Report: Results of Risk Model Quantitative Analysis

Initial Margin

Part 1: Historical Simulation Approach

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Purpose

- This paper examines the implementation of a Historical Simulation (HS) methodology for Initial Margin (IM) calculation via the development of proof-of-concept models and associated back-testing.
- The full paper is available here: https://www.pjm.com/-/media/committees-groups/task-forces/frmstf/20190925/20190925-item-07-results-of-risk-model-quantitative-analysis.ashx

Introduction: Variation Margin and Initial Margin

- Margin is the amount of **financial** collateral deposited by a market participant with the Central Counter-Party (CCP) to collateralize trade exposures introduced by the participant. There are two principal forms of margin: **Variation Margin (VM)** and **Initial Margin (IM)**.
- **Variation Margin (VM)** has been described in the Variation Margin and Post-Auction Settlement Discussion Paper. Key features of any variation margin methodology:
  - At the time of the variation margin posting the combined value of the participant's portfolio and the cash in the variation margin account is never negative. In other words, if the CCP unwinds the participant's portfolio precisely at the moment of variation margin posting, there will be no losses to the CCP.
  - Variation Margin is a **forward-looking quantity**. Its value is connected to the Mark-to-Auction value of the participant's portfolio, which in turn is determined by the participants' expectation of future conditions affecting LMPs, including expectations of future demand, generation, fuel prices, outages and changes in grid topology.

Introduction: Variation Margin and Initial Margin

- **Initial Margin (IM)** provides further protection in case the market participant is not able to post Variation Margin, hence triggering default.
- **IM** is a good-faith deposit, posted by a trading participant as collateral to protect against the financial consequences of default. It reflects potential losses that would be incurred by the participant's counter-party (in our case, by CCP) should the participant 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, if necessary, more frequently.

- Monthly auctions.
  - For each planning year there are 12 monthly auctions from May to April of the next year at times $t_{May}^{mo}, \ldots, t_{April}^{mo}$.

- Annual auctions.
  - For each planning year there are 4 rounds of annual auctions at times $t_1^{An}, \ldots, t_4^{An}$.

- Long Term Auctions.
  - For each planning year YYYY/YYYY+1 there are three rounds of auctions for the long term FTR contracts covering planning years: YYYY+1/YYYY+2, YYYY+2/YYYY+3, YYYY+3/YYYY+4.
  - The times of these rounds are denoted $t_1^{LT}, t_2^{LT}, t_3^{LT}$.

Notation

- Cleared prices per auction or auction round:
  - $P(t_i^{mo}, MMYYYY)$: $MMYYYY$ – month and year of *monthly* FTR contract
  - $P(t_i^{An}, YYYY^{An})$: $YYYY^{An}$ –contract year of the *annual* contract
  - $P(t_i^{LT}, YYYY_1^{LT}), P(t_i^{LT}, YYYY_2^{LT})$ $P(t_i^{LT}, YYYY_3^{LT})$:
    $YYYY_1^{LT}, YYYY_2^{LT}, YYYY_3^{LT}$ are three years of the *long term* contract.

- **Example 1**. FTR contracts bid in the AUG 2018 monthly auction on 07/16/2018 will include Aug2018, Sep2018, Oct2018, Nov2018, Dec2018, Jan2019, Feb2019, Mar2019, Apr2019, May2019.
- **Example 2**. The four rounds of the 18/19 Annual auction run during April of 2018 will clear the price of the annual FTR contract for the 2018/2019 planning year.
- **Example 3**. The three rounds of the 19/22 Long Term auction (Jun, Sep, Dec) of 2018 will clear the prices of the long term FTR contracts for the planning years 2019/2020, 2020/2021, 2021/2022.

Notation

- To unify the notation all prices described above can be denoted as

$$P_\mu(t_i, T_k; \tau)$$

- μ is the index of a particular path;
- t_i is the auction date of the auction i ;
- T_k is the beginning of the FTR period, $t_i < T_k$;
- τ is the length of the FTR period (e.g., 1 month, 1 year);
- $P_\mu(t_i, T_k; \tau)$ is the price for the path μ cleared during the auction i at time t_i; the price is for the contract that starts at T_k and has duration τ.
- $t_i \leq T_k$ where $t_i < T_k$ is the case of auction cleared prices, while $t_i = T_k$ means the settled price.

