L'assurance face au risque systémique de pandémie: le cas du risque pertes d'exploitation des entreprises

Pierre Picard

CREST-Ecole Polytechnique

- The COVID-19 crisis shows that **insurers were not prepared** to face the business interruption risk associated with a worldwide pandemic:

  - Business interruption was viewed as an indirect loss induced by property damage (e.g., fire) to be covered through mutualization.

  - Pandemic risk = very **large degree of correlation** within an insurer's portfolio and between insurers: mutualization is impossible.

- The business interruption pandemic risk can be qualified as a **systemic insurance risk** because:
  - Many small and medium-sized firms are concerned,
  - Risk pooling (within or between insurers' portfolios) cannot work properly,
  - There is a major macroeconomic crisis during the pandemic event.

- Many catastrophic risks of the 21th century have potentially this **systemic dimension:**

Correlation between exposure units

+

Correlation with (macroeconomic) financial shock

- **Examples**: pandemics, extreme man-made risks (large-scale terrorism, major cyber attacks), extreme consequences of climate change (e.g., heat-waves)

- **In the 1990s**, the increase in the consequences and frequency of natural disasters and industrial catastrophes triggered important innovations in the coverage of catastrophic risks by the insurance industry.

- Various forms of risk transfer toward financial markets through
  - concentration in the insurance and reinsurance industry,
  - Alternative Risk Transfer: cat-bonds, ILWs…

- Natural disasters, as large as they may be, are not systemic. Hurricane Katrina and Fukushima-Daichi nuclear catastrophe did not triggered financial crisis.

- **Innovations are required in the new era of systemic insurance risks**

7 June 2023

Inga Beale: product innovation is not achieved by adding exclusions

Inga Beale: former CEO of Lloyd’s of London

- Innovation is not achieved either through the **recycling of recipes** that are suitable for non-systemic catastrophic risks, e.g., insurance pools backed by governmental garantee (nuclear risk, terrorist attack…).

- Why should we pool insurance resources when all insurers may be affected simultaneously? What is the relevance of a 2b€ insurance pool, when aggregate business interruption losses reach 100b€?

- Insurance goes through the (*ex ante*) **anticipatory behavior of policyholders**. This should be clearly distinguished from the (*ex post*) assistance role of governments.

A pessimistic view:

" Despite financial resilience, P&C is losing economic relevance in important developed markets… A rapidly evolving insurable mass calls for product innovation and a reallocation of portfolio priorities. The reinvention is imperative."

State of Property & Casualty Insurance

McKinsey & Company (2020).

- Pandemic insurance: a portfolio management approach », Alexis Louaas and Pierre Picard, *Journal of Financial Transformation*, 2021, November, 54, 70-75.

- « A pandemic business interruption insurance », Alexis Louaas and Pierre Picard, *Geneva Risk and Insurance Review*, 2023, 48, 1-30.

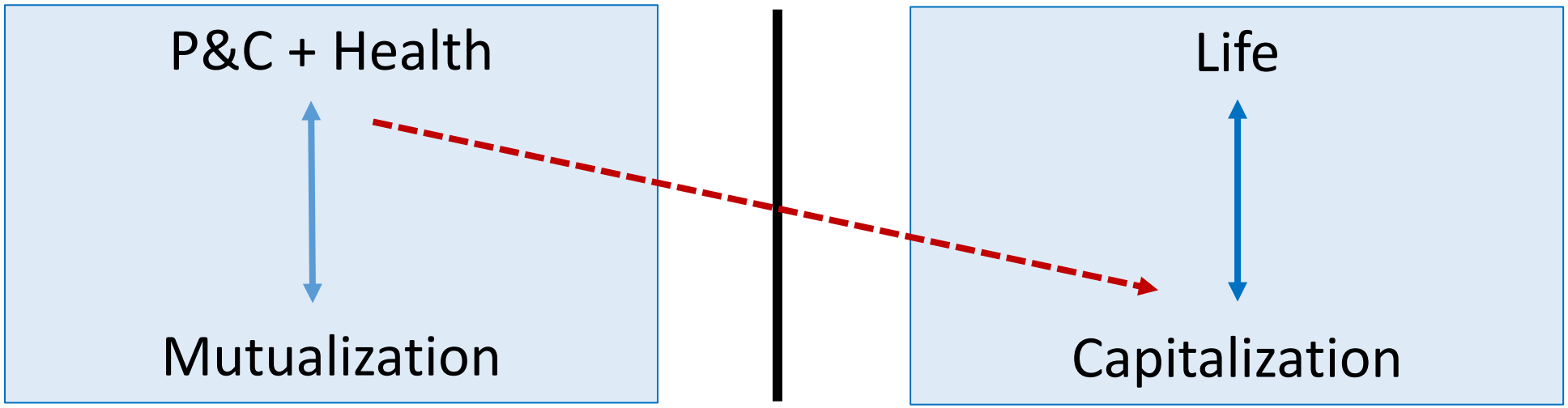
Usual organization of the insurance industry

P&C + Health

Mutualization (with non-refundable contributions)

Life

Capitalization (during the accumulation phase)



Basic idea:

Using capitalization to cover

the business interruption pandemic risk.

The Covid-19 crisis has affected sectors (and stocks) very differently

Dimension 1: Travel and work restrictions

−

Tourism, hotels and restaurants,
Airlines,
Manufacturing and craft,
Entertainment industries.

+

Pharmaceutical and biotech industries,
Online BtoB and BtoC platforms,
High-tech industries.

