Critical Review on Applicability of Risk Management

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Contents:

Introduction:

Louis Anthony Cox in his article “What’s Wrong with Hazard-Ranking Systems? An Expository Note” gives a critical review of priority-scoring systems of risk evaluation. He comes through several application examples of priority-scoring methods for different situations to show how the ranking system may fail to assess the situation. Specifically, she shows how this system miscounts correlated risks and may sometimes lead to inefficient resources allocation. In contrast to this, he insists on optimization techniques to implement in risk-reduction planning.

Based on the article written by Professor Aven, where he investigates what 'Scientific Uncertainty' means, Cox, in the article "Clarifying Types of Uncertainties: When are Models Accurate and Uncertainties Small?", attempts to give priority in clarifying few key terms like 'accurate' prediction model, where its inputs have 'small' uncertainty, as understanding these terms is essential before investigating on 'Scientific Uncertainty.' Cox tried to illustrate these terms how they are linked with predictive models with the help of 3 examples.

Example 1 is about analysing the assumption that scientific uncertainty is an increasing function of input uncertainty. Cox disproves in the example where input with larger uncertainty yields output with smaller uncertainty.

Example 2 is about investigating when a prediction model is 'Accurate'. Cox considers an epidemic situation, where it was analysed to identify how this epidemic spreads and how long will it last. He concludes that even though the model gives a highly accurate prediction for a shorter duration, when it comes to the longer duration, it is possible to give a highly inaccurate prediction using the same model.

Example 3 is about understanding that the accurate risk prediction model need not be causal. With an example of calculating mean residual life of a component, Cox shows that causality is just based on the purpose of the model created and risk management decision.

Haimes was interested in identifying the risk to systems-based philosophy and the essential elements that should be considered to get the best results. The papers define and quantify risk, which is vulnerability and resilience. To understand it in the best way is by using the systems engineering or analysis perspective. He was adding a new dimension that should be considered as a risk element. He points out the correlation between the evolution of the system during the time.

From his point of view, it is essential to define the state variables correctly. Haimes talked about the Kaplan and Garrick theory of scenario structuring (TSS). They raised three important questions, what can go wrong? What is the likelihood? What are the consequences? Haimes talked about Kolmogorov's theory of probability, which has become an excellent standard. Kolmogorov's approach is built on understanding the probabilities entirely because it is the primary variable of risk, then risk itself also espouses holism.

Haimes states to build a robust risk assessment. We need to understand the system and its relation to the environment to achieve creating a good model.

Case Study:

In this paper, we are going to solve the problem of budget distribution of 10,000 SEK between two variables: A) stock market, namely McDonald's Corporation (MCD) B) Crypto-currency market (BTC) with the methods discussed in Cox (2009, 2011) and Haimes (2009).

Rating System, Certainty & Correlations:

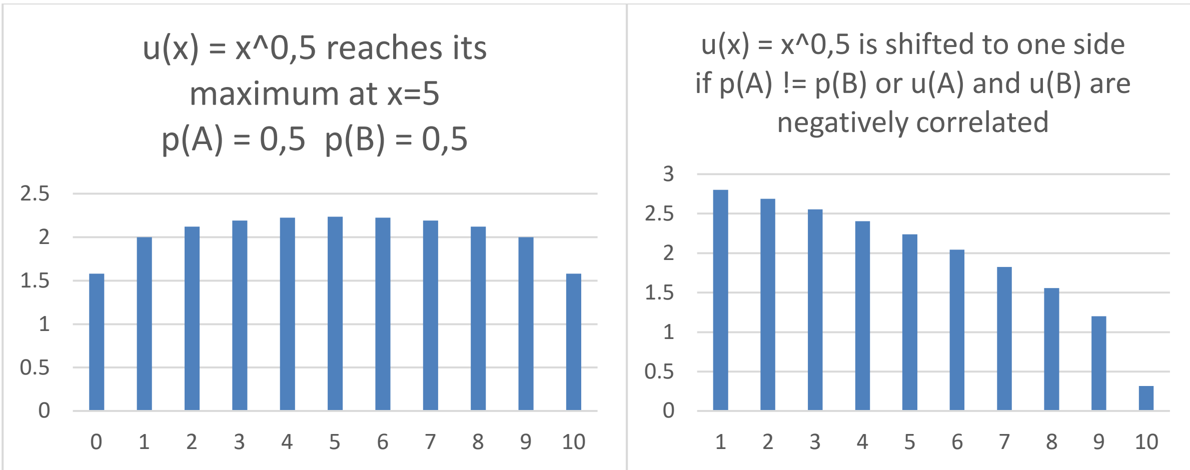
Cox recognizes that priority-setting process can help maximize total benefits by addressing the hazards in order of their decreasing values, giving priorities for known risk reductions, which will maximize total expected utility. In our case we assume, that we are risk averse and our utility function is an exponential representation of the expected return from investments. For the initial setting let us consider U_A and U_B are the expected growth rates for MCD stocks and BTC respectively (later we can supplement the numerical definition of utility). We assume we want to withdraw money after 1 month. Let X be the amount invested in stocks, then total utility may be calculated as:

$$Total\ utility = X * U_A + (10k - X) * U_B$$

Cox confirms that portfolio with the greater sum of certainty is preferred. Thus, in this case the one with higher return rate is preferred, after consideration of certainty equivalents and risk premiums. The closest rate certainty equivalent is Implied Volatility index (IV) for 30 days. If we consider 30-day IV for MCB and BTC, we can make the following assumptions: 1) BTS has higher Utility rate 2) BTS has much higher volatility rate. Thus, Total utility formula must be corrected with rates, representing expected losses.

Cox also claims that ranking-based approach yield poor risk management strategies for correlated risks. In the example 5.2.1 Cox references Jensen's inequality stating that 10 units should be distributed among A and B, and some combination between 0 and N will have highest total utility, while respective probabilities of A and B being true are unknown (the main factor that makes it difficult to find the perfect combination). Cox then concludes that rank system in this situation would concentrate all the resources on one side, while any random given combination would give a better result in terms of utility. The question is: how would a ranking-based approach rank A and B variants, if the nature of A and B is unknown? And if the nature was researched, given the utilities functions of A and B, how come p(A) and p(B) are not known then?

Under trivial example, when pA= pB = 0.5, total utilities were somehow derived and are similar for A and B, total probability within one-place resources does the lowest results in terms of utility, as its curve looks like a normal distribution (see Picture 1a). This solution works if p(A) = p(B) or if A and B share the same Utility function (if the function was somehow constructed properly). If U(A) and U(B) have different Utility functions (negatively correlated, which will make U(x) look much different) or p(A) is not equal to p(B), then total utility function shifts to one of the sides. If we combine different probabilities, different utilities functions (which also may be correlated) then the graph of the Total utility function makes literally any resource allocation given no information – equally useless in case of prediction, not just the extreme case of allocating all in either A or B (see Picture 1).



(a) (b)

Picture 1: Illustration for Cox (2009) Example 5.2.

Source: manually created using this example scenario.

Further he supposes that total risk reductions make A and B respective contributions negatively correlated in terms of total fixed and provided total utility function U(x). But having U(x) same for U(A) and U(B) together makes the mentioned example not just oversimplified, but biased about the nature of A and B which makes the problem itself seem impossible to be solved with the ranking method.

In our case it is true that investing all money into Bitcoin may be a viable option if the Total Utility function looks like “Picture 1b”, although we assume that growth rates for BTC and MDC are somewhat correlated. Common sense analysis of historical data shows that demand and prices in stock market may be both positively and negatively correlated depending on time period. Furthermore, the effect may have time delay and can hardly be calculated as part of our solution.

Adjustments:

Cox arithmetically demonstrates in the example 5.3.1 how combining two factors in resources allocation to a half of given computers may decrease the overall system vulnerability, in contrast to applying a single variant on the sample. However, this does not consider: a) relative damage that may occur after not installing “A” and/or “B”, which could also have a cumulative effect, similarly to installing both b) reinstatement costs. According to the numeric data for the instalment options, the installing “A and B” reduces the hazard rate. The reason why management would choose the ranking system may not just be the difficulties of computations or methodological ignorance of cumulative effects (as stated in 5.3.4), but because risk averse manager might consider possible loss of unprotected halve as irrational risking.

On the other hand, Haimes in his 2009 article gives five premises imply that risk is a vector of the same units as the consequences. Relating to our budget distribution case the following elements of risk should also be considered:

-Time. Our utility functions and the model in general is time-dependent, because the rates in it will change within time. We recognize this restriction and agree with Haimes that such model can resolve a problem in a moment of time and requires monitoring.

-The vector of the resulting consequences. We assume that we are risk adverse and realize a consequence of losing some money after 1 month. Nevertheless, out model must represent the expected loss and should consider different scenarios of market movements.

Thus the expected Total Utility in terms of money (i.e. rewards) will be complemented with expected Portfolio Variances (i.e. risks).