  – **Example.** If t_i is 07/16/2018, T_k is 12/01/2018, $\tau = 1$ *month*, then $P_\mu(t_i, T_k; \tau)$ denotes the FTR price for the path μ cleared during July 2018 monthly auction for the December 2018 contract.

Simulations using Historical Data: Methodology
Monthly Auctions

- Period duration $\tau = 1$ *month.*
- Historical data for HS method: 2006 - 2019. For each planning year since 2006/2007 we have path prices $P_\mu(t_i, T_k; 1m)$.
- $t_i < T_k$. To increase the data set $t_i = T_k$ is allowed. In this case the "auction price" is the settled price for the month i.

- Assume that participant's portfolio **Π** includes paths $\{\mu_1, \mu_2, \ldots, \mu_m\}$. The HS method requires to construct many scenarios of how current auction prices for these paths will change over the specified MPOR (**margin period of risk**, a.k.a **liquidation period**). MPOR can be 2,3, or more months.

Monthly Auctions

- How to compute the scenarios?
  - Choose a planning year in the past
  - Choose a contract month T_k in that planning year
  - Choose an auction month i and corresponding auction time t_i. The choice of the auction month is constrained by the requirement that $t_{i+MPOR} \leq T_k$.
  - Compute the changes for each path over MPOR:

$$D_{\mu}^{scen} = P_{\mu}(t_{i+MPOR}, T_k; 1m) - P_{\mu}(t_i, T_k; 1m), \quad scen = 1,2, \ldots$$

  - Create as many scenarios as possible by varying planning years and contracts
  - Apply these historical price moves to current auction prices to generate forward distribution of auction prices – each scenario corresponds to a set of potential auction prices at the end of MPOR over all paths in the portfolio.

Monthly Auctions

- **The main question:**

  Assuming that we need to liquidate the market participant's portfolio Π by the end of the MPOR, what would be our exposure with a high degree of confidence?

  In other words, we need to state that with high probability our losses will not exceed δ during the liquidation period. Then, requesting the participant to post IM that is greater than or equal to δ, we ensure that we are protected with high degree of confidence in case the participant defaults and we need to liquidate by the end of MPOR.

  To determine this critical loss level we will compute portfolio values for all price scenarios; then compute corresponding deviations of these values from the current portfolio value; rank these deviations and, finally, find the level such that percentage of scenarios with losses below this level does not exceed a small number (say, 1%).

Monthly Auctions

- For all price scenarios compute

$$\Delta\Pi^{scen} = \Pi(scenario\_prices) - \Pi(current\_prices)$$

- Find δ such that

$$\Pr(\Delta\Pi^{scen} < \delta) = 1\%$$

- **Initial Margin.** Once we determined that 99% of portfolio deviations over MPOR are above δ, the *initial margin (IM)* is defined as follows:

$$IM = Const \cdot \delta$$

where *Const* is a pre-fixed scaling factor, greater than or equal to 1.

Annul and Long Term Auctions

- **Annual Contract.** As we enter a given planning year, we determine the IM for the remaining balance of the corresponding Annual contract by splitting it into the monthly contracts and determining IM the same way we did it for monthly contracts.
- **Long Term Contract.** Similar methodology as in the case of monthly contracts with the following modifications:
  - $\tau = 1yr$ and not 1m
  - t_i is the time of a particular round of LT auction
  - $MPOR$ is now 6-9 months.

Price Scenario Structure

- ***conYYYY, conMM*** - year and month of the contract under consideration;
- ***inAucYYYY, inAucMM*** – year and month of the auction when we enter the contract;
- ***inPromptNum*** – the distance in months from the in-auction month to the contract month;
- ***outAucYYYY, outAucMM*** – year and month of the auction when we exit the contract (including the possibility of getting settled prices in the contract month);
- ***outPromptNum*** – the distance in months from the out-auction month to the contract month;
- ***MPOR*** – margin period of risk, the period between in-auction and out-auction;
- ***PriceIn, PriceOut, Diff*** – respectively, the price of the contract cleared in the in-auction, the price of the contract cleared in the out-auction and the difference between those prices.

conYYYY	conMM	inAucYYYY	inAucMM	inPromptNum	outAucYYYY	outAucMM	outPromptNum	MPOR	PriceIn	PriceOut	Diff
2017	**5**	2017	2	3	2017	5	0	3	1.4508	1.9109	0.46017

