Report

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Data Prep

Sudden Changes

In *suddenchanges.R* script, I prepared the data of sudden changes. I followed the following steps:

1. Used union of timestamps from 3 data set and joined these 3 datasets.
2. Filled missing price values with linear interpolation over time
3. Calculated changes in bid and ask prices for futures and spot market with log difference and multiplied with 10000 to convert them to bps. If passed time since the last observation is greater than 10ms, the price differences are entered 0.
4. To make calculation faster, filtered only price changes greater than 1bps in absolute value
5. Calculated price changes in last 3ms by summing price changes in last 3ms with rolling windows.
6. Also calculated the total quantity in the last 10ms and saved them as quantity_rolled
7. If bid price change in last 3ms is less than -7 it is noted sudden_bid_change_(s or f dependent on market)
8. If ask price change in last 3ms is greater than 7 it is noted sudden_ask_change_(s or f dependent on market)
9. The points with a sudden changes have been saved at *suddenchanges.csv*

Returns after Sudden Changes

In *returns.R* script, I prepared the data of returns after sudden changes. I followed the following steps:

1. Followed step 1 and 2 from previous part. This time used mid-price for price changes in step 3.
2. To make computation faster, filtered the time stamps that have an observation in *suddenchanges.csv* at least 10ms prior.
3. Then calculated and saved maximum of cumulative sums of price changes in 10ms future window as well as minimum of cumulative sums. I had maximum and minimum returns after every sudden changes in all markets.
4. These future returns have been saved at *returns.csv*

Tables, Graphs and Regressions

Average Tables

In the table below, average maximum and minimum returns in 10ms for each market after sudden decreases in bid prices shown

Spot_Bid	Futures_Bid	avg_spot_max	avg_spot_min	avg_futures_max	avg_futures_min	cases
FALSE	TRUE	0.6840064	-3.838857	2.424338	-3.950596	7403
TRUE	FALSE	1.7114142	-2.943086	1.226507	-3.682265	5400
TRUE	TRUE	0.4171339	-7.901556	2.300838	-8.323545	1885

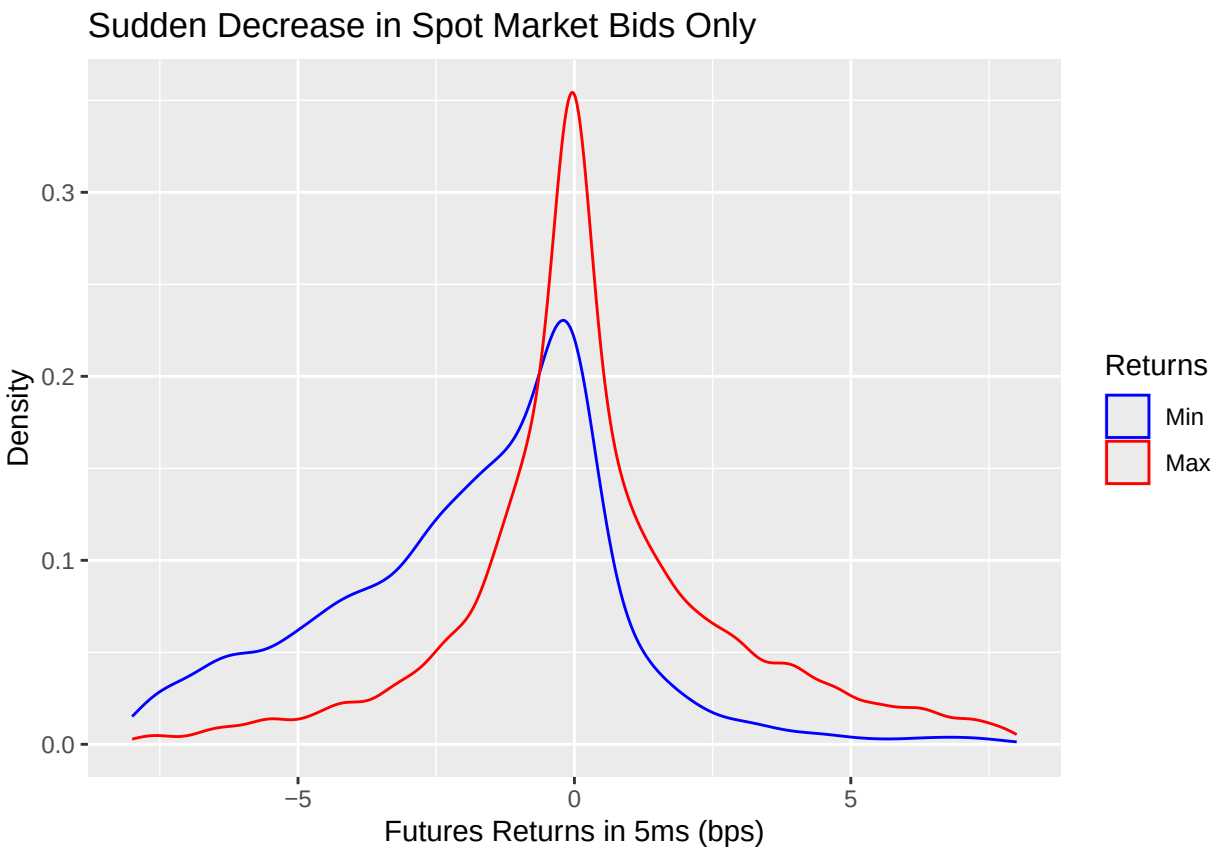
In the table below, average maximum and minimum returns in 10ms for each market after sudden increases in ask prices shown

