CHAIR « ETHICS AND FINANCE »

Sustainable financial risk modelling: the case of Solvency II

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Context: the HLEG 2018 report

- For several years, a huge wave of willingness to convert financial activities in the direction of sustainable finance taking into account the long term perspectives as well as environmental and societal issues (the UN’s SDGs) has been emerging in Europe.
- In 2017 the European Commission set up a high-level expert group (HLEG) to define a strategic action plan for the green transition of European finance.
- In 2018, the HLEG has delivered a final report and a set of recommendations that have led to the European Sustainable Finance Action Plan which aims to connect finance with sustainability.
- In its report, the HLEG
  - stresses: “sustainability cannot develop in a context where investment is dominated by short-term considerations”.
  - introduces the idea that the short-term behaviours could result from the regulation itself. There would be a risk created by the regulation, a regulation risk.
  - asked that consideration be given to “how Solvency II could be adapted to further facilitate long-term investments while maintaining a strong risk-based nature”.
- Aim of the paper: contributing to the abovementioned stake in order to interlock financial systems with long-term objectives, with the case of Solvency II

- Work made with the AF2i (French Association of Institutional Investors)

Summary

- In this paper, it is argued that a part of the observed short-termism on financial markets is indeed due to a regulation risk
- The regulation is based on a falsehood way to understand the randomness in the case of long-term horizons and uncertain risks
- The argument makes a detour via philosophy of science, exhibiting the Leibniz "principle of continuity": change is continuous.
- It is argued that short-termism created by regulation risk is the visible result of the choice of continuous randomness itself the outcome of the principle of continuity.

The big picture

Continuity	Discontinuity
Risk modelling orthodoxy: continuous stochastic processes	**Risk modelling heterodoxy**: discontinuous stochastic processes
Mainstream: Neoclassical Finance	Alternative finance: Scaling laws Complexity
Financialisation of society	*Critical perspective*
Financial accidents: 1987, …, 2008	Sustainable finance Green metrics

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Main assumption

- Some of the key differences between the competitive representations of financial uncertainty can be illuminated by reference to a familiar debate in philosophy of science over the "**principle of continuity**"
  - **Con**: This philosophical debate may seem to be a scholastic preoccupation within a tight circle of specialists in philosophy of science, far from the financial stakes of modelling and with no impact on concrete financial practices
  - **Pro**: I argue on the contrary that the divergent positions about the mindset behind the price changes implicate entirely different views of what it is important to capture and how to model it

The “principle of continuity”

- Change is continuous rather than discrete
  - Leibniz and Newton: *natura non facit saltus* (nature does not make jumps)
- Marshall’s *Principles of Economics* (1890)
  - Assumption of the principle
- Wiener’ *God and Golem* (1966)
  - “Just as primitive peoples adopt the Western modes of denationationalized clothing and of parliamentarism out of a vague feeling that these magic rites and vestments will at once put them abreast of modern culture and technique, so the economists have developed the habit of dressing up their rather imprecise ideas *in the language of the infinitesimal calculus*”

« De la même manière que les populations primitives adoptent les modes vestimentaires dénationalisées et le parlementarisme de l’Occident, parce qu’ils ont la vague impression que ces rites et ces vêtements magiques leur donneront accès à la culture et aux techniques modernes, les économistes ont pris l’habitude de maquiller leurs idées plutôt imprécises *avec la langue du calcul infinitésimal* »

Neoclassical finance and continuity

- The principle of continuity: ground
- Great success stories
  - 1973 formulas of Fisher Black, Myron Scholes, and Robert Merton
  - Replicating portfolio
    - MacKenzie and Spears (2014): “it is the strategy of Black-Scholes modelling writ large: find a perfect hedge, a *continuously-adjusted portfolio* of more basic securities that will have the same payoff as the derivative, whatever happens to the price of the underlying asset”
  - Fundamental theorem of asset pricing from Michael Harrison, Daniel Kreps, and Stanley Pliska (1979, 1981)
    - Risk-neutral approach
    - Efficient market and AOA
  - Risk disappears
- Quantification “convention” of neoclassical finance
  - Neoclassical metrology (Chiapello and Walter, 2016)
  - EMH and AOA

The three aspects of quantification convention

- **Epistemic dimension**
  - Principle of continuity adopted in academic circles
  - Brownian representation in finance curricula
  - Most statistical descriptions of time series assume(d) continuity
- **Pragmatic dimension**
  - Principle of continuity adopted by professionals
  - Dominant view in the financial industry
  - Many popular financial techniques (e.g. portfolio insurance) assume(d) continuity
- **Political dimension**
  - Principle of continuity adopted in policymaking
  - Underlies prudential regulation
  - Square-root-of-time-rule: Bale III, Solvency II

