UNIVERSITY OF PARIS 1 PANTHÉON-SORBONNE

Blockchain Network Analysis Project - Impact of SEC decision on Bitcoin network

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1 INTRODUCTION AND PROBLEMATICS

On January 10, 2024, the US Securities and Exchange Commission (SEC) approved the listing of a Bitcoin ETF, marking a significant step towards cryptocurrency adoption. This ETF allows investors to gain exposure to Bitcoin's price movements without direct investment in the cryptocurrency, by purchasing shares in the ETF that can be sold at any time. Our study aims to assess the impact of the SEC's decision on Bitcoin transactions.

In October 2021, the cryptocurrency market achieved a significant milestone with the introduction of the first ETF based on Bitcoin futures contracts, rather than direct investment in Bitcoin. This evolution followed traditional methods of accessing digital currencies, which involved opening a cryptocurrency exchange account and converting fiat currencies, like the dollar. The SEC's recent approval of ETF applications from 11 investment firms, including BlackRock, introduces a novel Bitcoin investment vehicle, heralding a pivotal advancement in cryptocurrency adoption with the potential to transform the industry. According to Swissquote analyst Ipek Ozkardeskaya, this move could draw substantial capital to the sector and significantly affect valuations across the cryptocurrency market. This anticipation has been reflected in the price of Bitcoin, which has surged over 150% in the past year, exceeding $45,000. Amidst geopolitical uncertainties, investors increasingly view crypto assets as a volatile yet safe haven, as suggested by BlackRock CEO Larry Fink.

2 DATA & DESCRIPTIVE STATISTICS

We have collected data from Blockchair to have transaction, input, output, address data on the 10th of January 2024.

Please refer to the following link to see where we download the database dump: **Blockchair databe dump**
Please note that we cannot include these dump into the zip file due to the huge size of the dump.

Unfortunately, we were unable to match all the hash addresses with the hash addresses for which we know the name of the entity. Indeed, the only entity we have managed to match is ebay So, for lack of data, we abandon the idea of being able to match the addresses of our graph with the names of entities

The Table 2.1 shows the number of transactions distributed over hours on the 10th of January 2024.

Also, we have computed the distribution of transaction amounts in USD in the Table 2.2. And lastly, to have an idea of the top 10 most active addresses, please refer to the Table 2.3.

Table 2.1: Transactions Distributed Over Hours on the 10th of January 2024

Time	Transactions	Time	Transactions	Time	Transactions	Time	Transactions
0	1174	6	3895	12	4424	18	1847
1	5804	7	4631	13	4259	19	4436
2	4775	8	5439	14	5563	20	3938
3	4407	9	3100	15	4900	21	2431
4	2895	10	6967	16	4879	22	3729
5	4189	11	9744	17	5709	23	2397

Table 2.2: Distribution of Transaction Amounts in USD

Statistic	Value (USD)	Statistic	Value (USD)
Count	105,532	Mean	$95,169.83
Std	$1,664,100	Min	$0.15
25%	$8.25	50%	$131.40
75%	$1,789.33	Max	$205,225,300

Table 2.3: 10 Most Active Addresses (to_transaction)

Address	Number of Transactions
bdb2a6c75b3677d263c1171eef18b2d7a571aa6c4ba6e40079e8e7a50044a6df	950
8cea47c00810efe7a090d13a6518d734bc0a4a45bb23c6de5a4259a336a39a17	145
3826b9a86ac58f3cd3b21d1196d214cb190a0e314bc1694b633c45b04238d186	132
17d849dad4cd4d3f83e9593025207048709599792efdf9b88fd9bd14dd404b70	128
d7d8ba08311a3f8eb9cca2108fa51c77c52b8bda15f89a2324541b0e6add5d0a	116
018795069b306e127d4da8f82f8d32e50702cd8e13454db6d219bde56a4a1802	108
242544cd0aad4601fd2687d8ecd553a270ac091d9dcc4fa82b5f908a6b0058f1	90
0b4e25278582a6af633953dbdf365f14d23427966a3beb8ed70a896a81e313d4	83
7b9ddc22ffa9c73858a646c5812a4374414a5c1b4ca235c5ccd6eca3ef8da761	83
454796a2eb1f8e5c7bd4b261e57bfa06fb41b7dd9949ad6a87ceef7174791a4b	83

3 Network Plots

Our network is acyclic. That's a good point because a transaction bitcoin network is directed acyclic graph because, it is not possible to make a transaction to oneself (i.e identical source address and target address for a given transaction)

Let's visualize an edge of the network:

- **source hash_adress:** `19164e615c48161141ff5c750c08c6a21202446b16720a4f27541fa32cd2c695`
- target **hash_adress:** `b3b8d806902bbbb45371a16344c004c77a3d09f280f92de83f341720aa537b7f`

3.1 Building nodes of the bitcoin transaction network

Node is a transaction with several attributes.

Let's visualize a node and its attributes. For instance, if we take the transaction hash "`19164e615c48161141ff5c750c08c6a21202446b16720a4f27541fa32cd2c695`", this node has the following attributes:

- `'time'`: '2024-01-10 00:35:31' - The timestamp when the transaction was recorded.
- `'size'`: 234 - The size of the transaction in bytes.
- `'weight'`: 609 - The weight of the transaction, considering its size and impact.
- `'input_count'`: 1 - The number of input transactions.

- `'output_count'`: 2 - The number of output transactions.
- `'input_total'`: 3,213,993 - The total value of the input transactions.
- `'input_total_usd'`: $1,477.569 - The total value of the input transactions in USD.
- `'output_total'`: 3,163,503 - The total value of the output transactions.
- `'output_total_usd'`: $1,454.3572 - The total value of the output transactions in USD.
- `'fee'`: 50,490 - The transaction fee.
- `'fee_usd'`: $23.2118 - The transaction fee in USD.
- `'is_coinbase'`: 0 - Indicates whether the transaction is a coinbase transaction (0 for false).

3.2 Descriptive statistics of the graph

The Table 3.1 provides a summary of the MultiDiGraph's key metrics.

Metric	Value
Number of nodes	383,774
Number of edges	105,532
Average degree	0.549969513307311
Density	$7.165297106718179 \times 10^{-7}$

Table 3.1: Summary of the MultiDiGraph's key metrics.

We can note that the number of nodes is more than 3 times greater than the number of edges in the graph. This explains why the density of the graph is very low. This means that a transaction block is generally linked to only one other transaction block. Furthermore, given that the number of degrees (i.e. the number of neighbors) is very small (0.5), we can deduce most of transaction blocks receive only one input transaction and don't have any output transaction.

The figure 3.1 shows a subset of the graph. The shape of the graph seems to confirm the above observations. Namely, the majority of transaction blocks are linked only to another transaction block. The vast majority of transaction blocks appear to have, on average, a single input and output. Visually, it's also clear that a large number of transaction blocks have only one input and no output.

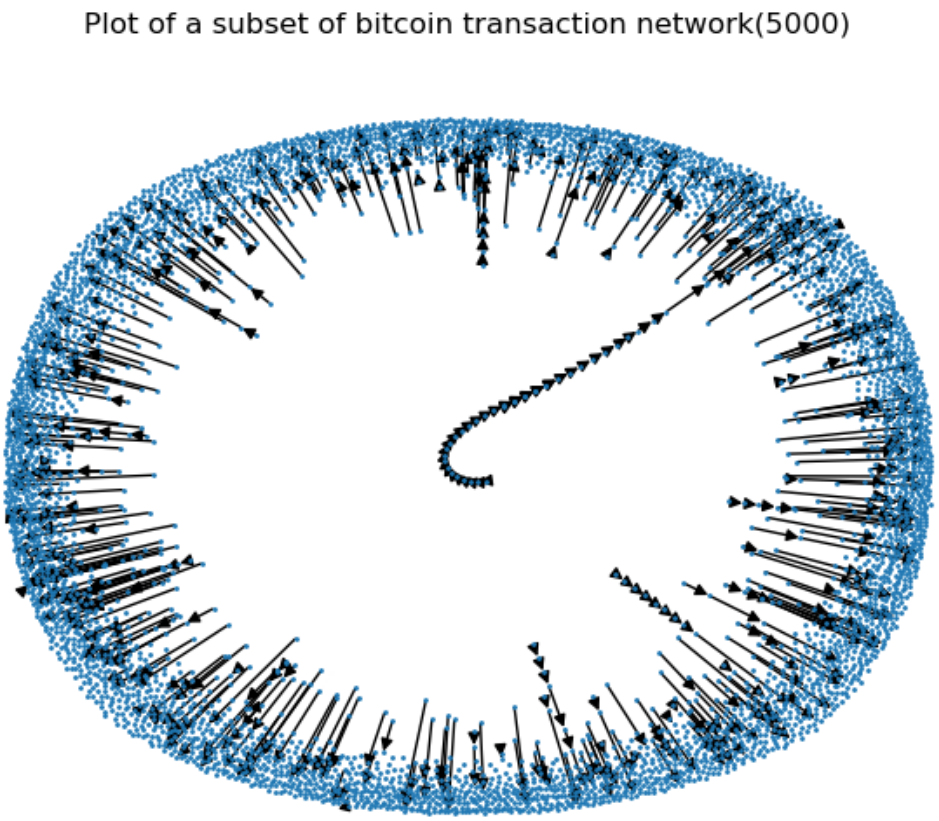


Figure 3.1: Plot of a subset of bitcoin transaction network (with 5000 nodes)

After preliminary data exploration, we asked ourselves one **first question: What do the interaction for one specific bitcoin transaction look like?**

The figure 3.2 shows the interactions for one specific bitcoin transaction with this hash: "`aa51f19748493441d743a0c408201507b99948795f7e2387a103d9c3f415c56a`". Here, we only focus on this transaction in particular. The choice of this transaction is completely arbitrary and the code can be parameterized to chose another transaction. Knowing the hash of the transaction in question, it is possible, thanks to the function, to trace all the interactions (input and output) of a block of transactions.

