In [3]:
```
import random
from scipy.stats import norm
import matplotlib.pyplot as plt
from scipy.stats import beta
import numpy as np
```

In [4]:
```
def tit_for_tat(num_trials):

    player_a_moves = ["C"]
    player_b_moves = ["C"]

    for _ in range(num_trials - 1):

        if player_b_moves[-1] == "C":
            player_a_moves.append("C")
        else:
            player_a_moves.append("D")


        opponent_response = random.choice(["C", "D"])
        player_b_moves.append(opponent_response)

    return player_a_moves, player_b_moves

def tit_for_tat_with_threshold(num_rounds, threshold):
    actions_a = []
    actions_b = []

    for round_num in range(1,num_rounds+1):
        if round_num <= threshold:
            actions_a.append("C")
            actions_b.append(random.choice(["C", "D"]))
        else:
            if actions_b[-1] == "C":
                actions_a.append("C")
            else:
                actions_a.append("D")
        opponent_response = random.choice(["C", "D"])
        actions_b.append(opponent_response)



    return actions_a, actions_b


def one_cooperating_strategy(num_trials):
    player_d_moves=[]
    player_c_moves=[]
    for _ in range(num_trials):

        player_d_moves.append(random.choice(["C", "D"]))
        player_c_moves.append("C")
    return player_d_moves, player_c_moves

def both_cooperating_strategy(num_trials):
    player_e_moves=[]
    player_f_moves=[]
    for _ in range(num_trials):
```

```
        player_e_moves.append("C")
        player_f_moves.append("C")
    return player_e_moves, player_f_moves

"""payoff_matrix = {
    "CC": (11, 11),  # Payoff for mutual cooperation
   "CD": (0, 20),  # Payoff for A: Cooperation, B: Defection
    "DC": (20, 0),  # Payoff for A: Defection, B: Cooperation
   "DD": (9, 9)   # Payoff for mutual defection
}"""
payoff_matrix ={'CC': (11, 11), 'CD': (0, 20), 'DC': (20, 0), 'DD': (9, 9


# Simulate trials
num_trials = 300
player_a, player_b = tit_for_tat(num_trials)
player_a1, player_b1 = tit_for_tat_with_threshold(num_trials, threshold=2
player_a2, player_b2 = one_cooperating_strategy(num_trials)
player_a3, player_b3 = both_cooperating_strategy(num_trials)

mu3 = 4
mu4 =0
sigma = 1
pdf_values_AB=[]
pdf_values_BA=[]
pdf_values1=[]
pdf_values2=[]
pdf_values3=[]


#print(f"Value of A: {player_a}, Value of y: {player_b}")
print("Strategy: Tit-for-Tat")
for round_num, (move_a, move_b) in enumerate(zip(player_a, player_b), sta
    print(f"Round {round_num}: Player A moves {move_a}, Player B moves {m

print("\nStrategy: Tit-for-Tat with Threshold")
for round_num, (move_a, move_b) in enumerate(zip(player_a1, player_b1), s
    print(f"Round {round_num}: Player A moves {move_a}, Player B moves {m

print("\nStrategy: One Cooperating Strategy")
for round_num, (move_a, move_b) in enumerate(zip(player_a2, player_b2), s
    print(f"Round {round_num}: Player A moves {move_a}, Player B moves {m


print("\nStrategy: Both Cooperating Strategy")
for round_num, (move_a, move_b) in enumerate(zip(player_a3, player_b3), s
    print(f"Round {round_num}: Player A moves {move_a}, Player B moves {m
```

```
Strategy: Tit-for-Tat
Round 1: Player A moves C, Player B moves C
Round 2: Player A moves C, Player B moves C
Round 3: Player A moves C, Player B moves D
Round 4: Player A moves D, Player B moves C
Round 5: Player A moves C, Player B moves C
Round 6: Player A moves C, Player B moves D
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Round 300: Player A moves D, Player B moves C

Strategy: Tit-for-Tat with Threshold
Round 1: Player A moves C, Player B moves C
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Round 193: Player A moves C, Player B moves C
Round 194: Player A moves C, Player B moves C
Round 195: Player A moves C, Player B moves D
Round 196: Player A moves C, Player B moves D
Round 197: Player A moves D, Player B moves D
Round 198: Player A moves D, Player B moves D
Round 199: Player A moves D, Player B moves D
Round 200: Player A moves C, Player B moves C
Round 201: Player A moves C, Player B moves C
Round 202: Player A moves D, Player B moves C
Round 203: Player A moves D, Player B moves C
Round 204: Player A moves C, Player B moves D
Round 205: Player A moves D, Player B moves C
Round 206: Player A moves D, Player B moves D
Round 207: Player A moves C, Player B moves D
Round 208: Player A moves C, Player B moves D
Round 209: Player A moves D, Player B moves C
Round 210: Player A moves D, Player B moves D
Round 211: Player A moves D, Player B moves D
Round 212: Player A moves C, Player B moves C
Round 213: Player A moves C, Player B moves C
Round 214: Player A moves D, Player B moves C
Round 215: Player A moves D, Player B moves C
Round 216: Player A moves D, Player B moves D
Round 217: Player A moves C, Player B moves D
Round 218: Player A moves D, Player B moves D
Round 219: Player A moves D, Player B moves C
Round 220: Player A moves C, Player B moves C
Round 221: Player A moves D, Player B moves D
Round 222: Player A moves D, Player B moves D
Round 223: Player A moves D, Player B moves C
Round 224: Player A moves D, Player B moves D
Round 225: Player A moves C, Player B moves D
Round 226: Player A moves D, Player B moves C
Round 227: Player A moves C, Player B moves C
Round 228: Player A moves D, Player B moves D
Round 229: Player A moves D, Player B moves D
Round 230: Player A moves D, Player B moves D
Round 231: Player A moves C, Player B moves C
Round 232: Player A moves C, Player B moves C
Round 233: Player A moves C, Player B moves D
Round 234: Player A moves C, Player B moves D
Round 235: Player A moves C, Player B moves D
Round 236: Player A moves D, Player B moves C
Round 237: Player A moves D, Player B moves D

Round 238: Player A moves C, Player B moves D
Round 239: Player A moves C, Player B moves C
Round 240: Player A moves C, Player B moves D
Round 241: Player A moves D, Player B moves D
Round 242: Player A moves D, Player B moves D
Round 243: Player A moves C, Player B moves D
Round 244: Player A moves C, Player B moves C
Round 245: Player A moves C, Player B moves D
Round 246: Player A moves D, Player B moves C
Round 247: Player A moves C, Player B moves D
Round 248: Player A moves D, Player B moves D
Round 249: Player A moves D, Player B moves D
Round 250: Player A moves D, Player B moves C
Round 251: Player A moves C, Player B moves C
Round 252: Player A moves C, Player B moves C
Round 253: Player A moves D, Player B moves C
Round 254: Player A moves D, Player B moves C
Round 255: Player A moves C, Player B moves D
Round 256: Player A moves C, Player B moves D
Round 257: Player A moves D, Player B moves C
Round 258: Player A moves D, Player B moves C
Round 259: Player A moves D, Player B moves C
Round 260: Player A moves D, Player B moves D
Round 261: Player A moves C, Player B moves D
Round 262: Player A moves C, Player B moves C
Round 263: Player A moves C, Player B moves C
