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Financial Black Swans: unpredictable threat or descriptive illusion?

Christian Walter¹

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This chapter discusses the threat posed by rare but high-impact events in finance: serious market crashes or financial meltdowns, such as the crisis of 2008. These crises have been metaphorically interpreted as “black swans” by Nassim Taleb in a book that made a worldwide impression, *The Black Swan: The Impact of the Highly Improbable* (2007). A “black swan” is an event that is very unlikely and not normally to be expected (i.e. an “outlier”) but which, if it does occur, will have extreme and possibly catastrophic consequences. Taleb’s “black swan theory” contains an analysis of these threats that presents them as radically unpredictable, articulating an inexpressible aspect of the markets that leaves us helpless. In this mental schema, nothing can be done to prevent black swans. All we can do is work out defences against them, so as to be in the least vulnerable position possible when they arise – as they certainly will.

While the issue of rare events is a relatively longstanding concern in the field of probability, as reflected in the development of extreme value theory generalising the older Pareto principle (the source of the “80/20” rule that 20% of events account for 80% of outcomes), the last few years have seen a renewed interest in analysis of high-impact rare events, initially stirred particularly by the financial crises and subsequently by the effects of global warming. Much research has recently been devoted to them, under designations such as “large-impact, hard-to-predict, and rare events” (Kjell & Netland, 2010) and “large-scale, large-impact rare events” (Werther, 2013). In the field of finance, a series of crises have led to political and regulatory decisions introducing international prudential rules for financial activities, and market regulation (Basel III, Solvency II etc.) intended to lower the threat of a global crisis by acting on the financial levers of systemic risks. Ten years after the 2008 meltdown, these financial rules and regulations do not appear to have achieved their aims, and we are still in a situation where the threat of systemic financial crisis is seemingly unextinguished. More importantly, unexpected and undesirable consequences of prudential regulation are becoming visible, for example market procyclicality (Bank of England, 2014), suggesting that far from reducing the threat of systemic risk, the new prudential rules have had the side-effect of increasing it. Black swans thus still lie before us in finance.

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The concept of the black swan was introduced by Taleb in a first book, *Fooled by Randomness: The Hidden Role of Chance in Life and in the Markets* (2001). To be clear that we are talking about the field of finance as distinct from “natural” black swans such as floods or earthquakes, the term “financial black swans” is used for the threat concerned by this chapter. It is discussed through the following questions about Taleb’s ideas: in the financial world, are black swans really an unpredictable threat embodying the radically unknown, so that we can only brace ourselves and hope to be well-prepared when the time comes? To answer this question, I express the problem as follows. *Ex post* explanations of financial black swans have emphasised economic causes (indebtedness, leverage, etc.), market failings (risk control, etc.), or less-than-ethical behaviour (greed on the part of the actors, etc.). So far, the effects of writing down the probable, i.e. mathematical risk modelling, have not been analysed. This chapter intends to discuss the threat of financial black swans from that perspective.

Let us be more specific. I am not an economist and am not going to join in the economists’ debate about the causes of the 2008 crisis. Instead, I will adopt an actuary’s standpoint. Actuarial methods focus on contingent futures, considering ways to capture probability and to symbolise it in writing (accounting entries, mathematical expressions). How can we evaluate the probable? How can we quantify it? How can we calculate the financial impact of the probable? One known application of actuarial methods is practised by insurers and reinsurers, and involves calculations of environmental, climate/weather, industrial, and financial risks. I shall address the question of the threat of black swans from an actuarial angle, i.e. through analysis of how the probable is written down in the technical tools of finance, and in financial prudential rules.

The objective of this chapter is thus to propose an alternative understanding of the threat of financial black swans. The argument is presented in four steps. 1) The financial probable is symbolised in mathematical language by written expressions of the measure of risk, based on specific assumptions about uncertainty, which I have called “the financial *Logos*” (Walter, 2016). 2) The mathematical language used to capture the financial probable is not merely a descriptive language for financial risks (representational view of language) but a language that produces a “speech act” (pragmatic view of language) in the sense of financial models understood as speech acts (Brisset, 2018): the financial *Logos* speaks and transforms the world through financial instruments and financial regulation. 3) The writing down of the probable lodged in risk models and prudential rules can thus be a source of the danger those very models and rules seek to contain (Lévy-Vehel & Walter, 2015). 4) Financial black swans can thus resemble unexpected consequences of the words (“speech act”) of the financial *Logos*. As a result, considering financial black swans as radically unpredictable events, in line with Taleb’s view, is a descriptive illusion. I thus counter the theory of Taleb’s financial black swans with the theory of the financial *Logos*, considering that the second of these theories offers better protection against the threat of financial crises.

