Songbird band update: impact of STP.02

Flare Analytics Team

May 29, 2023

1 Background

The Flare Time Series Oracle (FTSO) provides the Flare Network with decentralised prices [1]. The system has been running on Songbird since September 2021, providing prices such as BTC-USD to the network every 3 minutes. The Songbird Test Proposal 2 (STP.02) [2] provided a system update, aimed at further increasing decentralisation. The purpose of this report is to evaluate the impact of this update on the system. More precisely, the aim is to

1. analyse its impact on price accuracy, and
2. assess its impact on the system decentralisation.

The report is organized as follows: Section 2 outlines the analytical methods employed in this study, while Section 3 provides a comprehensive description of the data analyzed. In Section 4, we present the results of our analysis, complemented by a graphical comparison of the processed data in Section 5. The impact of these findings on the reward system is explored in Section 6. Lastly, Section 7 concludes this report with a final assessment of the results and their implications.

2 Methods

In this section we describe the methods that were used to aggregate and compare the data from the exchanges and the FTSO system.

2.1 An exchange aggregate

FTSO price epochs on Songbird last 3 minutes, so in order to compare the FTSO prices to the exchanges, exchange trade prices are aggregated as follows. The exchange trade price aggregate for FTSO price epoch i, denoted by eta_i, is calculated as

$$eta_i = (min_i + max_i)/2,$$

where min_i and max_i are the lowest and the highest trade price within the time span of price epoch i.

2.2 Relative Root Mean Square Error

FTSO and exchange trade price aggregates are compared using *relative root mean squared error* (rRMSE). Because RMSE squares the difference between predicted and actual values, it places greater weight on larger errors, which is useful in our case as it helps in identifying outliers or other problems with the FTSO model.

For a selected time window consisting of N price epochs $p, p+1, \ldots, p+N-1$, with FTSO prices FTSO_i and exchange trade price aggregates eta_i, for $i \in \{p, p+1, \ldots, p+N-1\}$, the rRMSE is given by

$$\text{rRMSE}(\text{FTSO}, \text{exchange}) = \sqrt{\frac{1}{N}\sum_{i=p}^{p+N-1}\left(1-\frac{eta_i}{\text{FTSO}_i}\right)^2}. \quad (1)$$

To calculate the relative root mean squared error among two exchanges, we used the equation

$$\text{rRMSE}(\text{exchange}_1, \text{exchange}_2) = \sqrt{\frac{1}{N}\sum_{i=p}^{p+N-1}\left(1-\frac{eta_{2,i}}{eta_{1,i}}\right)^2}. \quad (2)$$

Note that this value is relative to the first exchange.

2.3 Outside the min-max range

Another metric that we consider is the count and the percentage of the price epochs observed where the FTSO_i price falls outside the range $[min_i, max_i]$ for a given exchange, i.e. the FTSO price in price epoch i is lower than the minimal or higher than the maximal trade price in price epoch i on a selected exchange. We also compare the min-max ranges of the two exchanges and compute whether these ranges are disjoint.

2.4 Analysis

The rRMSE thus provides a metric for comparing the FTSO price output with the exchange aggregate. First, the rRMSE is computed on both Songbird and Flare in December 2022, where both oracles were rewarded using the initial scheme. Next, the rRMSE is computed for each network in April 2023, once the rewarding has been updated and running for a while on Songbird but *not* on Flare.

3 Data

This section describes the choice of cryptocurrencies, the source of the data and the selected time periods.

3.1 Exchange and price pair choice

We consider the three most-traded cryptocurrencies **BTC**, **ETH** and **XRP** that are available on the FTSO. For FTSOs, data are gathered on both Songbird and Flare. For exchanges, data are gathered from Bitstamp and Binance. This choice was motivated by the high liquidity of the relevant assets (as reported by Coinmarketcap) and the availability of historical data with minute-granularity, obtained from the corresponding public APIs [3] and [4].

3.2 Asset prices in USD vs. USDT

The price pairs provided by the FTSO system are given in USD. Therefore the exchange data was also obtained for the corresponding USD price pairs. On Bitstamp, cryptocurrencies are traded against both USD and USDT. Since there are significantly less trades against USDT than against USD, we collected the USD trades only. On Binance, prices of cryptocurrencies are in USDT, due to the regulatory requirements that the data on Binance are only available in USDT outside the United States. In order to compare all the prices, we converted the Binance prices to USD by using the Bitstamp's USDT/USD exchange rate in each time period. Note that on March 11, USDT/USD experienced a depegging event. Although USDT is now closer to USD, it is still not as stable as it was before March 11. The conversion of the Binance prices to USD thus has an effect on our analysis.

All the prices in this report are given in USD.

