Kraken exchange - FTSO price comparison

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1 Background

The FTSO outputs cryptocurrency price pairs such as BTC-USD every 3 minutes, termed a *price epoch*. More precisely, during price epoch N, prices are submitted by data providers. An estimate based on the submitted data is then computed as the price output. Price epochs are batched into *reward epochs*. The FTSO has been running since September 2021 on Songbird, Flare's canary network and since August 2022 on Flare, Flare's main network.

Cryptocurrencies such as XRP, BTC and ETH are traded at high volumes daily on the Kraken exchange. These can be traded for, amongst other currencies, USD or USDT. This report considers whether the FTSO reflects the currency prices on the Kraken exchange for ETH, BTC and XRP.

2 Data

2.1 Choosing time

The FTSO price calculated from the submissions by the end of epoch N are compared to the Kraken exchange trades corresponding to epoch N. Reward epochs 68 and 69 are chosen, for which data was retrieved from Kraken exchange and the Songbird network.

2.2 FTSO data

FTSO data is gathered on Songbird for reward epochs 68 and 69. Each reward epoch on Songbird lasts one week, meaning that there are 3360 price epochs within each reward epoch. The FTSO output price is computed for each price epoch. Reward epoch 68 started with price epoch 229200 which started on January 7, 2023, at 8:41 UTC. Reward epoch 69 ended with price epoch 235919 which ended on January 21, 2023, at 8:41 UTC.

2.3 Kraken exchange data

Trading orders for each cryptocurrency in both USD and USDT are gathered from Kraken exchange using the public Kraken API, for the timespan of reward epochs 68 and 69 on Songbird. We then assume that 1USD=1USDT[1], and thus gather USD and USDT orders into one data set.

[1] An assumption valid until March 11, 2023, according to `https://coinmarketcap.com/currencies/tether/`

3 Method

3.1 p-covering deviation band

The mean Kraken exchange price $\bar{y}_N$ for price epoch N is compared with the FTSO price calculated at the end of the price epoch N using a *p-covering deviation band*. For a given reward epoch, a *p-covering deviation band* d is said to cover p-part of an FTSO price if it is within the interval $[(1-d)\bar{y}_N, (1+d)\bar{y}_N]$ for at least $p\%$ of the price epochs within the reward epoch.

3.2 Relative Root Mean Square Error (RRMSE)

As the FTSO outputs one price per currency per price epoch and there are several transactions (trades) on Kraken exchange for the same currency within the price epoch, the relative RMSE between the FTSO price and the Kraken exchange trades is computed:

$$\text{rrmse}_N := \sqrt{\frac{\sum_{i=1}^{c_N} (1 - y_N(i)/FTSO_N)^2}{c_N}}, \tag{1}$$

where N denotes the price epoch, $y_N(i), i \in [1, \dots c_N]$ are prices of Kraken exchange trades within price epoch N and $FTSO_N$ is the FTSO price computed from prices submitted till the end of the price epoch N. Table 2 shows maximal and mean RRMSEs over reward epochs 68 and 69.

4 Results

4.1 p-covering deviation band

Table 1 shows d values for the deviation band width for $p = 90\%, 95\%, 99\%, 99.5\%$ for currencies XRP, BTC, ETH for reward epochs 68 and 69, separately, on Songbird. The averaging strategy for Kraken exchange trade prices within one epoch was the mean.

