



Scroll

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Executive Summary

The following report goes over transaction fees on Scroll and its profitability. It covers both the revenue side (gas fees acquired) and the cost side (transaction fee payments for DA and Proof submission on Ethereum). Proof generation costs are excluded due to the lack of publicly available data.

Scroll currently uses ETH for gas fees and follows the traditional Ethereum pre-EIP1559 fee pricing model, where users specify the gas price they are willing to pay (it must be higher than minimum). Although the fee model does not explicitly cover proof verification and generation costs, these are included in the Layer 2 (L2) fee portion and ensured by the minimum gas price. While Scroll claims to subsidize proof generation and verification costs, our assumption is that these costs can be covered by the revenue from transaction fees as they are in profit in 99% of the days. However, we must have in mind that the users are speculating on the potential Scroll airdrop so some of the fees are coming from farming.

Impact on our design: Overall, our position is that while their fee model is straightforward and ensures coverage of proof verification and generation costs (this is uncertain) , it is not optimal for our sharded system in the long run. This is because it lacks dynamic fee adjustment based on network congestion that other solutions implemented. Total profit is 4,172.24 ETH.

Introduction

Scroll is a Layer 2 Zero knowledge rollup built on Ethereum launched in October 2023. It uses ETH as its currency for paying transaction fees for interacting with and deploying on the network. It aims for a constant block time of 3 seconds and gas limit of 10,000,000 gas per block.

Goals & Methodology

The main goal of the report is to analyse Scroll data before and after EIP4844 upgrade and to determine:

- Average cost of verification

- Number of transactions over time
- Data Availability cost (ETH)
- Average time between submissions for both Data Availability and ZK Proofs
- Fee (movement, adj fee)
- Total revenue
- Economics specifics

This research is performed by obtaining both Ethereum Mainnet and Scroll data using Dune Analytics and performing statistical analysis. The Pricing mechanism and other specifics are acquired by reading official documentation, blogs, and other materials on Scroll network.

Results & Discussion

Transaction Pricing Mechanism Specifics

Scroll uses ETH as its utility (fee payment) token and employs the classic Ethereum pre-EIP1559 fee pricing model where the user specifies the price he is willing to pay per unit of gas. Although it uses the "classic" fee model it introduces new properties listed in the following paragraphs.

L2 Originated Transactions

The cost of transaction is constructed of:

- $I2TransactionExecutionFee$ - which is the classic Ethereum transaction fee pricing mechanism. It is calculated as follows:

$$I2TransactionExecutionFee = I2TransactionGasUsed \times I2TransactionGasPrice$$

- L1 fee - The cost of L1 fee for a transaction depends on the number of zeros and non-zero bytes in its payload. It can be estimated by using [L1GasPriceOracle](#).

L1 fee is based on:

- The bytes which are zeros and non-zeros of an RLP-encoded transaction with Signature
- $L1baseFee$ (accessible via oracle) - current base fee on Ethereum. It's updated every ~ 30seconds via relay run by Scroll
- overhead - additional gas overhead of a data commitment transaction (56) . To quote: "The overhead can be decreased as the cost of the batch submission goes down via contract optimizations" . It is added on top of L1 gas.
- scalar - used to account for price spikes (1050000000). It is used to increase the fees slightly in order to account for price spikes on L1. (see $L1GasFee$ formula)
- precision - a constant used to scale the final fee (1e9). This scales down the fee multiplied by the scalar.

We can observe that the proof verification and generation costs are not explicitly handled by the formula. They are covered by the $I2TransactionExecutionFee$ portion of the fee by ensuring minimum gas price.

It is computed as follows:

Parameters:

$tx_data_zero_gas = 4$
 $tx_data_non_zero_gas = 16$
 $L1BaseFee = \text{changes every 30 seconds}$
 $additional_non_zero_bytes^* = 4$
 $scalar = 1,050,000,000.00$

$l1Gas = zeros \times tx_data_zero_gas + (nonzeros + additional_non_zero_bytes) \times tx_data_non_zero_gas$

$$l1GasFee = \frac{(l1Gas + overhead) \times l1BaseFee \times scalar}{precision}$$

*Scroll reserves an additional 4 bytes in the non-zero bytes to store the number of bytes in the RLP-encoded transaction.