We can see that this transaction has way more inputs than outputs. Also, this transaction block is connected to 78 other transaction blocks (77 transactions inputs and 1 transaction output).

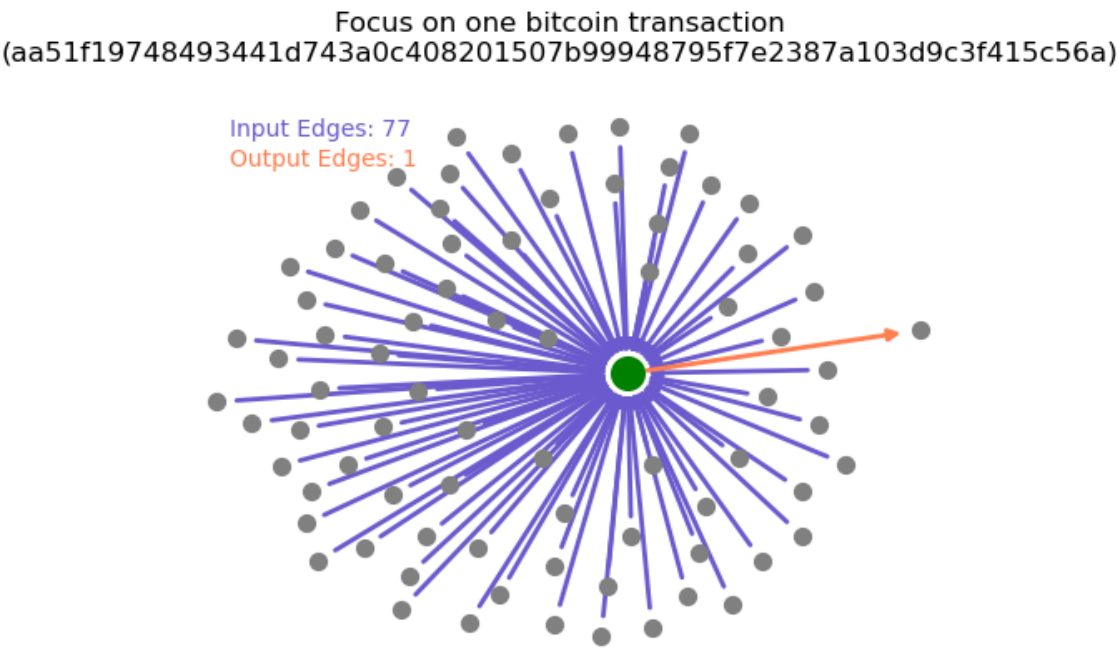


Figure 3.2: Plot of 1 bitcoin transaction

4 Analysis of the SEC's Bitcoin ETF approval on the Bitcoin transactions

The SEC's approval for the creation of Bitcoin Spot ETFs on US exchanges has important implications for the crypto sphere. It will offer a new way of investing in Bitcoin (BTC) for US investors, which could lead to increased demand and a higher Bitcoin price. Bitcoin Spot ETFs could also attract new investors, notably institutional investors.

So the aim of our study is to investigate the **impact of this announcement on Bitcoin transactions.**

To this end, we will analyze transactions that took place before and after the SEC's official announcement.

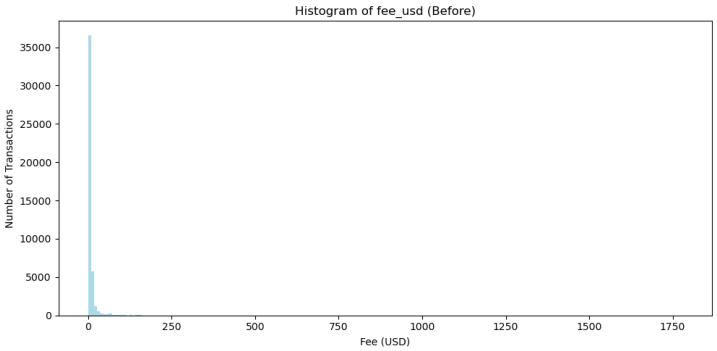
The SEC announcement took place on 10-01-2024 at 10:30pm French time, i.e. 4:30pm Wahshington time. Given that the timestamp used by bitcoin is UTC. The SEC's decision took place at 09:30pm.

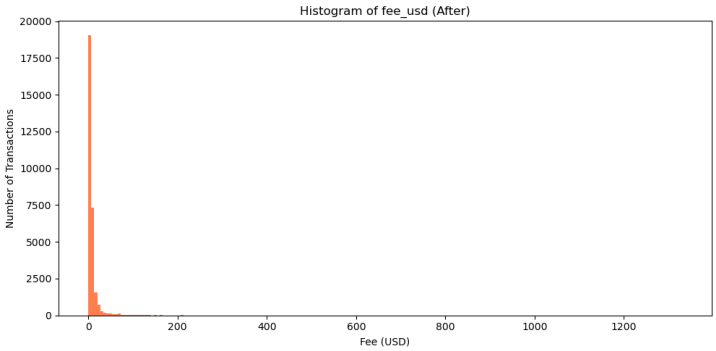
Consequently, we will analyze the transactions that took place 2 hours before and after the SEC announcement. This will also enable us to work on lighter graphs (containing fewer nodes and vertices).

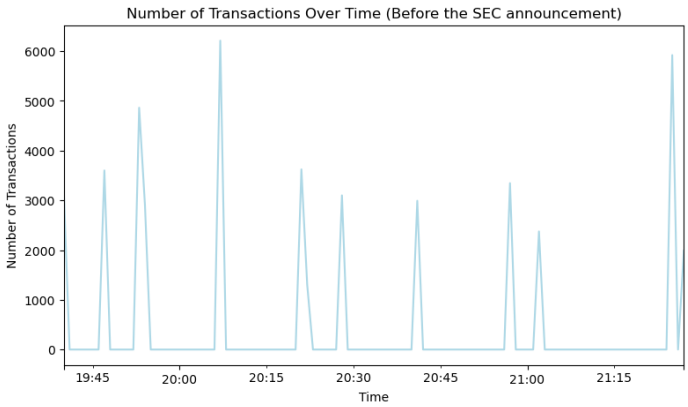
To answer to our problematic, **a second question here would be: In terms of transaction volumes, does the SEC approval have any impact?** The Figure 4.1 show that the SEC announcement on bitcoin ETFs does not seem to have had any impact on the number of bitcoin transactions. We might have expected the number of transactions to explode few minutes after the SEC's announcement, but it is not what we are seeing. In fact, the number of transactions decreased after the SEC announcement. Overall, we can observe around 3,000-4,000 transactions every 15 minutes before the SEC decision. The same phenomenon seems to reproduce after the SEC decision. We note, however, that the maximum number of transactions before the SEC decision is double the maximum number of transactions after the SEC decision.

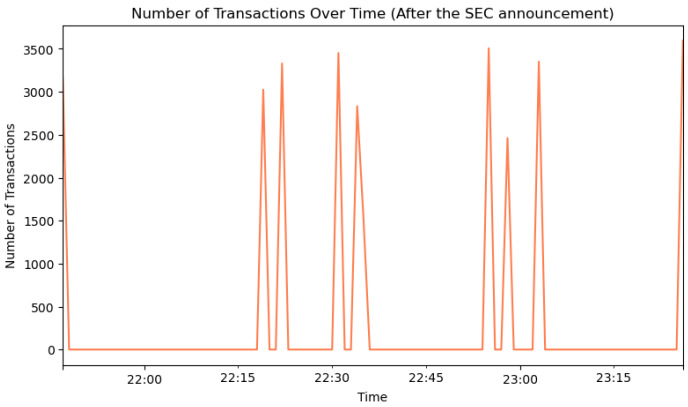
Regarding to the amounts involved in mining transaction blocks, we can observe that the fees for mining bitcoin transactions are overwhelmingly in the 2-digit range (i.e. between 0 dollars and 50 dollars). However, there are some transactions for which the mining fee is in 3 digits. For example, the maximum amount was 1750 dollars before the SEC announcement and around 1400 dollars after the SEC announcement.

