

Bitcoin Data Storage Methods: Efficiency Analysis

Summary

This report analyzes the efficiency of four different methods for storing data on the Bitcoin blockchain: OP_RETURN, MULTISIG, P2TR, and P2SH. We measured transaction sizes in both bytes and vbytes across various data sizes ranging from 10 bytes to 2KB. The analysis reveals that for small data (≤ 64 bytes), OP_RETURN is most efficient, while for larger data sizes, the new P2TR offers superior efficiency thanks to the witness discount. MULTISIG becomes impractical for large data storage due to its linear scaling with data size.

TLDR;

1. **For data ≤ 64 bytes:** Use **OP_RETURN** for the most efficient transactions.
2. **For data > 64 bytes:** Use **P2TR** for the most efficient transactions.
3. P2TR is strictly superior to MULTISIG and P2SH at all transaction sizes

Transaction Types and Data Storage Methods

1. LEGACY, OP_RETURN

- One legacy input
- One OP_RETURN output (containing data up to 80 bytes)
- One legacy change output
- *Data storage method:* Direct insertion in OP_RETURN output

2. LEGACY, MULTISIG

- One legacy input
- N multisig outputs (1-of-3, storing 64 bytes per output)
- One legacy change output
- *Data storage method:* Data embedded in multisig redeem scripts

3. BECH32, P2SH (two transactions)

- Transaction 1:
 - One bech32 input
 - One P2SH output
 - One bech32 change output
- Transaction 2:
 - One P2SH input
 - One OP_RETURN output
- *Data storage method:* Data embedded in P2SH scriptsig using `OP_FALSE OP_IF <data> OP_ENDIF`

4. BECH32, P2TR (two transactions)

- Transaction 1:
 - One bech32 input
 - One P2TR output
 - One bech32 change output
- Transaction 2:
 - One P2TR input
 - One OP_RETURN output
- *Data storage method:* Ordinal-style inscription in witness data using `OP_FALSE OP_IF <data> OP_ENDIF`

Transaction Size Comparison

Size	OP_RETURN	P2TR	MULTISIG	P2SH
	Bytes vBytes	Bytes vBytes	Bytes vBytes	Bytes vBytes
10	212 212	353 239	303 303	295 241
16	218 218	359 240	303 303	301 247
32	234 234	375 244	303 303	317 263
64	266 266	407 252	303 303	349 295
80	282 282	423 256	415 415	365 311
128	N/A N/A	471 268	415 415	413 359
256	N/A N/A	599 300	639 639	541 487
1KB	N/A N/A	1367 492	1983 1983	1309 1255
2KB	N/A N/A	2391 748	3775 3775	2333 2279

Efficiency Ratio (vBytes per byte of data)

Size	OP_RETURN	P2TR	MULTISIG	P2TR vs MULTISIG	P2SH	P2TR vs P2SH
10	21.20	23.90	30.30	21% cheaper	24.10	1% cheaper
16	13.63	15.00	18.94	21% cheaper	15.44	3% cheaper
32	7.31	7.63	9.47	19% cheaper	8.22	7% cheaper
64	4.16	3.94	4.73	17% cheaper	4.61	15% cheaper
80	3.52	3.20	5.19	38% cheaper	3.89	18% cheaper
128	N/A	2.09	3.24	35% cheaper	2.80	25% cheaper
256	N/A	1.17	2.50	53% cheaper	1.90	38% cheaper
1KB	N/A	0.48	1.94	75% cheaper	1.23	61% cheaper
2KB	N/A	0.37	1.84	80% cheaper	1.11	67% cheaper

Most Efficient Method by Data Size

Size	Optimal Method	Efficiency (vBytes/byte)
10	OP_RETURN	21.20
16	OP_RETURN	13.63
32	OP_RETURN	7.31
64	P2TR	3.94
80	P2TR	3.20
128	P2TR	2.09
256	P2TR	1.17
1KB	P2TR	0.48
2KB	P2TR	0.37