

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 0 in absolute value
5. Calculated price changes in last 3ms by summing price changes in last 3ms with rolling time 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 5ms 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 5ms 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 5ms 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

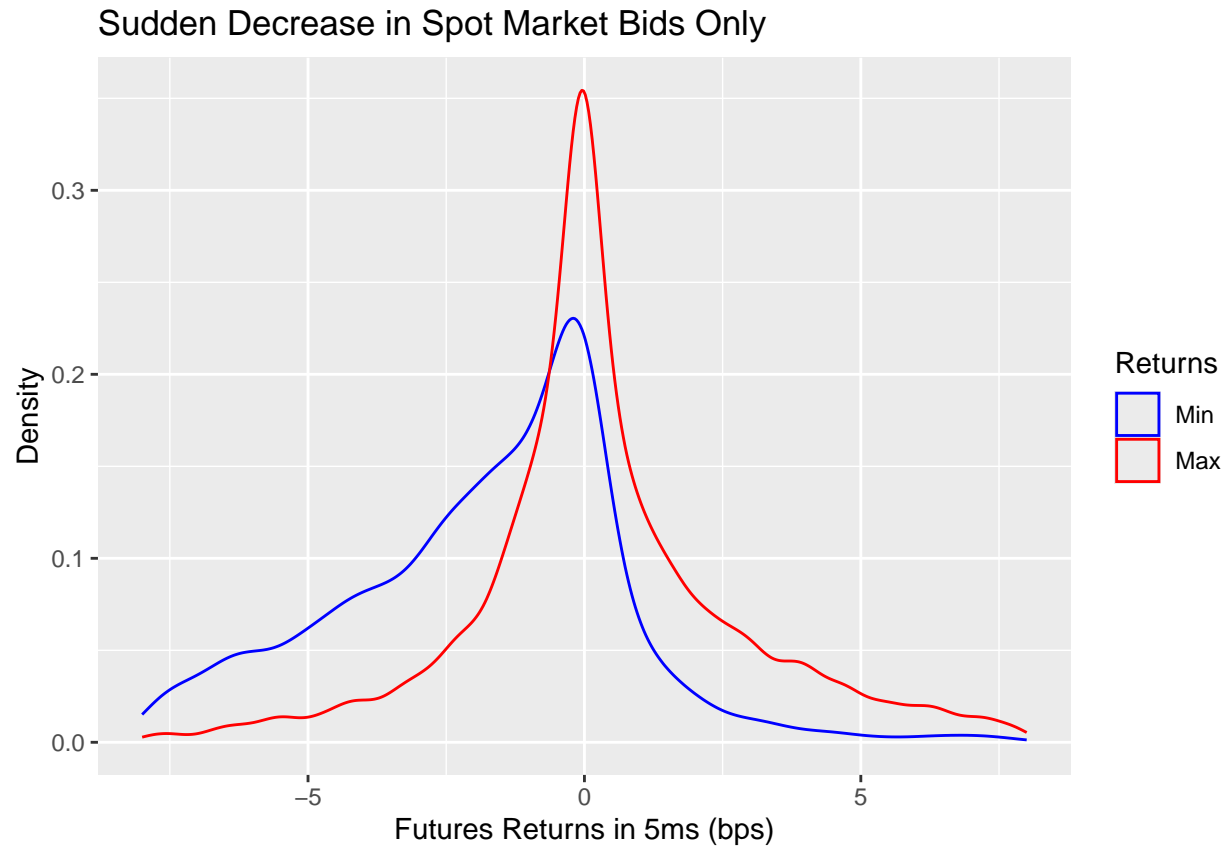
In both tables we observe that when the sudden changes happens in the futures and spot market at the same time, it is most powerful signal. When there is a sudden change in only one market, futures market gives slightly better signal for spot market than the other way around.