Spot_Ask	Futures_Ask	avg_spot_max	avg_spot_min	avg_futures_max	avg_futures_min	cases
FALSE	TRUE	4.220765	-0.6434251	4.102672	-2.351666	7809
TRUE	FALSE	3.202586	-1.5877102	3.880864	-1.132732	5193
TRUE	TRUE	8.387630	-0.2150019	8.575969	-2.526959	2077

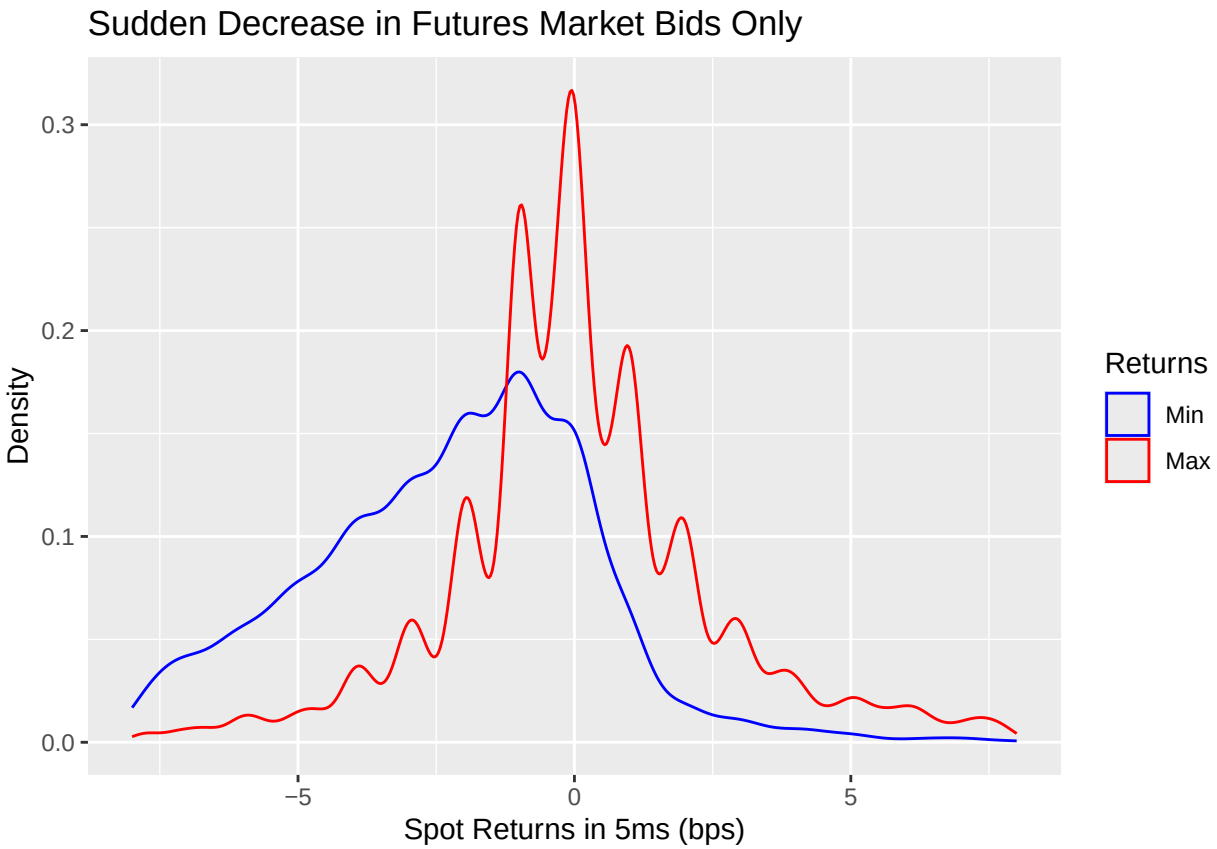
For the rest of the analysis, I will focus on the sudden changes when they happen in one market only.

