Inequality in the World State

- Description: For this test we wanted to look at how varying levels of inequality in the initial world affect outcomes now that we have the new features since the completion of part 1. We used the same measure of inequality, the mean log deviation(MLD) of each country's state quality. This is normalized so that an MLD of 0 represents completely equal state qualities and 1 represents only a single country having any resources at all. We ran tests over 10 rounds of the game on countries with high, limited, and no inequality.

- Test 1
    - Description: In this test case the MLD is 0, representing a completely equal initial world.
    - Parameters:
        - num_rounds = 10
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True
        - solution_limit = 1000
        - depth = 3
        - interventions_on = True
        - log_inequality = True
        - seed = 123456654321
        - initial_state_filename = "./input_files/no_inequality.xlsx"
        - initial_resource_filename = "./input_files/Resources.xlsx"
        - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
        - output_schedule_filename = "./output_files/ no_inequality.txt"
        - game_state_print = True
        - game_state_filename = "./game_output_files/ no_inequality.csv"
        - trade_selectivity_parameters = [0, 100, 1, 200]
    - Input:

Country	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	tradeSelectivity	warInclination
Atlantis	15000	600	2000	15000	20000	500	400	14000	13000	4000	2600	2000	1500	1	0.3
Brobdingnag	15000	600	2000	15000	20000	500	400	14000	13000	4000	2600	2000	1500	1	0.99
Carpania	15000	600	2000	15000	20000	500	400	14000	13000	4000	2600	2000	1500	1	0.99
Dinotopia	15000	600	2000	15000	20000	500	400	14000	13000	4000	2600	2000	1500	1	0.3
Erewhon	15000	600	2000	15000	20000	500	400	14000	13000	4000	2600	2000	1500	1	0.99
MyCountry	15000	600	2000	15000	20000	500	400	14000	13000	4000	2600	2000	1500	1	0.3

    - Output:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	11871.8	216	707	6948.75586	20000	500	38	3844.8	6223	4128	2600	2128	1500	-9199393
Brobdingnag	12834.38	8	2749	6948.75586	20000	664.18182	502.32558	5915	2825	4296	2600	2000	1500	-8983989
Carpania	11793.75	48	1580	11385	20000	134.36364	1152	9100	1044	4000	2600	2552	1500	-2169438
Dinotopia	12834.38	0	21.13	10209.375	20000	170.36364	1092.8372	5915	714.7	4128	2600	2344	1500	-3901234
Erewhon	12834.38	0	214.5	12375	20000	261.27273	334	5915	16567	4128	2600	2344	1500	-2674575
MyCountry	13875	0	1430	12375	20000	173.81818	1120.8372	9100	2119	4064	2600	2472	1500	-1202091

- Test 2
    - Description: In this test case the MLD is ~0.25, representing a world with limited resource inequality.
    - Parameters:
        - num_rounds = 10
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True
        - solution_limit = 1000
        - depth = 3
        - interventions_on = True
        - log_inequality = True
        - seed = 123456654321
        - initial_state_filename = "./input_files/low_inequality.xlsx"
        - initial_resource_filename = "./input_files/Resources.xlsx"
        - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
        - output_schedule_filename = "./output_files/ low_inequality.txt"
        - game_state_print = True
        - game_state_filename = "./game_output_files/ low_inequality.csv"
        - trade_selectivity_parameters = [0, 100, 1, 200]
    - Input:

Country	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	tradeSelectivity	warInclination
Atlantis	15000	1200	2800	6000	32500	1400	1000	9750	2000	5000	8000	4000	6000	1	0.3
Brobdingnag	15000	800	2500	5600	10000	1200	800	15000	3800	3000	6000	3000	2500	1	0.99
Carpania	15000	1800	2000	10000	12000	1200	2400	20000	2500	4000	5000	4500	4000	1	0.99
Dinotopia	15000	1700	3000	20000	25000	1200	2000	15000	3000	2000	1600	1400	1500	1	0.3
Erewhon	15000	2000	5000	25000	15000	3000	5000	15000	5000	2000	1600	1400	1500	1	0.99
MyCountry	15000	3000	8000	150000	30000	6000	7000	25000	6000	2000	1800	1600	1500	1	0.3

    - Output:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	7684.414	5.575493995	3287	1423.9	11332	16.389675	149.2193	1436.3	166	5192	8000	4424	6000	-7761265
Brobdingnag	10909.22	32	8508	2892.9	3550	1127.4545	929.8372	6337.5	1044	3000	6000	3768	2500	-2030894
Carpania	11204.06	813.6	455.5	5635.6	10800	1052.0364	1944.884	11700	898	4448	5000	4500	4000	-5397340
Dinotopia	8867.678	112.7363738	296.4	6316.8	9797	7.5090954	869.7792	4569.6	519	2256	1600	1792	1500	-24295489
Erewhon	13875	1232	0	14038	19300	3484	5098	9750	1373	2384	1600	1400	1500	-24079174
MyCountry	19624.97	3264.088132	5824	116107	69721	8264.6103	10920.28	36914	6114	2384	1800	1728	1500	-172171.5