First, results are similar across XRP, BTC and ETH, with a relatively smaller p-covering deviation band for BTC. Second, as expected, the size of the deviation band increases as p increases. Comparing p-covers of 95% to 99% (column 2 or 6 compared to column 3 or 7), the deviation band roughly doubles in size.

currency	r.e. 68 $p = 90\%$	r.e. 68 $p = 95\%$	r.e. 68 $p = 99\%$	r.e. 68 $p = 99.5\%$	r.e. 69 $p = 90\%$	r.e. 69 $p = 95\%$	r.e. 69 $p = 99\%$	r.e. 69 $p = 99.5\%$
XRP	0.00116	0.00155	0.00241	0.00303	0.00140	0.00183	0.00321	0.00392
BTC	0.00058	0.00077	0.00155	0.00187	0.00078	0.00102	0.00193	0.00253
ETH	0.00075	0.00094	0.00157	0.00227	0.00095	0.00123	0.00203	0.00240

Table 1: The price deviation band widths d for distinct p values as described in Section 3 for the selected three currencies, for reward epochs (r.e.) 68 and 69.

4.2 RRMSE over reward epochs

Table 2 shows the mean and the maximal relative root mean squared errors (RRMSE) of Kraken exchange prices compared to FTSO over the price epoch, with the mean and the maximum taken over the whole reward epoch (see Equation 1 for detailed definition of RRMSE of Kraken exchange prices compared to FTSO over the price epoch). Maximal RRMSE over

price epochs are up to 3.1% in reward epoch 68 (BTC) and 1.5% in reward epoch 69 (XRP), while mean RRMSE is up to 0.07% in reward epoch 68 (XRP) and 0.08% in reward epoch 69.

currency	$\max(rrmse_N)$ over price epochs N in reward epoch 68	$\text{mean}(rrmse_N)$ over price epochs N in reward epoch 68	$\max(rrmse_N)$ over price epochs N in reward epoch 69	$\text{mean}(rrmse_N)$ over price epochs N in reward epoch 69
XRP	0.0107	0.0007	0.0146	0.0008
BTC	0.0310	0.0004	0.0077	0.0006
ETH	0.0176	0.0005	0.0108	0.0006

Table 2: Maximal and average standard deviation of Kraken exchange transactions within reward epochs 68 and 69 from the FTSO price.

The average fluctuations of trade prices around the FTSO in one price epoch are an order of magnitude smaller than the fluctuations over the whole reward epoch. That can be concluded by observing Table 2 along with Figure 1 – from the y-axis scale of Figure 1, we can estimate the reward epoch price fluctuations while the table shows the numbers for the local price epoch fluctuations. Also, from Figure 1 alone, we see that the local behavior of prices is squeezed compared to the whole reward epoch. Note that Figure 1 shows hourly aggregated prices, i.e. 20 price epochs are aggregated to one point on x-axis. For average local behavior, refer to Figure 4.

Figure 1 shows Kraken exchange minimal, maximal and mean price and mean FTSO per hour for reward epoch 69. Together with table 2 we see that the fluctuations of the prices over the reward epoch are an order of magnitude larger than the differences in Kraken exchange min/max prices and FTSO. For instance, on the XRP graph in Figure 1, the prices over the reward epoch 69 fluctuate between 0.37 and 0.41, which is ± 0.2 around the Kraken exchange mean value of 0.39, corresponding to a 5% deviation. In contrast, the average RRMSE of Kraken exchange trades relative to FTSO prices for XRP in price epoch 69 is 0.1%, see Table 2.

4.3 Max RRMSE in reward epoch 69

Figure 3 shows Kraken exchange's min, max and average price over the price epochs along with FTSO median price on January 18, 2023, at 16:22:01UTC $\pm 1.5h$ (60 price epochs), where the RRMSEs for all the currencies being observed are 5–10 times above the average RRMSE in reward epoch 69 as described in Table 2.

Figure 2 focuses on three consecutive price epochs around the epoch with the maximal RRMSE for XRP (price epoch 234625). It shows Kraken exchange trade prices (non-aggregated) and FTSO medians on the graph for three price epochs.

4.4 Mean RRMSE in reward epoch 69

Figure 4 shows Kraken exchange's min, max and average price over the price epoch along with FTSO median price on January 17, 2023, at 8:40:01UTC $\pm 1.5h$ (60 price epochs), where the RRMSE was close to the RRMSE mean in reward epoch 69 (see Table 2). Note that the y-axis scale is about 5 times smaller than in Figure 3 meaning that the volatility around the time point from Figure 3 was higher which also results in bigger RRMSE compared to average.