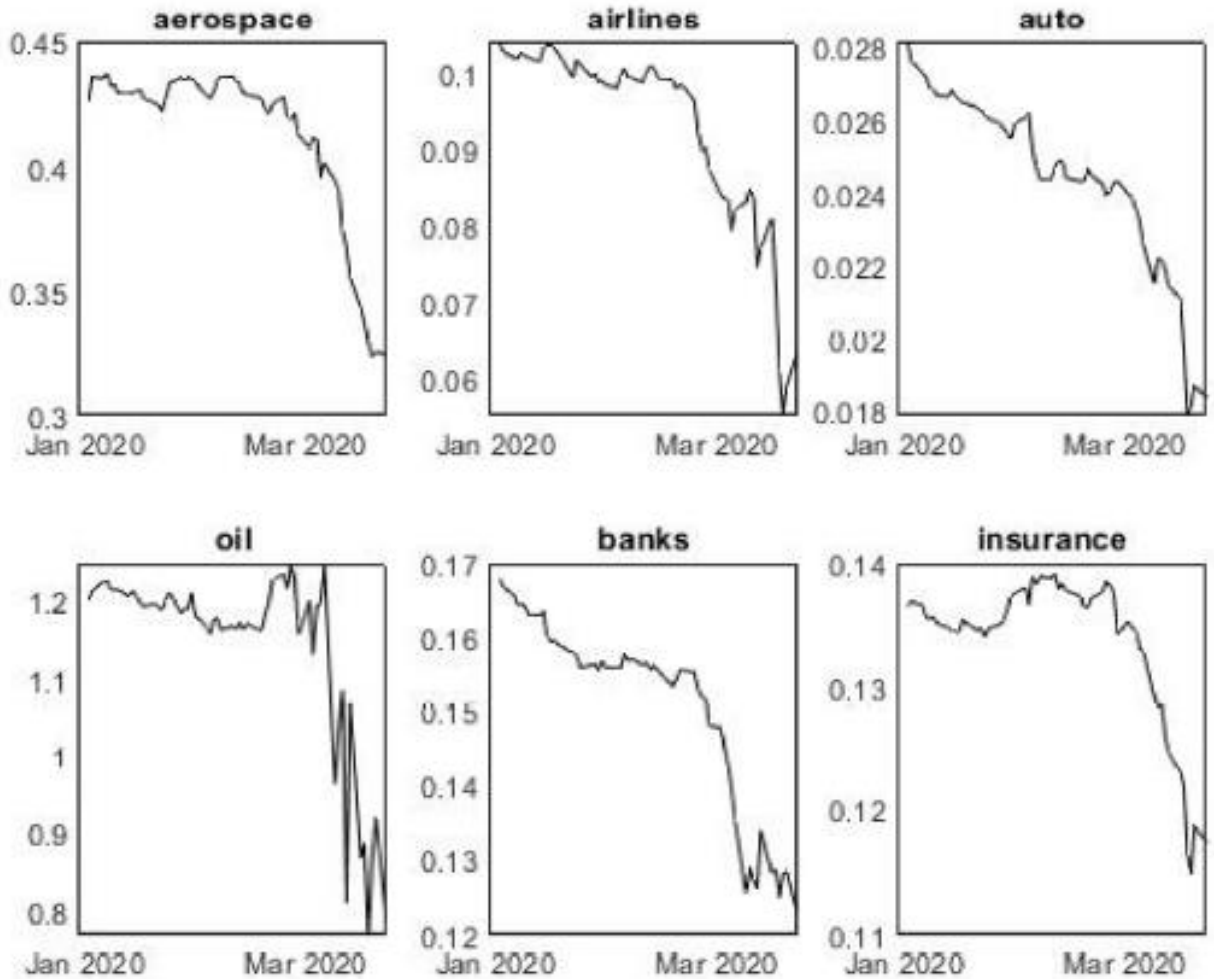
Dimension 2: Cyclical and defensive sectors

−

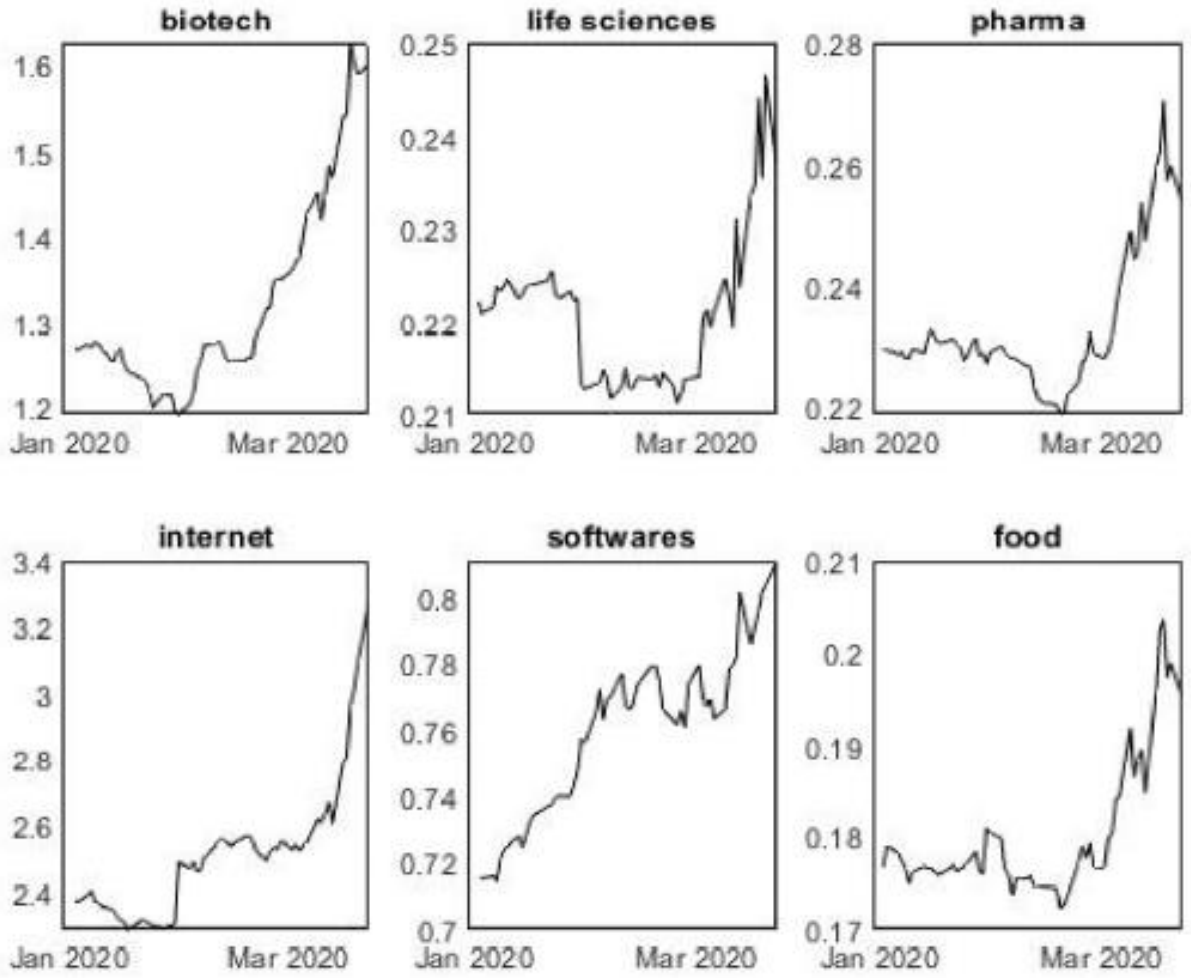
Automobile
Building, Real estate
Travel, hotels, restaurants
Leisure
Banks and reinsurance

