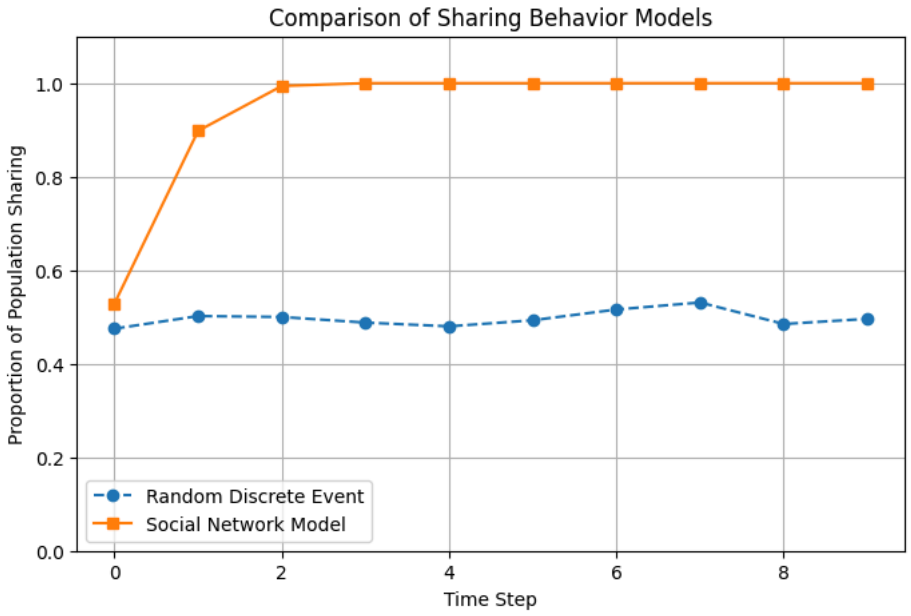
Initial Logic on why a Random Discrete Event Model works as a baseline

```
import numpy as np
import networkx as nx
import matplotlib.pyplot as plt

# Parameters
N = 1000  # Population size
p = 0.5  # Probability of sharing in the random model
timesteps = 10  # Number of iterations

# Random Discrete Event Model
random_shares = np.zeros(timesteps)
for t in range(timesteps):
    random_shares[t] = np.sum(np.random.rand(N) < p) / N

# Social Network Model (Small-World Network)
G = nx.watts_strogatz_graph(N, k=4, p=0.1)  # Small-world network
p0 = 0.50  # Base probability of sharing
alpha = 0.5  # Influence factor

# Initial sharing state (randomly selected)
shared = np.random.rand(N) < p0
network_shares = [np.mean(shared)]

# Influence-based sharing over time
for t in range(1, timesteps):
    new_shared = shared.copy()
    for node in G.nodes():
        neighbor_shares = np.mean([shared[neighbor] for neighbor in G.neighbors(node)])
        prob_share = p0 + alpha * neighbor_shares
        if not shared[node] and np.random.rand() < prob_share:
            new_shared[node] = True
    shared = new_shared
    network_shares.append(np.mean(shared))

# Plot results
plt.figure(figsize=(8, 5))
plt.plot(range(timesteps), random_shares, label="Random Discrete Event", marker='o', linestyle='--')
plt.plot(range(timesteps), network_shares, label="Social Network Model", marker='s', linestyle='-')
plt.xlabel("Time Step")
plt.ylabel("Proportion of Population Sharing")
plt.title("Comparison of Sharing Behavior Models")
plt.legend()
plt.ylim(0, 1.1)
plt.grid(True)
plt.show()

```



Claude Result

Simulation under random decision making about sharing

function privacy simulation 1

```
import numpy as np
import random
from typing import List, Dict

```

```

class PrivacySimulation:
    def __init__(self,
                 num_individuals: int = 100,
                 initial_corporate_aggression: float = 0.5,
                 corporate_step_boldness: float = 0.01):
        """
        Initialize the privacy exploitation simulation

        Args:
            num_individuals (int): Number of individual agents
            initial_corporate_aggression (float): Initial probability of corporate aggressive strategy
        """
        # Simulation parameters
        self.num_individuals = num_individuals
        self.corporate_aggression_prob = initial_corporate_aggression
        self.corporate_step_boldness = corporate_step_boldness

        # Track simulation state
        self.current_iteration = 0
        self.individual_sharing_history = []
        self.corporate_strategy_history = []
        self.corporate_decision_history = []
        self.corporate_decision = None
        # Initialize agents
        self.individual_agents = [IndividualAgent() for _ in range(num_individuals)]
        self.corporate_agent = CorporateAgent()


    def run_iteration(self):
        """
        Run a single iteration of the simulation

```

```
        Steps:
        1. Individual agents decide whether to share information
        2. Corporate agent chooses strategy based on current probabilities
        3. Update probabilities based on aggregate individual behavior
        """
        # Individual sharing decisions
        individual_sharing_decisions = [
            agent.decide_to_share() for agent in self.individual_agents
        ]

        # Calculate sharing rate
        sharing_rate = sum(individual_sharing_decisions) / self.num_individuals

        # Corporate strategy selection
        corporate_strategy = self.corporate_agent.choose_strategy(
            self.corporate_aggression_prob
        )

        if corporate_strategy == 'aggressive':
            self.corporate_decision = 1
        else:
            self.corporate_decision = 0

        # Update corporate aggression probability based on sharing rate
        if sharing_rate > 0.5:

            # If majority share, increase likelihood of aggressive strategy
            #self.corporate_decision = 1
            self.corporate_aggression_prob = min(
                1.0,
                self.corporate_aggression_prob + self.corporate_step_boldness
            )
        else:
            # If majority resist, decrease likelihood of aggressive strategy
            #self.corporate_decision = 0
            self.corporate_aggression_prob = max(
                0.0,
                self.corporate_aggression_prob - self.corporate_step_boldness
            )

        # Record history
        self.individual_sharing_history.append(sharing_rate)
        self.corporate_strategy_history.append(corporate_strategy)
        self.corporate_decision_history.append(self.corporate_decision)

        # Increment iteration
        self.current_iteration += 1

        return {
            'time': self.current_iteration,
            'sharing_rate': sharing_rate,
            'corporate_strategy': corporate_strategy,
            'corporate_aggression_prob': self.corporate_aggression_prob,
            'corporate_decision_history': self.corporate_decision
        }

    def run_simulation(self, time: int = 100):
        """
        Run the full simulation for specified number of iterations

        Args:
            num_iterations (int): Number of simulation iterations

        Returns:
            List of iteration results
        """
        results = []
        for _ in range(time):
            iteration_result = self.run_iteration()
            results.append(iteration_result)

        return results

```

```
1
2 class IndividualAgent:
```

```
    def __init__(self,
                 initial_sharing_prob: float = 0.5,
                 risk_tolerance: float = 0.5):
        """
        Initialize an individual agent

        Args:
            initial_sharing_prob (float): Probability of initially sharing information
            risk_tolerance (float): Agent's tolerance for privacy risk
        """
        self.sharing_prob = initial_sharing_prob
        self.risk_tolerance = risk_tolerance

    def decide_to_share(self) -> bool:
        """
        Stochastic decision to share information

        Returns:
            bool: Whether agent decides to share information
        """
        return random.random() < self.sharing_prob

class CorporateAgent:
    def choose_strategy(self, aggression_prob: float) -> str:
        """
        Select corporate strategy based on aggression probability

        Args:
            aggression_prob (float): Probability of choosing aggressive strategy

        Returns:
            str: Selected strategy ('aggressive' or 'fair')
        """
        return 'aggressive' if random.random() < aggression_prob else 'fair'


```

```
Start coding or generate with AI.
```

Simulation One Run. 1000 people, 2000 iterations - Random decision making. Neutral starting point for corporate strategy

```
# Example usage in Jupyter Notebook
simulation = PrivacySimulation(num_individuals=100, initial_corporate_aggression=0.5, corporate_step_boldness=0.01)
results = simulation.run_simulation(time=1000)
for result in results[:5]:
     print(f"time {result['time']}:")
     print(f"  Sharing Rate: {result['sharing_rate']:.2f}")
     print(f"  Corporate Strategy: {result['corporate_strategy']}")
     print(f"  Corporate Aggression Probability: {result['corporate_aggression_prob']:.2f}")
     print(f"  Corporate Decision: {result['corporate_decision_history']}")
```

```
time 1:
  Sharing Rate: 0.52
  Corporate Strategy: aggressive
  Corporate Aggression Probability: 0.51
  Corporate Decision: 1
time 2:
  Sharing Rate: 0.41
  Corporate Strategy: fair
  Corporate Aggression Probability: 0.50
  Corporate Decision: 0
time 3:
  Sharing Rate: 0.39
  Corporate Strategy: aggressive
  Corporate Aggression Probability: 0.49
  Corporate Decision: 1
time 4:
  Sharing Rate: 0.49
  Corporate Strategy: fair
  Corporate Aggression Probability: 0.48
  Corporate Decision: 0
time 5:
  Sharing Rate: 0.47
  Corporate Strategy: aggressive
  Corporate Aggression Probability: 0.47
```

```
Corporate Decision: 1
```

```
print(results)
```

```
[{'time': 1, 'sharing_rate': 0.52, 'corporate_strategy': 'fair', 'corporate_aggression_prob': 0.51, 'corporate_decision_history': 1
```

```
# prompt: read results into a pandas dataframe

# Assuming the code you provided is in a Jupyter Notebook cell and you've run it
# to generate the 'data' DataFrame.

import pandas as pd

# Create a DataFrame from the results of the simulation
results_df = pd.DataFrame(results)

# Print the first few rows of the DataFrame to see the results
print(results_df.head())

# You can now perform various analyses on this DataFrame
# for example:
# results_df.describe() # Descriptive statistics
# results_df.plot(x='iteration', y='sharing_rate') # Plot the sharing rate over time

```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.52               fair                       0.51
1     2          0.57               fair                       0.52
2     3          0.54               fair                       0.53
3     4          0.54               fair                       0.54
4     5          0.46               fair                       0.53

   corporate_decision_history
0                           1
1                           1
2                           1
3                           1
4                           0
```

```
results_df['corporate_decision_history'].value_counts()
```

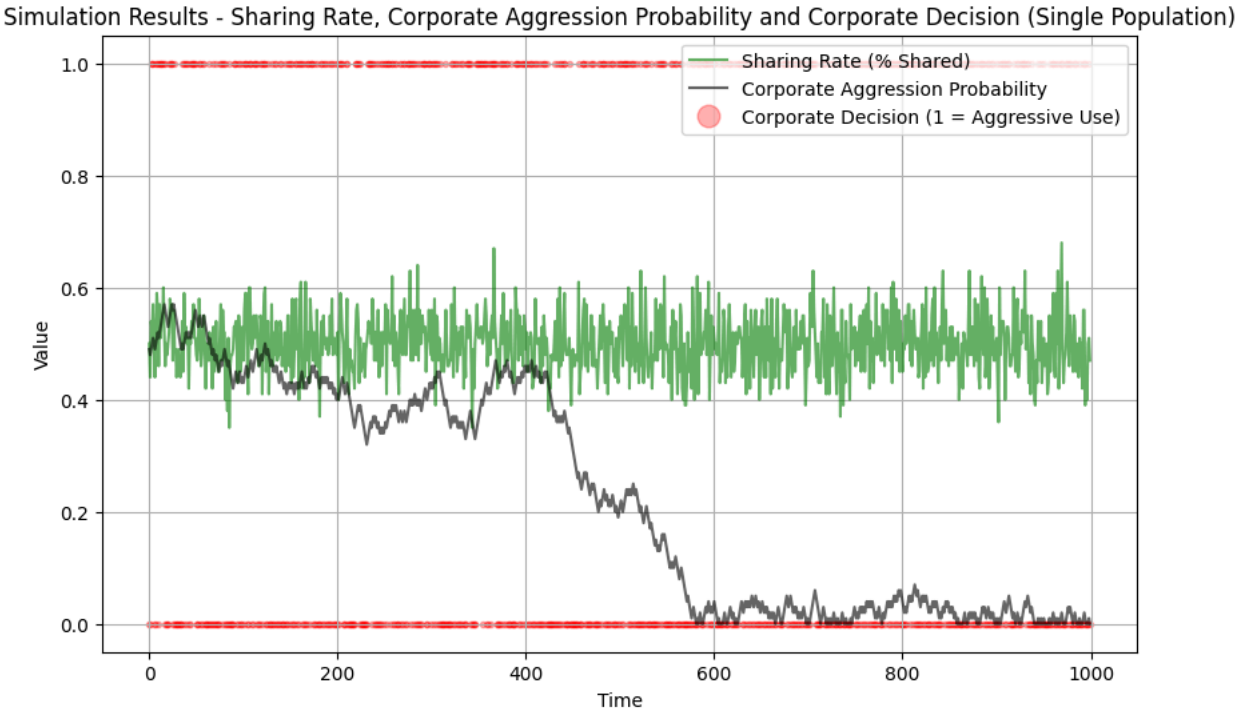
corporate_decision_history	count
0	541
1	459

dtype: int64

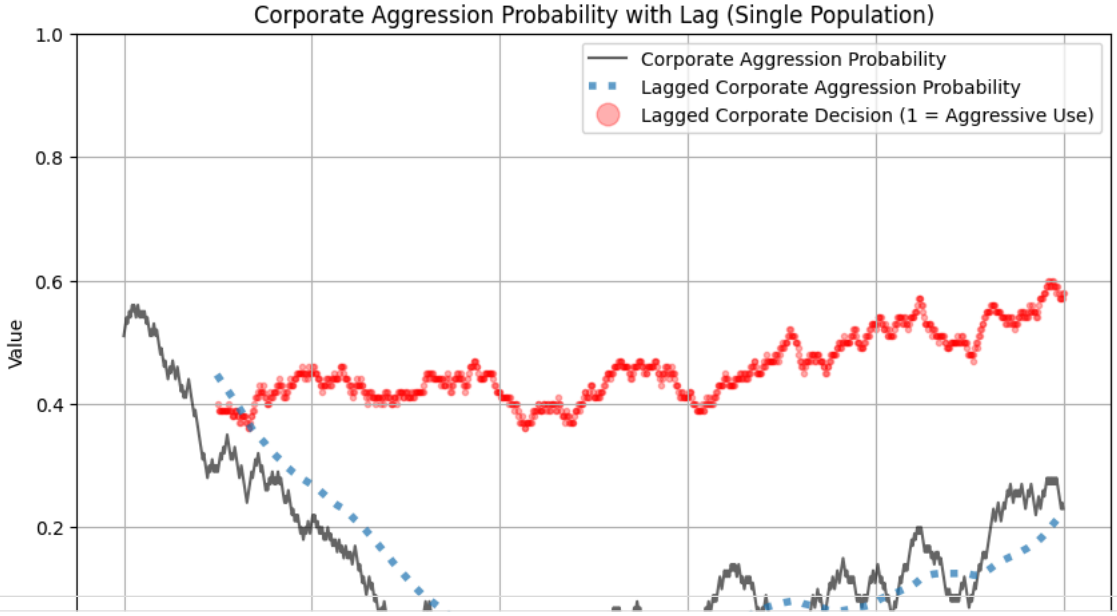
```
# prompt: correlation between numerical variables in result_df

# Assuming results_df is your DataFrame from the simulation
correlation_matrix = results_df.drop(columns = ['corporate_strategy']).corr()

# Display the correlation matrix
print(correlation_matrix)

# You can also focus on specific correlations
print(f"Correlation between sharing_rate and corporate_aggression_prob: {results_df['sharing_rate'].corr(results_df['corporate

```

```
                             time  sharing_rate  corporate_aggression_prob  \
time                     1.000000      0.064127                  -0.397633
sharing_rate             0.064127      1.000000                   0.014092
corporate_aggression_prob -0.397633      0.014092                   1.000000
corporate_decision_history  0.079127      0.804090                   0.046847

                           corporate_decision_history
time                                         0.079127
sharing_rate                                 0.804090
corporate_aggression_prob                    0.046847
corporate_decision_history                   1.000000
Correlation between sharing_rate and corporate_aggression_prob: 0.01409155828859307
```

```
# prompt: plot results
import matplotlib.pyplot as plt
# Assuming 'results' is a list of dictionaries as returned by the simulation
# Extract sharing rate and corporate aggression probability for plotting

sharing_rates = [result['sharing_rate'] for result in results]
corporate_aggression_probs = [result['corporate_aggression_prob'] for result in results]
corporate_decision = [result['corporate_decision_history'] for result in results]

# Create the plot
plt.figure(figsize=(10, 6))
plt.plot(sharing_rates, label='Sharing Rate (% Shared)', alpha = 0.6, color = 'green')
plt.plot(corporate_aggression_probs, label='Corporate Aggression Probability', alpha = 0.6, color = 'black')
plt.scatter(range(len(corporate_decision)),corporate_decision, label='Corporate Decision (1 = Aggressive Use)', alpha = 0.3, m
plt.xlabel('Time')
plt.ylabel('Value')
plt.title('Sharing Rate, Corporate Aggression Probability and Corporate Decision (Single Population)')
plt.legend(markerscale=4, handleheight=1)
plt.grid(True)
plt.show()

```

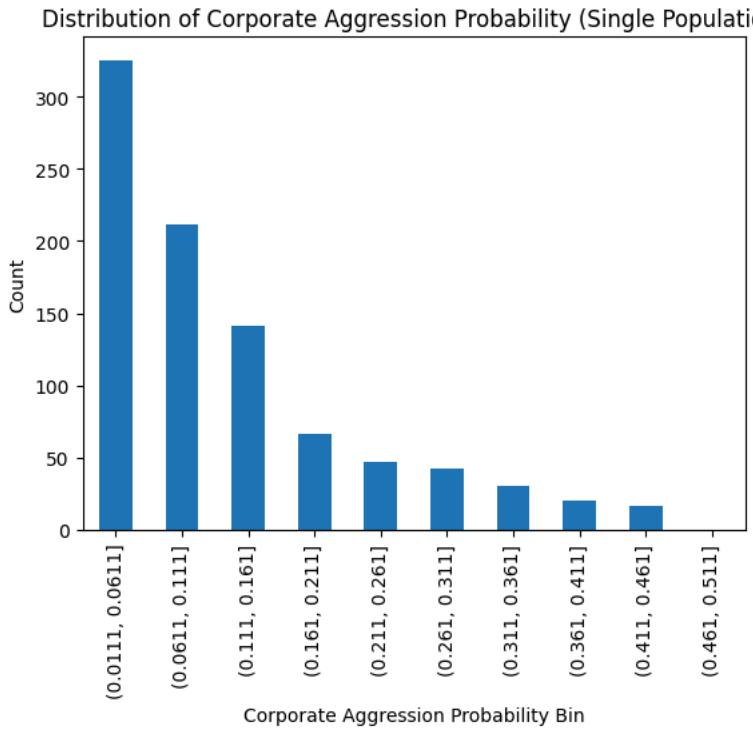



```
# prompt: add a lag column to results_df - the average of the previous five corporate agression prob and plot the new lagged va

# Calculate the lagged corporate aggression probability (5-iteration average)
results_df['lagged_corporate_aggression_prob'] = results_df['corporate_aggression_prob'].rolling(window=100).mean()
results_df['lagged_corporate_decision'] = results_df['corporate_decision_history'].rolling(window=100).mean()

# Plot the original and lagged corporate aggression probabilities
plt.figure(figsize=(10, 6))
plt.plot(results_df['corporate_aggression_prob'], label='Corporate Aggression Probability', alpha = 0.6, color = 'black')
plt.plot(results_df['lagged_corporate_aggression_prob'], label='Lagged Corporate Aggression Probability', alpha = 0.7,linestyle
plt.scatter(results_df['time'],results_df['lagged_corporate_decision'], label='Lagged Corporate Decision (1 = Aggressive Use)',
plt.xlabel('Time')
plt.ylabel('Value')
plt.title('Corporate Aggression Probability with Lag (Single Population)')
plt.legend(markerscale=4, handleheight=1)
plt.ylim(0, 1)
plt.grid(True)
plt.show()

```




```
# prompt: bin results_df['lagged_corporate_aggression_prob'] by bins with 0.1 width

# Assuming results_df is your DataFrame from the simulation
bins = np.arange(results_df['lagged_corporate_aggression_prob'].min(), results_df['lagged_corporate_aggression_prob'].max() +
results_df['lagged_corporate_aggression_prob_binned'] = pd.cut(results_df['lagged_corporate_aggression_prob'], bins=bins)

# Now, you can analyze the data by the created bins
# Example: Counting the number of rows in each bin:
bin_counts = results_df.groupby('lagged_corporate_aggression_prob_binned')['lagged_corporate_aggression_prob_binned'].count()
bin_counts.plot(kind='bar')
plt.xlabel('Corporate Aggression Probability Bin')
plt.ylabel('Count')
plt.title('Distribution of Corporate Aggression Probability (Single Population)')
plt.show()


```

```
<ipython-input-42-6277f6afe32c>:9: FutureWarning: The default of observed=False is deprecated and will be changed to True in a futu
  bin_counts = results_df.groupby('lagged_corporate_aggression_prob_binned')['lagged_corporate_aggression_prob_binned'].count()
```



Lagged effect of random sharing

Lagged Corporate Aggression Probability and Lagged Corporate Decision Making

```
# Example usage in Jupyter Notebook
step_1b_results = []
for iteration in range(100):
  simulation = PrivacySimulation(num_individuals=100, initial_corporate_aggression=0.5, corporate_step_boldness=0.01)
  results = simulation.run_simulation(time=1000)
  for result in results:
    result['iteration'] = iteration
  step_1b_results.append(results)

#step_1b_results_df = pd.DataFrame(step_1b_results)

```

```
##step_1b_results_df[0][0]
```

function - convert to dataframe

```
import numpy as np
import pandas as pd

def convert_to_dataframe(large_results_np):
    # Sample first entry to infer field names
    sample_entry = large_results_np[0][0]  # Assuming large_results_np[0][0] is a dictionary

    # Automatically detect field names
    field_names = list(sample_entry.keys())

    # Automatically determine dtype based on sample values
    def infer_dtype(value):
        if isinstance(value, int):
            return np.int32
        elif isinstance(value, float):
            return np.float64
        elif isinstance(value, str):
            return f'U{max(10, len(value))}'  # String with at least 10 characters
        else:
            return object  # Fallback for complex objects

    dtype = [(field, infer_dtype(sample_entry[field])) for field in field_names]

    # Convert list of dictionaries into structured NumPy array
    large_results_np_struc = np.array(
        [[tuple(item[field] for field in field_names) for item in row] for row in large_results_np],
        dtype=dtype
    )

    # Flatten the array to (1000*100, 5) for DataFrame compatibility
    flattened_array = large_results_np_struc.view(np.recarray).reshape(-1)

    # Convert the flattened array to a Pandas DataFrame
    df_large = pd.DataFrame(flattened_array, columns=large_results_np_struc.dtype.names)
    df_large['outer_iteration'] = np.repeat(np.arange(1, len(large_results_np) + 1), len(large_results_np[0]))

    return df_large


```

```


# Example usage
# Assuming `large_results_np` is a list of lists with dictionaries
step_1b_results_df = convert_to_dataframe(step_1b_results)

# Print the first few rows to verify
print(step_1b_results_df.head())

```

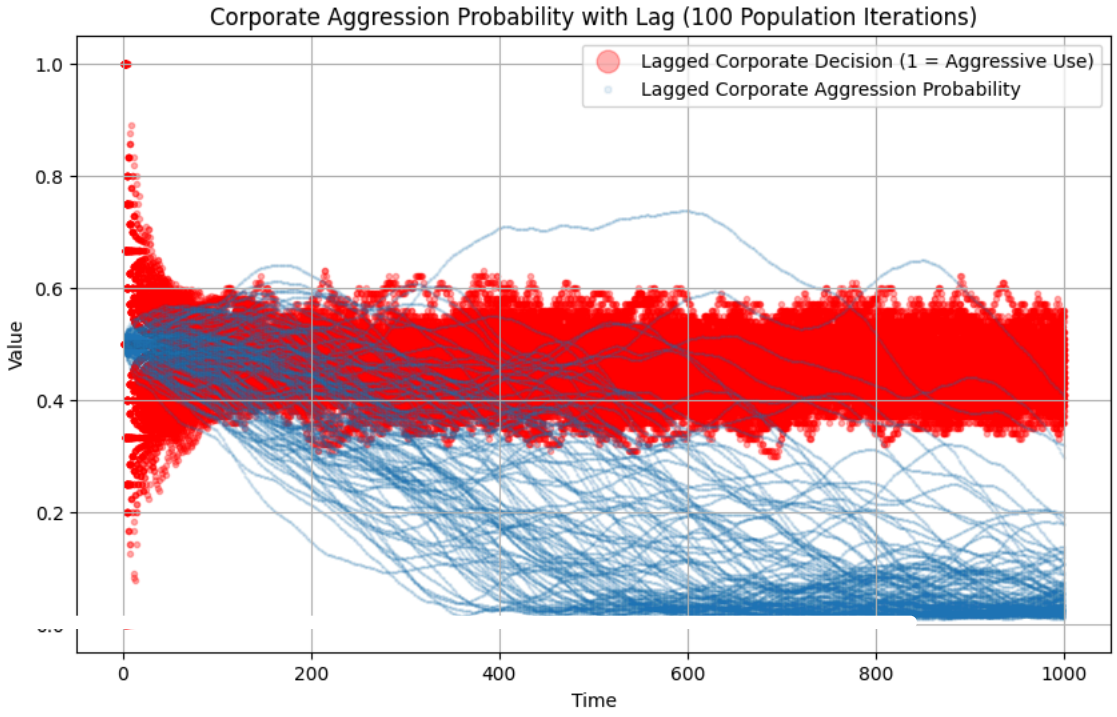
```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.54         aggressive                       0.51
1     2          0.48         aggressive                       0.50
2     3          0.51               fair                       0.51
3     4          0.49         aggressive                       0.50
4     5          0.51         aggressive                       0.51

   corporate_decision_history  iteration  outer_iteration
0                           1          0                1
1                           0          0                1
2                           1          0                1
3                           0          0                1
4                           1          0                1
```