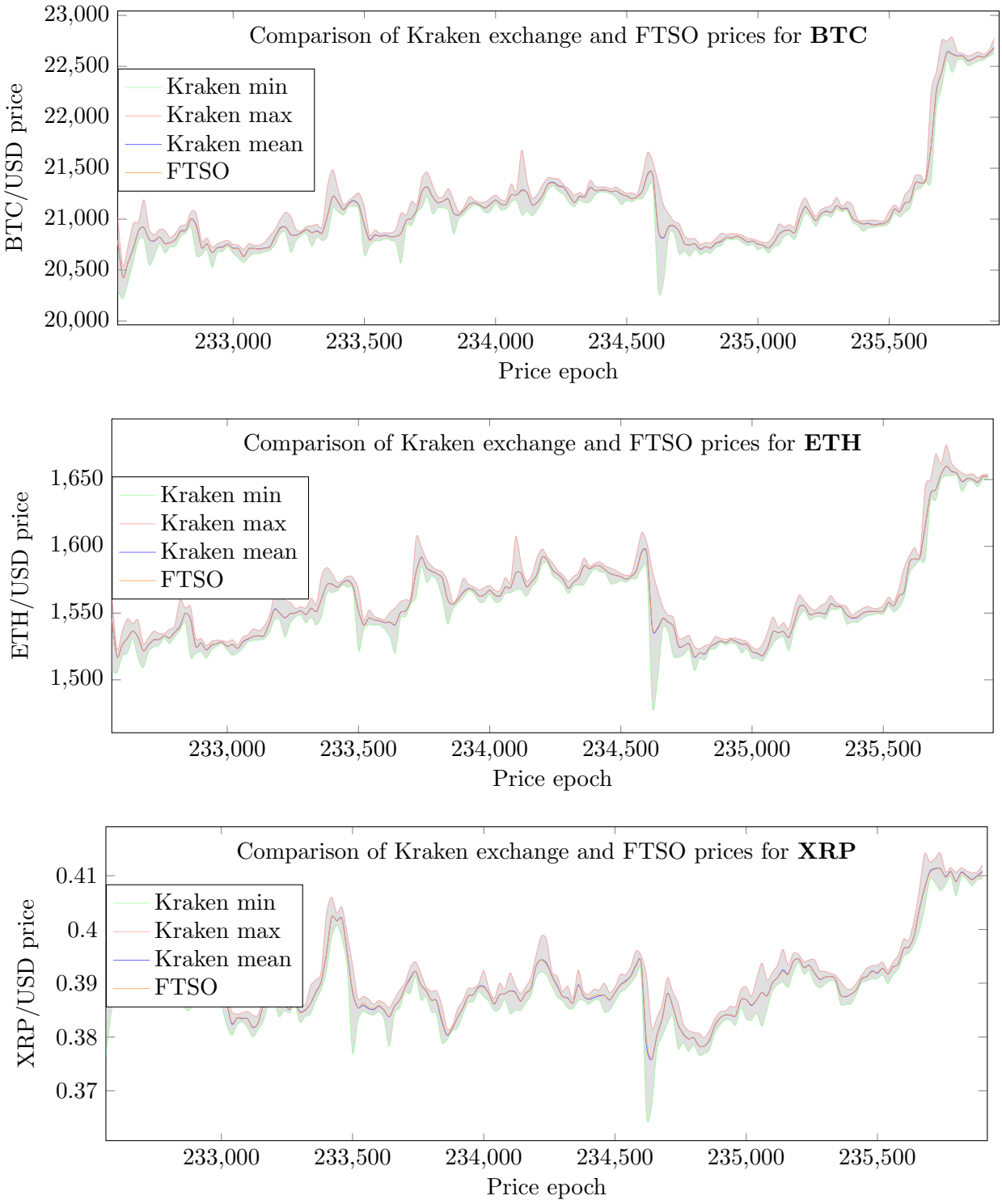

Figure 1: Hourly aggregates ower the whole reward epoch 69: Kraken exchange min, max and average trades prices and hourly FTSO average for BTC, ETH and XRP.

