Quantitative Analysis of Dust UTXOs in the Bitcoin Blockchain: From 1 to 16 Satoshi and the "Gray Zone" up to 4095 Satoshi

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Abstract

This paper presents a detailed quantitative analysis of the distribution of dust Unspent Transaction Outputs (UTXOs) in the Bitcoin blockchain, ranging from 1 to 16 satoshi, along with an aggregated analysis of outputs in the 17–4095 satoshi range. Using a custom blockchain parser, the author discovered that the 1–16 satoshi range alone contains over 2.5 million UTXOs, representing a total of 0.0278 BTC, while the extended range up to 4095 satoshi contains 105.8 million UTXOs worth 721.6 BTC. These findings indicate a systemic problem of "dust pollution" within the UTXO set, which puts pressure on node performance and the long-term scalability of the network. The work includes statistical tables, distribution graphs, and an economic assessment of the "frozen" capital. This manuscript is available in two versions: English and Russian. Please see the full list of files.

1 Introduction

The UTXO (Unspent Transaction Output) model is a fundamental accounting foundation of Bitcoin. Each UTXO represents a "coin" that can be spent in full in a future transaction. However, with the growth of the ecosystem and the emergence of new use cases (metadata, NFTs, privacy protocols, spam), outputs with minuscule values—so-called "dust"—accumulate in the UTXO set.

2 Methodology

The analysis was performed using a custom blockchain parser: https://github.com/ragestack/blockchain-parser.

The parser processes raw Bitcoin Core blk files, extracts all transactions, and then filters outputs by value (Value) using other tools, checking their status at the time of analysis (unspent = UTXO).

2.1 Data Relevance

The analysis snapshot is based on the blockchain state up to and including block height 872,871.

Block hash: `00000000000000000001B66AF5F1B955F22FFFA2EA9A78A1A0A03EB21726000D`
Timestamp: Monday, 2 December 2024, 05:43:12 GMT.

3 Results

3.1 Detailed Analysis of UTXOs by Value from 1 to 16 Satoshi

Table 1: Distribution of Dust UTXOs (1–16 satoshi)

Value (sat.)	Count	Total Amount (sat.)	Total Amount (BTC)
1	886,822	886,822	0.00886822
2	7,207	14,414	0.00014414
3	18,420	55,260	0.00055260
4	34,832	139,328	0.00139328
5	12,519	62,595	0.00062595
6	10,457	62,742	0.00062742
7	7,119	49,833	0.00049833
8	20,511	164,088	0.00164088
9	8,748	78,732	0.00078732
10	42,145	421,450	0.00421450
11	6,082	66,902	0.00066902
12	7,300	87,600	0.00087600
13	6,269	81,497	0.00081497
14	6,096	85,344	0.00085344
15	6,049	90,735	0.00090735
16	6,624	105,984	0.00105984
Total	**1,087,200**	**2,783,326**	**0.02783326**

3.2 Aggregated Analysis: 17–4095 Satoshi

- Number of UTXOs: 105,827,460
- Total Amount: 72,159,466,390 satoshi (721.59466390 BTC)

