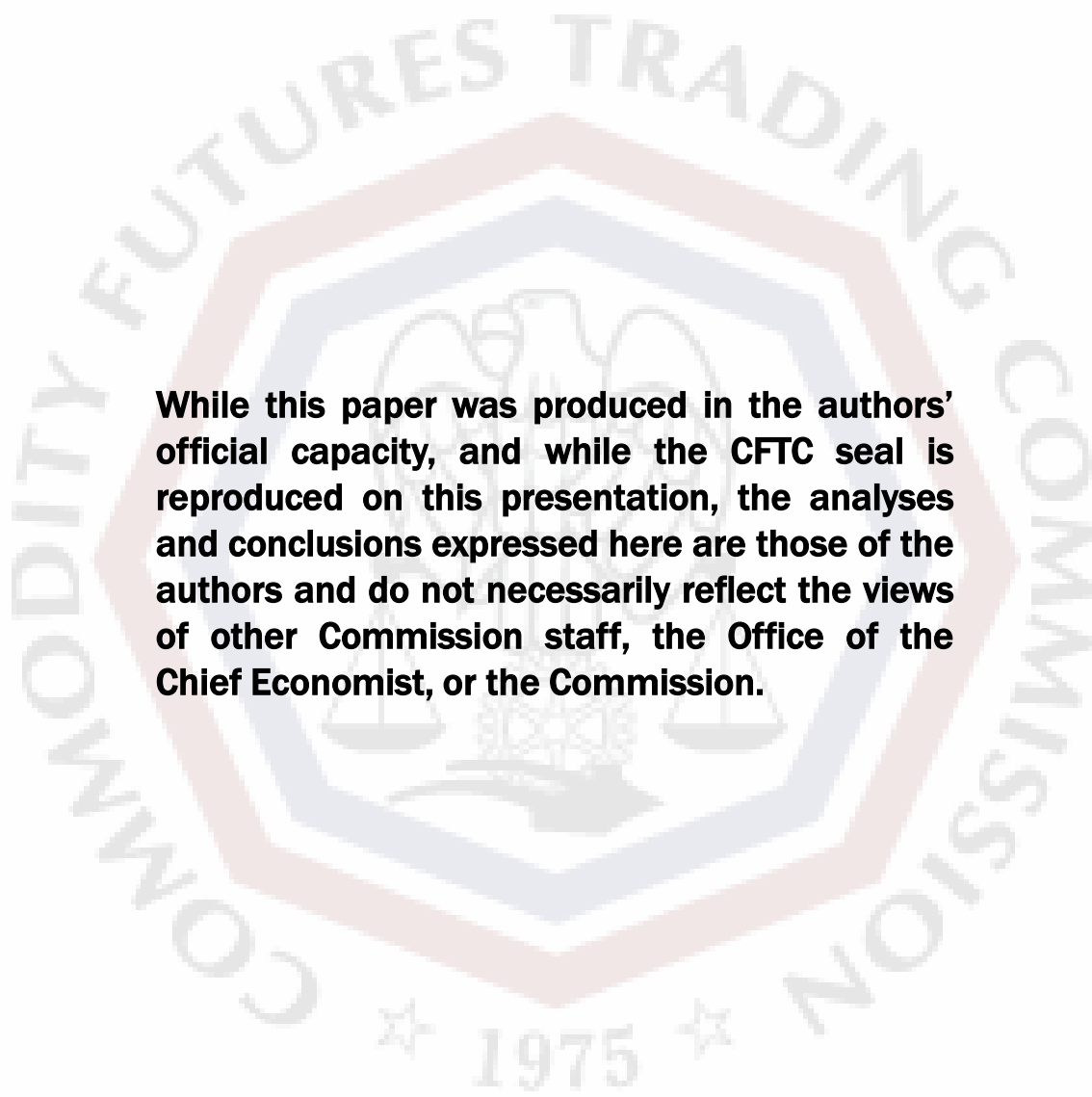# EFFECT OF MATCHING ALGORITHM CHANGES

MARCH 2019

DISCLAIMER

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BACKGROUND

- The 2Y Treasury contract is traded using a partial pro-rata matching algorithm.
  - This provides a mix of size and speed incentives