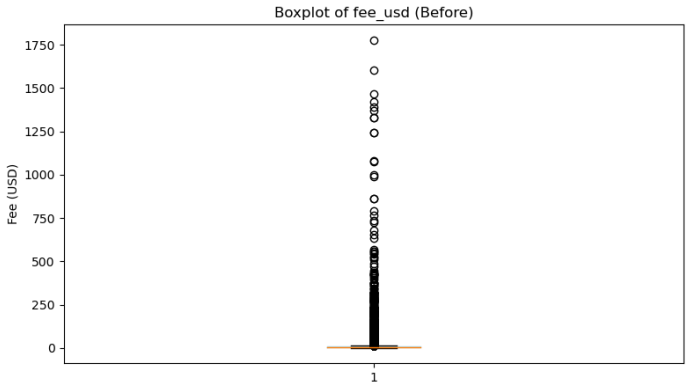
Finally, the weights associated with each bitcoin transaction block are mostly low. However, some transaction blocks stand out for their very high weights. We can imagine that these transactions are important nodes in our graph (large number of degrees). This suggests that certain nodes play the role of pivot nodes in our graph, due to the large number of neighbors. These nodes must have a large number of inputs and outputs.

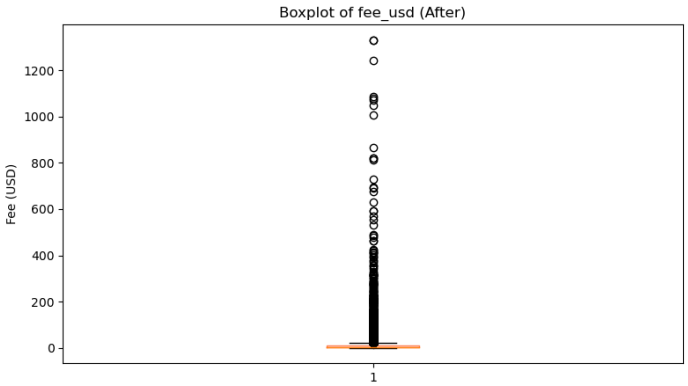

Histogram of fee_usd (Before)
Number of Transactions
Fee (USD)

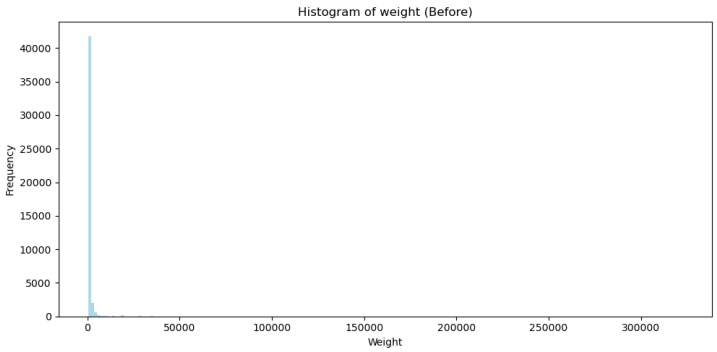

Histogram of fee_usd (After)
Number of Transactions
Fee (USD)

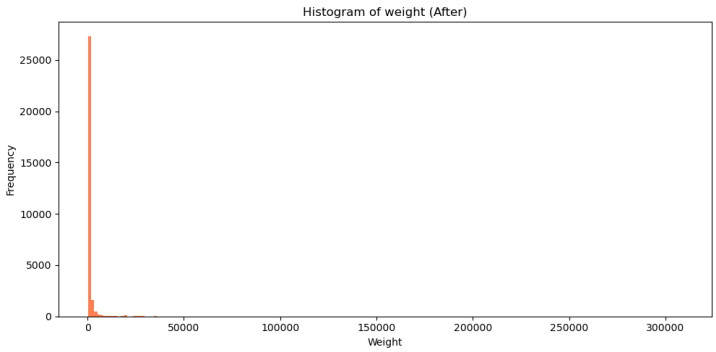

Number of Transactions Over Time (Before the SEC announcement)
Number of Transactions
Time


Number of Transactions Over Time (After the SEC announcement)
Number of Transactions
Time


Boxplot of fee_usd (Before)
Fee (USD)


Boxplot of fee_usd (After)
Fee (USD)


Histogram of weight (Before)
Frequency
Weight


Histogram of weight (After)
Frequency
Weight

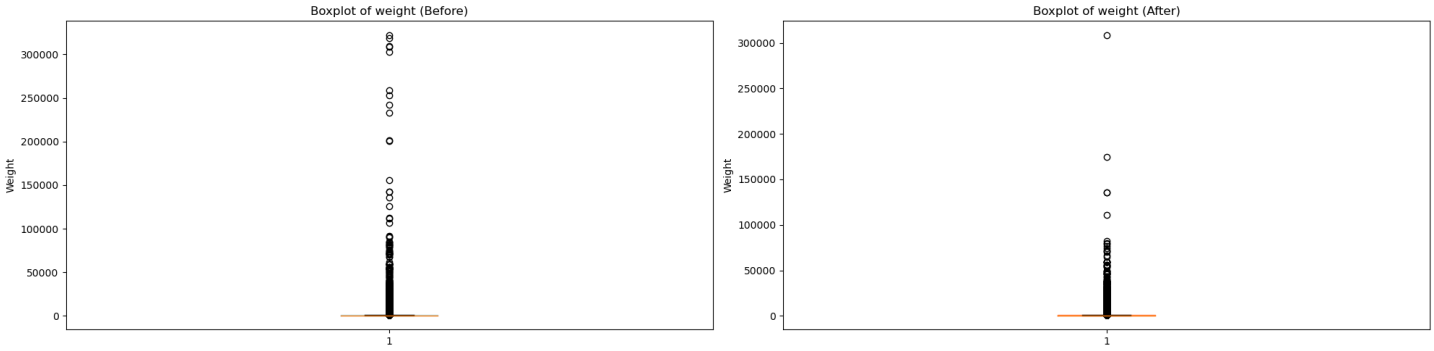


Figure 4.1: Bitcoin Transactions Plot

4.1 Focus on Two Bitcoin Transaction Networks before and after the SEC decision

To further analyse the impact of the SEC Approval, let's focus on 2 bitcoin transactions, one before and one after the SEC announcement. Our **third question is to understand how different the DiGraph could be before and after the SEC announcement in terms of nodes, edges, average degrees and density**.

Statistics before the SEC Announcement

The DiGraph before the SEC announcement exhibits the following characteristics:

Metric	Value
Number of nodes	45,415
Number of edges	6,035
Average degree	0.26577122096223715
Density	$2.9260935059919534 \times 10^{-6}$

Table 4.1: DiGraph Statistics Before the SEC Announcement.

Statistics after the SEC Announcement

Following the SEC announcement, the DiGraph changed as follows:

Metric	Value
Number of nodes	30,245
Number of edges	5,201
Average degree	0.3439246156389486
Density	$5.685832159088557 \times 10^{-6}$

Table 4.2: DiGraph Statistics After the SEC Announcement.

We can see that the statistics of the transaction graphs before and after the SEC decision on the use of bitcoin ETFs are very similar overall. However, the number of nodes in the graph after the SEC decision is lower than the graph before the SEC decision (-15,000 fewer nodes after the SEC decision). Consequently, the average number of neighbors is higher after the SEC decision.

4.2 Most Important Bitcoin Transactions

After exploring the network differences in terms of its attributes, we asked ourselves a **fourth question, which is to see which were the most important bitcoin transactions during that timestamp?**.
To do so, we have identified the nodes with the highest degrees, then we have plotted the 3000 most important nodes (thus with the highest degrees).

Note that the graph before the SEC decision has more nodes with a large number of degrees (yellow and green nodes) than the graph after the SEC decision. On the other hand, the graph after the SEC decision seems to have 2 very important nodes with more degrees (35 neighbors) than the most important nodes (25 neighbors) in the graph before the SEC decision.

Overall, the graphs confirm the statistics we calculated earlier, as they show very similar patterns. Consequently, the SEC's decision seems to have little impact on the dynamics of bitcoin transactions.