+

Food,
Health,
Utilities,
Telecom
Financial services.



Under-performing S&P 500 sub-indices 1Q2020



Over-performing S&P500 sub-indices 1Q2020

STOCK	SUB-INDUSTRY	YTD	PUT YTD
UNIB-RODAM-WES	Real Estate	-64.1%	807.92%
RENAULT	Automobiles	-58.4%	252.25%
SOCIETE GENERALE	Bank	-57.2%	152.61%
AIRBUS	Aerospace	-57.0%	164.47%
BNP PARIBAS	Bank	-45.5%	116.70%
ACCOR	Hotels	-45.0%	220.33%
CREDIT AGRICOLE	Bank	-43.8%	118.29%
SAFRAN	Aerospace	-41.1%	170.40%
SODEXO	Restaurants	-38.0%	538.70%
PEUGEOT	Automobiles	-37.0%	122.60%
AXA	Insurance	-35.4%	157.20%
PUBLICIS GROUPE	Media Agency	-35.0%	192.40%

Under-performing CAC40 stocks with put yields 1Q2020

STOCK	SUB-INDUSTRY	YTD	CALL YTD
HERMES	Clothing	2.0%	10.40%
SANOFI	Pharmaceutical	-0.1%	44.90%
STMICRO	Semi-conductors	-2.5%	2.80%
L'OREAL	Cosmetics	-4.0%	-28%
DASSAULT SYSTEMES	Software	-4.2%	37.90%
AIR LIQUIDE	Chemicals	-5.0%	-7.50%
ATOS	Computer services	-11.0%	44.20%
CARREFOUR	Food retailer	-11.1%	-41.90%
SCHNEIDER ELECTRIC	Electrical components	-12.1%	0.30%
DANONE	Food products	-13.3%	-46.40%
PERNOD RICARD	Distiller and vintner	-14.2%	-27.50%
LVMH	Clothing	-15.0%	-14.00%

Over-performing CAC40 stocks with call yields 1Q2020

Relationship between Covid-linked hospitalizations and stock returns

$$r_{it} - r_{mt} = \alpha + \beta_1 h_t + \beta_2 h_{t-1} + \varepsilon_{it}$$

where

r_{it} = return of stock *i* on day *t*

r_{mt} = market return on day *t*

h_t = growth rate of Covid-linked hospitalizations on day *t*

Sample: CAC40 + CAC Next 20

Time Period: from March 18th to May 18th, 2020

Regressions reveal two groups of stocks: $\beta_1 > 0$ in Group 1, $\beta_1 < 0$ in Group 2

Group 1

- Stocks stimulated by the pandemic: biotech, pharmaceuticals, business services, videogames,
- Intrinsically defensive stocks: alcohol, luxury goods,
- Stocks relatively sheltered from fluctuations in consumer demand: chemicals, oil and gas.

Actions	β_1	*p* value	Secteurs
Groupe 1			
Air Liquide	0,0630	0,00	Chimie de base, santé
BioMérieux	0,2529	0,00	Biotechnologies
Lvmh	0,0668	0,00	Luxe
Pernod-Ricard	0,0392	0,00	Alcools
Sanofi	0,0516	0,02	Industrie pharmaceutique
Total Energies	0,0999	0,00	Pétrole et gaz
Ubisoft	0,0838	0,00	Jeux vidéo
Worldline	0,0978	0,00	Services aux entreprises

Group 2

- Sectors strongly impacted by the decrease in household demand: automobile, real estate, consumer demand,
- Sectors reliant on governmental investment decisions: aerospace/defense, engineering/construction, railway,
- Sectors whose services were required by other firms: steel, chemicals, electrical equipment,
- Banks and insurance reflect the general state of the economy, and they are negatively impacted by bad news about the spread of the pandemic.