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

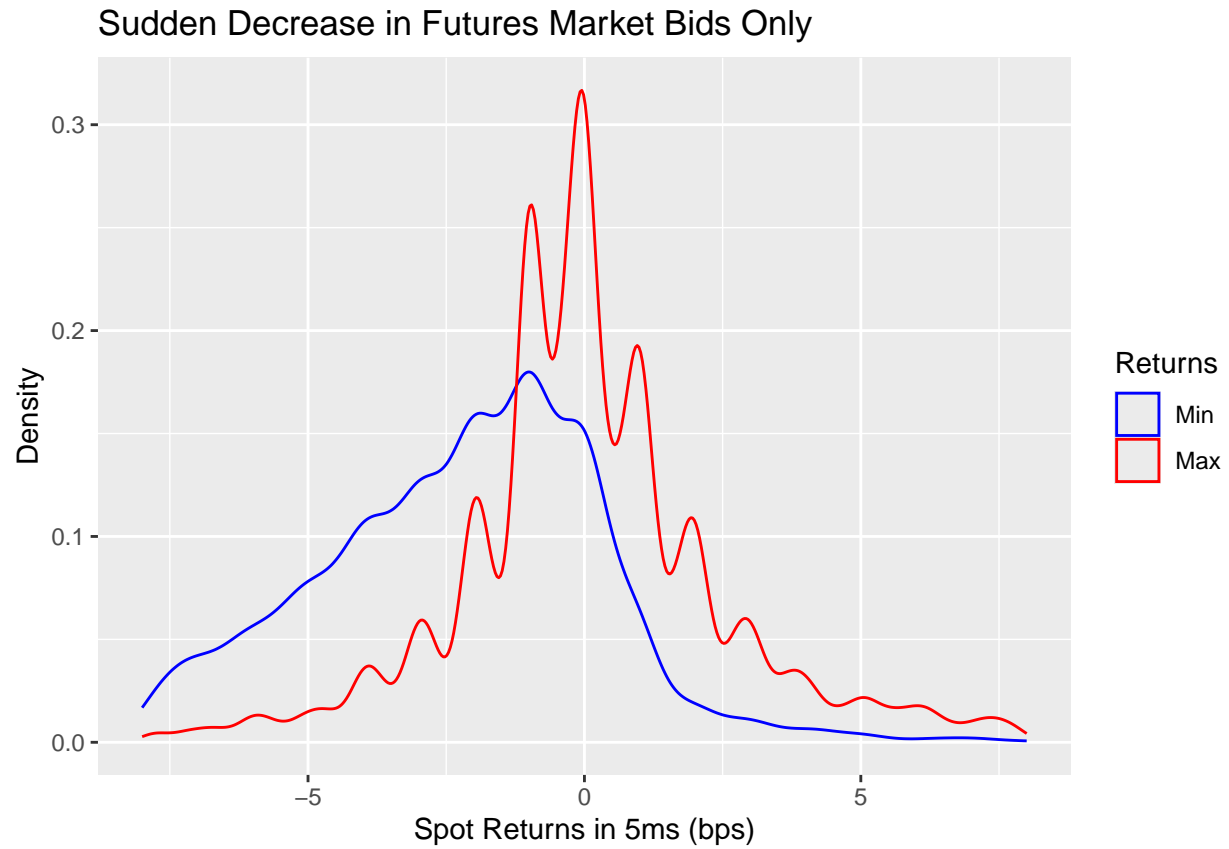
Density Graphs

In this part, I plot the density of max and min returns in 5ms for a market when there is a sudden change in the other market only. The graphs also confirms that sudden ask/bid price changes in one market signals a price change in the other.

