Tethys Optimal Execution

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Auction Volume Report: Americas

Tethys Auction Volume Report is an independent analysis of auctions in global equity markets. We provide spot information, trend data and factor cross-section analysis. The data presented in this report is a subset of the information used in our award-winning settlement price benchmark **ECLOS** algorithm. The attached report covers all major listing exchanges in North and South America.

For the purpose of this report, the phrase *auction* incorporates both auction and cross based market open and close mechanisms.

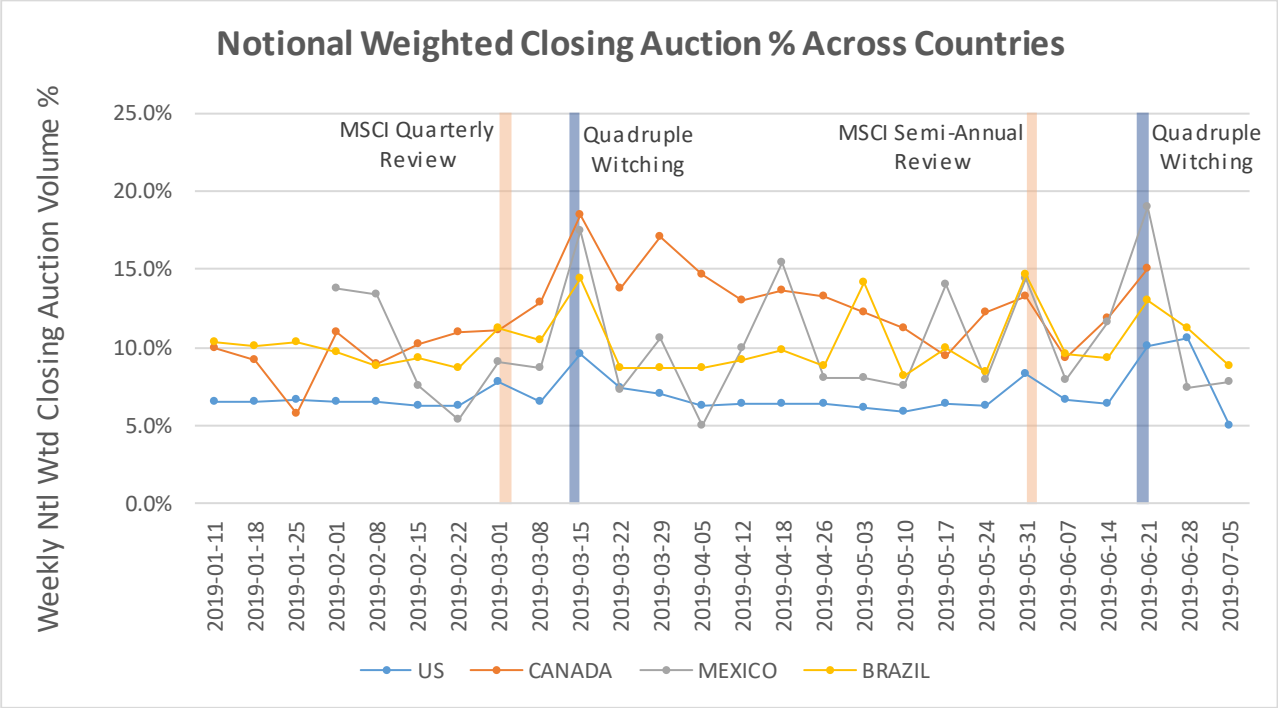
We include both the median and the notional traded weighted data. The two metrics may have significant differences. The difference provides an insight into the auction participation divergence across the liquidity spectrum. In the closing auction analysis, we only include securities that have a median closing auction size of at least 1000 shares; the corresponding cutoff for the opening auction analysis is 500 shares.

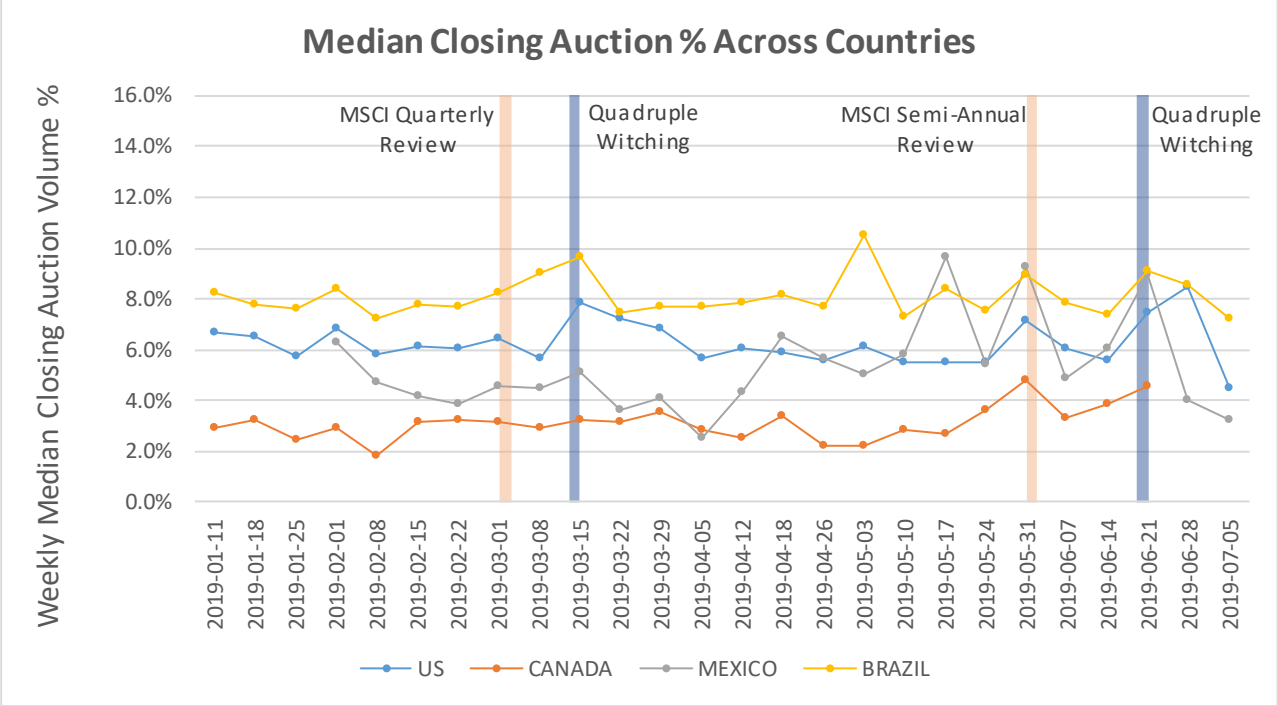
Auction Volume% = Auction volume on the primary exchange / Total traded volume across all venues

The current six-month median and notional weighted auction data for the Americas region:

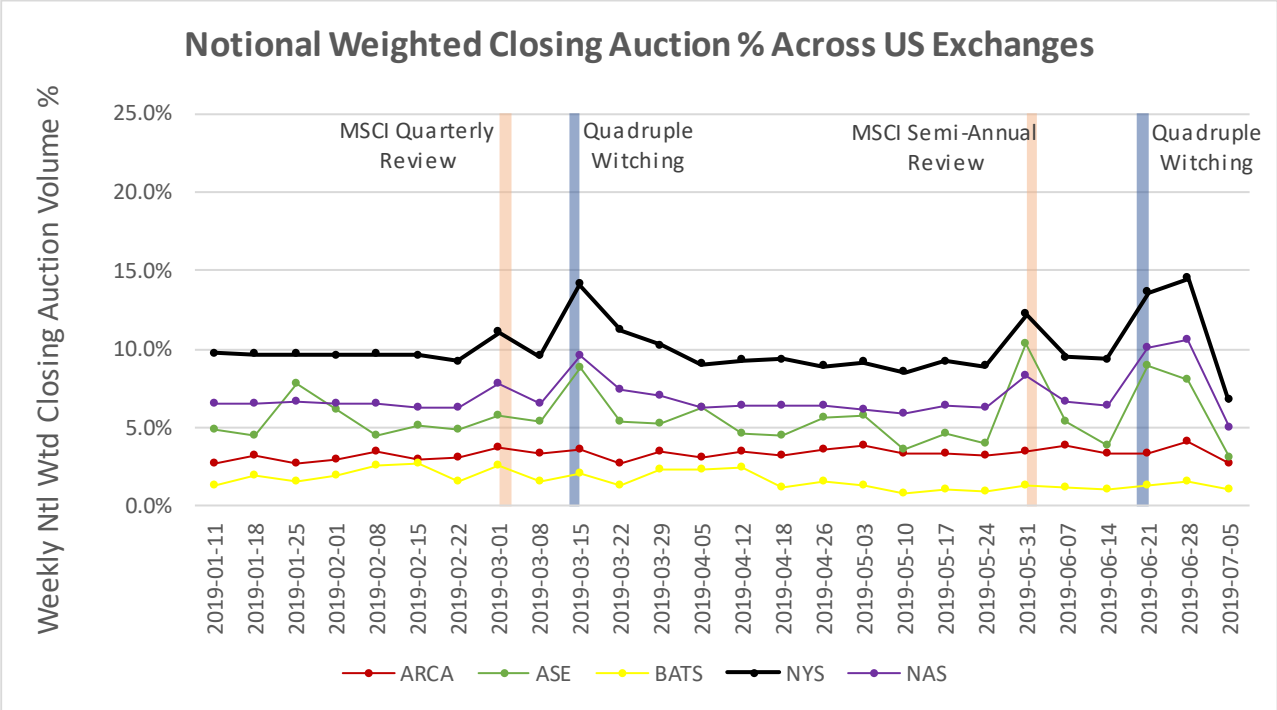
	Daily Median Closing Auction Volume %	Daily Notional Weighted Closing Auction Volume %	Daily Median Opening Auction Volume %	Daily Notional Weighted Opening Auction Volume %
BSP (Brazil)	8.0%	10.1%	0.2%	0.6%
TOR (Canada)	3.1%	12.0%	0.7%	1.2%
TSX (Canada)	0.1%	0.7%	1.7%	2.3%
MEX (Mexico)	5.0%	10.2%	0.02%	0.06%
ARCA (US)	0.7%	3.3%	1.3%	0.6%
ASE (US)	2.2%	5.6%	1.5%	1.4%
BATS (US)	0.8%	1.6%	1.1%	0.8%
NYS (US)	7.4%	10.1%	0.9%	1.3%
NAS (US)	6.2%	7.0%	0.8%	1.1%

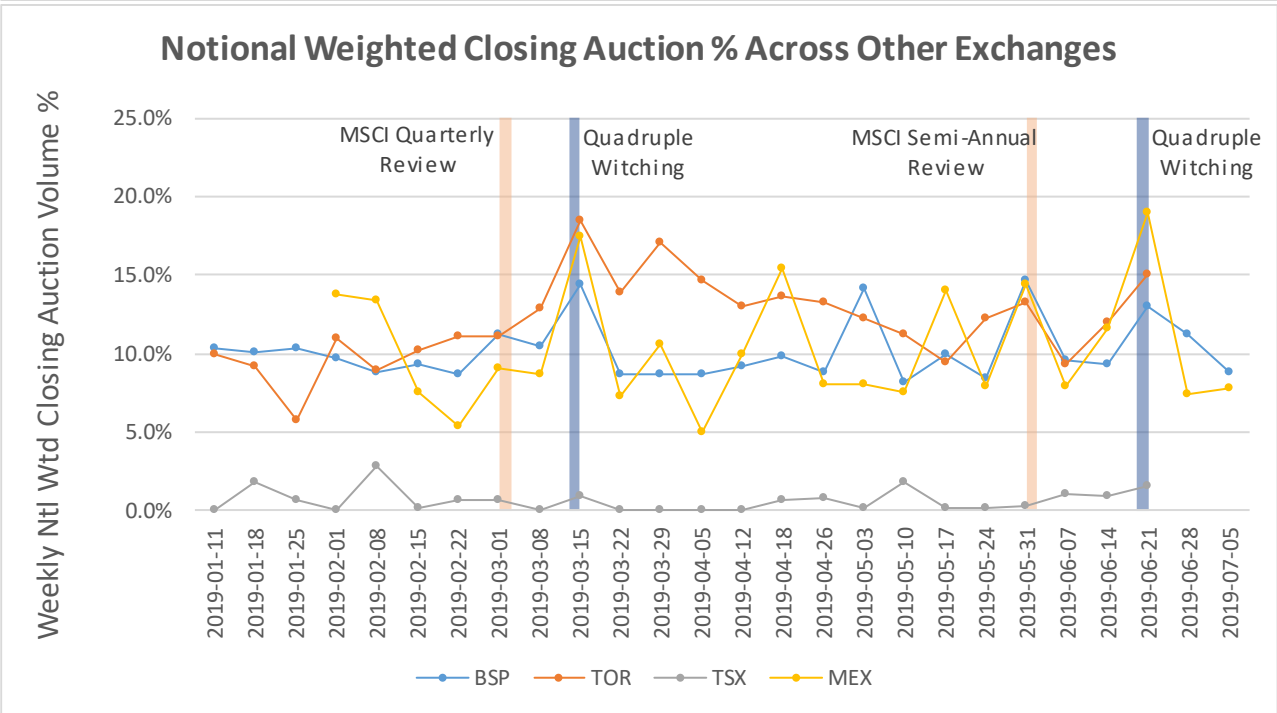
Closing Auction Volume % Trend by Country