Groupe 2			
Alstom	-0,0769	0,00	Chemin de fer
Arcelor Mittal	-0,1328	0,01	Acier
Arkema	-0,1463	0,00	Produits chimiques
Axa	-0,0637	0,01	Assurance
Bnp Paribas	-0,0880	0,00	Banque
Bureau Veritas	-0,0325	0,00	Services aux entreprises
Dassault Systèmes	-0,0878	0,01	Spatial, défense
Eiffage	-0,0926	0,02	Bâtiment, travaux publics
Engie	-0,0698	0,06	Gaz (distribution)
Gencina	-0,0886	0,02	Immobilier
Essilorluxottica	-0,1208	0,00	Produits de consommation
Klépierre	-0,0504	0,07	Immobilier
Legrand	-0,0495	0,07	Equipement électrique
Peugeot	-0,1119	0,00	Automobile
Safran	-0,1629	0,08	Spatial, défense
Saint Gobain	-0,0518	0,00	Produits chimiques
Société Générale	-0,0753	0,00	Banque
Solvay	-0,0732	0,00	Produits chimiques
Teleperformance	-0,1812	0,00	Technologie

Overall picture of the model

- A risk-averse small or medium-sized firm suffers a large loss due to business interruption, should a pandemic occur.
- The firm can cover its risk exposure through a portfolio of financial assets (managed by an insurer or a bank).
- **Similar to unit-linked life insurance**, but here the firm is the policyholder.
- Stock returns depend on the ups and downs of the business cycle, and they react very differently to the occurrence of a pandemic event.

The most simple case: the financial market is complete

Return of securities

$s \backslash i$	0	1	2
u	r_f	$R_1 + h$	$R_2 + h$
d	r_f	$R_1 - h'$	$R_2 - h'$
p	r_f	$R_1 + H$	$R_2 - H'$

→ The insured firm suffers a loss L in state p

States *s* = *u*,*d* or *p* (for *up*, *down*, *pandemic*)
Securities *i* = 0 (riskless asset),1 and 2 (stocks that react differently to the pandemic event).

Main assumption: *stock 2 is more severely affected by a pandemic event than stock 1*

Main theoretical results

- When the financial market is complete, the optimal insurance strategy consists in **going long on stock 1 and short on stock 2 (or purchasing stock 1 call options and stock 2 put options)** while adjusting the firm's productive capital requirement through risk-less debt (or holding liquid reserves).

- The pandemic risk exposure is fully (partially) covered and the non-pandemic risks are fully (partially) hedged if security pricing reflects the preferences of risk-neutral (risk-averse) investors.

- **Apparent similarity and substantive difference** with the standard insurance demand model (Mossin, 1968; Smith, 1968).

- **In practice**: a self-funded insurance scheme managed by an insurance company or a bank (similar to unit-linked insurance).

Two forms of market incompleteness:

- precautionary effect when corporate losses are uncertain
- Possibly, overhedging of non-pandemic risk in order to improve the pandemic risk coverage when stock returns are uncertain in the pandemic state.

Uncertain stock return in the pandemic state

$s \backslash i$	0	1	2
u	r_f	$R_1 + h$	$R_2 + h$
d	r_f	$R_1 - h'$	$R_2 - h'$
p	r_f	$R_1 + H + \varepsilon_1$	$R_2 - H' + \varepsilon_2$

Random perturbations

Trade-off between two effects

- Uncertainty of stock returns in the pandemic state: when H is small (e.g., $H = 0$) the risk-averse firm prefers to cover the pandemic risk through a short position on stock 2 than through a long position on stock 1, hence the over-hedging of the non-pandemic risk (i.e. state d vs state u) when investors are risk-neutral.

- The risk aversion of financial investors goes in the opposite direction.

Numerical simulations with French data

Two fund strategy with French data

- **Fund 1**: call options on CAC40 stocks that over-performed in 1Q2020.
- **Fund 2**: put options on CAC40 stocks that under-performed in 1Q2020.

- The insured firm allocates 20,000€ every year on April 1st, from 2020 to 2031, which is added to the residual value of the two funds, and evenly spread between funds and stocks. A new pandemic starts on August 1st, 2031, and the option portfolio is liquidated on October 1st, 2031.

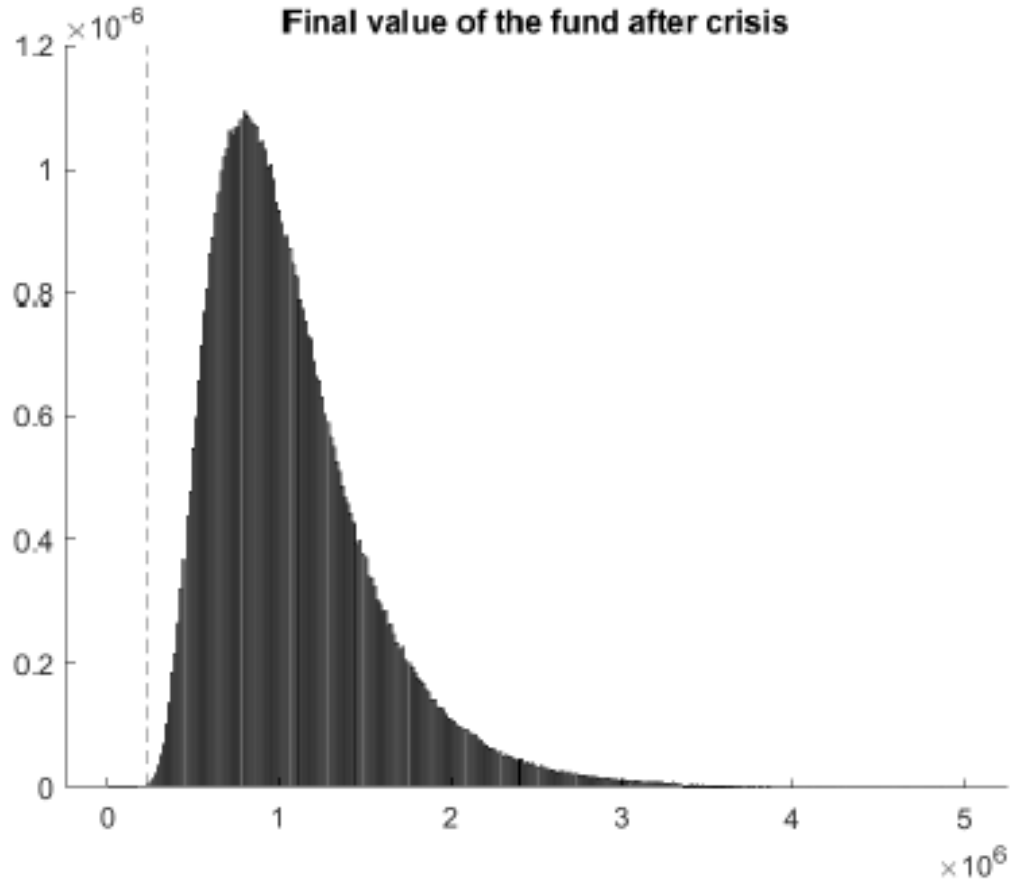
- The option portfolio is rolled over, with strike price equal to the current price of underlying stocks, and 2 year maturity at purchase and 1 year at sale. Option prices are derived from Black-Scholes formula.
- We simulate a large number of stock price trajectories following geometric Brownian motions, with drift during the non-pandemic period equal to what was observed between January 1st 2007 and February 1st 2020.
- Scenarios differ according to stock return reactions during the next pandemic event (from August 1st to October 1st 2031).
- For each stock, volatility is calibrated on historical values.
- Risk-free interest rate remains constant and equal to its value on April 1st, 2020.