Cognitive consequence of continuity principle

- The extreme value issue: unsolved
  - Truncation of financial time series into two market regimes
    - “Normal” periods: the supposed continuous market
    - Periods of “insanity” where markets are deemed “irrational” and “greedy”: extreme value behaviours.
  - Cleavage: explained continuity + unexplained jumps
- Financiers unable to explain the transition from one regime to another
  - Alan Greenspan
    - “We can never anticipate all discontinuities in financial markets.”
    - For Greenspan, (financial) nature does not make leaps

Risk-neutral technology and market value

- The principle of continuity trickled down into all of neoclassical finance.
- The “Absence of Opportunity of Arbitrage” (AOA) which represents the intellectual cornerstone of the dominant contemporary financial approaches derives from the principle of continuity.
  - The “risk-neutral” technology of valuation
- The “market consistency” valuation in Solvency II is a result of the risk-neutral valuation
- The time-scaling of risk in Solvency II is a result of the Brownian representation

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Market consistency and martingales

QC1: EMH as research program

Si l'on note S_t^j le cours de l'action j aux dates $t = 0$ et $t = 1$, Fama définit en 1970 l'efficacité informationnelle par la relation

$$E\left(S_1^j|\Phi_0\right) = S_0^j\left(1 + E(R_1^j|\Phi_0)\right) \quad (3)$$

où la rentabilité **espérée** $E(R_1^j|\Phi_0)$ est donnée par le CAPM.

Posons $\mu_j = E(R_1^j|\Phi_0)$. D'où (3) devient

$$S_0^j = \frac{E\left(S_1^j|\Phi_0\right)}{1+\mu_j} = E_0\left[\frac{S_1^j}{1+\mu_j}\right] \quad (4)$$

C'est la **forme de FAMA (1970)**.

Plus généralement, le taux et l'espérance peuvent dépendre d'un **modèle** m :

$$S_0^j = E_0^m\left[\frac{S_1^j}{1+x_j}\right] \quad (5)$$

C'est la **forme de FAMA (1976)**.

Dans ces deux formes, le taux d'actualisation dépend du **titre**.

Avec la condition de non existence d'arbitrages (marché arbitré), la finance des années 80 actualise à un taux qui dépend du **marché**. Traduction moderne de l'efficacité informationnelle.

1. **ROSS–HARRISON–PLISKA (1976–1981)**
   Il existe une probabilité Q telle que

   $$S_0^j = E_0^Q\left[\frac{S_1^j}{1+r}\right] \quad (6)$$

   où r est le taux du monétaire (monde dual).
2. **LONG–GEMAN (1990–1995)**
   Il existe un portefeuille numéraire B tel que :

   $$S_0^j = E_0^P\left[\frac{S_1^j}{1+R_B}\right] \quad (7)$$

   où R_B est le taux de rentabilité du portefeuille numéraire, ou **benchmark** (monde réel).

QC2: EMH as the making of markets

“Martingalisation” of markets

- After the second quantification, “martingalisation” of real economy (Walter, 2006) : a **stochastic convention**

Risk-Free Interest Rate Term Structures
European Insurance and Occupational Pensions Authority (EIOPA)

Accounting standards IAS 39

The financialisation of “real” economy

P-world — Fama (1970) — CAPM

$$\begin{cases} 150,00 = 0,8824 \times 140 \times 0,50 + 0,8824 \times 200 \times 0,50 \\ 63,89 = 0,7517 \times 50 \times 0,50 + 0,7517 \times 120 \times 0,50 \end{cases}$$

QC1

Q-world — Harrison–Pliska (1981) — Risk-free rate

$$\begin{cases} 150,00 = 0,9804 \times 140 \times 0,78 + 0,9804 \times 200 \times 0,22 \\ 63,89 = 0,9804 \times 50 \times 0,78 + 0,9804 \times 120 \times 0,22 \end{cases}$$

MPK

P-world — Hansen–Richard (1987), Long (1990)

$$\begin{cases} 150,00 = 1,5373 \times 140 \times 0,50 + 0,4234 \times 200 \times 0,50 \\ 63,89 = 1,5373 \times 50 \times 0,50 + 0,4234 \times 120 \times 0,50 \end{cases}$$

QC2

Arrow-Debreu securities (primary assets) — General equilibrium

$$\begin{cases} 150,00 = 0,7694 \times 140 + 0,2114 \times 200 \\ 63,89 = 0,7694 \times 50 + 0,2114 \times 120 \end{cases}$$

The neoclassical finance and QC2

- By the grace of the second quantification, all assets and all liabilities can be securitised
  - This is the property of “market-consistent” valuation
  - This is what the second quantification propose
- The second quantification is associated with a overhaul of the EMH (1980s) in financial economics
  - The key word is “arbitrage”
  - One of the main cause of financialisation