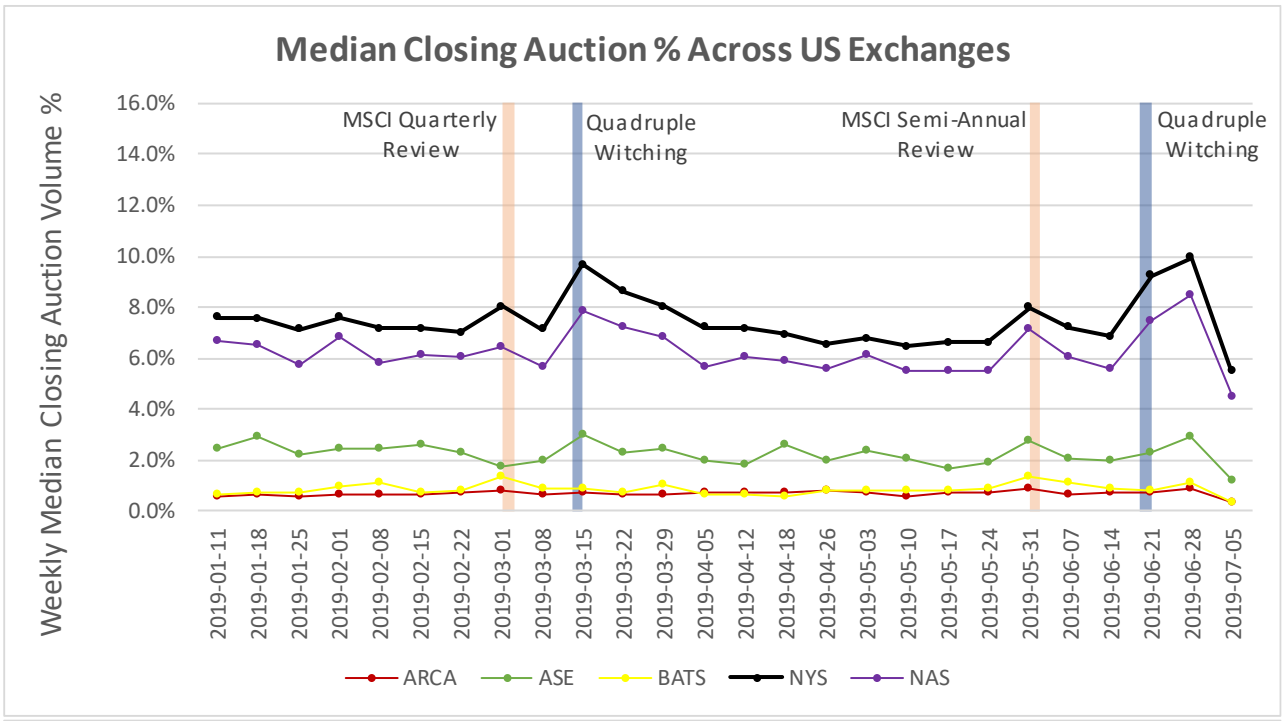


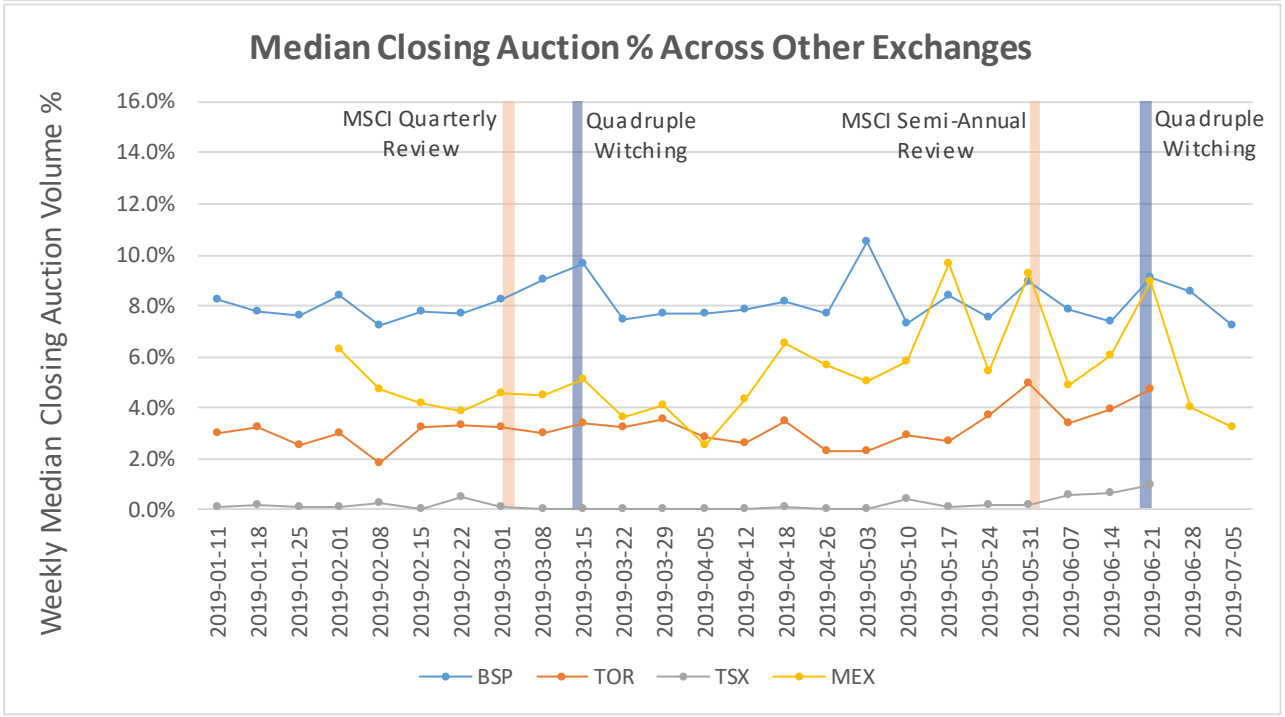


Closing Auction Volume % Trend by Exchange









Summary

On a notional traded basis, the Brazilian Bovespa, the Mexican BMV, the New York Stock Exchange and the Toronto Stock Exchange standout for the high level of closing auction participation. The Brazilian Bovespa, the Nasdaq and the NYSE stand out for the widespread use of closing auctions through the liquidity spectrum. As seen in the table above, the overall level of closing participation is high at these exchanges and the spread between auction participation of the low liquidity and the high liquidity securities is narrow.

It is notable that quadruple witching plays an important role across all exchanges in closing auctions. Please look at the charts below. We will publish a separate report studying the influence of quadruple witching on opening auctions.

BATS and ARCA are dominated by ETF listings. ETFs have low Auction Volume % participation except for low liquidity ETFs and certain US listed Asian and European focused funds.

There is a significant closing auction participation difference between the highest liquidity securities and the remainder of the listings on the Toronto Stock Exchange. This is because the TOR liquid universe is dominated by inter-listed (US-Canada cross listing) securities. US auction levels strongly influence these securities.

As expected, the median Auction Volume % data is significantly more stable than the notional weighted data.

Price level is the factor with the highest explanatory power in the list of factors we presented in this report. Please note that market capitalization and security price have a significant correlation.

Positive correlation between Auction Volume % and average daily trading volume is observed in the majority of the exchanges. Higher liquidity leads to higher Auction Volume %. Unexpected auction impact costs come from a misjudgment of auction volumes and the resulting imbalance. Higher liquidity securities have less volume variability and afford higher confidence to investors. At Tethys, we have made a significant effort in refining our auction volume prediction model. This is one of the cornerstones of the success of our **ECLOS** (closing benchmark) algorithm.

Volatility has a negative correlation with Auction Volume %. This is explicable as spreads tend to be higher for these securities and imbalances will have a proportionately higher impact.

A positive correlation between Auction Volume % and price level is also observed in US (non-ETF) and Canadian Inter-listed securities. There is a relationship between price levels and average daily trading volume.

Trade size fragmentation has an interestingly negative correlation with Auction Volume %, which we will offer reasons for in a future report. There is an intriguing retail angle to be explored.

The Brazilian Bovespa has a distinct and efficient closing auction mechanism. There is a separate closing auction session, unlike the U.S. and Canadian exchanges where the auction period overlaps continuous trading. The exchange provides real time dissemination of the imbalance and the expected clearing price. The provision for auction extension and the randomization of the closing time reduces gaming.

Exchange and Factor Description

The primary listing exchanges covered in our report are given below. These exchanges encompass a majority of the auction volume in North America and LATAM. Tethys offers execution algorithms for all the countries below as well as Chile and Colombia, which will be included in upcoming reports.

Brazil

- BSP: Brazilian Stock Exchange (BOVESPA)

Canada

- TOR: Toronto Stock Exchange
- TSX: Toronto Stock Exchange Venture

Mexico

- MEX: Mexican Stock Exchange (BMV)

United States

- ARCA: NYSE ARCA
- ASE: NYSE American
- BATS: BATS Exchange
- NYS: New York Stock Exchange
- NAS: NASDAQ

For brevity we only include commonly known trading related factors to analyze closing auction volumes. Fundamental factors like market capitalization are not included in this report. Tethys maintains an extensive list of factors in context of auctions. Please note the factors are not mutually orthogonal (i.e. not completely independent of each other). The factors presented are:

- Daily Trading Volume
- Price Level = 0.5 * (Open + Settle Price)
- Daily Price Range = Ln (High/Low), *where Ln is the natural logarithm*
- Notional Value Traded = Daily Trading Volume * Price Level
- Average Trade Size = Daily Trading Volume / Number of Trades

Closing Auction Volume in Multi-Dimensional Factor Space

Closing Auction Volume is affected by various factors. Analyzing Closing Auction Volume % with respect to each factor conveys an understanding of the closing auction microstructure behavior for each exchange. Please note that the factors are not mutually independent.

We divided the respective stock universe into 5 bins with respect to each factor.

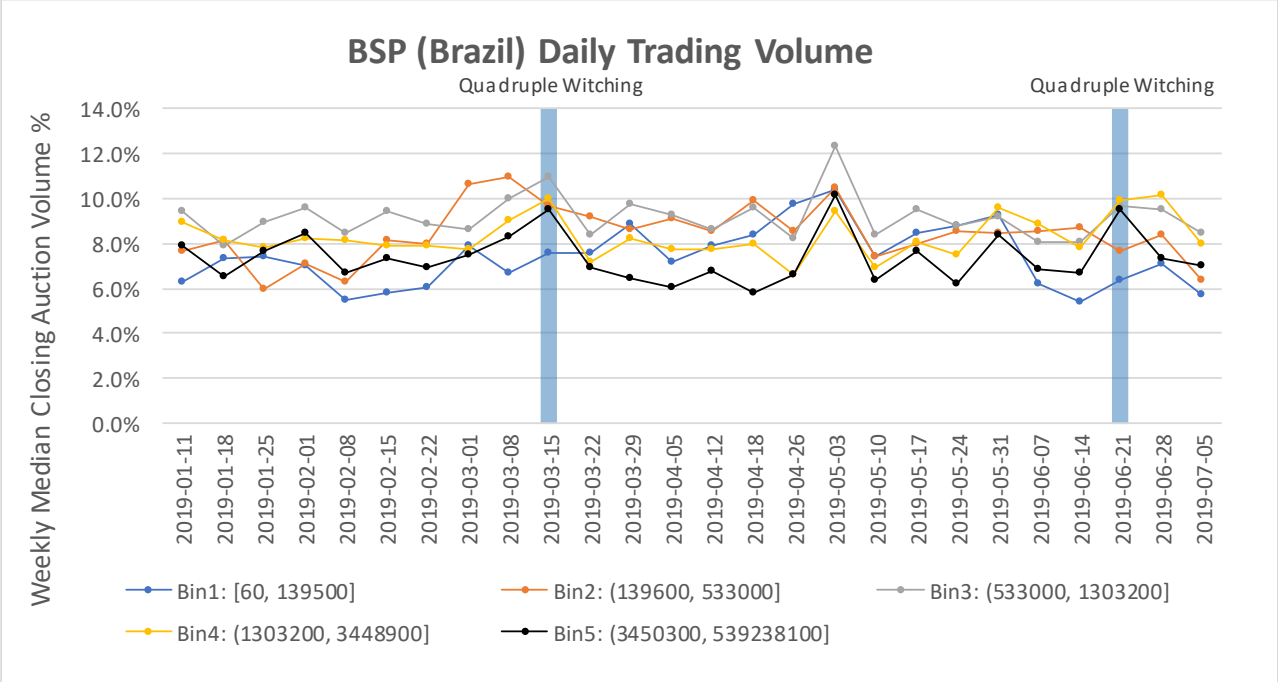
For example: Factor Daily Trading Volume, Bin1 contains tickers in the lowest 20% of the Daily Trading Volume and Bin5 contains tickers in the highest 20%. Respectively, Bin2, Bin3 and Bin4 have tickers in the 20%-40%, 40%-60%, 60%-80% of the Daily Trading Volume value distribution. Each bin then calculates the median and notional weighted average closing auction volume % weekly. Note that we only include securities that have median close auction volume > 1000 shares.

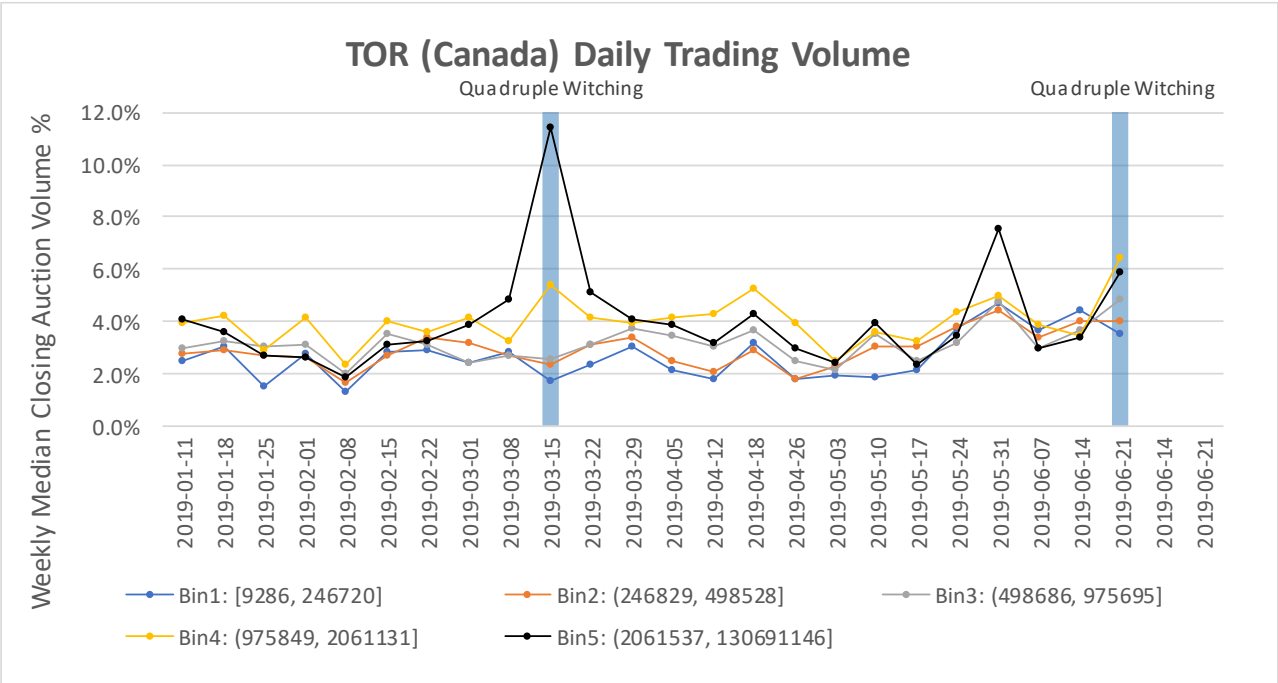
The chart below summarizes the overall statistically significant correlation between closing auction volume % and each factor by exchange. The plus "+" indicates positive correlation and minus "-" negative correlation. A blank cell indicates that we can't validate there is a correlation by using the