Round 264: Player A moves C, Player B moves C
Round 265: Player A moves D, Player B moves D
Round 266: Player A moves C, Player B moves C
Round 267: Player A moves D, Player B moves D
Round 268: Player A moves C, Player B moves D
Round 269: Player A moves D, Player B moves D
Round 270: Player A moves C, Player B moves C
Round 271: Player A moves D, Player B moves C
Round 272: Player A moves C, Player B moves D
Round 273: Player A moves C, Player B moves D
Round 274: Player A moves D, Player B moves C
Round 275: Player A moves C, Player B moves C
Round 276: Player A moves C, Player B moves D
Round 277: Player A moves D, Player B moves D
Round 278: Player A moves C, Player B moves D
Round 279: Player A moves C, Player B moves D
Round 280: Player A moves C, Player B moves C
Round 281: Player A moves C, Player B moves C
Round 282: Player A moves D, Player B moves C
Round 283: Player A moves C, Player B moves C
Round 284: Player A moves C, Player B moves D
Round 285: Player A moves C, Player B moves C
Round 286: Player A moves C, Player B moves D
Round 287: Player A moves C, Player B moves C
Round 288: Player A moves C, Player B moves D
Round 289: Player A moves C, Player B moves C
Round 290: Player A moves D, Player B moves D
Round 291: Player A moves D, Player B moves C
Round 292: Player A moves C, Player B moves C
Round 293: Player A moves D, Player B moves D
Round 294: Player A moves D, Player B moves C
Round 295: Player A moves D, Player B moves C
Round 296: Player A moves C, Player B moves D
Round 297: Player A moves D, Player B moves C

Round 298: Player A moves D, Player B moves C
Round 299: Player A moves C, Player B moves C
Round 300: Player A moves C, Player B moves C

Strategy: One Cooperating Strategy
Round 1: Player A moves C, Player B moves C
Round 2: Player A moves D, Player B moves C
Round 3: Player A moves D, Player B moves C
Round 4: Player A moves C, Player B moves C
Round 5: Player A moves C, Player B moves C
Round 6: Player A moves D, Player B moves C
Round 7: Player A moves D, Player B moves C
Round 8: Player A moves C, Player B moves C
Round 9: Player A moves D, Player B moves C
Round 10: Player A moves C, Player B moves C
Round 11: Player A moves D, Player B moves C
Round 12: Player A moves C, Player B moves C
Round 13: Player A moves C, Player B moves C
Round 14: Player A moves D, Player B moves C
Round 15: Player A moves D, Player B moves C
Round 16: Player A moves D, Player B moves C
Round 17: Player A moves D, Player B moves C
Round 18: Player A moves C, Player B moves C
Round 19: Player A moves D, Player B moves C
Round 20: Player A moves C, Player B moves C
Round 21: Player A moves C, Player B moves C
Round 22: Player A moves C, Player B moves C
Round 23: Player A moves D, Player B moves C
Round 24: Player A moves C, Player B moves C
Round 25: Player A moves D, Player B moves C
Round 26: Player A moves D, Player B moves C
Round 27: Player A moves C, Player B moves C
Round 28: Player A moves C, Player B moves C
Round 29: Player A moves D, Player B moves C
Round 30: Player A moves D, Player B moves C
Round 31: Player A moves D, Player B moves C
Round 32: Player A moves C, Player B moves C
Round 33: Player A moves D, Player B moves C
Round 34: Player A moves C, Player B moves C
Round 35: Player A moves D, Player B moves C
Round 36: Player A moves D, Player B moves C
Round 37: Player A moves C, Player B moves C
Round 38: Player A moves C, Player B moves C
Round 39: Player A moves D, Player B moves C
Round 40: Player A moves C, Player B moves C
Round 41: Player A moves D, Player B moves C
Round 42: Player A moves C, Player B moves C
Round 43: Player A moves C, Player B moves C
Round 44: Player A moves D, Player B moves C
Round 45: Player A moves D, Player B moves C
Round 46: Player A moves C, Player B moves C
Round 47: Player A moves C, Player B moves C
Round 48: Player A moves D, Player B moves C
Round 49: Player A moves C, Player B moves C
Round 50: Player A moves D, Player B moves C
Round 51: Player A moves D, Player B moves C
Round 52: Player A moves C, Player B moves C
Round 53: Player A moves C, Player B moves C
Round 54: Player A moves D, Player B moves C
Round 55: Player A moves C, Player B moves C

Round 56: Player A moves C, Player B moves C
Round 57: Player A moves C, Player B moves C
Round 58: Player A moves D, Player B moves C
Round 59: Player A moves D, Player B moves C
Round 60: Player A moves D, Player B moves C
Round 61: Player A moves C, Player B moves C
Round 62: Player A moves C, Player B moves C
Round 63: Player A moves C, Player B moves C
Round 64: Player A moves C, Player B moves C
Round 65: Player A moves C, Player B moves C
Round 66: Player A moves C, Player B moves C
Round 67: Player A moves D, Player B moves C
Round 68: Player A moves D, Player B moves C
Round 69: Player A moves D, Player B moves C
Round 70: Player A moves D, Player B moves C
Round 71: Player A moves C, Player B moves C
Round 72: Player A moves D, Player B moves C
Round 73: Player A moves C, Player B moves C
Round 74: Player A moves D, Player B moves C
Round 75: Player A moves D, Player B moves C
Round 76: Player A moves C, Player B moves C
Round 77: Player A moves D, Player B moves C
Round 78: Player A moves C, Player B moves C
Round 79: Player A moves C, Player B moves C
Round 80: Player A moves D, Player B moves C
Round 81: Player A moves C, Player B moves C
Round 82: Player A moves D, Player B moves C
Round 83: Player A moves C, Player B moves C
Round 84: Player A moves C, Player B moves C
Round 85: Player A moves C, Player B moves C
Round 86: Player A moves D, Player B moves C
Round 87: Player A moves D, Player B moves C
Round 88: Player A moves C, Player B moves C
Round 89: Player A moves D, Player B moves C
Round 90: Player A moves C, Player B moves C
Round 91: Player A moves C, Player B moves C
Round 92: Player A moves C, Player B moves C
Round 93: Player A moves D, Player B moves C
Round 94: Player A moves C, Player B moves C
Round 95: Player A moves C, Player B moves C
Round 96: Player A moves C, Player B moves C
Round 97: Player A moves C, Player B moves C
Round 98: Player A moves C, Player B moves C
Round 99: Player A moves D, Player B moves C
Round 100: Player A moves D, Player B moves C
Round 101: Player A moves D, Player B moves C
Round 102: Player A moves D, Player B moves C
Round 103: Player A moves C, Player B moves C
Round 104: Player A moves C, Player B moves C
Round 105: Player A moves C, Player B moves C
Round 106: Player A moves D, Player B moves C
Round 107: Player A moves C, Player B moves C
Round 108: Player A moves C, Player B moves C
Round 109: Player A moves C, Player B moves C
Round 110: Player A moves D, Player B moves C
Round 111: Player A moves C, Player B moves C
Round 112: Player A moves C, Player B moves C
Round 113: Player A moves D, Player B moves C
Round 114: Player A moves C, Player B moves C
Round 115: Player A moves C, Player B moves C

Round 116: Player A moves C, Player B moves C