The crisis of 2008

We now turn to the economic collapse of 2008. First, I present an interpretation of that collapse through the lens of black swan theory. I follow this by introducing an analysis of the writing down of the probable as an additional cause of the crisis. Finally, I propose the theory of the financial *Logos*.

Taleb's black swan theory: *Fortuna* gets its card.

The term “black swan” was used by the Latin poet Juvenal in his sixth *Satire* in the expression “a rare bird in the lands and very much like a black swan”, as it was believed at the time that black swans did not exist. Why should something radically unpredictable be called a “black swan”? By allusion to the Europeans’ surprise at discovering black swans in Australia, since their previous observations had led them to suppose that all swans were white. An earlier reference to the idea also exists in the personage of *Fortuna*, fortune, whose effects are described by Machiavelli (1469-1527) in *I Capitoli* (1513). The radically unpredictable event is literally the unforeseen, because we *cannot yet see it*. The idea is expressed by Machiavelli’s prosopopoeia spoken by *Fortuna*: “I have in front all my dishevelled hair, with which I cover both my face and breast, So that no one may know I am right there.” Metaphorically, a black swan is thus “something” that disrupts the organisation of what we are always – vainly – trying to control in order to make the world around us as predictable as possible. Any policy must negotiate a certain amount of unpredictability, and the black swans here are (black) signs of the action of *Fortuna*. A force of nature bursts onto the scene of human plans, as if to remind us that any desire for complete control of phenomena is simply a reflection of the deadly temptation of totalitarianism (Rodarie, 2015). According to this argument, it is economists’ desire for control that has exposed them to the misadventure of the black swan: something radically unpredictable that upsets the soundest forecasts.

In Taleb’s view, it is possible to talk of a “black swan” if the following three criteria are fulfilled: first, the event is a surprise (for the observer); second, this event has extreme consequences; third, after its first occurrence, the event is rationalised with hindsight as if it had been expected all along. This retrospective rationalisation is possible because the information that would have indicated the event’s forthcoming arrival was already present but was not taken into consideration.

This forecasting error deriving from inductive reasoning (based on repeated observation of white swans, it is deduced that all swans are white) was systematised in the parable of the inductivist turkey, which was invented by the English mathematician and philosopher Bertrand Russell (1872-1970). The parable goes as follows. A turkey observes that every morning without fail, it is fed by humans. Applying inductive reasoning after collecting a number of observations considered sufficient (in this case 364 days), the turkey concludes that humans are a benevolent race and are good to turkeys, and placidly awaits the 365th morning. But the 365th morning falls on Christmas day, and the turkey is killed for Christmas dinner! For 99.73% of the time (364 out of 365 days), the turkey’s conjectures were correct, increasing confidence in its predictions. But the final day of the year crushed its expectation: just like the economists at the time of the 2008 crisis, who saw a black swan suddenly appear in the form of defaults on subprime mortgage repayments, the inductivist turkey experienced a crisis of predictability. And like the economists, the turkey lost its head...

In *The Black Swan*, Taleb gives some examples of invalid inductive reasoning, including the following two. The first concerns Captain Smith, who died in the sinking of the *Titanic* on 14th April 1912. In 1907, he had declared: “But in all my experience, I have never been in any accident... of any sort worth speaking about. I have seen but one vessel in distress in all my years at sea. I never saw a wreck and never have been wrecked nor was I ever in any predicament that threatened to

end in disaster of any sort” (p. 42). Just five years later, Smith went down with his ship. Another example, from the financial world this time, concerns the Amaranth hedge fund. In September 2006, the asset management company, Amaranth issued a statement to reassure investors, telling them that although the business environment was difficult, they had twelve risk management specialists monitoring its dangers in order to reduce threats, and nothing could go seriously wrong. Just a few days later, on 19th September 2006, Amaranth’s market value plummeted by 65% or around 7 billion dollars, at the time “the most impressive loss in trading history”.