3.3 Time periods

For both FTSOs and exchanges, data was gathered from two time periods: December 2022 and April/May 2023. More precisely, the two time periods (in UTC) are

- T1: December 19, 2022, 06:58:30 – December 29, 2022, 18:58:30, and
- T2: April 24, 2023, 06:58:30 – May 5, 2023, 18:58:30.

4 Results

In this section we compare the cryptocurrency prices from the exchanges with the FTSO prices, for each of the time periods from Section 3.3. The columns in the tables represent the number of all price epochs observed (*#p.e.*), the number and the percentage of FTSO prices falling out of the exchange's min-max trading price range (*#out* and *%out*), and the relative root mean squared error as defined in Equations 1 and 2 (*rRMSE*). Additionally, Tables 3 and 6 contain the number and the percentage of price epochs where min-max ranges of Binance and Bitstamp were disjoint (*#disjoint* and *%disjoint*).

Binance trade prices were converted from cryptocurrency/USDT to cryptocurrency/USD using Bitstamp's USDT/USD trades.

4.1 Time period T1 – December 2022

Tables 1 and 2 show FTSO and exchange aggregated price comparison for Bitstamp and Binance, respectively, for the data from time period T1 in December 2022. Observe that despite many epochs with FTSO prices lying completely outside the min-max band, the rRMSE is very small.

Table 1: FTSO vs. Bitstamp, December 2022

	Flare				Songbird			
	#p.e.	#out	%out	rRMSE	#p.e.	#out	%out	rRMSE
BTC	5031	2815	56	0.00027	5031	2889	57	0.0003
ETH	4982	2079	42	0.00036	4982	2191	44	0.00042
XRP	4786	1750	37	0.00059	4786	1863	39	0.00063

Table 2: FTSO vs. Binance [USD converted], December 2022

	Flare				Songbird			
	#p.e.	#out	%out	rRMSE	#p.e.	#out	%out	rRMSE
BTC	5040	740	15	0.00026	5040	1021	20	0.0003
ETH	5040	1171	23	0.00038	5040	1291	26	0.00044
XRP	5040	392	8	0.00043	5040	435	9	0.00047

Table 3 compares the min-max ranges between the two exchanges.

Table 3: Binance [USD converted] vs. Bitstamp, December 2022

	#p.e.	#disjoint	%disjoint	rRMSE
BTC	5031	578	11	0.00021
ETH	4982	550	11	0.00022
XRP	4786	349	7	0.00047

The percentage of FTSO prices falling out of the exchange's min-max trading price range is similar on both Songbird and Flare, for both Bitstamp and Binance. Furthermore, the rRMSEs

are similar across networks and exchanges. Even though the fraction of the price epochs where FTSOs lie outside the min-max ranges of the exchanges is relatively high, this is not unexpected, given that the two exchanges themselves have disjoint min-max ranges in about 10% of the epochs and the FTSO data providers typically consider several exchanges (not just Binance and Bitstamp) when computing the prices. Note that both networks are closer to Binance than Bitstamp.

4.2 Time period T2 – April/May 2023

Tables 4 and 5 show FTSO and exchange aggregated price comparison for Bitstamp and Binance, respectively, for the data from time period T2.

Table 4: FTSO vs. Bitstamp, April/May 2023

	Flare				Songbird			
	#p.e.	#out	%out	rRMSE	#p.e.	#out	%out	rRMSE
BTC	5038	1938	38	0.00057	5038	1769	35	0.00055
ETH	5011	2128	42	0.00055	5011	2109	42	0.00056
XRP	4579	2130	47	0.00065	4579	2145	47	0.00066

Table 5: FTSO vs. Binance [USD converted], April/May 2023

	Flare				Songbird			
	#p.e.	#out	%out	rRMSE	#p.e.	#out	%out	rRMSE
BTC	5040	1484	29	0.00054	5040	1413	28	0.00052
ETH	5040	1412	28	0.00053	5040	1419	28	0.00054
XRP	5040	1181	23	0.0006	5040	1201	24	0.00061

Table 6 compares the min-max ranges between the two exchanges. We observe that the fraction of disjoint ranges has decreased. This can be attributed to the increase in min-max range (indicating increased volatility, as can be seen on the graphs in Section 5).

Table 6: Binance [USD converted] vs. Bitstamp, April/May 2023

	#p.e.	#disjoint	%disjoint	rRMSE
BTC	5038	106	2	0.0002
ETH	5011	150	3	0.00023
XRP	4579	146	3	0.00038

Once again, Flare and Songbird networks are comparable, both in out percentages and in rRMSEs. The addition of the percentage reward band thus does not have a significant impact on the FTSO prices.