Example: time-scaling in Solvency II

- Path-continuity in regulatory framework: the time-scaling of risk
  - Continuous Brownian motion entails time scaling of risk in the sense that one given horizon (e.g., t) of a return distribution is scaled to another (e.g., $t \times a$).
  - This means that the distribution of $X(t \times a)$ is the same as the distribution of $X(t) \times \sqrt{a}$.
  - This is called the *scaling property* of Brownian motion or the *square-root-of-time rule* of scaling for risk-based approaches
- The minimum capital requirement is an estimated quantile of a return distribution (10-day 95% VaR metrics)
  - The 10-day VaR is obtained by applying time scaling of risk using the square-root-of-time rule: VaR (10-day) = VaR (1-day)$\times \sqrt{10}$.
  - This relationship is not "natural" but results from strong assumptions about the price process: its Brownian continuity

Epistemic choices

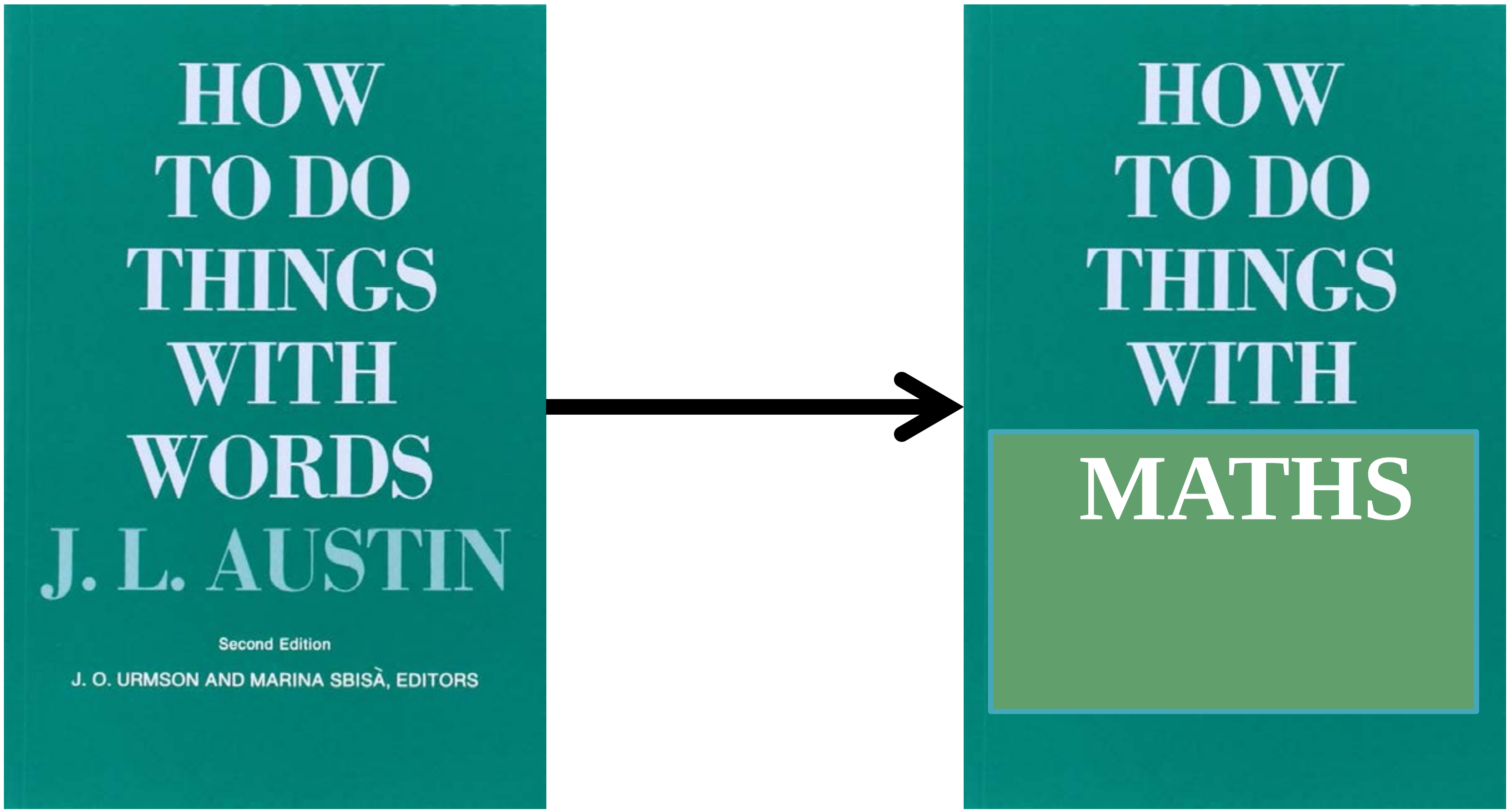
Increments of stochastic processes	Risk modelling with stochastic processes	Years	Time-scaling of risk for practitioners	
non I and non-ID		**2020s**	No simple scaling rule	
I and non-ID	**Sato processes**	**2000s**	Multiscale analysis	
IID non-stable	**Lévy processes**	**1990s**	Multiscale analysis	
IID alpha-stable	**Lévy motion**	**1960s**	Scale invariance	
IID 2-stable	**Brownian motion**	**1900**	Scale invariance	"Square-root-of-time rule" (Jules Regnault, 1863)

