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IDEASQUARE COFFEE PAPER

Is Small Beautiful?

In addition to its main purpose of publishing experimental innovation research related results, CIJ also publishes lighter, inspirational food-for-thought intended "IdeaSquare Coffee Papers". These pieces are collaborative efforts prepared by researchers from various walks of life visiting or staying at the CERN IdeaSquare premises. The identity of the contributing authors is kept anonymous (although known) but helpful hints can be found in the literature references.

EXECUTIVE SUMMARY

The IdeaSquare innovation team confronts a question many hardly dare to ask. But as always, it never shies away from a good challenge. This time, the journey starts with questioning the universality of the way particle physics research scales up. Is bigger better? The adventure then starts, bottom up, from asking whether small is beautiful. Then, relying on dimensions of politics, biology and finally, physics, the IdeaSquare innovation team find the Universal Truth to answer… (or not) the very question everyone is wondering.

INTRODUCTION

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius — and a lot of courage — to move in the opposite direction. Modern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it".

Ernst Friedrich Schumacher, in "*Small Is Beautiful: A Study of Economics As If People Mattered, 1973*".

The IdeaSquare innovation team is sent tons of emails from fans all around the world asking deep questions about science, innovation and the future of our planet[1]. We were recently asked: "If new discoveries in fundamental particle physics require ever higher energies and thus bigger accelerators and detectors, is bigger then better??".

This triggered lively discussions in the IdeaSquare coffee room as indeed, higher concentrations of (collision) energy are needed to penetrate into smaller things[2], and this in turn scales up with size. Then, of course, the discussion drifted into asking whether or not size matters and whether or not big is beautiful (if it is better). The more culturally sensitive members of IdeaSquare then steered – wisely – the discussion into heterogenous findings in academic research. Examples were found both ways: for example, physical size does appear to influence aesthetic preference judgments (Silvera et al., 2002). Larger markets seem to increase competition and facilitate process innovation (Desmet and Parente, 2010). Volumes of Big Data seem to improve predictive modelling power (Junqué de Fortuny et al., 2014). But on the other side, small environmental units emerge as preferable to large in the study of environmental effects on crime (Oberwittler and Wikström, 2009): Smaller heterogeneous decision tree ensembles appear to be better than large homogeneous ones (Gashler et al., 2008). Related to innovation, it seems locating in a science park, smaller firms benefit more than larger firms in terms of innovation performance (Huang et al., 2012).

So… what to make of this? And is better also more beautiful? As good manners in physics remind us, better start from the bottom.

[1] Thanks to our efficient spam filter, none actually get through but by mistake, one did and it triggered this Coffee Paper.

[2] We all recall Plank's law $E = hf = hc/\lambda$ back from our high school days.

SMALL IS SMALL UNDER ANY POLICY…BUT IS IT BEAUTIFUL?

Plenty has been written about proportions, therefore the team's chosen starting point could be no other than…Politics. After all, this is where the question of size seems to emerge constantly[3].

Our first hero is Leopold Kohr[4] (1909–1994), an Austrian economist, jurist and political scientist characteristically known for two things. First, his opposition to the "cult of bigness" in social organization. Second, being the one, together with others, who inspired the *Small Is Beautiful* movement.

Gifted with his up-beat sense of humour, Leopold's thoughts on "human scale" could roughly be summed up in two axioms:

- *When something gets bigger, it will soon get over-complicated.*
- *When something gets over-complicated, the surprises will be nasty ones.*

Up to you drawing conclusions or take-aways, especially regarding the words "something" and "surprises". What Leopold truly meant? We might never really know.

As always with good teachers, Leopold left an enduring imprint on his students. Especially one of them, Ernst Friedrich Schumacher[5], ended up writing a kind of an adult entertainment book, that, in 1995, The Times Literary Supplement ranked among the 100 most influential ones published since World War II. Its title was as daring as "*Small Is Beautiful: A Study of Economics As If People Mattered*"[6].