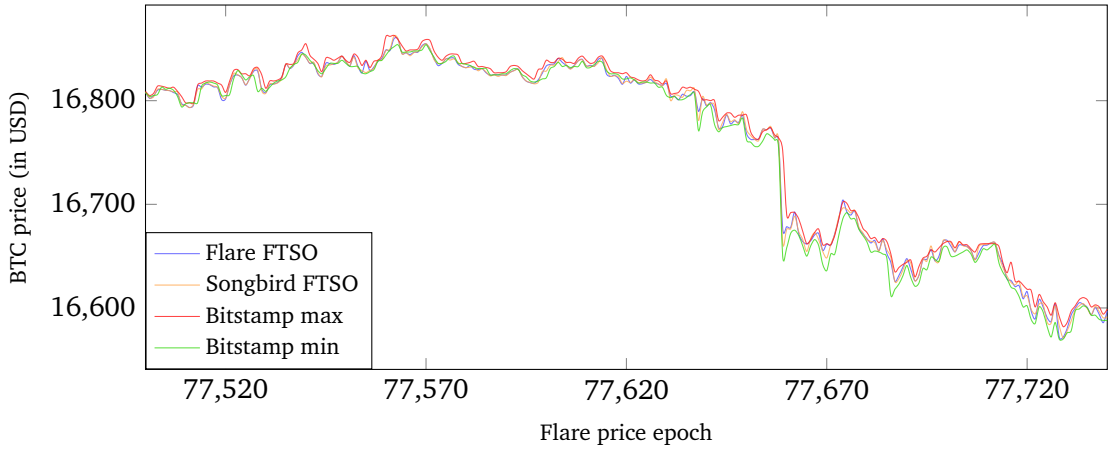
5 Graphical comparison of exchanges vs. FTSO

The following subsections compare BTC, ETH and XRP trade price aggregates on Bitstamp and Binance downloaded from [3] and [4] for 240 price epochs (12 hours) on December 22, 2022, and 240 price epochs on April 28, 2023. The values on the x-axis correspond to the price epochs on the Flare network; the price epochs from Songbird were aligned using the timestamps. Note that prices of cryptocurrencies on Bitstamp are available against USD, while on Binance, prices of cryptocurrencies are in USDT and were converted to USD for comparison, as mentioned above.

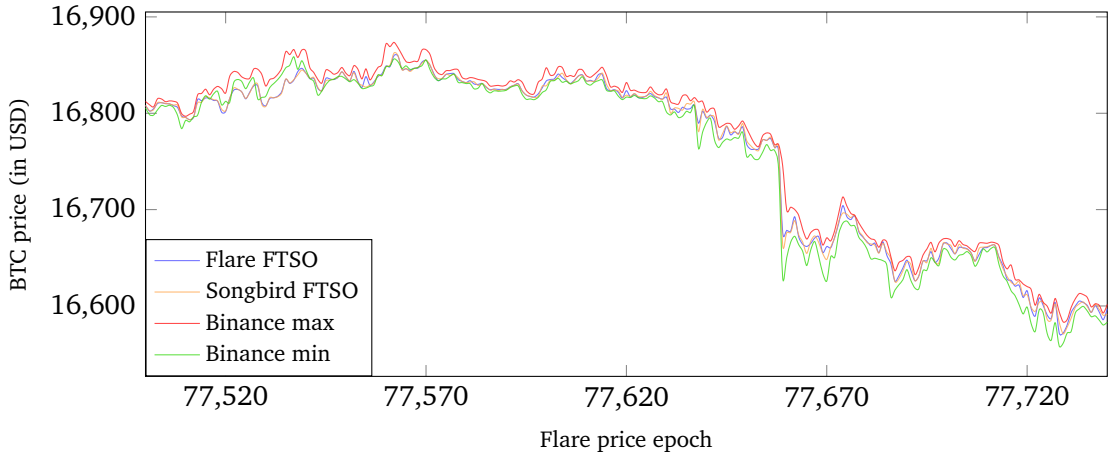
The graphs show exchange's min and max price and Flare and Songbird FTSO prices as described in each graph's title and legend.

5.1 BTC

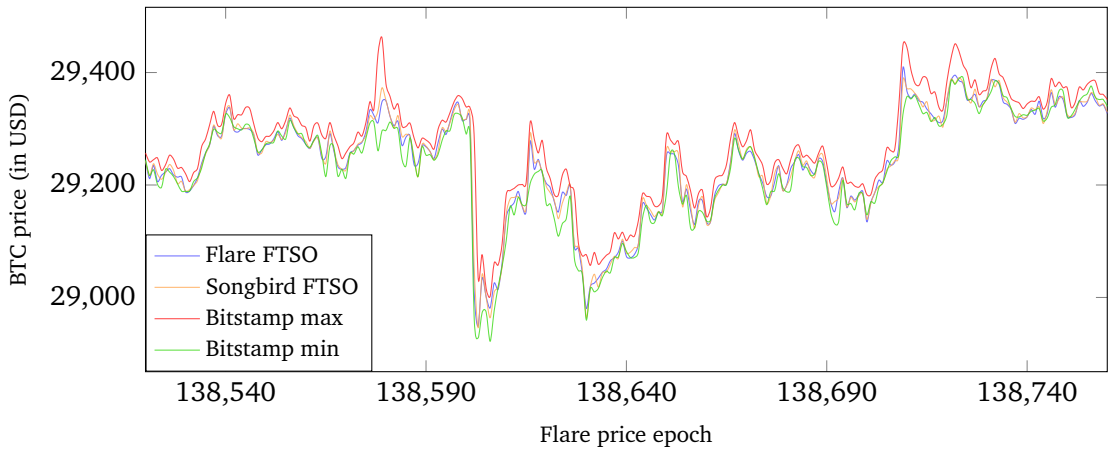
Graph 1: Bitstamp vs. FTSO prices for BTC, December 22, 2022