5 Conclusion

As the liquidity of BTC, ETH and XRP is so large, non-zero RRMSE is expected, as several trades with different prices happen within 3-minute time window. The volatility of the crypto-

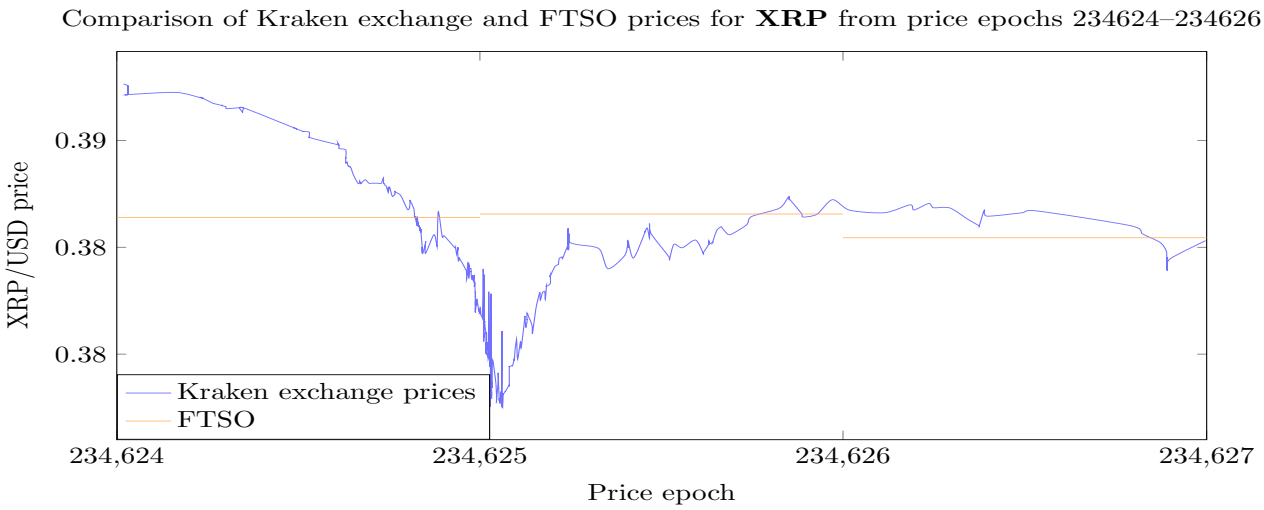

Figure 2: Kraken exchange XRP-USD prices for price epochs 234624–234626 and FTSO XRP-USD prices for price epochs 234624–234626.

currency prices as well as the difference in prices among different exchanges (which may be considered by data providers when calculating their submissions) imply that the difference between the FTSO and one specific exchange (Kraken in our case) is expected. Ultimately, as the Kraken exchange trade price span within one price epoch is an order of magnitude smaller than the trade price span within one reward epoch, we conclude that there is no significant difference in FTSO prices compared to Kraken exchange prices.

The data thus shows that the FTSO comes to consensus on price feeds from decentralized sources, which for reward epochs 68 and 69 of Songbird are aligned (and stored on-chain) with the price feed from one of the most respected centralized exchanges in the industry.