1. Baseline scenario

- The expected value of the daily stock returns during the new pandemic is equal to the average daily return observed during the two first months of the COVID-19 crisis.

Liquidation value of the two-fund portfolio

Risk-free cumulated financial investment = €235,730. The two-fund strategy has a larger liquidation value with probability 99.23%.

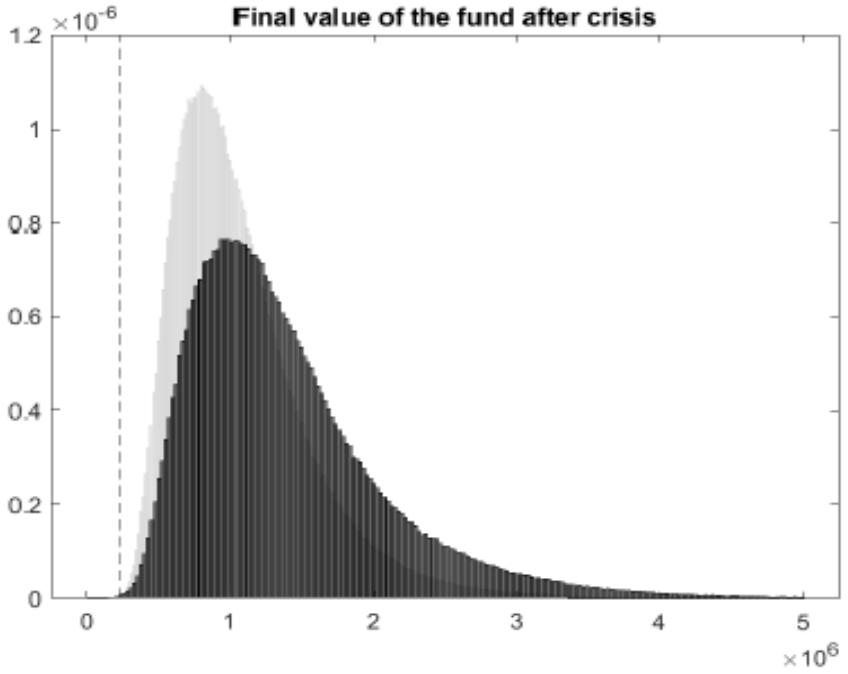


(a) Strike prices equal to underlying prices. Mean value: €1.0690 million, median: €967,030, 5th percentile: €497,660, 1st percentile: €385,260.

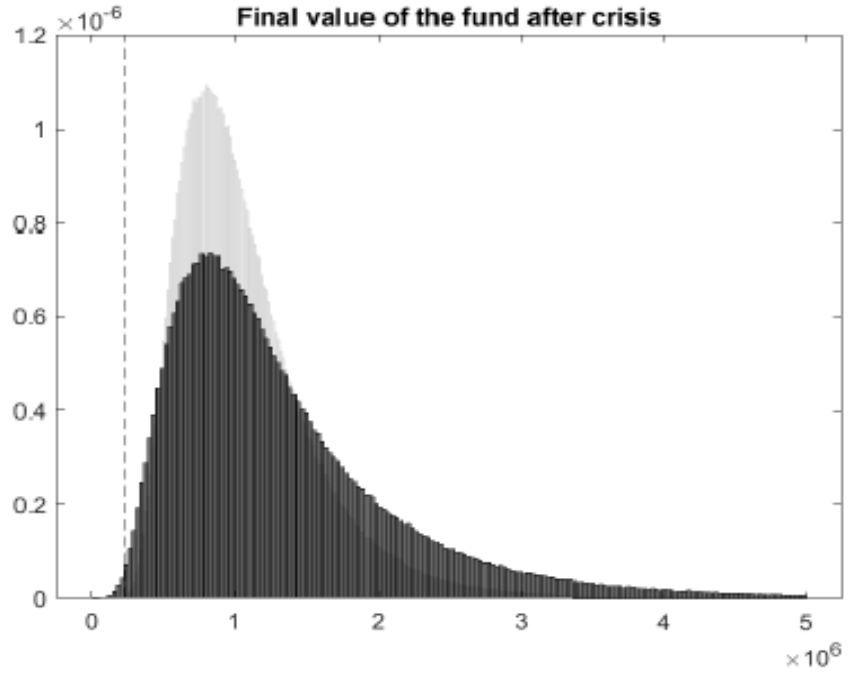
2. Case where the future pandemic differs from COVID-19

- The expected returns of stocks during the 2031 pandemics are randomly drawn, with expected value equal to what was observed in 1Q2020, and with or without correlation.