Density Graphs

Sudden Bid Price Decreases



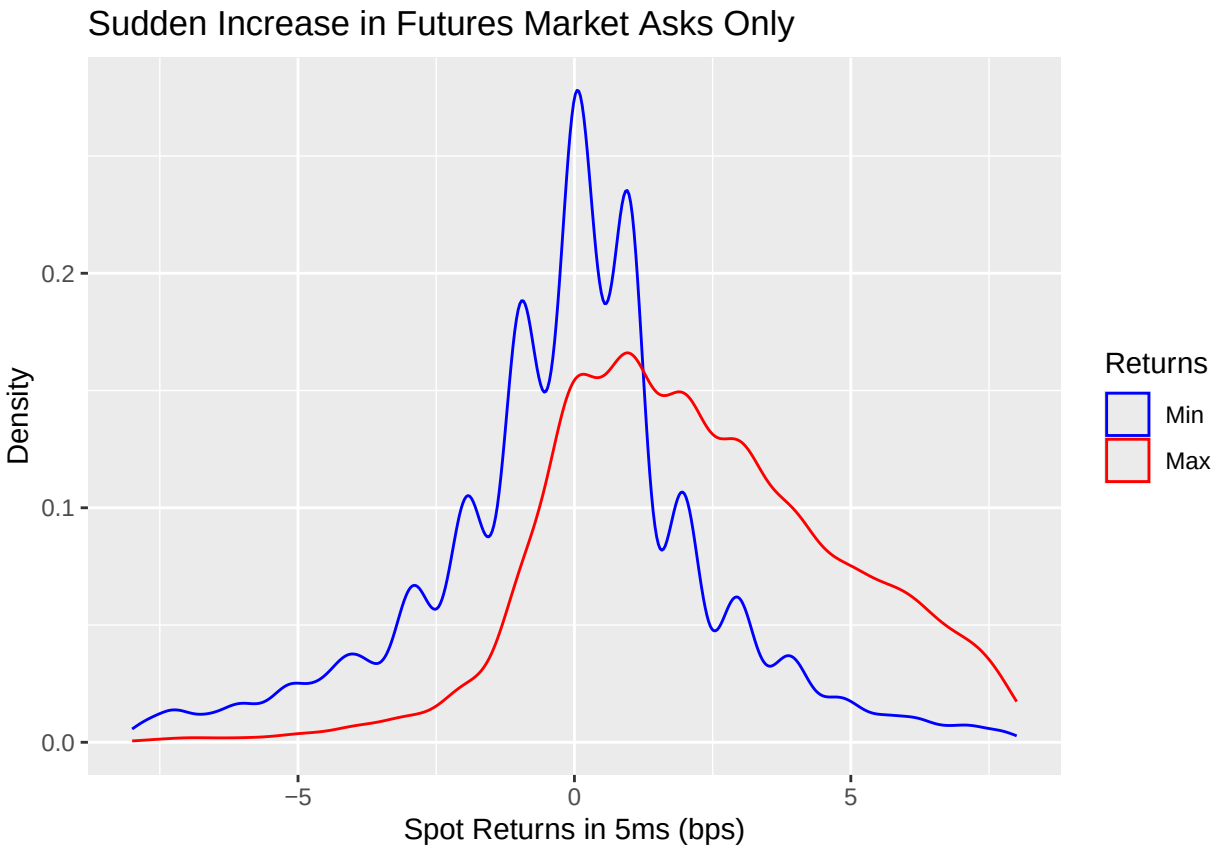
In the graph above, density of maximum and minimum returns in futures market after a bid decrease in spot market only.