Taleb’s comments on this second example are interesting. I present them here in the form of a dialogue between us:

- (Me) The number of risk managers made no difference. Why?
- (Taleb) Even if the company had had 112 risk managers, it wouldn’t have made much difference; it would still have collapsed.
- Why does the number of risk managers add nothing?
- It’s obviously impossible to manufacture more information than the past can give us; if you bought a hundred copies of the *New York Times*, I’m not sure that would help you build up incremental knowledge of the future.
- Why?
- Quite simply, we don’t know how much information there is in the past. (p. 42).

In the end, Taleb considers that when market meltdown occurs, the situation is rather like Fortuna intervening directly in the world of finance. Nothing can be said or done to prevent it, and this kind of threat can never be controlled. This attitude leads to scepticism regarding risk models’ ability to reduce the danger of a crisis on the markets. An illustration and interesting confirmation of this sceptical, disillusioned attitude comes from one of the highest-profile representatives of the financial market authorities, Alan Greenspan, who was president of the US Federal Reserve from 1987 to 2006. After the financial crisis, Greenspan wrote in the *Financial Times* (16/3/2008) that “We will never be able to anticipate all discontinuities in financial markets” and that consequently, “Risk management can never reach perfection. It will eventually fail”. The key word in this opinion piece by Greenspan is the word “discontinuities”: it indicates that in a continuist conception of stock market dynamics, the black swan takes the form of a radical, and therefore radically unpredictable, discontinuity. Taleb’s theory can thus be summed up as follows:

Proposition 1: reformulation of Taleb’s view

In finance, a discontinuity is a financial black swan.

The choice of whether to include discontinuities in the mathematical writing down of the probable is a mathematical decision, which should be made upstream, before any risk model is constructed. Focusing on this choice places our analysis earlier than Taleb’s: we focus on predictability crises rather than forecast failures. This leads into closer consideration of how the probable is written down.

Financial black swans as consequences of killer formulas

It is a well-known and well-documented fact today that one of the central problems in the 2008 financial crisis lay in a specific equation, a mathematical formula that gave the price of credit

default swaps (CDS), the financial instruments supposed to provide protection against default risks: the formula or equation devised by David Li and known as “Li’s copula”. This formula was faulty, not in the sense that the risks were miscalculated, but in the sense that they were mismodelled. There have been many debates about this equation, which a famous article by Felix Salmon called a “Recipe for disaster: The Formula That Killed Wall Street” (Salmon, 2009, Lee, 2009, Embrechts, 2009; Donnelly and Embrechts, 2010); MacKenzie and Spears, 2012). The devil, the saying goes, is in the detail. Playing with the words, I would say that, in this case, the detail was a D-tail, meaning the distribution tail. The distribution tails of a law of probability (the tail risk) describe the behaviour of a random variable (the risk, in this case) in the zone that is furthest from its central value (mean risk). Distribution tails can be “thin” (indicating a very low probability of a major risk arising) or “fat” (indicating the opposite: a very high probability of a major risk arising). Li thought that the risks of simultaneous mortgage credit default could be modelled using a coupling function (a “copula”). But he chose to use a symbol-based form of writing to express the probable (in this case, the probability of simultaneous default) based on Gaussian law (a Gaussian copula formula). The logic of the Gaussian probable underestimates the probability of rare events and creates the illusion that the risk is under control. The Gaussian copula formula encouraged excessive risk-taking because it gave precisely that illusion (Walter, 2008).

This faulty risk modelling is very well depicted, with great epistemological accuracy, in Jeffrey Chandor’s film, *Margin Call* (2011), which tells the story of the fall of Lehman Brothers bank. One sequence of dialogue is crucial to grasp the epistemological and ethical issues involved in the writing down of the probable: a conversation between the risk management officer, Sarah Robertson, and the head of fixed income securities, Jared Cohen. The scene happens late at night, just after they have realised there is a problem with the mathematical risk assessment formula and are beginning to estimate the consequences, in terms of potential losses for the bank. Robertson joins Cohen in his office and the following exchange takes place. It is such an almost-perfect illustration of the difference between risk calculation and risk modelling that it should be part of every financial ethics course:

- (Sarah Robertson) It’s legit... the kid killed it. The formula’s worthless.
- (Jared Cohen) What does that mean?
- (Sarah Robertson) It’s broken.
- (Jared Cohen) There are 8 trillion dollars of paper around the world relying on that equation!
- (Sarah Robertson) Well, we were wrong.

