# A multivariate approach for the joint modelling of market risk and credit risk for cryptocurrencies

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*Extended Abstract*

Cryptocurrencies and the crypto-market are the most popular trend in finance in the last years. Different people – from criminals to investors – are interested in these new financial tools. Large market capitalizations for the most popular cryptocurrencies, increasing number of crypto funds, growing number of Initial Coin Offerings (ICOs) and, at the same time, a frequent number of hacks and frauds – make the topic of cryptocurrencies' risk a really urgent problem. Hence, the main goal of this paper is to propose a unified framework for the joint modelling of credit and market risk.

It is obvious that a crypto-currency itself does not have debt and therefore cannot default in a classical sense. However, its price and investors' demand might drop dramatically because of a revealed scam, hack or other hidden problems that cannot be observed directly from the market data. Because of that, we believe that such risk is not exactly a market one and therefore we propose a definition of credit risk which is somewhat different from the classic one: credit risk for a crypto-coin is its `death' -- a situation when its price drops significantly and a coin becomes illiquid.

The first contribution of the paper is a set of multivariate models which can be used to estimate the market risk for a portfolio of crypto-currencies by using the Value-at-Risk and the Expected Shortfall, and simultaneously to estimate also their credit risk using the Zero Price Probability (ZPP) model by Fantazzini et al (2008), which is a methodology to compute the probabilities of default using only market prices. Recent papers by Li et al. (2016), Su et al. (2010) and Dalla Valle et al. (2016) showed the ZPP's dominance in terms of default probability estimation with respect to competing models.

The second contribution of this work is the development of closed-form formulas for the ZPP in two special cases, namely the random walk with drift and a GARCH(1,1) model with normal errors, using recent results from barrier option theory by Su and Rieger (2009). Even though crypto-assets are far from being normally distributed, these closed-form formulas can provide a quick estimate of the probability of the coin death and they can give an investor at least a rough idea of the crypto-asset credit risk.

The third contribution of the paper is a backtesting exercise using two datasets of 5 and 15 coins for market risk forecasting and a dataset of 42 coins for credit risk forecasting. For the joint modelling of a portfolio of cryptocurrencies, we employ VAR-DCC and VAR-Copula-GARCH models with different specifications for the error terms. The Value-at-Risk and the Expected Shortfall for the single coins and for an equally weighted portfolio are calculated during a back-testing exercise and then evaluated with several tests. The ZPP approach is used for the estimation of the probability of default/death for the single coins and compared to classical credit scoring models (logit and probit) and to a machine learning algorithm (Random Forest). Our results show that a t-copula-GARCH model with skewed Student's t errors outperform the competing models for market risk, while ZPP-based models outperform the other models for credit risk.

## *References*


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