Putting March 2023 In Perspective: Path-Dependency in Execution in Volatile Times

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Abstract
A couple of days in mid-March 2023 will enter records as some of the most volatile times for fixed income returns. Whether measured in yield change or change in futures prices, the sudden bond appreciation starting on March 10 represented moves of the order of multiple standard deviations. Historically, the closest event in terms of market moves dates back to Black Monday in 1987. Turbulent markets often lead to a large dispersion in performance for systematic traders. In this note we investigate how different execution paths following the market shock of March 10 would have resulted in wildly different PnL outcomes, over a period of less than a week.

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1. Introduction

Market shocks are by definition surprising events. When bonds rallied on March 10, 2023 after a sustained period of downward price trends, this caught many market participants by surprise. The turn in price trajectory was not only sudden, but also of a magnitude rarely seen before. Market shocks persisted the following days. The magnitude of the moves represented price changes of the order of multiple standard deviations, so far out on a Gaussian distribution that they qualify colloquially as a 'Black Swan' event. We show volatility-normalized market returns (using 10-year trailing volatility) for the US 2Y T-Note in Figure 1.

During times of high market volatility, market participants tend to show a larger dispersion in performance than during comparatively quiet times, even with similar trading styles. One example of this was the start of the Covid pandemic, where we have shown how small changes in circumstances can lead to different PnL outcomes for trend-following models, see Bethke and Tricker (2020). In this note we look at market volatility on a more granular level, by tracking how execution differences can affect PnL over a short period of time.

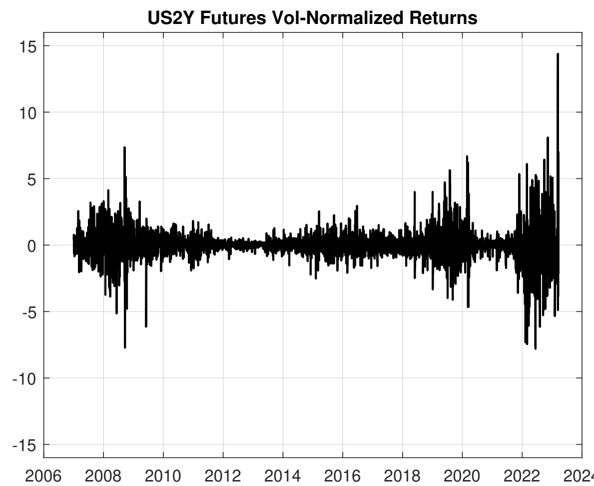

Figure 1. Vol-normalized returns for the US 2Y T-Note.

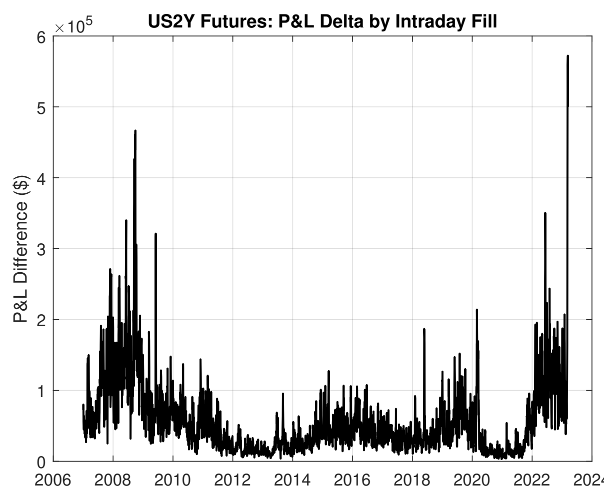

Figure 2. PnL dispersion when liquidating -$100m of US 2Y T-Note futures.

2. An Anecdote

To gain intuition, we step through an execution example on a day-by-day basis. We assume we are short $100mm of US 2Y T-Note futures that we wish to liquidate over the course of four days. We simplify reality by assuming our entire trade on any given day is filled instantaneously at a set price (though we will use prices that capture the reality of execution over a set time horizon). We use different fill price assumptions: Open, High, Low, Close (less realistic), and three volume-weighted average prices (VWAP) (more realistic). The daily PnL is marked Close-to-Close. Table 1 shows the daily PnL for each of the scenarios, as well as the daily and overall best and worst PnL. We find large dispersion intraday, and a large difference between the overall best and worst outcome, at -$665,975 and -$1,791,950, respectively. Even if we only consider VWAP, the best and worst PnL differ significantly, with -$868,350 and -$1,395,175, respectively.

