Nietzsche and Fractal Geometry: a philosophical continuity

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Abstract

"A reference to Aristotle and Leibniz has long ceased to be required in serious books", said Benoit Mandelbrot, father of fractal geometry. A reference to Nietzsche could increasingly become a requirement in economics books.

The purpose of this work is to highlight the epistemological proximity between Nietzsche's and the underlying philosophical principles of fractal geometry. This work also aims to find the end of this philosophical continuity, finding an important divergence in their different approach to risk.

Keywords: Nietzsche, Mandelbrot, Epistemology, Mathematics, Fractal Geometry, Finance, Risk, Risk Management, Models.

Nietzsche, physics and faith

Friedrich Wilhelm Nietzsche refused to structure an epistemological framework throughout his works, leading to different readings over his view on the philosophical significance of the practice of science. In an earlier set of works, that scholars define "middle period" (1878-1882), the German philosopher praises the scientific method mainly as opposed to religious faith (in particular, Christianity) in what is generally considered a Pro-Enlightenment stance (Garrard, 2008). Nietzsche undertakes a major reversal through the works of the "later period" (starting from 1882), in which he strongly condemns the concept of causality and other deterministic principles, reserving his most heated criticism to the practitioners of physics and mathematics.

Scholars (such as Campa, 2007) have highlighted that Nietzsche never abandoned the idea that the scientific method is superior to religious faith, mainly because it does not aim to offer absolute truths. This idea is introduced briefly in "*Human, All Too Human"* (1878), in which the philosopher claims that the promises of science concern *"as little pain as possible, as long a life as possible"* (HH, I, 128), adding that science's goals are *"very modest as compared with the promises of religions."*. The characterization of science as "*modest*" is resumed in the "*Antichrist"* (1888), where Nietzsche states that science has less appeal than religion precisely because the scientific method – that is *"quiet, cautious, distrustful"* (AC, 13) and forces scientists not to make unsubstantiated claims – does not offer the same certainty as religion, which instead has a *"picturesque effectiveness"*.

It is key to highlight that Nietzsche's praise of science has always been related to process rather than outcomes*: "The value of strictly pursuing science for a time does not lie precisely*

in its results" (HH, I, 256); mathematicians are praised for their *"subtlety and rigour"* (GS, 246) and physicists for being *"creators"* (GS, 335).

Negri (1994) speculates that Nietzsche's distrust of physics (and by proxy - mathematics and logic) was prompted by the success of Newton's law of universal gravitation and by its impact on the scientific method: gravity and forces of attractions are often mentioned in the philosopher's fragments and in "*Thus Spoke Zarathustra"* (1883), the German philosopher goes as far as defining the *"spirit of gravity"* (I, On the Vision and the Riddle) as his *"devil"* and *"arch-enemy".*

In the late XIX century, the British scientist's legacy was so powerful that his theories were being used as a base for virtually all new development in physics: German physicist and philosopher Ernst Mach would mention in his *"Science of Mechanics"* (1893) that Newtonian theories were being used "*as points of departures*" and that "*the impulse to inquire after their origin soon disappeared almost completely*". Kuhn (1962) would later define the Newtonian revolution as a *"paradigm shift"*, a scientific theory that constituted the base of later scientific development. This paradigm shift had triggered a period of *"normal science"*, a phase in which science was being carried out on the basis of *"achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice".*

Nietzsche is ostensibly disappointed by the fact that physicists could *"not get rid of the effect [action] at a distance"* (FP, 36 [31], June-July 1885) - of which gravity is a prime example - and that the *"belief in even the ability to explain"* these forces (FP, 36 [34], June-July 1885) had been lost. Physicists had become guilty – pretty much like the priests – of offering *"safety"* against the *"fear of the incalculable"* (FP, 5, 10, 1886). In Garrard's (2008) words, he came to see the scientific research being carried out in that period as "*just another herd*

mentality". Negri (1994) concludes that it is not unlikely that the study of Newtonian theories appeared the equivalent of a theology to Nietzsche's eyes.

Nietzsche and mathematical formalism

A related element of Nietzsche's critique of science is his position against mathematical formalism. The German philosopher could not conceive science as *"an indoor diversion for mathematicians"* (GS, 373) and believed that mathematics was *"too crude"* (FP, 34 [124], April-June 1885) to be used to interpret the world. In what is probably his clearest contribution to the philosophy of mathematics, Nietzsche recognised that *"mathematics is only the means to general and final knowledge of humanity",* but only to *"ascertain our human relation to things"* (GS, 246). In a period when physicists and mathematicians were indulging into formalism to illustrate mechanical principles, the German philosopher warned that *"our knowledge has become scientific to the extent that it is able to employ number and measure"* (WP, 710). Steinhart (1999) found Nietzsche's thought to be *"squarely in line with those of intuitionism"*, a philosophy of mathematics based on the idea that mathematics is a languageless activity – i.e. discerning mathematical intuition from mathematical formality.

