Report: Results of Monte Carlo Simulation Analysis

Initial Margin

Part 2

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Purpose

The objective of the Part 2 of the paper is to:

- Examine the implementation of a Monte Carlo Simulation (MC) methodology for Initial Margin (IM) calculation
- Analyze the impact of MC Simulation methodology
- Discuss the next steps in the implementation of the methodologies

Part 1 of this paper introduced both Variation Margin (VM) and Initial Margin (IM). The main characteristics of the IM are:

- **IM** is a good-faith deposit, posted by a Market Participant as collateral to protect against the financial consequences of default. It reflects potential losses that would be incurred by the PJM members in case of default, calculated to a high degree of statistical likelihood, across the participant's entire portfolio.
- **IM** must cover the period between the time when the position was incurred or variation margin (VM) last levied, and the time when the position could be liquidated or taken to final settlement (whichever is sooner) in the event of default. This time period is called the **Margin Period of Risk (MPOR)**, and is also known as "liquidation period".
- **IM** is computed at the time of every auction and, potentially more frequently.

Monte Carlo (MC) Simulation Methodology

- This paper describes an alternative approach to simulating the exposure of a market participant over the MPOR. The main idea underlying this approach is that the congestion component of the LMP price at any node is a function of fundamental drivers, such as nodal loads, generation and transmission constraints, fuel prices, etc. Once the values of these fundamental drivers are specified, we can run an optimization program, for example, PROMOD, to determine economic dispatch solution and LMP prices at every node x, and particularly its congestion component (*CLMP*)

$$c^x = \Phi\left(L^y, \dots, G^z, \dots, T^b, \dots U\right)$$

- where L^y denotes the load at a node y, G^z denotes generation constraints at the node z, T^b is the transmission constraint at the branch *b* and *U* is the vector of fuel prices.

Monte Carlo (MC) Simulation Methodology

- The consequence of our ability to generate CLMPs as a function of primary drivers, is that for any given path we can generate the distribution of CLMP price differentials for that path by generating the distribution of the primary drivers over the MPOR. The benefit of this approach is that the statistical properties of primary drivers (loads, fuel prices, topology) are stable and their distribution can be reliably validated. Having the distribution of the path prices over MPOR will allow us to simulate the distribution of a Market Participant's portfolio values, which ultimately will lead us to the calculation of the IM.

- *Question:* How to generate distributions of primary drivers?

Primary Inputs for Monte Carlo Simulation Proof of Concept

- Fuel Prices

- Load

- Topology Changes

Generating distributions of the primary drivers

- **Fuel prices**. At the current stage of the model implementation we concentrate on NG prices. For our implementation we will generate distributions of NG forward prices for at least 4 years into the future at the following locations (more locations will be added as needed):

  Henry
  TETCO-M3';
  TGP-Z4_Sta-219
  Transco-Z5_North'
  Transco-Z5_South
  Transco-Z6_(non-NY)
  Transco-Z6_(NY)
  Col_Gas_TCO
  Dominion-South

- These distributions will result from modeling the joint evolution over margin period of risk (MPOR) of the forward price curves with market implied volatilities and historical correlations.

Generating distributions of the primary drivers

- **Load.** A market simulation tool like PROMOD requires expected forward loads as inputs. We will generate scenarios for expected forward loads changes over MPOR and use them in PROMOD. The scenarios are based on historical zonal load forecasts from which we compute the forward load volatilities and correlation coefficients. Scenarios for zonal loads are then used for scenarios for nodal loads. AS MPOR is relatively short we don't model load growth.

Generating distributions of the primary drivers

- **Generation and transmission outages and future topology changes.** These important fundamental drivers will be modeled in the next phase.

Monte Carlo (MC) Simulation Methodology

- Using simulation parameters described before (forward fuel prices, forward expected loads, volatilities, correlations) we generate *N* scenarios to be used in optimization program, e.g., PROMOD. For each NG and load scenario this program will generate a corresponding set of FTR prices for each relevant path and for every month into the future (4 years). Then the difference between the scenario FTRs and base case FTRs will be computed for each path to obtain a desired distribution of FTR prices into the future – thus, simulating uncertainty of FTR prices over the liquidation period, MPOR.
- After the scenarios for FTR price movements are computed, we will compute corresponding movements of the given portfolio values using the information about the portfolio positions for every path. This will generate the distribution of portfolio values over MPOR representing potential changes of the portfolio values, as compared to today, at the end of the liquidation period.