The sequencer will absorb any changes to L1 gas costs between a transaction's inclusion in a block and when the sequencer commits the data to L1. As the block time is 3 seconds the changes are "**minimal**".

L1 Originated Transactions

When sending a message from L1 (Ethereum) to Scroll, the sender pays transaction fees on L1. However, they must account for L2 execution fees, which cover the cost of processing the transaction on L2.

To estimate these fees, the sender can use the [L1MessageQueueWithGasPriceOracle](#), which provides the current $l2BaseFee$ updated by a Scroll relay. This includes L2 execution fees in the transaction's overall cost.

Proof Generation

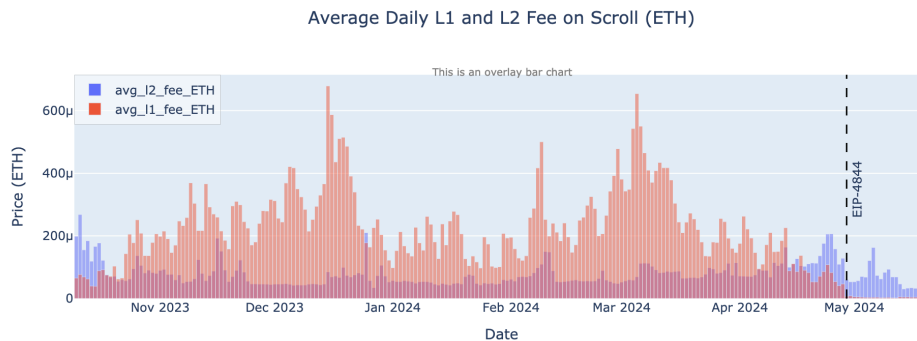
Currently, the computation required for proof generation and gas for proof verification on L1 is paid by Scroll and undisclosed proving partners. It is partially covered by setting a **floor to L2 Gas Price to 0.4 Gwei**. On May 14th they reduced the **L2 Gas Price to 0.2 Gwei**. We have no insight on the proof generation costs as this information is not publicly available.

Data Analysis

Source Dune analytics.

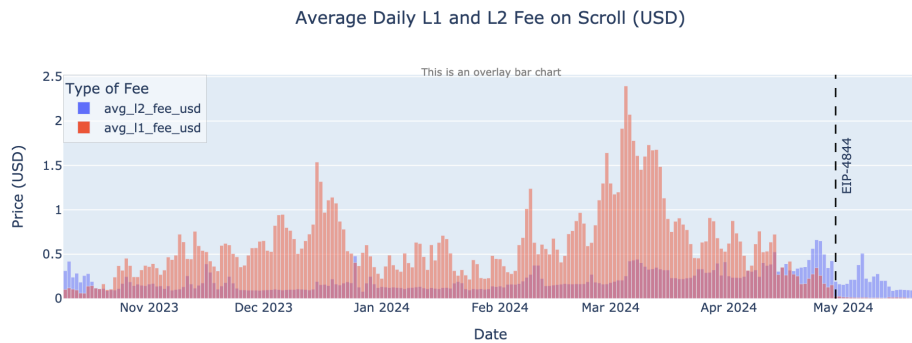
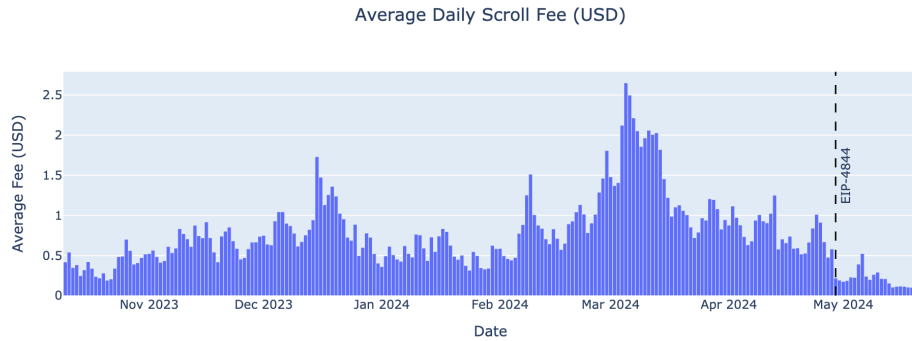
Revenue (Transaction Fees paid by users of Scroll L2 Network)

Average Daily L1 and L2 Fee movement in ETH:



We can see that once they change the minimum gas price the average L2 fee follows the same path. They halved it on May 14th.