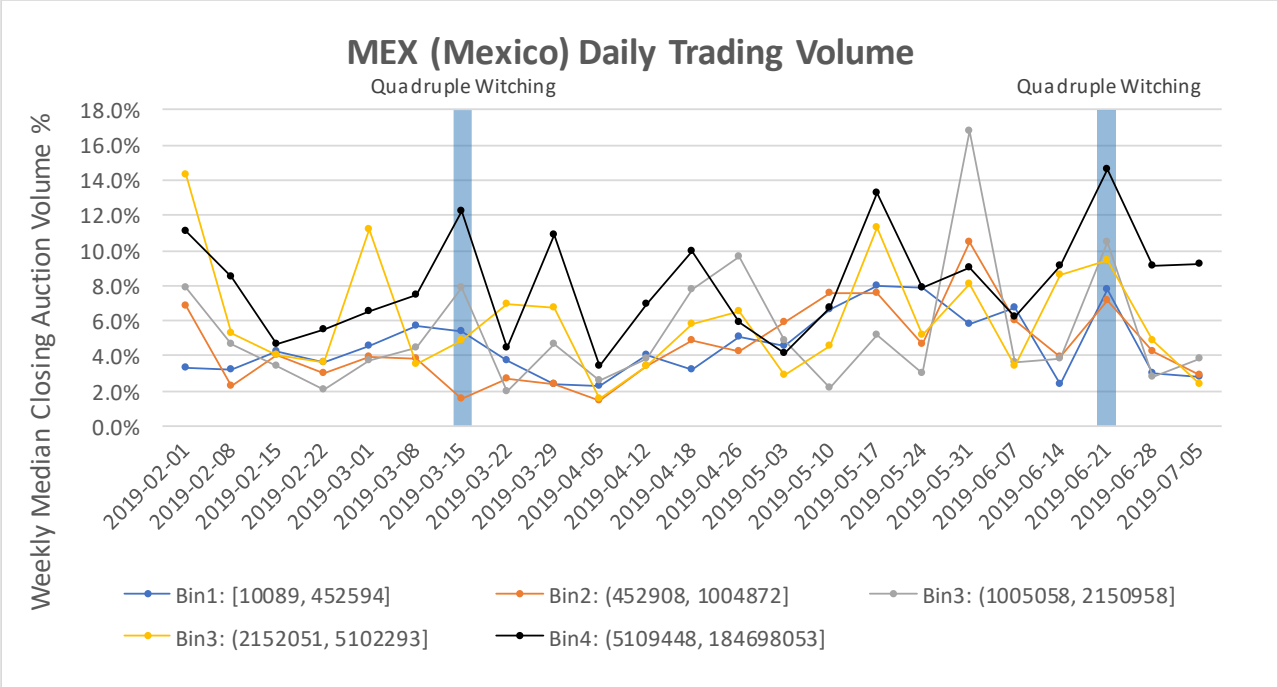
Correlation between Closing Auction Volume % and Factors

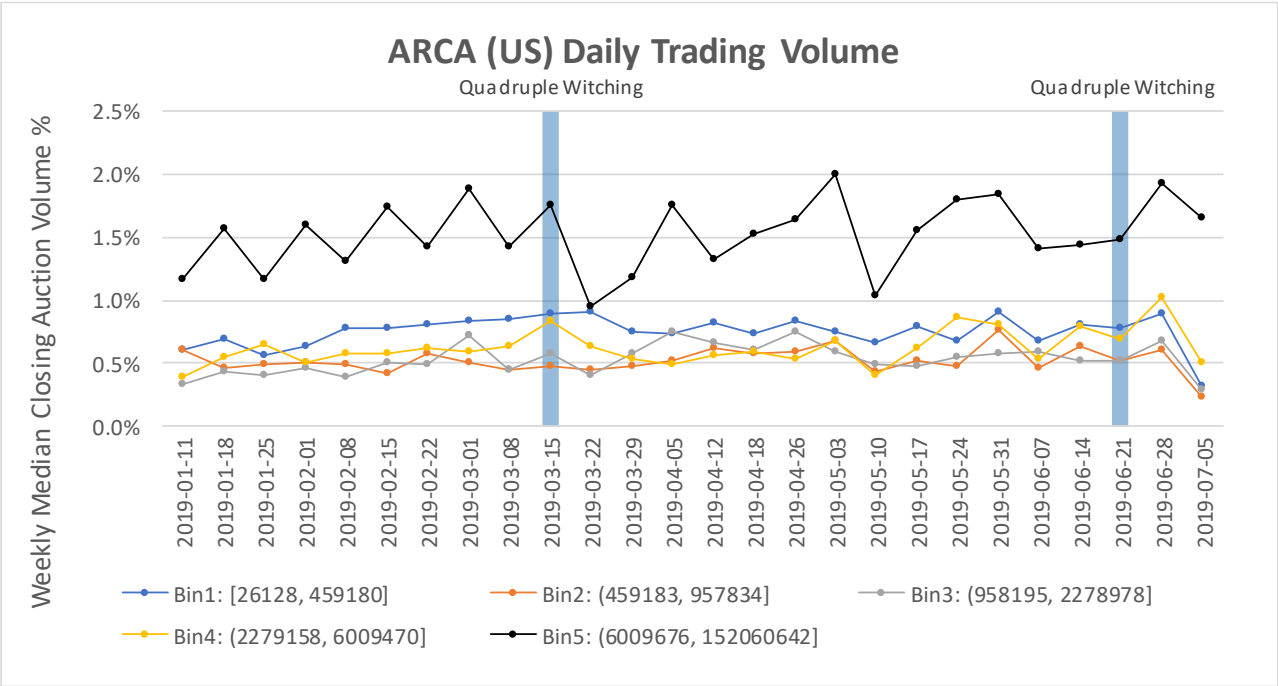
Factors / Exchanges	Daily Trading Volume	Price Level	Daily Price Range	Notional Value Traded	Average Trade Size
BSP (Brazil)		+	-		-
TOR (Canada)		+	-	+	-
TSX (Canada)					
MEX (Mexico)					
ARCA (US)	-	+			
ASE (US)	-	+	-		-
BATS (US)	-				
NYS (US)	-	+	-	+	-
NAS (US)	-	+	-		-

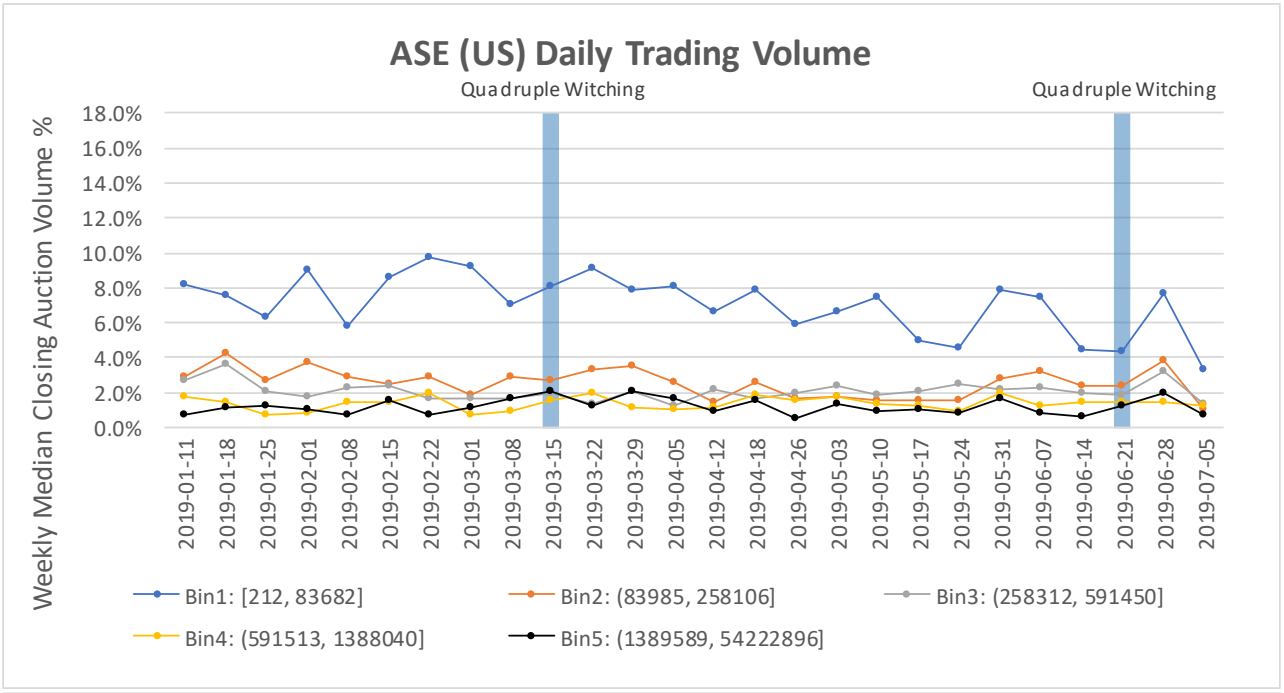
I. Weekly Median Closing Auction Volume % Binned by Daily Trading Volume