Round 117: Player A moves C, Player B moves C
Round 118: Player A moves D, Player B moves C
Round 119: Player A moves D, Player B moves C
Round 120: Player A moves C, Player B moves C
Round 121: Player A moves C, Player B moves C
Round 122: Player A moves C, Player B moves C
Round 123: Player A moves D, Player B moves C
Round 124: Player A moves D, Player B moves C
Round 125: Player A moves C, Player B moves C
Round 126: Player A moves D, Player B moves C
Round 127: Player A moves C, Player B moves C
Round 128: Player A moves C, Player B moves C
Round 129: Player A moves D, Player B moves C
Round 130: Player A moves D, Player B moves C
Round 131: Player A moves D, Player B moves C
Round 132: Player A moves C, Player B moves C
Round 133: Player A moves D, Player B moves C
Round 134: Player A moves D, Player B moves C
Round 135: Player A moves C, Player B moves C
Round 136: Player A moves D, Player B moves C
Round 137: Player A moves C, Player B moves C
Round 138: Player A moves D, Player B moves C
Round 139: Player A moves C, Player B moves C
Round 140: Player A moves D, Player B moves C
Round 141: Player A moves C, Player B moves C
Round 142: Player A moves D, Player B moves C
Round 143: Player A moves D, Player B moves C
Round 144: Player A moves D, Player B moves C
Round 145: Player A moves D, Player B moves C
Round 146: Player A moves D, Player B moves C
Round 147: Player A moves C, Player B moves C
Round 148: Player A moves D, Player B moves C
Round 149: Player A moves C, Player B moves C
Round 150: Player A moves D, Player B moves C
Round 151: Player A moves D, Player B moves C
Round 152: Player A moves C, Player B moves C
Round 153: Player A moves D, Player B moves C
Round 154: Player A moves D, Player B moves C
Round 155: Player A moves C, Player B moves C
Round 156: Player A moves D, Player B moves C
Round 157: Player A moves D, Player B moves C
Round 158: Player A moves C, Player B moves C
Round 159: Player A moves C, Player B moves C
Round 160: Player A moves D, Player B moves C
Round 161: Player A moves C, Player B moves C
Round 162: Player A moves D, Player B moves C
Round 163: Player A moves C, Player B moves C
Round 164: Player A moves D, Player B moves C
Round 165: Player A moves D, Player B moves C
Round 166: Player A moves C, Player B moves C
Round 167: Player A moves D, Player B moves C
Round 168: Player A moves D, Player B moves C
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Round 170: Player A moves D, Player B moves C
Round 171: Player A moves C, Player B moves C
Round 172: Player A moves D, Player B moves C
Round 173: Player A moves C, Player B moves C
Round 174: Player A moves C, Player B moves C
Round 175: Player A moves C, Player B moves C

Round 176: Player A moves D, Player B moves C
Round 177: Player A moves D, Player B moves C
Round 178: Player A moves D, Player B moves C
Round 179: Player A moves C, Player B moves C
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Round 181: Player A moves D, Player B moves C
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Round 204: Player A moves C, Player B moves C
Round 205: Player A moves D, Player B moves C
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Round 218: Player A moves C, Player B moves C
Round 219: Player A moves D, Player B moves C
Round 220: Player A moves C, Player B moves C
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Round 223: Player A moves D, Player B moves C
Round 224: Player A moves C, Player B moves C
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Round 226: Player A moves C, Player B moves C
Round 227: Player A moves D, Player B moves C
Round 228: Player A moves C, Player B moves C
Round 229: Player A moves D, Player B moves C
Round 230: Player A moves C, Player B moves C
Round 231: Player A moves C, Player B moves C
Round 232: Player A moves D, Player B moves C
Round 233: Player A moves D, Player B moves C
Round 234: Player A moves C, Player B moves C
Round 235: Player A moves C, Player B moves C

Round 236: Player A moves D, Player B moves C
Round 237: Player A moves C, Player B moves C
Round 238: Player A moves C, Player B moves C
Round 239: Player A moves D, Player B moves C
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Round 241: Player A moves D, Player B moves C
Round 242: Player A moves C, Player B moves C
Round 243: Player A moves C, Player B moves C
Round 244: Player A moves D, Player B moves C
Round 245: Player A moves D, Player B moves C
Round 246: Player A moves D, Player B moves C
Round 247: Player A moves C, Player B moves C
Round 248: Player A moves C, Player B moves C
Round 249: Player A moves C, Player B moves C
Round 250: Player A moves C, Player B moves C
Round 251: Player A moves D, Player B moves C
Round 252: Player A moves D, Player B moves C
Round 253: Player A moves D, Player B moves C
Round 254: Player A moves D, Player B moves C
Round 255: Player A moves D, Player B moves C
Round 256: Player A moves D, Player B moves C
Round 257: Player A moves C, Player B moves C
Round 258: Player A moves D, Player B moves C
Round 259: Player A moves D, Player B moves C
Round 260: Player A moves C, Player B moves C
Round 261: Player A moves C, Player B moves C
Round 262: Player A moves C, Player B moves C
Round 263: Player A moves D, Player B moves C
Round 264: Player A moves D, Player B moves C
Round 265: Player A moves D, Player B moves C
Round 266: Player A moves C, Player B moves C
Round 267: Player A moves C, Player B moves C
Round 268: Player A moves D, Player B moves C
Round 269: Player A moves D, Player B moves C
Round 270: Player A moves D, Player B moves C
Round 271: Player A moves D, Player B moves C
Round 272: Player A moves C, Player B moves C
Round 273: Player A moves C, Player B moves C
Round 274: Player A moves D, Player B moves C
Round 275: Player A moves D, Player B moves C
Round 276: Player A moves C, Player B moves C
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Round 280: Player A moves C, Player B moves C
Round 281: Player A moves C, Player B moves C
Round 282: Player A moves C, Player B moves C
Round 283: Player A moves C, Player B moves C
Round 284: Player A moves C, Player B moves C
Round 285: Player A moves C, Player B moves C
Round 286: Player A moves D, Player B moves C
Round 287: Player A moves D, Player B moves C
Round 288: Player A moves D, Player B moves C
Round 289: Player A moves C, Player B moves C
Round 290: Player A moves D, Player B moves C
Round 291: Player A moves C, Player B moves C
Round 292: Player A moves C, Player B moves C
Round 293: Player A moves D, Player B moves C
Round 294: Player A moves D, Player B moves C
Round 295: Player A moves D, Player B moves C

Round 296: Player A moves C, Player B moves C
Round 297: Player A moves D, Player B moves C
Round 298: Player A moves D, Player B moves C
Round 299: Player A moves D, Player B moves C
Round 300: Player A moves D, Player B moves C

Strategy: Both Cooperating Strategy