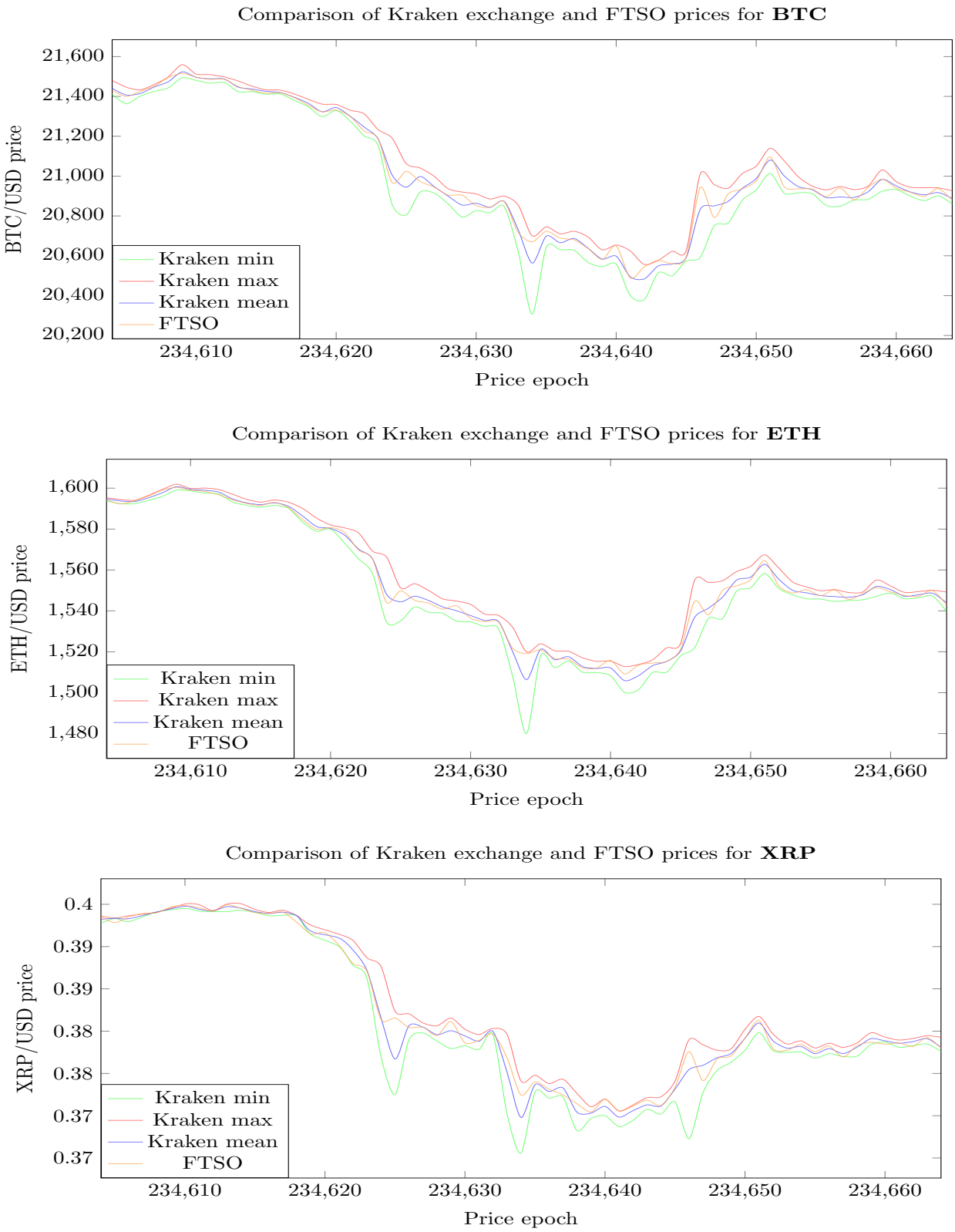

Figure 3: Comparison of Kraken exchange and FTSO prices surrounding price epoch 234635, the one with RRMSEs for all currencies being far above the average.