Average Daily L1 and L2 Fee movement in USD:



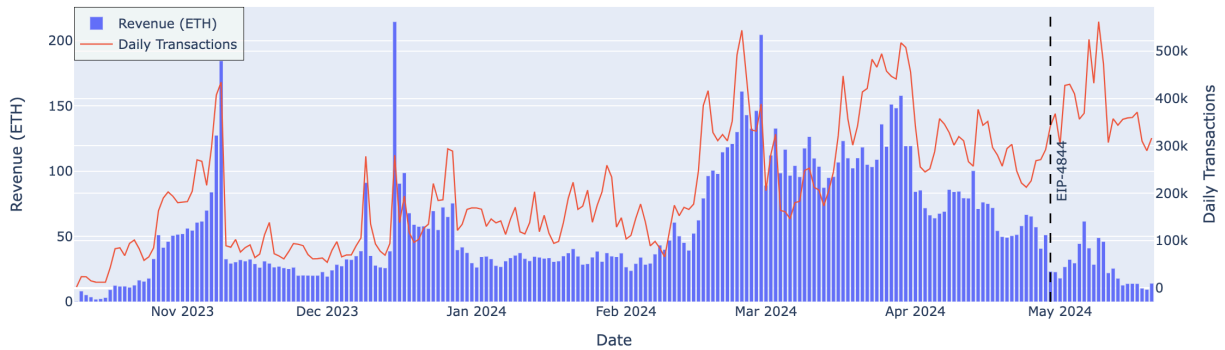
The same stands as we are essentially looking at the same graph just with different denomination.

Average scroll fee (L1 + L2 fee):

We can see that essentially what is left of the fee is 99% L2 fees.

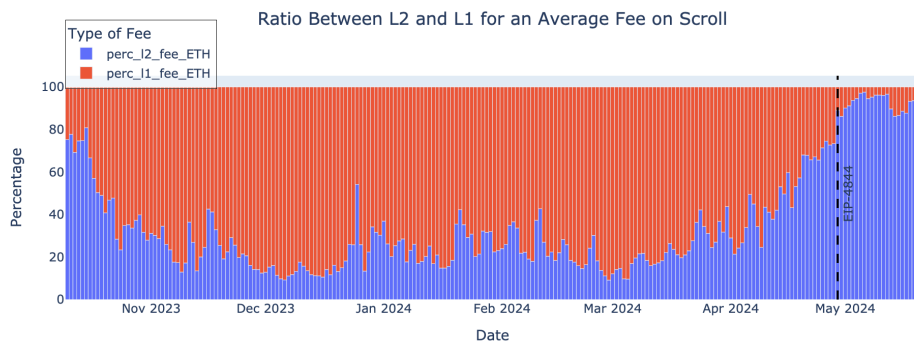
Number of transactions and fee revenue:

Daily Fee Revenue (ETH) and Number of Transactions on Scroll Over Time



EIP4844 did not influence an unusual growth in number of transactions. Number of transactions is stochastic in nature. The revenue is lesser as a result of the EIP-4844 upgrade, but the costs are also reduced so Scroll can afford it. We will examine it further in the Profitability section.