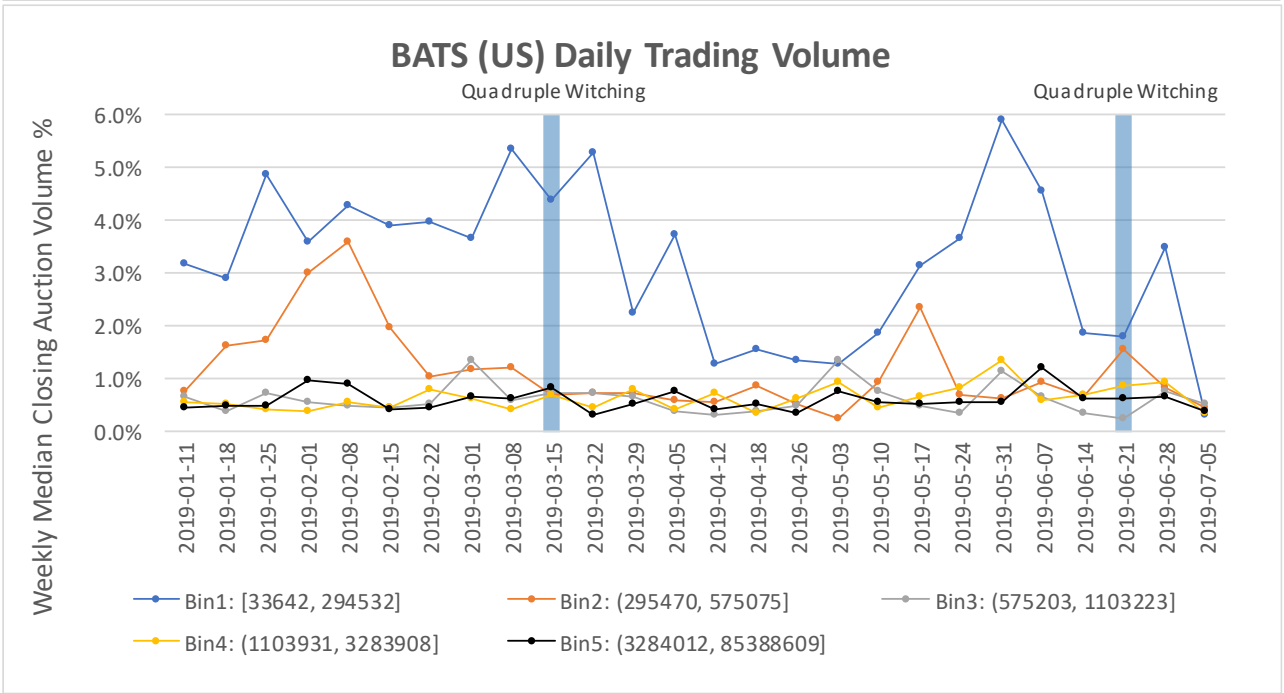


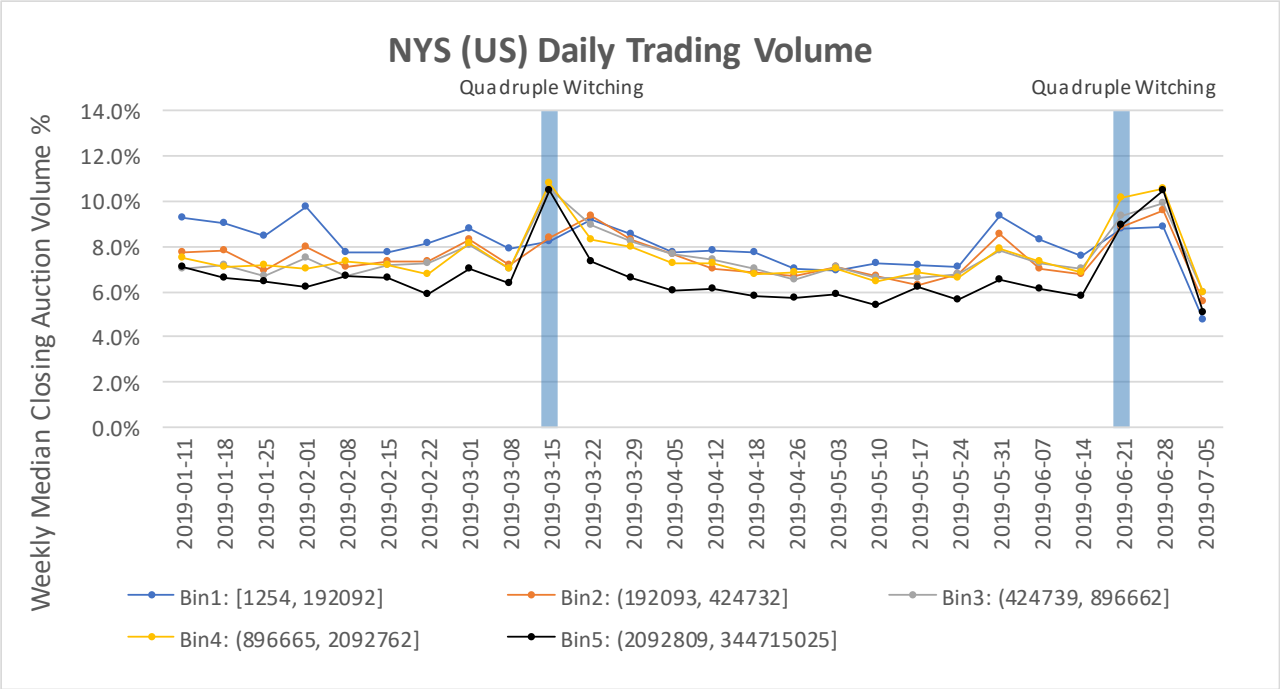


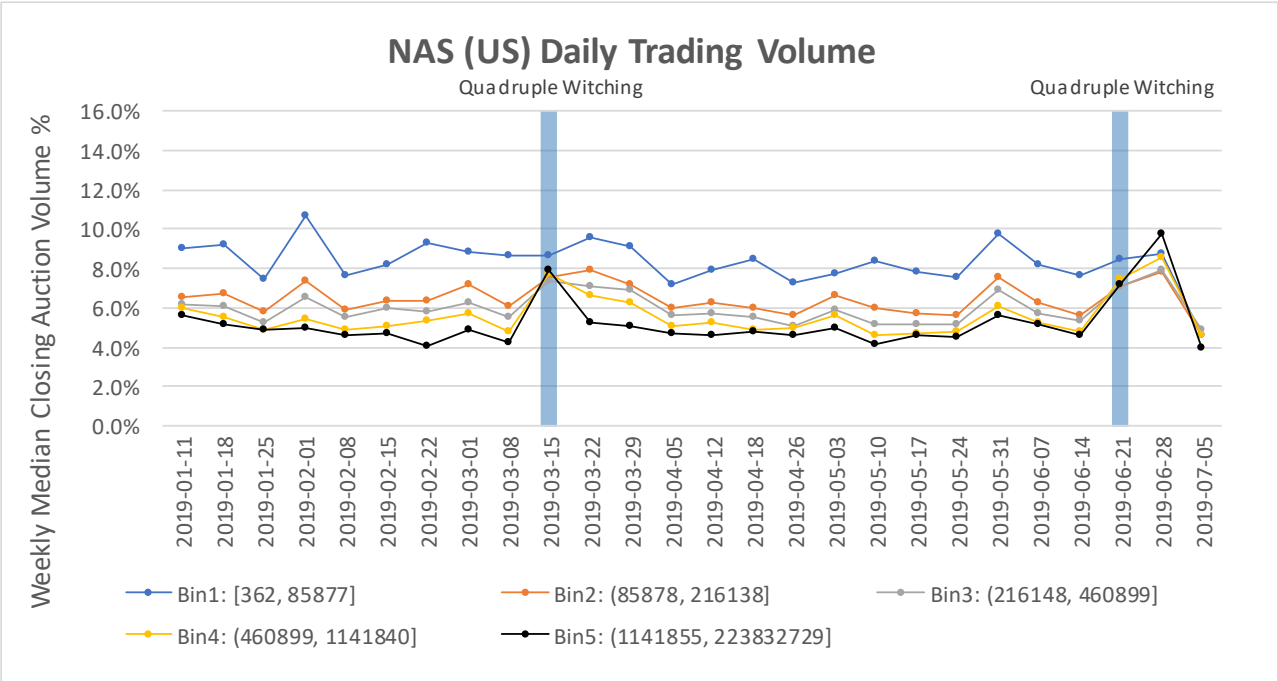




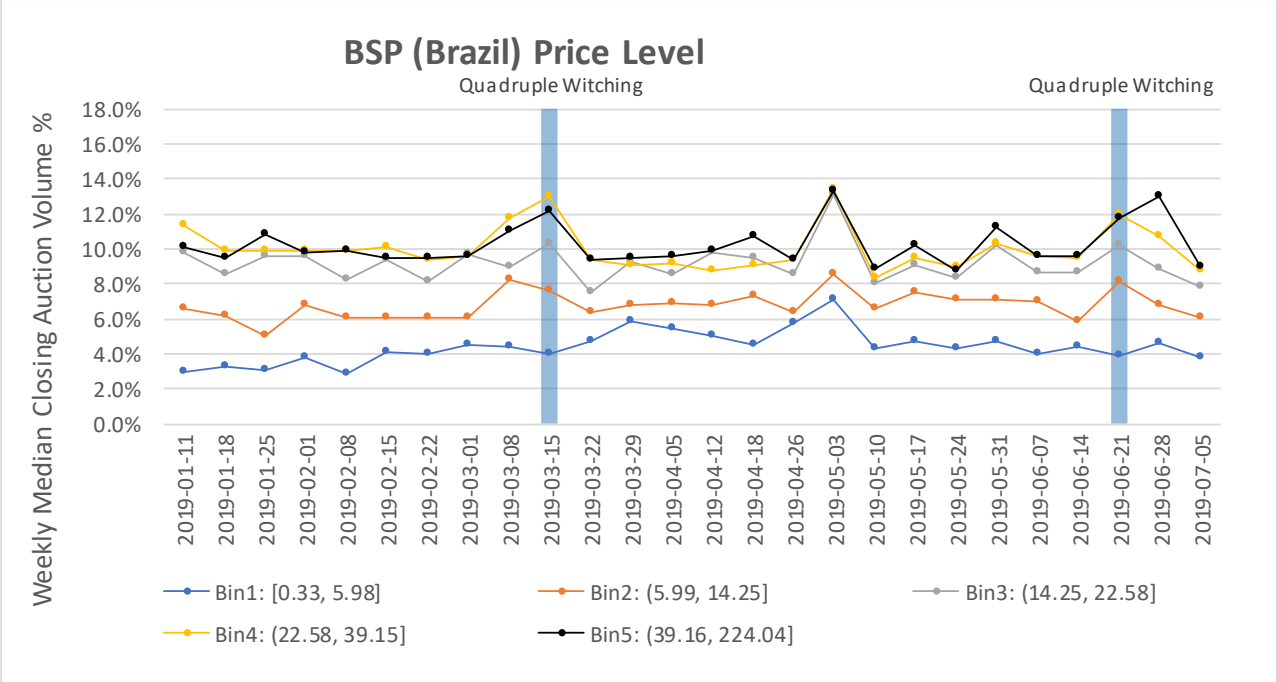


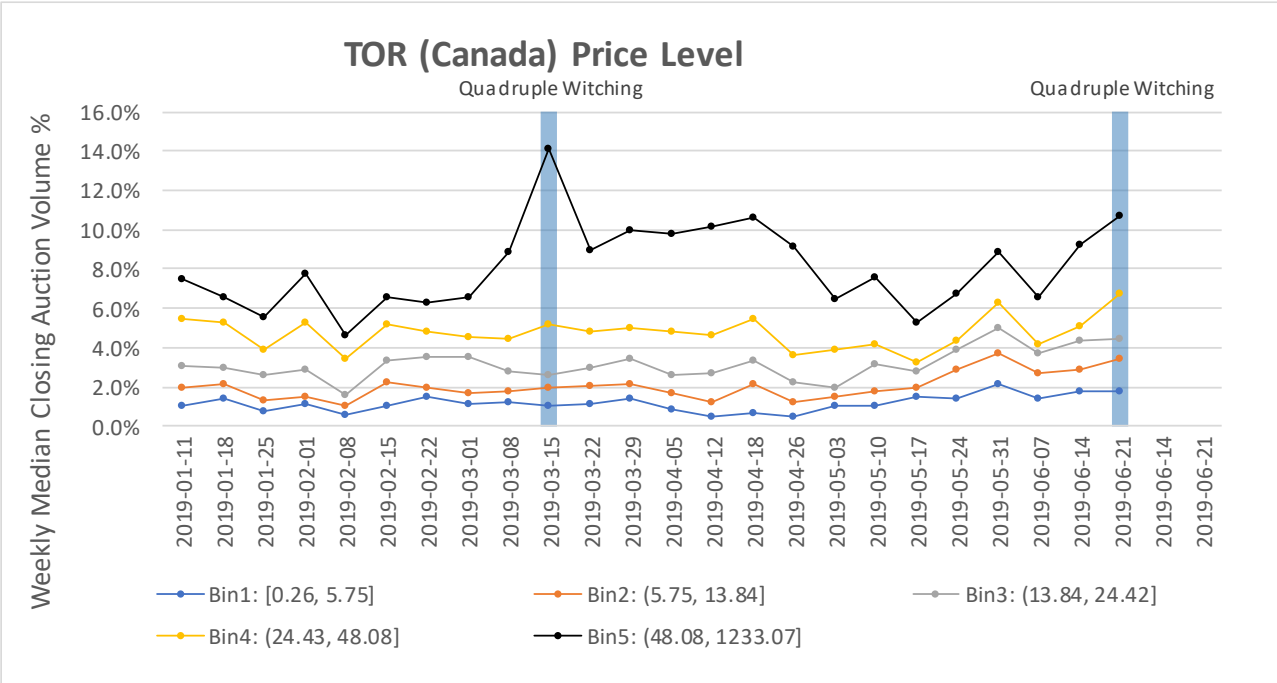


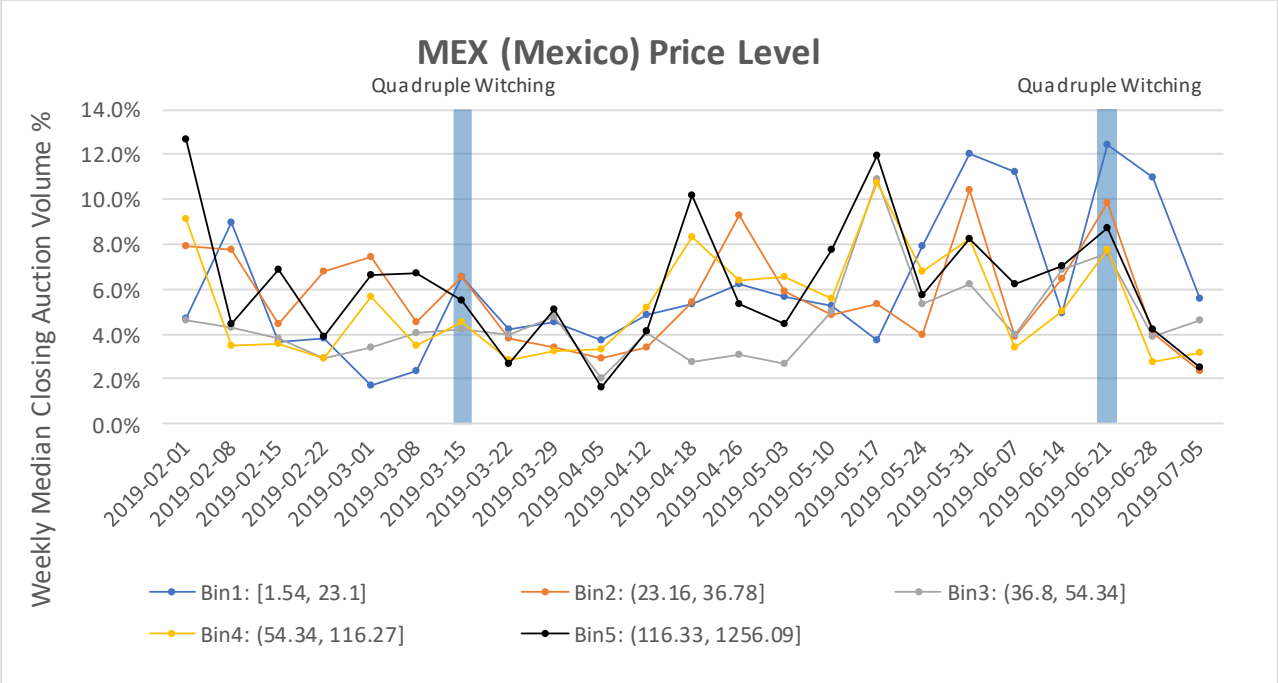


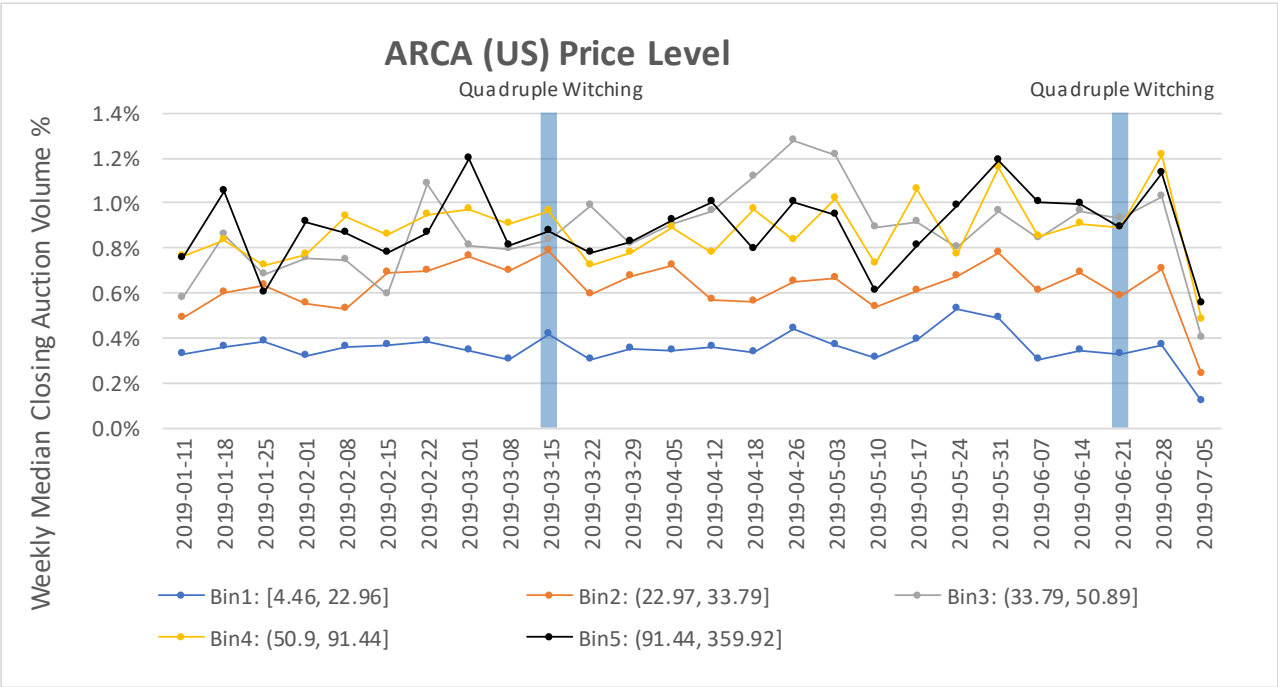


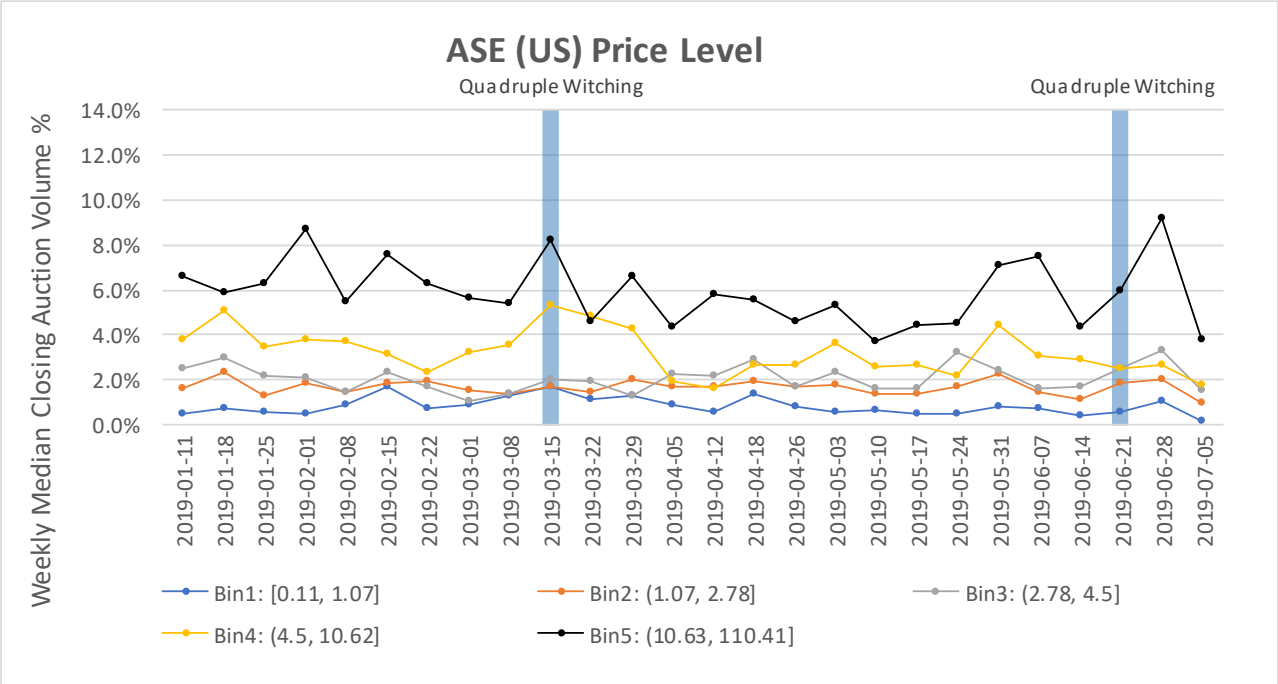
II. Weekly Median Closing Auction Volume % Binned by Price Level