Before the SEC Announcement

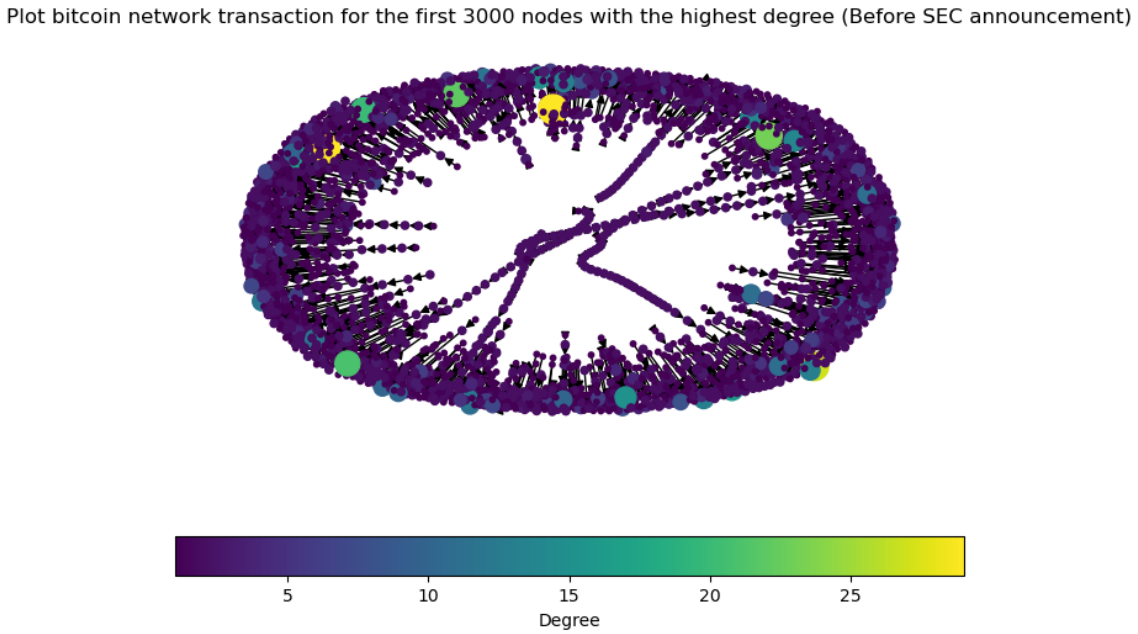


Figure 4.2: The first 3000 nodes with the highest degree BEFORE the SEC announcement

After the SEC Announcement

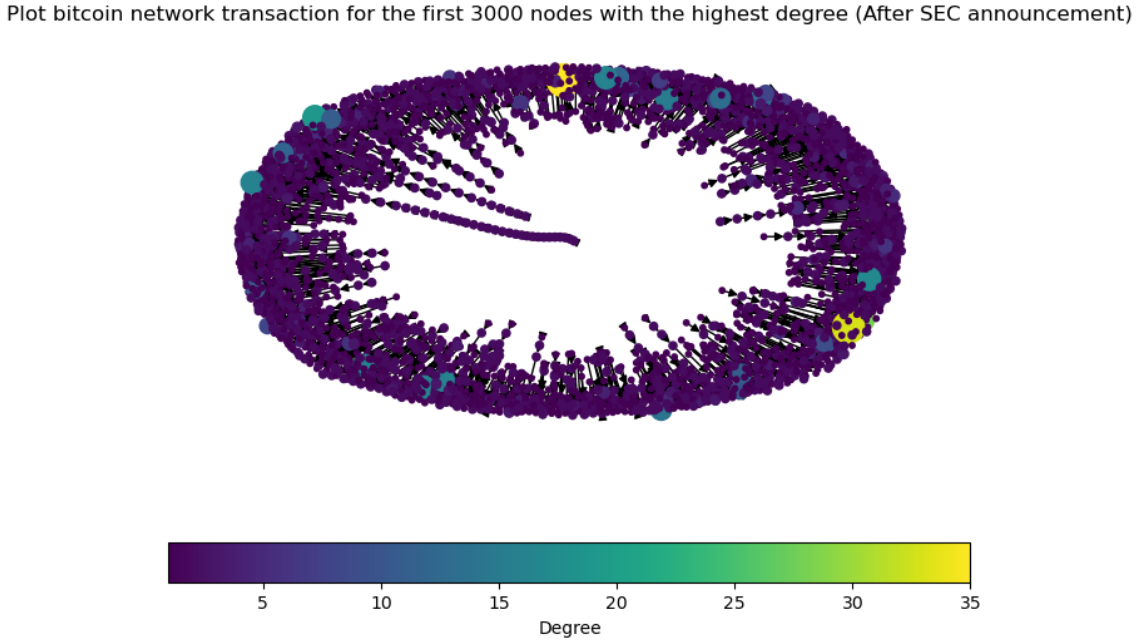


Figure 4.3: The first 3000 nodes with the highest degree AFTER the SEC announcement

5 Analysis of the 10 most important nodes

Until now, we have seen that the SEC announcement doesn't seem to have significant impact on the overall transactions during the 10th of January or the day of announcement. The number of nodes and edges, as well as the average degree of the network and its density are quite similar. This is why we want to focus on the 10 major bitcoin transaction, thus on the 10 most important nodes with the highest degree in order to answer to **our fifth and most important question of our study: Does the SEC Approval impact the most active transaction addresses?** This is to further explore the difference of the characteristics in the most active nodes. We wanted to focus on the 10 major nodes also for obvious computational reasons.

The rest of our study will focus on 10 most important nodes.

The Table 5.1 shows the statistics of the DiGraph before the SEC announcement and the Table 5.2 shows the statistics after the announcement.

Metric	Value
Number of nodes	229
Number of edges	219
Average degree	1.9126637554585153
Density	0.004194438060216042

Table 5.1: Statistics of the DiGraph Before the SEC Announcement.

Metric	Value
Number of nodes	222
Number of edges	212
Average degree	1.90990990990991
Density	0.004321063144592557

Table 5.2: Statistics of the DiGraph After the SEC Announcement.

By focusing our analysis on the interactions of the 10 largest transactions that took place before and after the SEC ruling, we note that these transactions show similar patterns as well. Indeed, the descriptive statistics of the two graphs (before and after the SEC decision) are very close. For example, the average number of degrees is identical. Most nodes have 2 neighbors. This suggests that most nodes have a single input and a single output.

The figure 5.1 below shows that the graph after the SEC decision has more nodes with higher degrees (over 30 nodes) than the graph before the SEC decision.

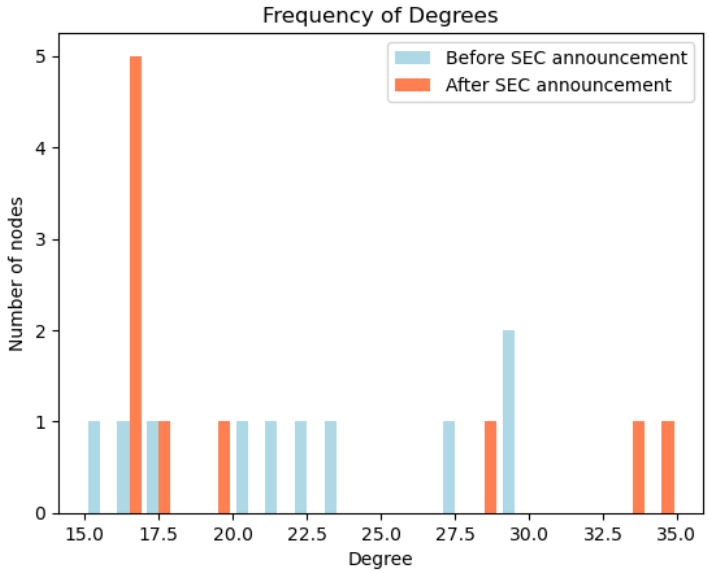


Figure 5.1: Frequency of Degrees before and after SEC Announcement

This highlights the fact that the graph after the SEC decision has 2-3 nodes playing a pivotal (very important) role.

5.1 Network Plot Before and After the Announcement

We then plot the two network before and after the SEC announcement, as shown in the Figure 5.2. The 2 graphs are very similar. The number of input and output transactions committed before and after the SEC decision are almost identical. As a result, the SEC's announcement about bitcoin ETFs does not seem to be creating a buzz among bitcoin investors.

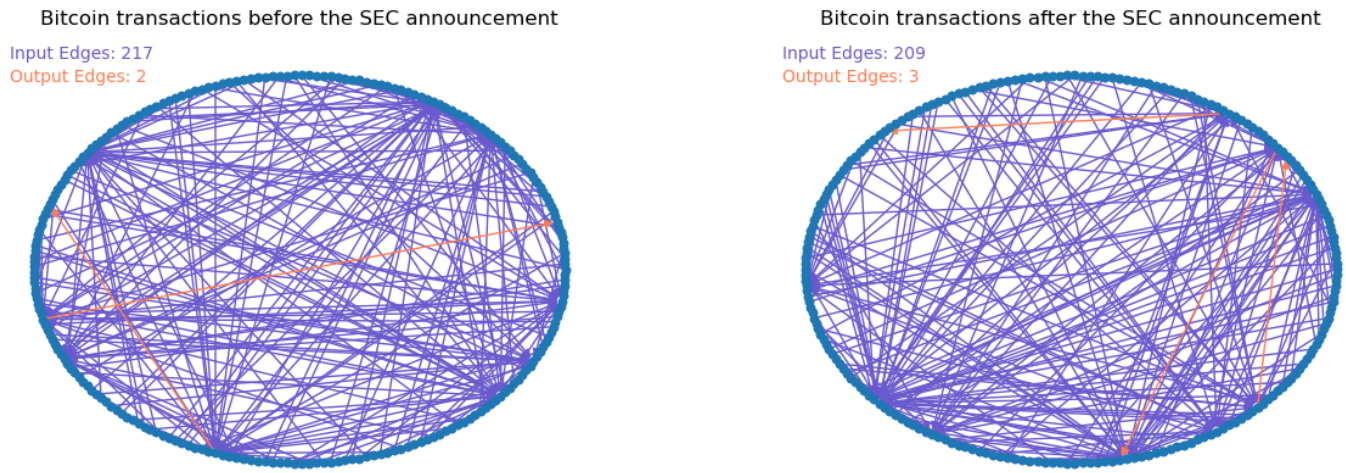


Figure 5.2: Network Plot Before and After the SEC Announcement

5.2 Betweenness

Betweenness is a measure of centrality based on shortest paths. The betweenness centrality for each node is the number of these shortest paths that pass through the node. The figure 5.3 and 5.4 show the comparison of the betwenness before and after the SEC approval.