- Pro rata algorithms have often been used for very low-volatility contracts, to distribute trades across a larger set of liquidity providers

- For a few days in May of 2015, the 2Y Treasury contract unexpectedly defaulted to a pure FIFO algorithm, matching the other Treasury contracts' algorithms

- We analyze the effects by comparing changes in the 2 year contract with other Treasury activity

TWO YEAR MARKET - PRICES

May 12, FIFO
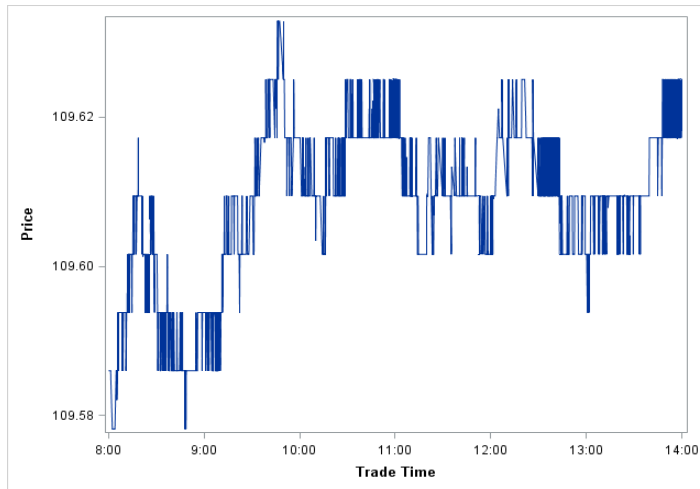
May 13, Pro Rata
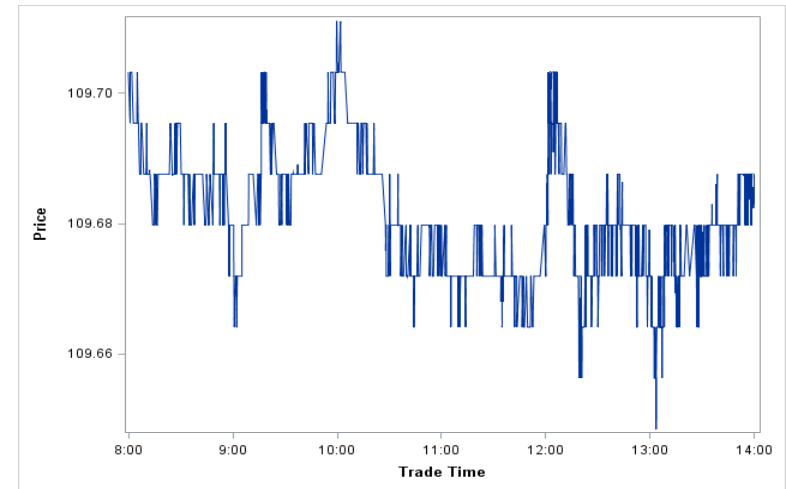
- During the active trading day, prices move very slowly, hitting only a few price points

- Pro Rata algorithms are designed to distribute orders at a given price point across a number of liquidity providers

- We will see that trade sizes on May 12 were much larger than May 13, because they did not get split up

HYPOTHESES – MOVE TO FIFO

- Trades
  - Average trade size will increase, because aggressive orders are not broken up into pieces
  - The average number of trades will go down, for the same reason
  - Passive order fill ratios will increase

- Orders
  - Firms will decrease the frequency of partial cancellations, because they no longer have to "upsize" their quotes
  - Firms will generally reduce passive order sizes for a similar reason
  - Liquidity provision is more concentrated, because trades are not broken up across orders
  - Firms will accumulate lower inventory, because they won't get "over-filled"

HYPOTHESES

- Trades
  - Average trade size will increase, because aggressive orders are not broken up into pieces (Yes)
  - The average number of trades will go down, for the same reason (Yes)
  - Passive order fill ratios will increase (Yes, especially for largest orders)