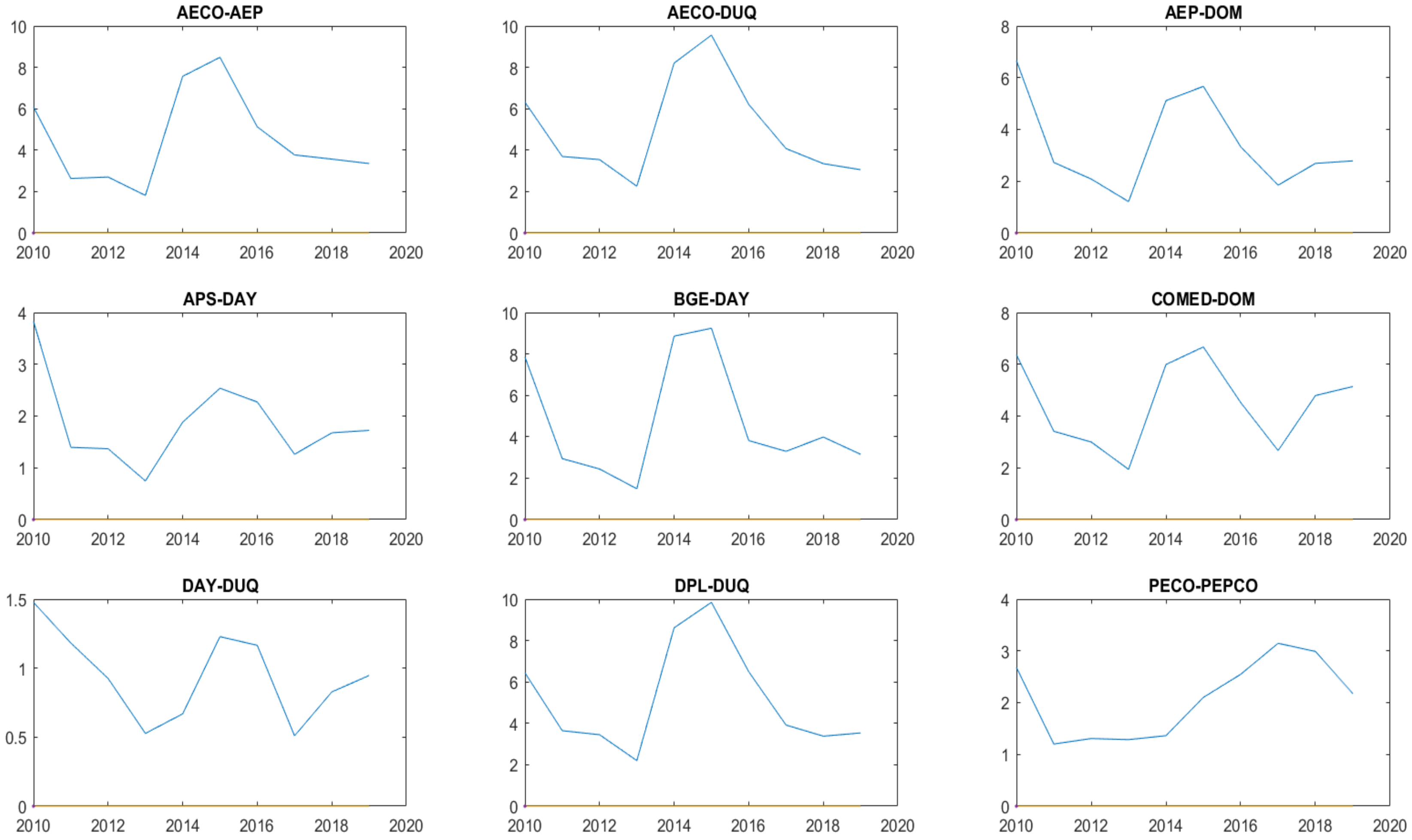
Properties of Historical Price Movement Distributions

- The analysis of price distributions, as well as all back tests, except the last one, will be performed on zonal paths, due to the fact that the historical data for zonal prices is more reliable and readily available.
- Ultimately, we intend to perform similar analysis on all paths relevant to participants' portfolios.
- In this presentation, most of the analysis and test results are given in a reduced form. The full set of results can be found in the paper in the Appendix.