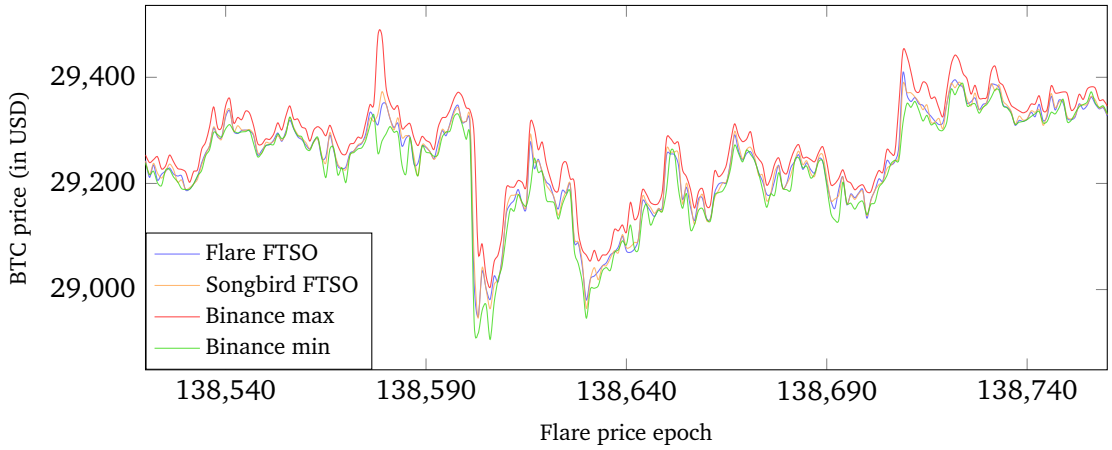
Graph 2: Binance [USD converted] vs. FTSO prices for BTC, December 22, 2022