This dialogue illustrates that a mathematical writing down of the probable, in this case Li’s copula, led to financial disaster because it was overtaken by reality (“the formula’s worthless”). The observation that a simple, but false, equation can lead to financial catastrophe had already been made by French physicist, Pierre Duhem, in the early 20th century. In *The Aim and Structure of Physical Theory* (1906), Duhem questioned the role of models in science, with the following comment on the relationship between mathematical models and serious incidents: “We shall remind industrialists, who have no care for the accuracy of a formula provided it is convenient, that the simple but false equation sooner or later becomes, by an unexpected act of revenge of logic, the undertaking which fails, the dike which bursts, the bridge which crashes; it is financial

ruin when it is not the sinister reaper of human lives.” Li’s formula was convenient, but not “true” as regards the accuracy of the mathematical writing down of the probable.

The other important line in this dialogue is Sarah Robertson’s remark “we were wrong”. This is “a form of socially elaborated and shared knowledge, with a practical aim, that helps to construct a reality common to a social group” (Jodelet, 1984, my own translation), here a knowledge of the risks of default on mortgage loans. The symbol-based writing down of the probable by the mathematics of risk led to “construction of a reality common to” all professionals in the field of finance. The financial *Logos* is the means of constructing this common reality through mathematical models.

The influence of writing down the probable can thus be summarised as follows:

Proposition 2: influence of shared knowledge

In finance, a discontinuity is a financial black swan for a continuist mental schema.

Financial *Logos* theory: mathematical black signs matter

I now introduce and summarise the concept of the financial *Logos* introduced in a previous publication (Walter, 2016). The financial *Logos* is a structuring discourse which is incorporated into the financial management arrangements of banks, insurance companies and asset management companies, and monitoring and controlling practices for financial activities. This discourse has three kinds of component: written (e.g. formalisation of rules for investment or risk dispersion), oral (e.g. the discourse on appropriate financial management for a pension fund or an investment bank) and technical (e.g. the methods for calculating risk for equity). This discourse engrains financial metrics and reasoning in places previously untouched by finance and, in this sense, the financial *Logos* is a vector of “financialisation” (Epstein, 2005) as described by Chiapello, i.e. colonisation by specific financialised techniques and calculation methods. This discourse particularly concerns representations of risk, forming a specific culture monitored by the epistemic authorities of financial regulation, in a sharing of mandatory knowledge about the nature of risk.

Professional players in finance are driven by technical mathematical tools whose conceptual foundations they no longer perceive, like Monsieur Jourdain in Molière’s *Le Bourgeois Gentilhomme*, who is delighted to discover that without knowing it, he has been speaking “prose” all his life. Furthermore, the players are unaware of which prose, or language, they are speaking. When this language was related to the representations of risk, and those representations were simplified to the extreme by using Gaussian mental schemas, the result was the financial meltdowns of 1987 and 2008. In other words, theories in the financial world seem to have a distinguishing feature setting them apart from theories in the natural sciences: they appear to influence what they aim to “describe”, and this resonates with the definition of postmodern reflexive knowledge.

In sum, echoing the title of Austin’s (1962) *How to do things with words*, I argue that “writing down the probable is doing things with the words of the mathematics of risk”. Performativist school of sociology has discussed this idea extensively: “scientific theories and models are not statements of findings; they are actively engaged in the construction of the reality they describe” (MacKenzie,

Muniesa and Su, 2007). This is the reason why financial mathematics gradually became an ingredient of systemic risk (Bouchaud, 2010). This assumption is close to those of Brisset's (2018) account of financial models as speech acts.