- This adds another layer of uncertainty on stock returns, and the liquidation value of the option portfolio is larger in expected terms and its distribution is more spread-out.



(a) No correlation between future expected returns. Mean value: €1.3894 million, median: €1.2187 million, 5th percentile: €571,530, 1st percentile: €430,510.



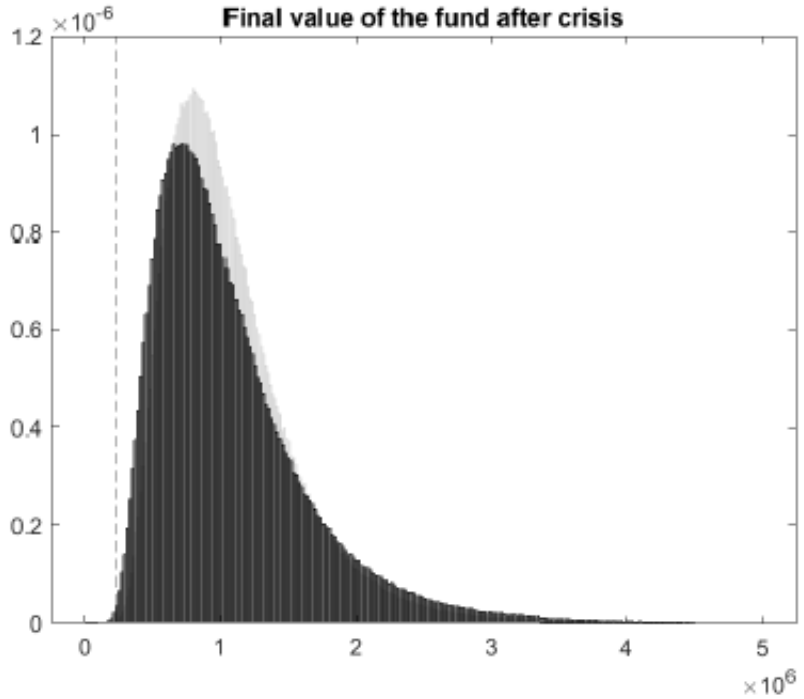
(b) Positive correlation between future expected returns. Mean value: €1.3971 million, median: €1.1300 million, 5th percentile: €442,990, 1st percentile: €298,400.

Light grey = baseline scenario; dark grey = scenario with uncertain expected stock returns during the 2031 pandemics

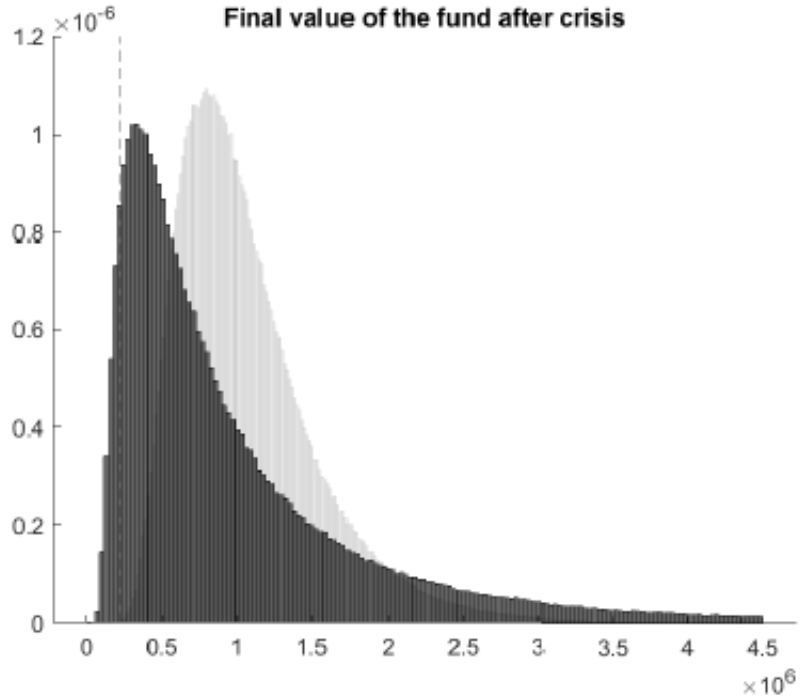
3. Errors in the choice of underlying stocks

- Sofar, we have considered the case of a cautious investor who is just able to isolate the list of underlyings to be considered in Funds 1 and 2, without knowing more about the expected return of each stock during a pandemic event.

- We may consider the case of a less conservative investor who selects a smaller number of underlyings with errors (about the stocks with the largest overperformance or underperformance during the next pandemic).



(a) Random selection of 9 out of the 12 assets. Mean value: €1.0823 million, median: €934,940, 5th percentile: €425,980, 1st percentile: €316,350.



(b) Random selection of 3 out of the 12 assets. Mean value: €1.1718 million, median: €720,660, 5th percentile: €201,990, 1st percentile: €133,530.