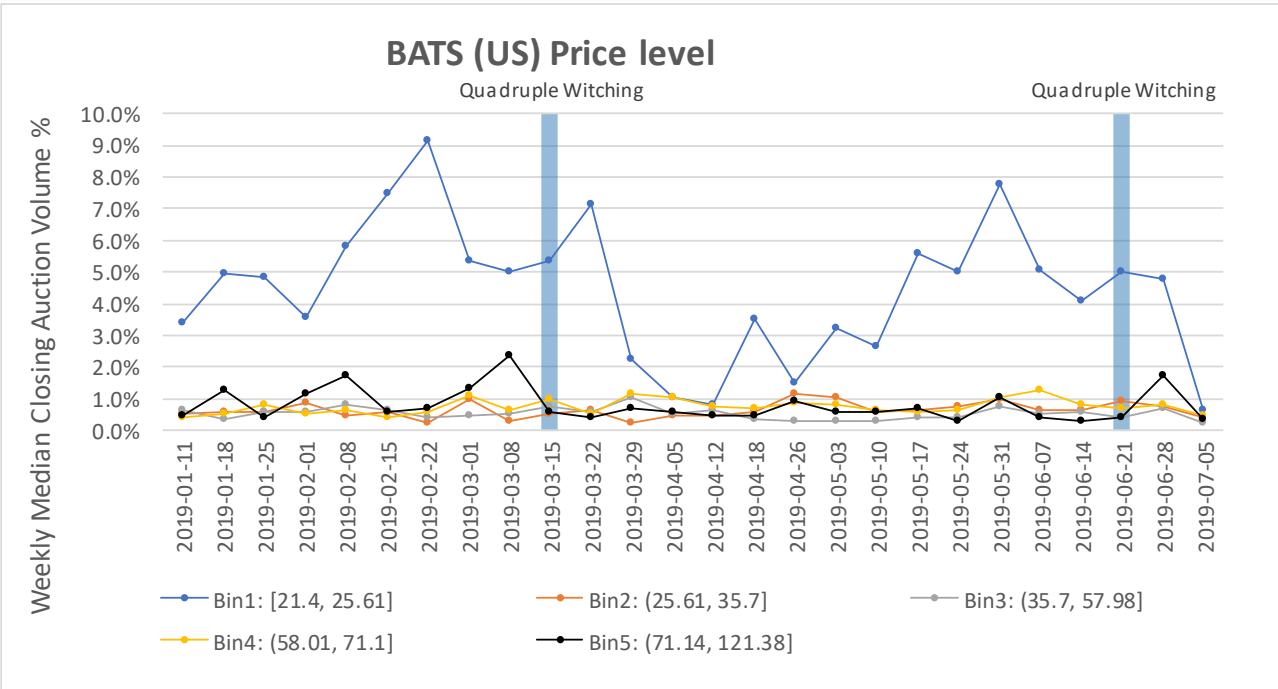


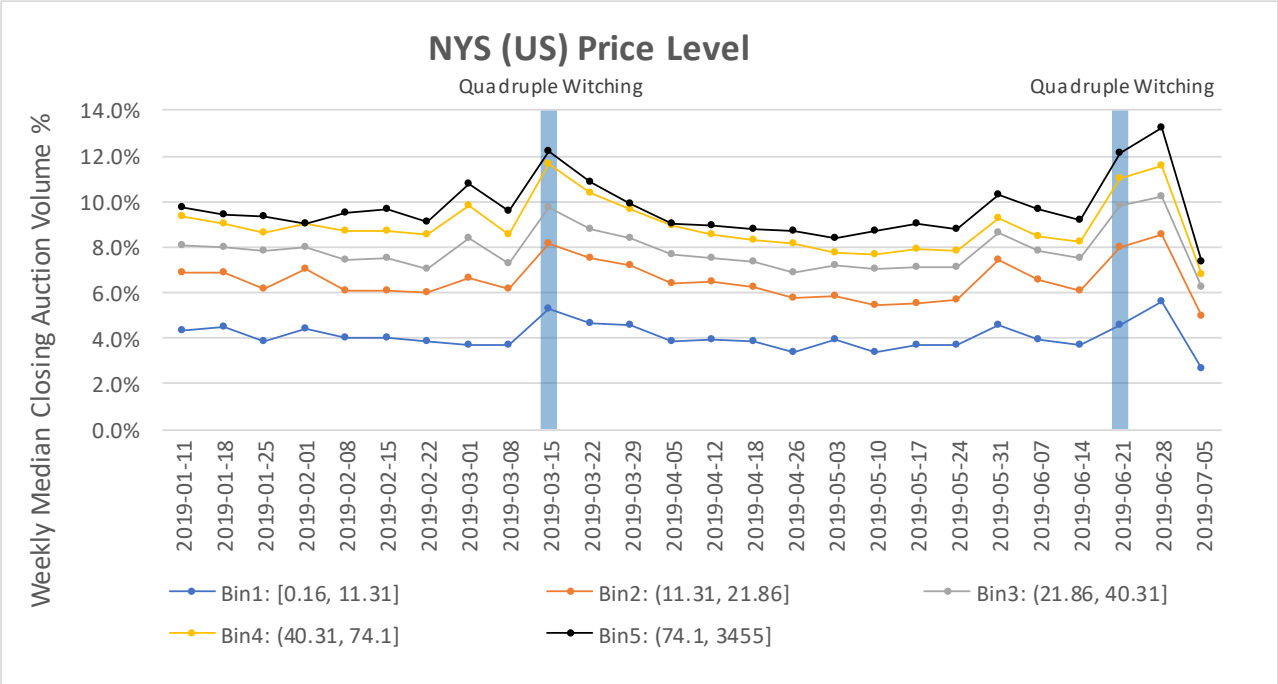


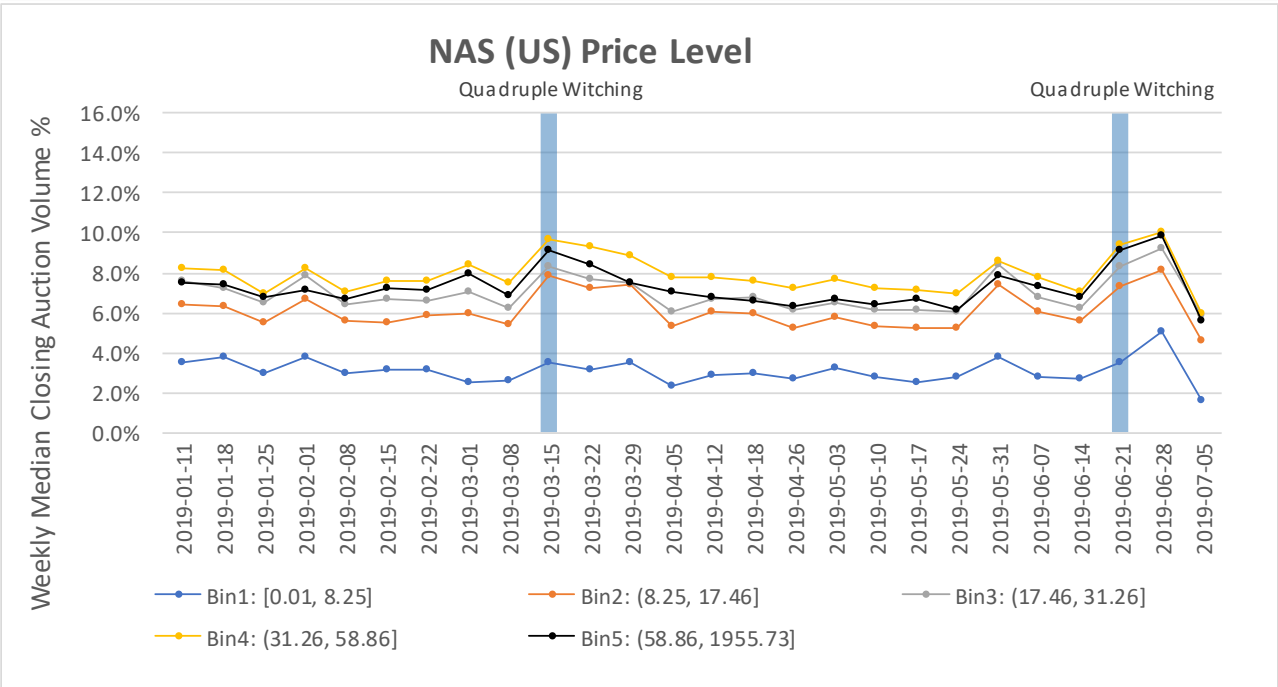




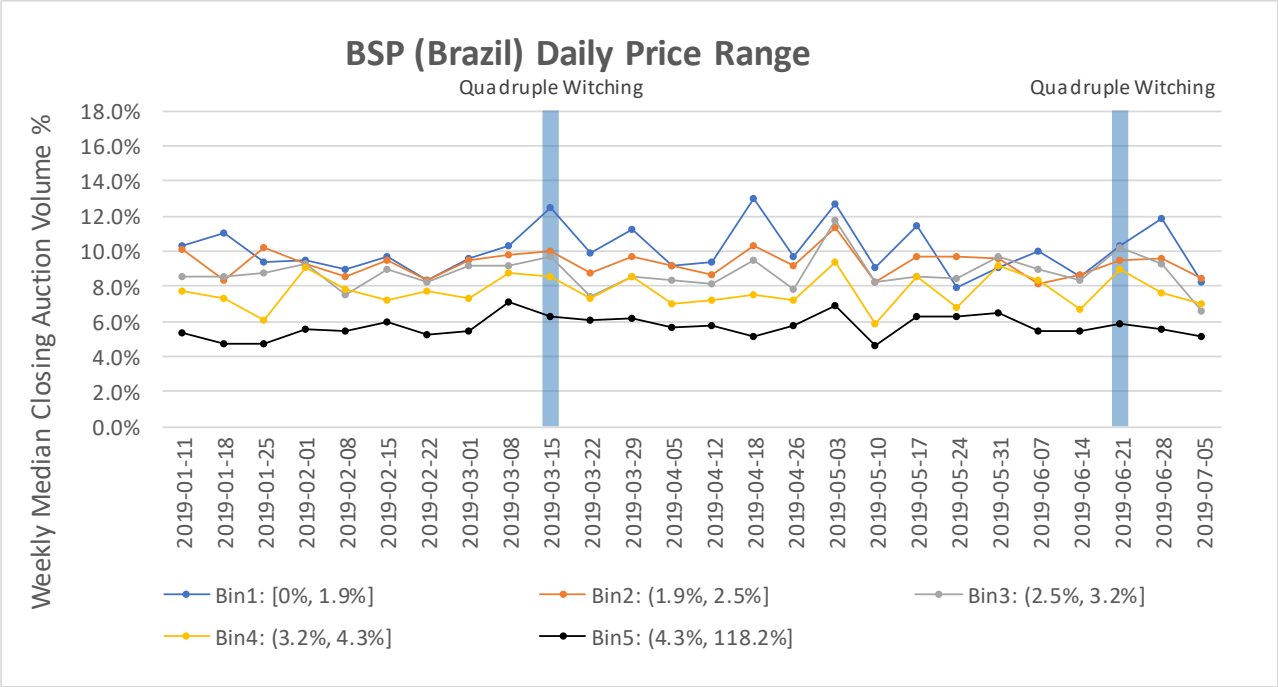


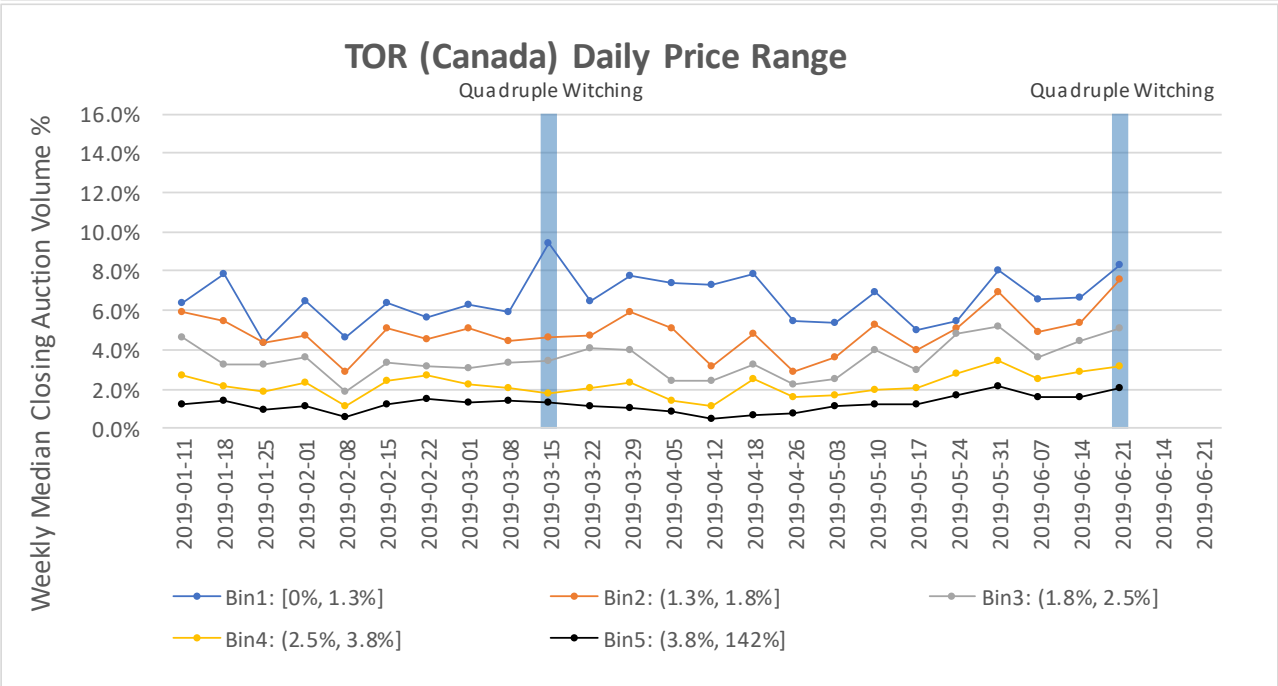