Ratio:

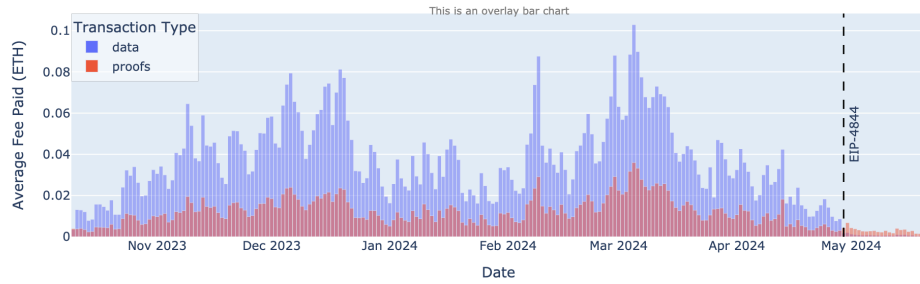


We can see that the EIP-4844 upgrade reduced the L1 fee participation in the fee.

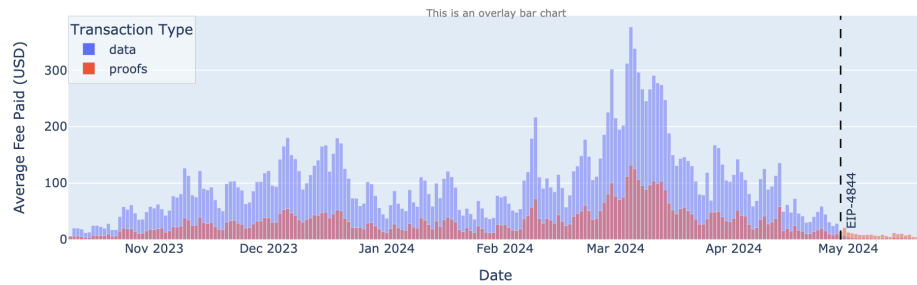
Costs (Transaction Fees paid by Committing for Ethereum Data Availability and sending proofs)*

*Overlay bar charts, not stacked

Average Fee Paid (per transaction) in ETH Over Time for DA and Proofs

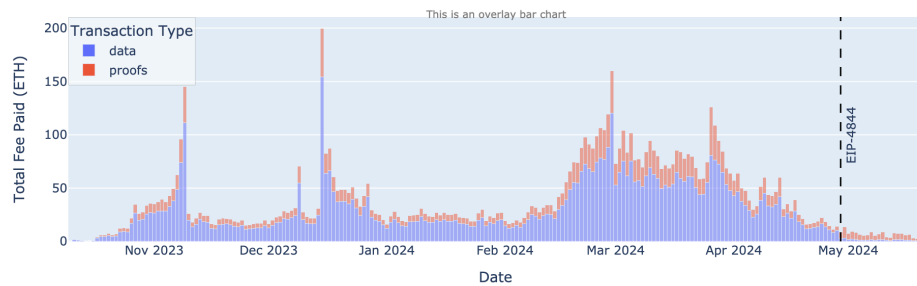


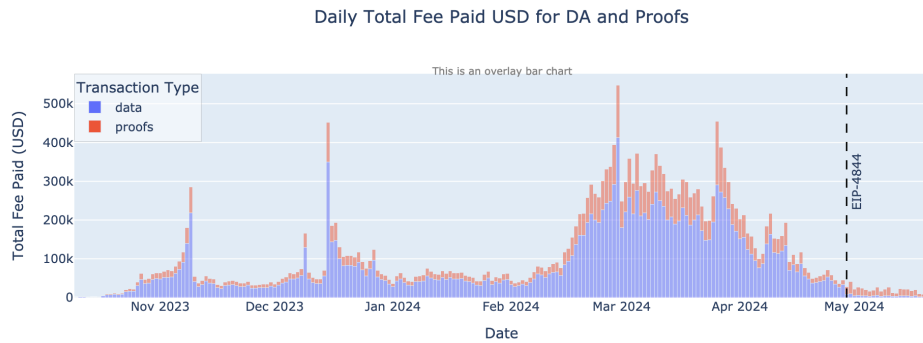
Average Fee Paid (per transaction) in USD Over Time for DA and Proofs