Let us take a rough snapshot of it to check whether it stands the test of time, since it was published in 1973:

- In Part I, Ernst asserts that the modern economy is unsustainable due to the treatment of natural resources, such as fossil fuels, as expendable income instead of capital. He argues that such resources are non-renewable and will eventually be depleted. Additionally, he claims that the environment's ability to withstand pollution is limited, and sustainable development should be a government priority. He proposes a philosophy of "enoughness," emphasizing the appropriate use of technology and a consideration of human needs and limitations.
- In Part II, Ernst highlights education as the greatest resource, and explores the topics of land, industry, nuclear energy, and the impact of technology on humanity.
- In Part III, he criticizes the gap between the "world's center" and the "developing world", especially in the context of culture and unemployment.
- Finally in Part IV, Ernst offers a Theory of Large-Scale Organization, which among others, discusses globalisation, identifying it as the "idolatry of gigantism". He also challenges the common beliefs about capitalism as a social order and presents alternatives.

The physics connection here is of course obvious. Ernst's sister, Elizabeth, was no one else but physicist Werner Heisenberg's wife! Yes, the very man that when finally found the time, he did not have enough energy and vice versa[7].

BUT THEN IF IT IS ABOUT SIZE…IT SHOULD BE BIOLOGY, RIGHT?

When it is about size, Biology is indeed queen. Across a vast range of orders of magnitude, five scaling rules appear to be applicable to the animal kingdom[8]:

1. Strength~Weight$^{2/3}$
2. Surface ~ Weight$^{2/3}$

[3] It seems also to be corroborated by just by taking a look to the world news lately.
[4] https://en.wikipedia.org/wiki/Leopold_Kohr
[5] https://en.wikipedia.org/wiki/E._F._Schumacher
[6] https://youtu.be/ZWYErhMd8GA
[7] Just to be sure we do not lose our Dear Reader in translation: this refers to the well-known "Heisemberg's Uncertainty Principle" $\Delta E \Delta t \geq h$.
[8] The superscripts (α, β and γ) above the term "weight" denote exponents, with specific numerical values provided when they appear to be consistent across numerous studies. In cases where the universality of numerically fractional exponents is still debated across various studies, a letter is used as a placeholder. See bibliography at the end.

3. Metabolic rate ~ Weight$^{\gamma}$
4. Abundance ~ Weight$^{-\beta}$
5. Complexity ~ Weight$^{\alpha}$

The five rules are based on the empirical evidence that key parameters ensuring the existence and development of an organism, are affected by an organism's size, indicated by its weight. They include the need for appropriate strength to support movement (1), the requirement for an adequate surface area to enable the diffusion of oxygen and food substances to reach inner tissues (2), the need for an appropriate rate of metabolism to support its functioning (3) and the necessity for an appropriate division of labour (complexity, for example in cell types) to ensure the organism functions properly (5). Additionally, the abundance of animals and plants in nature is affected by their size, with larger organisms requiring more space (4). These rules, as mentioned, serve as the pillars supporting the impact of size in living organisms.

The self-appointed IdeaSquare innovation team, at this point started to play around with the five rules above since they treasure an enormous amount of wisdom when speculating their applicability to other realms beyond Biology.

As CERN is well known to be the birthplace of the World Wide Web (WWW), let us take, for example, rule (5) and apply it to the WWW content. Yes, the web sites! We all like, when we search, getting the "good stuff" since after all, why would anybody be interested in the junk? It is specially the case when talking about adult entertainment[9].