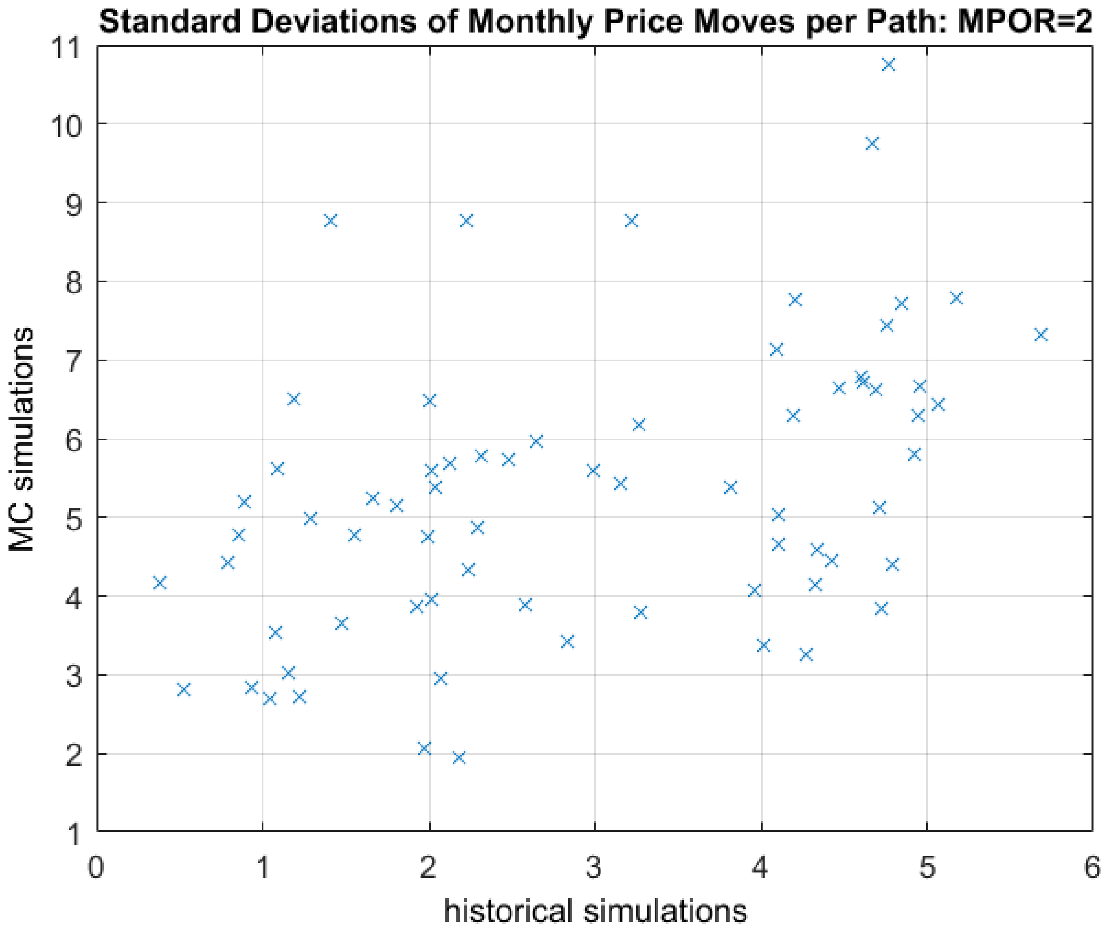
- Once the distribution over MPOR of the portfolio values is determined, the initial margin (IM) is computed the same way as in the Historical Simulation methodology, namely, as the 1st percentile of this distribution (99% confidence level).

POC tests:

- PROMOD
- 150 scenarios
- Only evolution of NG forward prices and forward expected loads
- *Test 1.* Simulations of zonal FTR price distributions and comparison with corresponding distributions generated by the Historical Simulation method
- *Test 2.* Computing the IM for the GreenHat portfolio for a given auction and comparing it with the IM calculated by the Historical Simulation Method.

MC simulations vs Historical Simulations

- Statistical characteristics of MC simulations are realistic and not far from HS



MC simulations vs Historical Simulations

- GreenHat
- Auction: June 2016
- MC Simulations: IM = $16.9 million
- Historical Simulations: IM = $17.5 million

Pros and Cons of MC approach

- Pros:
  - Well suited for modeling future changes
  - Can generate a large number of scenarios
- Cons:
  - More complex than HS
  - More maintenance efforts