```
# prompt: add a lag column to results_df - the average of the previous five corporate agression prob and plot the new lagged v

import pandas as pd

# Assuming 'iteration' is a column and your DataFrame has it
# Apply the rolling mean calculation per iteration group, and ensure index alignment

# First, ensure that the 'iteration' column is part of the index
# If iteration is not an index, you can group by it directly.

step_1b_results_df['lagged_corporate_aggression_prob'] = step_1b_results_df.groupby('iteration')['corporate_aggression_prob'].

step_1b_results_df['lagged_corporate_decision'] = step_1b_results_df.groupby('iteration')['corporate_decision_history'].apply(

# Verify the results
print(step_1b_results_df.head())

```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.54         aggressive                       0.51
1     2          0.48         aggressive                       0.50
2     3          0.51               fair                       0.51
3     4          0.49         aggressive                       0.50
4     5          0.51         aggressive                       0.51

   corporate_decision_history  iteration  outer_iteration  \
0                           1          0                1
1                           0          0                1
2                           1          0                1
3                           0          0                1
4                           1          0                1

   lagged_corporate_aggression_prob  lagged_corporate_decision
0                          0.510000                   1.000000
1                          0.505000                   0.500000
2                          0.506667                   0.666667
3                          0.505000                   0.500000
4                          0.506000                   0.600000
```

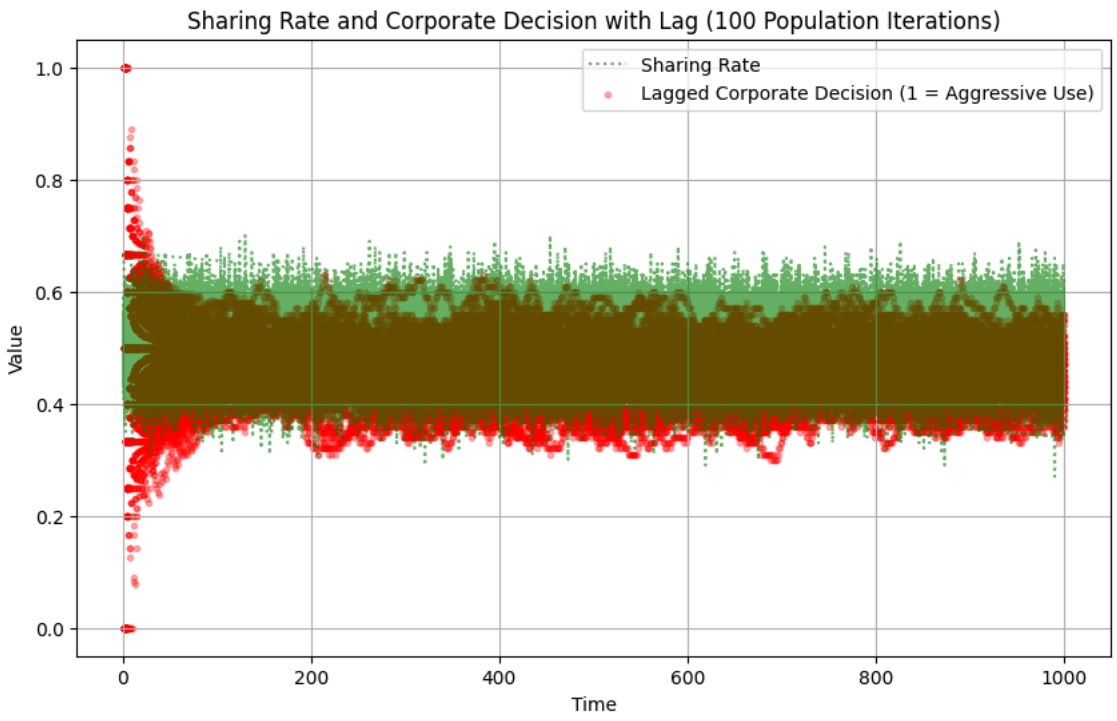
```
import matplotlib.pyplot as plt

# Assuming step_1b_results_df is your DataFrame with the relevant columns

# Plot the original and lagged corporate aggression probabilities for each iteration
plt.figure(figsize=(10, 6))

# Plot the lagged corporate decision
plt.scatter(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_decision'], label='Lagged Corporate Decision (1 =

# Plot the corporate aggression probability
#plt.plot(step_1b_results_df['time'], step_1b_results_df['corporate_aggression_prob'], label='Corporate Aggression Probability

# Plot the lagged corporate aggression probability
#plt.plot(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_aggression_prob'], label='Lagged Corporate Aggressi

# Plot using scatter with line style
plt.scatter(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_aggression_prob'], label='Lagged Corporate Aggres

# To connect the scatter points with a line
#plt.plot(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_aggression_prob'], label='Lagged Corporate Aggressi


# Adding labels and title
plt.xlabel('Time')
```

```
plt.ylabel('Value')
plt.title('Corporate Aggression Probability with Lag (100 Population Iterations)')

# Show legend
plt.legend(markerscale=4, handleheight=1)

# Display the grid
plt.grid(True)

# Display the plot
plt.show()

```




```
import matplotlib.pyplot as plt

# Assuming step_1b_results_df is your DataFrame with the relevant columns

# Plot the original and lagged corporate aggression probabilities for each iteration
plt.figure(figsize=(10, 6))

# Plot the corporate aggression probability
#plt.plot(step_1b_results_df['time'], step_1b_results_df['corporate_aggression_prob'], label='Corporate Aggression Probability

# Plot the lagged corporate aggression probability
#plt.plot(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_aggression_prob'], label='Lagged Corporate Aggressi

# Plot using scatter with line style
#plt.scatter(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_aggression_prob'], label='Lagged Corporate Aggre

# To connect the scatter points with a line
plt.plot(step_1b_results_df['time'], step_1b_results_df['sharing_rate'],label='Sharing Rate', linestyle=':', alpha=0.6, color=


# Plot the lagged corporate decision
plt.scatter(step_1b_results_df['time'], step_1b_results_df['lagged_corporate_decision'], label='Lagged Corporate Decision (1 =

# Adding labels and title
plt.xlabel('Time')
plt.ylabel('Value')
plt.title('Sharing Rate and Corporate Decision with Lag (100 Population Iterations)')

# Show legend
plt.legend()

# Display the grid
plt.grid(True)

```

```
# Display the plot
plt.show()

```



Step 1c - manual stepped runs

Lagged Corporate Aggression Probability and Lagged Corporate Decision Making at Different levels of B

```
# Example usage in Jupyter Notebook
step_1c_results = []
for corporate_step_boldness in [0.001,0.005,0.01,0.05,0.1,0.5]:
  for iteration in range(100):
    simulation = PrivacySimulation(num_individuals=100, initial_corporate_aggression=0.5, corporate_step_boldness=corporate_st
    results = simulation.run_simulation(time=1000)
    for result in results:
      result['iteration'] = iteration
      result['corporate_step_boldness'] = corporate_step_boldness
    step_1c_results.append(results)

#step_1b_results_df = pd.DataFrame(step_1b_results)


# Example usage
# Assuming `large_results_np` is a list of lists with dictionaries
step_1c_results_df = convert_to_dataframe(step_1c_results)

# Print the first few rows to verify
print(step_1c_results_df.head())

```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.43         aggressive                      0.499
1     2          0.51         aggressive                      0.500
2     3          0.52         aggressive                      0.501
3     4          0.50               fair                      0.500
4     5          0.54               fair                      0.501

   corporate_decision_history  iteration  corporate_step_boldness  \
0                           0          0                    0.001
1                           1          0                    0.001
2                           1          0                    0.001
3                           0          0                    0.001
4                           1          0                    0.001

   outer_iteration
```

```
0               1
1               1
2               1
3               1
4               1
```

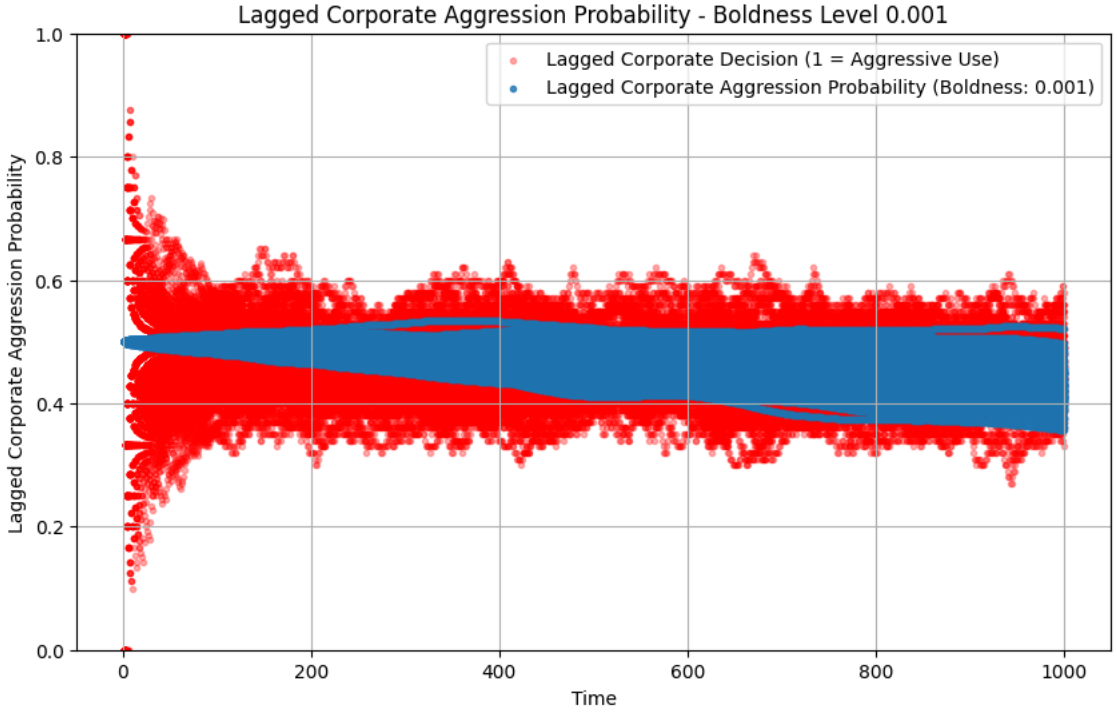
```
# prompt: add a lag column to results_df - the average of the previous five corporate agression prob and plot the new lagged v

import pandas as pd

# Assuming 'iteration' is a column and your DataFrame has it
# Apply the rolling mean calculation per iteration group, and ensure index alignment

# First, ensure that the 'iteration' column is part of the index
# If iteration is not an index, you can group by it directly.

# Compute rolling mean per iteration using transform instead of apply
step_1c_results_df['lagged_corporate_aggression_prob'] = (
    step_1c_results_df.groupby('iteration')['corporate_aggression_prob']
    .transform(lambda x: x.rolling(window=100, min_periods=1).mean())
)

step_1c_results_df['lagged_corporate_decision'] = (
    step_1c_results_df.groupby('iteration')['corporate_decision_history']
    .transform(lambda x: x.rolling(window=100, min_periods=1).mean())
)

# Verify the results
print(step_1c_results_df.head())

```

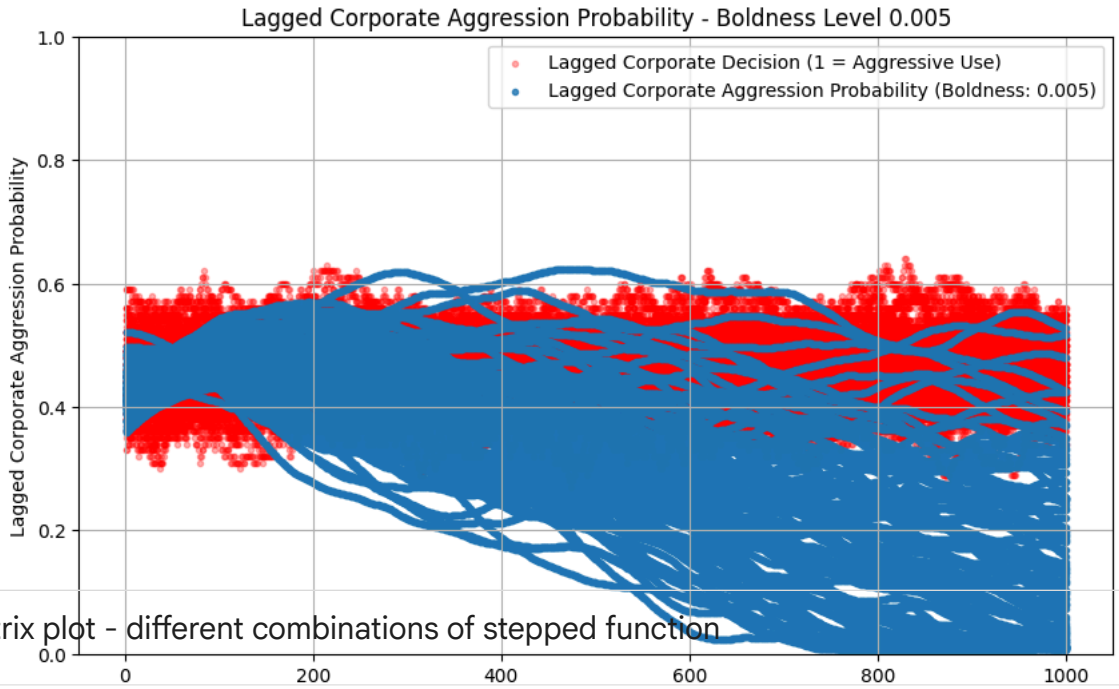
```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.43         aggressive                      0.499
1     2          0.51         aggressive                      0.500
2     3          0.52         aggressive                      0.501
3     4          0.50               fair                      0.500
4     5          0.54               fair                      0.501

   corporate_decision_history  iteration  corporate_step_boldness  \
0                           0          0                    0.001
1                           1          0                    0.001
2                           1          0                    0.001
3                           0          0                    0.001
4                           1          0                    0.001

   outer_iteration  lagged_corporate_aggression_prob  \
0                1                            0.4990
1                1                            0.4995
2                1                            0.5000
3                1                            0.5000
4                1                            0.5002

   lagged_corporate_decision
0                   0.000000
1                   0.500000
2                   0.666667
3                   0.500000
4                   0.600000
```

```
# Check if first value of each iteration is identical before and after transformation
check = step_1c_results_df.groupby('iteration').head(1)[['corporate_decision_history', 'lagged_corporate_decision']]
print(check)

```

```
       corporate_decision_history  lagged_corporate_decision
0                               0                        0.0
1000                            0                        0.0
2000                            0                        0.0
3000                            0                        0.0
4000                            0                        0.0
...                           ...                        ...
95000                           1                        1.0
96000                           0                        0.0
97000                           1                        1.0
98000                           0                        0.0
99000                           1                        1.0

[100 rows x 2 columns]
```

```
import matplotlib.pyplot as plt

# Assuming 'corporate_step_boldness' is a column in your DataFrame
unique_boldness_levels = step_1c_results_df['corporate_step_boldness'].unique()

# Create a separate plot for each unique level of corporate_step_boldness
for level in unique_boldness_levels:
    # Filter the data for the current level of corporate_step_boldness
    level_data = step_1c_results_df[step_1c_results_df['corporate_step_boldness'] == level]

    # Create a new plot
    plt.figure(figsize=(10, 6))
    # Plot the lagged corporate decision
    plt.scatter(level_data['time'], level_data['lagged_corporate_decision'], label='Lagged Corporate Decision (1 = Aggressive

    plt.scatter(level_data['time'], level_data['lagged_corporate_aggression_prob'],
                label=f'Lagged Corporate Aggression Probability (Boldness: {level})',
                alpha=0.8, marker='.')



    # Add labels and title
    plt.xlabel('Time')
    plt.ylabel('Lagged Corporate Aggression Probability')
    plt.title(f'Lagged Corporate Aggression Probability - Boldness Level {level}')
    plt.ylim(0, 1)
    # Show the legend
    plt.legend()

    # Display the plot
    plt.grid(True)
    plt.show()

```

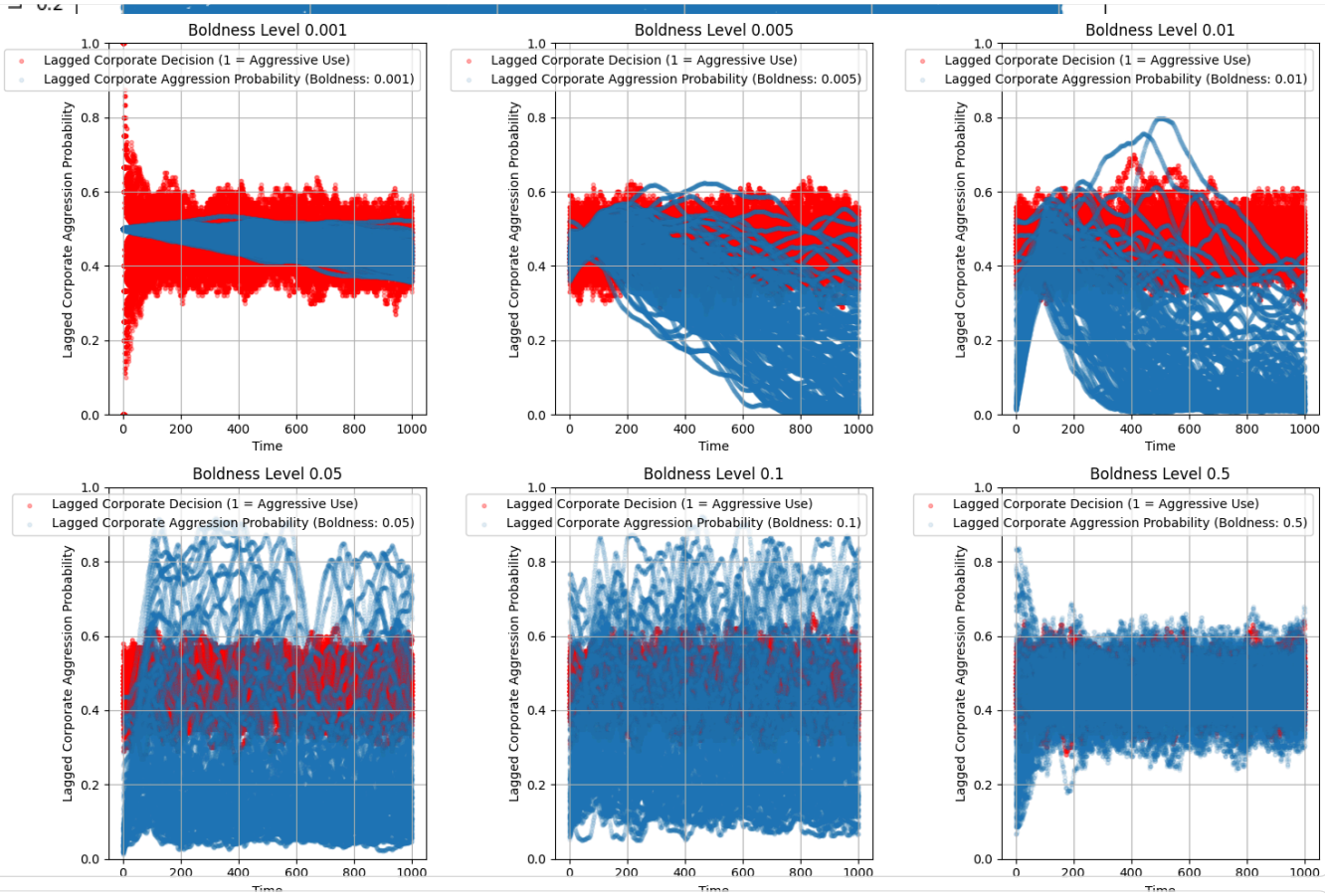




matrix plot - different combinations of stepped function

```
import matplotlib.pyplot as plt
import numpy as np

# Assuming 'corporate_step_boldness' is a column in your DataFrame
unique_boldness_levels = step_1c_results_df['corporate_step_boldness'].unique()

# Determine the number of rows and columns for the grid layout
n_plots = len(unique_boldness_levels)
n_cols = 3  # Number of columns in the grid (adjust as needed)
n_rows = int(np.ceil(n_plots / n_cols))  # Number of rows in the grid

# Create the subplots grid
fig, axes = plt.subplots(n_rows, n_cols, figsize=(15, 5 * n_rows))

# Flatten the axes array to easily index it
axes = axes.flatten()

# Create a separate plot for each unique level of corporate_step_boldness
for i, level in enumerate(unique_boldness_levels):
    # Filter the data for the current level of corporate_step_boldness
```

```
    level_data = step_1c_results_df[step_1c_results_df['corporate_step_boldness'] == level]

    # Get the current axis to plot on
    ax = axes[i]

    # Scatter plot and line plot
    ax.scatter(level_data['time'], level_data['lagged_corporate_decision'],
               label='Lagged Corporate Decision (1 = Aggressive Use)', color='red', alpha=0.3, marker = '.')
    ax.scatter(level_data['time'], level_data['lagged_corporate_aggression_prob'],
               label=f'Lagged Corporate Aggression Probability (Boldness: {level})',
               alpha=0.1, marker='.')
    # Add labels and title
    ax.set_xlabel('Time')
    ax.set_ylabel('Lagged Corporate Aggression Probability')
    ax.set_title(f'Boldness Level {level}')
    ax.set_ylim(0, 1)
    # Show legend
    ax.legend()

    # Enable grid
    ax.grid(True)

# Remove any empty subplots if there are fewer levels than the total number of subplots
for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

# Adjust layout to avoid overlapping elements
plt.tight_layout()
plt.show()

```

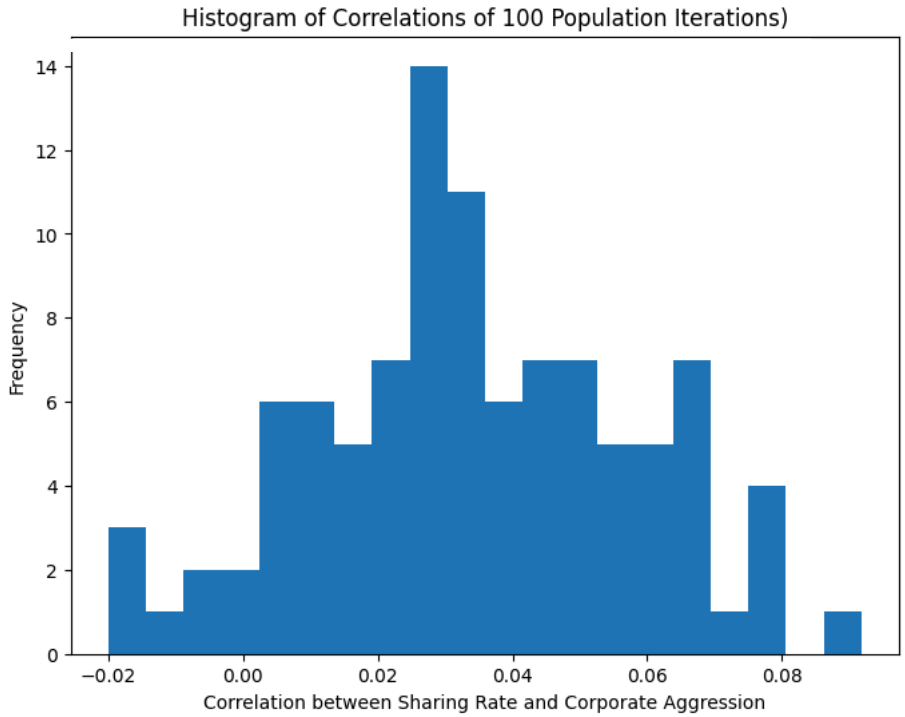