Round 1: Player A moves C, Player B moves C
Round 2: Player A moves C, Player B moves C
Round 3: Player A moves C, Player B moves C
Round 4: Player A moves C, Player B moves C
Round 5: Player A moves C, Player B moves C
Round 6: Player A moves C, Player B moves C
Round 7: Player A moves C, Player B moves C
Round 8: Player A moves C, Player B moves C
Round 9: Player A moves C, Player B moves C
Round 10: Player A moves C, Player B moves C
Round 11: Player A moves C, Player B moves C
Round 12: Player A moves C, Player B moves C
Round 13: Player A moves C, Player B moves C
Round 14: Player A moves C, Player B moves C
Round 15: Player A moves C, Player B moves C
Round 16: Player A moves C, Player B moves C
Round 17: Player A moves C, Player B moves C
Round 18: Player A moves C, Player B moves C
Round 19: Player A moves C, Player B moves C
Round 20: Player A moves C, Player B moves C
Round 21: Player A moves C, Player B moves C
Round 22: Player A moves C, Player B moves C
Round 23: Player A moves C, Player B moves C
Round 24: Player A moves C, Player B moves C
Round 25: Player A moves C, Player B moves C
Round 26: Player A moves C, Player B moves C
Round 27: Player A moves C, Player B moves C
Round 28: Player A moves C, Player B moves C
Round 29: Player A moves C, Player B moves C
Round 30: Player A moves C, Player B moves C
Round 31: Player A moves C, Player B moves C
Round 32: Player A moves C, Player B moves C
Round 33: Player A moves C, Player B moves C
Round 34: Player A moves C, Player B moves C
Round 35: Player A moves C, Player B moves C
Round 36: Player A moves C, Player B moves C
Round 37: Player A moves C, Player B moves C
Round 38: Player A moves C, Player B moves C
Round 39: Player A moves C, Player B moves C
Round 40: Player A moves C, Player B moves C
Round 41: Player A moves C, Player B moves C
Round 42: Player A moves C, Player B moves C
Round 43: Player A moves C, Player B moves C
Round 44: Player A moves C, Player B moves C
Round 45: Player A moves C, Player B moves C
Round 46: Player A moves C, Player B moves C
Round 47: Player A moves C, Player B moves C
Round 48: Player A moves C, Player B moves C
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Round 54: Player A moves C, Player B moves C
Round 55: Player A moves C, Player B moves C
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Round 60: Player A moves C, Player B moves C
Round 61: Player A moves C, Player B moves C
Round 62: Player A moves C, Player B moves C
Round 63: Player A moves C, Player B moves C
Round 64: Player A moves C, Player B moves C
Round 65: Player A moves C, Player B moves C
Round 66: Player A moves C, Player B moves C
Round 67: Player A moves C, Player B moves C
Round 68: Player A moves C, Player B moves C
Round 69: Player A moves C, Player B moves C
Round 70: Player A moves C, Player B moves C
Round 71: Player A moves C, Player B moves C
Round 72: Player A moves C, Player B moves C
Round 73: Player A moves C, Player B moves C
Round 74: Player A moves C, Player B moves C
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Round 76: Player A moves C, Player B moves C
Round 77: Player A moves C, Player B moves C
Round 78: Player A moves C, Player B moves C
Round 79: Player A moves C, Player B moves C
Round 80: Player A moves C, Player B moves C
Round 81: Player A moves C, Player B moves C
Round 82: Player A moves C, Player B moves C
Round 83: Player A moves C, Player B moves C
Round 84: Player A moves C, Player B moves C
Round 85: Player A moves C, Player B moves C
Round 86: Player A moves C, Player B moves C
Round 87: Player A moves C, Player B moves C
Round 88: Player A moves C, Player B moves C
Round 89: Player A moves C, Player B moves C
Round 90: Player A moves C, Player B moves C
Round 91: Player A moves C, Player B moves C
Round 92: Player A moves C, Player B moves C
Round 93: Player A moves C, Player B moves C
Round 94: Player A moves C, Player B moves C
Round 95: Player A moves C, Player B moves C
Round 96: Player A moves C, Player B moves C
Round 97: Player A moves C, Player B moves C
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Round 99: Player A moves C, Player B moves C
Round 100: Player A moves C, Player B moves C
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Round 112: Player A moves C, Player B moves C
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Round 123: Player A moves C, Player B moves C
Round 124: Player A moves C, Player B moves C
Round 125: Player A moves C, Player B moves C
Round 126: Player A moves C, Player B moves C
Round 127: Player A moves C, Player B moves C
Round 128: Player A moves C, Player B moves C
Round 129: Player A moves C, Player B moves C
Round 130: Player A moves C, Player B moves C
Round 131: Player A moves C, Player B moves C
Round 132: Player A moves C, Player B moves C
Round 133: Player A moves C, Player B moves C
Round 134: Player A moves C, Player B moves C
Round 135: Player A moves C, Player B moves C
Round 136: Player A moves C, Player B moves C
Round 137: Player A moves C, Player B moves C
Round 138: Player A moves C, Player B moves C
Round 139: Player A moves C, Player B moves C
Round 140: Player A moves C, Player B moves C
Round 141: Player A moves C, Player B moves C
Round 142: Player A moves C, Player B moves C
Round 143: Player A moves C, Player B moves C
Round 144: Player A moves C, Player B moves C
Round 145: Player A moves C, Player B moves C
Round 146: Player A moves C, Player B moves C
Round 147: Player A moves C, Player B moves C
Round 148: Player A moves C, Player B moves C
Round 149: Player A moves C, Player B moves C
Round 150: Player A moves C, Player B moves C
Round 151: Player A moves C, Player B moves C
Round 152: Player A moves C, Player B moves C
Round 153: Player A moves C, Player B moves C
Round 154: Player A moves C, Player B moves C
Round 155: Player A moves C, Player B moves C
Round 156: Player A moves C, Player B moves C
Round 157: Player A moves C, Player B moves C
Round 158: Player A moves C, Player B moves C
Round 159: Player A moves C, Player B moves C
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Round 171: Player A moves C, Player B moves C
Round 172: Player A moves C, Player B moves C
Round 173: Player A moves C, Player B moves C

Round 174: Player A moves C, Player B moves C
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Round 294: Player A moves C, Player B moves C
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Round 300: Player A moves C, Player B moves C
```
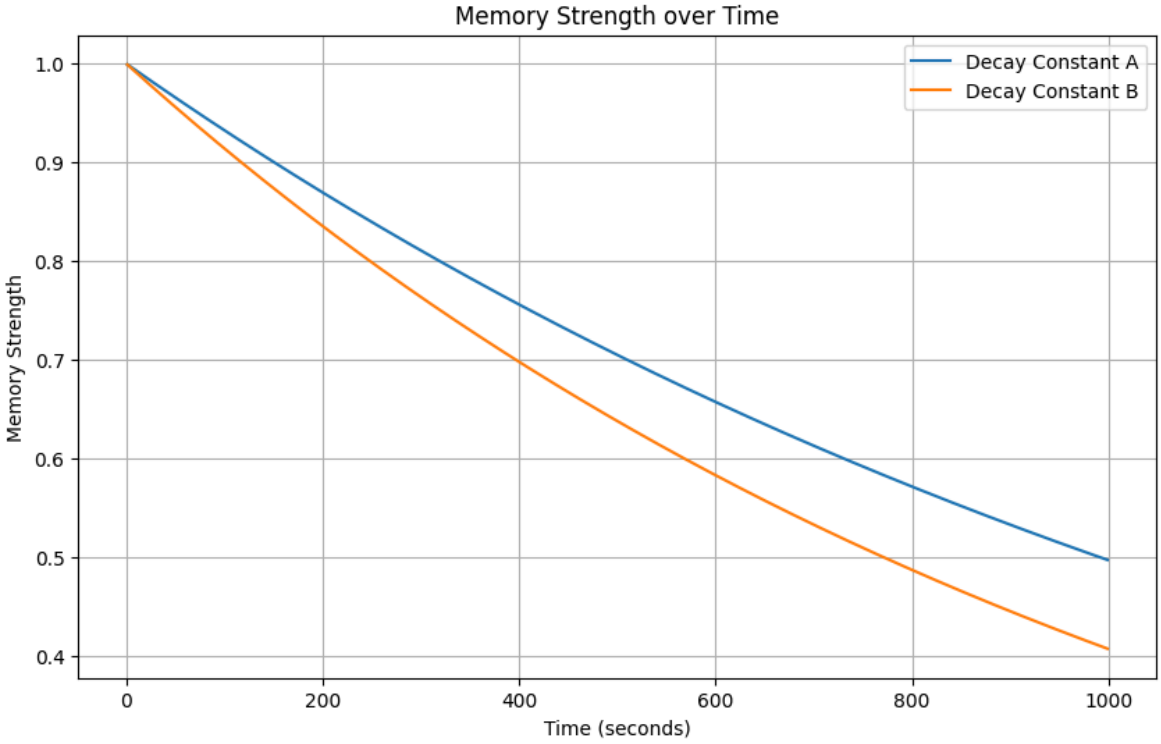
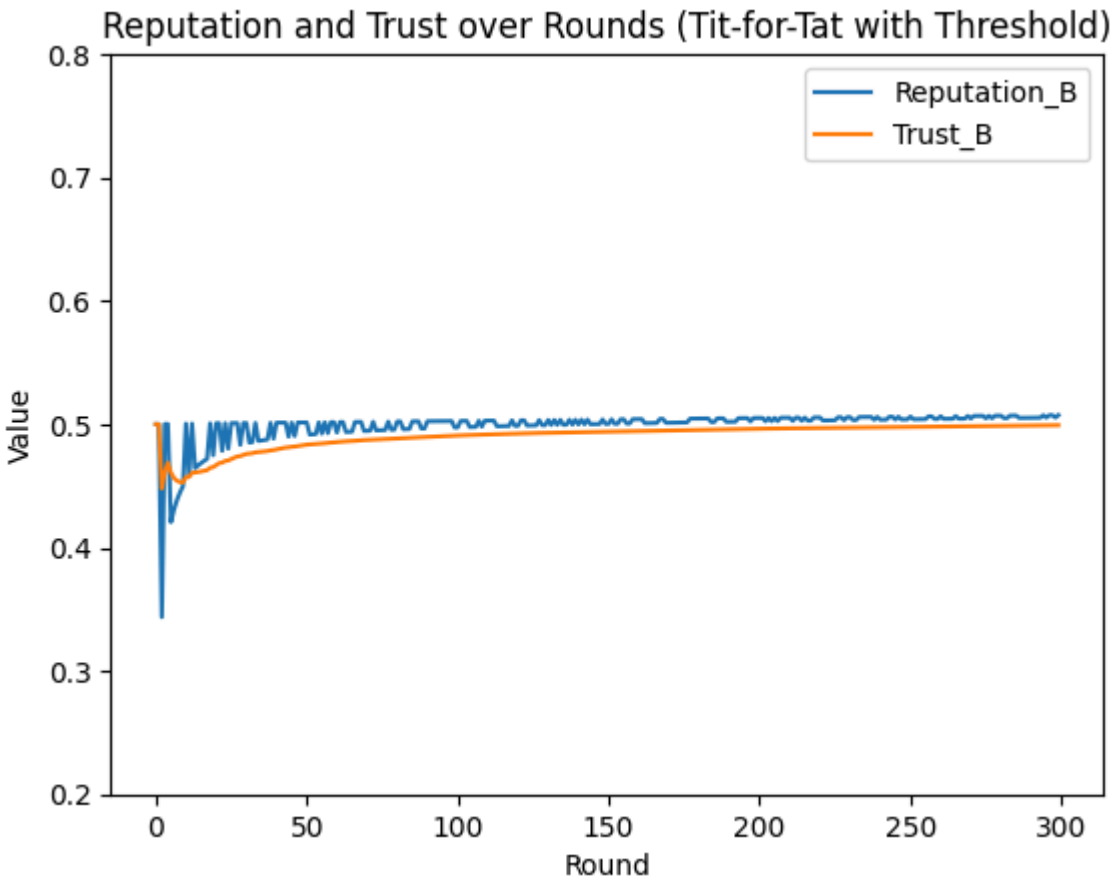

In [6]:

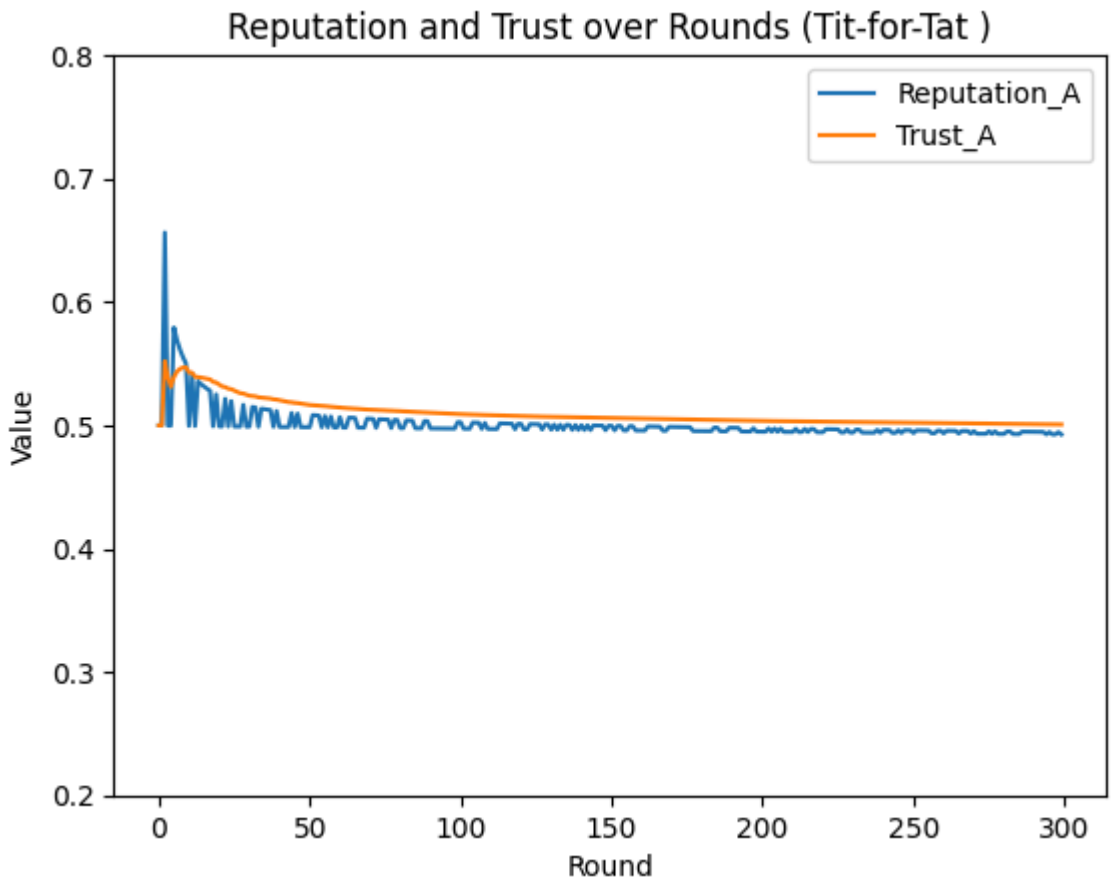
```python
import math
import numpy as np
import matplotlib.pyplot as plt

def memory_strength(initial_strength, decay_constant, time):
    """
    Calculate memory strength at a given time using an exponential decay

    Parameters:
        initial_strength (float): Initial strength of memory.