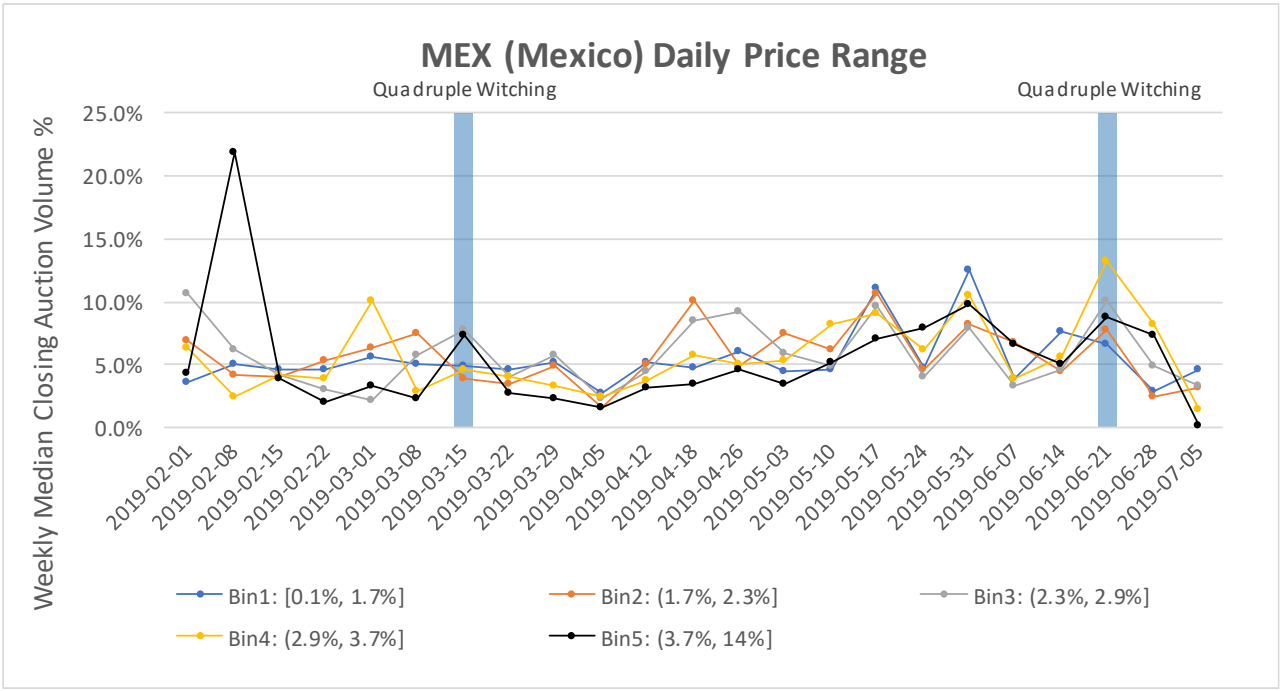


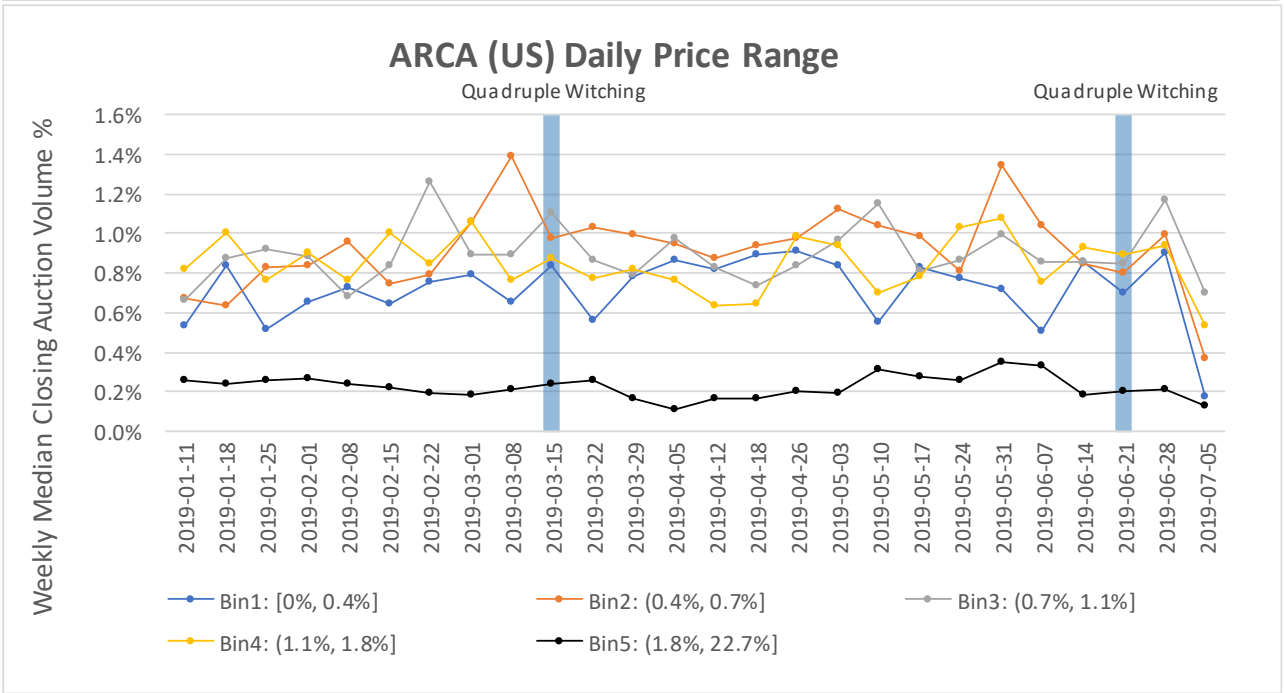


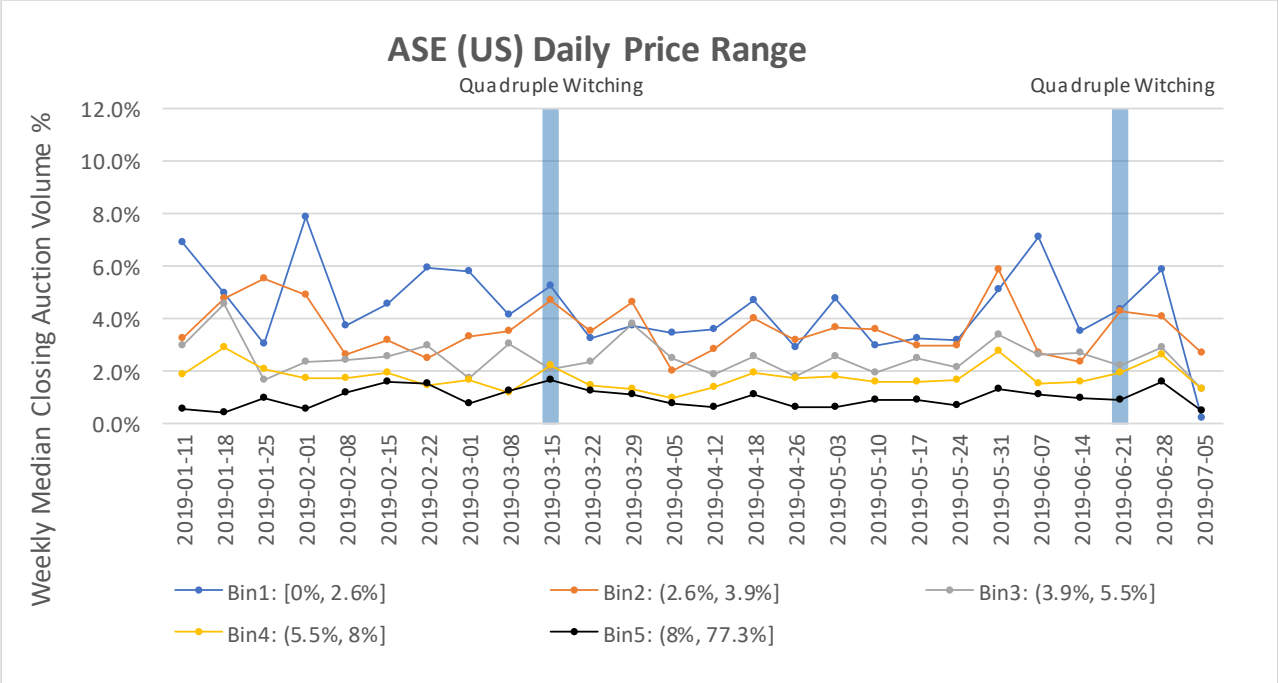
III. Weekly Median Closing Auction Volume % Binned by Daily Price Range