```
Start coding or generate with AI.
```

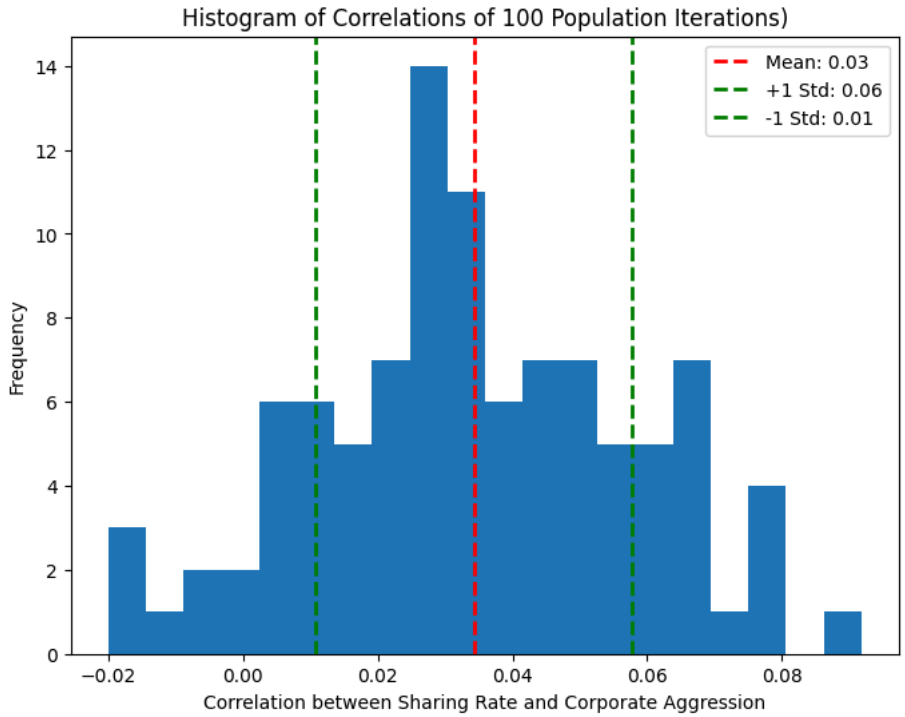
Simulate correlations between sharing rate and corporate aggression for 100 population iterations


```
# prompt: simulate this 100 times, for each time check the correlation between sharing rate and corporate aggression. and plot

```

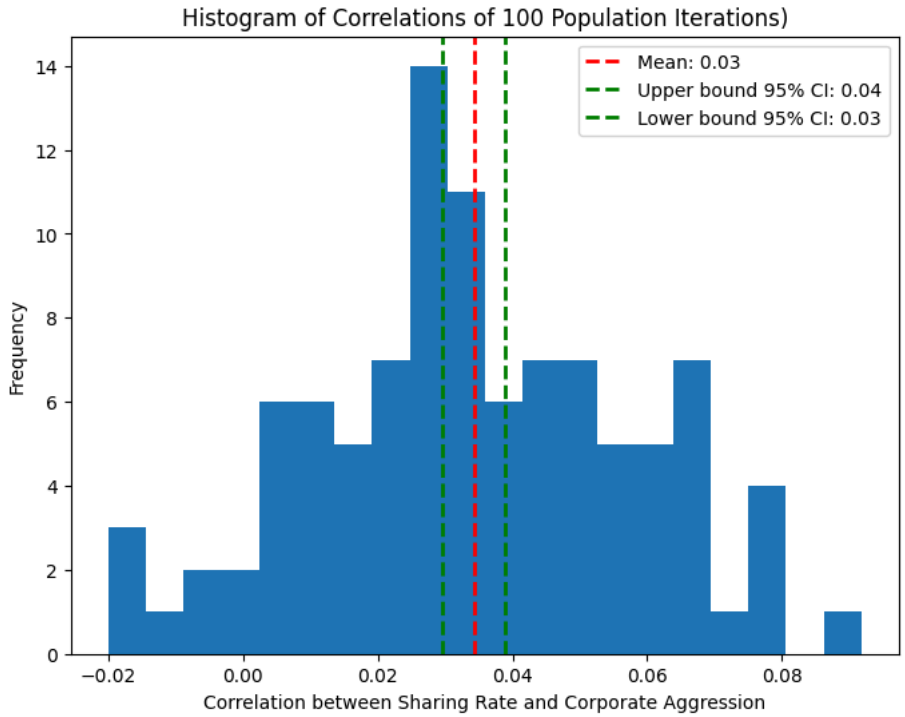
```
correlations = []
large_results_df = []
for iteration in range(100):
  simulation = PrivacySimulation(num_individuals=100, initial_corporate_aggression=0.5)
  results = simulation.run_simulation(time=1000)
  for result in results:
    result['iteration'] = iteration
  large_results_df.append(results)
  results_df = pd.DataFrame(results)
  correlation = results_df['sharing_rate'].corr(results_df['corporate_aggression_prob'])
  correlations.append(correlation)

# Plot the correlations in a histogram
plt.figure(figsize=(8, 6))
plt.hist(correlations, bins=20)
plt.xlabel('Correlation between Sharing Rate and Corporate Aggression')
plt.ylabel('Frequency')
plt.title('Histogram of Correlations of 100 Population Iterations)')
plt.show()

```




```
# prompt: create a histogram of the object correlations showing the mean and std on the plot

import matplotlib.pyplot as plt

# Assuming 'correlations' is the list of correlation values from your simulation
plt.figure(figsize=(8, 6))
plt.hist(correlations, bins=20)
plt.xlabel('Correlation between Sharing Rate and Corporate Aggression')
plt.ylabel('Frequency')
plt.title('Histogram of Correlations of 100 Population Iterations)')
# Calculate the mean and standard deviation of the correlations
mean_correlation = np.mean(correlations)
std_correlation = np.std(correlations)


# Add the mean and std to the plot
plt.axvline(mean_correlation, color='red', linestyle='dashed', linewidth=2, label=f'Mean: {mean_correlation:.2f}')
plt.axvline(mean_correlation + std_correlation, color='green', linestyle='dashed', linewidth=2, label=f'+1 Std: {mean_correlat
plt.axvline(mean_correlation - std_correlation, color='green', linestyle='dashed', linewidth=2, label=f'-1 Std: {mean_correlat

plt.legend()
plt.show()

```




```
# prompt: create a histogram of the object correlations showing the mean and std on the plot

import matplotlib.pyplot as plt

# Assuming 'correlations' is the list of correlation values from your simulation
plt.figure(figsize=(8, 6))
plt.hist(correlations, bins=20)
plt.xlabel('Correlation between Sharing Rate and Corporate Aggression')
plt.ylabel('Frequency')
plt.title('Histogram of Correlations of 100 Population Iterations)')
# Calculate the mean and standard deviation of the correlations
mean_correlation = np.mean(correlations)
std_correlation = 1.96 * np.std(correlations)/np.sqrt(len(correlations))


# Add the mean and std to the plot
plt.axvline(mean_correlation, color='red', linestyle='dashed', linewidth=2, label=f'Mean: {mean_correlation:.2f}')
plt.axvline(mean_correlation + std_correlation, color='green', linestyle='dashed', linewidth=2, label=f'Upper bound 95% CI: {m
plt.axvline(mean_correlation - std_correlation, color='green', linestyle='dashed', linewidth=2, label=f'Lower bound 95% CI: {m

plt.legend()
plt.show()

```



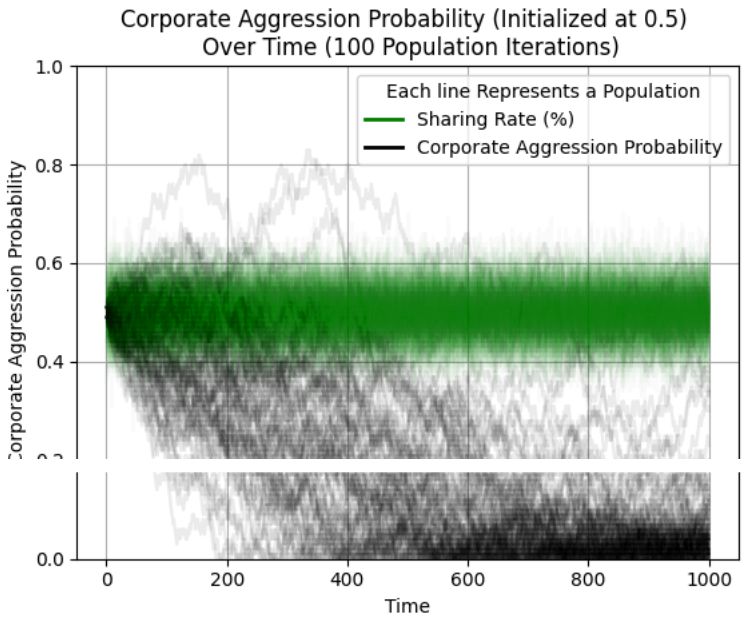
processing large results df

```
1
2
3 # Example usage
4 # Assuming `large_results_np` is a list of lists with dictionaries
5 df_large = convert_to_dataframe(large_results_df)
6
7 # Print the first few rows to verify
8 print(df_large.head())
9
```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.54         aggressive                       0.51
1     2          0.46               fair                       0.50
2     3          0.45               fair                       0.49
3     4          0.53               fair                       0.50
4     5          0.41         aggressive                       0.49

   corporate_decision_history  iteration  outer_iteration
0                           1          0                1
1                           0          0                1
2                           0          0                1
3                           1          0                1
4                           0          0                1
```

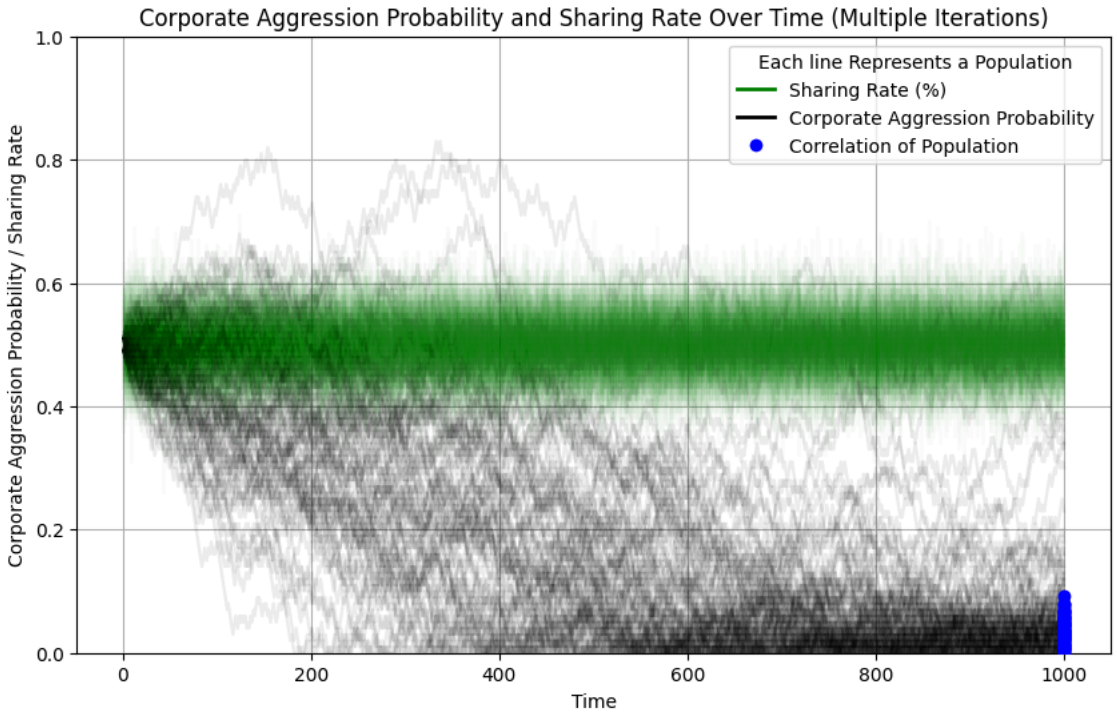
```
1 # prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic
2
3 import matplotlib.pyplot as plt
4 from matplotlib.lines import Line2D
5
6
7 # Assuming df_large is your DataFrame
8 for population in df_large['iteration'].unique():
9   df_subset = df_large[df_large['iteration'] == population]
10   #plt.plot(df_subset['iteration'], df_subset['sharing_rate'], label=f'Outer Iteration {outer_iteration}', alpha = 0.1)
11   plt.plot(df_subset['time'], df_subset['sharing_rate'], label=f'Population {population}', alpha = 0.02,color = 'green')
12
13   plt.plot(df_subset['time'], df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Outer Iteration {outer_ite
14
15 plt.xlabel('Time')
16 plt.ylabel('Corporate Aggression Probability')
17 plt.title('Corporate Aggression Probability (Initialized at 0.5) \n Over Time (100 Population Iterations)')
18 plt.grid(True)
19 plt.ylim(0, 1)
```

```
20
21 # Create dummy legend elements
22 legend_elements = [
23     Line2D([0], [0], color='green', lw=2, label='Sharing Rate (%)'),
24     Line2D([0], [0], color='black', lw=2, label='Corporate Aggression Probability')
25 ]
26
27 # Add legend to the plot (including existing plot and dummy legend)
28 plt.legend(handles=legend_elements, title="Each line Represents a Population")
29
30 plt.show()
31
```

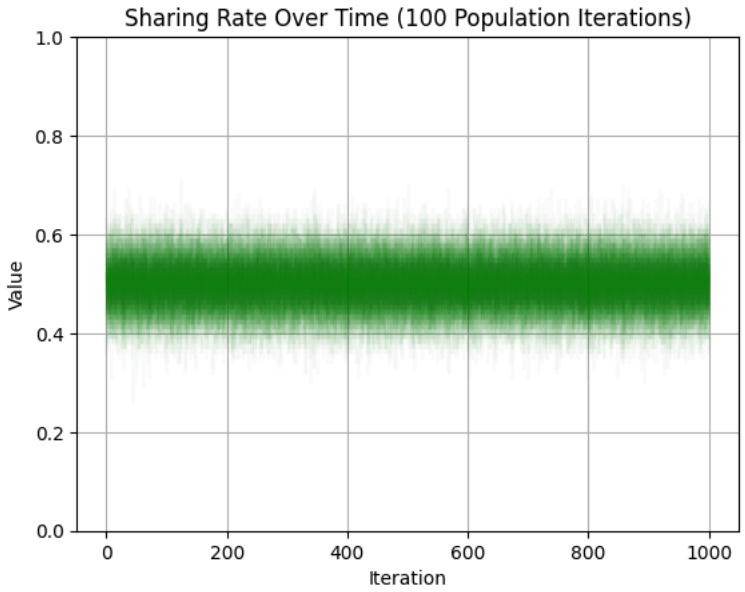



```
 1 import matplotlib.pyplot as plt
 2 from matplotlib.lines import Line2D
 3
 4 # Assuming df_large is your DataFrame
 5 # Assuming you want to plot the correlation for each population at the end of each line
 6 # Calculate correlation for each population at the end of the plot
 7
 8 # Create the plot
 9 plt.figure(figsize=(10, 6))
10 pos = 0
11 # Loop through each population and plot sharing rate and corporate aggression probability
12 for population in df_large['iteration'].unique():
13     cor_point = correlations[pos]
14     df_subset = df_large[df_large['iteration'] == population]
15
16     # Plot sharing rate (left y-axis)
17     plt.plot(df_subset['time'], df_subset['sharing_rate'], label=f'Population {population}', alpha=0.02, color='green')
18
19     # Plot corporate aggression probability (left y-axis)
20     plt.plot(df_subset['time'], df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Population {population})
21
22     # Plot correlation dot at the end of the line (right y-axis)
23     plt.scatter(df_subset['time'].iloc[-1], cor_point, color='blue',marker='o', zorder=5)  # Blue dot for correlation
24     pos += 1
25
26 # Add legend to the plot
27 # Set labels and title for the plot
28 plt.xlabel('Time')
29 plt.ylabel('Corporate Aggression Probability / Sharing Rate', color='black')
30 plt.title('Corporate Aggression Probability and Sharing Rate Over Time (Multiple Iterations)')
31 plt.grid(True)
32 plt.ylim(0, 1)
33
34 # Create dummy legend elements
35 legend_elements = [
36     Line2D([0], [0], color='green', lw=2, label='Sharing Rate (%)'),
37     Line2D([0], [0], color='black', lw=2, label='Corporate Aggression Probability'),
```

```
    Line2D([0], [0], marker='o', color='w', markerfacecolor='blue', markersize=8, label='Correlation of Population', lw=0)  #

]

# Add legend to the plot (including existing plot and dummy legend)
plt.legend(handles=legend_elements, title="Each line Represents a Population")

# Show the plot
plt.show()

```




```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for population in df_large['iteration'].unique():
  df_subset = df_large[df_large['iteration'] == population]
  plt.plot(df_subset['time'], df_subset['sharing_rate'], label=f'Population {population}', alpha = 0.02,color = 'green')
  #plt.plot(df_subset['iteration'], df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Outer Iteration {out


plt.xlabel('Iteration')
plt.ylabel('Value')
plt.title('Sharing Rate Over Time (100 Population Iterations)')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```



Part Two - Correlations of Sharing Rate and Aggression Prob

```
1 Start coding or generate with AI.
```

Plotting correlations against Initial corporate aggression

```
# prompt: simulate this 100 times for initial_gorporate_aggression going from 0.01 to 1.00 for each time check the correlatior

correlations_data = []
vlarge_results_df = []
for initial_aggression in np.linspace(0.01, 1.00, 100):
  correlations = []
  corporate_decisions = []
  for population in range(100):
    simulation = PrivacySimulation(num_individuals=100, initial_corporate_aggression=initial_aggression)
    results = simulation.run_simulation(time=1000)
    for result in results:
      result['init_aggression'] = initial_aggression
      result['iteration'] = population
    vlarge_results_df.append(results)
    results_df = pd.DataFrame(results)
    results_df['corporate_decision_history'] = results_df['corporate_decision_history'].astype(int)
    correlation = results_df['sharing_rate'].corr(results_df['corporate_aggression_prob'])
    correlations.append(correlation)
    corporate_aggr_decisions = results_df['corporate_decision_history'].sum()/len(results_df['corporate_decision_history'])


  # Calculate mean and confidence interval
  mean_correlation = np.mean(correlations)
  std_correlation = np.std(correlations)
  confidence_interval = 1.96 * (std_correlation / np.sqrt(len(correlations)))  # 95% CI

  results_df['corporate_decision_history']
  correlations_data.append({
      'initial_aggression': initial_aggression,
      'mean_correlation': mean_correlation,
      'confidence_interval': confidence_interval,
      'correlation_stdev': std_correlation,
      'corporate_decision_history': corporate_aggr_decisions
  })


# Create a DataFrame from the correlations data
correlations_df = pd.DataFrame(correlations_data)

```

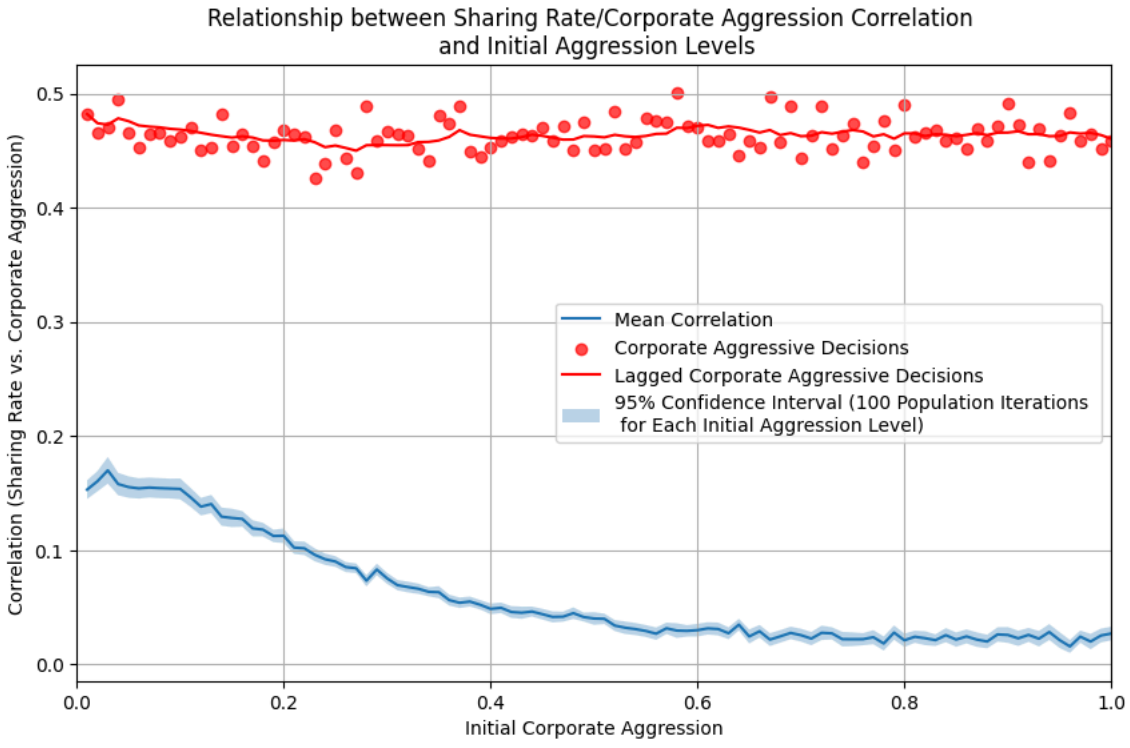
```
40
41
```

```
1 # prompt: create a lagged corporate_aggr_decisions from correlation_df window = 10
2
3 # Assuming correlation_df is your DataFrame and it has columns 'iteration' and 'corporate_aggr_decisions'
4 # Group by 'iteration' and apply a rolling window with a window size of 10
5
6 correlations_df['lagged_corporate_decision_history'] = (
7     correlations_df['corporate_decision_history']
8     .transform(lambda x: x.rolling(window=10, min_periods=1).mean())
9 )
10
```

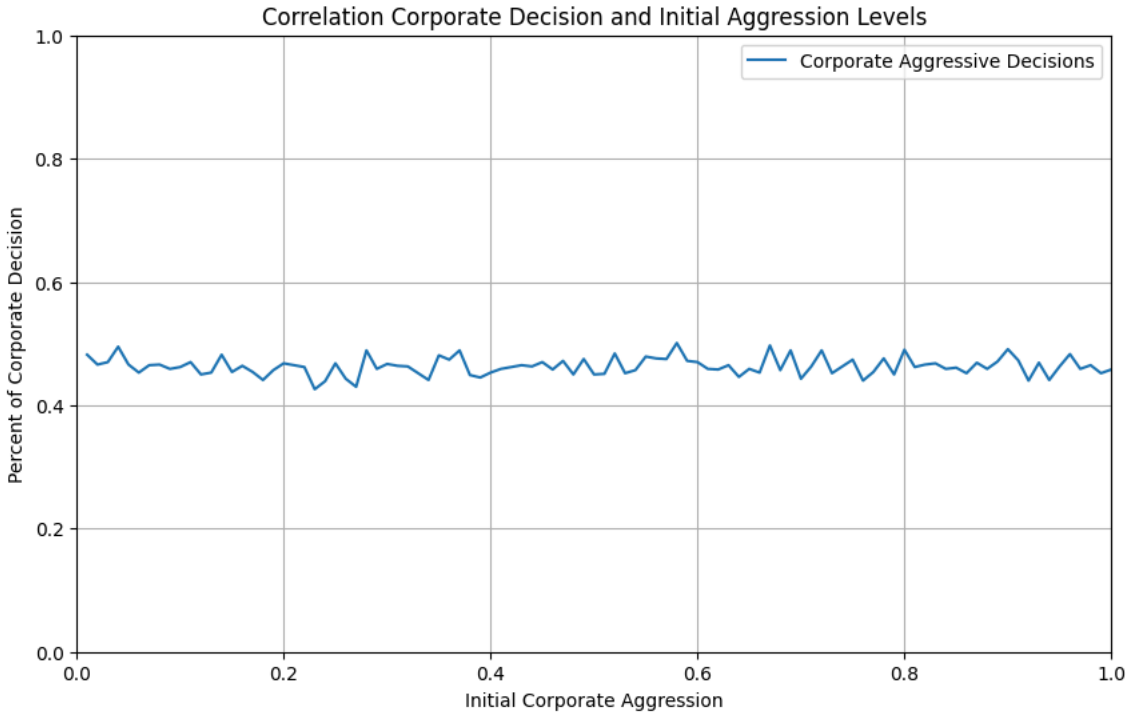
```
1 correlations_df.shape
```