- Orders
  - Firms will decrease the level of modifications and cancellations, because they no longer have to "upsize" their quotes (Generally no)
  - Firms will generally reduce passive order sizes for a similar reason (Yes, but mostly just for the largest orders)
  - Liquidity provision is more concentrated, because trades are not broken up across orders (Very slight change)
  - Firms will accumulate lower inventory, because they won't get "over-filled" (No)

TRADE ACTIVITY OVERVIEW – LARGE CHANGE

Trade Count

Average Trade Size
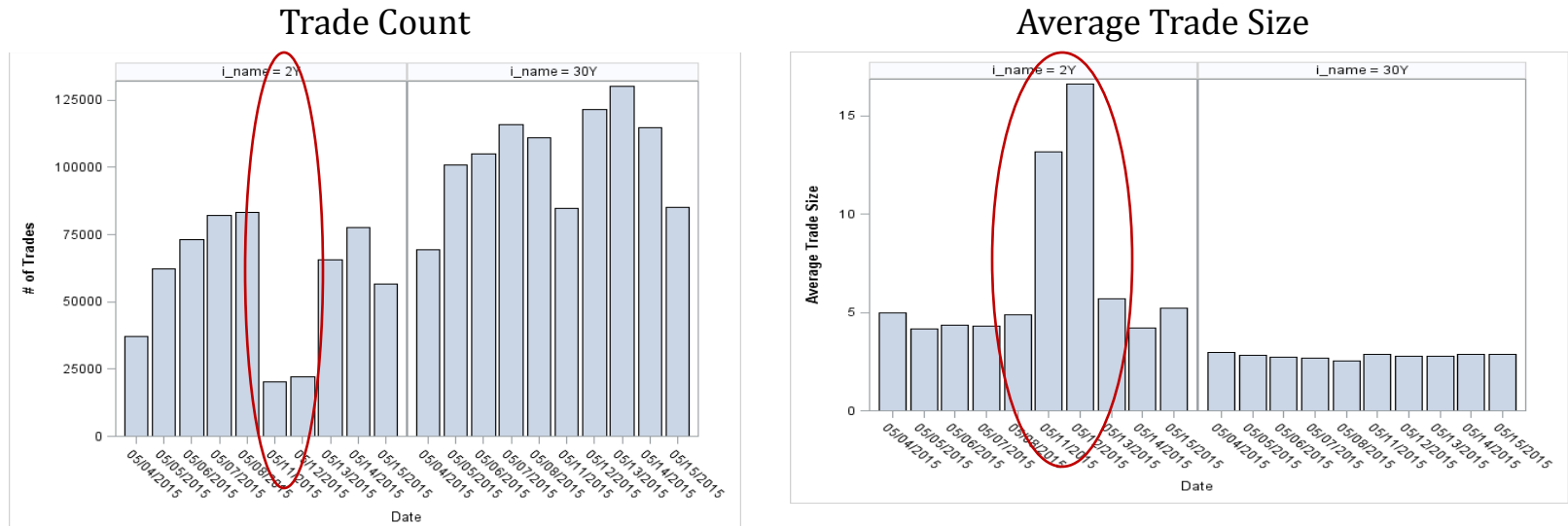
- The characteristics of trading during the FIFO regime are completely changed – the 30Y control saw little if any difference

- Trade sizes almost triple, the number of trades plummets, order to trade ratios increase, etc

- This is EXACTLY aligned with expectations, since in FIFO, individuals don't get broken up – they fill against a full individual order