Sudden Bid Price Decreases

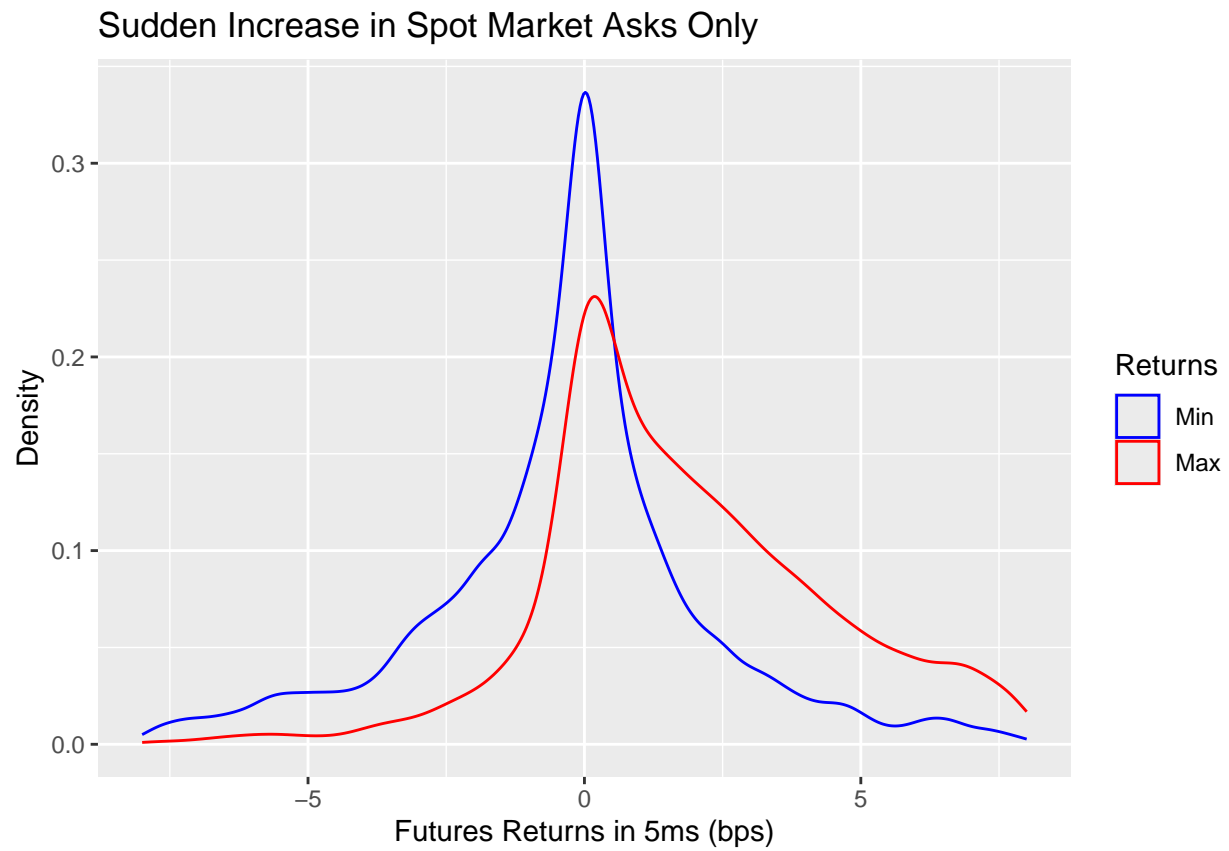


In the graph above, density of maximum and minimum returns in futures market after a bid decrease in spot market only.



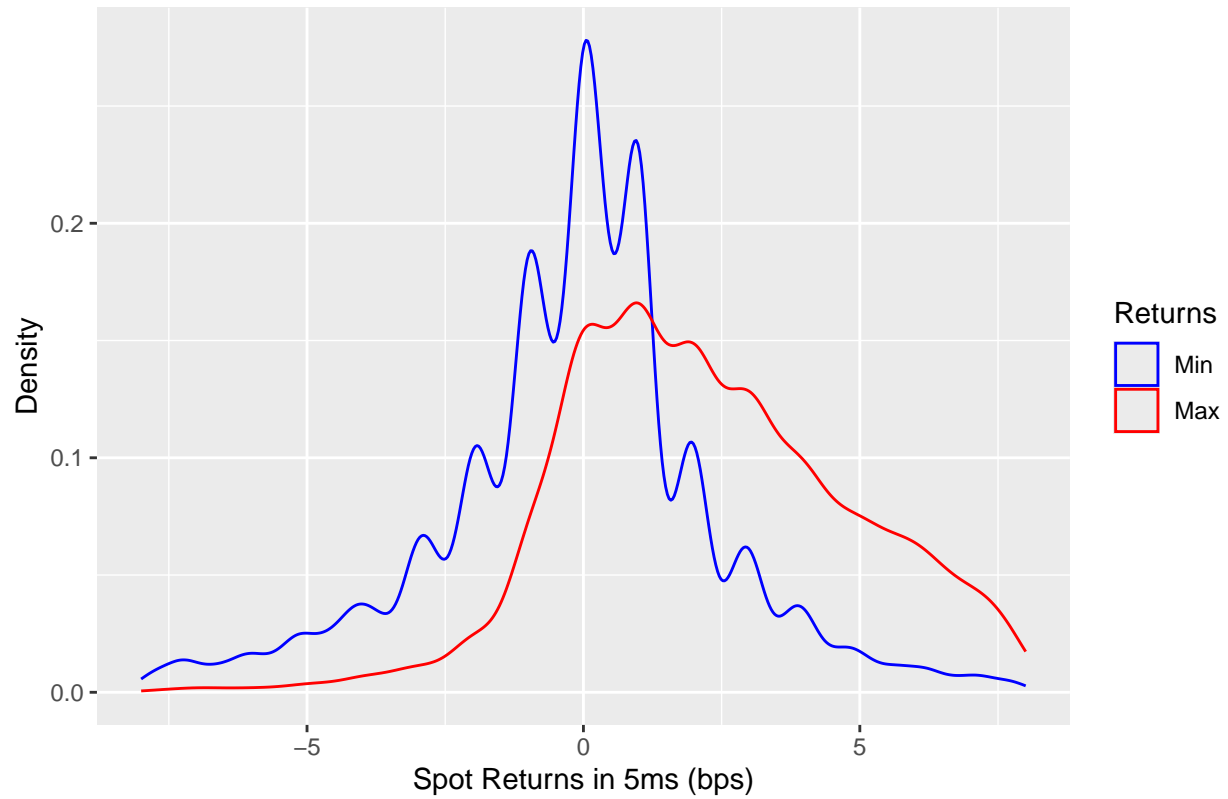
In the graph above, density of maximum and minimum returns in spot market after a bid decrease in futures market only.