The debates about the role mathematics played in the 2008 financial crisis have seen clashes between defenders and adversaries of the use of mathematic modelling in finance. To shed light on these debates and present them by exhibiting the hinge of the arguments, I will use a metaphor. After the crisis, the defenders of financial mathematics argued that their models are designed for 20° environments ("temperate" markets), so it is not surprising that they no longer work if put into environments where the temperature is close to 50° ("tropical" markets or "financial cyclones"). The assumption of this intellectual position is that awareness of the model's limitations should be enough to ensure it is used appropriately. The financial *Logos* hypothesis makes a different argument: a certain form of written expression of the probable, when plunged into a 20° environment, pushes the temperature up to 50°. In other words, writing down the probable produces the conditions for its own invalidation, since the mathematical statement "speaks" and constructs a "common reality".

My proposition here is that the symbol-based writing down of the probable should thus be considered as "black signs", since black signs are precisely what form the mathematical symbols used to express risk in writing, in accounting entries or actuarial calculations. From this statement we understand that what is at stake in the overall understanding of economic and financial risks is not so much trusting that Mother Nature will absorb any shocks affecting the banks, but ultimately realising how the way the probable is written down in financial models and standards produces our financial crises.

The influence of the mental schema can thus be summarised as follows:

Proposition 3: discontinuities as unexpected consequences of mental models

A continuist mental model can generate real discontinuities in financial markets.

Financial *Logos* and financial black swans

It is time now to develop my own proposal. In this second part I propose a new way to understand the appearance of financial black swans by connecting them to the words of the financial *Logos*. The deliberate decision to use a specific kind of randomness embedded in the financial *Logos* stems from a school of thought on risk that places simple measures of probability in more complex, uncertain situations. I first present a working hypothesis to differentiate two traditions of financial risk modelling, and then outline the key points of my proposal.

Brownian finance and non-Brownian finance

Everyone knows the expression "Euclidian geometry", meaning the "ruler and compass" type of geometry found in Euclid's *Elements* (c. 300 BC), with its rigorous definition of the concepts of "line", "plane" and "area". This geometry was shaped and constructed by major propositions such as Pythagoras' theorem (580-495 BC) and Thales' intercept theorem (624-547 BC). Of course, non-Euclidean geometries also exist. As spacetime is not flat, spacetime geometry is not Euclidian. A non-Euclidian geometry is thus geometry of curved spacetime. This type of geometry

has become essential for incorporating the effects of gravity when measuring radio wave frequencies: in particular, the atomic clocks of the satellites in the Global Positioning System (GPS) need adjustments due to the Earth's gravitational field. In other words, without non-Euclidian geometry, no GPS or "satnav" device would work. As Keynes stated in *The General Theory* (p. 26), "The classical theorists resemble Euclidean geometers in a non-Euclidean world who, discovering that in experience straight lines apparently parallel often meet, rebuke the lines for not keeping straight – as the only remedy for the unfortunate collisions which are occurring. Yet, in truth, there is no remedy except to throw over the axiom of parallels and to work a non-Euclidean geometry. Something similar is required today in economics."

I now aim to do "something similar" in finance, and I now propose the following working hypothesis. Just as Euclidian geometry and non-Euclidian geometry both exist, Brownian finance and non-Brownian finance both exist, and non-Brownian finance is just as important to risk management as non-Euclidian geometry is (with the GPS) for managing our travel on earth.

By "Brownian finance", I mean an approach to finance in which the representation of stock price movements – and by extension, changes in economic and financial quantities – uses a stochastic process devised in 1827 by the Scottish botanist, Robert Brown (1773-1858) and described mathematically by Norbert Wiener (1894-1964), Louis Bachelier (1870-1946) and Marian Smoluchowski (1872-1917), known as "Brownian motion". This motion was introduced into finance by Louis Bachelier in 1900. By "non-Brownian finance", I mean an approach to finance in which the same stock price movements are modelled by a stochastic process that differs from Brownian motion and is to Brownian motion what non-Euclidian geometry is to Euclidian geometry: a way of incorporating consideration of the "depth" of space, i.e. in finance, the depth of the risk. The stochastic processes that gave rise to non-Brownian finance were invented by French mathematician Paul Lévy (1886-1971) and are called "Lévy processes". They were introduced into finance by Benoît Mandelbrot (1924-2010) in the 1960s. The two men who, in the 20th century, were the intellectual forces behind these two approaches to finance, two faces of modelling, were thus Bachelier and Mandelbrot.