A glimpse into Nietzsche's own epistemology can be found in *"On Truth and Lies in a Nonmoral Sense"* (1873), a short essay in which Nietzsche discusses the pursuit of knowledge, the philosopher attributes the power to reach the truth to *"(forbidden) metaphors"* and *"metonymies"*: the knowledge seeker (here called *"intuitive man"*) is *"guided by intuitions rather than concepts"* and avoids taking a *"regular path"*. In this world, mathematical formalism binds the truth through the *"cool breath of logic"* into *"concepts",* which are *"merely the residue of a metaphor"*.

Nietzsche believes that the "*reduction*" of phenomena into formulae is a "*human*" activity and necessary for their interpretation, but he emphasizes that scientific formalism is a sub-optimal lens to understand the world. *"How much of a piece of music is understood"* (WP 624) by the formulae that describe it, i.e. musical notation?

Mandelbrot and a crisis of intuition

In an essay published in the second edition of "*The Fractal Geometry of Nature*" (1982), Polish mathematician and father of fractal geometry Benoit Mandelbrot explains the circumstances under which fractal geometry was developed, with particular reference to the crisis related to the role of intuition in the development of mathematics, which served as a backdrop for the development of his theories.

In particular, Mandelbrot reports several excerpts from Felix Klein's lectures at Northwestern University: Klein was a German mathematician, known for his work on non-Euclidean geometry, and his classes focused on whether the cultivation of abstract mathematics – which, in Klein's own words, lack *"any practical application"* – had to be separated from applied sciences. Klein's conclusion is that it is not possible to base science on axioms alone and discard intuition entirely, stating that *"splendid [theoretical] researches"* would have been impossible without the *"constant use of geometrical intuition"*.

Mandelbrot quotes a second set of lectures, this time from Hans Hahn - mathematician known for the study of vector spaces – to comment on an opposite view. Hahn believed that *"intuition is a wholly unreliable guide"* and called for a *"task of completely formalizing mathematics"*. In Nietzsche's words, Hans believed that the comprehension of the world was indeed an *"indoor diversion for mathematicians"*.

Mandelbrot expresses his disdain for Hans' theories in his comment to the lectures, claiming that Hans' theories had provided for the *"excesses of pure mathematics"* and that his own research on fractal geometry showed that *"intuition is not invariable but can and must be trained to perform new tasks"*. Nietzsche would agree: *"the extent to which we possess science today is precisely the extent to which we have decided to accept the testimony of the senses and learned to sharpen them"* (TWI, Reason in Philosophy, 3).

The Polish mathematician was surprised of the *"visual barrenness"* of XIX century mathematics works, and comfortably stated that *"a rough drawing is a more adequate geometric model of a thread than the mathematical line itself."* He was proud that fractal geometry had allowed *"the eye to link mathematics with concrete work in economics and physics, and even with everyday experience"*, which is coherent with Nietzsche's interpretation of the goals of mathematics - *"making phenomena more comprehensible"* (FP, 5, 16, 1886).

After more than a century of mathematics developments after Nietzsche's death, Mandelbrot claimed that *"Clouds are not round, mountains are not cones, coastlines are not smooth"* (2008). Nietzsche's was equally unimpressed by Galilei, who could see triangles and circles in the universe, and Descartes, who saw in mathematics *"firm and solid fundamentals"*, stating that *"in Nature there are no exactly straight lines, no real circle, no absolute standard of size"* (HH, I, 11).

The mariner lost at sea

Perhaps the most striking similarity between the mathematician and the philosopher's works is the usage of an image that represents a cornerstone of Nietzsche's epistemology: the mariner.

First introduced in "*The Birth of Tragedy"* (1872) – and inspired by the works of Schopenhauer and Leopardi – the sailor is depicted as sitting *"peacefully"* in a *"weak craft [boat]"* navigating in a *"stormy sea"*. Mandelbrot (1999) described fractal geometry as a tool reflecting the *"mariner's warning that on even the calmest sea, a gale may be just over the horizon"* and scientists making use of it as able to *"prepare for inevitable sea changes"*. Nietzsche is clearly more radical here: the mariner is in a "weak craft", i.e. is not equipped with the means of certainty (faith, logic or mathematics) and this is the condition of a true knowledge seeker. Mandelbrot instead believes the mariner is not equipped enough for the risk they are facing, and fractal geometry is the adequate tool to prepare.