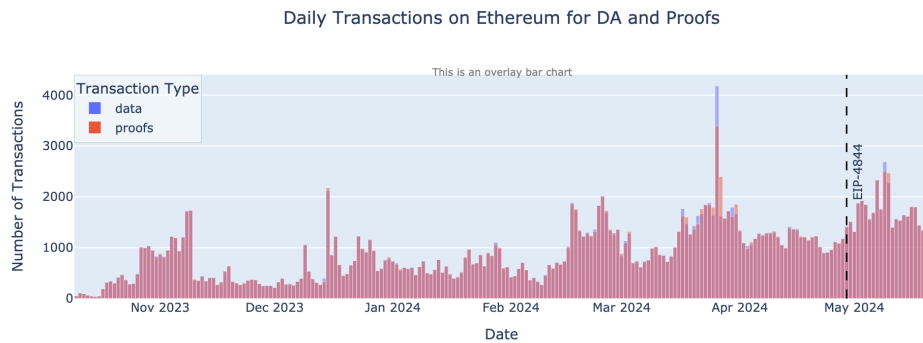
Naturally we can see the substantial fall of DA fees on L1 as a result of EIP-4844 upgrade.

Daily Total Fee Paid ETH for DA and Proofs

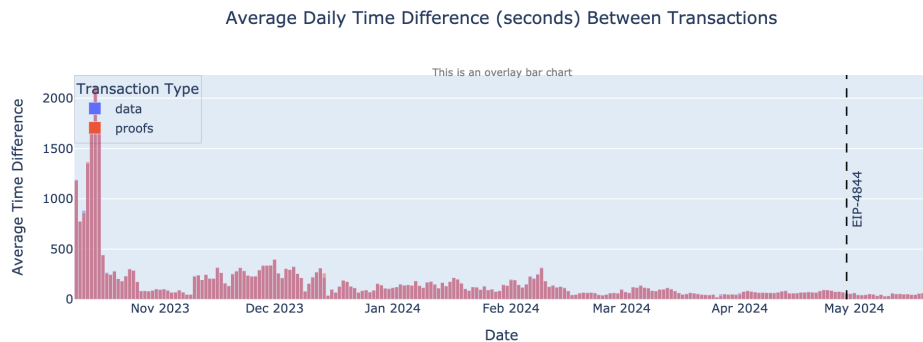




We can notice that Scroll pays a lot less L1 fees from the upgrade.



We see no significant change of number of daily transactions for DA and proofs.



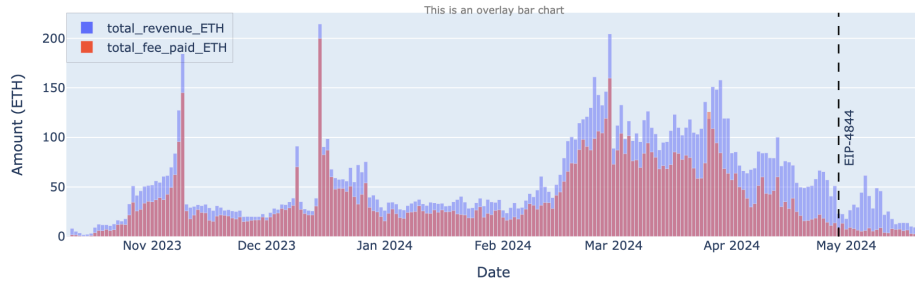
The time difference is the same since essentially 1 DA = 1 Proof in Scroll's case.

Profitability (Revenue - Costs)*

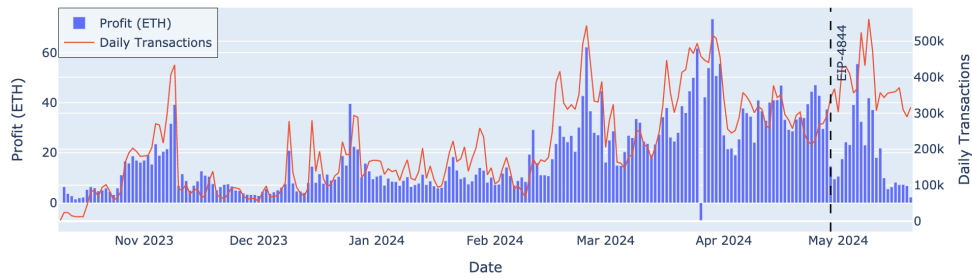
*Overlay bar charts, not stacked

Important thing to note is that for this section we have not taken proof generation costs into consideration since they are not disclosed nor publicly available.