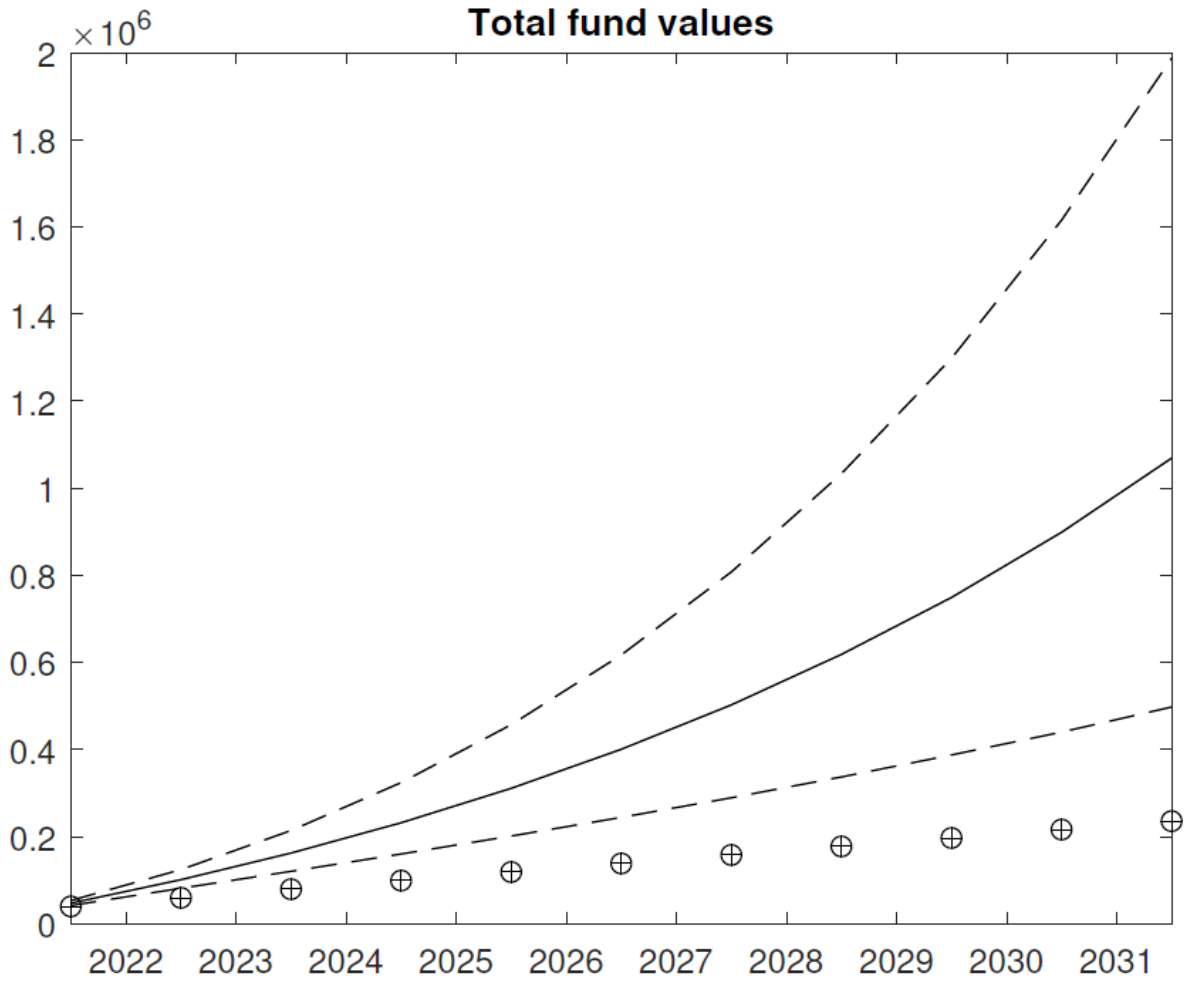
4. Uncertainty about the date of the future pandemic

: Expected payoff

: 5% and 95% quantiles

⊕ : risk-free strategy payoff

The 5% quantile of the two-fund payoff is above the risk-free strategy payoff at all horizons



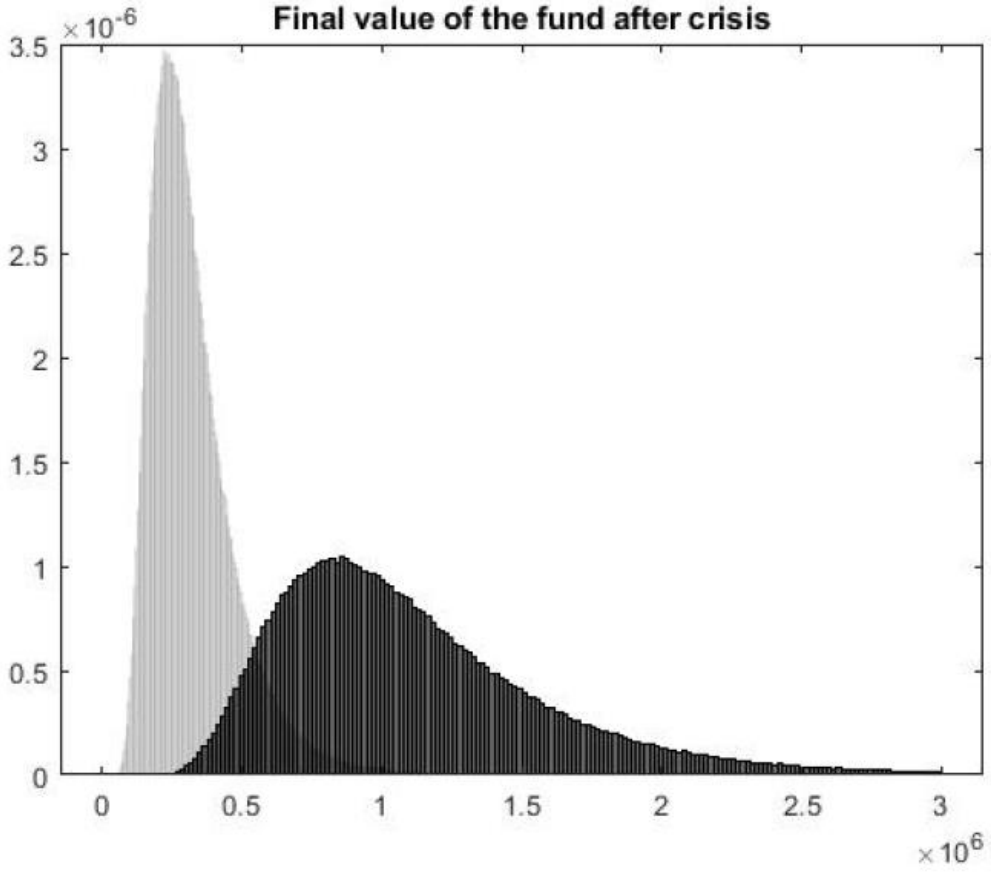
Liquidation value of the two-fund portofolio at different pandemic horizons