        decay_constant (float): Decay constant determining the rate of de
        time (float): Time elapsed since memory formation.

    Returns:
        float: Memory strength at the given time.
    """
    return initial_strength * math.exp(-decay_constant * time)

# Define parameters
initial_strength = 1.0  # Initial strength of memory
decay_constant_A = 0.0007   # Decay constant
decay_constant_B = 0.0009
# Time range from 0 to 100 seconds with 0.1 second intervals
time_range = np.arange(1, 1000, 1)

# Calculate memory strength at each time point
memory_strength_values_A = [memory_strength(initial_strength, decay_const
#print(memory_strength_values)
# Calculate memory strength at each time point
memory_strength_values_B = [memory_strength(initial_strength, decay_const

# Plotting
plt.figure(figsize=(10, 6))
plt.plot(time_range, memory_strength_values_A, label='Decay Constant A')
plt.plot(time_range, memory_strength_values_B, label='Decay Constant B')
plt.title('Memory Strength over Time')
plt.xlabel('Time (seconds)')
plt.ylabel('Memory Strength')
plt.legend()
plt.grid(True)
plt.show()
```



In [7]:
```python
# For the tit-for-tat
payoffs_a = []
w_payoffs_a = []
payoffs_b = []
w_payoffs_b = []
sum_rep_AB=0
sum_rep_BA=0
#A has for B=AB
trust_values_tit_tat_AB = []
trust_values_tit_tat_BA = []
rep_values_AB=[]
rep_values_BA=[]
for i in range(len(player_a)):
    action_a = player_a[i]
    action_b = player_b[i]
    key = action_a + action_b
    payoffs_a.append(payoff_matrix[key][0])
    payoffs_b.append(payoff_matrix[key][1])
    for j in range(len(payoffs_a)):
        w_payoffs_a.append( memory_strength_values_A[j]*payoffs_a[len(pay
        w_payoffs_b.append( memory_strength_values_B[j]*payoffs_b[len(pay
    if (sum(w_payoffs_a)+sum(w_payoffs_b)) == 0:
        rep_values_AB.append(0.4)  # Set trust value to a default value
        rep_values_BA.append(0.4)
    else:
        rep_values_AB.append(sum(w_payoffs_a) / (sum(w_payoffs_a)+sum(w_p
        rep_values_BA.append(sum(w_payoffs_b) / (sum(w_payoffs_a)+sum(w_p
    w_payoffs_a.clear()
    w_payoffs_b.clear()


    for k in range(len(rep_values_AB)):
        sum_rep_AB+=rep_values_AB[k]
        sum_rep_BA+=rep_values_BA[k]
    trust_values_tit_tat_AB.append(sum_rep_AB/(k+1))
    trust_values_tit_tat_BA.append(sum_rep_BA/(k+1))
```

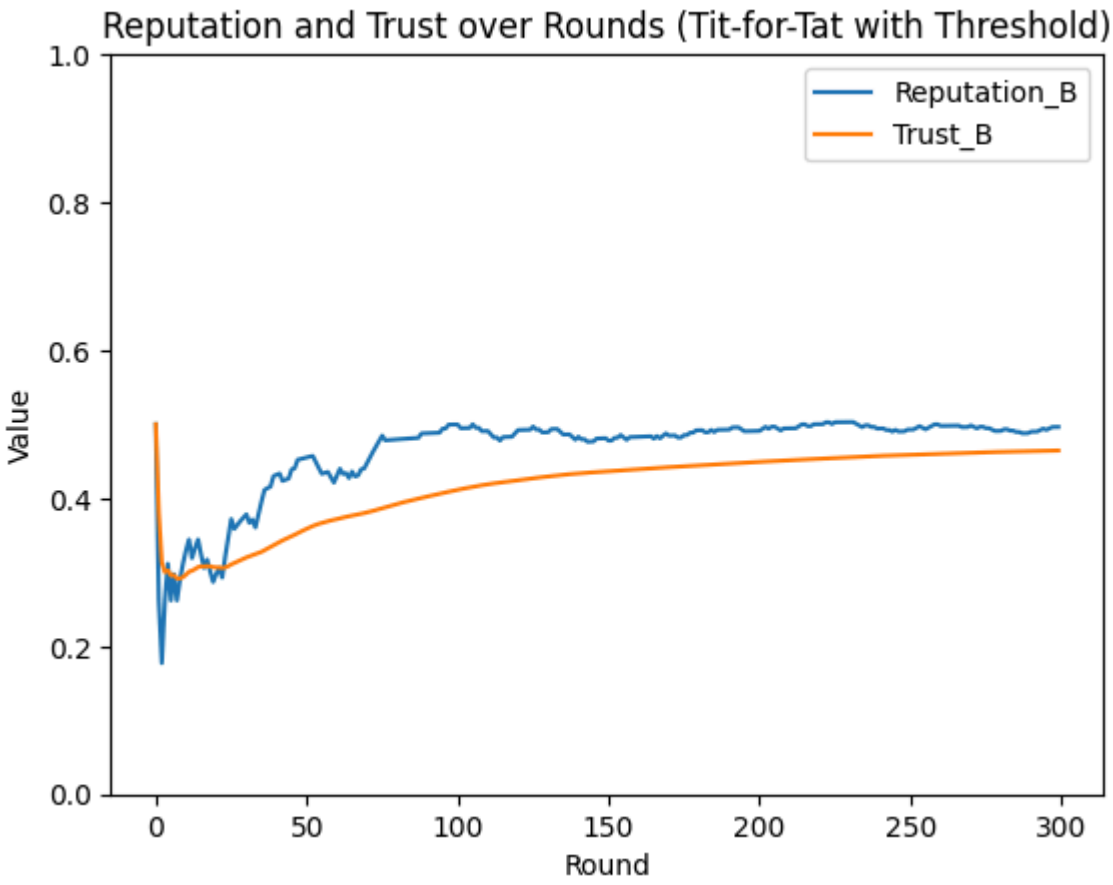
```
    sum_rep_AB=0
    sum_rep_BA=0


#print(trust_values_tit_tat_BA)
#print(trust_values_tit_tat_AB)


# Plot Rep values and Trust values for tit-for-tat FOR AB
plt.plot(range(len(rep_values_AB)), rep_values_AB, label='Reputation_B')
plt.plot(range(len(trust_values_tit_tat_AB)), trust_values_tit_tat_AB, la
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (Tit-for-Tat with Threshold)'
plt.legend()
plt.ylim(0.2, 0.8)  # Set y-axis limits