Graph 3: Bitstamp vs. FTSO prices for BTC, April 28, 2023

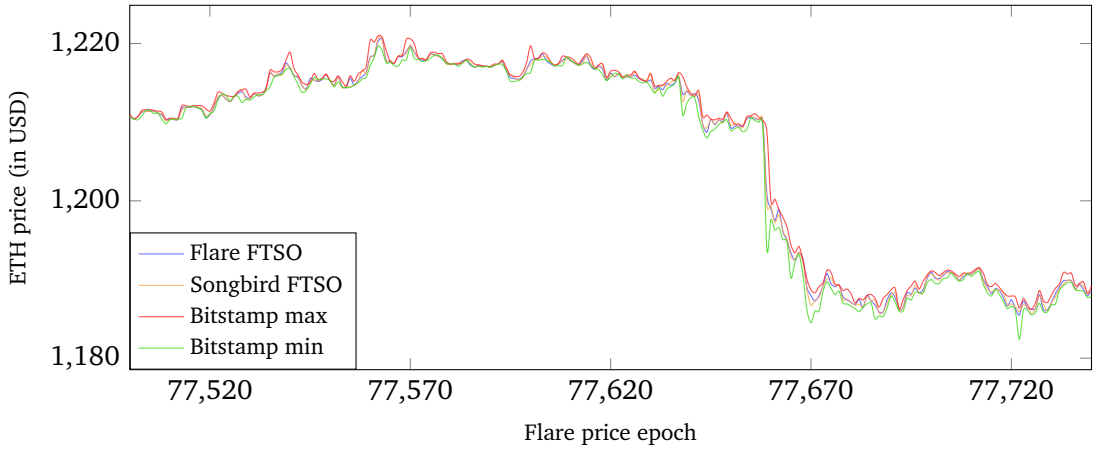


Graph 4: Binance [USD converted] vs. FTSO prices for BTC, April 28, 2023

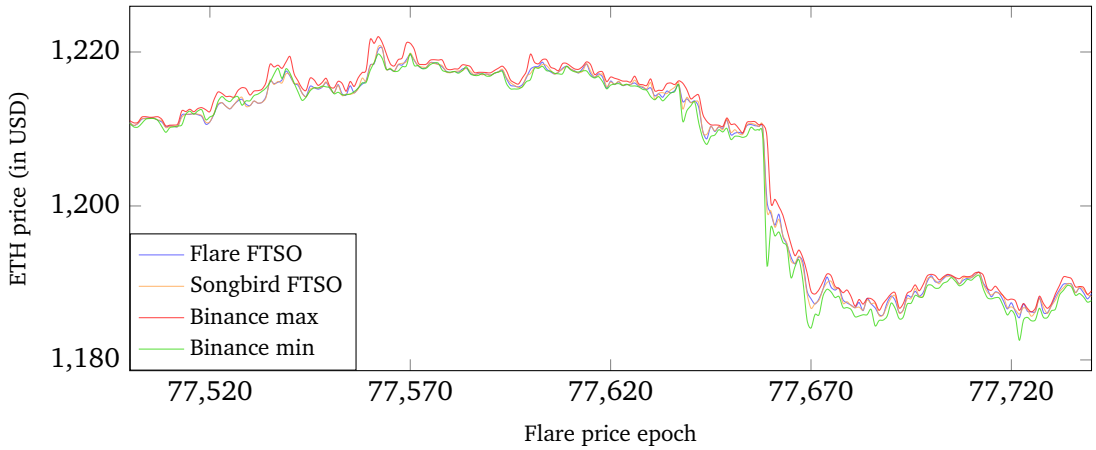


5.2 ETH

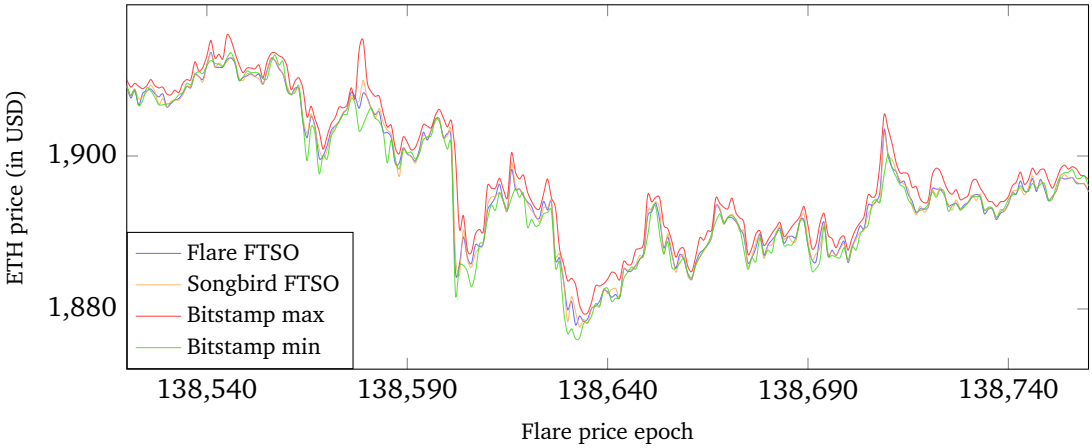
Graph 5: Bitstamp vs. FTSO prices for ETH, December 22, 2022



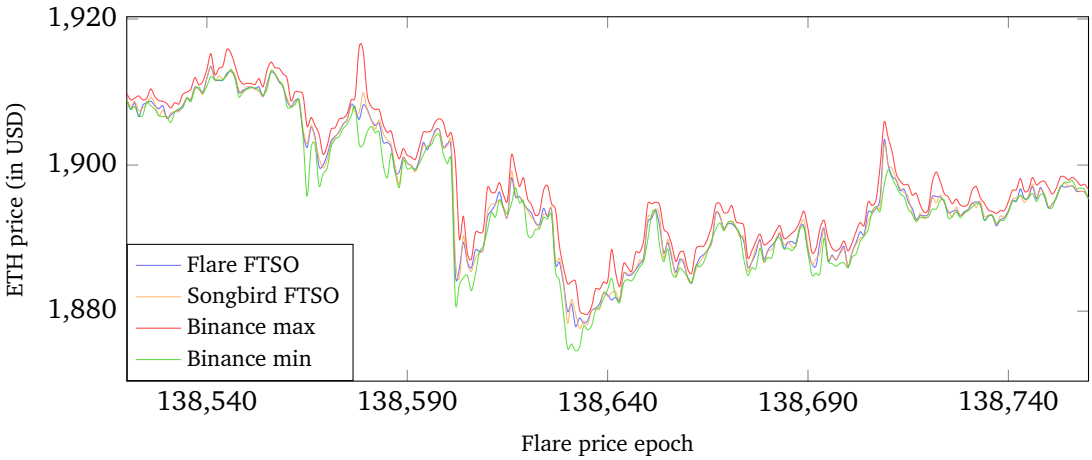
Graph 6: Binance [USD converted] vs. FTSO prices for ETH, December 22, 2022