```
(100, 5)
```

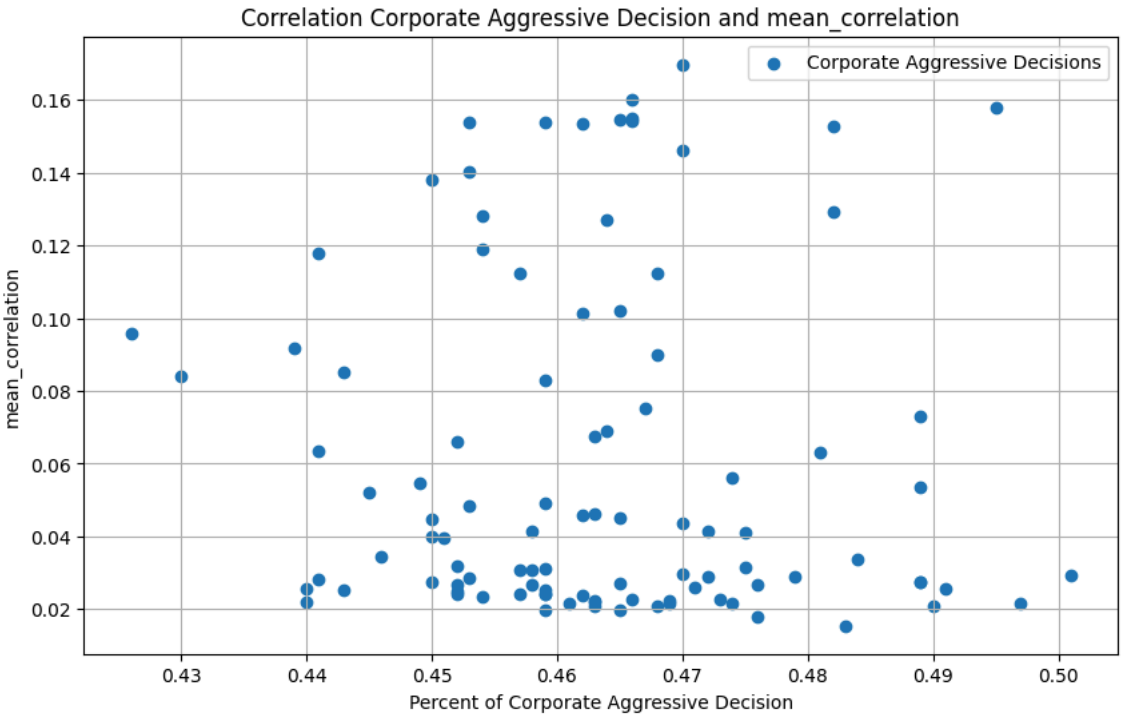
```
1 # Plot the correlations against initial corporate aggression
2 plt.figure(figsize=(10, 6))
3 plt.plot(correlations_df['initial_aggression'], correlations_df['mean_correlation'], label='Mean Correlation')
4 plt.scatter(correlations_df['initial_aggression'], correlations_df['corporate_decision_history'], label='Corporate Aggressive
5 plt.plot(correlations_df['initial_aggression'], correlations_df['lagged_corporate_decision_history'], label='Lagged Corporate
6
7 plt.fill_between(
8     correlations_df['initial_aggression'],
9     correlations_df['mean_correlation'] - correlations_df['confidence_interval'],
10    correlations_df['mean_correlation'] + correlations_df['confidence_interval'],
11    alpha=0.3,
12    label='95% Confidence Interval (100 Population Iterations \n for Each Initial Aggression Level)'
13 )
14
15
16 plt.xlabel('Initial Corporate Aggression')
17 plt.ylabel('Correlation (Sharing Rate vs. Corporate Aggression)')
18 plt.title('Relationship between Sharing Rate/Corporate Aggression Correlation \n and Initial Aggression Levels')
19 #plt.ylim(0, 1)  # Set the y-axis limits to 0 and 1
20 plt.xlim(0, 1)  # Set the y-axis limits to 0 and 1
21
22 plt.legend()
23 plt.grid(True)
24 plt.show()
```



```
# Plot the correlations against initial corporate aggression
plt.figure(figsize=(10, 6))
plt.plot(correlations_df['initial_aggression'], correlations_df['corporate_decision_history'], label='Corporate Aggressive Dec
plt.xlabel('Initial Corporate Aggression')
plt.ylabel('Percent of Corporate Decision')
plt.title('Correlation Corporate Decision and Initial Aggression Levels')
plt.legend()
plt.grid(True)
plt.ylim(0, 1)  # Set the y-axis limits to 0 and 1
plt.xlim(0, 1)  # Set the y-axis limits to 0 and 1

plt.show()
```



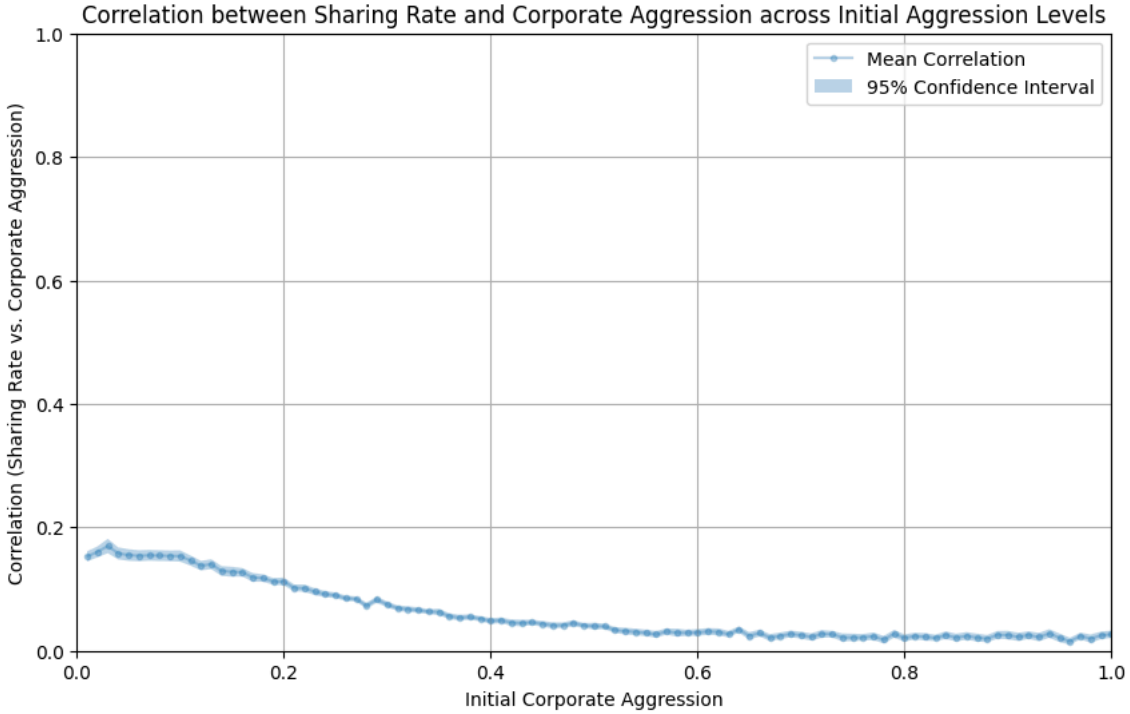

```
# Plot the correlations against initial corporate aggression
plt.figure(figsize=(10, 6))
plt.scatter(correlations_df['corporate_decision_history'],correlations_df['mean_correlation'],  label='Corporate Aggressive De
plt.ylabel('mean_correlation')
plt.xlabel('Percent of Corporate Aggressive Decision')
plt.title('Correlation Corporate Aggressive Decision and mean_correlation')
plt.legend()
plt.grid(True)
#plt.ylim(0, 1)  # Set the y-axis limits to 0 and 1
#plt.xlim(0, 1)  # Set the y-axis limits to 0 and 1

plt.show()
```




```
1 correlations_df.columns
```

```
Index(['initial_aggression', 'mean_correlation', 'confidence_interval',
       'correlation_stdev', 'corporate_decision_history',
       'lagged_corporate_aggr_decisions', 'lagged_corporate_decision_history'],
      dtype='object')
```

```
 1 # prompt: in the code below also include the dots in the plot. # Plot the correlations against initial corporate aggression
 2
 3 # Plot the correlations against initial corporate aggression
 4 plt.figure(figsize=(10, 6))
 5 plt.plot(correlations_df['initial_aggression'], correlations_df['mean_correlation'], label='Mean Correlation', marker='.', alp
 6 plt.fill_between(
 7     correlations_df['initial_aggression'],
 8     correlations_df['mean_correlation'] - correlations_df['confidence_interval'],
 9     correlations_df['mean_correlation'] + correlations_df['confidence_interval'],
10     alpha=0.3,
11     label='95% Confidence Interval'
12 )
13 plt.xlabel('Initial Corporate Aggression')
14 plt.ylabel('Correlation (Sharing Rate vs. Corporate Aggression)')
15 plt.title('Correlation between Sharing Rate and Corporate Aggression across Initial Aggression Levels')
16 plt.legend()
17 plt.ylim(0, 1)  # Set the y-axis limits to 0 and 1
18 plt.xlim(0, 1)  # Set the y-axis limits to 0 and 1
19 plt.grid(True)
20 plt.show()
21
```

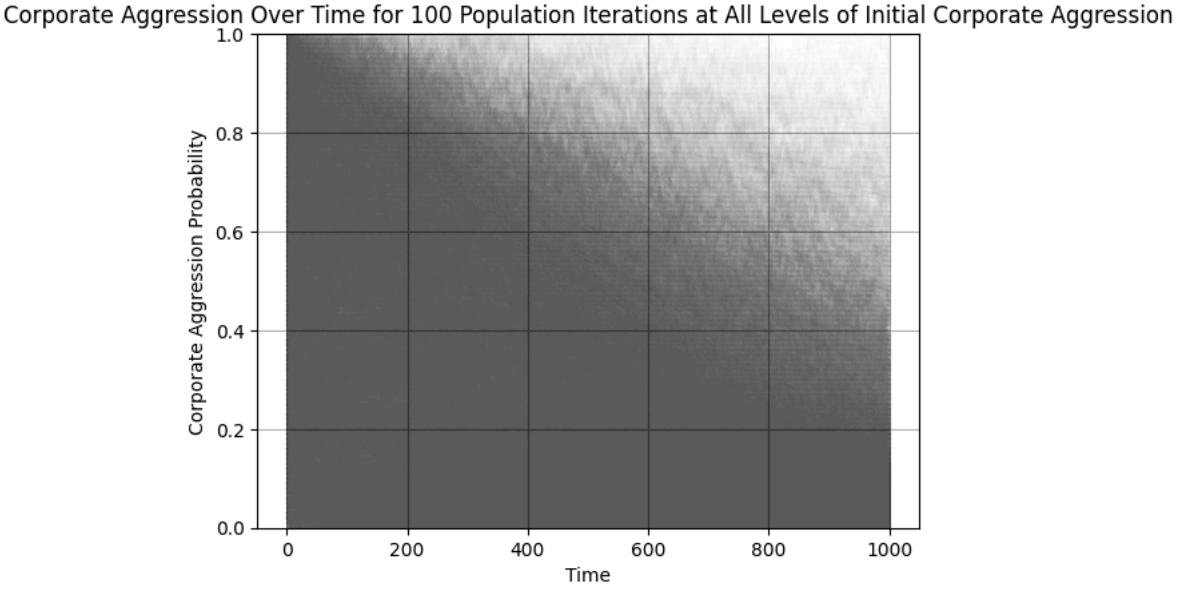


Processing vlarge_df

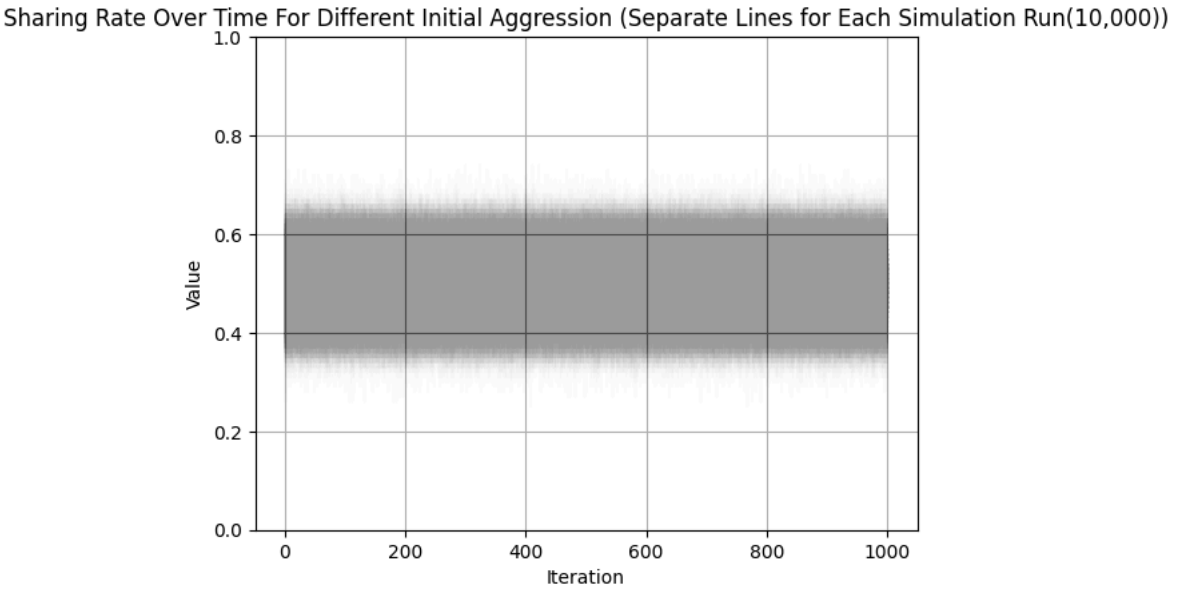
```
# Example usage
# Assuming `large_results_np` is a list of lists with dictionaries
df_vlarge = convert_to_dataframe(vlarge_results_df)

# Print the first few rows to verify
print(df_vlarge.head())

```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.43               fair                       0.00
1     2          0.49               fair                       0.00
2     3          0.54               fair                       0.01
3     4          0.51               fair                       0.02
4     5          0.43               fair                       0.01

   corporate_decision_history  init_aggression  iteration  outer_iteration
0                           0             0.01          0                1
1                           0             0.01          0                1
2                           1             0.01          0                1
3                           1             0.01          0                1
4                           0             0.01          0                1
```

```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for population in df_vlarge['iteration'].unique():
  df_subset = df_vlarge[df_vlarge['iteration'] == population]
  #plt.plot(df_subset['iteration'], df_subset['sharing_rate'], label=f'Outer Iteration {outer_iteration}', alpha = 0.1)
  plt.plot(df_subset['time'], df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Outer Iteration {outer_ite


plt.xlabel('Time')
plt.ylabel('Corporate Aggression Probability')
plt.title('Corporate Aggression Over Time for 100 Population Iterations at \n All Levels of Initial Corporate Aggression')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```

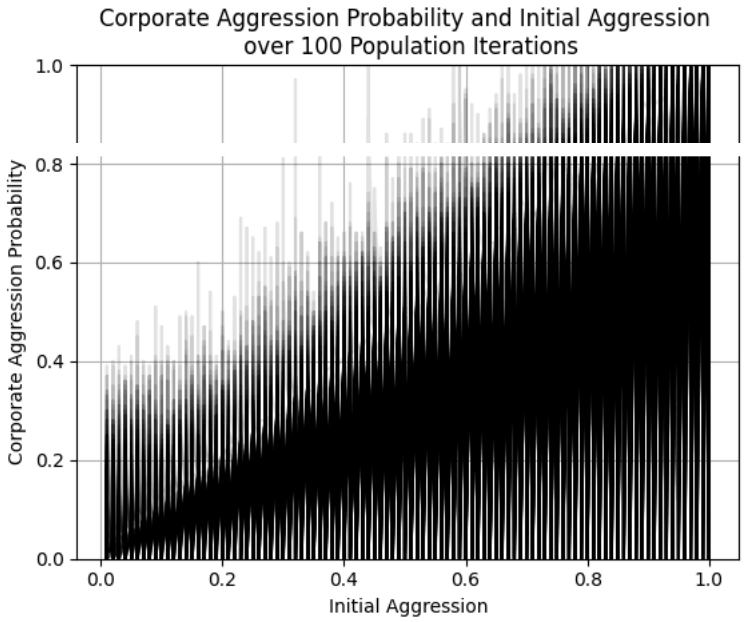



```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for population in df_vlarge['iteration'].unique():
  df_subset = df_vlarge[df_vlarge['iteration'] == population]
  plt.plot(df_subset['time'], df_subset['sharing_rate'], label=f'Population {population}', alpha = 0.002,color = 'black')
  #plt.plot(df_subset['iteration'], df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Outer Iteration {out


plt.xlabel('Iteration')
plt.ylabel('Value')
plt.title('Sharing Rate Over Time For Different Initial Aggression (Separate Lines for Each Simulation Run(10,000))')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```

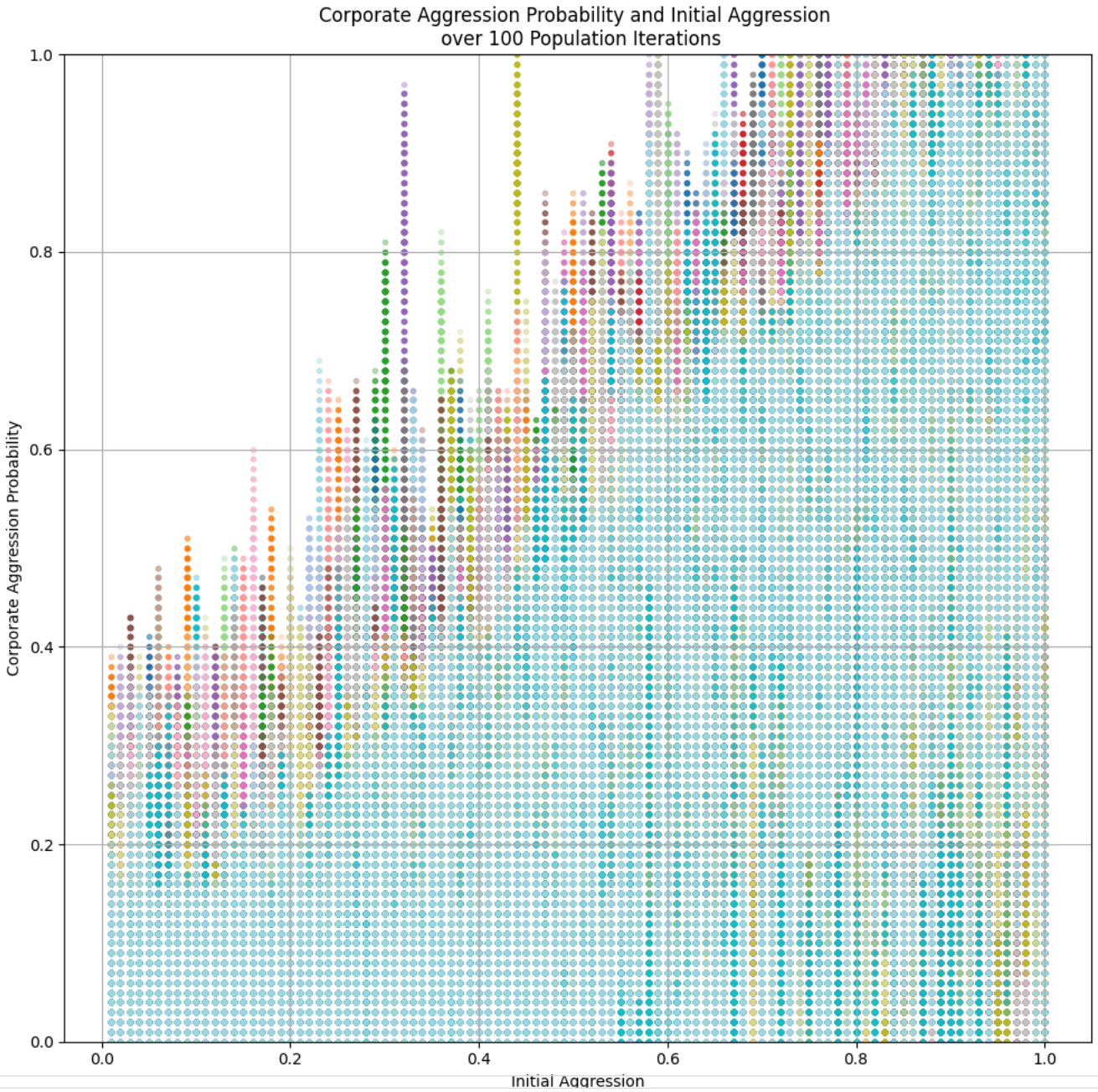



```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for population in df_vlarge['iteration'].unique():
```

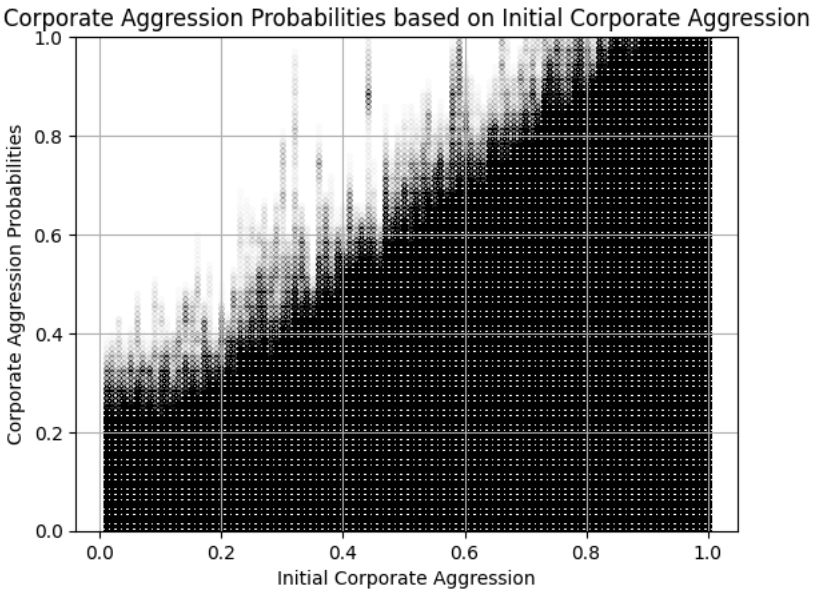
```
  df_subset = df_vlarge[df_vlarge['iteration'] == population]
  #plt.plot(df_subset['iteration'], df_subset['sharing_rate'], label=f'Outer Iteration {outer_iteration}', alpha = 0.1)
  plt.plot(df_subset['init_aggression'],df_subset['corporate_aggression_prob'], label=f'Corporate Aggression in Population {pc


plt.ylabel('Corporate Aggression Probability')
plt.xlabel('Initial Aggression')
plt.title('Corporate Aggression Probability and Initial Aggression \n over 100 Population Iterations')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```



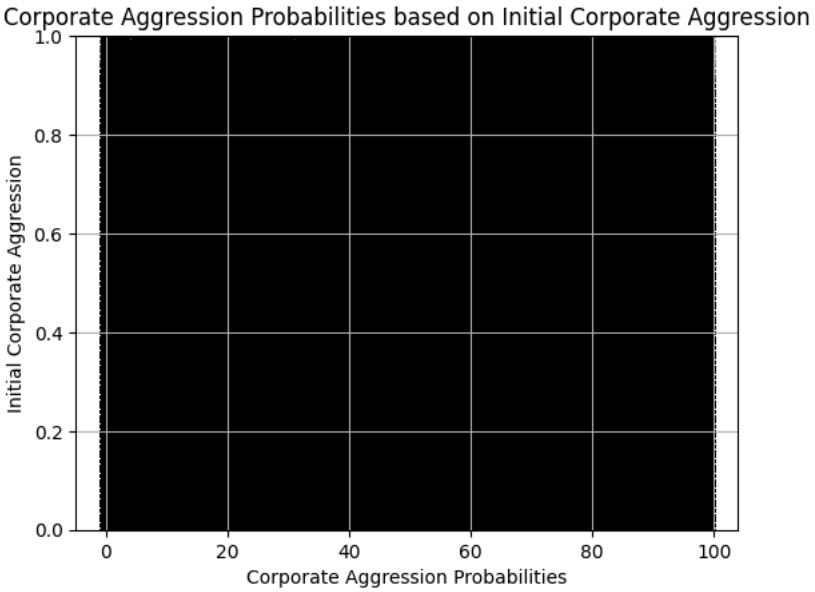

```
import matplotlib.pyplot as plt
import seaborn as sns

# Assuming df_vlarge is your DataFrame
# Use Seaborn color palette to get unique colors for each population
colors = sns.color_palette("tab20", n_colors=len(df_vlarge['iteration'].unique()))  # "tab20" is a set of distinct colors

# Create the plot
plt.figure(figsize=(10, 10))

# Loop through each population and plot sharing rate and corporate aggression probability
for idx, population in enumerate(df_vlarge['iteration'].unique()):
    df_subset = df_vlarge[df_vlarge['iteration'] == population]

    # Plot corporate aggression probability with a unique color for each population
    plt.scatter(df_subset['init_aggression'], df_subset['corporate_aggression_prob'],
             label=f'Population {population}', alpha=0.3, color=colors[idx], marker='.')