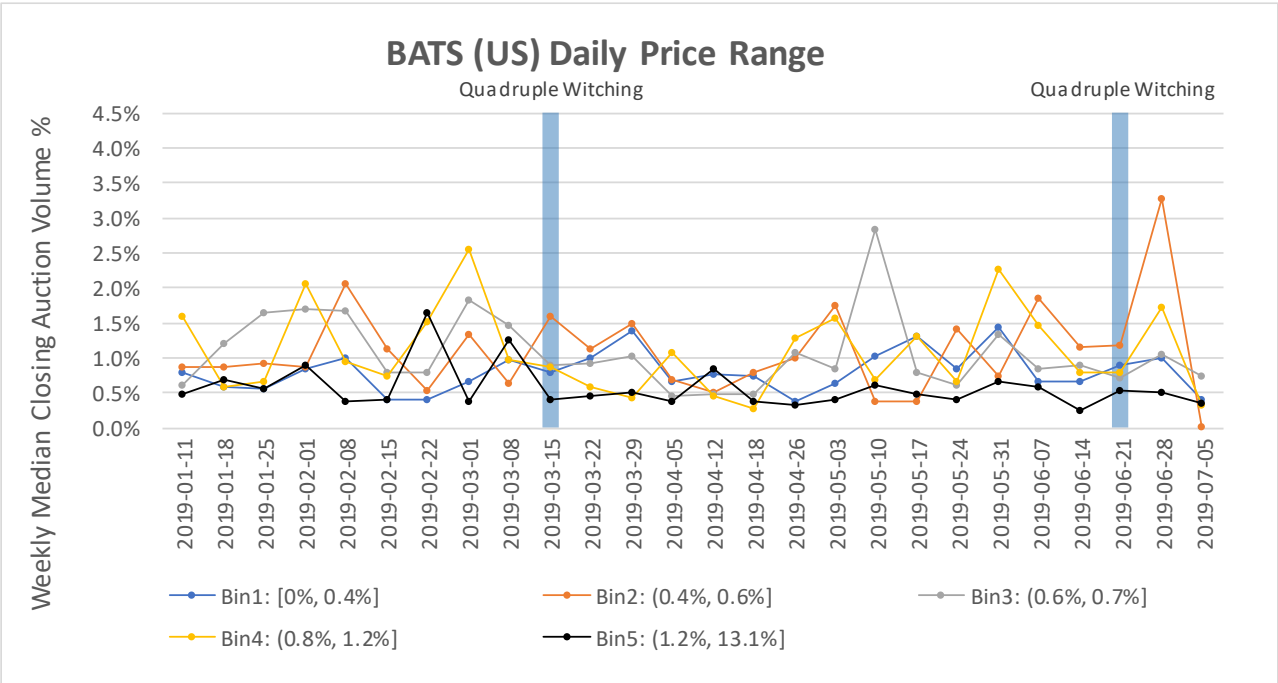


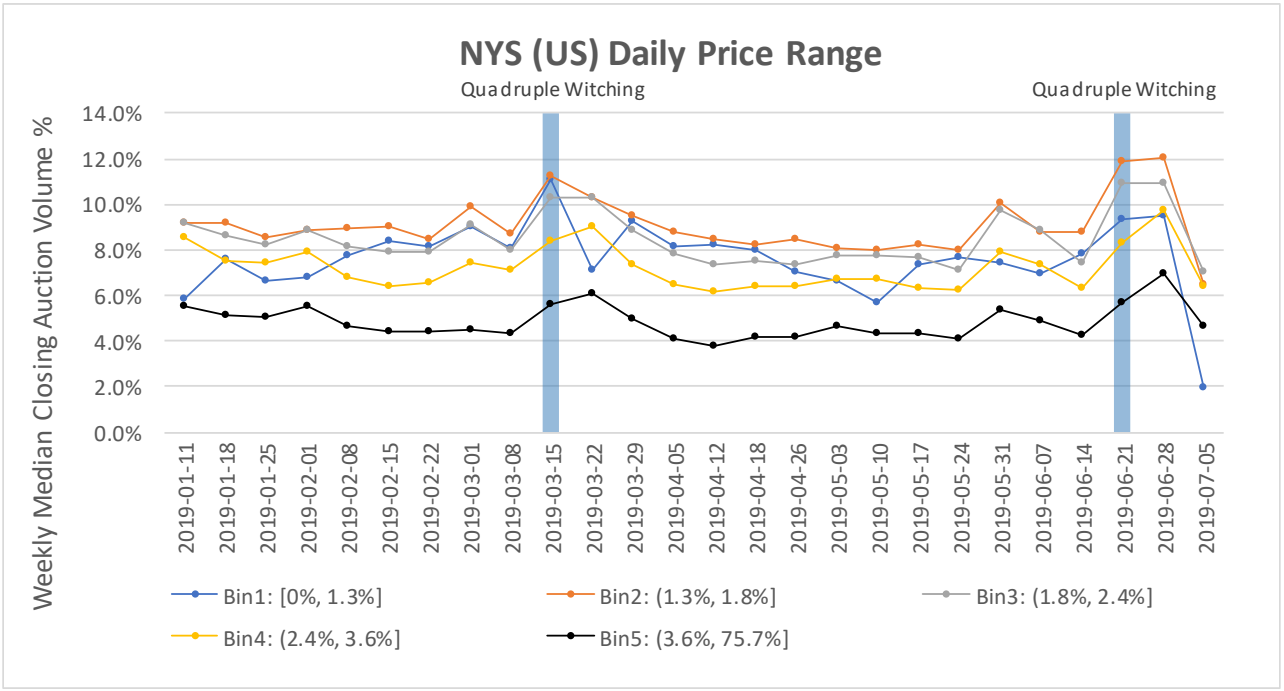


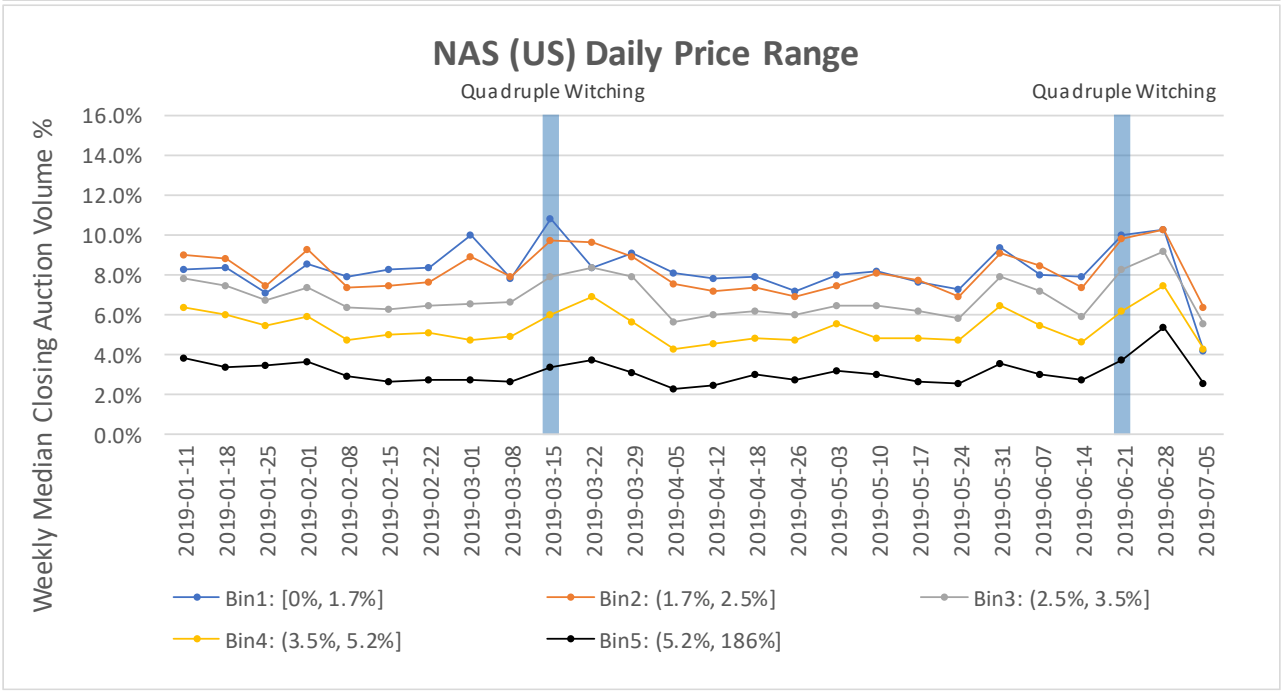




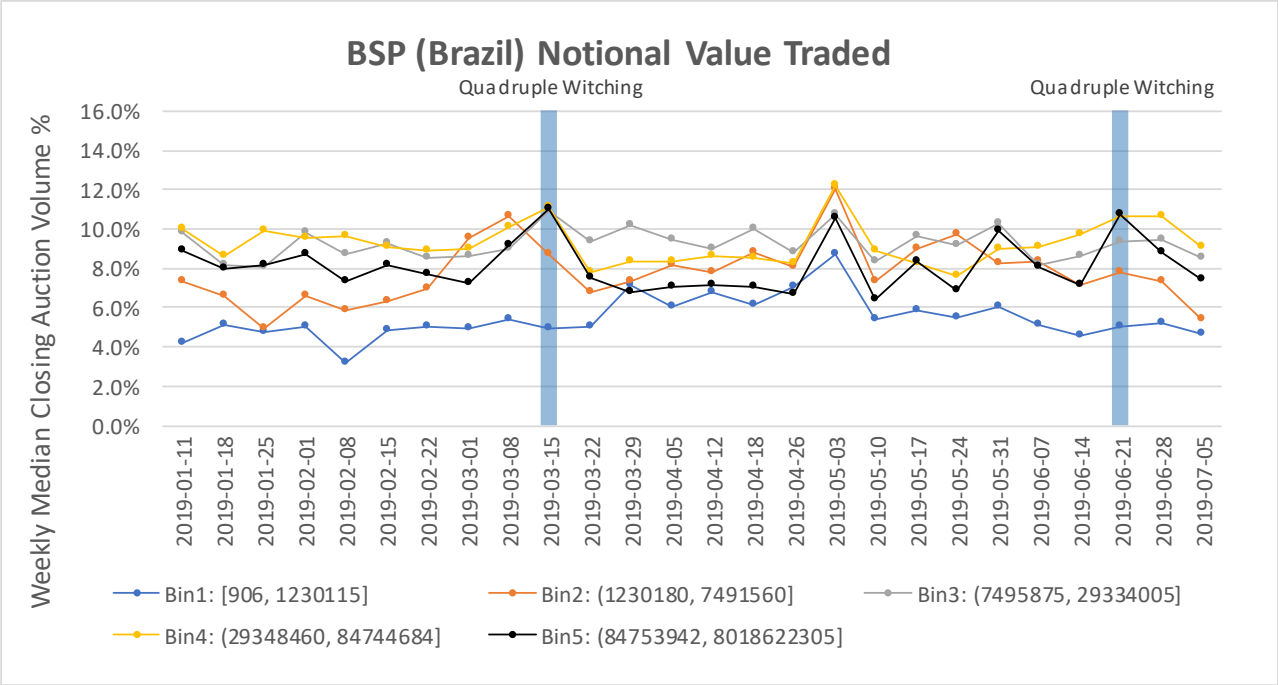


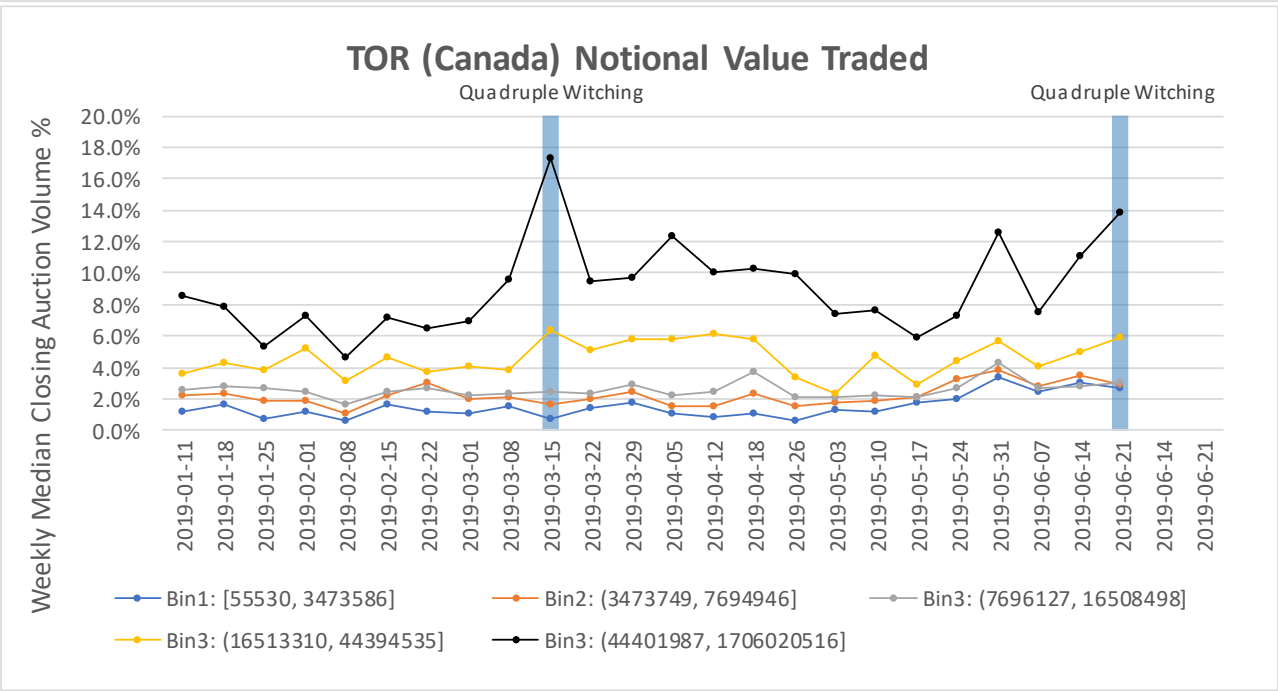


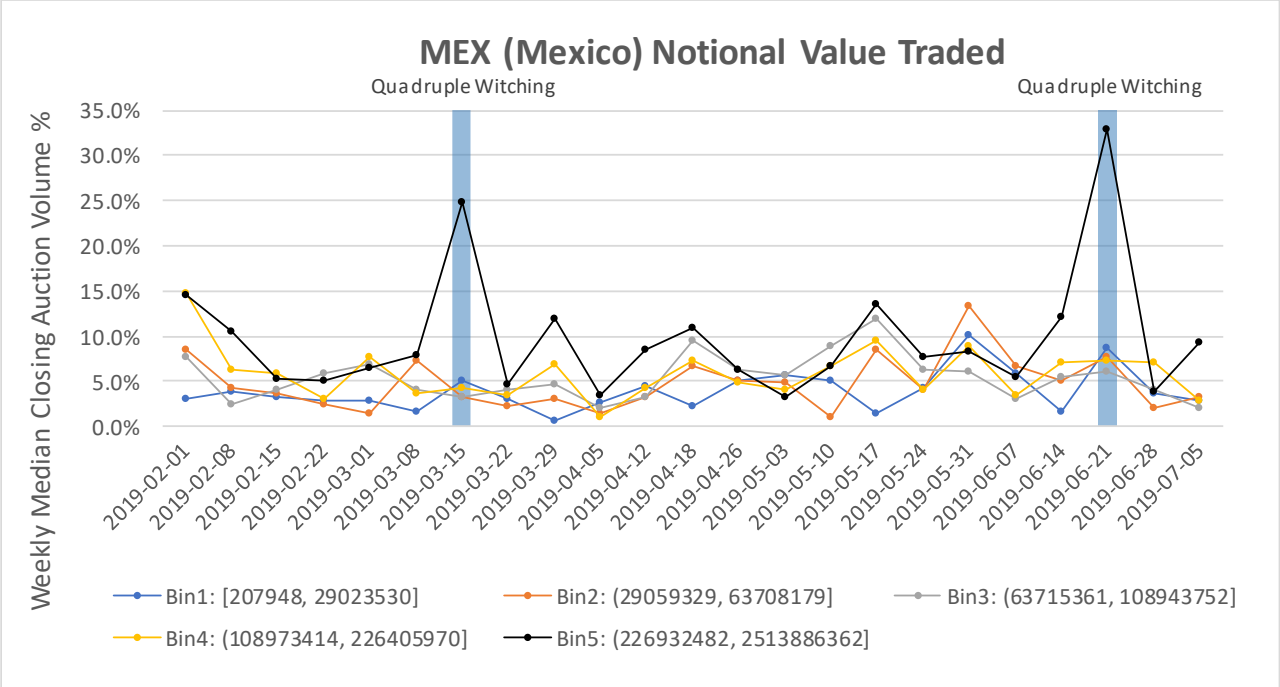


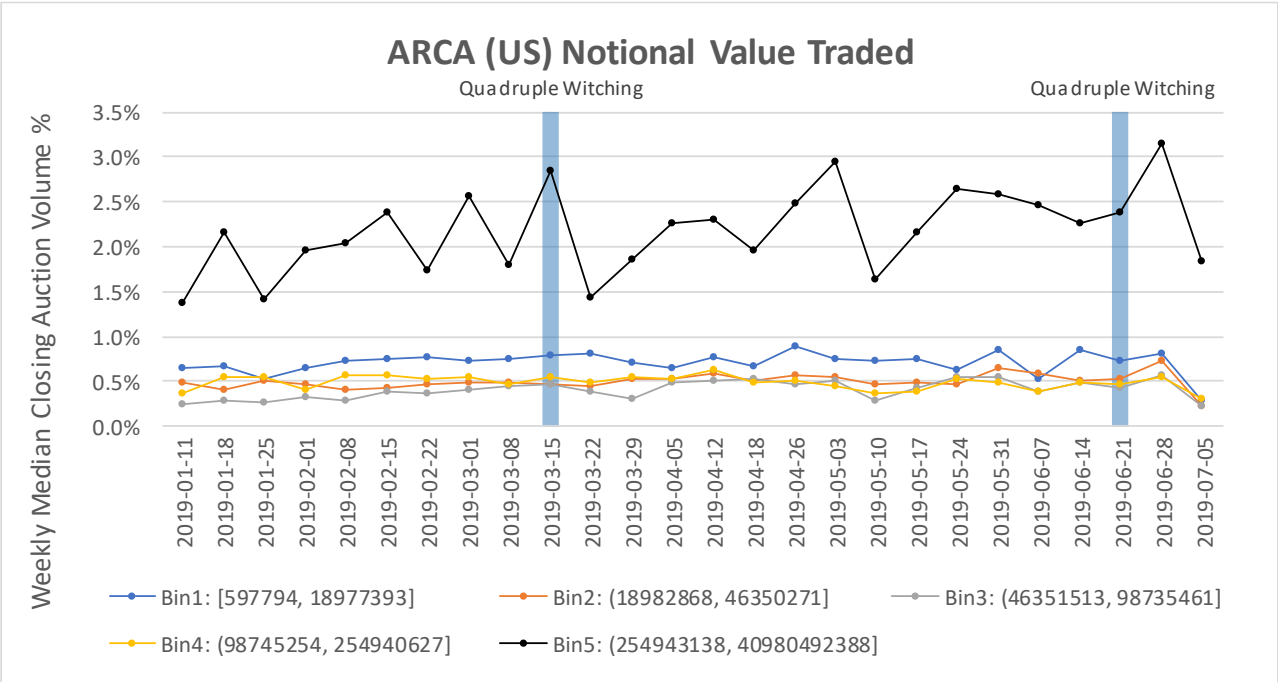