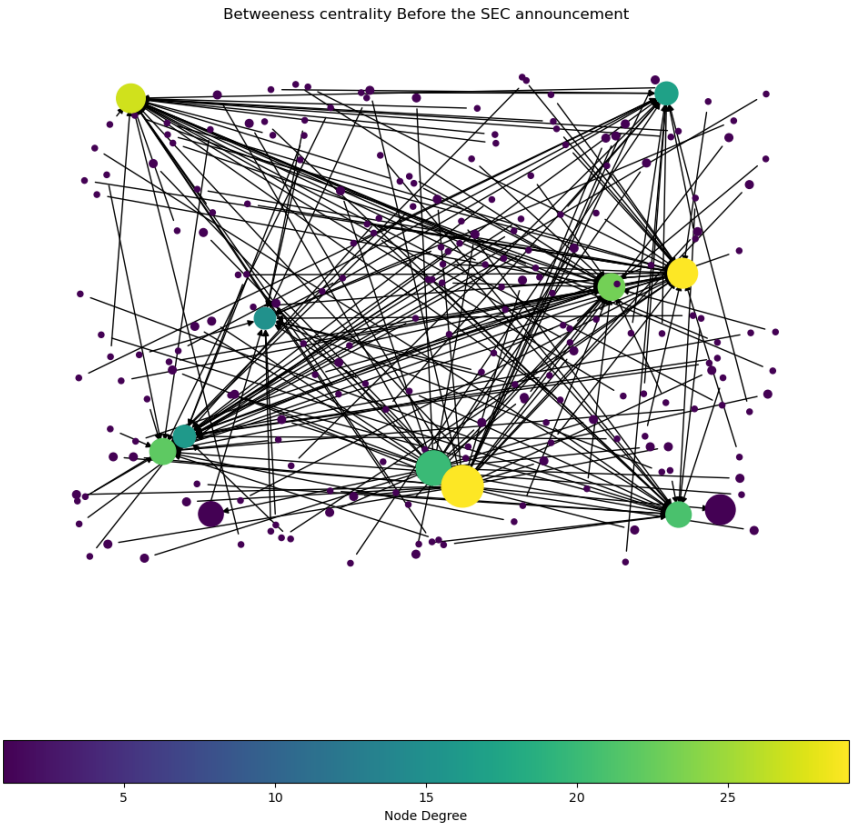


Figure 5.3: Network Betweenness Before the SEC Announcement

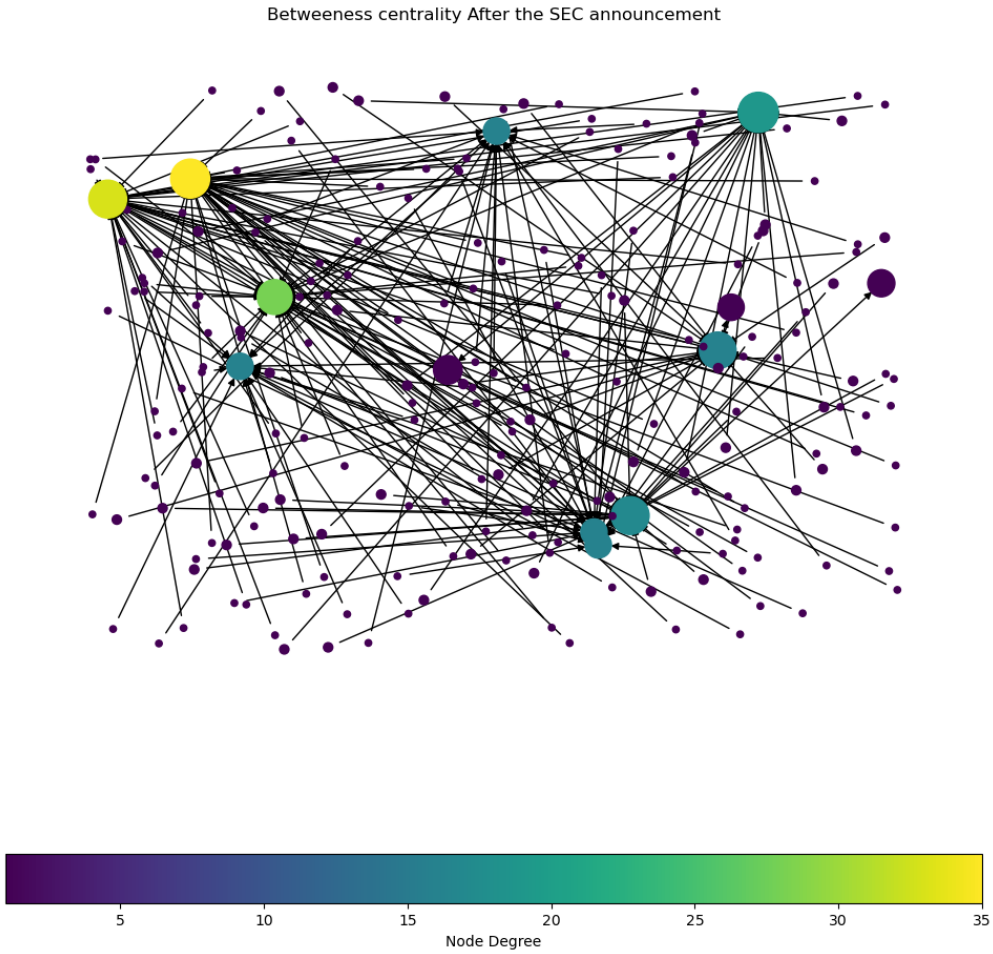


Figure 5.4: Network Betweenness After the SEC Announcement

We can see that for both graphs (before and after the SEC decision), some nodes have high betweenness centrality compared to the others. This means that this nodes are crucial for maintaining efficient communication and information flow within the network. We note that this phenomenon seems more pronounced on the graph after the decision of the SEC because this graph contains more nodes with high sizes.

5.3 Betweenness Centrality Distribution

Betweenness centrality can be useful in identifying critical nodes in a network, such as key connectors or bottlenecks, and can provide insights into how information or influence spreads throughout the network.

We can see on Figure 5.5 the that the betweenness centrality of the both graph (before and after the SEC announcement) are very low. This means that no node in the graph acts as a bridge along the shortest path between pairs of other nodes in both networks. Hence, no nodes seems to be crucial for maintaining communication and facilitating the flow of transaction between different parts of the network.

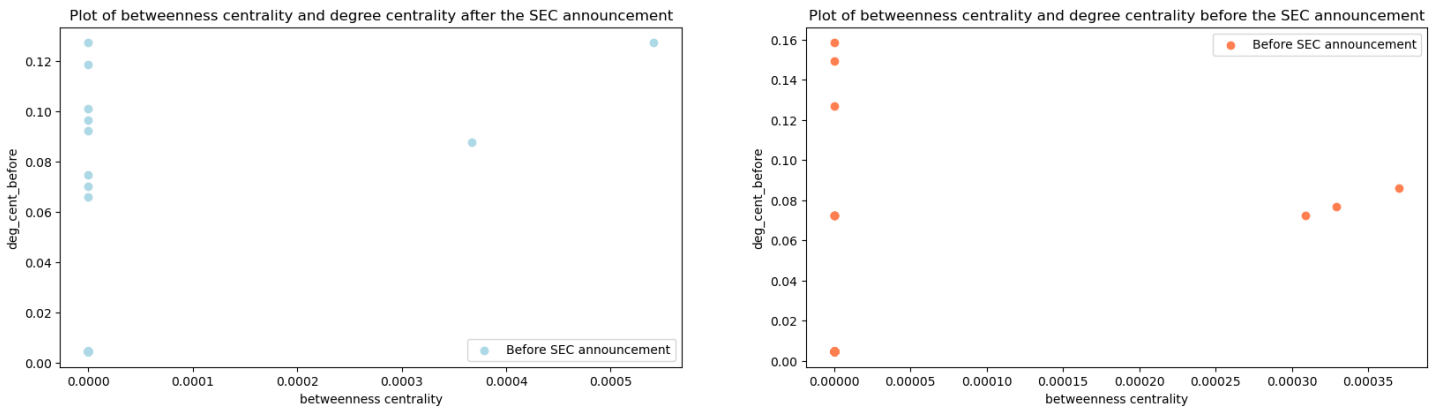


Figure 5.5: Betweenness Centrality

5.4 Degree Distribution & Degree Centrality

The degree centrality measures the number of direct connections a node has. Nodes with high degree centrality are highly connected to other nodes in the network and are often considered important for information dissemination.