- First question: was there a systemic change in price volatility? For example, was there steady increase or decrease in volatility?

Two-year moving window volatility of monthly FTR prices for zonal paths

- No manifested systemic change in volatility (to be continuously monitored)



Properties of FTR Price Distributions

- Standard deviation, first percentile, and kurtosis of the zonal path FTR price distributions. *MPOR* = 2.

PATH	STD	1%	Kurtosis
AECO-AEP	4.19	-10.19	102.3
AEP-BGE	4.56	-12.09	121.66
APS-DOM	2.23	-5.92	60.11
DOM-DUQ	4.02	-11.64	42.47
PENELEC-PEPCO	3.28	-8.21	97.12

Term structure of FTR Price Volatility

- Volatility decays for farther contracts. Standard deviation for each FTR contract is calculated for the distribution corresponding to MPOR=2

PATHS	Auction month + 2	Auction month + 3	Auction month + 5	Auction month + 7	All
AECO-AEP	8.50	2.92	2.50	2.19	4.19
AEP-DPL	8.79	3.08	2.46	2.24	4.33
DOM-DUQ	7.81	3.07	2.36	2.42	4.02
PECO-PEPCO	3.77	1.78	1.27	1.17	2.02
PENELEC-EKPC	4.28	1.67	1.06	0.60	2.00

Back-Testing

- Back-testing is a standard method for validating a particular trading or risk management methodology. The back-testing procedure works as follows:
  - Fix a particular time *t* in the past and calculate IM using historical data for times preceding *t*.
  - Assume that a default happens at time *t* and it takes a time period equal to MPOR to unwind the position.
  - Compare the loss during MPOR with the computed IM.
  - Repeat this test for a number of times *t* and compute a percentage of times IM was less than actual loss.
  - Check if this frequency is consistent with target risk percentile fixed in IM calculation methodology.

- Back-testing results for zonal path prices. MPOR = 2, inPromptNum = 3

PATH	# TESTS	# FAILS
AECO-AEP	62	0
AECO-APS	62	0
AECO-BGE	62	0
AECO-COMED	62	0
AECO-DAY	62	0
AECO-DOM	62	1
AECO-DPL	62	2

- **Total Number of Tests = 10724**
- **Total Number of Fails = 139**
- **Fails/Total = .013**