plt.show()

# Plot Rep values and Trust values for tit-for-tat FOR BA
plt.plot(range(len(rep_values_BA)), rep_values_BA, label='Reputation_A')
plt.plot(range(len(trust_values_tit_tat_BA)), trust_values_tit_tat_BA, la
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (Tit-for-Tat )')
plt.legend()
plt.ylim(0.2, 0.8)  # Set y-axis limits
plt.show()
```

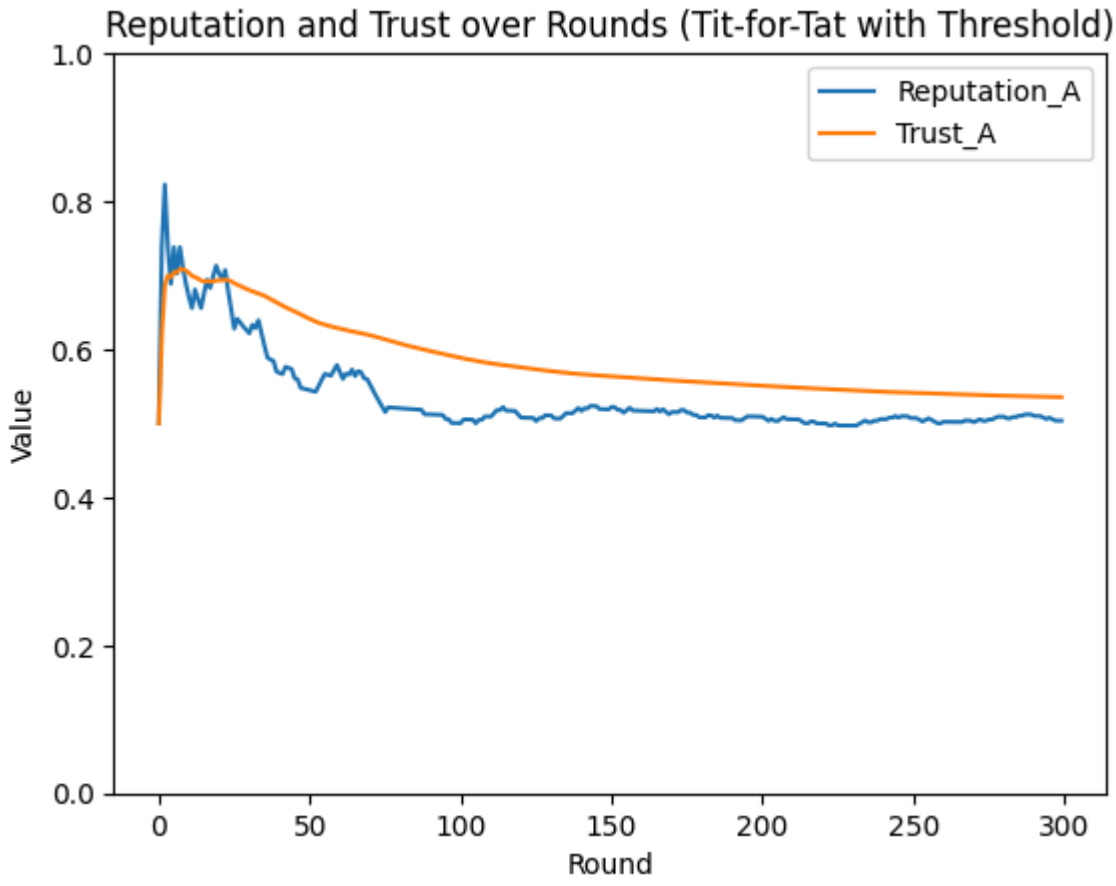




In [8]:
```
# For the tit-for-tat with threshold strategy
payoffs_a1 = []
w_payoffs_a1 = []
payoffs_b1 = []
w_payoffs_b1 = []
sum_rep_AB1=0
sum_rep_BA1=0
#A has for B=AB
trust_values_tit_tat_AB1 = []
trust_values_tit_tat_BA1= []
rep_values_AB1=[]
rep_values_BA1=[]
for i in range(len(player_a)):
    action_a1 = player_a1[i]
    action_b1 = player_b1[i]
    key = action_a1 + action_b1
    payoffs_a1.append(payoff_matrix[key][0])
    payoffs_b1.append(payoff_matrix[key][1])
    for j in range(len(payoffs_a1)):
        w_payoffs_a1.append( memory_strength_values_A[j]*payoffs_a1[len(p
        w_payoffs_b1.append( memory_strength_values_B[j]*payoffs_b1[len(p
    if (sum(w_payoffs_a1)+sum(w_payoffs_b1)) == 0:
        rep_values_AB1.append(0.4)  # Set trust value to a default value
        rep_values_BA1.append(0.4)
    else:
        rep_values_AB1.append(sum(w_payoffs_a1) / (sum(w_payoffs_a1)+sum(
        rep_values_BA1.append(sum(w_payoffs_b1) / (sum(w_payoffs_a1)+sum(
    w_payoffs_a1.clear()
    w_payoffs_b1.clear()
    for k in range(len(rep_values_AB1)):
        sum_rep_AB1+=rep_values_AB1[k]
        sum_rep_BA1+=rep_values_BA1[k]
```

```
    trust_values_tit_tat_AB1.append(sum_rep_AB1/(k+1))
    trust_values_tit_tat_BA1.append(sum_rep_BA1/(k+1))
    sum_rep_AB1=0
    sum_rep_BA1=0


#print(trust_values_tit_tat_BA1)
#print(trust_values_tit_tat_AB1)


# Plot Rep values and Trust values for tit-for-tat FOR AB
plt.plot(range(len(rep_values_AB1)), rep_values_AB1, label='Reputation_B'
plt.plot(range(len(trust_values_tit_tat_AB1)), trust_values_tit_tat_AB1,
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (Tit-for-Tat with Threshold)'
plt.legend()
plt.ylim(0, 1)  # Set y-axis limits
plt.show()

# Plot Rep values and Trust values for tit-for-tat FOR BA
plt.plot(range(len(rep_values_BA1)), rep_values_BA1, label='Reputation_A'
plt.plot(range(len(trust_values_tit_tat_BA1)), trust_values_tit_tat_BA1,
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (Tit-for-Tat with Threshold)'
plt.legend()
plt.ylim(0, 1)  # Set y-axis limits
plt.show()
```





In [9]:
```python
# For one ever co-operating
payoffs_a2 = []
w_payoffs_a2 = []
payoffs_b2 = []
w_payoffs_b2 = []
sum_rep_AB2=0
sum_rep_BA2=0
#A has for B=AB
trust_values_tit_tat_AB2 = []
trust_values_tit_tat_BA2= []
rep_values_AB2=[]
rep_values_BA2=[]
for i in range(len(player_a2)):
    action_a2 = player_a2[i]