The density of a graph is calculated by the formula:

$$\text{Density} = \frac{\text{Number of neighbours I have}}{\text{Number of neighbours I could possibly have}}$$

This formula is a measure of how many edges are in the graph compared to the maximum number of edges that could possibly exist between nodes.

Degree Centrality of a node can range from 0 (if the node has no connection) to 1 (if the node is connected to every other node in the network)

As shown in Figure 5.6, we note that the distributions of the number of degrees and the distribution of degree centrality are very similar for both network (before and after the SEC announcement). In addition, we can see that the higher the number of degrees is, the higher the degree of centrality is.

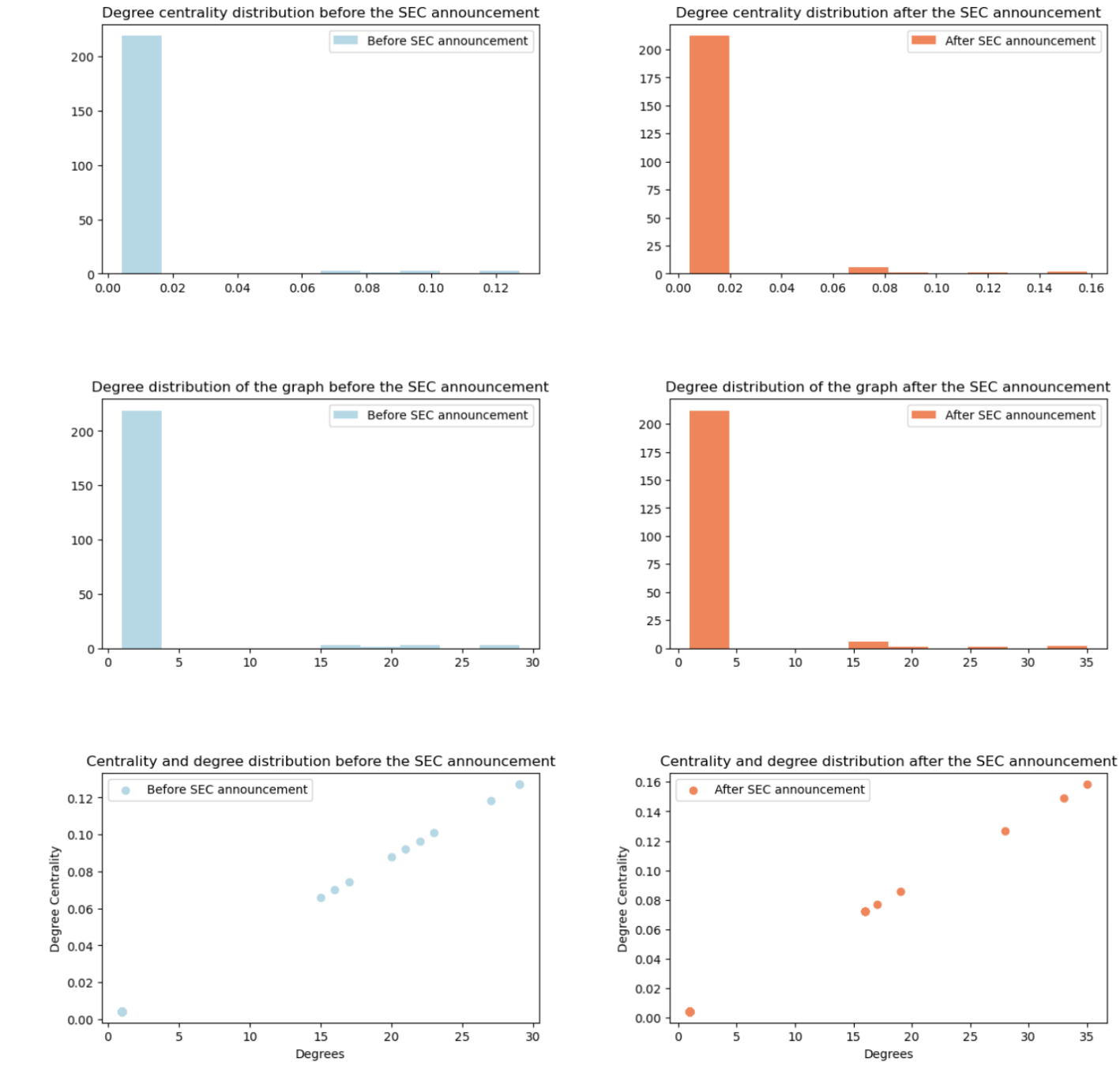


Figure 5.6: Degree Distribution

6 Highest input total in USD

Finally, we are also interested in the total input in terms of USD before and after the announcement of the SEC. **Our sixth question is: Is there any difference in terms of total input in USD because of the SEC approval?** Figure 6.1 shows the 2 circos plots of the top 10 transactions in terms of total input in USD before and after the announcement.

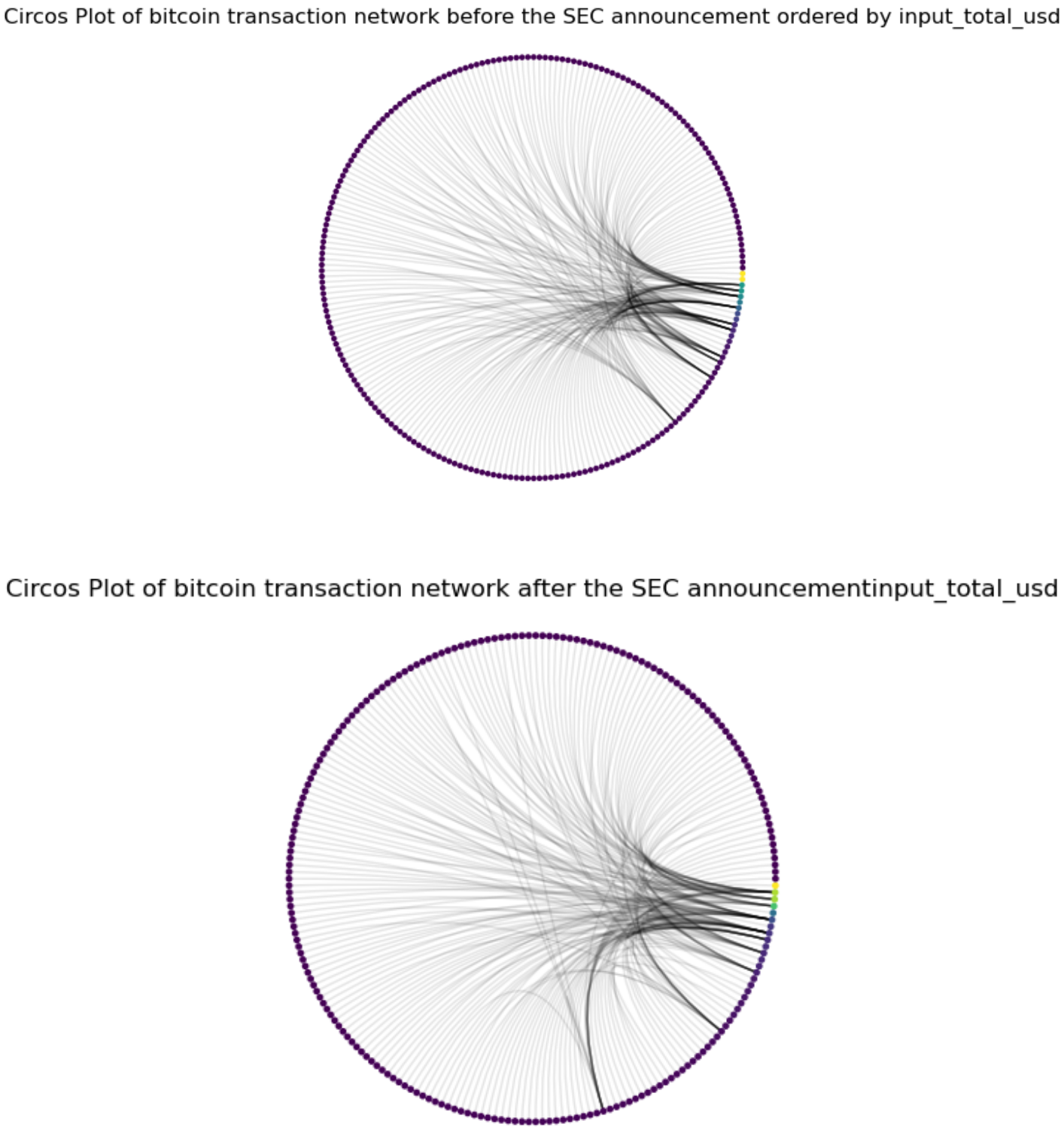


Figure 6.1: Circos Plot of the top 10 Transactions by the total input in USD BEFORE and AFTER the SEC Announcement

Let's also plot the top 10 transactions with the highest amount in USD (see Figure 6.2).