Daily Revenue vs Costs (in ETH)

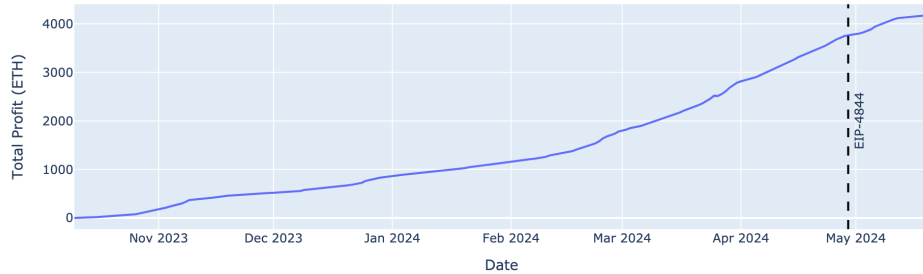


Daily Profit (ETH) and Number of Transactions on Scroll Over Time



We can see that Scroll is profitable in General (ignoring proof generation costs). Another thing we can notice is that the EIP-4844 upgrade brought slightly lower profit on average, especially after lowering the minimum fee per gas.

Total Profit (ETH)



Conclusion

Based on the available data, it is evident that Scroll generally operates profitably on a daily basis. This raises questions regarding their claim of subsidizing proof verification and generation costs. The EIP-4844 upgrade has undoubtedly contributed to a reduction in DA expenses. Given that Scroll has not yet launched its token, it is reasonable to assume that a significant portion of the accumulated transaction fees results from users speculating on a potential airdrop and engaging in farming activities.

Our assumption is that, at present, Scroll should be able to cover data availability (DA) and proof generation and verification costs through the collected fees. However, it remains uncertain whether this will continue to be the case once the speculative farming activity slows down.

Data Tables

Profit table per month:

Year	Month	Profit (ETH)
2023	October	161.027312
2023	November	352.637484
2023	December	337.365412
2024	January	296.167477
2024	February	624.807385
2024	March	1007.677455
2024	April	984.710494
2024	May	984.710494

Average Fee Info Before EIP-4844 Implementation (ETH)

Statistic	avg_l2_fee_ETH	avg_l1_fee_ETH	avg_scroll_fee_ETH
mean	0.0000807750917472142	0.0002275992491882917	0.0003083743409355084
std	0.000038362027625917446	0.0001208931154606205	0.00011695819298244952
min	0.00003503045579875803	0.000039502852562265694	0.0001179723858985
25%	0.000054278695671806685	0.00014605952001735001	0.00022478792582272502
50%	0.00007023060375370503	0.0002094752044275	0.0002869574413265
75%	0.0000929056726849618	0.000280263783641925	0.000360875846742925
max	0.0002682999917612	0.0006789486582423	0.0007642059704209

Average Fee Info After EIP-4844 Implementation (ETH)

Statistic	avg_l2_fee_ETH	avg_l1_fee_ETH	avg_scroll_fee_ETH
mean	0.00006273930968841837	0.000004596524261193459	0.00006733583394960695
std	0.000032340666723289925	0.0000017885263524693759	0.00003204295169908725
min	0.00003075649092819128	0.0000021074414288806977	0.000032863932357073166
25%	0.000035092333884824094	0.0000034190566924786067	0.00004048933789158248
50%	0.0000589073513993384	0.000004375179172516263	0.00006447175205825885
75%	0.00007033311034115958	0.0000053493743365513186	0.00007471143370927947
max	0.0001631962033742	0.000008630850184579466	0.000167257371915

Average Fee Info Before EIP-4844 Implementation (USD)