In the graph above, density of maximum and minimum returns in spot market after a bid decrease in futures market only.

Sudden Ask Price Increases

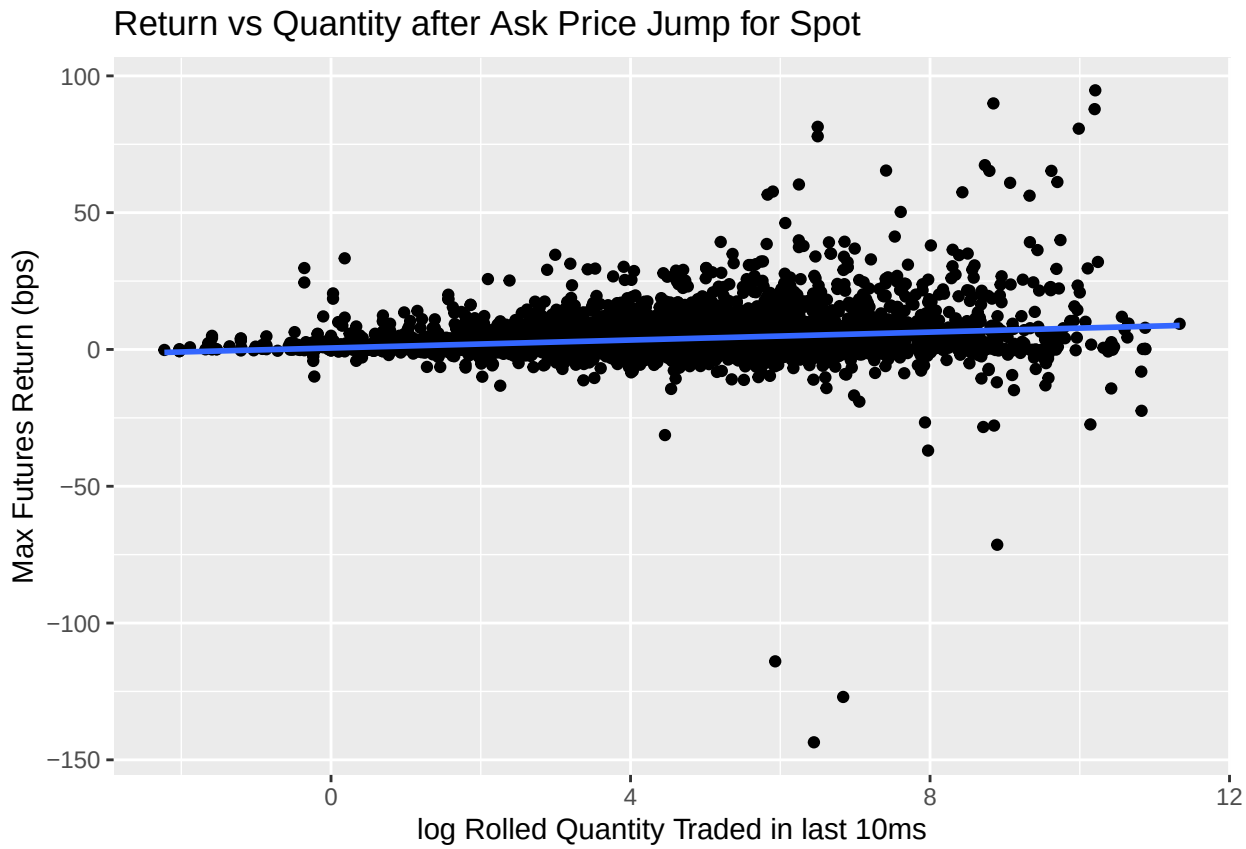
In the graph above, density of maximum and minimum returns in futures market after a ask increase in spot market only.