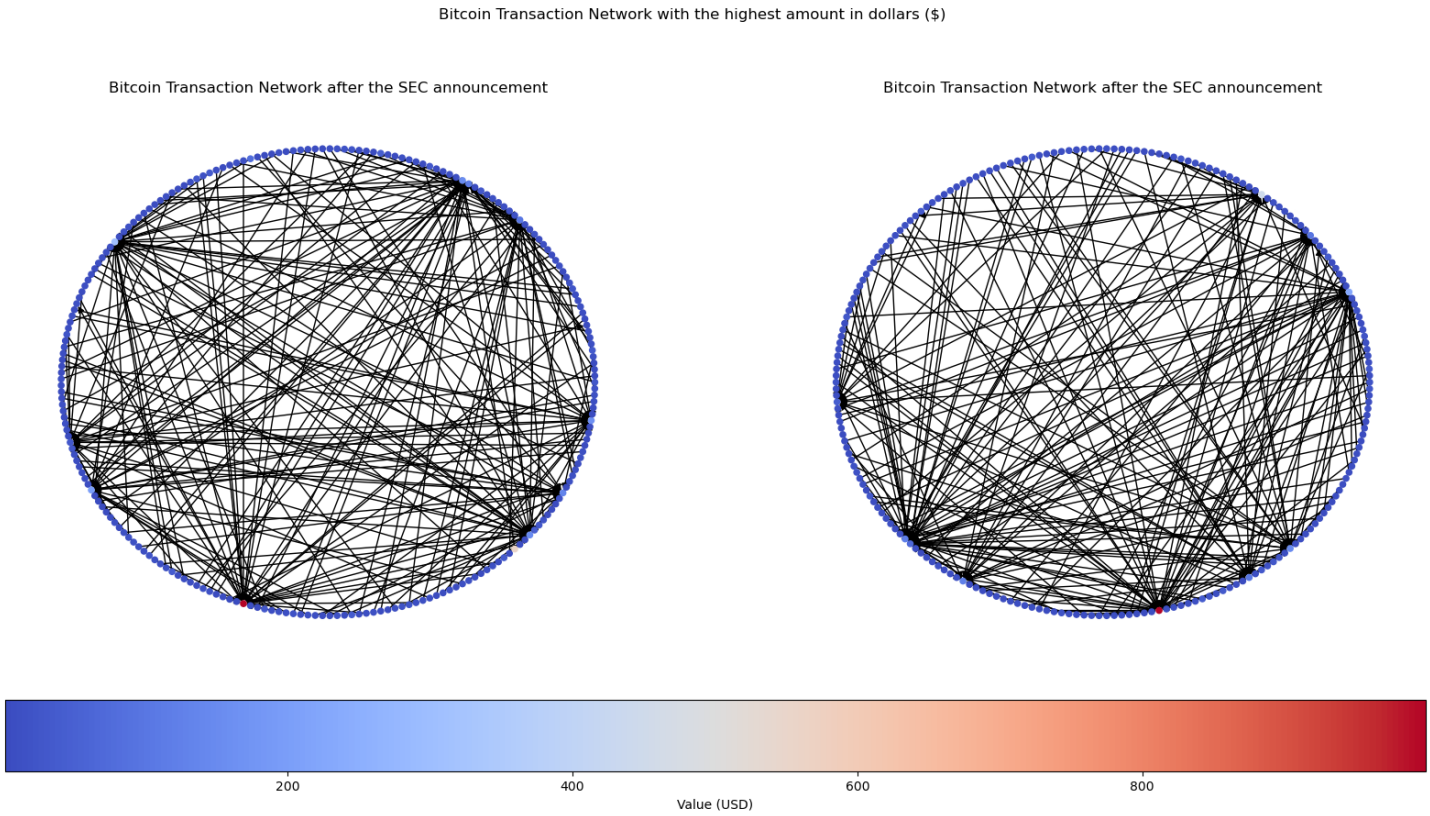


Figure 6.2: Top 10 Transactions with the highest amount in USD

The figure 6.3 shows the bitcoin transaction graphs with node size based on the number of neighbors (degrees) and node color based on the dollar amount of the input.

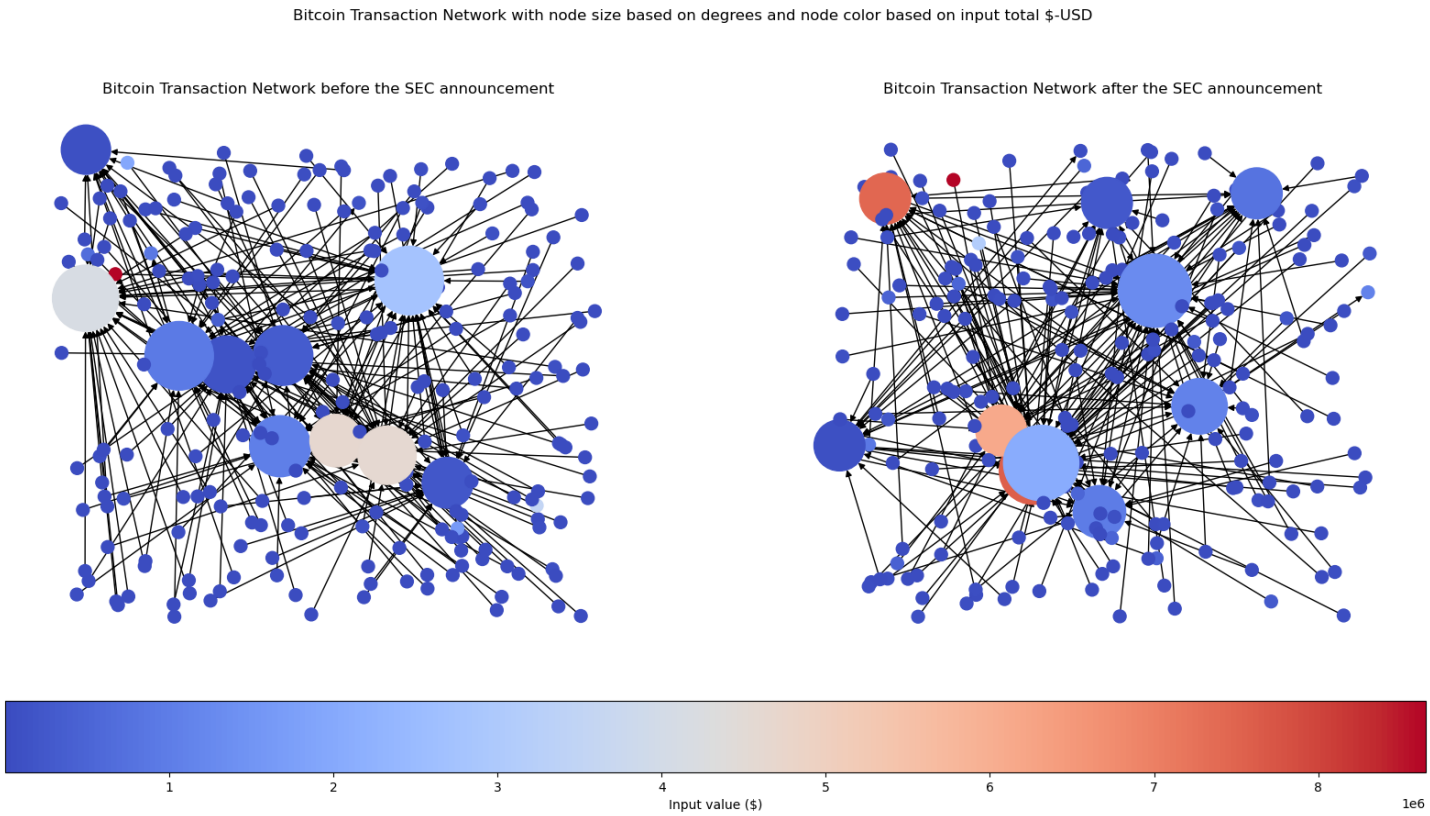


Figure 6.3: Node size based on the numbers of neighbors and input amount in USD

Another way is to see the bitcoin transaction network with node size based on degrees and node color based on the total input in USD and edge size based on the value of the transaction in USD before and after the SEC announcement (Figure 6.4)