Graph 7: Bitstamp vs. FTSO prices for ETH, April 28, 2023

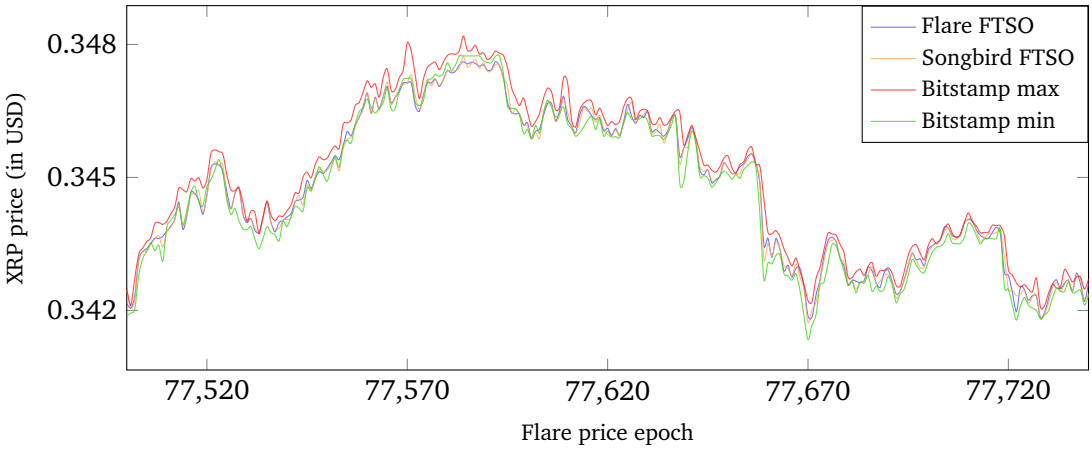


Graph 8: Binance [USD converted] vs. FTSO prices for ETH, April 28, 2023

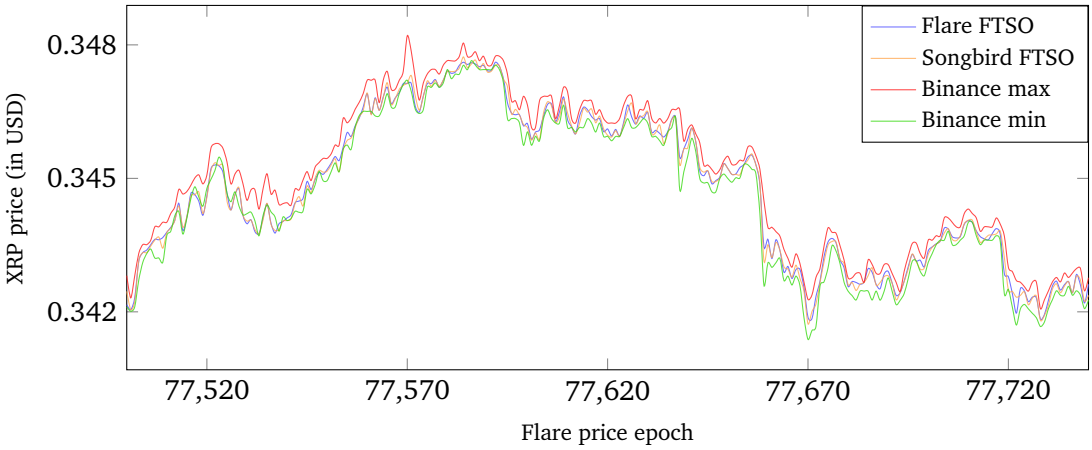


5.3 XRP

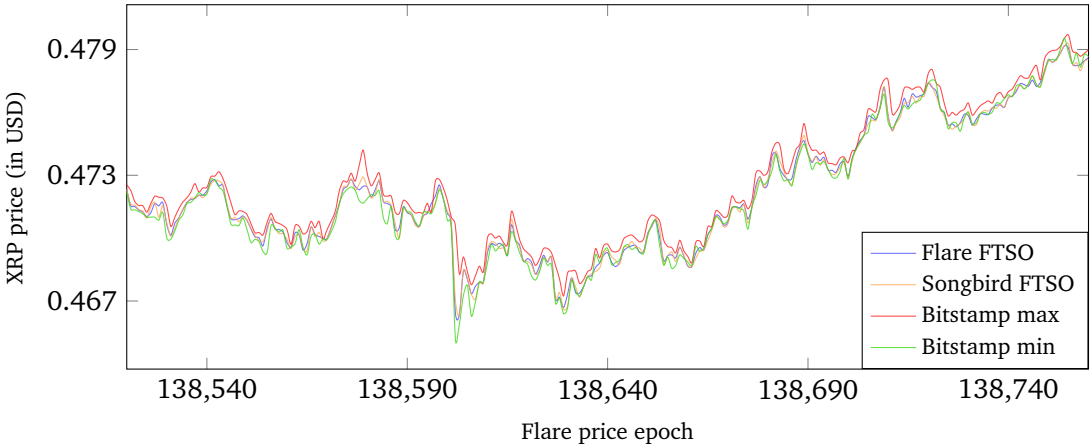
Graph 9: Bitstamp vs. FTSO prices for XRP, December 22, 2022