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.

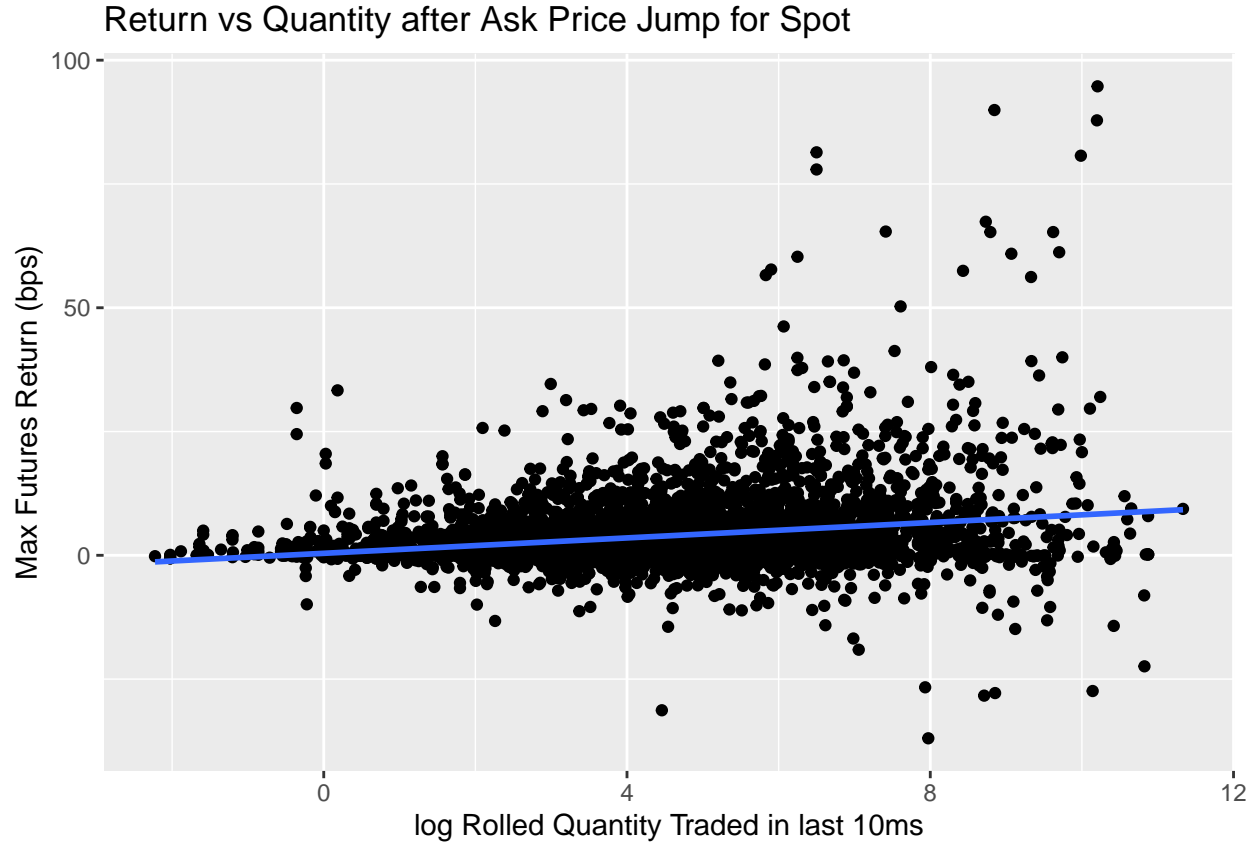
Sudden Increase in Futures Market Asks Only



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 and futures ask. When quantity traded in last 10ms is greater than the median, the averages max returns increases however the risk (avg minimum return) also slightly increases.