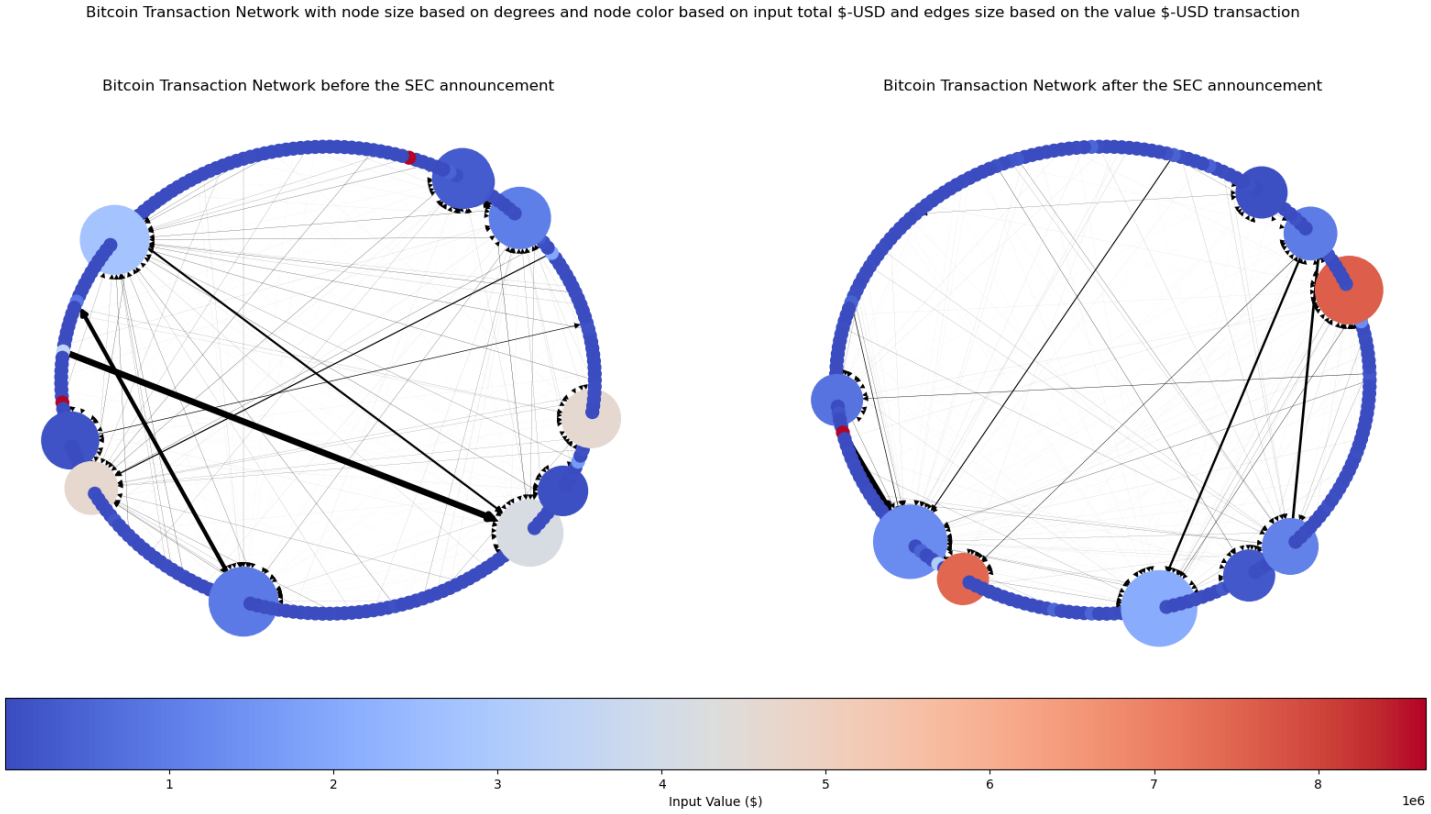


Figure 6.4: Network based on node, edge side in USD transaction value

The interesting thing to notice on graph 6.4 is the following: The chart before the SEC decision seems to contain larger edges. This means that larger transactions in terms of USD were made before the SEC decision. We can interpret this by the fact that some investors anticipated the SEC decision. We could also think that the flows of Bitcoin shifted to buy Bitcoin ETFs, this could perhaps explain as well the drop of transactions after the SEC announcement.

7 Page Rank

PageRank is an algorithm used by Google Search to rank web pages in their search engine results. It is a way of measuring the importance of website pages. For example, PageRank works by counting the number and quality of links to a page to determine a rough estimate of how important the website is. The PageRank algorithm iteratively calculates a score for each node in the network based on the importance of the nodes that link to it. Initially, all nodes are assigned an equal score. Then, in each iteration, the score of each node is updated based on the scores of its neighboring nodes. This process continues until the scores converge to stable values.

Nodes with higher PageRank scores are considered more important within the network. In the context of a Bitcoin transaction network, if a node has a high PageRank score, it suggests that it is highly connected to other important nodes in the network. In this context, importance might be interpreted as reliability, influence, or trustworthiness.

We tried to show the comparison in the Figure 7.1. We can see that the graph before the SEC decision appears to contain more nodes with a high PageRank score than the graph after the SEC decision. This means that, the Bitcoin transaction network after the SEC decision might be a well-connected and widely trusted node that reliably processes transactions or facilitates communication within the network.

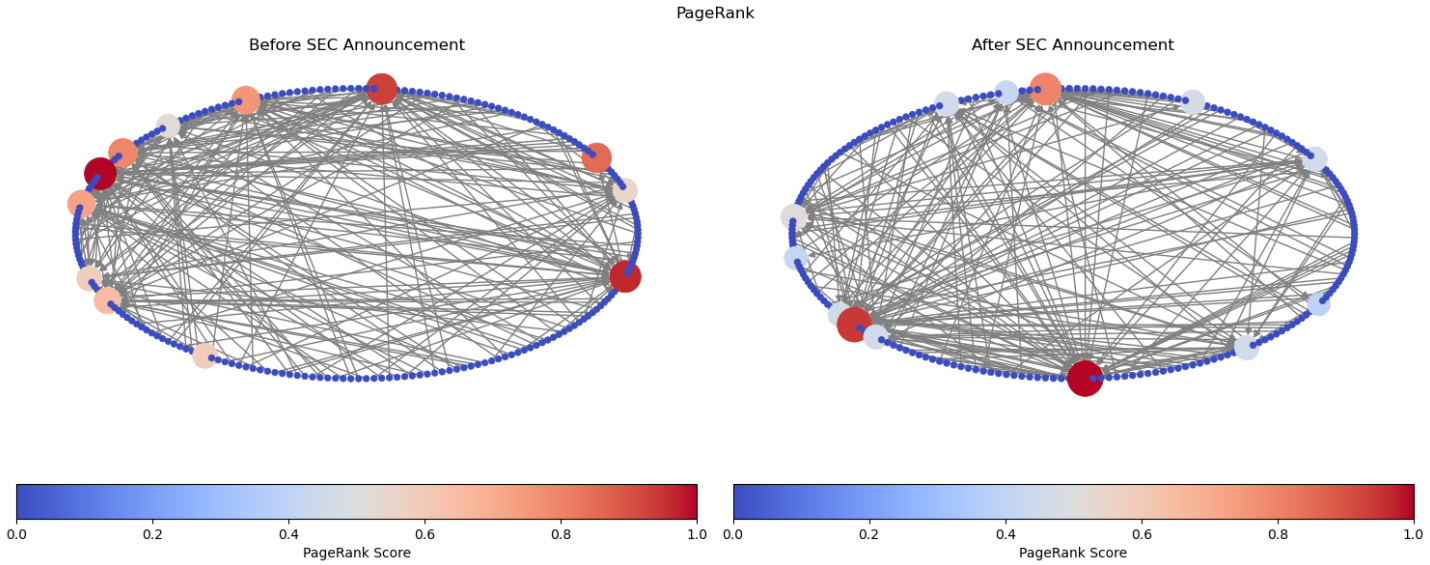


Figure 7.1: Page Rank Before and After SEC Announcement

8 Conclusion

In comparing the state of the Bitcoin transaction network before and after the SEC's announcement of a Bitcoin ETF, several key insights emerge.

Firstly, the reduction in the number of nodes post-announcement suggests that while there may have been an anticipation or speculation leading to increased activity before the announcement, the actual event led to a consolidation rather than an expansion in transaction activity. Despite the lower number of nodes, the increase in average degree and density indicates that the transactions that did occur were more interconnected, possibly reflecting a more cautious or strategic approach by those transacting in Bitcoin immediately after the announcement.

Interestingly, the descriptive statistics, such as average degree and density, are relatively close before and after the announcement, suggesting that the overall structure and connectivity of the network remained stable. This stability points to the underlying robustness of the Bitcoin network and indicates that major news events may not have as dramatic an immediate impact as might be expected.

The circos depicting the top transactions by total input in USD before and after the announcement demonstrate the concentration of transaction volume among a few significant nodes. These focal nodes could represent large institutional moves or aggregations of smaller transactions by intermediaries.

Finally, betweenness centrality metrics suggest that the network does not rely on a few nodes to facilitate transaction flows. A low betweenness centrality across the network indicates a distributed interconnectivity that does not bottleneck at particular nodes. This further underpins the decentralized nature of the Bitcoin transaction network.

Overall, the SEC's announcement appears to have had a more nuanced effect on the Bitcoin network than might be presumed. Instead of a surge in transaction activity, there seems to be a strategic shift in the way transactions are conducted, notably people have started to buy ETFs, and not bitcoin itself, with the most significant transactions playing a pivotal role. These insights highlight the complex and multifaceted response of decentralized networks to regulatory and external stimuli.

Contribution

Hugo helped to merge all the dataset, plotted the nodes network figures, the degree distribution graph and the figures related to the network transaction in terms of USD, the page rank plot, as well as with the report.

Ondine helped to create the descriptive statistics, plots about the betwenness of the network, the circos plot, as well as with the report.