# Set labels and title for the plot
plt.ylabel('Corporate Aggression Probability')
plt.xlabel('Initial Aggression')
plt.title('Corporate Aggression Probability and Initial Aggression \n over 100 Population Iterations')
plt.grid(True)
plt.ylim(0, 1)

# Show the plot
plt.tight_layout()
plt.show()

```




```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for init_aggression in df_vlarge['init_aggression'].unique():
  df_subset = df_vlarge[df_vlarge['init_aggression'] == init_aggression]
  plt.scatter(df_subset['init_aggression'],df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Outer Iterati


plt.ylabel('Corporate Aggression Probabilities')
plt.xlabel('Initial Corporate Aggression')
plt.title('Corporate Aggression Probabilities based on Initial Corporate Aggression')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```

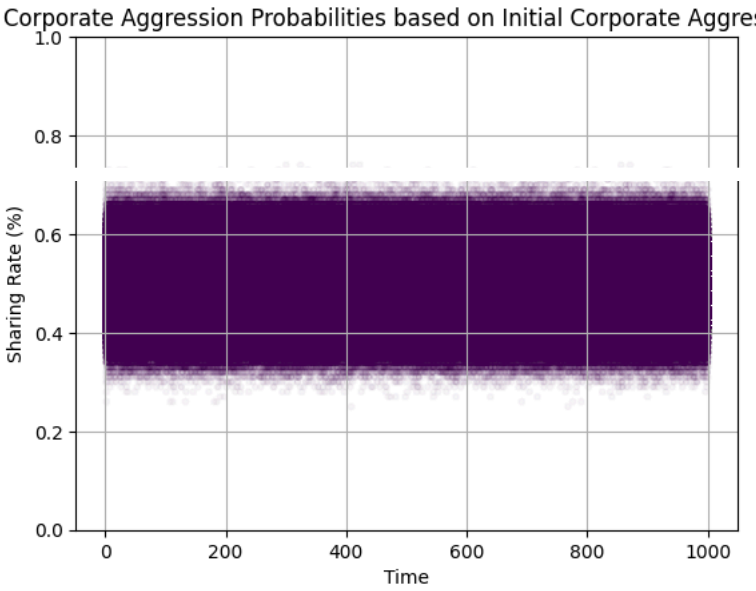



```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for init_aggression in df_vlarge['init_aggression'].unique():
  df_subset = df_vlarge[df_vlarge['init_aggression'] == init_aggression]
  plt.scatter(df_subset['iteration'],df_subset['corporate_aggression_prob'], label=f'Corporate Aggression (Outer Iteration {ir


plt.xlabel('Corporate Aggression Probabilities')
plt.ylabel('Initial Corporate Aggression')
plt.title('Corporate Aggression Probabilities based on Initial Corporate Aggression')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```

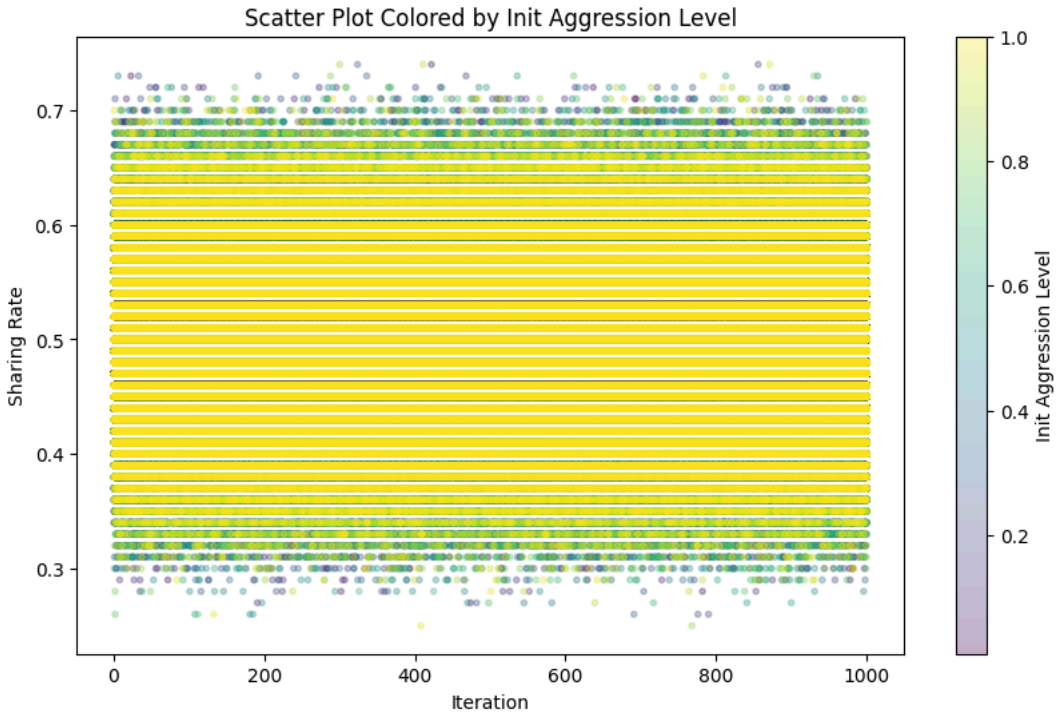



```
# prompt: plot sharing rate and corporate aggression from df_large with a separate line for each outer iteration. Use iteratic

import matplotlib.pyplot as plt

# Assuming df_large is your DataFrame
for init_aggression in df_vlarge['init_aggression'].unique():
  df_subset = df_vlarge[df_vlarge['init_aggression'] == init_aggression]
```

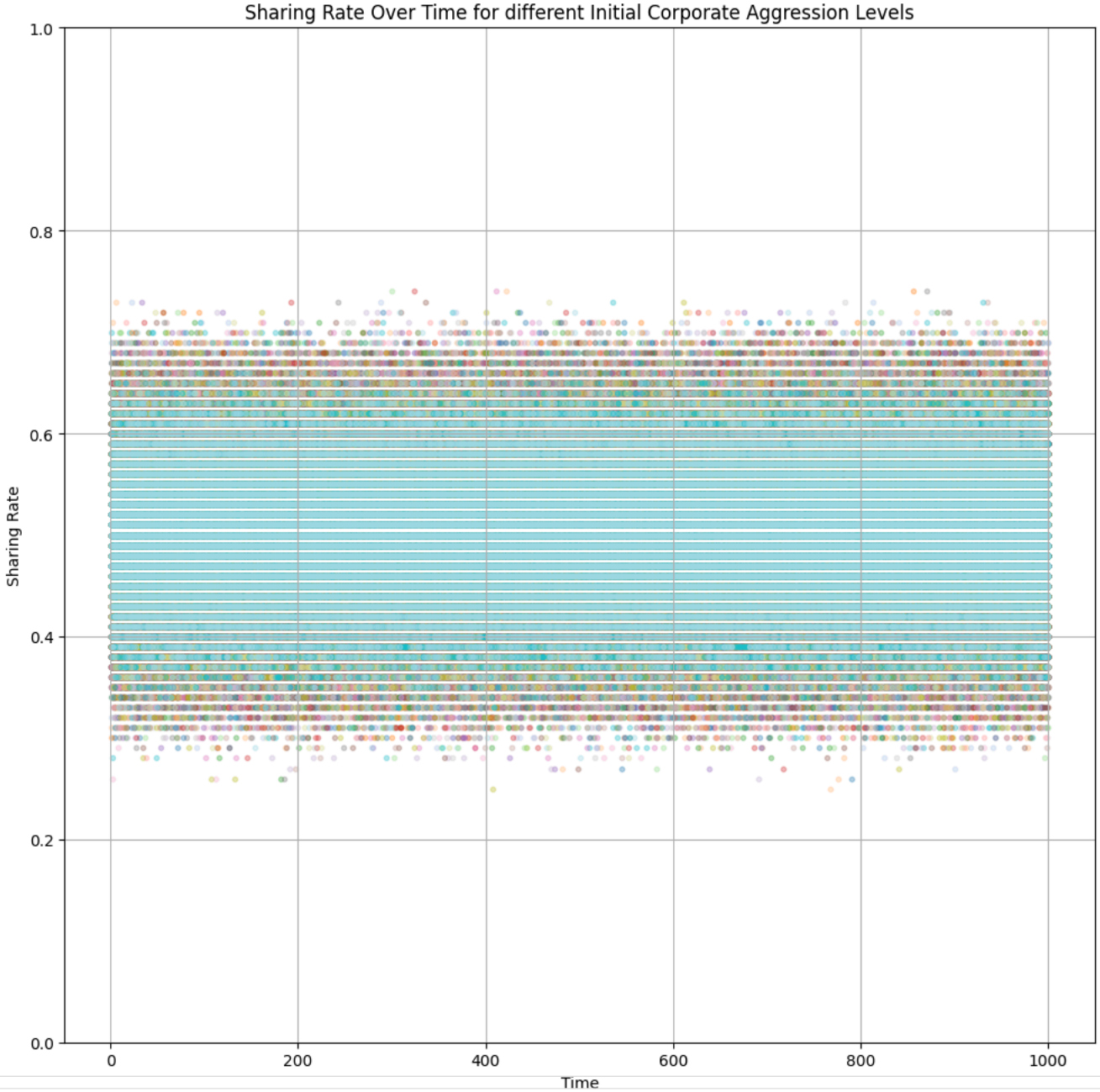
```
  plt.scatter(df_subset['time'],df_subset['sharing_rate'], label=f'Corporate Aggression (Outer Iteration {init_aggression})',c

plt.xlabel('Time')
plt.ylabel('Sharing Rate (%)')
plt.title('Sharing Rate over Time for all Initial Corporate Aggression Levels')
plt.grid(True)
plt.ylim(0, 1)
plt.show()

```



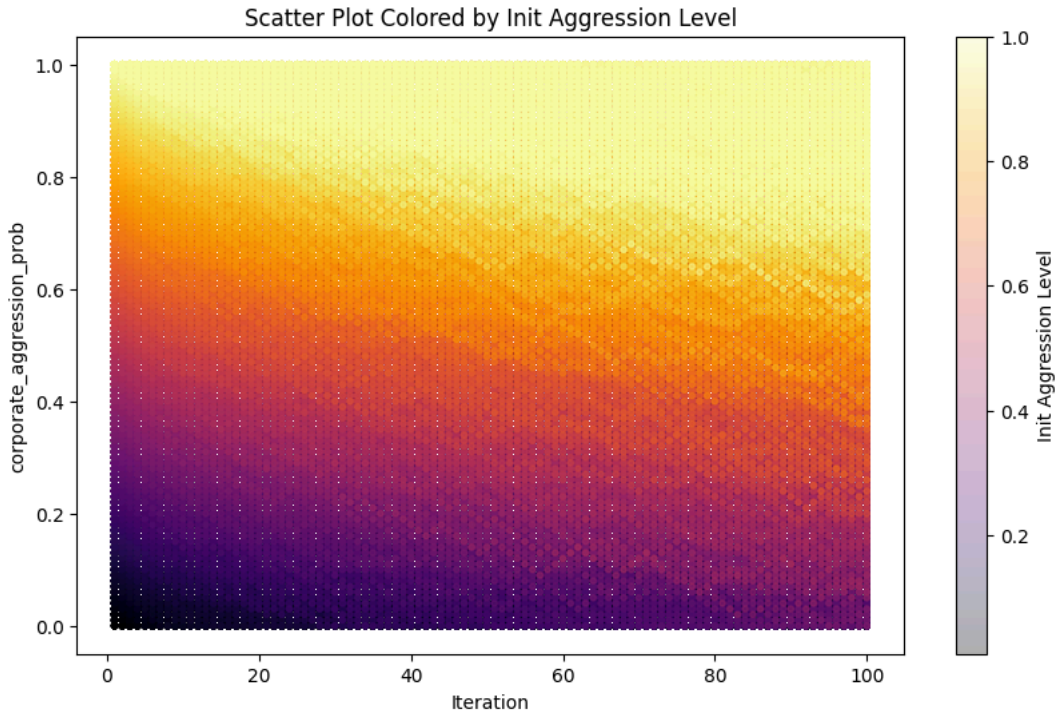

```
import matplotlib.pyplot as plt

# Create the scatter plot, coloring by 'init_aggression' from the entire DataFrame
plt.figure(figsize=(10, 6))
scatter = plt.scatter(df_vlarge['time'], df_vlarge['sharing_rate'],
                      c=df_vlarge['init_aggression'],  # Color by init_aggression
                      cmap='viridis',  # Choose your desired colormap
                      alpha=0.3,
                      marker='.')

# Add a colorbar to show the mapping from init_aggression values to colors
plt.colorbar(scatter, label='Init Aggression Level')

# Add labels and title
plt.xlabel('Time')
plt.ylabel('Sharing Rate')
plt.title('Sharing Rate Over Time Colored by Init Aggression Level')
plt.ylim(0, 1)
# Show the plot
plt.show()
```




```
import matplotlib.pyplot as plt
import seaborn as sns

# Assuming df_vlarge is your DataFrame
# Use Seaborn color palette to get unique colors for each population
colors = sns.color_palette("tab20", n_colors=len(df_vlarge['init_aggression'].unique()))  # "tab20" is a set of distinct color

# Create the plot
plt.figure(figsize=(10, 10))

# Loop through each population and plot sharing rate and corporate aggression probability
for idx, init_aggr in enumerate(df_vlarge['init_aggression'].unique()):
    df_subset = df_vlarge[df_vlarge['init_aggression'] == init_aggr]

    # Plot corporate aggression probability with a unique color for each population
    plt.scatter(df_subset['time'], df_subset['sharing_rate'],
             label=f'Initial Aggression Level {init_aggr}', alpha=0.3, color=colors[idx], marker='.')

# Set labels and title for the plot
plt.ylabel('Sharing Rate')
plt.xlabel('Time')
plt.title('Sharing Rate Over Time for different Initial Corporate Aggression Levels')
plt.grid(True)
plt.ylim(0, 1)

# Show the plot
plt.tight_layout()
plt.show()

```

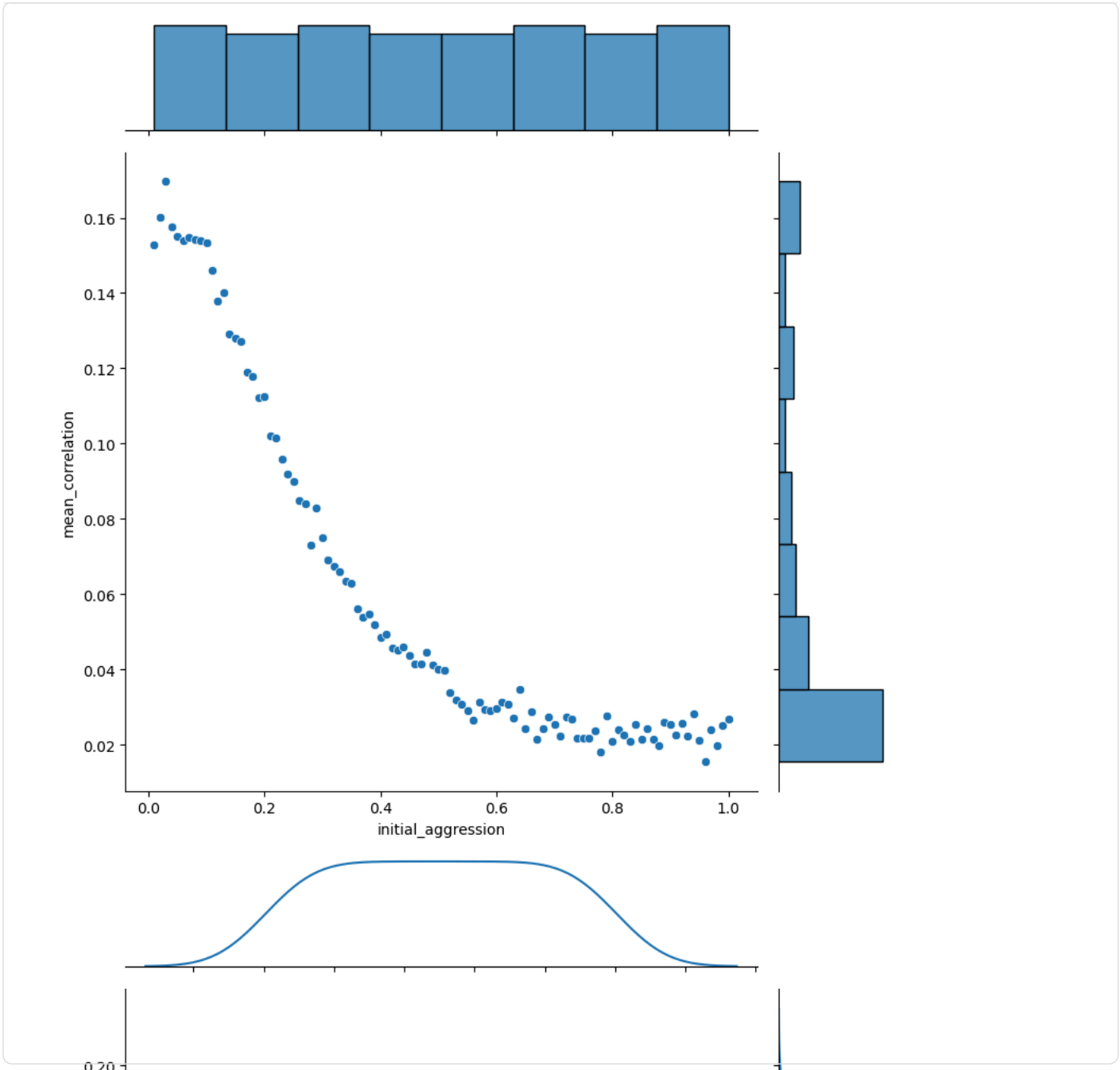



```
import matplotlib.pyplot as plt

# Create the scatter plot, coloring by 'init_aggression' from the entire DataFrame
plt.figure(figsize=(10, 6))
scatter = plt.scatter(df_vlarge['iteration'], df_vlarge['corporate_aggression_prob'],
                      c=df_vlarge['init_aggression'],  # Color by init_aggression
                      cmap='inferno',  # Choose your desired colormap
                      alpha=0.3,
                      marker='.')

# Add a colorbar to show the mapping from init_aggression values to colors
plt.colorbar(scatter, label='Init Aggression Level')

# Add labels and title
plt.xlabel('Iteration')
plt.ylabel('corporate_aggression_prob')
plt.title('Scatter Plot Colored by Init Aggression Level')

# Show the plot
plt.show()
```




```
#correlations_df.to_csv("mar25_100ind2000runs.csv")
```

```
# prompt: seaborn plot all values scatter and edge histogram in correlations_df, place confidence interval around each mean pc

import seaborn as sns

# Assuming correlations_df is your DataFrame with 'initial_aggression' and 'mean_correlation'
sns.jointplot(data=correlations_df, x='initial_aggression', y='mean_correlation', kind="scatter", height=8)
plt.show()


# Alternatively, you can use a scatter plot with marginal histograms using jointplot
sns.jointplot(data=correlations_df, x='initial_aggression', y='mean_correlation', kind="kde", height=8)
plt.show()

# Customize the plot further using seaborn's options
# For example, you can add a title and change the colors

# sns.jointplot(data=correlations_df, x='initial_aggression', y='mean_correlation', kind="kde", height=8).fig.suptitle("Correl
# plt.show()

```



Part Three: Learning Rate

Simulation after adding a Learning Rate

function - privacy simulation 2

```
import numpy as np
import random
from typing import List, Dict
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

class PrivacySimulation_2:
    def __init__(self,
                 num_individuals: int = 100, #N
                 initial_corporate_aggression: float = 0.5, #S_a,0
                 initial_norm: float = 0.5, #R_i,0
                 norm_learning_rate: float = 0.1, #beta, LR
```

```
                corporate_step_boldness: float = 0.01, #B
                dr_pause: int = 10, #D_r
                initial_sharing_prob: float = 0.5, #P_i,0
                platform_tenure: int = 10, #T_p
                corporate_aggression_sensitivity: float = 0.1, #phi, CAS
                social_influence_strength: float = 0.2): #alpha, SI
        """
        Initialize the privacy exploitation simulation with norm dynamics

        Args:
            N num_individuals (int): Number of individual agents
            S_a,0 initial_corporate_aggression (float): Initial probability of corporate aggressive strategy
            R_i,0 initial_norm (float): initial individual probability of sharing (coin toss)
            LR, Beta norm_learning_rate (float): Rate at which agents update their behavior based on observed norms
            B corporate_step_boldness (float): The percentage increase/decrease in corporate boldness after observing sharing
            D_r dr_pause (int): pause after deciding not to post for naturalness. set to -1 to ignore
            P_i,0 initial_sharing_prob (float): Initial probability of sharing information (coin toss)
            T_p platform_tenure (int): the length of time before/after the pause is applied
            CAS, Phi corporate_aggression_sensitivity (float): Sensitivity of individuals to corporate aggression, multiplies
            SI, alpha social_influence_strength (float): Strength of social influence on individual decisions

        """
        # Simulation parameters
        self.num_individuals = num_individuals
        self.corporate_aggression_prob = initial_corporate_aggression
        self.corporate_step_boldness = corporate_step_boldness
        self.initial_sharing_prob = initial_sharing_prob
        self.initial_corporate_aggression = initial_corporate_aggression
        self.norm_learning_rate = norm_learning_rate
        self.social_influence_strength = social_influence_strength
        self.corporate_aggression_sensitivity = corporate_aggression_sensitivity
        self.R_s = initial_norm #initialized with R_i,0 then calculated subsequently
        self.dr_pause = dr_pause
        self.platform_tenure = platform_tenure

        # Track simulation state
        self.current_iteration = 0
        self.corporate_decision = None
        self.individual_sharing_history = []
        self.corporate_strategy_history = [] #text
        self.corporate_decision_history = [] #boolean
        self.decision_history = []
        self.pop_norm_history = [] #list of R_s calculated
        self.live_adjusted_sharing_probs = []


        # Initialize agents and pass simulation arguments to each to begin.
        self.individual_agents = [
            IndividualAgent_2(
                norm_learning_rate=self.norm_learning_rate,
                social_influence_strength=self.social_influence_strength,
                corporate_aggression_sensitivity=self.corporate_aggression_sensitivity,
                dr_pause=self.dr_pause,
                initial_sharing_prob=self.initial_sharing_prob,
                platform_tenure = self.platform_tenure
            ) for _ in range(num_individuals)
        ]
        self.corporate_agent = CorporateAgent_2()

    def run_iteration(self):
        """
        Run a single iteration of the simulation with norm dynamics
        """

        # Individual sharing decisions
        agent_response_full = [ #index is separate individuals
            agent.decide_to_share(social_norm = self.R_s) for agent in self.individual_agents
        ]


        agent_response_1, agent_response_2 = zip(*agent_response_full)
        individual_sharing_decisions = list(agent_response_1)
        live_adjusted_sharing_probs = list(agent_response_2)
        live_adjusted_sharing_probs = sum(live_adjusted_sharing_probs) / len(live_adjusted_sharing_probs)

        #if self.current_iteration % 17 == 0:
            #print("Sharing norm: ", self.R_s)
```

```
            #print(agent_response_2)


        # Calculate sharing rate
        self.R_s = sum(individual_sharing_decisions) / self.num_individuals


        # Update individual agents' norms based on aggregate behavior
        for agent in self.individual_agents:
            agent.update_sharing_norm(self.R_s)

        # Corporate strategy selection
        corporate_strategy = self.corporate_agent.choose_strategy(
            self.corporate_aggression_prob
        )
        if corporate_strategy == 'aggressive':
            self.corporate_decision = 1
        else:
            self.corporate_decision = 0

        # Update corporate aggression probability based on sharing rate. Try with fixed 0.5 or with comparison with aggressic
        #if self.R_s > 2 * self.corporate_aggression_prob:
        if self.R_s > 0.5:
            # If majority share, increase likelihood of aggressive strategy
            #self.corporate_decision = 1
            self.corporate_aggression_prob = min(
                1.0,
                self.corporate_aggression_prob + self.corporate_step_boldness
            )
        else:
            # If majority resist, decrease likelihood of aggressive strategy
            #self.corporate_decision = 0
            self.corporate_aggression_prob = max(
                0.0,
                self.corporate_aggression_prob - self.corporate_step_boldness
            )
        # Collect personal sharing history for all agents
        personal_sharing_histories = [
            agent.get_personal_sharing_history() for agent in self.individual_agents
        ]
        updated_individual_norms = [agent.personal_sharing_norm for agent in self.individual_agents]