US 2Y T-Note							
3/10/2023	**Prev. Position**	**Trade**	**Close**	**PrevClose**	**Fill Price**		**PnL ($)**
	-500	125	102.3164	101.6641	Open	101.7227	-503,875
					High	102.3359	-657,175
					Low	101.7109	-500,925
					Close	102.3164	-652,300
					First Hour VWAP	101.8837	-544,125
					Last Hour VWAP	102.3102	-650,750
					All Day VWAP	102.1067	-599,875
						Best	-500,925
						Worst	-657,175
3/13/2023	**Prev. Position**	**Trade**	**Close**	**PrevClose**	**Fill Price**		**PnL ($)**
	-375	125	103.4102	102.3164	Open	102.3281	-549,825
					High	103.6133	-871,125
					Low	102.3242	-548,850
					Close	103.4102	-820,350
					First Hour VWAP	102.6091	-620,075
					Last Hour VWAP	103.1035	-743,675
					All Day VWAP	103.1328	-751,000
						Best	-548,850
						Worst	-871,125
3/14/2023	**Prev. Position**	**Trade**	**Close**	**PrevClose**	**Fill Price**		**PnL ($)**
	-250	125	103.0195	103.4102	Open	103.4922	77,175
					High	103.8242	-5,825
					Low	102.6602	285,175
					Close	103.0195	195,350
					First Hour VWAP	103.1342	166,675
					Last Hour VWAP	102.8077	248,300
					All Day VWAP	102.9672	208,425
						Best	285,175
						Worst	-5,825
3/15/2023	**Prev. Position**	**Trade**	**Close**	**PrevClose**	**Fill Price**		**PnL ($)**
	-125	125	103.5273	103.0195	Open	102.9492	17,575
					High	104.0508	-257,825
					Low	102.6250	98,625
					Close	103.5273	-126,950
					First Hour VWAP	102.8293	47,550
					Last Hour VWAP	103.6559	-160,100
					All Day VWAP	103.5682	-137175
						Best	98,625
						Worst	-257,825
						Overall Best	-665,975
						Overall Worst	-1,791,950

Table 1. An execution example using various fill prices for US 2Y T-Note Futures. We liquidate 500 contracts, representing around $100mm in notional, over the course of four days. We record the best and worst PnL outcome per day, and overall.

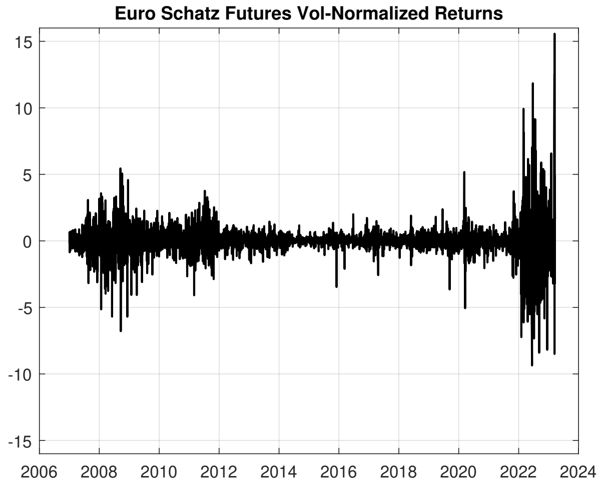

Figure 3. Vol-normalized returns for the Euro Schatz.

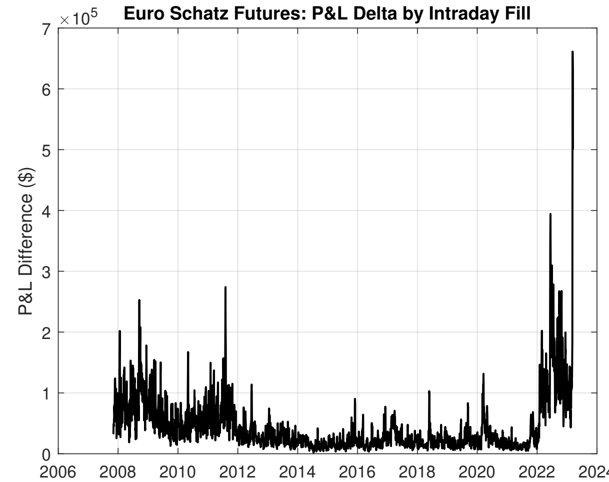

Figure 4. PnL dispersion when liquidating -$100m of Euro Schatz futures.

3. An Experiment

The example in Table 1 illustrates how PnL dispersion arises from intra-day price volatility. It is directly affected by the fill price achieved when executing a trade. To put this dispersion into context, we now look at all consecutive four day periods starting in 2007. Again we start each of these periods with a position corresponding to $100mm, which we liquidate in equal sized lots each day for four days. On each day we compute three possible fill prices: first hour VWAP, last hour VWAP, and all day VWAP. We then take the difference between the best possible PnL and the worst possible PnL given those three options. Figure 2 plots the resulting PnL dispersion through time. We see mid-March 2023 as a massive spike, an outlier within the entire history considered, even larger than the spike during the 2008 crisis. We also see an increase in dispersion in the year 2022, which was characterized by higher market volatility. It follows a similar pattern to that seen for the vol-normalized returns, as expected. We show results of the same analysis for Euro Schatz Futures in Figures 3 and 4. The recent market turmoil stands out even more in this case. Similar results can be found across other fixed income markets.

We have not addressed other ways in which volatility can affect PnL dispersion. The primary mechanism is where price volatility affects realized fill price and therefore PnL. Moreover, systematic traders typically size their positions inversely with volatility, meaning that when volatility changes quickly (i.e. when the volatility of volatility spikes), they need to adjust their positions in greater amounts. This affects the order size, which in combination with a volatile fill price, exacerbates the problem.

4. Conclusion

In this note we use some representative futures markets, US 2Y T-Note futures and Euro Schatz futures, to illustrate how price volatility can affect PnL through variability in fills achieved during trade execution. This variability will lead to otherwise similar trading systems experiencing much larger dispersion in realized PnL than during quieter market periods. Our analysis shows the latest period of market upheaval, March 10, 2023 and the days that followed, to be exceptionally volatile in this sense. We expect market participants with otherwise similar trading strategies, such as different trend followers, to have weathered this period with different losses, which can be attributed to some extent to small differences in trade execution.

References

N. Bethke and E. Tricker. Trend-Following: What's Luck Got To Do With It? Research Note, Graham Capital Management, June 2020.

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