Hinge: choice between	**Route 1**	**WILD randomness**	**IID with non-Gaussian distributions**	**Alternative finance**
	Route 2	MILD randomness	Non-IID with Gaussian distributions	Neoclassical finance

Source : Walter (2013) *The random walk model in finance*

The culture of “risk”

- One way of defining “risk”
  - Risk is defined by the variance only
  - This is the hallmark of the “financial *Logos*” (financialisation)



Risk culture

- A particular risk culture is created based on a probabilistic hypothesis
  - A form of socially elaborated and shared knowledge with a practical aim, which helps to construct a **culture of models** common to a financial group, the culture of “how a model works” (Svletlova, 2018).
  - The culture of models is based on calculation and quantification conventions (Desrosières, 2008).
  - **Quantification conventions ensure the same risk culture for financial practitioners**
- The culture of models is an “epistemic culture” in the sense of Knorr Cetina (1999), specific to each group of practitioners
  - This risk culture diffuses a general way of thinking about technical objects
  - The technical objects of finance are overloaded with probabilistic techniques
- Probabilistic techniques have had an enormous influence on risk assessment and the formation of quantification conventions
- Risk culture for the Anthropocene?

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- Beyond the technical choices of ingredients for financial risk culture, a philosophical background has existed during the 20th century
- This philosophical backgrounds acted as a “mental model” (Mantzavinos, 2001)
  - Mantzavinos considers that, whatever their activity or intellectual aspirations, people must first ensure their material existence and, in order to do so, they must have mental models to act on
  - Shared mental models lead to the emergence of norms. An epistemic framework on risk measurement has resulted from a shared mental model on uncertainty
  - Mathematical models of financial risk are based on an “underlying epistemological layer” related to the morphology of randomness which produces a specific risk culture, and that this epistemological hidden foundation needs to be modified

Risk culture in the regulation

- Multilateral institutions have acknowledged the need for a profound reform of the global financial system with emergence of
  - Principles for Responsible Banking (PRB)
  - Principles for Sustainable Insurance (PSI)
  - Principles for Responsible Investment (PRI)
- Responsible regulation is at least as important as responsible banking or responsible investment, and sustainable regulation is at least as important as sustainable insurance
- The prudential regulations established after the 2008 crisis have had unexpected effects, just as dangerous as the ones they sought to address
  - The risk culture of continuity is not adapted to protect against financial accidents, and may even, through the regulation it carries, cause them.
  - Black swans and extreme values can thus be understood as effects of the regulation of Brownian finance
- The hinge of my alternative can be summarised as follows:
  - There are two fundamentally different risk cultures for financial risk modelling.
    - The first is “Leibnizian”: It takes the continuity as a cornerstone for financial risk modelling.
    - On the contrary, “anti-Leibnizian” position holds that discontinuity exists at all scales, even very small scales. The presence of discontinuities at all scales, even micro-scales (micro-crashes), allows grasping the profound nature of financial risk

Sustainable and unsustainable risk culture

- Unsustainability
  - The main problem with unsustainable neoclassical finance risk modelling is its underlying morphology of randomness that creates a dangerous risk culture
    - Leibniz’s principle of continuity and Quetelet’s theory of average are cornerstones of classical risk culture in finance, acting as a mental model for financial experts and practitioners
    - Link the notion of sustainability with the morphology of randomness
- Sustainable risk culture
  - Hypothesis: sustainability or unsustainability of risk culture is related to the morphology of randomness that shapes the tools for risk calculations and modelling
  - I consider that a difference in randomness structure between a risk model and the reality of that risk is a cause of unsustainability.
  - Reciprocally, a similarity between the morphology of randomness is a necessary but not sufficient condition of sustainability

- Regulation is challenged
  - – Falsehood of models carrying the principle of continuity
  - – Mental model embedded in a quantification convention
  - – Hazardous shaping of business practices can provoke unexpected events and negative spillover
    - “Regulation risk”: new risk created by hazardous regulation (Le Courtois, Lévy-Véhel, Walter 2020)