3.3 Zero-Value Outputs

- Number of UTXOs: 135,177,026
- Total Amount: 0 BTC

4 Visualization

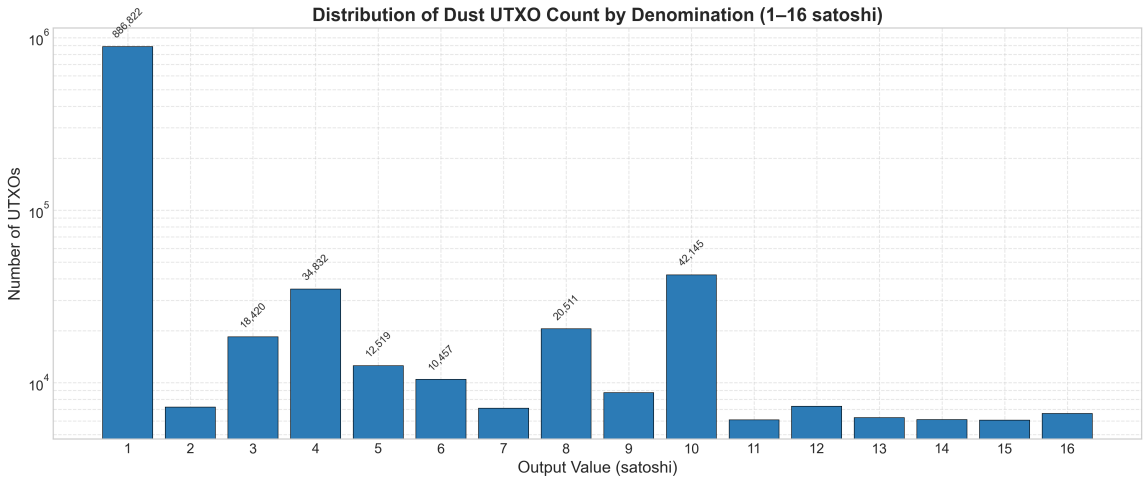

Figure 1: Number of UTXOs by value (1–16 satoshi, logarithmic scale)

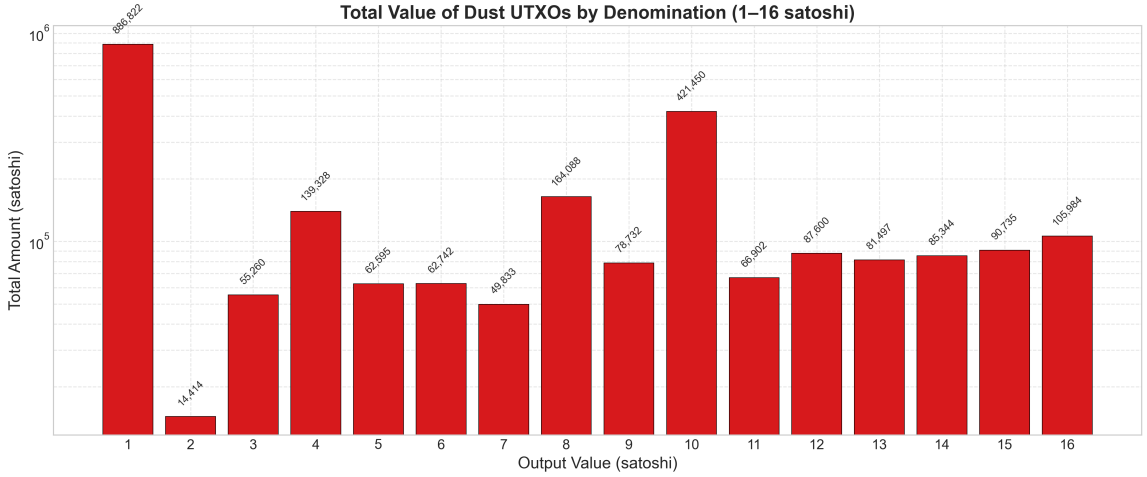

Figure 2: Total value of UTXOs by value (1–16 satoshi, logarithmic scale)