# FILL RATIOS FOR LARGE PASSIVE ORDERS: LARGE CHANGE
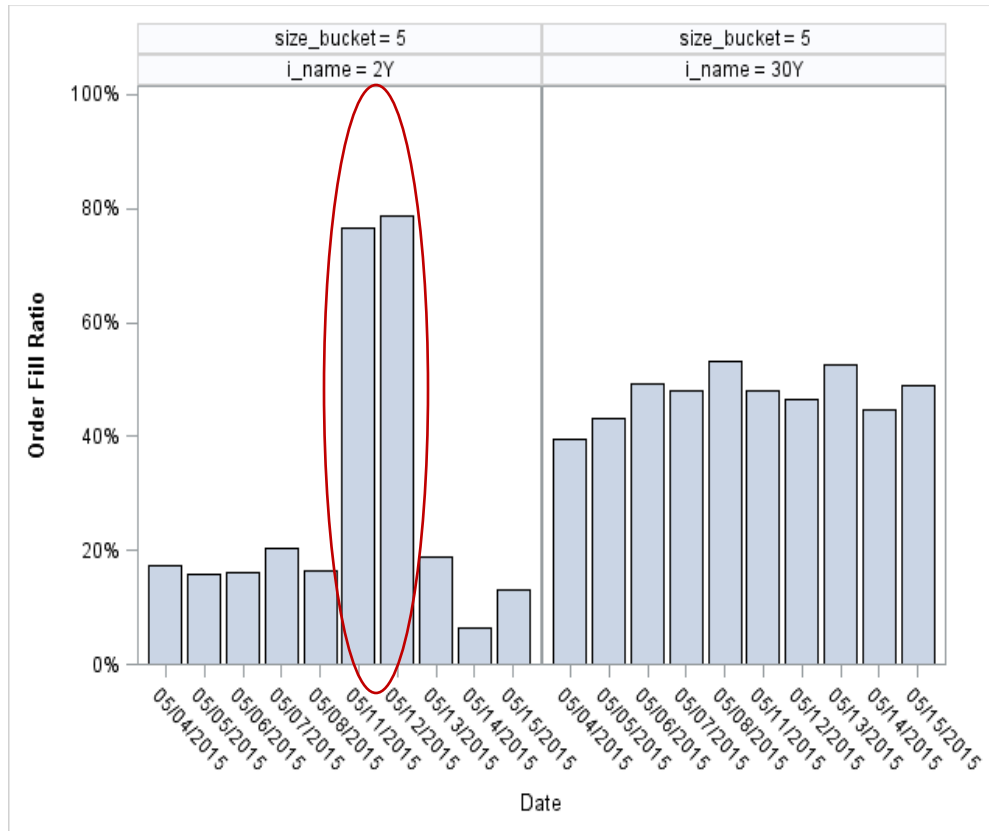
- The chart shows fill ratios, in the 2Y and 30Y contracts, for passive orders of at least 100 contracts

- Fill ratios dramatically increase over the two days, because aggressive orders fill the first order in line before the next one. However, more passive orders see no fills

- Fill ratios for aggressive orders barely change over the days (not shown)

ORDER ACTIVITY OVERVIEW – LITTLE CHANGE

- There does not appear to be any major change in new order submissions or modifications – note that Mondays generally seem less active

- Firms do not appear to be adjusting the types of their orders because of the change to the new matching algorithm – we show the distribution of order types in the new slide

- This contrasts with the change in trade frequency, which dropped significantly over the two days