        # Flatten the structure for easier access
        #flattened_personal_sharing_histories = [
        #    sharing_history for agent_history in personal_sharing_histories for sharing_history in agent_history
        #]

        #self.decision_history.append(flattened_personal_sharing_histories)

        # Record history
        self.individual_sharing_history.append(individual_sharing_decisions)
        self.live_adjusted_sharing_probs.append(live_adjusted_sharing_probs)
        self.corporate_strategy_history.append(corporate_strategy)
        self.corporate_decision_history.append(self.corporate_decision)
        self.pop_norm_history.append(self.R_s)
        #self.decision_history.append(self.corporate_decision)

        # Increment iteration
        self.current_iteration += 1

        return {
            'time': self.current_iteration,
            'sharing_rate': self.R_s,
            'corporate_strategy': corporate_strategy,
            'corporate_aggression_prob': self.corporate_aggression_prob,
            #'sharing_norm': R_s,
            'corporate_decision_history': self.corporate_decision,
            'corporate_step_boldness': self.corporate_step_boldness,
            'norm_learning_rate': self.norm_learning_rate,
            'social_influence_strength': self.social_influence_strength,
            'individual_sharing_histories': self.individual_sharing_history,  # Add individual histories
            'updated_individual_norms': updated_individual_norms,
            'corporate_aggression_sensitivity': self.corporate_aggression_sensitivity,
            'live_adjusted_sharing_probs': self.live_adjusted_sharing_probs
        }

    def reset_simulation(self):
```

```
        """Reset all necessary attributes to initial conditions for each population."""
        self.sharing_prob = self.initial_sharing_prob  # Reset sharing probability
        # Add other parameters that should reset for each population
        self.corporate_aggression_prob = 0.5
        self.personal_sharing_history = []
        self.corporate_strategy_history = []
        self.corporate_decision_history = []
        self.decision_history = []
        self.pop_norm_history = []
        self.live_adjusted_sharing_probs = []
        self.R_s = 0.5

    def run_simulation(self, time: int = 100):
        """
        Run the full simulation for specified number of populations
        """
        results = []
        for _ in range(time):
            iteration_result = self.run_iteration()
            results.append(iteration_result)

        self.reset_simulation()  # Ensure parameters reset
        return results


```

```
class IndividualAgent_2:
    def __init__(self,
                 initial_sharing_prob: float = 0.50, #P_i(t,0) updates to P_i(t)
                 corporate_aggression_sensitivity: float = 0.1, #phi
                 norm_learning_rate: float = 0.1, #beta,
                 platform_tenure: int = 10, #t_p
                 dr_pause: int = 10, #pause after not posting for naturalness
                 social_influence_strength: float = 0.2): #alpha
        """
        Initialize an individual agent with norm-based decision-making

        Args:
            initial_sharing_prob (float): Initial probability of sharing information
            risk_tolerance (float): Agent's tolerance for privacy risk
            norm_learning_rate (float): Rate of updating personal norm based on social norm
            social_influence_strength (float): Strength of social norm influence
        """
        # Individual characteristics
        self.sharing_prob = initial_sharing_prob #live decision starts at P_i(t,0)
        self.corporate_aggression_sensitivity = corporate_aggression_sensitivity
        self.live_decision_sharing_prob = None
        # Norm-related attributes
        self.personal_sharing_norm = initial_sharing_prob #R'_s (t), the first time this runs, we use an inherent probability
        self.norm_learning_rate = norm_learning_rate
        self.social_influence_strength = social_influence_strength

        # Personal sharing history
        self.personal_sharing_history = []  # Track individual decisions. Index is Time
        self.dr_pause = dr_pause #pause after not posting
        self.initial_pause = dr_pause
        self.platform_tenure = platform_tenure

    def decide_to_share(self, social_norm) -> bool:
        """
        Stochastic decision to share information, influenced by personal and social norms

        Returns:
            bool: Whether agent decides to share information
        """
        #print(self.personal_sharing_history)
        try:
          if self.dr_pause > 0 & self.personal_sharing_history[-1] == False & len(self.personal_sharing_history) < self.platf
            self.dr_pause -= 1
            #print("didnt share last go... pausing", self.dr_pause)
            self.sharing_prob = 0
            if self.dr_pause < 0:
                decay_factor = 0.8
                #print("restarting pause")
                #print(self.personal_sharing_history)
                historical_level = sum(self.personal_sharing_history)/len(self.personal_sharing_history)
```

```
                self.personal_sharing_norm = (self.personal_sharing_norm * decay_factor) + (historical_level * (1 - decay_fac
                self.sharing_prob = historical_level
                self.dr_pause = self.initial_pause
        except IndexError:
            pass
        #print("CONTINUE...")
        # Combine personal probability with norm influence for LIVE decision making
        self.live_decision_sharing_prob = (
            self.sharing_prob * (1 - self.social_influence_strength) +
            self.personal_sharing_norm * self.social_influence_strength
            * (1 - (social_norm * self.corporate_aggression_sensitivity))
        )
        #print("live decision: ",self.live_decision_sharing_prob)
        self.sharing_prob = self.live_decision_sharing_prob

        # Make a decision based on the adjusted probability
        decision = random.random() < self.live_decision_sharing_prob

        #include pause after not posting

        # Record the decision in the personal sharing history
        self.personal_sharing_history.append(decision)

        return [decision, self.live_decision_sharing_prob]

    def update_sharing_norm(self, current_social_norm: float):
        """
        Update personal sharing norm based on observed social norm

        Args:
            current_social_norm (float): Aggregate sharing rate in the population
        """
        # Gradually adjust personal norm towards social norm
        #self.personal_sharing_norm += self.norm_learning_rate * (
        #    current_social_norm - self.personal_sharing_norm
        #)

        self.personal_sharing_norm = ((current_social_norm - self.live_decision_sharing_prob) * self.norm_learning_rate) + se

        #print(self.personal_sharing_norm)

        # Optional: Update individual sharing probability as well
        #self.sharing_prob = (
        #    self.sharing_prob * (1 - self.norm_learning_rate) +
        #    self.personal_sharing_norm * self.norm_learning_rate
        #)

    def get_personal_sharing_history(self):
            """
            Return the individual agent's sharing history
            """
            return self.personal_sharing_history

class CorporateAgent_2:
    def choose_strategy(self, aggression_prob: float) -> str:
        """
        Select corporate strategy based on aggression probability

        Args:
            aggression_prob (float): Probability of choosing aggressive strategy

        Returns:
            str: Selected strategy ('aggressive' or 'fair')
        """
        return 'aggressive' if random.random() < aggression_prob else 'fair'


```

Simulation Two Run. 1000 people, 2000 iteration - decision making is influenced by social norms at a given learning rate (speed of conforming to norms)

```
# Example usage comment for Jupyter Notebook
simulation = PrivacySimulation_2(
    num_individuals=100,
```

```
    initial_corporate_aggression=0.3,
    norm_learning_rate=0.3,  # How quickly agents adapt to social norms
    social_influence_strength=0.4,  # How much social norms impact individual decisions
    corporate_aggression_sensitivity = 2 #phi
    )
results2 = simulation.run_simulation(time=100)
```

```
# prompt: read results into a pandas dataframe

# Assuming the code you provided is in a Jupyter Notebook cell and you've run it
# to generate the 'data' DataFrame.

import pandas as pd
pd.set_option('display.float_format', lambda x: '%.2f' % x)

# Create a DataFrame from the results of the simulation
results2_df = pd.DataFrame(results2)

results2_df['avg_personal_norm'] = results2_df['updated_individual_norms'].apply(lambda x: np.mean(x) if isinstance(x, list) e
results2_df['avg_live_sharing'] = results2_df['live_adjusted_sharing_probs'].apply(lambda x: np.mean(x) if isinstance(x, list)

#results2_df['avg_personal_norm'] = results2_df['individual_sharing_histories'].apply(lambda x: np.mean(x[0]) if isinstance(x,

# Print the first few rows of the DataFrame to see the results
print(results2_df.head().round(2))

# You can now perform various analyses on this DataFrame
# for example:
# results_df.describe() # Descriptive statistics
# results_df.plot(x='iteration', y='sharing_rate') # Plot the sharing rate over time


```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.14               fair                       0.29
1     2          0.09               fair                       0.28
2     3          0.11               fair                       0.27
3     4          0.20               fair                       0.26
4     5          0.11               fair                       0.25

   corporate_decision_history  corporate_step_boldness  norm_learning_rate  \
0                           0                     0.01                0.30
1                           0                     0.01                0.30
2                           0                     0.01                0.30
3                           0                     0.01                0.30
4                           0                     0.01                0.30

   social_influence_strength  \
0                       0.40
1                       0.40
2                       0.40
3                       0.40
4                       0.40

                       individual_sharing_histories  \
0  [[False, False, False, False, False, True, Fal...
1  [[False, False, False, False, False, True, Fal...
2  [[False, False, False, False, False, True, Fal...
3  [[False, False, False, False, False, True, Fal...
4  [[False, False, False, False, False, True, Fal...

                          updated_individual_norms  \
0  [0.147, 0.147, 0.147, 0.147, 0.147, 0.147, 0.1...
1  [0.11963520000000001, 0.11963520000000001, 0.1...
2  [0.11604936192000001, 0.11604936192000001, 0.1...
3  [0.135174797795328, 0.135174797795328, 0.13517...
4  [0.10081424470681191, 0.10081424470681191, 0.1...

   corporate_aggression_sensitivity  \
0                                 2
1                                 2
2                                 2
3                                 2
4                                 2

                        live_adjusted_sharing_probs  avg_personal_norm  \
0  [0.15000000000000024, 0.13233600000000031, 0.1...               0.15
1  [0.15000000000000024, 0.13233600000000031, 0.1...               0.12
2  [0.15000000000000024, 0.13233600000000031, 0.1...               0.12
3  [0.15000000000000024, 0.13233600000000031, 0.1...               0.14
```

```
4  [0.15000000000000024, 0.13233600000000031, 0.1...              0.10

   avg_live_sharing
0              0.03
1              0.03
2              0.03
3              0.03
4              0.03
```

```
1 results2_df['live_adjusted_sharing_probs']
```

	live_adjusted_sharing_probs
0	[0.15000000000000024, 0.13233600000000031, 0.1...
1	[0.15000000000000024, 0.13233600000000031, 0.1...
2	[0.15000000000000024, 0.13233600000000031, 0.1...
3	[0.15000000000000024, 0.13233600000000031, 0.1...
4	[0.15000000000000024, 0.13233600000000031, 0.1...
...	...
95	[0.15000000000000024, 0.13233600000000031, 0.1...
96	[0.15000000000000024, 0.13233600000000031, 0.1...
97	[0.15000000000000024, 0.13233600000000031, 0.1...
98	[0.15000000000000024, 0.13233600000000031, 0.1...
99	[0.15000000000000024, 0.13233600000000031, 0.1...

100 rows × 1 columns

dtype: object

```
1 import pandas as pd
2
3 # Unpack nested lists
4 results2_df_unpacked = pd.DataFrame(
5     results2_df['live_adjusted_sharing_probs'].apply(lambda x: [float(item) for item in x]).to_list()
6 )
7
8 # Rename columns if needed
9 results2_df_unpacked.columns = [f'time_{i}' for i in range(results2_df_unpacked.shape[1])]
10
11 # Display the new DataFrame
12 print(results2_df_unpacked.head())
13
```

```
   time_0  time_1  time_2  time_3  time_4  time_5  time_6  time_7  time_8  \
0    0.15    0.13    0.12    0.11    0.10    0.09    0.08    0.08    0.07
1    0.15    0.13    0.12    0.11    0.10    0.09    0.08    0.08    0.07
2    0.15    0.13    0.12    0.11    0.10    0.09    0.08    0.08    0.07
3    0.15    0.13    0.12    0.11    0.10    0.09    0.08    0.08    0.07
4    0.15    0.13    0.12    0.11    0.10    0.09    0.08    0.08    0.07

   time_9  ...  time_90  time_91  time_92  time_93  time_94  time_95  time_96  \
0    0.07  ...     0.01     0.01     0.01     0.01     0.01     0.01     0.01
1    0.07  ...     0.01     0.01     0.01     0.01     0.01     0.01     0.01
2    0.07  ...     0.01     0.01     0.01     0.01     0.01     0.01     0.01
3    0.07  ...     0.01     0.01     0.01     0.01     0.01     0.01     0.01
4    0.07  ...     0.01     0.01     0.01     0.01     0.01     0.01     0.01

   time_97  time_98  time_99
0     0.01     0.01     0.01
1     0.01     0.01     0.01
2     0.01     0.01     0.01
3     0.01     0.01     0.01
4     0.01     0.01     0.01

[5 rows x 100 columns]
```

```
1 results2_df['individual_sharing_histories'].shape
```

```
(100,)
```

```
len(results2_df['individual_sharing_histories'][0])
```

```
100
```

```
len(results2_df['individual_sharing_histories'][0][0])
```

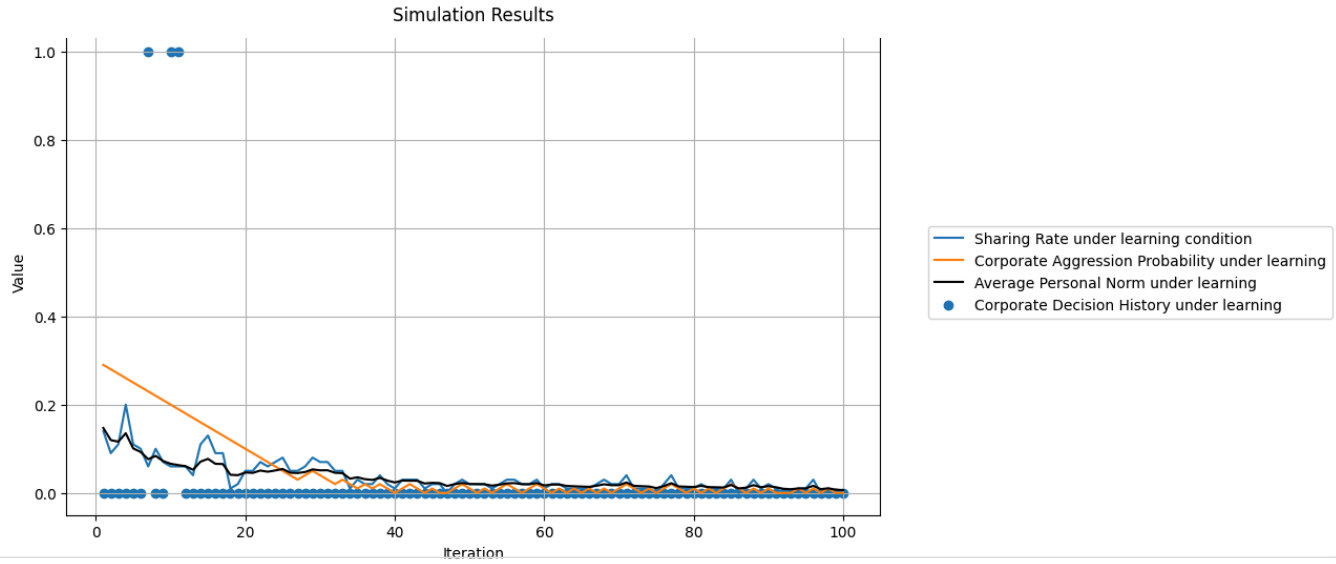
```
100
```

```
# prompt: correlation between numerical variables in result_df

# Assuming results_df is your DataFrame from the simulation
correlation_matrix2 = results2_df.drop(columns = ['corporate_strategy','individual_sharing_histories','updated_individual_norm

# Display the correlation matrix
print(correlation_matrix2)

# You can also focus on specific correlations
print(f"Correlation between sharing_rate and corporate_aggression_prob: {results2_df['sharing_rate'].corr(results2_df['corpora

```

```
                                time  sharing_rate  \
time                            1.00         -0.75
sharing_rate                   -0.75          1.00
corporate_aggression_prob      -0.76          0.82
corporate_decision_history     -0.25          0.12
corporate_step_boldness          NaN           NaN
norm_learning_rate               NaN           NaN
social_influence_strength        NaN           NaN
corporate_aggression_sensitivity NaN           NaN
avg_personal_norm              -0.83          0.93
avg_live_sharing                 NaN           NaN

                                corporate_aggression_prob  \
time                                            -0.76
sharing_rate                                     0.82
corporate_aggression_prob                        1.00
corporate_decision_history                       0.35
corporate_step_boldness                           NaN
norm_learning_rate                                NaN
social_influence_strength                         NaN
corporate_aggression_sensitivity                  NaN
avg_personal_norm                                0.93
avg_live_sharing                                  NaN

                                corporate_decision_history  \
time                                             -0.25
sharing_rate                                      0.12
corporate_aggression_prob                         0.35
corporate_decision_history                        1.00
corporate_step_boldness                            NaN
norm_learning_rate                                 NaN
social_influence_strength                          NaN
corporate_aggression_sensitivity                   NaN
avg_personal_norm                                 0.21
avg_live_sharing                                   NaN

                                corporate_step_boldness  norm_learning_rate  \
time                                                NaN                 NaN
sharing_rate                                        NaN                 NaN
corporate_aggression_prob                           NaN                 NaN
corporate_decision_history                          NaN                 NaN
corporate_step_boldness                             NaN                 NaN
norm_learning_rate                                  NaN                 NaN
social_influence_strength                           NaN                 NaN
corporate_aggression_sensitivity                    NaN                 NaN
avg_personal_norm                                   NaN                 NaN
avg_live_sharing                                    NaN                 NaN

                                social_influence_strength  \
time                                              NaN
sharing_rate                                      NaN
corporate_aggression_prob                         NaN
corporate_decision_history                        NaN
corporate_step_boldness                           NaN
norm_learning_rate                                NaN
social_influence_strength                         NaN
corporate_aggression_sensitivity                  NaN
avg_personal_norm                                 NaN
```

```
# prompt: plot results
import matplotlib.pyplot as plt
```

```
# Assuming 'results' is a list of dictionaries as returned by the simulation
# Extract sharing rate and corporate aggression probability for plotting


# Create the plot
plt.figure(figsize=(10, 6))
plt.plot(results2_df['time'],results2_df['sharing_rate'], label='Sharing Rate under learning condition')
plt.plot(results2_df['time'],results2_df['corporate_aggression_prob'], label='Corporate Aggression Probability under learning'
plt.plot(results2_df['time'],results2_df['avg_personal_norm'], label='Average Personal Norm under learning', color = 'black')
plt.scatter(results2_df['time'],results2_df['corporate_decision_history'], label='Corporate Decision History under learning')
plt.xlabel('Iteration')
plt.ylabel('Value')
plt.title('Simulation Results')
plt.legend(bbox_to_anchor=(1.05, 0.5), loc='center left')
plt.grid(True)
plt.show()

```



Effect of the Pause

```
# Example usage in Jupyter Notebook
step_3a_results = []
for dr_pause in [0,1,3,7,14,30]:
  for iteration in range(100):
    simulation = PrivacySimulation_2(num_individuals=100,
                                     initial_corporate_aggression=0.15,
                                     dr_pause=dr_pause,
                                     platform_tenure = 10)
    results = simulation.run_simulation(time=100)
    for result in results:
      result['iteration'] = iteration
      result['dr_pause'] = dr_pause
    step_3a_results.append(results)

#step_1b_results_df = pd.DataFrame(step_1b_results)


# Example usage
# Assuming `large_results_np` is a list of lists with dictionaries
step_3a_results_df = convert_to_dataframe(step_3a_results)


```

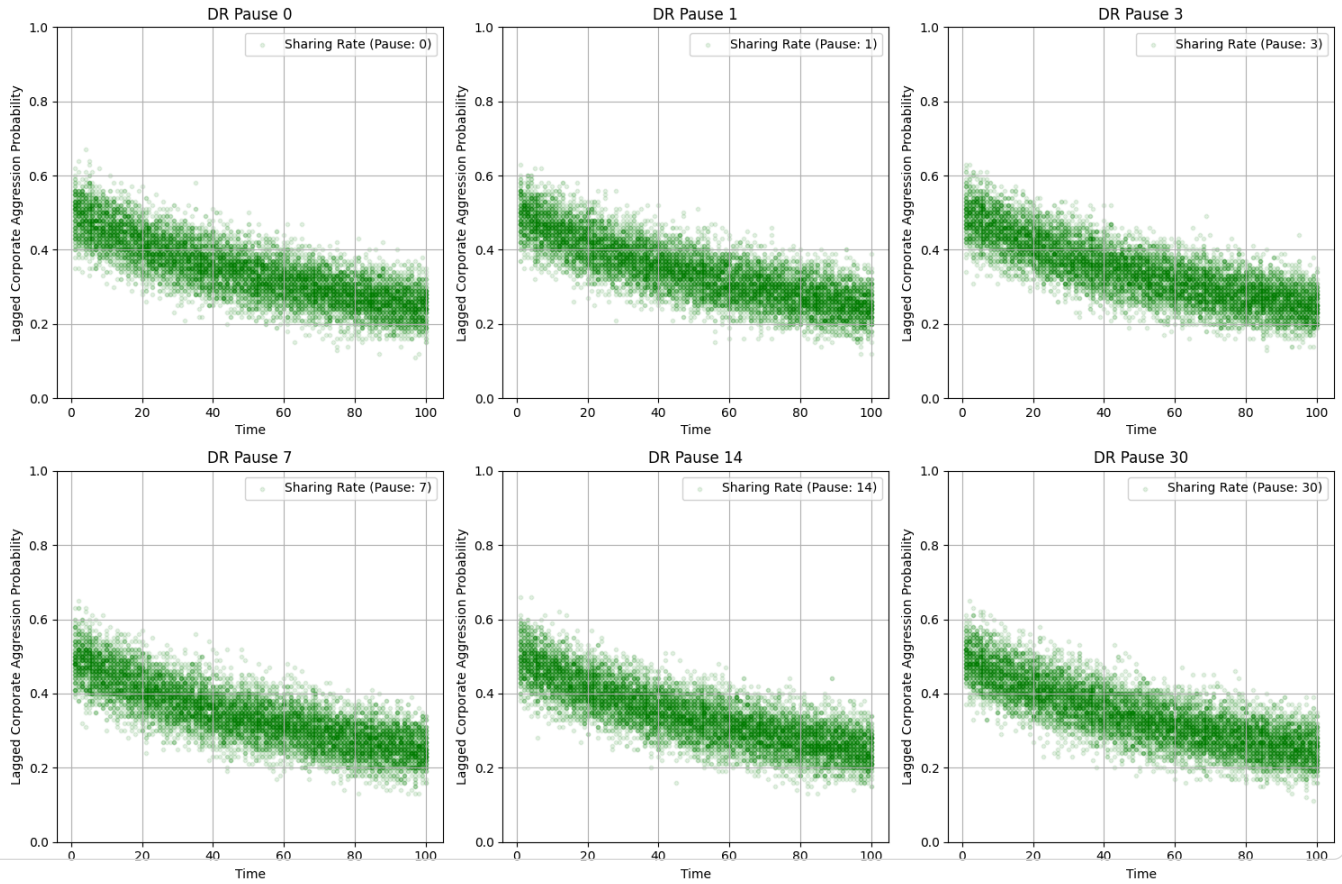
```
# prompt: add a lag column to results_df - the average of the previous five corporate agression prob and plot the new lagged v

import pandas as pd

# Assuming 'iteration' is a column and your DataFrame has it
# Apply the rolling mean calculation per iteration group, and ensure index alignment

# First, ensure that the 'iteration' column is part of the index
```

```
# If iteration is not an index, you can group by it directly.

# Compute rolling mean per iteration using transform instead of apply
# Ensure rolling calculations reset per iteration
step_3a_results_df['lagged_corporate_aggression_prob'] = (
    step_3a_results_df.groupby('iteration')['corporate_aggression_prob']
    .apply(lambda x: x.rolling(window=100, min_periods=1).mean())
    .reset_index(level=0, drop=True)  # Keep index aligned
)

step_3a_results_df['lagged_corporate_decision'] = (
    step_3a_results_df.groupby('iteration')['corporate_decision_history']
    .apply(lambda x: x.rolling(window=100, min_periods=1).mean())
    .reset_index(level=0, drop=True)  # Keep index aligned
)

# Verify the results
print(step_3a_results_df.head())

```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.51               fair                       0.16
1     2          0.41               fair                       0.17
2     3          0.40               fair                       0.18
3     4          0.48               fair                       0.19
4     5          0.41               fair                       0.20

   corporate_decision_history  corporate_step_boldness  norm_learning_rate  \
0                           0                     0.01                 0.1
1                           0                     0.01                 0.1
2                           0                     0.01                 0.1
3                           0                     0.01                 0.1
4                           0                     0.01                 0.1

   social_influence_strength  \
0                        0.2
1                        0.2
2                        0.2
3                        0.2
4                        0.2

                       individual_sharing_histories  \
0  [[False, False, False, True, False, True, True...
1  [[False, False, False, True, False, True, True...
2  [[False, False, False, True, False, True, True...
3  [[False, False, False, True, False, True, True...
4  [[False, False, False, True, False, True, True...