    action_b2 = player_b2[i]
    key = action_a2 + action_b2
    payoffs_a2.append(payoff_matrix[key][0])
    payoffs_b2.append(payoff_matrix[key][1])
    for j in range(len(payoffs_a2)):
        w_payoffs_a2.append( memory_strength_values_A[j]*payoffs_a2[len(p
        w_payoffs_b2.append( memory_strength_values_B[j]*payoffs_b2[len(p
    if (sum(w_payoffs_a2)+sum(w_payoffs_b2)) == 0:
        rep_values_AB2.append(0.4)  # Set trust value to a default value
        rep_values_BA2.append(0.4)
    else:
        rep_values_AB2.append(sum(w_payoffs_a2) / (sum(w_payoffs_a2)+sum(
        rep_values_BA2.append(sum(w_payoffs_b2) / (sum(w_payoffs_a2)+sum(
    w_payoffs_a2.clear()
    w_payoffs_b2.clear()
    for k in range(len(rep_values_AB2)):
        sum_rep_AB2+=rep_values_AB2[k]
        sum_rep_BA2+=rep_values_BA2[k]
```

```
    trust_values_tit_tat_AB2.append(sum_rep_AB2/(k+1))
    trust_values_tit_tat_BA2.append(sum_rep_BA2/(k+1))
    sum_rep_AB2=0
    sum_rep_BA2=0


#print(trust_values_tit_tat_BA2)
print(trust_values_tit_tat_AB2)


# Plot Rep values and Trust values for tit-for-tat FOR AB
plt.plot(range(len(rep_values_AB2)), rep_values_AB2, label='Reputation_B'
plt.plot(range(len(trust_values_tit_tat_AB2)), trust_values_tit_tat_AB2,
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (One Cooperating)')
plt.legend()
plt.ylim(0, 1)  # Set y-axis limits
plt.show()

# Plot Rep values and Trust values for tit-for-tat FOR BA
plt.plot(range(len(rep_values_BA2)), rep_values_BA2, label='Reputation_A'
plt.plot(range(len(trust_values_tit_tat_BA2)), trust_values_tit_tat_BA2,
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (One Cooperating)')
plt.legend()
plt.ylim(0, 1)  # Set y-axis limits
plt.show()
```

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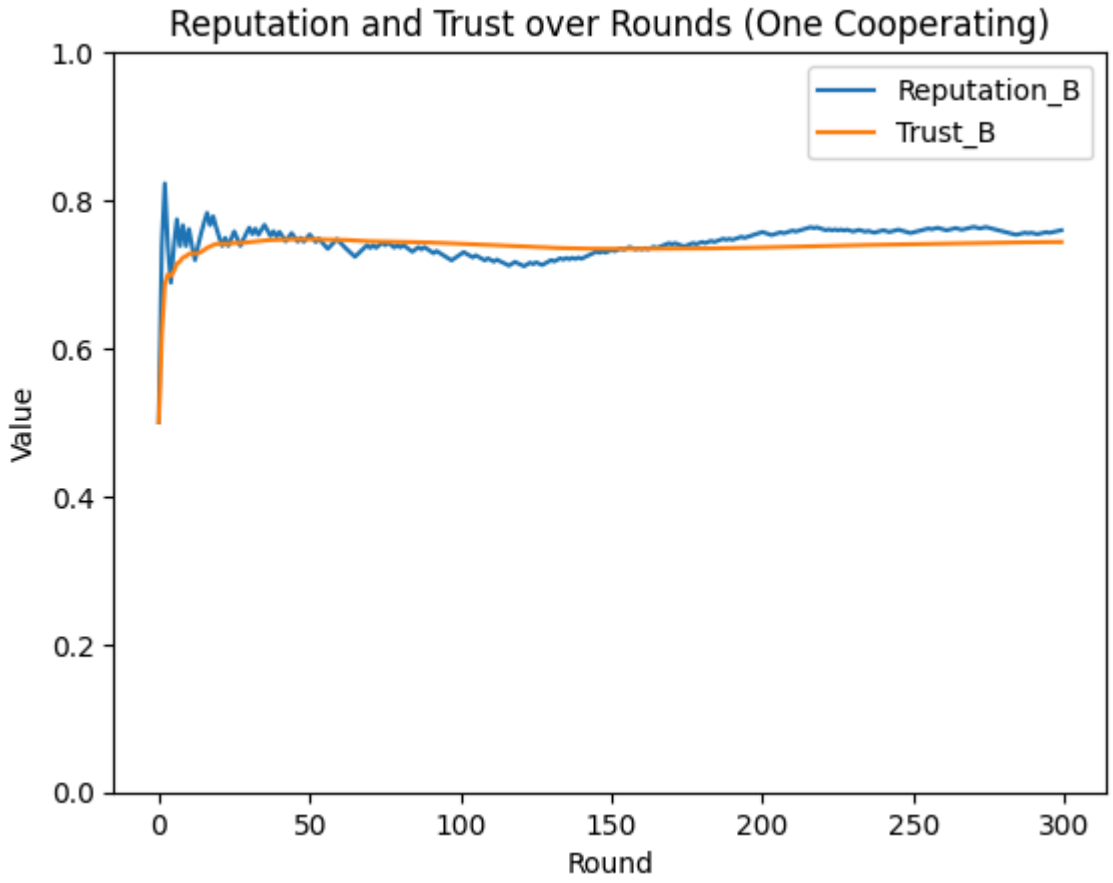
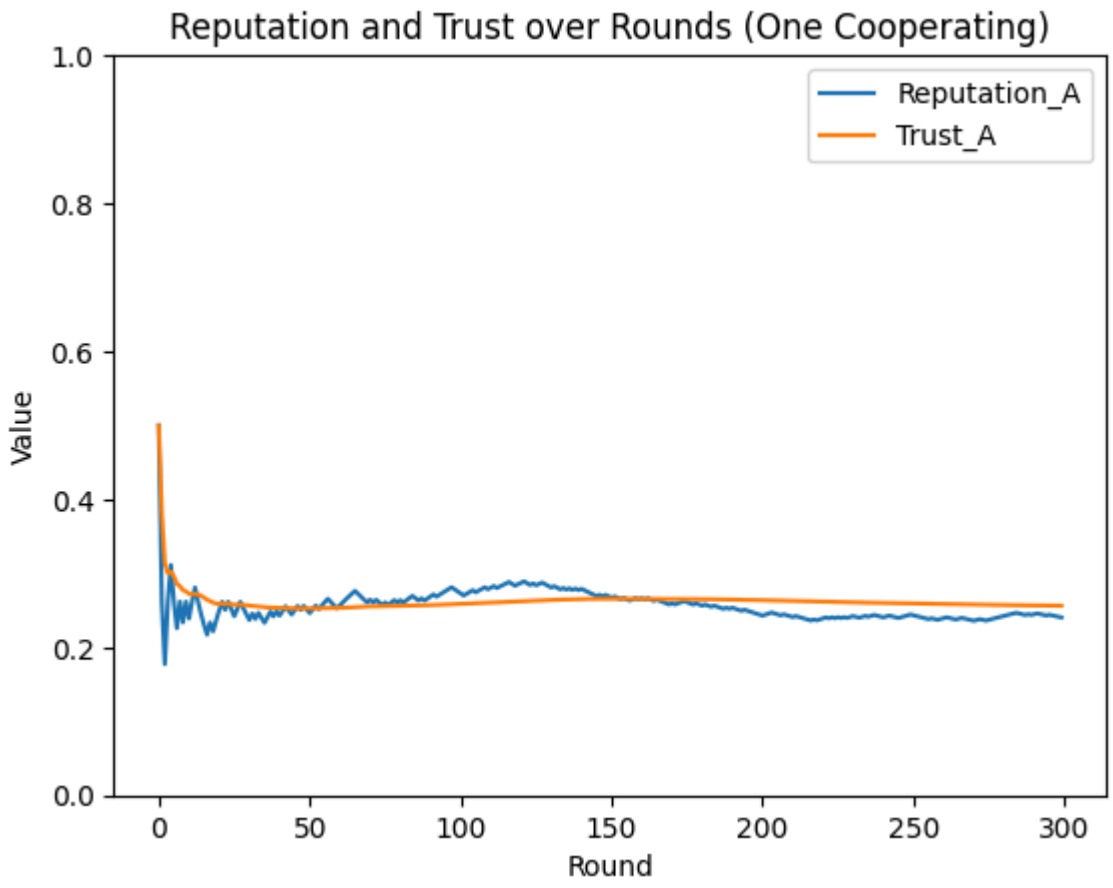




In [10]:

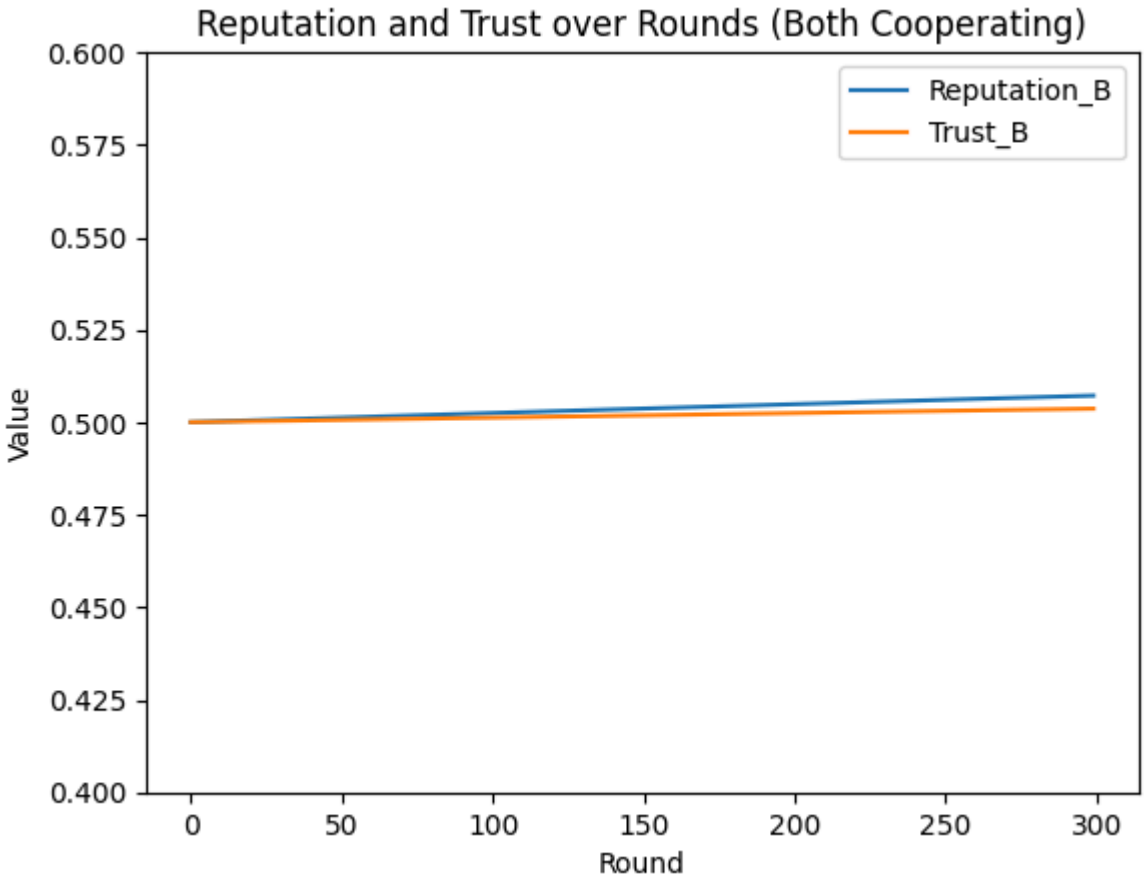
```
# For both ever co-operating
payoffs_a3= []
w_payoffs_a3 = []
payoffs_b3 = []
w_payoffs_b3 = []
sum_rep_AB3=0
sum_rep_BA3=0
#A has for B=AB
trust_values_tit_tat_AB3 = []
trust_values_tit_tat_BA3= []
rep_values_AB3=[]
rep_values_BA3=[]
for i in range(len(player_a3)):
    action_a3 = player_a3[i]
    action_b3 = player_b3[i]
    key = action_a3 + action_b3
    payoffs_a3.append(payoff_matrix[key][0])
    payoffs_b3.append(payoff_matrix[key][1])
    for j in range(len(payoffs_a3)):
        w_payoffs_a3.append( memory_strength_values_A[j]*payoffs_a3[len(p
        w_payoffs_b3.append( memory_strength_values_B[j]*payoffs_b3[len(p
    if (sum(w_payoffs_a3)+sum(w_payoffs_b3)) == 0:
        rep_values_AB3.append(0.4)  # Set trust value to a default value
        rep_values_BA3.append(0.4)
    else:
        rep_values_AB3.append(sum(w_payoffs_a3) / (sum(w_payoffs_a3)+sum(