In the graph above, density of maximum and minimum returns in spot market after an ask increase in futures market only.

Quantity Effect

The graph below shows the effect of quantity.



The graph above shows that quantity traded in the last moments plays a significant role to predict the effect. We could see similar graphs with variations but I will use this one only to show visually. The table below shows the difference between averages for higher and lower half of quantity traded before the sudden increase in spot ask.

QuantityTraded	avg_max_futures_return	avg_min_futures_return
Lower Half	2.575748	-0.8502876
Upper Half	5.186483	-1.4152862

Linear Regressions

% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sat Jun 28 23:48:08 2025

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.3008	0.2939	1.02	0.3062
log(quantity_rolled)	0.7999	0.0593	13.48	0.0000

Table 4: Sudden Ask Increase in Spot Only, Max Future Return against Log Quantity

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% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sat Jun 28 23:48:08 2025

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	2.2228	0.1456	15.26	0.0000
log(quantity_rolled)	0.5911	0.0333	17.75	0.0000

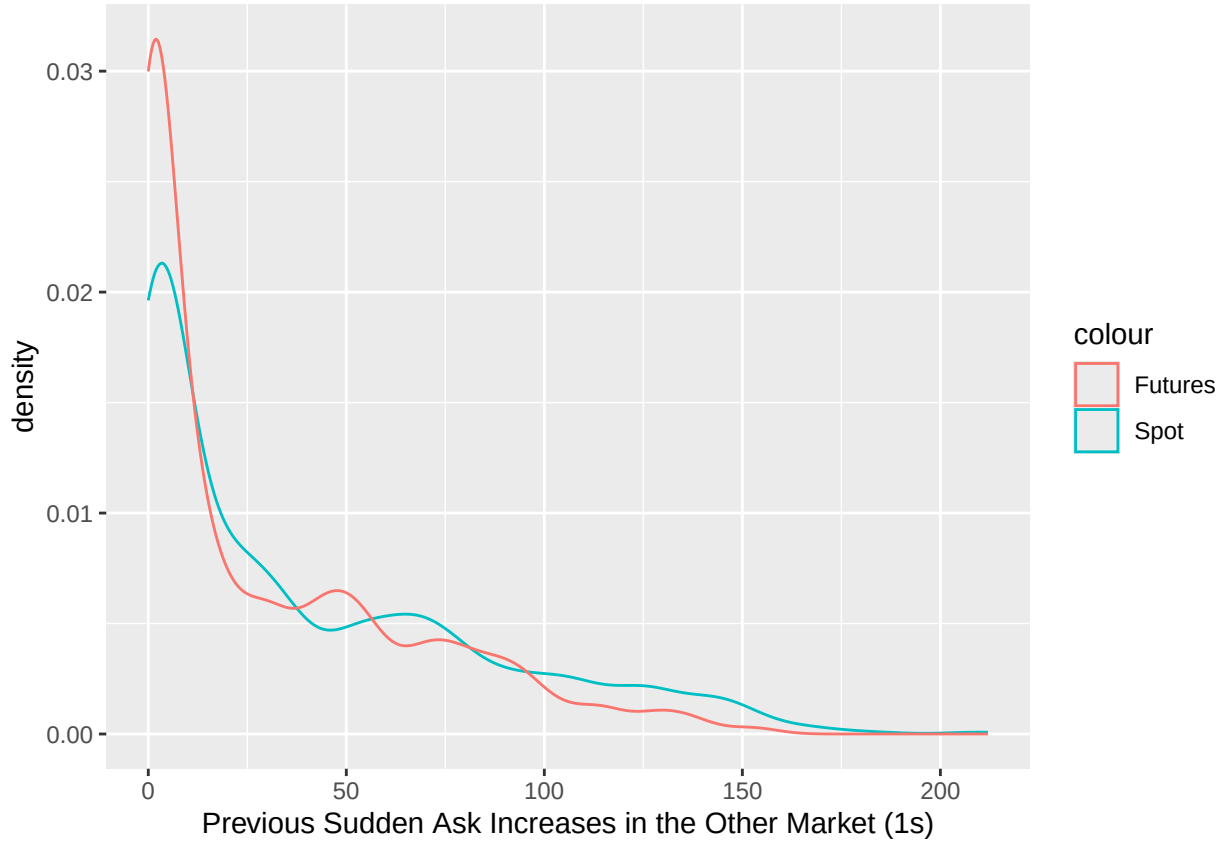
Table 5: Sudden Ask Increase in Futures Only, Max Spot Return against Log Quantity