New Order Count
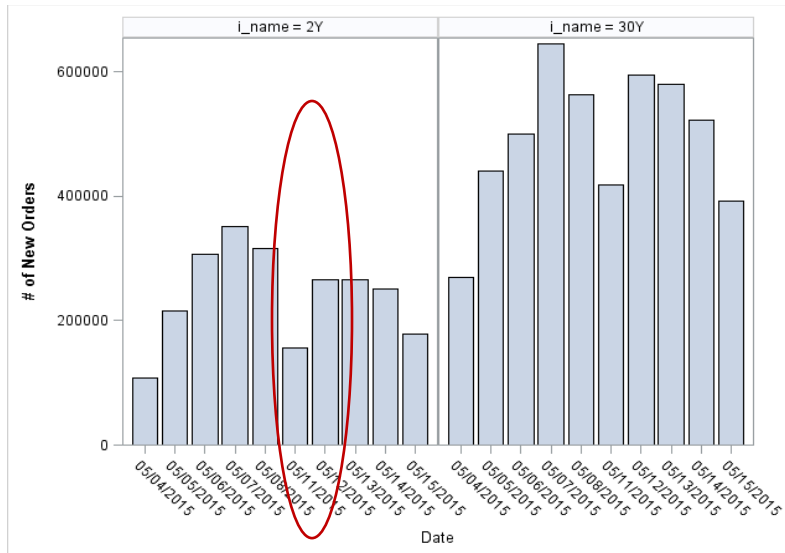
Modifications Count
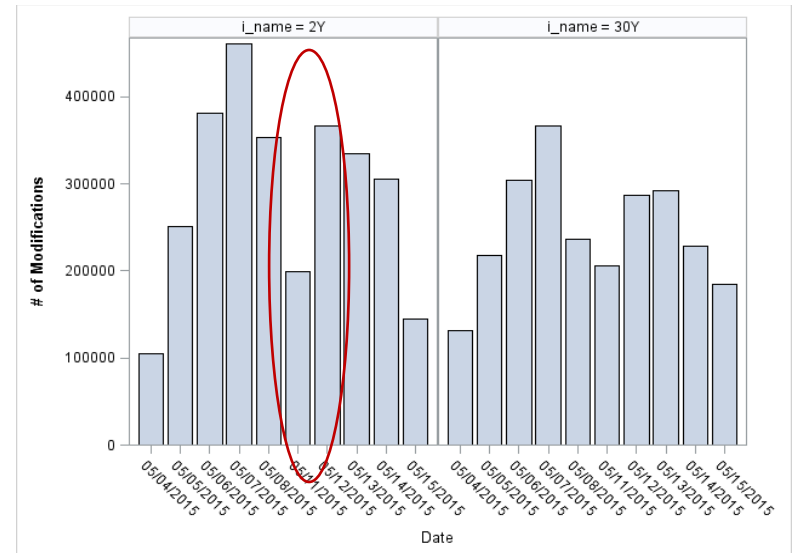
DISTRIBUTION OF ORDER TYPES – LITTLE CHANGE

- The chart shows a breakdown of all messages into:
  - New (Green)
  - Modifications (Red)
  - Cancellations (Blue)
  - and Trades (Brown)

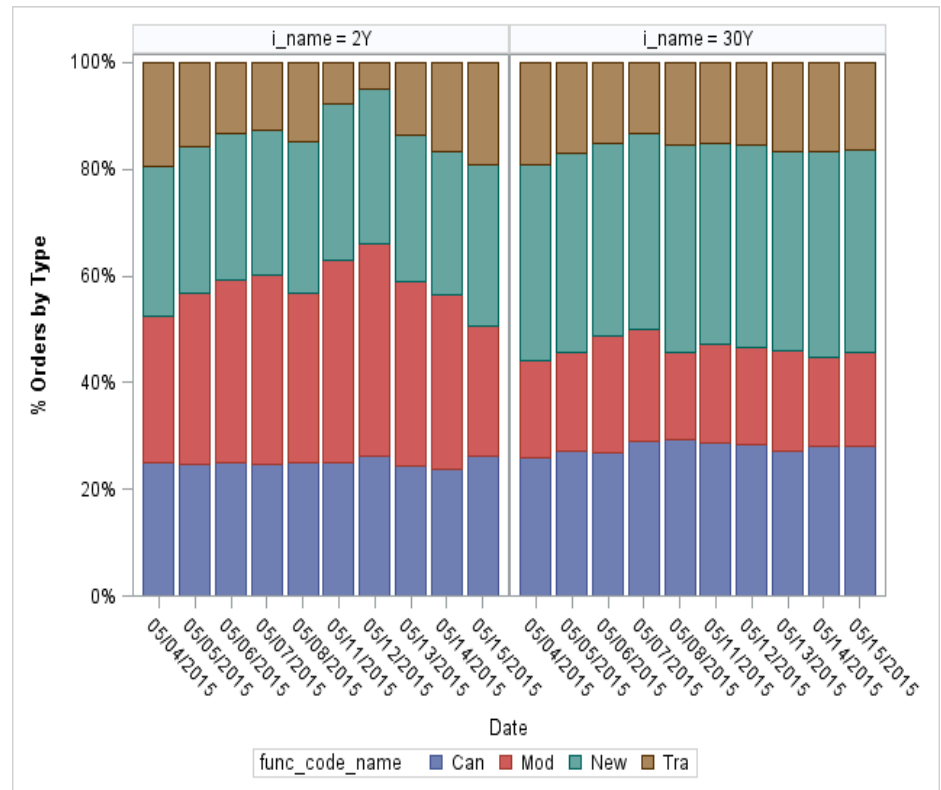- There does not seem to be any major change in behavior on the 11th and 12th – except for a much smaller number of trades (as noted before)