        rep_values_BA3.append(sum(w_payoffs_b3) / (sum(w_payoffs_a3)+sum(
    w_payoffs_a3.clear()
    w_payoffs_b3.clear()
    for k in range(len(rep_values_AB3)):
        sum_rep_AB3+=rep_values_AB3[k]
        sum_rep_BA3+=rep_values_BA3[k]
```

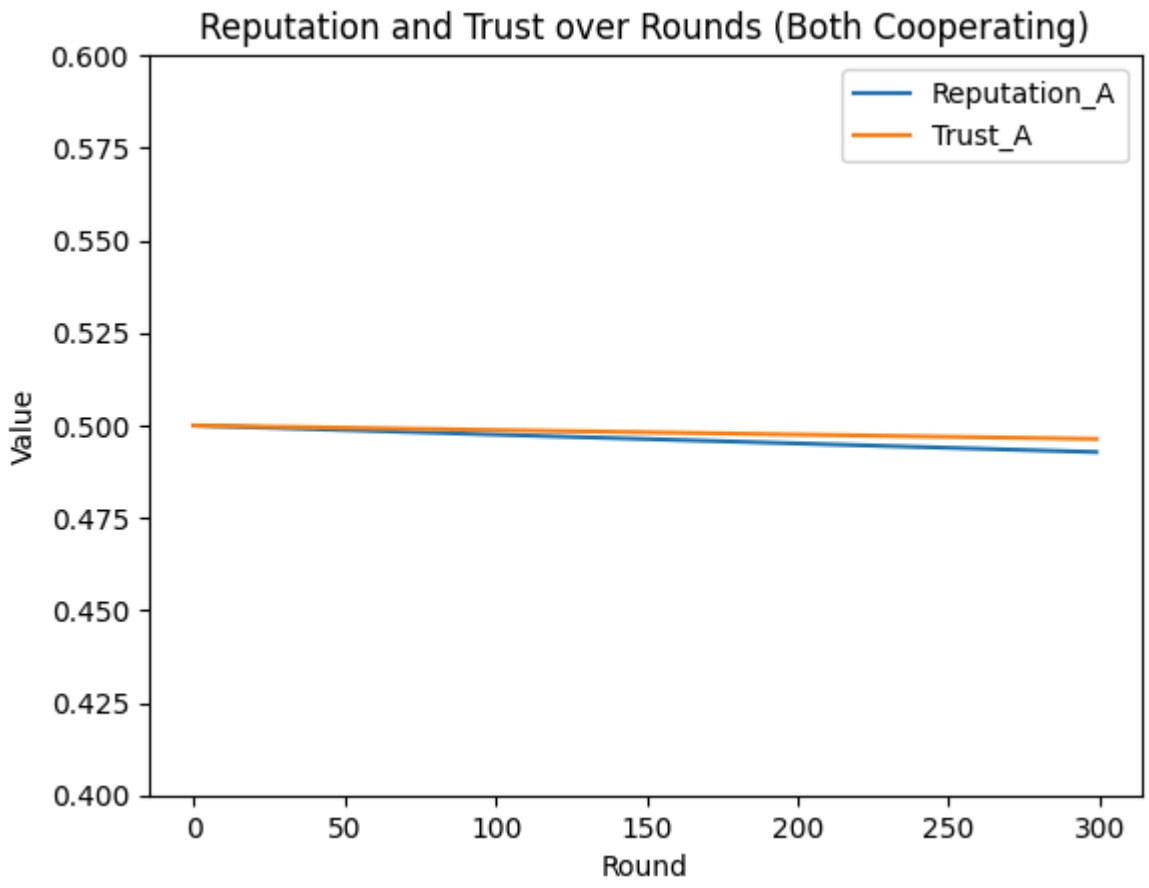
```
    trust_values_tit_tat_AB3.append(sum_rep_AB3/(k+1))
    trust_values_tit_tat_BA3.append(sum_rep_BA3/(k+1))
    sum_rep_AB3=0
    sum_rep_BA3=0


#print(rep_values_AB3)
#print(trust_values_tit_tat_AB3)


# Plot Rep values and Trust values for tit-for-tat FOR AB
plt.plot(range(len(rep_values_AB3)), rep_values_AB3, label='Reputation_B'
plt.plot(range(len(trust_values_tit_tat_AB3)), trust_values_tit_tat_AB3,
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (Both Cooperating)')
plt.legend()
plt.ylim(0.4, 0.6)  # Set y-axis limits
plt.show()

# Plot Rep values and Trust values for tit-for-tat FOR BA
plt.plot(range(len(rep_values_BA3)), rep_values_BA3, label='Reputation_A'
plt.plot(range(len(trust_values_tit_tat_BA3)), trust_values_tit_tat_BA3,
plt.xlabel('Round')
plt.ylabel('Value')
plt.title('Reputation and Trust over Rounds (Both Cooperating)')
plt.legend()
plt.ylim(0.4, 0.6)  # Set y-axis limits
plt.show()
```





In [8]:
```python
payoff_matrix = {
    "CC": (1, 1),  # Payoff for mutual cooperation
    "CD": (-10, 10),  # Payoff for A: Cooperation, B: Defection
    "DC": (10, -10),  # Payoff for A: Defection, B: Cooperation
    "DD": (-1, -1)   # Payoff for mutual defection
}

# Find the minimum payoff value
min_payoff = min(min(payoff) for payoff in payoff_matrix.values())

# Subtract the minimum payoff value from all payoffs to normalize
normalized_payoff_matrix = {
    key: tuple(payoff - min_payoff for payoff in value)
    for key, value in payoff_matrix.items()
}

print(normalized_payoff_matrix)
```

```
{'CC': (11, 11), 'CD': (0, 20), 'DC': (20, 0), 'DD': (9, 9)}
```

In [9]:
```python
import numpy as np

payoff_matrix = {
    "CC": (1, 1),  # Payoff for mutual cooperation
    "CD": (-10, 10),  # Payoff for A: Cooperation, B: Defection
    "DC": (10, -10),  # Payoff for A: Defection, B: Cooperation
    "DD": (-1, -1)   # Payoff for mutual defection
}

# Extract the payoffs
all_payoffs = [payoff for payoffs in payoff_matrix.values() for payoff in
```

```python
# Calculate mean and standard deviation
mean_payoff = np.mean(all_payoffs)
std_dev_payoff = np.std(all_payoffs)

# Standardize the payoffs
standardized_payoff_matrix = {
    key: tuple((payoff - mean_payoff) / std_dev_payoff for payoff in valu
    for key, value in payoff_matrix.items()
}

print(standardized_payoff_matrix)
```

```
{'CC': (0.14071950894605836, 0.14071950894605836), 'CD': (-1.4071950894605
838, 1.4071950894605838), 'DC': (1.4071950894605838, -1.4071950894605838),
'DD': (-0.14071950894605836, -0.14071950894605836)}
```