The difference between Brownian motion and a Lévy process can be grasped intuitively by looking at visual representations of their trajectories. Although both show irregular movements up and down, including small downturns in the upward movements and vice versa, there is a glaring graphic distinction between the trajectories followed by the two processes. Financial movements look "smoother" in Brownian motion than in non-Brownian stochastic processes, which have noticeable breaks almost everywhere, whether they are large or small, "jumps" or "discontinuities", in Greenspan's sense in his 2008 declaration. Even taken to limits, as the time lapse between two points (two quotations on a stock market) is reduced, the discontinuities remain. Lévy processes are discontinuous everywhere. A more intuitive way to express this is to say that the trajectories "jump" all the time, whatever the scale of analysis.

If financial risk is defined as the possibility of not achieving the hoped-for result (either because the investment is lost, or because the gain is less than expected), then Brownian motion paints a picture of a regular, reassuring risk. It definitely exists, but is not too unpredictable because there are no sudden jumps. Non-Brownian stochastic processes, however, paint a very different picture of risk, with much more uncertainty, as the trajectory (of the financial asset) "jumps" all

the time. To borrow Mandelbrot's vocabulary, the difference between these two representations of risk is the difference between "smooth" and "rough". In Brownian finance, risk is imagined as "smooth", like the plane space of Euclidian geometry: no breaks, no shocks, no market crashes, no bank collapses. In non-Brownian finance, risk is perceived as "rough", like the curved space of non-Euclidian geometry. Risk has "depth" and "relief", preventing the belief that it can be controlled simply by calculating statistical indicators, such as volatility. When the jump occurs, linear forecasts are found wanting. Hence Greenspan's assertion that "[w]e will never be able to anticipate all discontinuities in financial markets".

Yet for forty years, for reasons more to do with ideology than science, research into risk modelling deliberately ignored the discontinuities generated by the appearance of significant variations (De Bruin and Walter, 2017; Walter, 2017). A convention of continuity thus operated as a single approach to understanding the probable. The risks of mortgage default were modelled by Brownian finance, in the belief that credit risks could be controlled by that calculation: financial disaster followed. Brownian finance and the convention of continuity are dangerous for the real-life economy.

Similarly, the regulators who developed the prudential standards for banks (Basel III), insurance (Solvency II) and portfolio managers (UCITS V) overwhelmingly used this Brownian approach to finance, making it mandatory to calculate equity requirements by the "square-root-of-time" rule, i.e. a rule using one of the cardinal properties of a mental schema built on a Brownian representation of risk. The minimum capital requirement for a 10-day horizon, intended to cushion a firm against a market shock, is calculated as the minimum capital requirement for a 1-day horizon multiplied by the square root of 10. The connection between technical tools for calculations (the square root of time) and the regulatory framework (the doctrine for capital adequacy calculations) can be understood as a quantification convention (Chiapello and Walter, 2016) that structures the world of finance.

[From mathematical black signs to financial black swans](#)

If the mathematical language of the probable is understood to "do things with words", is not the production of words relating to Brownian finance ultimately the source of dangerous behaviour that leads to the incidents Taleb interprets after the event as black swans? Is there not an error of interpretation regarding financial crises? This is the question we shall now examine.

It is not possible within the confines of this chapter to present a detailed reasoning clearly establishing how we get from the financial *Logos* to black swans. I simply wish to set out an agenda for future research, by discussing what the principal stages of that journey might be. My proposition is as follows, presented in seven points.

1. A highly specific way of writing down the probable (taking the mathematical form of Brownian motion) that is not corroborated by available data, and is in fact invalidated by almost all the statistical tests performed in financial econometrics over several decades, became established and remained dominant in the field of finance (Walter, 2017). This mathematical modelling of risk can be considered to have influenced professionals' thinking, acting as a "prenotion" as defined by Durkheim (1894), a "schematic, summary representation that we employ in our normal way of life", formed by and for practice – except that this prenotation

derives from science itself, not from reflection conducted prior to the science, and has produced a somewhat spontaneous epistemology that forms a mental schema.