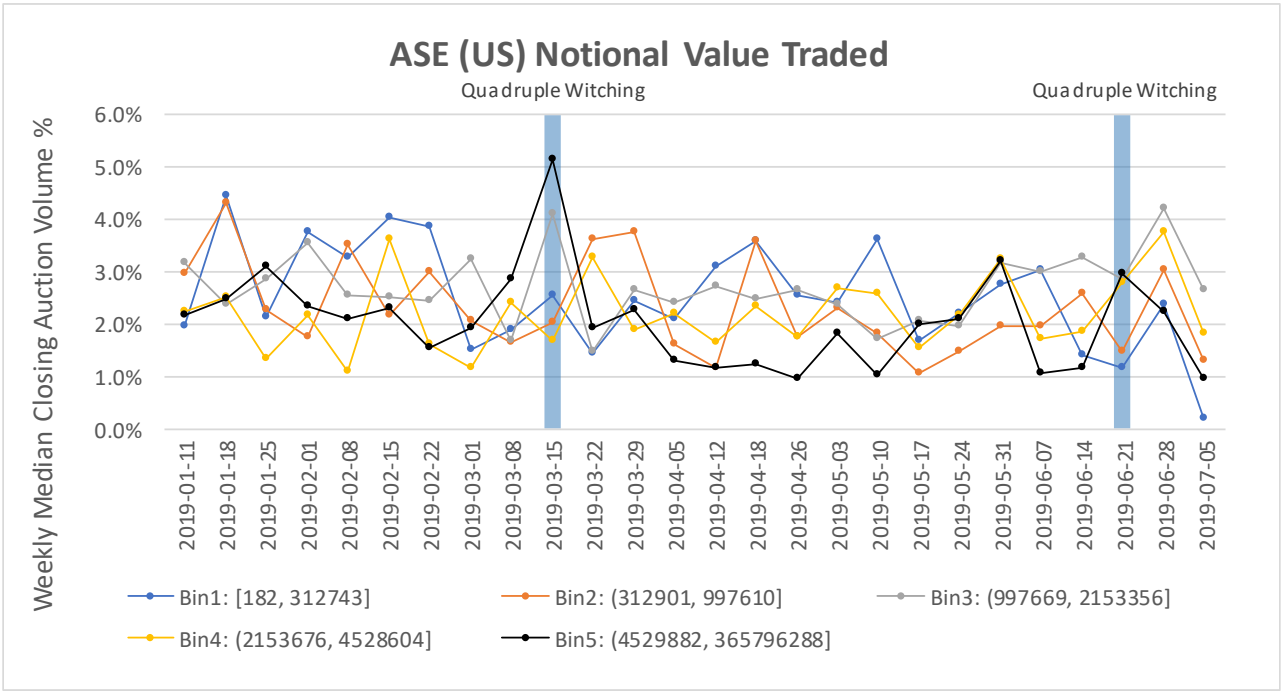
IV. Weekly Median Closing Auction Volume % Binned by Notional Value Traded

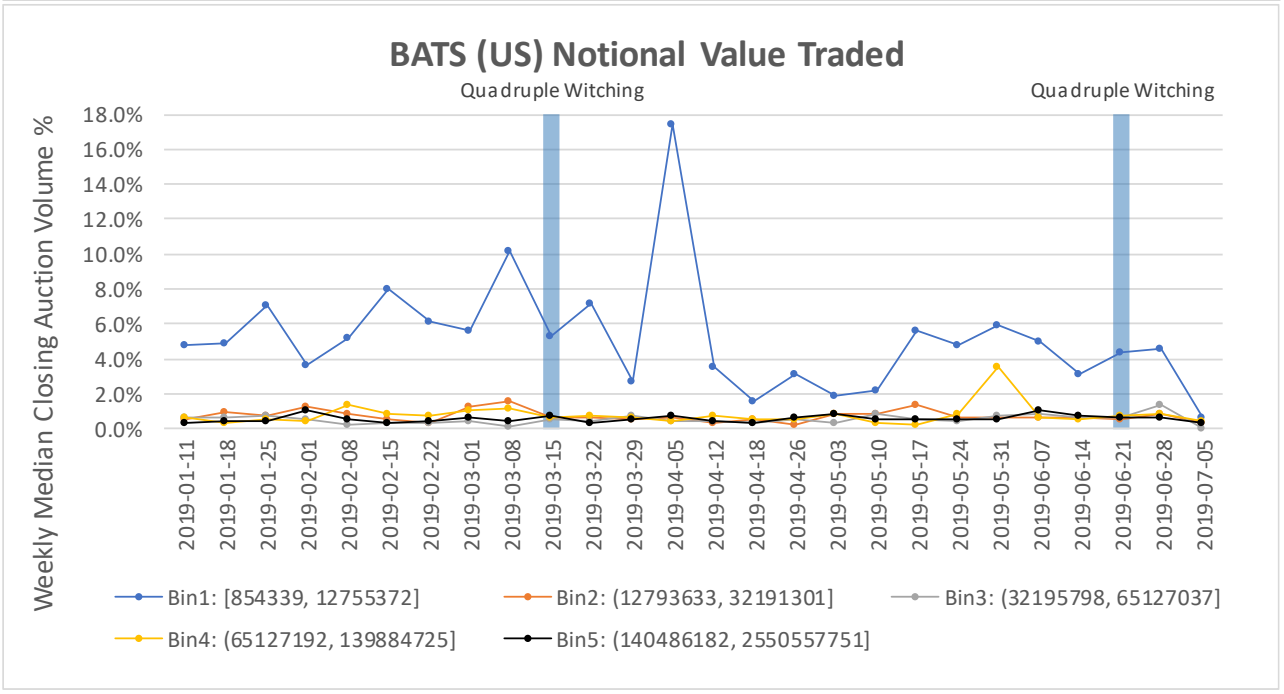


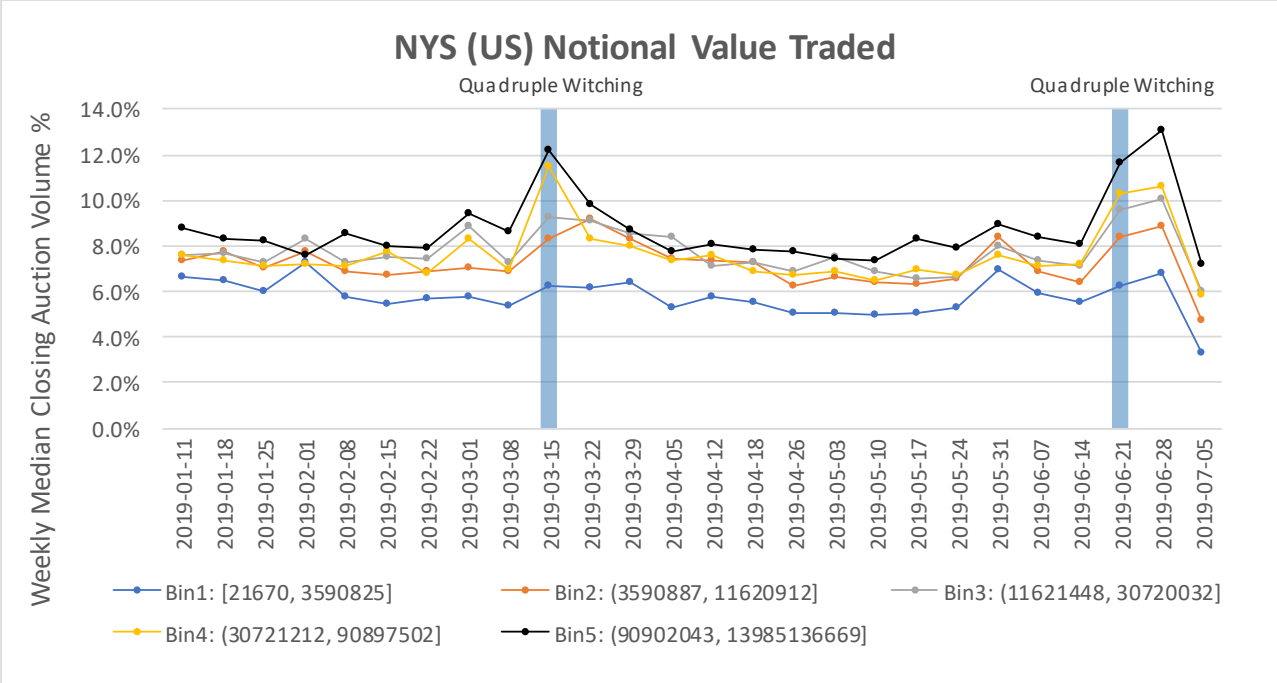


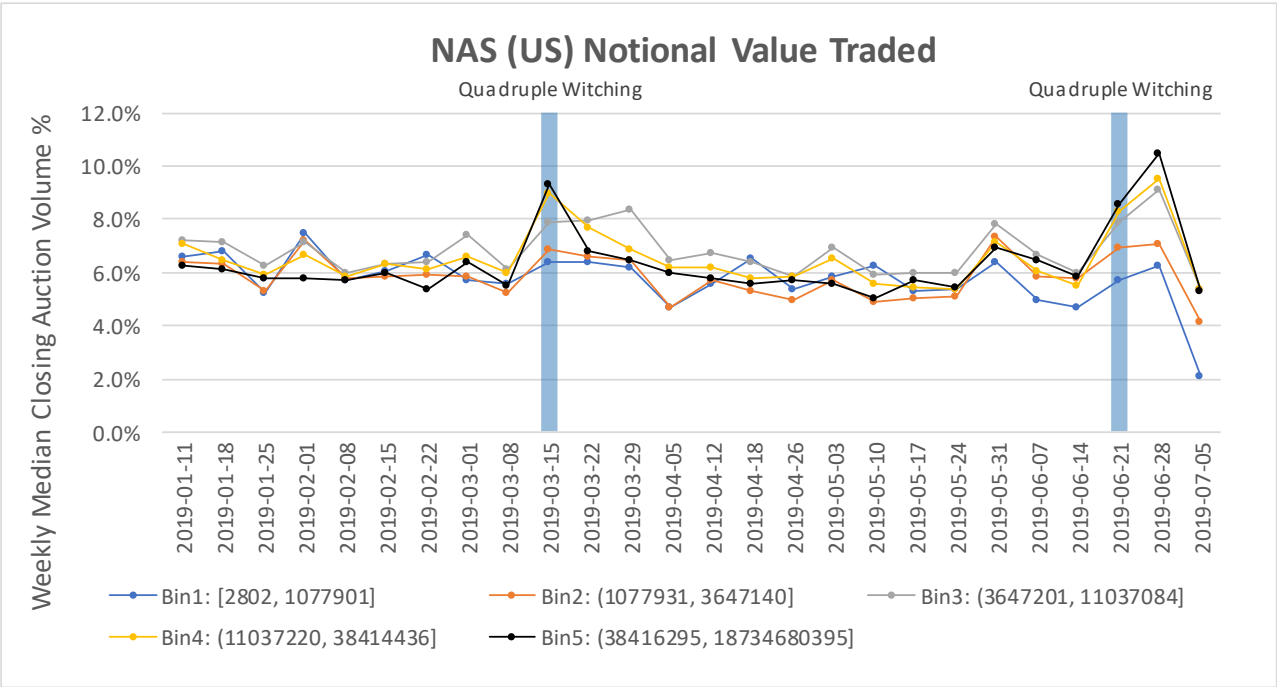












V. Weekly Median Closing Auction Volume % Binned by Average Trade Size