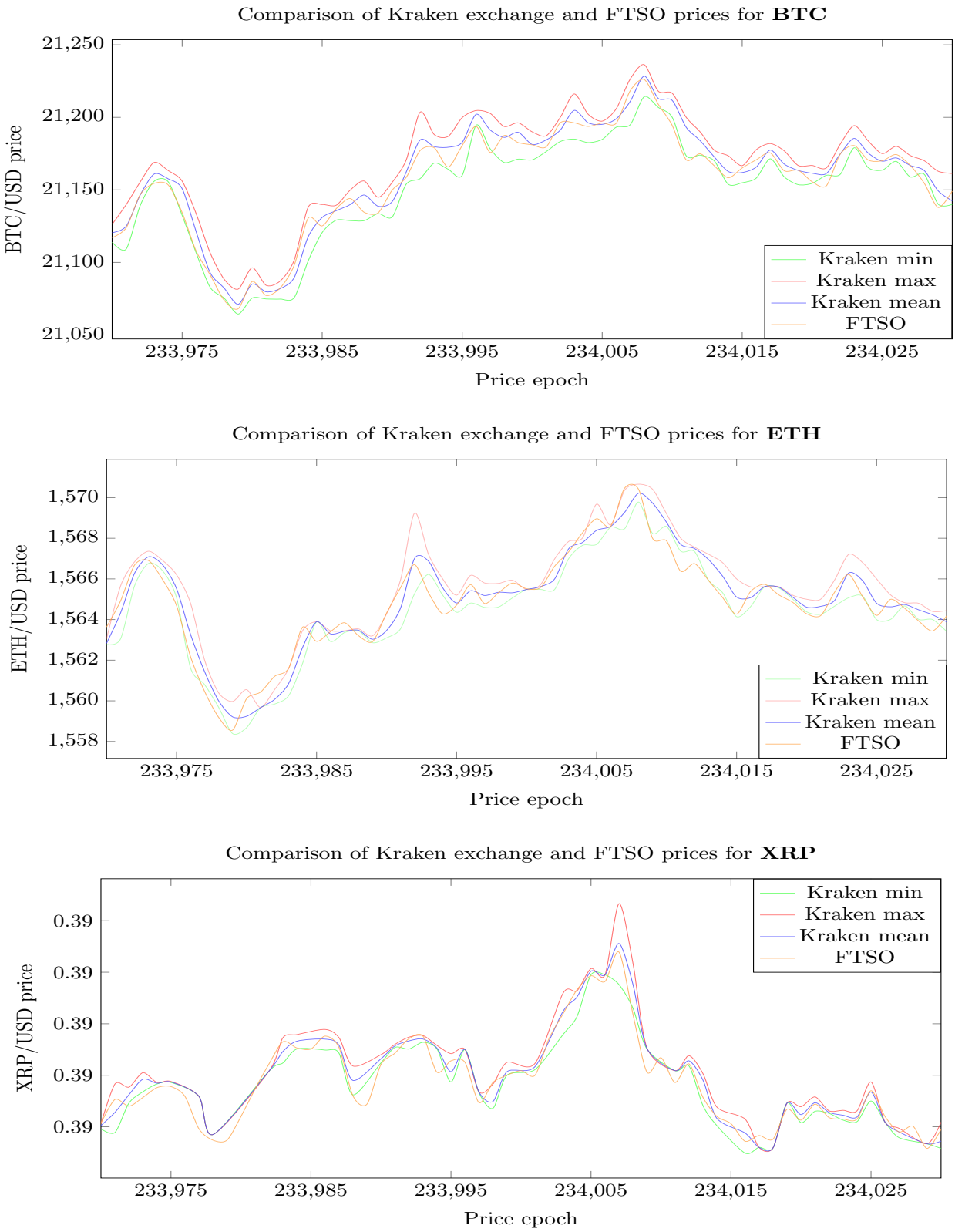

Figure 4: Comparison of Kraken exchange and FTSO prices around the price epoch 234000, where RRMSEs were around the average RRMSE for all the currencies.