QuantityTraded	SuddenChange	AvgMaxFuturesRet	AvgMinFuturesRet	AvgMaxSpotRet	AvgMinSpotRet
Lower Half	Futures Ask	2.944036	-1.8610031	3.354829	-0.3420548
Lower Half	Spot Ask	2.521588	-0.7970236	1.930620	-1.3759178
Upper Half	Futures Ask	5.885449	-3.1066436	5.553171	-1.1071396
Upper Half	Spot Ask	4.871361	-1.3773620	4.129461	-1.7420424

Linear Regressions

% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sun Jun 29 14:15:17 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

% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sun Jun 29 14:15:17 2025

% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sun Jun 29 14:15:17 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

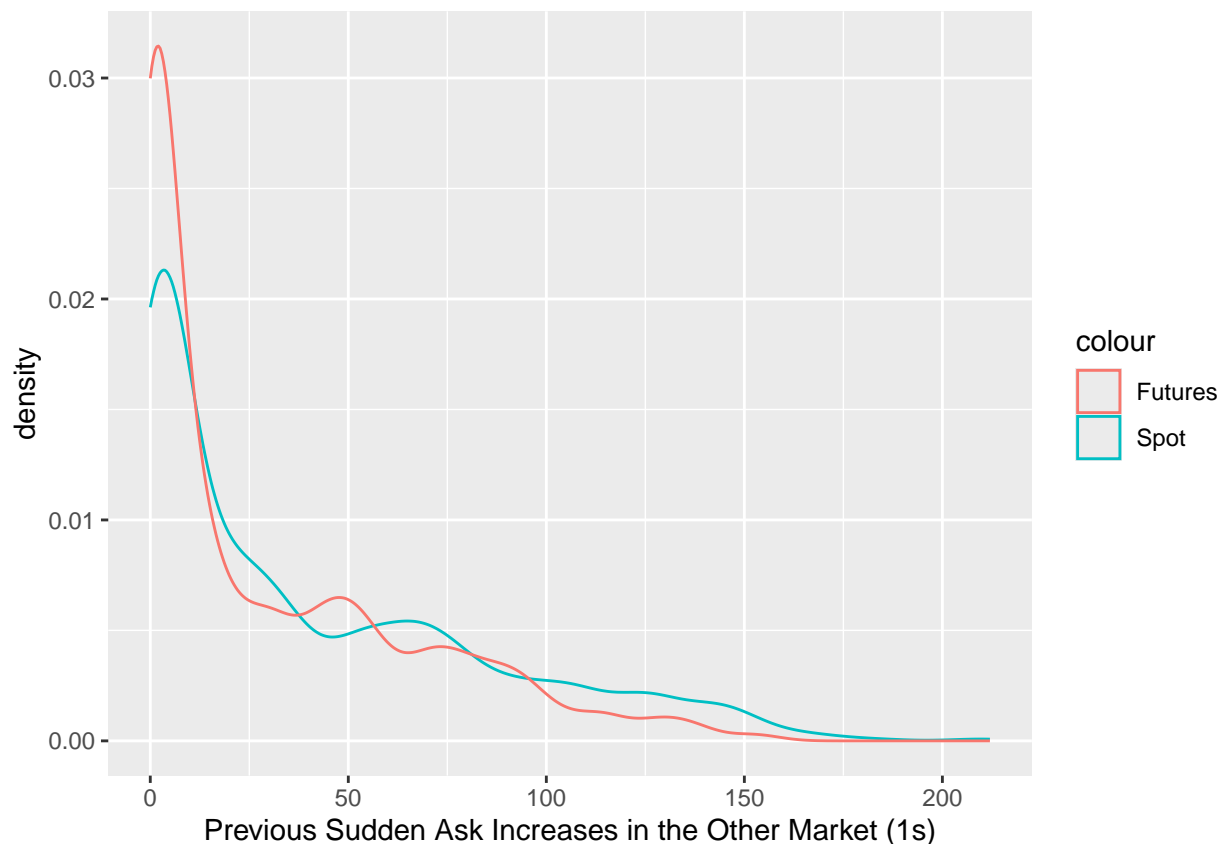
% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sun Jun 29 14:15:17 2025

[1] “End of regressions”

In the regressions above, we see that the quantity traded in last 10ms is affects signal quality and this effect is much more greater for the signals coming from spot market than the signals coming from the futures market.