Statistic	avg_l2_fee_usd	avg_l1_fee_usd	avg_scroll_fee_usd
mean	0.210188919830453	0.6060033822258766	0.816192302056327
std	0.11355981358944466	0.4032880909833549	0.43360630529120964
min	0.0802445193122867	0.0615252155395936	0.1904137390859273
25%	0.12264860983210933	0.3456754672134511	0.5234426155019887
50%	0.1684844694474501	0.5149906112226931	0.7232685514232902
75%	0.26955835432910025	0.7353190863389696	0.9524189407926551
max	0.6629775942469361	2.3948073693355845	2.6501753409511166

Average Fee Info After EIP-4844 Implementation (USD)

Statistic	avg_l2_fee_usd	avg_l1_fee_usd	avg_scroll_fee_usd
mean	0.19084217916740986	0.01397455063699214	0.20481672980439775
std	0.10123896116221824	0.005641154987154237	0.10054245170757103
min	0.0901234308604421	0.0065276160834083	0.1017931651519317
25%	0.10659683428834597	0.010302568810653126	0.12312508482546665
50%	0.17946890538491178	0.0132458620750608	0.19529182592611188
75%	0.21438134556407307	0.015747579982978575	0.2283475640139485
max	0.5103533607144654	0.0264960049142114	0.5230536011023521

Descriptive Statistics for DA and Proofs Before EIP-4844

statistic	metric	data	proofs
total_transactions	mean	845.9257425742575	845.7821782178218
total_transactions	std	522.8155876951337	510.74655345861964
total_transactions	min	40	40
total_transactions	25%	427.75	419.25
total_transactions	50%	749	746
total_transactions	75%	1196	1200.5
total_transactions	max	4181	3390
avg_time_diff	mean	180.8406648596	179.65592412617195
avg_time_diff	std	256.04531474005233	256.302100302428
avg_time_diff	min	20.656302320019133	25.465486725663716
avg_time_diff	25%	72.18575777246973	71.70595578072673
avg_time_diff	50%	115.17220246530655	112.64345650921965
avg_time_diff	75%	201.18938510974345	200.05897322957958
avg_time_diff	max	2117.1	2119.8
avg_fee_paid_ETH	mean	0.03798805604210263	0.012652710009997877
avg_fee_paid_ETH	std	0.01928436030509169	0.00650819360471451
avg_fee_paid_ETH	min	0.0036045467547742	0.0023870146707629
avg_fee_paid_ETH	25%	0.023852693512694426	0.00816409102955575
avg_fee_paid_ETH	50%	0.0349448294345703	0.0117646245390279
avg_fee_paid_ETH	75%	0.047334563465982596	0.016033820968609724
avg_fee_paid_ETH	max	0.1029516345096625	0.0360406015719124

Descriptive Statistics for DA and Proofs After EIP-4844

statistic	metric	data	proofs
total_transactions	mean	1735.7142857142858	1736.3333333333333
total_transactions	std	344.3479552512462	340.3567735969615
total_transactions	min	1312	1316
total_transactions	25%	1518	1519
total_transactions	50%	1641	1645
total_transactions	75%	1851	1847
total_transactions	max	2688	2505
avg_time_diff	mean	51.31782020286924	51.222672877314075
avg_time_diff	std	8.759907544884792	8.78344575045083
avg_time_diff	min	32.125	34.39041916167665
avg_time_diff	25%	46.62560777957861	46.64212236058473
avg_time_diff	50%	52.56307129798903	52.44984802431611
avg_time_diff	75%	56.87747035573123	56.587228439763
avg_time_diff	max	65.8170731707317	65.1063829787234
avg_fee_paid_ETH	mean	0.0008905566013562524	0.003217819274593948
avg_fee_paid_ETH	std	0.0003768755198957643	0.001350562740677903
avg_fee_paid_ETH	min	0.0004626730202207	0.0015447325475555
avg_fee_paid_ETH	25%	0.0007032842535035	0.0024471890689108
avg_fee_paid_ETH	50%	0.0007626210654859	0.0029506670447261
avg_fee_paid_ETH	75%	0.0010239857112203	0.0036399797850191
avg_fee_paid_ETH	max	0.0020208921502216	0.0068689494183198