The management of risk is indeed central in the application of Mandelbrot's tools, with particular focus on financial markets[1]. Through the use of fractal geometry, Mandelbrot was one of the first critics of commonly used risk management models in finance, proposing (2008) the use of alternate metrics which would not rely on the assumption of normally distributed (i.e. highly predictable) prices for financial assets. The hidden flaws of such formally correct models were exposed by Mandelbrot, that described at length the *"benign neglect"* (1999) of their underlying assumptions, claiming that they *"embraced continuity"*; or as Nietzsche would say, expected to find *"regularity in phenomena in order to apply abbreviation formulae"* (FP, 5, 10, 1886).

Nietzsche's philosophy of risk taking

The philosophical continuity between Nietzsche and Mandelbrot is evident when it comes to warning against the faith in pure mathematical formalism and emphasizing the essential role of intuition in the pursuit of knowledge, but their thoughts diverge on the necessary role of risk.

Mandelbrot's legacy is that risk can be managed – and still with formal mathematics: fractal geometry triggered a new phase in the use of models (in particular, risk management models) in finance, based on the refusal of assumptions regarding the regularity of variables that affect the markets. The overreliance on abstract models and theoretical formulae in finance is now part of the academic debate, through the works – among others - of Goldstein and Taleb (2007) and Derman (2010)[2]. Among these Peters (2019), who aims to resolve "*many puzzles besetting the current economic formalism [..] in a natural and empirically testable way".*

Nietzsche's intuitive man, instead, *"suffers more intensively and more frequently"* (OTL), yet they are rewarded with *"a harvest of continually inflowing illumination, cheer, and redemption"*. The image of the harvest and the reference to physical suffering is used again in one of the most vivid excerpts of "*The Gay Science"* (1882), in which we read:

[…] the secret for harvesting from existence the greatest fruitfulness and the greatest enjoyment is - to live dangerously! Build your cities on the slopes of Vesuvius! Send your ships into uncharted seas! Live at war with your peers and yourselves! Be robbers and conquerors as long as you cannot be rulers and possessors, you seekers of knowledge! Soon the time will be past in which you had to be content living bidden in forests like shy deer! Finally the search for knowledge will reach for its due; it will want to rule and possess, and you with it!" (GS, 283).

The importance of this excerpt in the context of Nietzsche's thought is substantiated by the fact that it is curiously titled *"Preparatory human beings"*, almost hinting at the creation of a new form of human beings which will later become the *Übermensch*. This new human being – which Nietzsche would alternatively call the "intuitive man" - is someone that "*does not hesitate to offer human sacrifices, to risk every danger, to take upon oneself whatever is bad and worst"* (WP, 26) and seeks *"life raised to a higher power, life lived in danger"* (WP, 929).

Contrary to Mandelbrot, Nietzsche did not believe in effective risk management. The German philosopher's legacy is that risk is embedded in knowledge-seeking. Exposure to risk must be voluntary ("building on the slopes of the Vesuvius") and its consequences a necessary mean to reach scientific conclusions: Empedocles throwing himself into the crater of Etna is the absolute *"form of science"* (FP, 7 [101], April 1871).

Conclusions

Nietzsche's philosophy has been associated in the past to complex system and fractal geometry (see Douglas, 1996) due to his dynamic interpretation of forces and the relationship between time and space.

The purpose of this work is to highlight the epistemological proximity of Nietzsche's thought with the underlying philosophical principles of fractal geometry. In particular, Mandelbrot and the German philosopher shared their view on the limits of mathematical formalism – especially when not substantiated by inputs coming from intuition and observation.

The work aims to find the end of this philosophical continuity, finding a relevant divergence in their approach to the management of risk. In particular, fractal geometry triggered a radical

overhaul of the use of mathematical models and Mandelbrot himself presented a series of tools for the management of (financial) risk. When it comes to Nietzsche, the exposure to risk became a central component of his epistemology, turning the philosopher into a theorist of taking risks for knowledge's sake.

Endnotes

1. According to Nassim Nicholas Taleb, Mandelbrot was particularly keen on the application of fractal geometry to finance markets because he could rely on vast data sets.

2. Readers will recognize that Derman (2010) uses the word "metaphors" to describe financial models in a complete opposite meaning to Nietzsche's, i.e. to deem them imprecise and far from scientific standards**.**

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