Suppose there is a simple way to measure the complexity of the WWW, such as the ratio of time spent searching for information versus the time spent for finding the "good stuff". Let us call this ratio, τ. Let us also apply rule (5) with, let's say, α=1, to make it simple. The complexity can be represented as:

$$Complexity \sim \frac{Time\ it\ takes\ to\ find\ the\ "good\ stuff"}{Time\ spent\ looking\ for\ info} \sim \tau \sim Weight \sim WWW\ size$$

Or in a more succinct form:

$$\tau \sim L$$

Where we have identified WWW Size = L. Think of the WWW size as the number of websites, for example. Anyone spending time surfing the WWW soon realises that it is hard to get to the "good stuff". Therefore, only a fraction of the WWW provides it. Let us call it δ. This means that:

$$\tau \sim L - \delta L \sim (1 - \delta)L$$

Everyone wants τ to be as small as possible, meaning they can find the "good stuff" quickly without spending much time searching. However, increasing the size of the WWW will not make it, as a larger L leads to a larger τ.

The key is improving the quality of the WWW by increasing δ, which will reduce the time it takes to find "the good stuff". In other words, you may interpret the quantity between brackets above as a density of "good stuff" per WWW size. Only by increasing this density we will have a better WWW and not just making it larger.

So, voilà, quality over quantity, following the rules of Biology!

THE BEARABLE SMALLNESS OF TRAVELLING… FAST

Having navigated the waters of Politics and Biology, the IdeaSquare self-appointed innovation team, as it could not be otherwise, immersed in the realm of safe-harbour of … Physics.

As far as the legend goes, Albert Einstein referred to Special Relativity as the theory of clocks and meter rods. "A rod is something that measures length, a clock is something that measures time", he apparently said[10].

Therefore, since this is an in-depth investigation on the question "Does size matter?" it is mandatory examining what Special Relativity has to say about size.

On that, Albert is clear. His theory has a peculiar aspect whereby objects moving at high speeds undergo a contraction along the dimension coinciding with the direction of motion[11]. When observed by someone at rest

[9] If your mind, appreciated reader, wonders too much, let us be clear that we refer here to the kind of adult entertainment that Ernst wrote…just in case.

[10] See bibliography at the end.

[11] By high speeds we mean comparable to the speed of light which is 300.000 Km/s.

(relative to the object), the object appears to be shorter in length. For example, an object of 1 meter long when at rest, will have a shorter measured length when moving at high speeds relative to the observer/measurer.

This phenomenon is not due to measurement errors or faulty observations, but rather because the object is actually contracted in length as viewed from the stationary observer. The degree of contraction depends on the object's speed relative to the observer.

Thus, for Albert it is a no brainer. Do you want to move fast? Then shrink before my eyes, my friend. In other words, smaller means faster.

SHALL I COMPARE THEE TO AN INNOVATOR?

At this point the self-appointed IdeaSquare innovation team was truly exhausted. The journey was a deeply intellectual and emotional adventure pursuing the answer to "is bigger better?". The conclusion was: not always. Quality matters more!

As daring as it was to ask such questions, a satisfactory ending was achieved as the following distilled, collective wisdom finally emerged:

- Small is beautiful.
- Smaller means faster.
- Quality over quantity.
- When something gets bigger, it will soon get over-complicated.
- When something gets over-complicated, the surprises will be nasty.

Inspired by the ultimate innovator who elevated words into concepts of bigger meaning[12], the self-appointed IdeaSquare innovation team decided to end this journey with one of his famous sonnets, as it could not be otherwise:

Innovation, like a summer's day,
In May, seem lovely, yet often fades away.
Its course may be short, like summer's lease,
And winds of change may shake its budding peace.
Sometimes too hot, innovation's fire,
Can dim its shine and mask its desire.
And every new idea, though far away it seems,
May fall from being small[13], by chance or changing schemes.
But true innovation, like eternal summer,
Will not fade or lose its rightful number.
Nor will death claim it for its own,
For in time's eternal lines, it's grown.
As long as humans breathe, and eyes can see,
Innovation's legacy will forever be.
And it will give life, long after we're gone,
In the eternal lines of innovation's song.

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[12] More about that here, for example: https://www.abcschool.co.uk/blog/shakespeare-the-ultimate-innovator/

[13] It is obvious that Shakespeare was referring here to SMEs and Startups and not to Large Corporations.

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