                           updated_individual_norms  \
0  [0.4965, 0.4965, 0.4965, 0.4965, 0.4965, 0.496...
1  [0.48221213, 0.48221213, 0.48221213, 0.4822121...
2  [0.47620916188060003, 0.47620916188060003, 0.4...
3  [0.47925627267744775, 0.47925627267744775, 0.4...
4  [0.4681303730279656, 0.4681303730279656, 0.468...

   corporate_aggression_sensitivity  \
0                               0.1
1                               0.1
2                               0.1
3                               0.1
4                               0.1

                        live_adjusted_sharing_probs  iteration  dr_pause  \
0  [0.4949999999999993, 0.49023569999999966, 0.48...          0         0
1  [0.4949999999999993, 0.49023569999999966, 0.48...          0         0
2  [0.4949999999999993, 0.49023569999999966, 0.48...          0         0
3  [0.4949999999999993, 0.49023569999999966, 0.48...          0         0
4  [0.4949999999999993, 0.49023569999999966, 0.48...          0         0

   outer_iteration  lagged_corporate_aggression_prob  \
0                1                             0.160
1                1                             0.165
2                1                             0.170
3                1                             0.175
4                1                             0.180

   lagged_corporate_decision
0                        0.0
```

```
import matplotlib.pyplot as plt
import numpy as np

```

```
# Assuming 'corporate_step_boldness' is a column in your DataFrame
unique_dr_pause = step_3a_results_df['dr_pause'].unique()

# Determine the number of rows and columns for the grid layout
n_plots = len(unique_dr_pause)
n_cols = 3  # Number of columns in the grid (adjust as needed)
n_rows = int(np.ceil(n_plots / n_cols))  # Number of rows in the grid

# Create the subplots grid
fig, axes = plt.subplots(n_rows, n_cols, figsize=(15, 5 * n_rows))

# Flatten the axes array to easily index it
axes = axes.flatten()

# Create a separate plot for each unique level of corporate_step_boldness
for i, level in enumerate(unique_dr_pause):
    # Filter the data for the current level of corporate_step_boldness
    level_data = step_3a_results_df[step_3a_results_df['dr_pause'] == level]

    # Get the current axis to plot on
    ax = axes[i]

    # Scatter plot and line plot
    #ax.plot(level_data['time'], level_data['lagged_corporate_decision'],
     #          label='Lagged Corporate Decision (1 = Aggressive Use)', color='red', alpha=0.3, marker = '.')
#    ax.scatter(level_data['time'], level_data['lagged_corporate_aggression_prob'],
#               label=f'Lagged Corporate Aggression Probability (Pause: {level})',
#               alpha=0.1, marker='.')
    ax.scatter(level_data['time'], level_data['sharing_rate'],
               label=f'Sharing Rate (Pause: {level})', color = 'green',
               alpha=0.1, marker='.')
    # Add labels and title
    ax.set_xlabel('Time')
    ax.set_ylabel('Lagged Corporate Aggression Probability')
    ax.set_title(f'DR Pause {level}')
    ax.set_ylim(0, 1)
    # Show legend
    ax.legend()

    # Enable grid
    ax.grid(True)

# Remove any empty subplots if there are fewer levels than the total number of subplots
for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

# Adjust layout to avoid overlapping elements
plt.tight_layout()
plt.show()

```



The Effect of Platform Tenure

```
# Example usage in Jupyter Notebook
step_3a_results = []
for platform_tenure in [0,1,3,5,10,25,50,75,100]:
  for iteration in range(100):
    simulation = PrivacySimulation_2(num_individuals=100,
                                     initial_corporate_aggression=0.15,
                                     dr_pause=-1,
                                     platform_tenure = platform_tenure)
    results = simulation.run_simulation(time=100)
    for result in results:
      result['iteration'] = iteration
      result['p_tenure'] = platform_tenure
    step_3a_results.append(results)

#step_1b_results_df = pd.DataFrame(step_1b_results)


# Example usage
# Assuming `large_results_np` is a list of lists with dictionaries
step_3a_results_df = convert_to_dataframe(step_3a_results)


```

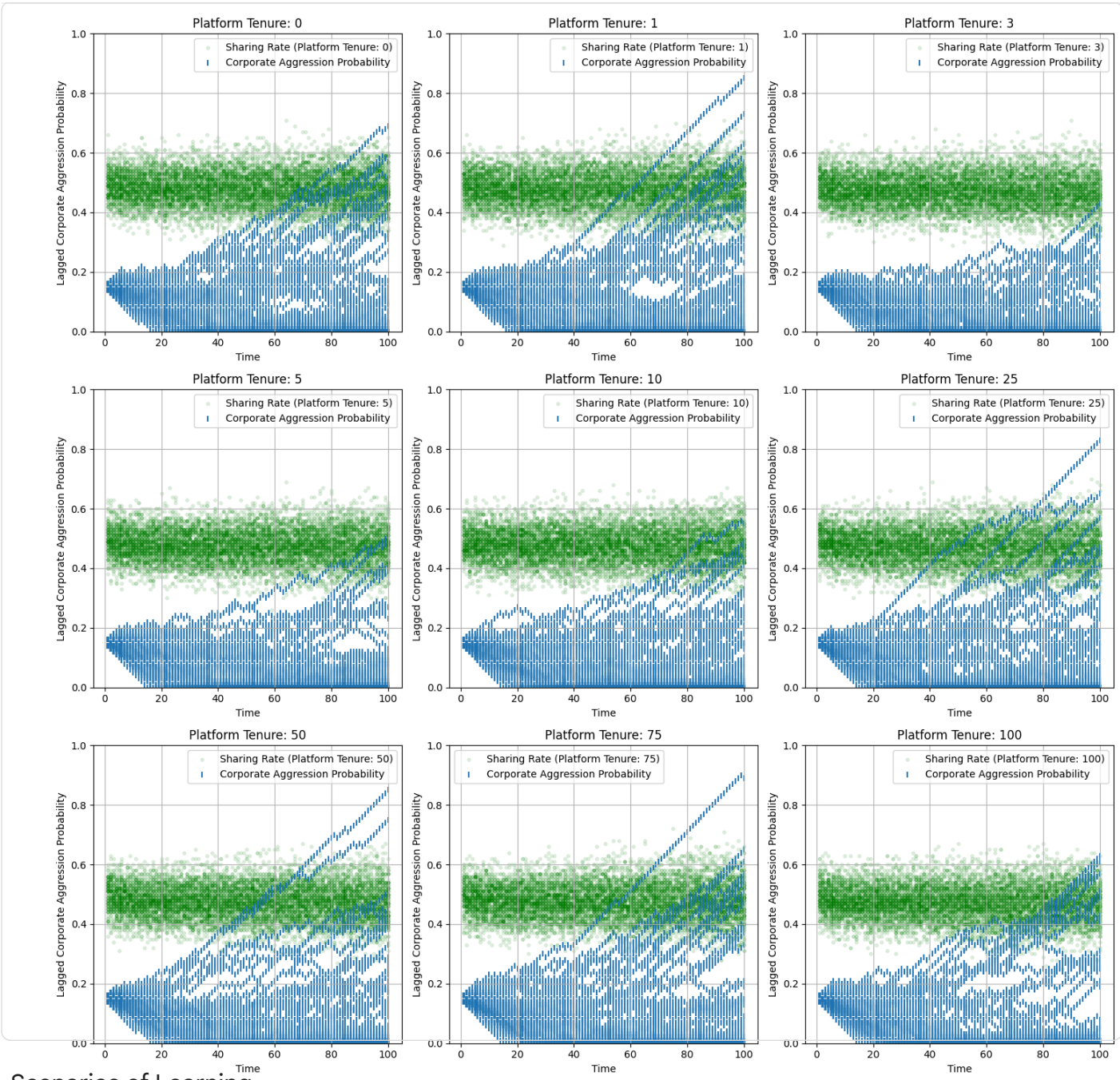
```
# prompt: add a lag column to results_df - the average of the previous five corporate agression prob and plot the new lagged v

import pandas as pd

# Assuming 'iteration' is a column and your DataFrame has it
# Apply the rolling mean calculation per iteration group, and ensure index alignment

# First, ensure that the 'iteration' column is part of the index
# If iteration is not an index, you can group by it directly.

# Compute rolling mean per iteration using transform instead of apply
# Ensure rolling calculations reset per iteration
step_3a_results_df['lagged_corporate_aggression_prob'] = (
    step_3a_results_df.groupby('iteration')['corporate_aggression_prob']
```

```
    .apply(lambda x: x.rolling(window=100, min_periods=1).mean())
    .reset_index(level=0, drop=True)  # Keep index aligned
)

step_3a_results_df['lagged_corporate_decision'] = (
    step_3a_results_df.groupby('iteration')['corporate_decision_history']
    .apply(lambda x: x.rolling(window=100, min_periods=1).mean())
    .reset_index(level=0, drop=True)  # Keep index aligned
)

# Verify the results
print(step_3a_results_df.head())

```

```
   time  sharing_rate corporate_strategy  corporate_aggression_prob  \
0     1          0.49         aggressive                       0.14
1     2          0.51               fair                       0.15
2     3          0.46               fair                       0.14
3     4          0.48               fair                       0.13
4     5          0.54               fair                       0.14

   corporate_decision_history  corporate_step_boldness  norm_learning_rate  \
0                           1                     0.01                 0.1
1                           0                     0.01                 0.1
2                           0                     0.01                 0.1
3                           0                     0.01                 0.1
4                           0                     0.01                 0.1

   social_influence_strength  \
0                        0.2
1                        0.2
2                        0.2
3                        0.2
4                        0.2

                       individual_sharing_histories  \
0  [[True, True, True, False, True, False, True, ...
1  [[True, True, True, False, True, False, True, ...
2  [[True, True, True, False, True, False, True, ...
3  [[True, True, True, False, True, False, True, ...
4  [[True, True, True, False, True, False, True, ...

                          updated_individual_norms  \
0  [0.4995, 0.4995, 0.4995, 0.4995, 0.4995, 0.499...
1  [0.50139951, 0.50139951, 0.50139951, 0.5013995...
2  [0.49860255530020003, 0.49860255530020003, 0.4...
3  [0.4980516547852322, 0.4980516547852322, 0.498...
4  [0.5037280308661471, 0.5037280308661471, 0.503...

   corporate_aggression_sensitivity  \
0                               0.1
1                               0.1
2                               0.1
3                               0.1
4                               0.1

                        live_adjusted_sharing_probs  iteration  p_tenure  \
0  [0.4949999999999993, 0.4910049, 0.487969546998...          0         0
1  [0.4949999999999993, 0.4910049, 0.487969546998...          0         0
2  [0.4949999999999993, 0.4910049, 0.487969546998...          0         0
3  [0.4949999999999993, 0.4910049, 0.487969546998...          0         0
4  [0.4949999999999993, 0.4910049, 0.487969546998...          0         0

   outer_iteration  lagged_corporate_aggression_prob  \
0                1                          0.140000
1                1                          0.145000
2                1                          0.143333
3                1                          0.140000
4                1                          0.140000

   lagged_corporate_decision
0                   1.000000
```

```
import matplotlib.pyplot as plt
import numpy as np

# Assuming 'corporate_step_boldness' is a column in your DataFrame
unique_dr_pause = step_3a_results_df['p_tenure'].unique()

# Determine the number of rows and columns for the grid layout
n_plots = len(unique_dr_pause)
n_cols = 3  # Number of columns in the grid (adjust as needed)
```

```
n_rows = int(np.ceil(n_plots / n_cols))  # Number of rows in the grid

# Create the subplots grid
fig, axes = plt.subplots(n_rows, n_cols, figsize=(15, 5 * n_rows))

# Flatten the axes array to easily index it
axes = axes.flatten()

# Create a separate plot for each unique level of corporate_step_boldness
for i, level in enumerate(unique_dr_pause):
    # Filter the data for the current level of corporate_step_boldness
    level_data = step_3a_results_df[step_3a_results_df['p_tenure'] == level]

    # Get the current axis to plot on
    ax = axes[i]

    # Scatter plot and line plot
    #ax.plot(level_data['time'], level_data['lagged_corporate_decision'],
     #          label='Lagged Corporate Decision (1 = Aggressive Use)', color='red', alpha=0.3, marker = '.')
#    ax.scatter(level_data['time'], level_data['lagged_corporate_aggression_prob'],
#               label=f'Lagged Corporate Aggression Probability (Pause: {level})',
#               alpha=0.1, marker='.')
    ax.scatter(level_data['time'], level_data['sharing_rate'],
               label=f'Sharing Rate (Platform Tenure: {level})', color = 'green',
               alpha=0.1, marker='.')
    ax.scatter(level_data['time'],level_data['corporate_aggression_prob'], marker='|', label='Corporate Aggression Probability
    # Add labels and title
    ax.set_xlabel('Time')
    ax.set_ylabel('Lagged Corporate Aggression Probability')
    ax.set_title(f'Platform Tenure: {level}')
    ax.set_ylim(0, 1)
    # Show legend
    ax.legend()

    # Enable grid
    ax.grid(True)

# Remove any empty subplots if there are fewer levels than the total number of subplots
for j in range(i + 1, len(axes)):
    fig.delaxes(axes[j])

# Adjust layout to avoid overlapping elements
plt.tight_layout()
plt.show()
```



Scenarios of Learning

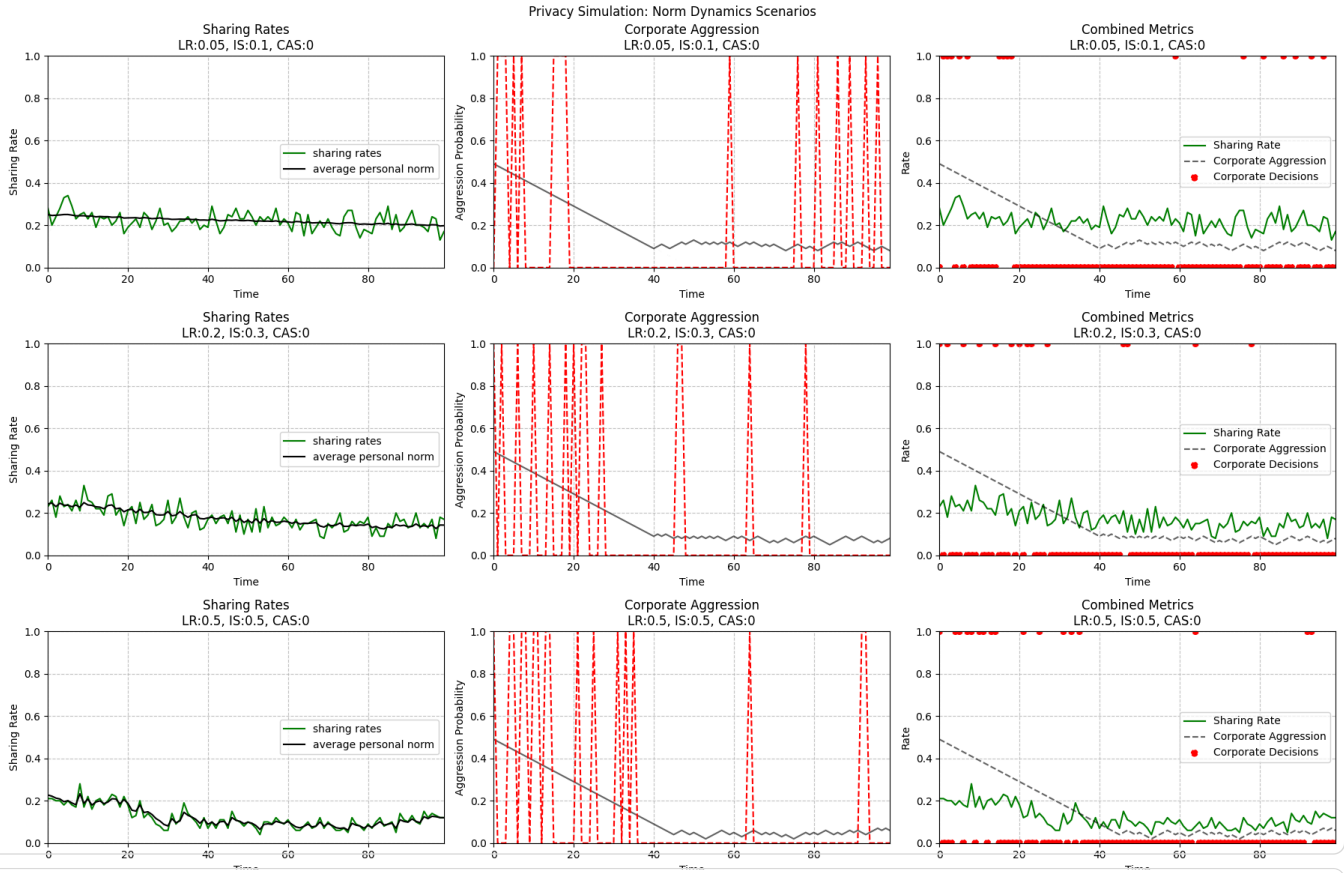
function - Using a scenario comparison function.

Set the number of individuals in Run_Scenario_Comparison function

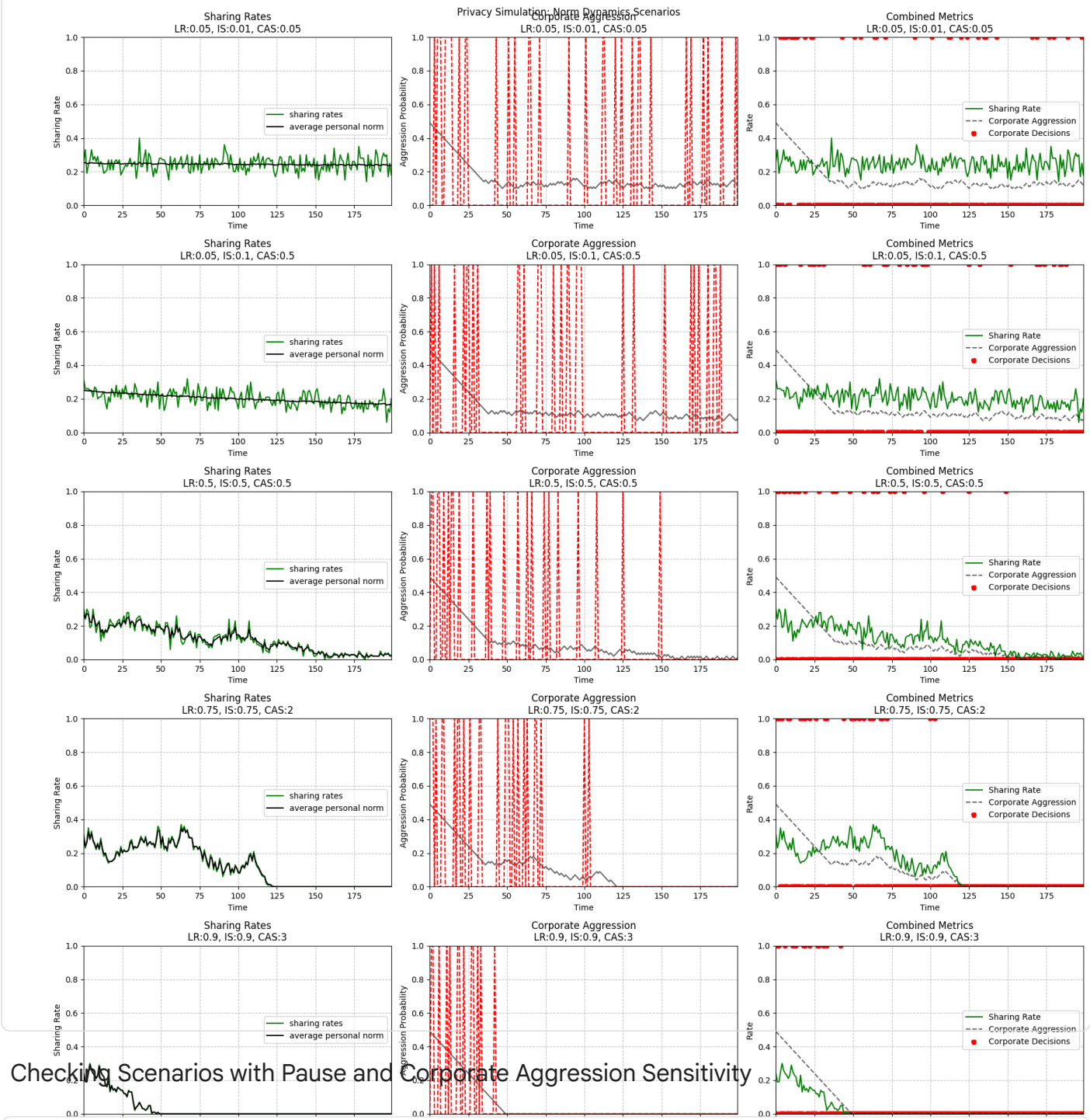
```
def run_scenario_comparison(scenarios, time=20):
    """
    Run and visualize multiple simulation scenarios
    """
    # Set up the plot
    fig, axs = plt.subplots(len(scenarios), 3, figsize=(18, 4*len(scenarios)))
    fig.suptitle('Privacy Simulation: Norm Dynamics Scenarios')

    # Colors for different scenarios
    colors = ['blue', 'green', 'red']

    # Run each scenario
    for i, scenario in enumerate(scenarios):
        # Run simulation
        simulation = PrivacySimulation_2(
```

```
            num_individuals=100,
            norm_learning_rate=scenario['learning_rate'],
            social_influence_strength=scenario['influence_strength'],
            #initial_corporate_aggression=scenario['updated_corporate_aggression']
        )
        results = simulation.run_simulation(time=time)

        # Extract data
        sharing_rates = [result['sharing_rate'] for result in results]
        corporate_aggression = [result['corporate_aggression_prob'] for result in results]
        corporate_decisions = [result['corporate_decision_history'] for result in results]
        iterations = range(time)
        avg_personal_norm = [result['updated_individual_norms'][0] for result in results]

        # Scenario label
        scenario_label = f'LR:{scenario["learning_rate"]}, IS:{scenario["influence_strength"]}, CAS:{scenario["corporate_aggre

        # Sharing Rates Plot
        axs[i, 0].plot(iterations, sharing_rates, color="green", label="sharing rates")
        axs[i, 0].plot(iterations, avg_personal_norm, color="black", label ="average personal norm")
        axs[i, 0].set_title(f'Sharing Rates\n{scenario_label}')
        axs[i, 0].set_xlabel('Time')
        axs[i, 0].set_ylabel('Sharing Rate')
        axs[i, 0].grid(True, linestyle='--', alpha=0.7)
        # Set x and y axis to start at 0
        axs[i, 0].set_xlim(0, time-1)
        axs[i, 0].set_ylim(0, 1)
        axs[i, 0].legend(loc='center right')


        # Corporate Aggression Plot
        axs[i, 1].plot(iterations, corporate_aggression, color="black", alpha = 0.6)
        axs[i, 1].set_title(f'Corporate Aggression\n{scenario_label}')
        axs[i, 1].plot(iterations, corporate_decisions, label='Corporate Decisions', color="red", linestyle='--')
        axs[i, 1].set_xlabel('Time')
        axs[i, 1].set_ylabel('Aggression Probability')
        axs[i, 1].grid(True, linestyle='--', alpha=0.7)
        # Set x and y axis to start at 0
        axs[i, 1].set_xlim(0, time-1)
        axs[i, 1].set_ylim(0, 1)

        # Combined Plot
        axs[i, 2].plot(iterations, sharing_rates, label='Sharing Rate', color="green", linestyle='-')
        axs[i, 2].plot(iterations, corporate_aggression, label='Corporate Aggression', color="black",alpha=0.6, linestyle='--'
        axs[i, 2].scatter(iterations, corporate_decisions, label='Corporate Decisions', color="red", linestyle='--')
        axs[i, 2].set_title(f'Combined Metrics\n{scenario_label}')
        axs[i, 2].set_xlabel('Time')
        axs[i, 2].set_ylabel('Rate')
        axs[i, 2].legend( loc='center right') #bbox_to_anchor=(1.05, 0.5),
        axs[i, 2].grid(True, linestyle='--', alpha=0.7)
        # Set x and y axis to start at 0
        axs[i, 2].set_xlim(0, time-1)
        axs[i, 2].set_ylim(0, 1)

    plt.tight_layout()
    plt.show()

```

```
scenarios = [
    {'learning_rate': 0.05, 'influence_strength': 0.1, 'corporate_aggression_sensitivity':0}, #slow norm adaptation and minima
    {'learning_rate': 0.2, 'influence_strength': 0.3, 'corporate_aggression_sensitivity':0}, #moderate norm change and moderat
    {'learning_rate': 0.5, 'influence_strength': 0.5, 'corporate_aggression_sensitivity':0} #rapid norm adaptation and strong
]