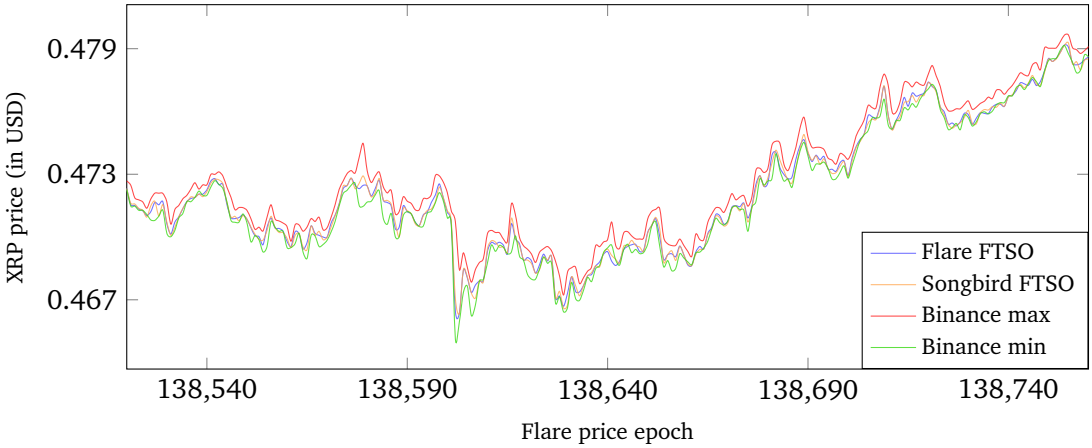
Graph 10: Binance [USD converted] vs. FTSO prices for XRP, December 22, 2022



Graph 11: Bitstamp vs. FTSO prices for XRP, April 28, 2023



Graph 12: Binance [USD converted] vs. FTSO prices for XRP, April 28, 2023



6 Impact on rewards

In December 2022, the strategy was to reward 50% of the vote power centered at the weighted median on both chains (the interquartile range). In April 2023, the rewards on Flare network were still calculated using the median strategy while on Songbird, STP.02 was already implemented and therefore the percentage band was also taken into account when determining the providers eligible for rewards. Tables 8 and 9 show:

- the average percentage of rewarded data providers (%dp),
- the average percentage of rewarded voting power relative to the reward epoch's total vote power (%vp),

- the average percentage of rewarded voting power relative to the sum of all the vote powers of the providers that submitted prices in each price epoch (%*vp**),
- the width of the percentage band as defined by STP.02 (only on Songbird network in period T2),

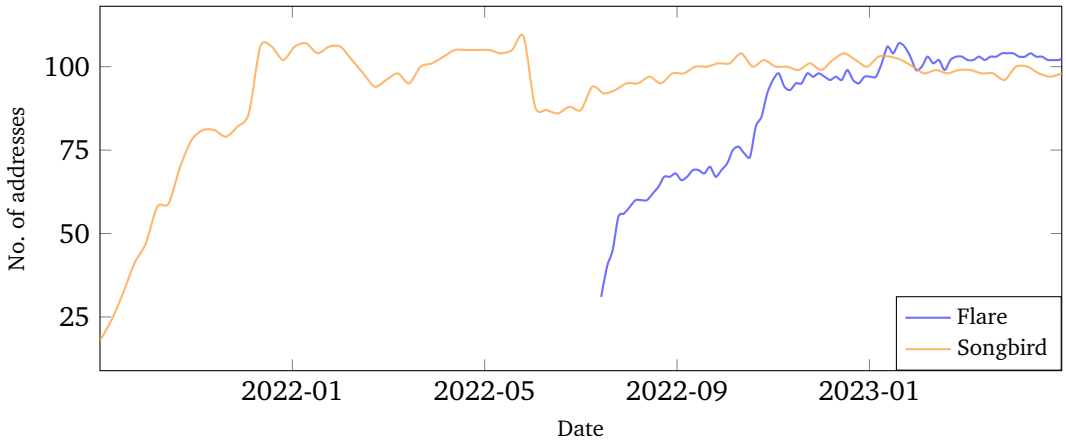
on each network for the periods T1 and T2 according to the rewarding strategy that was valid during each period.