5. Selection of underlying stocks

- We select underlying stocks from CAC40 + CAC NEXT 20 on the basis of their intrinsic features:
  - **Fund 1** : Activity positively affected or unaffected by restrictions to travel and work + defensive sector.
  - **Fund 2**: Activity negatively affected by restrictions to travel and work + cyclical sector.

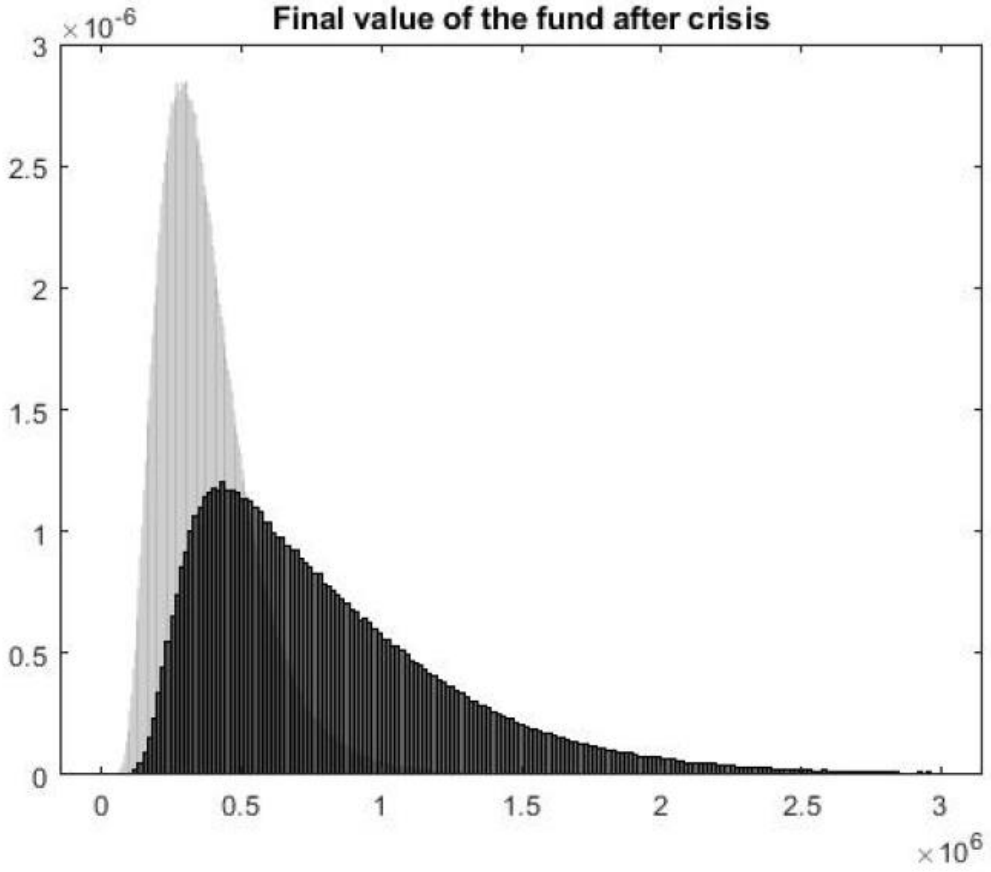
  - We add stocks with strong defensive features to Fund 1 and stocks with strong cyclical features to Fund 2.
  - Defensiveness and cyclicality are based on unlevered beta (Damodaran, 2021). This is just for illustrative purpose: in practice, this requires an assessment of each stock, based on the specificity of its activity (often based on the triptych Quality-Value-Momentum by financial analysts) and on its debt level.

	Effect of travel and work restrictions on activity			
	Positive	**Neutral**		**Negative**
Defensive Sectors	**Fund 1**			
	Orange, Worldline, Edenred, Eurofins Scientific, Orpea,			
		Carrefour, Pernod-Ricard, Suez, Veolia		
Cyclical Sectors			**Fund 2**	
			Alstom, Faurecia, Hermés Intl, Legrand, Safran, Schneider Elec., Scor, STMicroelectronics, Thalès.	
				Accor, Sodexo, Unibail-R-W, Airbus



Baseline scenario

Average payoff: two-fund strategy: €1,112 million; CAC40: €323,860



Case where half of the stocks do not react to the crisis (their trend is unchanged)

Average payoff: two-fund strategy: €818,660; CAC40: €345,050

Dark grey: two-fund strategy payoff; light grey: CAC40 payoff

Concluding comments

1. The systemic dimension of the pandemic risk makes usual P&C insurance mechanisms inefficient (mutualization through the law of large number does not work).
2. Capitalization mechanisms (similar to unit-linked insurance) allow insurers to offer coverage to small-and medium-sized firms exposed to the pandemic risk.
3. This would be based on portfolios of long-short and/or call-put options, allowing firms to be in a much better position, should a new pandemic occur in the future.
4. This should lead insurers to base their underwriting strategy (on behalf of their corporate clients) on a precise and constantly updated analysis of how stock markets would react to a new pandemic event.
5. New forms of cooperation between banks and insurers may arise from this challenge.