse...
Two lessons...

If something grows exponentially it means really, really fast.

Whatever happens as a consequence it hits up really, really hard in the last moment.
How does exponential growth looks like?

Amount of stuff

Time
Let me show you some examples of “stuff” that seems to grow exponentially in this planet.
Source:
Atmosphere: Ozone Depletion

Climate: Great Floods

Ocean Ecosystems

Terrestrial Ecosystems: Loss of Tropical Rain Forest and Woodland

BE AWARE!!

Sometimes (global) exponentials hide inequality in wealth distribution.


Pablo Garcia Tello, CERN, IdeaSquare
Now that we have a feeling about “exponential” allow me to offer you some food for thought (3 cases).
Case 1

Will science and technology alone save the day?

My answer: I don’t know…

I am just a physicist.
Technology seems to grow exponentially…

As well as the way several technologies are converging, adopted and the possibilities they may bring…

Source: Deloitte 4.0 report 2015
...but this doesn’t come for free...

(India figures)

The graph above shows that our environmental problems are growing exponentially...should we advance exponentially towards a “green economy”?

Any answers?
What do we do with the people that will lose their jobs in nowadays polluting energy generation sectors?

My answer: Hell I know!
Case 3: Another provocative question….

An exponential growth of the capability of our technology will be good or bad?

Any answers?

Quite some wise voices are starting to talk about “The Great Decoupling”: productivity is rising, but employment may not.
"The Great Decoupling": Breaking most sacred economic dogmas

Rise in productivity = rise in employment = rise in wealth.
For ending my talk let me show you some quick math useful for getting a fast feeling for “exponential”.

I know I promised no formulas …but you remained with me… so now I take my chances.
The rule of 70

If something grows exponentially at a constant rate it is interesting to get a feeling about how much time it takes for this something to double (= doubling time).

Doubling time is the amount of time it takes for a given quantity to double in size.
The rule of 70

Quick math trick

Doubling time = $\frac{70}{\% \text{ growth rate}}$

For example, if somebody tells you that unemployment in your region has 2% annual growth it will double in just 35 years.
Transformation wanted!

- **Facts** (No Innovation)
- **Possibles** (Incremental Innovation)
- **Paradigms** (Transformative Innovation)
- **Potentials** (Breakthrough Innovation)

- **Knowns**
- **Unknowns**
If we meet again my talk will be about

Super-exponential…
…when things get really scary
Conclusion: I hope humankind will follow the right law…

But it is just hope…after all, I am a physicist working at CERN…
Thanks for your attention questions...

The greatest shortcoming of the human race is our inability to understand the exponential function.

Albert A. Bartlett (1923-2013), Physicist