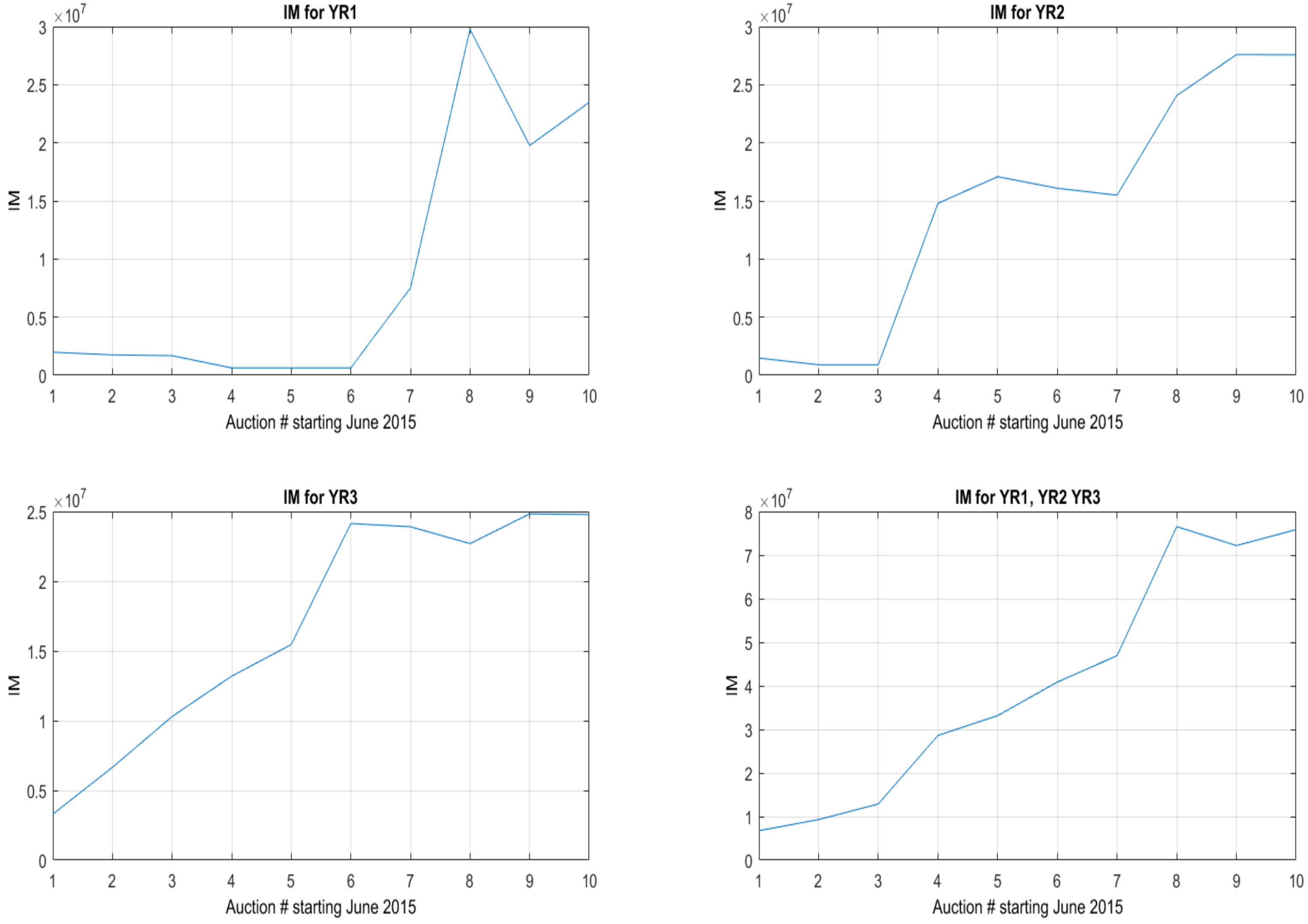
- ***Const*** = 125%

MPOR	inPromptNum	numFails/numScenarios
2	2	0.0092
2	3	0.0053
2	4	0.0043
2	5	0.0034
2	6	0.0029
2	7	0.0026
3	3	0.0041
3	4	0.0042
3	5	0.0038
3	6	0.0035
3	7	0.0032

- ***Const*** = 100%

MPOR	inPromptNum	numFails/numScenarios
2	2	0.0226
2	3	0.0130
2	4	0.0106
2	5	0.0085
2	6	0.0073
2	7	0.0065
3	3	0.0106
3	4	0.0113
3	5	0.0103
3	6	0.0096
3	7	0.0090

GreenHat Portfolio: IM for LT portfolio for auctions starting June 2015



Discussion

- The concepts underlying the approach are common and preferred by regulators and market governing bodies. See, for example, Standard Initial Margin Model for Non-cleared Derivatives, ISDA, 2013
- Although called Historical Simulations, the method uses historical data only to determine the distribution around the forward prices and *not* the forward prices themselves. The forward prices, which at any auction reflect participants' expectations of future settled FTR prices, are determined at the auction time and, ideally, incorporate all information participants have about the future, including topology changes, outages, fuel prices, etc.
- Changes in participants' expectations result in changes in auction prices, changes in Mark-to-Auction portfolio values, and, finally, changes in VM which is levied to protect CCP against adverse movements of portfolio values.
- Initial Margin provides an additional protection against participant's default.

- IM is computed after we construct distributions of potential movements of all forward contract prices over relatively short period of time, MPOR. These distributions are constructed using historical price movements.
- **Summary.** VM is needed to neutralize portfolio losses due to changes in forward expectations, while IM is needed to protect (with a high degree of confidence) against losses during the period of liquidation caused by default. Calculation of IM never requires predicting of forward prices.
- Key benefit of HS approach – it produces a joint distribution of price movements without requiring correlation or covariance inputs.

- More work required:
  - *Adjustment for liquidity.* More analysis is needed to determine how adjust IM in case of illiquid paths.
  - *Choice of MPOR and other parameters for IM calculation.* We need to do more back testing of different portfolios to establish a definitive choice of these parameters.

POC: Historical Simulation Method

- At the initial stage HS has proved to be a reasonable methodology to be considered for computing IM.
- HS can also be a simple and reliable back-up method in production or for testing purposes.
- HS can also be used to improve effectiveness of other methodologies, such as Monte Carlo simulations, resulting is some kind of hybrid method.