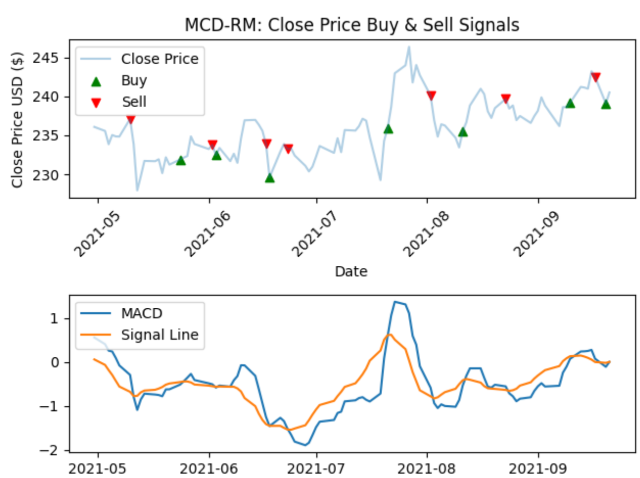
$$Portfolio\ Variance = w_1^2 * \sigma_1^{\,2} + w_2^2 * \sigma_2^{\,2} + 2\, w_1\, w_2 Cov_{1,2}$$

Model Review:

Considering the data on September 2021, we may still assume that investing all the 10k SEK in BTC is still preferable. However, we cannot enter the market without considering the current market trend. It is hard to predict the growth rate for a 1 month with 100% warranty, but it is much easier to realize if you should enter the market now or not. In general, market state can be bullish and bearish (uptrend or downtrend).

Generally, we do not want to buy anything for a higher price than it will be in 1 month. If the market is bearish, we refrain from buying from it. We should also not buy a stock/crypto if it fluctuates higher than usual. Let us introduce the third option in case A and B both are unsuitable to purchase – to leave all the money in a bank deposit for now.

Finally, if the market is growing we should consider the growth rates of A and B and their volatilities to see if it is better to invest all the money in one of them (rating A and B) or we should hedge our risk distributing money among A and B. The rate if we should enter markets A and B or not may be defined simply as 0 and 1 (+/-). This can be defined using indicators like MACD, Implied volatility, various historical data and target companies' financial statement analysis (see Picture 2).



Picture 2. Example of checking if we should enter the market A using tech indicators.

Source: historical data of MCD stock prices.

Thus several scenarios to consider must be implemented which Haimes referenced as "scenario structuring". In different risk scenarios (see Picture 3) we can define their likelihoods and the consequences (expected losses) and then suggest our actions for budget distribution.

Scenario 1. A+B+ Action: B is preferred due to higher Utility.	**Scenario 3**. A+B- Action: A is preferred due to lower risk.
Scenario 2. A-B- Action: bank deposit is suggested.	**Scenario 4.** A-B+ Action: B is preferred.

Picture 3. Scenarios considering market patterns (bull or bear) and Utilities of the random variables A, B.

Results:

Considering open-source data, we engineered a data frame of scenarios instead of a simple rating system (following Cox' and Hayes' reasoning). Stating ourselves as moderate risk averse managers, we may suggest Scenario 3 (A is preferred) to be the solution for our case, as we consider the risk of losing of money in Scenario 1 less significant than having deposit increment. The situation on the A market is considered as positive, and on B negative. Thus total utility may be evaluated as:

*Total utility = 10k SEK * UA + 0 * UB + 0* [deposit]*

Conclusions & Recommendations:

Some examples we considered in the articles seem too radical to approach directly and are applicable only in those radical cases. In the same way, the results provided in this case study seem viable for the current scenario, but while the prediction model is not casual, out result is somewhat same, as a rating system would provide. Here we should notice that if market B appeared to be positive, the real Utility U(B) considering volatilities would be hard to consider with high confidence and should be a matter of a deeper research.

Answering the Cox's question: "If the model is accurate?" The answer is no.

We assume we do not trade actively during this month, neither we have an active trading strategy. We also do not include "Low probabilities with extreme consequences" referenced by Cox's 2011 article.

Suggested additions to this model to be more accurate: risk/risk premium dependence analysis, inflation rate, additional utility of dividends, political risks, other market indicators. Those additions will construct a larger scenario grid and total expected utility will become much higher to compute.

References:

1. Louis Anthony (Tony) Cox, J. (2009). What's Wrong with Hazard-Ranking Systems? An Expository Note: Perspective. Risk Analysis, 29(7), 29(7), 940-948.
2. Louis Anthony (Tony) Cox, J. (2011). Clarifying Types of Uncertainty: When Are Models Accurate, and Uncertainties Small? Risk Analysis: An International Journal, 31(10), 1530-1533
3. Haimes, Y. Y. (2009). On the Complex Definition of Risk: A Systems-Based Approach. Risk Analysis, 29(12), 1647-1654.

Internet Resources:

1. BTC IV: https://t3index.com/indices/bit-vol/
2. Implied Volatility theory: https://www.investopedia.com/ask/answers/032515/what-options-implied-volatility-and-how-it-calculated.asp
3. Implied Volatility MCD: https://marketchameleon.com/Overview/MCD/IV/
4. Risk-averse: https://economictimes.indiatimes.com/definition/risk-averse
5. Portfolio-variance: https://www.investopedia.com/terms/p/portfolio-variance.asp