- So, as a group, firms do not appear to be changing their overall message strategy

DISTRIBUTIONS: PASSIVE ORDER SIZES

		Passive Order Quantity				
Instrument	Date	N Obs	Mean	75th Pctl	90th Pctl	95th Pctl
30 Year	5/4/2015	142,214	5	6	11	17
	5/5/2015	235,908	4	4	10	15
	5/6/2015	210,297	4	5	10	15
	5/7/2015	223,175	4	5	10	15
	5/8/2015	231,250	5	5	11	17
	5/11/2015	208,693	5	5	11	17
	5/12/2015	251,512	5	6	12	18
	5/13/2015	314,713	5	5	12	17
	5/14/2015	265,054	5	6	10	17
	5/15/2015	200,573	5	6	10	17
2 Year	5/4/2015	54,394	114	48	130	300
	5/5/2015	109,851	64	30	100	190
	5/6/2015	145,214	60	30	91	179
	5/7/2015	120,121	41	40	88	150
	5/8/2015	106,793	84	40	100	200
	5/11/2015	65,274	37	38	80	115
	5/12/2015	100,990	35	30	80	105
	5/13/2015	128,626	65	58	130	300
	5/14/2015	133,537	171	56	225	1111
	5/15/2015	81,093	76	52	130	300

- The table summarizes the distribution of new passive order sizes, by instrument and date

- Though average passive order size does not change much over the period, orders of very high quantity become rarer when the algorithm changes; the switch from pro rata to FIFO removes size priority
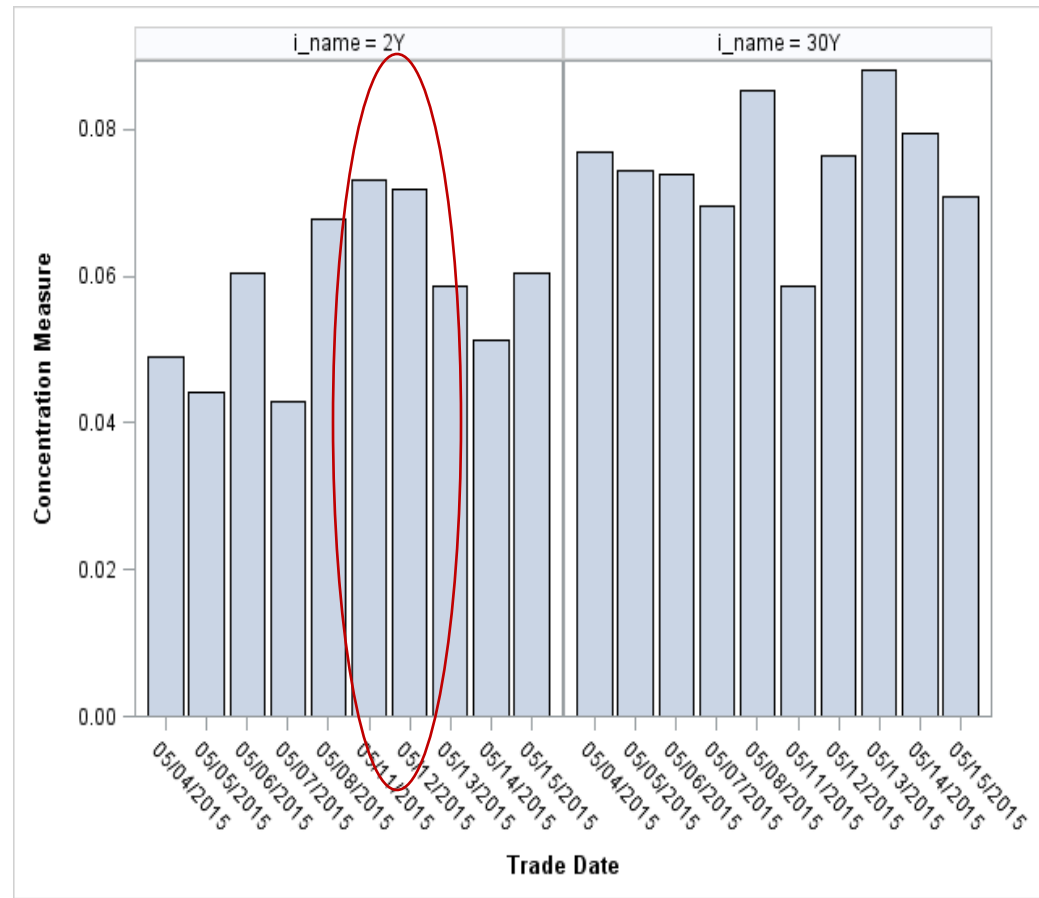
DISTRIBUTIONS:
ORDER BOOK DEPTH