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.4526	0.2817	-1.61	0.1082
log(quantity_rolled)	-0.7121	0.0564	-12.63	0.0000

Table 6: Sudden Bid Decrease in Spot Only, Min Futures Return against Log Quantity

More Investigation

It was not clear in the previous analysis that which market triggers the other. It looks like sudden changes in both markets leads to similar returns in the other. To refine my results, I add new variables for previous sudden changes in last second. To keep the report short, I want to focus on ask increases only for spot and futures market.



The graph below shows the distribution of number of previous sudden increases in the ask price in the other market. It tells us sudden ask increases in spot market have more previous ask price jumps previously in the futures market than the other way around.

Spot_Bid	Futures_Bid	avg_spot_max	avg_spot_min	avg_futures_max	avg_futures_min	cases
FALSE	TRUE	0.6840064	-3.838857	2.424338	-3.950596	7403
TRUE	FALSE	1.7114142	-2.943086	1.226507	-3.682265	5400

Spot_Bid	Futures_Bid	avg_spot_max	avg_spot_min	avg_futures_max	avg_futures_min	cases
TRUE	TRUE	0.4171339	-7.901556	2.300838	-8.323545	1885

Moreover, I generate a similar table to the first one but this time I filter the sudden ask increases that has no other sudden ask increases in the last 1 second in either market.

Spot_Ask	Futures_Ask	avg_spot_max	avg_spot_min	avg_futures_max	avg_futures_min	cases
FALSE	TRUE	4.619562	-0.2543060	3.006989	-1.5316539	681
TRUE	FALSE	2.374976	-0.8432434	2.500800	-0.4565884	416
TRUE	TRUE	8.126117	1.2553437	6.579712	-0.0764318	55

In this table we see that highest average max and average min returns are coming from spot market when there is a sudden ask increases in the futures market only. If there was no sudden ask increases 1 second prior in either market, most powerful signal is an sudden increase in the ask price in future market to position long in the spot market. In the table below, I also filter out the cases with any type of previous bid decrease in last second to remove the mean revert effect. The same result persist. The futures market triggers the spot market more than the other way around.

Spot_Ask	Futures_Ask	avg_spot_max	avg_spot_min	avg_futures_max	avg_futures_min	cases
FALSE	TRUE	5.032311	0.0860427	3.243406	-1.1378066	551
TRUE	FALSE	2.473272	-0.7423306	2.850673	-0.0636060	316
TRUE	TRUE	8.529540	1.5608494	6.996770	-0.1817727	47

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-1.9142	0.1418	-13.50	0.0000
log(quantity_rolled)	-0.5934	0.0328	-18.12	0.0000

Table 7: Sudden Bid Decrease in Futures Only, Min Spot Return against Log Quantity