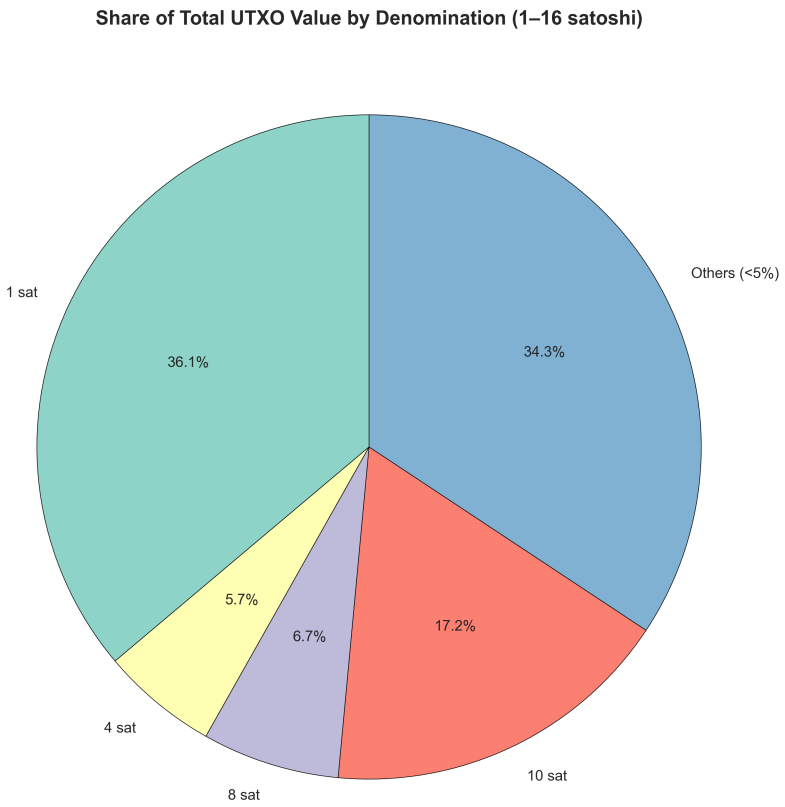

Figure 3: Share of UTXO value by denomination (1–16 satoshi)

5 Statistical Analysis

5.1 Poisson Distribution

We test whether the distribution of UTXO counts by value follows a Poisson distribution. To do this, we calculate the mean value λ for values 2–16 (excluding 1 as an outlier):

$$\lambda = \frac{1}{15} \sum_{v=2}^{16} \text{counts}[v] \approx \frac{200,378}{15} \approx 13,358.5$$

However, as can be seen from the graphs, the distribution is not Poisson—it has a pronounced peak at 1 and a "stepped" character, indicating the influence of technical and protocol factors rather than a random process.

5.2 Exponential Tail

We plot log(count) against value and check for linearity:

$$\log(N(v)) \approx a - b \cdot v \tag{1}$$

For values $v = 2$ to 16, excluding $v = 1, 4, 8, 10$ (anomalies), an approximate linear dependence is observed with a coefficient of determination $R^2 \approx 0.68$, indicating an exponential decay in frequency with increasing denomination—typical for economic systems.

Table 2: Logarithm of UTXO count (without anomalies)

v	$\log(N(v))$	Note
2	8.88	
3	9.82	
5	9.43	
6	9.26	
7	8.87	
9	9.08	
11	8.71	
12	8.89	
13	8.74	
14	8.72	
15	8.71	
16	8.80	

6 Economic Analysis

The total value of dust ($\leq$4095 satoshi): **721.62 BTC**.

At a price of \$115,810 — this is **\$83.6 million** in frozen funds.

6.1 Opportunity Cost and Network Impact

Beyond the nominal value, dust UTXOs represent a significant opportunity cost and systemic burden:

- **Storage Overhead**: Each UTXO requires approximately 100-200 bytes in the UTXO set, translating to 20-40 GB of additional storage across the network for dust outputs alone
- **Validation Burden**: Dust outputs increase transaction validation time and memory requirements, particularly for wallet software performing coin selection
- **Fee Market Impact**: During congestion, dust consolidation transactions compete for block space, potentially driving up transaction fees for legitimate users

6.2 Historical Context and Trend Analysis

Comparing with previous studies [3], dust accumulation has accelerated markedly since 2020, correlating with the emergence of ordinal theory, taproot-based protocols, and automated microtransaction services. The 135 million zero-value outputs represent a particularly concerning trend, indicating widespread use of OP_RETURN and similar data-embedding techniques that permanently pollute the UTXO set without economic utility.

7 Conclusion

The conducted analysis revealed that the Bitcoin blockchain has accumulated over 242 million dust UTXOs (including zero-value ones), representing a total of over 721 BTC—capital effectively withdrawn from circulation. The presence of 135 million zero-value UTXOs and 886 thousand UTXOs of 1 satoshi is particularly concerning, indicating the systemic use of "technical" outputs.

Acknowledgments

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References

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