| Instrument	Date	N Obs	Top of Book Depth						
			1st Pctl	5th Pctl	10th Pctl	Median	90th Pctl	95th Pctl	99th Pctl
30 Year	5/4/2015	21,601	135	169	184	258	367	415	554
	5/5/2015	21,601	102	126	139	197	308	350	437
	5/6/2015	21,601	110	133	145	198	303	360	554
	5/7/2015	21,601	95	116	128	175	261	295	392
	5/8/2015	21,601	80	100	111	159	233	265	379
	5/11/2015	21,601	122	144	157	216	350	421	629
	5/12/2015	21,601	103	124	136	195	300	348	468
	5/13/2015	21,601	81	109	121	169	260	301	390
	5/14/2015	21,601	101	130	144	206	308	352	449
	5/15/2015	21,601	90	154	174	257	409	467	684
2 Year	5/4/2015	21,601	4,798	5,498	5,892	9,308	15,668	18,527	34,903
	5/5/2015	21,601	2,712	3,664	4,066	7,281	12,584	14,092	22,310
	5/6/2015	21,601	3,812	4,477	4,817	6,494	12,603	14,767	26,542
	5/7/2015	21,601	3,447	3,835	4,106	5,573	9,700	11,906	17,290
	5/8/2015	21,601	2,721	3,172	3,512	5,885	10,469	22,973	75,720
	5/11/2015	21,601	5,674	6,258	6,696	8,145	9,717	10,347	11,625
	5/12/2015	21,601	4,244	5,210	5,740	7,191	9,515	10,739	13,011
	5/13/2015	21,601	2,709	3,252	3,563	5,882	9,616	11,963	25,289
	5/14/2015	21,601	3,501	4,378	4,684	7,005	19,349	41,245	85,423
	5/15/2015	21,601	3,415	4,227	4,872	6,563	9,610	12,500	26,175

- Because orders at the back of the queue get similar preference to those near the top, depth peaks at much higher levels for pro-rata markets

- In addition, minimum depth levels are lower for pro rata markets, leading to a much higher variance in top-of-book depth than the FIFO equivalent

LIQUIDITY PROVISION CONCENTRATION

- The chart summarizes the concentration of liquidity provision over the two weeks in the two contracts

- Concentration increases very slightly in the 2Y contract on the two days, but concentration is almost always lower than that for the 30Y contract

- Generally, concentration levels are low across all days and contracts, indicating there is a wide variety of market makers

