Rapport Projet de Recherche IEF *Derivative Accounting Principles at the Test of the Covid-19*

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23 décembre 2021

The objective of derivative portfolios' pricing and hedging drives models' development. The risk in a derivative portfolio can be partitioned between market and model risk. The former focuses on the second or higher moments of the return distribution and is often managed by overnight Delta or Vega hedging strategies. Contrary, as we will discuss, model-risk revolves around the first moment and results in systemic and autocorrelated leakages that manifest as a bias over longer periods.

If the model-risk is only analyzed backward-looking the model's performances, then a realized leakage is interpreted as a "black swan" event, an interpretation that precludes disentangling econometrically sound models and low-quality models. In the black swan line of thought, a trader always perceives upfront profits as realized, and models' blow-ups take the role of rare and unlucky events she has no margin of maneuver to prevent.

By contrast, this article proposes a scientific explanation of financial blow-ups based on models' behavioral analysis. More specifically, we develop a forward-looking model-risk framework for structured products sharing similar features. By trading structural products, a bank buys volatility and convexity from investors and sells out-of-the-money options trading at a premium for risk management purposes. Model-risk manifests in yield enhancement features, such as optional callability or auto-callability, without which the bank could statically replicate these products without incurring any model-risk. Examples include callable range accruals hedged by digital swaptions (our case study), structured equity products such as autocallables and cliquets, power-reversal dual currency options, and target redemption forwards.

Quality ranking for models is subjective and a function of the utility of the model user. Typically, a user with interests aligned with the bank would prefer more realistic models, which have lower short-term profitability but far less long-term risk. However, an agent might select a lower-quality model as its usage could extract more short-term wealth in exchange for long-term risk.

The model risk pattern might resemble a virus's behavior [1], whereby, from among the universe of econometrically unrealistic models, the ones that can threaten the bank's survival should verify the following phases [2] :

0. **The Attachment :** *A lower-quality model must enter the bank without impairing its survival in the short term.*
1. **The Penetration :** *The usage of a lower-quality model must proliferate into the bank, e.g., by over-valuating structured products at inception.*

1. see e.g. Perelson (2002) for a review of the viral dynamic modelling literature.
2. see e.g. Wodarz et al. (2014) for a review of the viruses' phases.

2. **The Incubation :** *A lower-quality model surviving the test of time must conceal its presence in the short to medium term, e.g., by generating over-hedging profits, which have to overall offset and surpass the systematic losses engendered by the initial over-valuation.*
3. **The Infection :** *In the medium to long run, a lower-quality model is bound to generate inescapable PnL blow-ups.*

The initial condition acts as a “survival of the host corollary" in the short-run, a corollary that allows the lower-quality model to enter the bank, proliferate and become an accepted derivatives market pricing standard. Condition 1 relates to the bank's internal ramification of the model usage, achieved via competitive pricing. An over-valuation at inception implies that an investor's upfront payment could be greater than the price indicated by a sound model. The over-valuation makes the model competitive in the market, a necessary model's survival condition, or else a trader would discard the model as its usage would attract no business. Over-valuation is a necessary condition for the survival of a model. However, it is not sufficient. In line with the Doob-Meyer theorem decomposition of supermartingales, the mirroring companion of over-valuation at inception is a negative alpha-leakage as time goes on. Hence, Condition 1 raises a profitability puzzle : how can the lower-quality model's systematic PnL losses be sustained over time ? During the ramification period, the model must disguise its losses in the short to medium run. The loss concealment of Condition 2 is a model's necessary survival condition as, otherwise, model risk reserves and capital add-ons would constraint the model's usage. Lower-quality models can also mutate their appearance through marginal changes to their specifications (e.g., adding stochasticity to a previously deterministic parameter). However, the risk of a lower-quality model is bound to accumulate and blow-up in the long-run (last phase).

As discussed in the paper, model-risk pattern is predictable as it manifests as an autocorrelated *alpha* remainder. An alpha remainder can not be replicated or hedged in the traditional sense and, thus, it is arbitrageable. As a rule, the alpha leaked by a market-maker is the alpha gained by a skilled investor taking option positions and hedging them back with a better model than the market-maker's one.

A virologist could interpret the Bank's and Regulatory's model risk management processes as an immunity system that aims to constraint or eradicate the low-quality model risk. However, alpha leakages' symptoms are undetectable by market risk tools such as VaR, Expected Shortfall, and Stressed VaR models as these frameworks focus on the return distributions' second or higher moments over short-time horizons. Backward-looking statistical and Machine Learning methods estimate only the realized alpha terms, and, in the worst case, they take the role of post-mortem forensic tools. Contrarily, the forward-looking state-space analysis of this paper anticipates the PnL's infection risk, as model-risk losses surface using a Challenger model to simulate the Champion model's hedging strategy.

Références

Perelson, A. S. (2002). Modelling viral and immune system dynamics. *Nature Reviews Immunology 2*(1), 28–36.

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