2. To explain this spontaneous epistemology, I propose that the mathematical language of risk should be considered as a speech act that “does things with words” as Austin says - except that in this case, the words are the symbols of the mathematical writing of the probable. I have used the name “financial *Logos*” for the “words” about risk that the mathematical risk models “speak” to the professional world through this writing down of the probable (Walter, 2016) and considered that those words about risk expressed the probable through Brownian-based modelling.
3. Applying the classification presented by Austin (1970), I consider that the financial *Logos* has three dimensions, locutionary, illocutionary and perlocutionary, defined as follows. The locutionary dimension is what the mathematical models of the probable say about financial risk (the Brownian expression of modelling). The illocutionary dimension is what mathematical models of the probable do to the financial world in saying what they say about risk via Brownian-based modelling (risk measurements and prudential norms based on the Brownian hypothesis). The perlocutionary dimension is the unforeseen effect resulting from what the mathematical models of the probable say and do about risk.
4. The performative property of the illocutionary act of the financial *Logos* became operational with the introduction of a regulatory and institutional framework that enabled conventional procedures (prudential rules and accounting standards, instruments of calculation) to guarantee the felicity (success) of the illocutionary in rules and calculations. Through this conventional framework, the financial *Logos* speaks, and what it says comes to pass: here a certain way of thinking about, treating, quantifying, purchasing and selling risk. This conventional framework has been called the “stochastic convention” (Walter, 2006) for the triple reason that the convention concerns a representation of the probable (Duhem’s epistemic accord), perpetuates the status quo as long as this representation exists (Keynes’ institutional accord) and could have been different (Lewis’ coordination accord).
5. With these institutional and contextual conditions for efficiency, mathematical models of risk under a Brownian representation (locutionary act) have a practical impact on the professional space (illocutionary performative act) as Austin said in his eighth lecture: Brownian-based modelling “convinced [people] that...” (Austin, 1962, p. 102) risk should be managed by... etc. The illocutionary act of the financial *Logos* leads to risk being conceived in terms of volatility.
6. In Austin’s view, “the consequential effects of perlocutions are really consequences, which do not include (...) conventional effects” (Austin, 1962, p. 102). This highlights the failures of the performative, as the markets do not seem to conform to the theories (Brisset, 2017): major illustrations of this point are provided by several financial crises (the 1987 crash, the LTCM crisis, the tech bubble, etc.) and the crisis of 2008. I consider these failures of the performative as the perlocutionary dimension of the financial *Logos*. Brownian-based modelling “convinced [people] that” risk could be controlled, and maybe even eliminated. Because of this cognitive bias – a kind of cognitive distortion – in the perception of risks, dangerous behaviours were able to emerge in professional practices, leading to one financial meltdown after another.
7. I consider that Taleb’s “black swans” arise from the effects of the black signs of mathematics writing down the probable on the white pages of financial mathematics books, which the modellers fill with Brownian-based modelling. To put it differently, like the goddess of fate, Moira, the “black swans” are present but invisible in the illocutionary and are created by the mathematical words expressing the probable with Brownian-based modelling and risk with volatility. This explains the appearance of a “black swan”: something that comes to pass

when the illocutionary induces an unforeseen non-conventional effect. Such is the specific dimension of the perlocutionary in the field of finance.

Conclusion

Starting from the rare event of the financial crisis of 2008, I have examined the potential threat of systemic financial crises, and black swan theory developed to explain them and provide a defence against them. Regarding black swan theory, I adopted an actuarial standpoint to analyse the symbol-based writing down of the probable, and a philosophical standpoint that considers writing down the probable as an Austinian “speech act”, calling the speech act corresponding to the statements of the probable in Brownian finance “the financial *Logos*”. This identified the symbol-based writing down of the probable as one of the causes of the 2008 crisis and other financial disasters. I have outlined a programme for research in which financial black swans would be considered as a descriptive illusion, an *ex-post* reconstruction of events that were partly foreseeable. In short, I propose that financial black swans should be understood as a perlocutionary effect of the financial *Logos*. Hence, if the financial *Logos* represents a threat for societies, it is because of the black swans that it can produce.

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