As described in the Flare white paper [1], in each price epoch an FTSO is randomly chosen for the reward. This means that each cryptocurrency is relevant for rewards calculation for approximately 1/12 of price epochs. In our calculation of the percentage of the rewarded data providers, we used all the price epochs where any of the three currencies being analysed was rewarded. There may be slight deviation from the actual reward percentages due to the random selection of providers whose price lies on the borders of the interquartile reward band.

Table 7: Number of distinct addresses with non-zero vote power submitting FTSO prices

Network	December 2022	April/May 2023
Flare	88	99
Songbird	104	98

Graph 13: Number of distinct addresses submitting FTSO prices, zero vote power included



Note also that the vote power cap on Flare is 2.5% while on Songbird, the vote power cap was lowered from 10% in period T1 to 2.5% in period T2.

Table 8: Flare vs. Songbird average portion of rewarded data providers, December 2022

	FLR			SGB		
	%dp	%vp	%vp*	%dp	%vp	%vp*
BTC	49	40	50	20	44	50
ETH	49	40	50	18	44	50
XRP	49	39	49	17	34	39
ADA	48	39	49	23	42	48
ALGO	49	39	49	24	43	49
DOGE	43	34	43	26	36	41
BCH	49	40	50	27	54	61
DGB	40	32	41	34	39	44
FIL	49	40	50	27	53	61
FLR[1]/SGB	/	/	/	29	35	42
LTC	49	40	50	26	54	61
XLM	45	36	45	24	36	41

[1]There are no FLR price submissions before January 18, 2023.

Table 9: Flare vs. Songbird average portion of rewarded data providers, April/May 2023

	FLR			SGB			
	%dp	%vp	%vp*	%dp	%vp	%vp*	d[%]
BTC	23	41	53	66	80	90	0.010
ETH	24	41	53	75	83	92	0.015
XRP	23	33	43	72	82	92	0.015
ADA	23	34	44	75	83	93	0.020
ALGO	25	32	42	68	80	90	0.020
DOGE	29	32	42	75	83	93	0.020
BCH	27	40	52	69	80	90	0.050
DGB	34	33	43	61	73	82	0.020
FIL	27	41	52	73	82	92	0.020
FLR/SGB	28	30	40	52	64	72	0.050
LTC	26	41	52	76	83	93	0.020
XLM	25	31	40	63	78	87	0.020
XRP	23	33	43	72	82	92	0.015

As can be seen from Table 8, significantly less than half of the providers were rewarded on Songbird during T1, although roughly 50% of the vote power was being rewarded. This leads to more centralisation of the network as token holders prefer to delegate to those providers that are being rewarded. In contrast, we observe no such behavior on Flare network during T1 as there were no significant token holders (aside from the foundation) that could have delegated to different providers. The situation on Flare network changed after the TDE on January 9, 2023. This is reflected in the reward data for T2 in Table 9, where the fraction of the providers that are rewarded on the Flare network is very similar to the situation on the Songbird network during T1. In contrast to this, the effect of STP.02 on the reward distribution is positive, since more providers are being rewarded, leading to a more decentralised network.

7 Conclusion

The analysis in Section 4 shows that adding the percentage reward band did not have a negative impact on the price quality on Songbird. Specifically, the quality of the submitted prices on Songbird is comparable to the quality on Flare, during T1 and T2, although no change in rewarding took place on Flare. Indeed, this is supported by Section 4, which shows that the rRMSE as well as the percentage of FTSO prices falling out of the exchange's min-max range trading price are similar in both T1 (December 2022) and T2 (April 2023) between the networks. Thus, we conclude that STP.02 has no significant impact on FTSO price accuracy.

Note that both of these metrics increase across each network from T1 to T2. The increase in rRMSE and the number of epochs where the Flare/Songbird prices lie outside the min-max interval of the exchanges is thus not related to the changes implemented by STP.02 and is more likely a consequence of a more volatile market – the downfall of Silicon Valley Bank, Signature Bank and Silvergate Bank, all within a short time, drastically affected the stablecoins USDC and USDT, which lost their peg to the U.S. dollar, creating a panic in the crypto industry. The effect of the depeg event on the FTSO system will be analysed in a separate report.

Section 6 shows that the introduction of the percentile band increased the percentage of rewarded providers from approximately 25% to 66%. Thus, we concluded that STP.02 has a positive impact on decentralisation.

References

[1] Flare Networks. *The Flare network and FLR token*. https://flare.network/wp-content/uploads/Flare-White-Paper-v2.pdf. 2022.

[2] Flare Networks. *Songbird Test Proposal 02: Add a secondary band to FTSO reward calculation*. https://flare.network/stp02/. 2023.

[3] Binance. *Binance API*. https://api.binance.com/api/v3/klines. 2023.

[4] Bitstamp. *Bitstamp API*. https://www.bitstamp.net/api/v2/ohlc/*/'. 2023.