More Investigation with prior sudden changes

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 even though the futures market has slightly higher predictive power. 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.



	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

The graph above 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.

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

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. Moreover, when we remove the cases in which there is a sudden change in 1 second prior, the signal quality of future market changes increases a lot but the signal quality of spot market changes decreases.

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	-1.137807	551
TRUE	FALSE	2.473272	-0.7423306	2.850673	-0.063606	316

Simple Prediction with Linear Regression

When there is a sudden ask price increase in the futures market, I would like to predict max return in 5ms in the spot market. I use quantity traded in last 10ms, prior sudden changes in both markets from ask and bid changes in last 1s as my predictors. I filter out the simultaneous ask price changes in the spot market for the regression but I add sudden bid changes as predictors.

% latex table generated in R 4.4.2 by xtable 1.8-4 package % Sun Jun 29 14:15:25 2025

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	4.2271	0.1073	39.39	0.0000
quantity_rolled	0.0005	0.0000	13.97	0.0000
pre_sudden_ask_s	0.0103	0.0066	1.57	0.1172
pre_sudden_ask_f	-0.0031	0.0051	-0.61	0.5426
pre_sudden_bid_s	-0.0112	0.0065	-1.74	0.0825
pre_sudden_bid_f	0.0056	0.0047	1.20	0.2311
sudden_bid_change_sTRUE	-0.7909	0.3006	-2.63	0.0085
sudden_bid_change_fTRUE	-1.2291	0.3227	-3.81	0.0001

Table 10: Sudden Ask Increase in Futures Only, Max Future Return Prediction with simple OLS

A short part for the momentum

With the current final data I am generating my report on, I decided to measure the momentum as the difference between *sudden ask increases* and *sudden bid decreases* in the following 1 second. In the table below, you could see the average measured momentum after sudden ask price increases and also with different traded quantity groups.

SuddenChange	Avg_Spot_Momentum	Avg_Futures_Momentum	cases
Both	5.456909	9.754454	2077
Futures Ask	2.318991	6.264182	7809
Spot Ask	2.918544	4.655113	5193

QuantityTraded	SuddenChange	Avg_Spot_Momentum	Avg_Futures_Momentum	cases
Lower Half	Both	6.441096	9.487671	365
Lower Half	Futures Ask	2.216353	6.570251	4733
Lower Half	Spot Ask	3.793056	5.560987	2189
Upper Half	Both	5.247079	9.811332	1712
Upper Half	Futures Ask	2.476918	5.793238	3076
Upper Half	Spot Ask	2.281292	3.995007	3004

As expected, the momentum increases a lot when the sudden change happens in both markets simultaneously. On the other hand, an interesting observation here is that the quantity traded before the sudden spot ask price increase does not increase the momentum, it even decreases the momentum.

To further investigate this, I generate same tables for the observation with no prior sudden changes.

SuddenChange	Avg_Spot_Momentum	Avg_Futures_Momentum	cases
Both	2.106383	2.4680851	47
Futures Ask	1.185118	2.1923775	551
Spot Ask	1.066456	0.6613924	316

QuantityTraded	SuddenChange	Avg_Spot_Momentum	Avg_Futures_Momentum	cases
Lower Half	Both	1.6666667	3.0000000	3
Lower Half	Futures Ask	0.9434524	2.2440476	336
Lower Half	Spot Ask	1.0645161	0.3010753	93
Upper Half	Both	2.1363636	2.4318182	44
Upper Half	Futures Ask	1.5627907	2.1116279	215
Upper Half	Spot Ask	1.0672646	0.8116592	223

When there is no prior sudden changes in the last 1 second, the effect of quantity on the momentum of spot ask increase is not the same as before. However the number of cases decreases a lot to conclude something with these tables right now.