# Run the scenario comparison
run_scenario_comparison(scenarios, time=100)
```

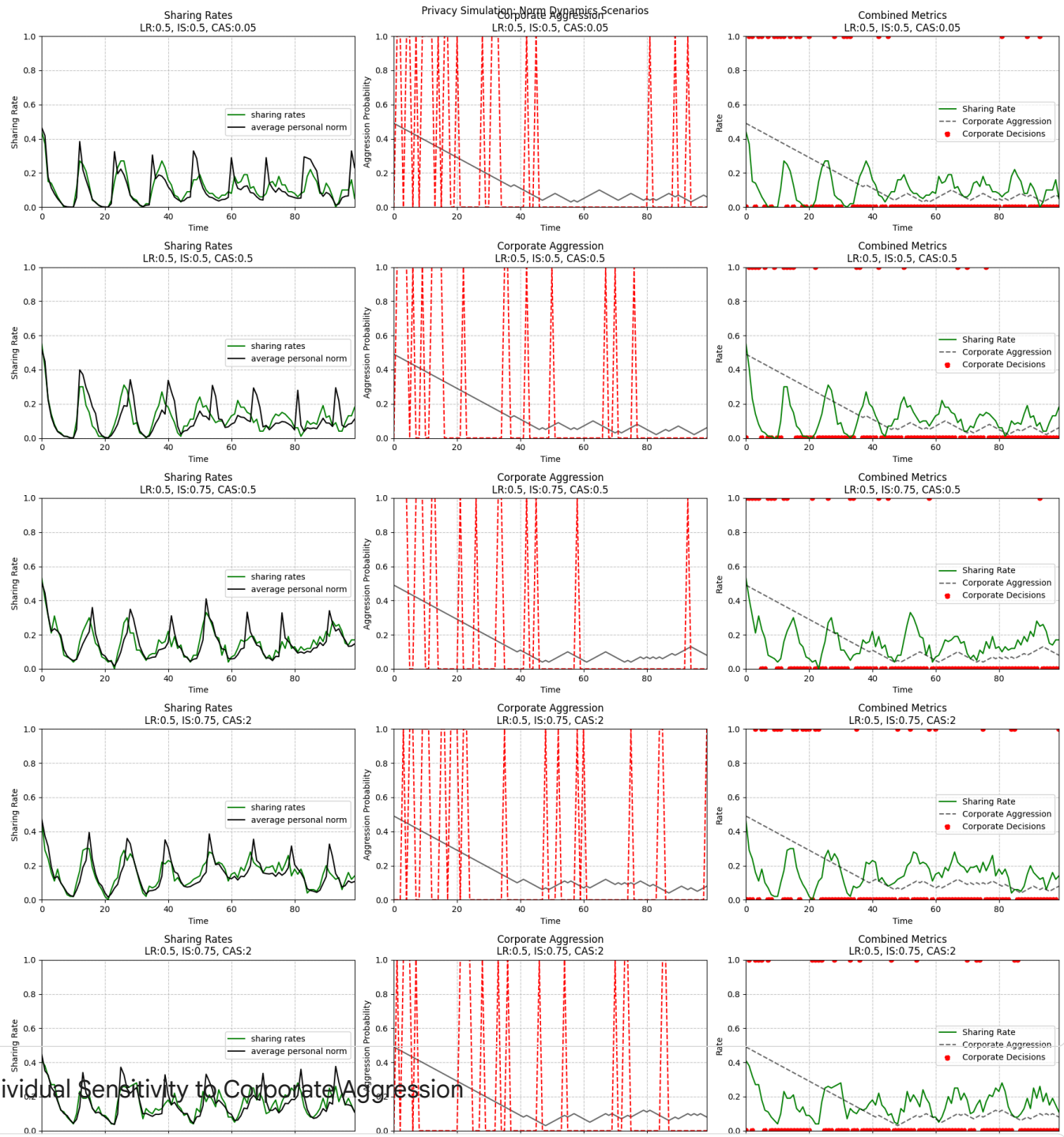



```
scenarios = [
    {'learning_rate': 0.05, 'influence_strength':0.01,'corporate_aggression_sensitivity': 0.05}, #slow norm adaptation and mir
    {'learning_rate': 0.05,'influence_strength':0.1, 'corporate_aggression_sensitivity': 0.5}, #moderate norm change and moder
    {'learning_rate': 0.5,'influence_strength':0.5, 'corporate_aggression_sensitivity': 0.5}, #rapid norm adaptation and stror
    {'learning_rate': 0.75,'influence_strength':0.75, 'corporate_aggression_sensitivity': 2}, #rapid norm adaptation and stror
    {'learning_rate': 0.90,'influence_strength':0.90, 'corporate_aggression_sensitivity': 3} #rapid norm adaptation and strong

]

# Run the scenario comparison
run_scenario_comparison(scenarios, time=200)
```



Checking Scenarios with Pause and Corporate Aggression Sensitivity

```
scenarios = [
    {'dr_pause':30,'learning_rate': 0.5, 'influence_strength':0.5,'corporate_aggression_sensitivity': 0.05}, #slow norm adapta
    {'dr_pause':2,'learning_rate': 0.5,'influence_strength':0.5, 'corporate_aggression_sensitivity': 0.5}, #moderate norm char
    {'dr_pause':7,'learning_rate': 0.5,'influence_strength':0.75, 'corporate_aggression_sensitivity': 0.5}, #rapid norm adapta
    {'dr_pause':14,'learning_rate': 0.5,'influence_strength':0.75, 'corporate_aggression_sensitivity': 2}, #rapid norm adaptat
    {'dr_pause':0,'learning_rate': 0.5,'influence_strength':0.75, 'corporate_aggression_sensitivity': 2} #rapid norm adaptatic

]

# Run the scenario comparison
run_scenario_comparison(scenarios, time=100)
```



Individual Sensitivity to Corporate Aggression

```
class IndividualAgent:
    def __init__(self,
                 initial_sharing_prob: float = 0.5,
                 risk_tolerance: float = 0.5,
                 norm_learning_rate: float = 0.1,
                 social_influence_strength: float = 0.2,
                 corporate_aggression_sensitivity: float = 0.5):
        """
        Initialize an individual agent with sensitivity to corporate aggression

        Args:
            corporate_aggression_sensitivity (float): How much corporate aggression
            influences individual sharing decisions (0-1 range)
        """
        # Individual characteristics
        self.sharing_prob = initial_sharing_prob
        self.risk_tolerance = risk_tolerance

        # Norm-related attributes
```

```
        self.personal_sharing_norm = initial_sharing_prob
        self.norm_learning_rate = norm_learning_rate
        self.social_influence_strength = social_influence_strength

        # Corporate aggression sensitivity
        self.corporate_aggression_sensitivity = corporate_aggression_sensitivity

        # Track last known corporate aggression level
        self.last_corporate_aggression = 0.5

    def decide_to_share(self, current_corporate_aggression: float) -> bool:
        """
        Stochastic decision to share information, influenced by:
        - Personal and social norms
        - Corporate aggression level

        Args:
            current_corporate_aggression (float): Current level of corporate aggression

        Returns:
            bool: Whether agent decides to share information
        """
        # Store current corporate aggression for potential use in norm updates
        self.last_corporate_aggression = current_corporate_aggression

        # Reduce sharing probability based on corporate aggression
        aggression_reduction = (
            current_corporate_aggression * self.corporate_aggression_sensitivity)

        sharing_encouragement = 1 - aggression_reduction

        # Combine personal probability with norm influence and aggression reduction
        adjusted_sharing_prob = (
            self.sharing_prob * (1 - self.social_influence_strength) +
            self.personal_sharing_norm * self.social_influence_strength
        ) * (1 - aggression_reduction) #+ (aggression_amplification * 0.5)

        return random.random() < max(0, adjusted_sharing_prob)

    def update_sharing_norm(self, current_social_norm: float):
        """
        Update personal sharing norm based on observed social norm
        and current corporate aggression
        """
        # Gradually adjust personal norm towards social norm
        self.personal_sharing_norm += self.norm_learning_rate * (
            current_social_norm - self.personal_sharing_norm
        )

        # Modify norm based on corporate aggression
        self.personal_sharing_norm *= (1 - self.last_corporate_aggression * 0.5)

        # Update individual sharing probability
        self.sharing_prob = (
            self.sharing_prob * (1 - self.norm_learning_rate) +
            self.personal_sharing_norm * self.norm_learning_rate
        )


```

```
class PrivacySimulation:
    def __init__(self,
                 num_individuals: int = 1000,
                 initial_corporate_aggression: float = 0.5,
                 norm_learning_rate: float = 0.1,
                 social_influence_strength: float = 0.2,
                 corporate_aggression_sensitivity: float = 0.5):
        """
        Initialize the privacy exploitation simulation

        Added corporate_aggression_sensitivity to pass to individual agents
        """
        # Simulation parameters
        self.num_individuals = num_individuals
        self.corporate_aggression_prob = initial_corporate_aggression
        self.norm_learning_rate = norm_learning_rate
```

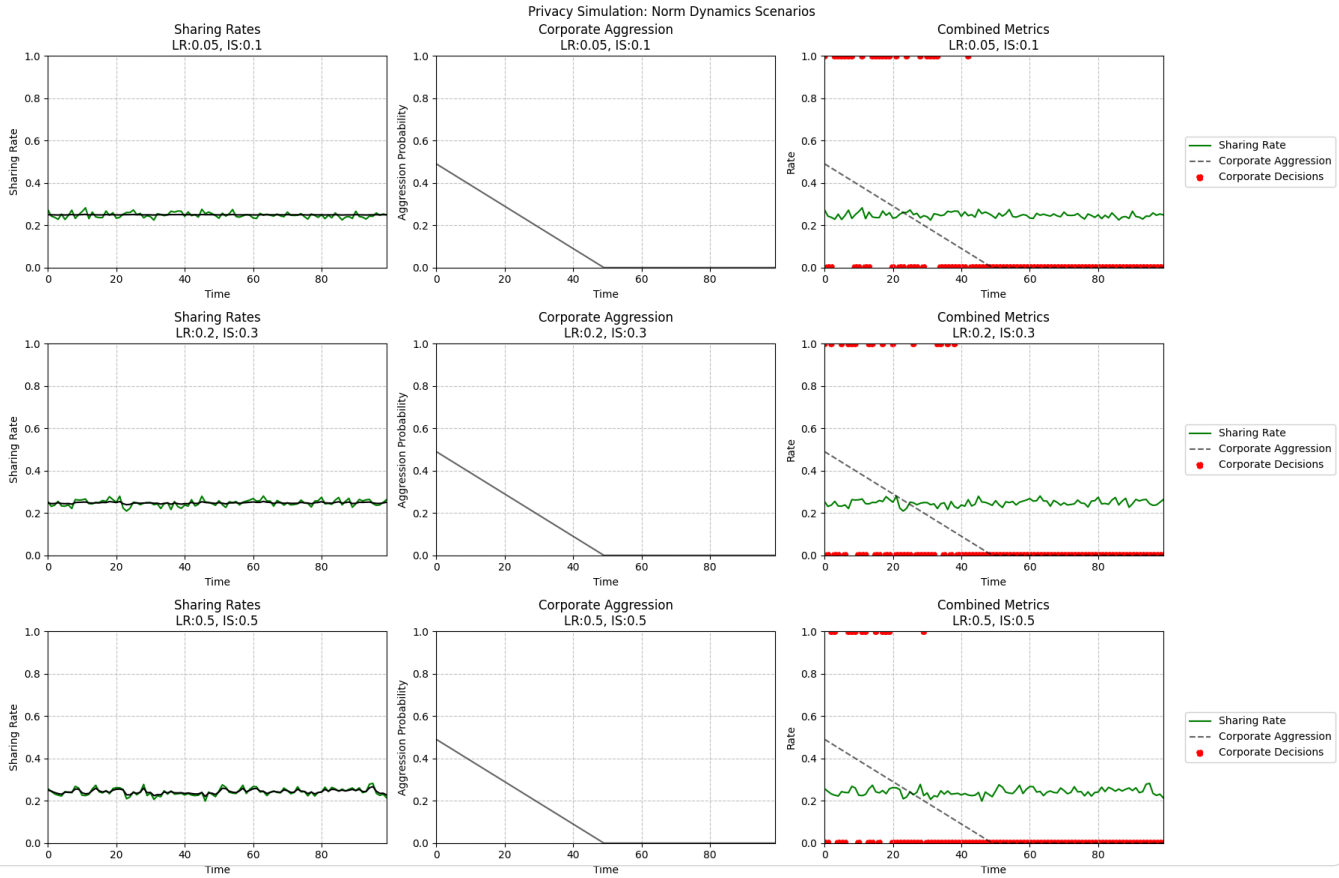
```
        self.social_influence_strength = social_influence_strength

        # Track simulation state
        self.current_iteration = 0
        self.individual_sharing_history = []
        self.corporate_strategy_history = []
        self.norm_history = []

        # Initialize agents with corporate aggression sensitivity
        self.individual_agents = [
            IndividualAgent(
                norm_learning_rate=self.norm_learning_rate,
                social_influence_strength=self.social_influence_strength,
                corporate_aggression_sensitivity=corporate_aggression_sensitivity
            ) for _ in range(num_individuals)
        ]
        self.corporate_agent = CorporateAgent()

    def run_iteration(self):
        """
        Run a single iteration of the simulation
        """
        # Individual sharing decisions
        individual_sharing_decisions = [
            agent.decide_to_share(self.corporate_aggression_prob)
            for agent in self.individual_agents
        ]

        # Calculate sharing rate
        sharing_rate = sum(individual_sharing_decisions) / self.num_individuals

        # Update individual agents' norms based on aggregate behavior
        for agent in self.individual_agents:
            agent.update_sharing_norm(sharing_rate)

        # Corporate strategy selection
        corporate_strategy = self.corporate_agent.choose_strategy(
            self.corporate_aggression_prob
        )

        # Update corporate aggression probability based on sharing rate
        if sharing_rate > 0.5:
            # If majority share, increase likelihood of aggressive strategy
            self.corporate_aggression_prob = min(
                1.0,
                self.corporate_aggression_prob + 0.1
            )
        else:
            # If majority resist, decrease likelihood of aggressive strategy
            self.corporate_aggression_prob = max(
                0.0,
                self.corporate_aggression_prob - 0.1
            )

        # Record history
        self.individual_sharing_history.append(sharing_rate)
        self.corporate_strategy_history.append(corporate_strategy)
        self.norm_history.append(sharing_rate)

        # Increment iteration
        self.current_iteration += 1

        return {
            'iteration': self.current_iteration,
            'sharing_rate': sharing_rate,
            'corporate_strategy': corporate_strategy,
            'corporate_aggression_prob': self.corporate_aggression_prob,
            'sharing_norm': sharing_rate
        }

    def run_simulation(self, num_iterations: int = 10):
        """
        Run the full simulation for specified number of iterations
        """
        results = []
        for _ in range(num_iterations):
            iteration_result = self.run_iteration()
```

```
            results.append(iteration_result)

        return results
```

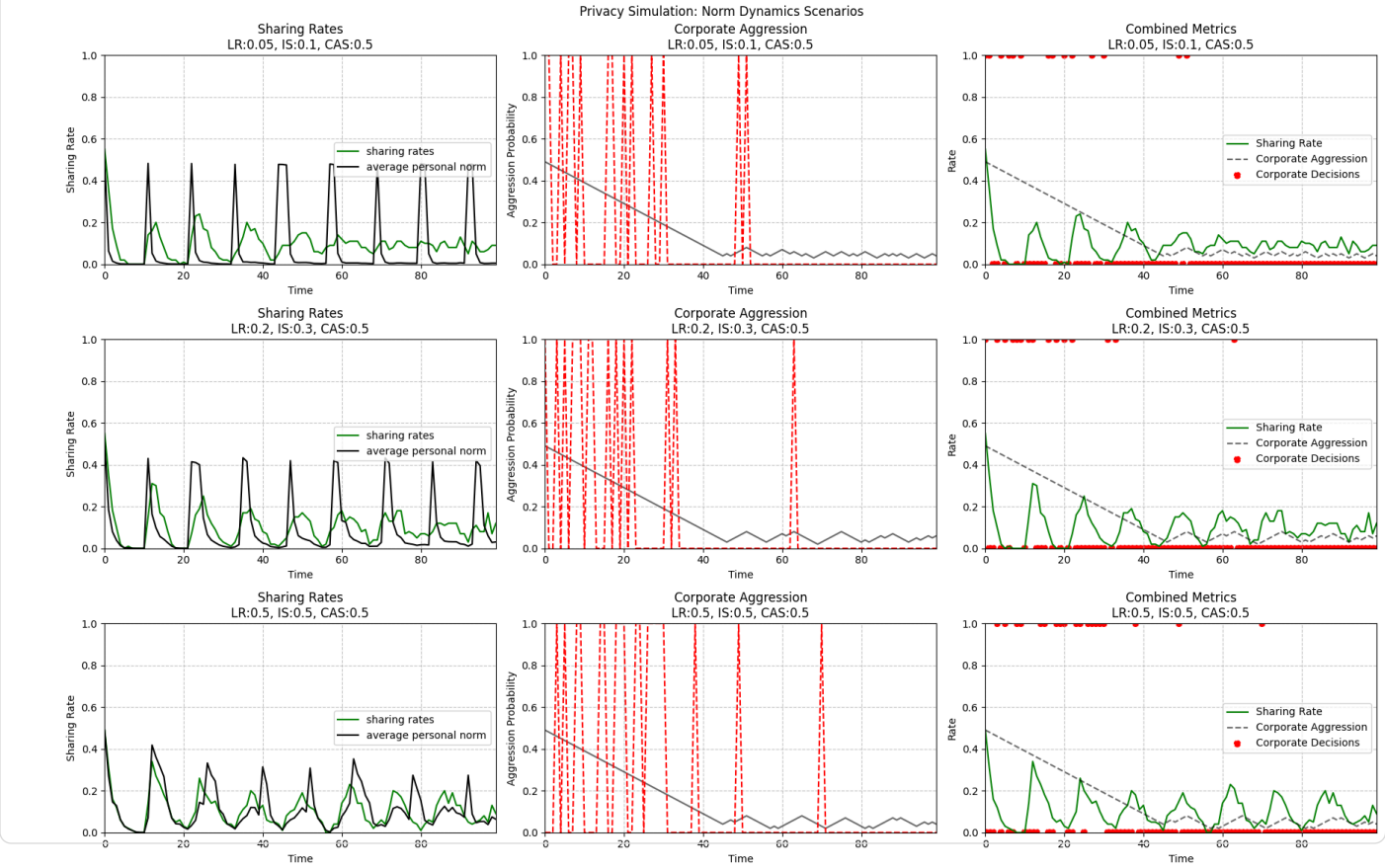
Run Scenarios under the updated individual agent

```
scenarios = [
    {'learning_rate': 0.05, 'influence_strength': 0.1, 'corporate_aggression_sensitivity': 0.8, 'initial_corporate_aggression'
    {'learning_rate': 0.2, 'influence_strength': 0.3, 'corporate_aggression_sensitivity': 0.8, 'initial_corporate_aggression':
    {'learning_rate': 0.5, 'influence_strength': 0.5, 'corporate_aggression_sensitivity': 0.8, 'initial_corporate_aggression':
]

# Run the scenario comparison
run_scenario_comparison(scenarios, time=100)
```

```
Sharing norm:  0.5
Sharing norm:  0.236
Sharing norm:  0.251
Sharing norm:  0.233
Sharing norm:  0.253
Sharing norm:  0.258
Sharing norm:  0.5
Sharing norm:  0.259
Sharing norm:  0.221
Sharing norm:  0.258
Sharing norm:  0.259
Sharing norm:  0.261
Sharing norm:  0.5
Sharing norm:  0.237
Sharing norm:  0.219
Sharing norm:  0.246
Sharing norm:  0.239
Sharing norm:  0.256
```



```
scenarios = [
    {'learning_rate': 0.05, 'influence_strength': 0.1, 'corporate_aggression_sensitivity': 0.5},  # Moderate aggression sensit
    {'learning_rate': 0.2, 'influence_strength': 0.3, 'corporate_aggression_sensitivity': 0.5}, # Moderate aggression sensitiv
    {'learning_rate': 0.5, 'influence_strength': 0.5, 'corporate_aggression_sensitivity': 0.5} # Moderate aggression sensitivi
]

# Run the scenario comparison
run_scenario_comparison(scenarios, time=100)
```



Recreating 100 population Iterations Under Corporate Aggression Sensitivity, Learning Rate and Social Influence

```
# Example usage in Jupyter Notebook
step_3b_results = []
for population in range(100):
  simulation = PrivacySimulation(num_individuals=100, initial_corporate_aggression=0.5, corporate_step_boldness=0.01)
  results = simulation.run_simulation(time=1000)
  for result in results:
    result['iteration'] = population
  step_3b_results.append(results)

#step_1b_results_df = pd.DataFrame(step_1b_results)

```

Change Due to Corporate Aggression Sensitivy

```
# prompt: simulate this 100 times for initial_gorporate_aggression going from 0.01 to 1.00 for each time check the correlati

correlations_data = []
cas_sensitivity_large = []
for cas in np.linspace(0.01, 3.00, 100):
  correlations = []
  late_aggression_list = []
  corporate_aggr_decisions_list = []
  for population in range(100):
    simulation = PrivacySimulation_2(num_individuals=100,
                                     corporate_aggression_sensitivity=cas,
```

```
                                    norm_learning_rate=0,
                                    initial_norm= 0.5,
                                    initial_sharing_prob= 0.5,
                                    corporate_step_boldness=0.01,
                                    platform_tenure = 10,
                                    social_influence_strength=0,
                                    initial_corporate_aggression=0.5,
                                    dr_pause=0)
    results = simulation.run_simulation(time=100)
    #for result in results: #comment this out to skip building large dataset
    #  result['cas_level'] = cas
    #  result['iteration'] = population
    #cas_sensitivity_large.append(results) #comment this out to skip building large dataset
    results_df = pd.DataFrame(results)
    results_df['corporate_decision_history'] = results_df['corporate_decision_history'].astype(int)
    correlation = results_df['sharing_rate'].corr(results_df['corporate_aggression_prob'])
    correlations.append(correlation)
    corporate_aggr_decision = results_df['corporate_decision_history'].sum()/len(results_df['corporate_decision_history'])
    corporate_aggr_decisions_list.append(corporate_aggr_decision)


    # Determine the index for the last quartile
    last_quartile_start = int(0.75 * len(results_df['corporate_decision_history']))

    # Extract the last quartile of corporate decision history
    last_quartile_data = results_df['corporate_decision_history'].iloc[last_quartile_start:]

    # Compute late aggression
    late_aggression = last_quartile_data.sum() / len(last_quartile_data)
    late_aggression_list.append(late_aggression)

  # Calculate mean and confidence interval
  mean_correlation = np.mean(correlations)
  std_correlation = np.std(correlations)
  mean_corp_decisions = np.mean(corporate_aggr_decisions_list)
  std_corp_decisions = np.std(corporate_aggr_decisions_list)
  confidence_interval = 1.96 * (std_correlation / np.sqrt(len(correlations)))  # 95% CI
  std_late_aggression = np.std(late_aggression_list)
  mean_late_aggression = np.mean(late_aggression_list)

  correlations_data.append({
      'cas_level': cas,
      'mean_correlation': mean_correlation,
      'confidence_interval': confidence_interval,
      'correlation_stdev': std_correlation,
      'corporate_decision_history': corporate_aggr_decisions,
      'mean_late_aggression': late_aggression,
      'late_aggression_stdev': std_late_aggression,
      'mean_corp_decisions': mean_corp_decisions,
      'corp_decisions_stdev': std_corp_decisions

  })


# Create a DataFrame from the correlations data
cas_correlations = pd.DataFrame(correlations_data)


```

```
cas_correlations['lagged_corporate_decision_history'] = (
    cas_correlations['mean_corp_decisions']
    .transform(lambda x: x.rolling(window=10, min_periods=1).mean())
)

```

```
cas_correlations
```

	cas_level	mean_correlation	confidence_interval	correlation_stdev	corporate_decision_history	mean_late_aggression	late_agg
0	0.010000	0.115375	0.020466	0.104417	0.18	0.00	
1	0.040202	0.283335	0.020273	0.103435	0.18	0.04	
2	0.070404	0.391171	0.020166	0.102888	0.18	0.16	