DISTRIBUTIONAL EFFECTS (30 SEC WINDOW)
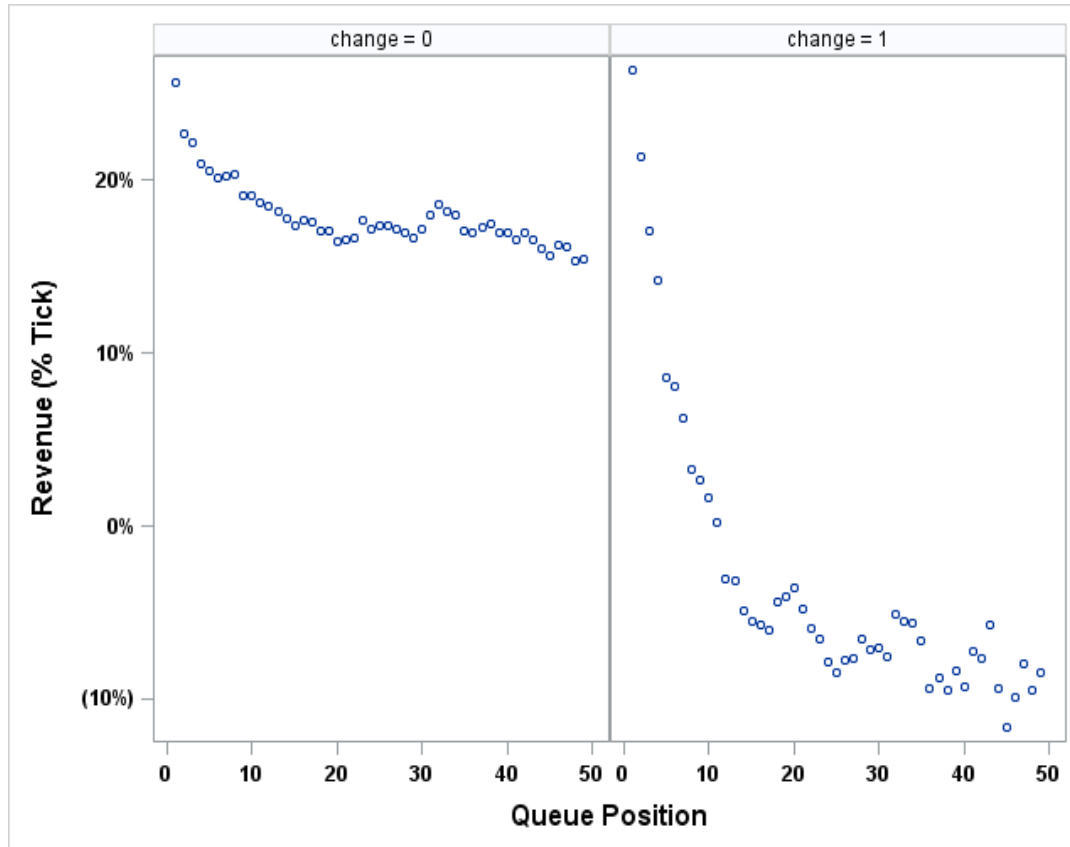
- The FIFO algorithm prioritizes speed, so higher trade revenue should be awarded to the top of the queue

- Pro rata allocations should be much flatter

- This is what we see when we compare the "traditional" 2 Year algorithm to the change

DISTRIBUTIONAL EFFECTS - REGRESSION

Passive Trade Revenue		
	Coefficient	**Pr > |t|**
Intercept	0.230***	<.0001
Orig Queue Position	-0.0127***	<.0001
Two Year (B)	0.096***	<.0001
PositionxTwo	0.0085***	<.0001
PositionxTwoxChange	-0.011***	<.0001

PRICE EFFICIENCY TESTS

Reversal Probability		
	Coefficient	P Value
Intercept	0.3142***	<.0001
Two Year (B)	0.534***	<.0001
Algo Change (B)	-0.0335*	0.0383
Volume Since Price Change	-0.00318***	<.0001
Time since Price Change	-6e-7	0.7847
TwoxAlgo Change	-0.1087*	0.0457
TwoxVolume	0.00221***	<.0001
TwoxTime	6e-6*	0.0488

- Because the 2 year experiences little volatility, price changes usually reverse (bid-ask bounce)

- During the period of the algorithm change, price reversals are less common

- This may be due to reduced order book depth which acted as volatility buffer

CONCLUSION

- The algorithm change did have an effect on order and trade metrics for the 2 year contract

- In addition, the algorithm change appeared to potentially have more "economic" effects
  - Some change in revenue distributions
  - Some change to "price efficiency" metrics