- Test 3
    - Description: In this test case the MLD is ~0.5, representing a world with high resource inequality.
    - Parameters:
        - num_rounds = 10
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True
        - solution_limit = 1000
        - depth = 3
        - interventions_on = True
        - log_inequality = True
        - seed = 123456654321
        - initial_state_filename = "./input_files/high_inequality.xlsx"
        - initial_resource_filename = "./input_files/Resources.xlsx"
        - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
        - output_schedule_filename = "./output_files/ high_inequality.txt"
        - game_state_print = True
        - game_state_filename = "./game_output_files/ high_inequality.csv"
        - trade_selectivity_parameters = [0, 100, 1, 200]
    - Input:

Country	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	tradeSelectivity	warInclination
Atlantis	15000	1200	900	1500	3000	500	400	9750	1000	5000	8000	4000	6000	1	0.3
Brobdingnag	15000	800	2500	4200	4000	600	800	12000	3800	3000	6000	3000	2500	1	0.99
Carpania	15000	1800	2000	10000	8000	1200	2400	13000	2500	4000	5000	4500	4000	1	0.99
Dinotopia	15000	1700	3000	20000	10000	700	2000	15000	3000	2000	1600	1400	1500	1	0.3
Erewhon	15000	2000	5000	24000	15000	3000	5000	15000	5000	2000	1600	1400	1500	1	0.99
MyCountry	15000	2400	6000	27000	15000	4000	6000	18000	6000	2000	1800	1600	1500	1	0.3

    - Output:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	9223.411	209.226708	104.6	1461.5	2185	111.3829	332.6897	1797.2	330	5128	8000	4452	6000	-133013.3
Brobdingnag	15016.83	369.053292	10553	2490.5	5145	339.54801	1478.903	6275.9	819	3064	6000	3512	2500	1283661
Carpania	12311.94	871.2	2423	7692.5	8270	1265.9455	2711.651	8820.7	1708	4512	5000	4500	4000	-2410210
Dinotopia	7684.414	46.86033376	61.66	5753.2	3487	202.60886	154.6861	2209.7	384	2256	1600	1792	1500	-24577515
Erewhon	12834.38	1104	250.3	19800	15000	3458	5120	6337.5	3250	2448	1600	1400	1500	-9927009
MyCountry	19111.77	2103.659666	584.4	31027	20913	5186.5148	8158.07	16354	5125	2512	1800	1600	1500	6235108

- Results and analysis:

	Test 1		Test 2		Test 3	
Round	Inequality	# of wars	Inequality	# of wars	Inequality	# of wars
Start	0		0.251509		0.498422	

1	0.002323	0	0.294582	2	0.544651	2
2	0.004054	0	0.326407	2	0.436395	2
3	0.008479	0	0.400244	2	0.497292	1
4	0.008792	0	0.406111	2	0.491902	2
5	0.010472	0	0.436193	2	0.464207	1
6	0.004700	0	0.422146	2	0.454362	1
7	0.005740	0	0.422090	2	0.477241	2
8	0.016614	0	0.454691	2	0.513168	2
9	0.027315	0	0.463609	2	0.540466	2
10	0.038455	0	0.516405	3	0.560339	1

We see that when the countries are all equal, no one chooses to go to war as no one has an advantage so only disasters can introduce a degree of inequality. Inequality seems to rise exponentially, suggesting inequality causes greater inequality in our system. When the inequality starts higher, at 0.25, inequality grows much more quickly, then slows down, getting up to around 0.5. When the MLD starts high, at 0.5, inequality changes much less, hovering around 0.5. This suggests an equilibrium in equality. The way our simulation works and the strategies of our actors leads to unequal world states. This is realistic in that in the real world there has always been severe inequality between countries throughout history. The most wars occur in test 2, when inequality changed the most. Test 1 had little change to inequality and no wars. Test 3 was in between. We see that wars cause changes in the equality of the world.

Varying aggressiveness in regards to war
- Description: We wanted to observe the effect of countries having different inclinations towards going to war. We use a country resource called warAmbition for this. If this value is lower than the computed war_inclination between 2 countries, war is considered, otherwise it is not. This value is normalized such that 1 represents never going to war and 0 represents taking every war that is perceived as profitable. For each test case all that changes are the warAmbitions. The world state has high inequality to promote war and MyCountry is of average wealthto give it the most options.
- Test 1:
  - Description: All countries have a warAmbition of 1 so there are no wars.
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = False
    - use_dynamic_depth_limit = False
    - solution_limit = 100
    - depth = 4
    - interventions_on = True
    - log_inequality = True
    - seed = 123456654321
    - initial_state_filename = "./input_files/war_ambition1.xlsx"
    - initial_resource_filename = "./input_files/Resources.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/war_ambition1.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/war_ambition1.csv"
    - trade_selectivity_parameters = [0, 100, 1, 200]
  - Input:

Country	population	etalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	talAlloysWa	ousingWast	ctronicsWa	foodWaste	tradeSelectivity	warInclination
Atlantis	20000	1800	9500	10000	40000	1300	500	20000	18000	1000	1600	1400	1000	1	1
Brobdingnag	14000	1600	12500	25000	55000	700	900	12000	20000	2000	1000	1200	1200	1	1
Carpania	20000	1200	3500	10000	60000	900	500	18000	12000	1800	1400	1400	1200	1	1
Dinotopia	20000	2000	7000	35000	50000	500	500	20000	20000	1000	2000	1200	1200	0	1
Erewhon	10000	2000	6000	30000	55000	1500	1300	18000	18000	1000	1000	1800	1200	0	1
MyCountry	20000	1600	19000	20000	35000	700	1300	20000	14000	1000	1000	2000	1600	0	1

  - Output:

Name	population	metalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysW	housingWast	electronicsW	foodWaste	score
Atlantis	20000	1616	15750	20362.656	50000	1303.4545	802.51163	20000	2574.6528	1464	1600	1456	2000	-9865560.6
Brobdingnag	13300	1224	3450	33250	40000	1482.9091	1517.4884	15000	9569.4444	2056	1200	2064	2000	94893.477
Carpania	14000	824	12844	28500	56000	25.090909	1438	22000	16425.389	1864	1000	1848	1008	-2294851.2
Dinotopia	12635	984	6970	15000	50000	80.545455	1408	11250	21522.222	1064	1000	1288	1400	406678.66
Erewhon	14000	768	1850	20000	40000	1423.4545	1692	12000	22000	2120	1600	2192	1400	238432.76
MyCountry	16000	232	9844	15000	56000	220.54545	1702	14000	21096.222	2128	1600	2312	1208	871594.47

- Test 2:
  - Description: All countries have a warAmbition of 1 except MyCountry which has an ambition of 0.95, representing a strong reluctance to go to war.
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = False
    - use_dynamic_depth_limit = False
    - solution_limit = 100
    - depth = 4
    - interventions_on = True
    - log_inequality = True
    - seed = 123456654321
    - initial_state_filename = "./input_files/war_ambition2.xlsx"
    - initial_resource_filename = "./input_files/Resources.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/war_ambition2.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/war_ambition2.csv"
    - trade_selectivity_parameters = [0, 100, 1, 200]
  - Input:

Country	population	etalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	talAlloysW	ousingWast	ctronicsWa	foodWaste	tradeSelectivity	warInclination
Atlantis	12000	1800	5250	15000	40000	900	500	14000	22000	1600	1400	1200	1600	1	1
Brobdingnag	10000	2000	6000	30000	35000	900	1100	16000	16000	2000	1400	1600	2000	1	1
Carpania	16000	1600	14250	15000	55000	1100	900	18000	14000	1800	1600	1400	1200	1	1
Dinotopia	18000	2000	8750	25000	45000	1100	900	18000	12000	2000	1200	1800	1400	0	1
Erewhon	16000	1200	12250	35000	55000	700	900	16000	12000	1800	1000	1800	1200	0	1
MyCountry	16000	1800	19500	30000	45000	1500	700	22000	22000	1600	1800	1400	1200	0	0.95

  - Output:

Name	population	metalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysW	housingWast	electronicsW	foodWaste	score
Atlantis	16000	368	12830	30008.125	50000	1234.90909	979.162791	22000	11818.5764	2192	2000	2248	1000	363947.473
Brobdingnag	19000	688	18902	28500	45000	80	1474	15000	10416.6667	2064	1400	1784	1400	-2977408.6
Carpania	14000	632	5000	9500	35000	893.090909	548.837209	22000	11972.2222	1384	1600	1000	2000	-497355.26
Dinotopia	9025	600	17	10000	40000	1360	1390	11250	17611.1111	1720	1400	1160	1800	699309.515
Erewhon	16000	1216	8350	30000	55000	1268	1316	12000	16388.8889	2384	2000	1216	1800	821731.014
MyCountry	10000	904	2150	25000	55000	1372	1484	22000	13333.3333	2056	2000	1784	1600	1181768.05

- Test 3:
    - Description: All countries have a warAmbition of 1 except MyCountry which has an ambition of 0.9, representing a weak reluctance to go to war.
    - Parameters:
        - num_rounds = 7
        - frontier_size = 100
        - use_dynamic_solution_limit = False
        - use_dynamic_depth_limit = False
        - solution_limit = 100
        - depth = 4
        - interventions_on = True
        - log_inequality = True
        - seed = 123456654321
        - initial_state_filename = "./input_files/war_ambition3.xlsx"
        - initial_resource_filename = "./input_files/Resources.xlsx"
        - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
        - output_schedule_filename = "./output_files/war_ambition3.txt"
        - game_state_print = True
        - game_state_filename = "./game_output_files/war_ambition3.csv"
        - trade_selectivity_parameters = [0, 100, 1, 200]
    - Input:

Country	population	etalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	talAlloysWa	ousingWast	ctronicsWa	foodWaste	tradeSelectivity	warInclination
Atlantis	10000	1200	22750	35000	45000	1500	1100	14000	18000	1800	1400	1400	1000	1	1
Brobdingnag	18000	2000	8000	10000	35000	1500	500	14000	20000	1200	1200	2000	1000	1	1
Carpania	18000	1000	22750	35000	45000	1100	900	14000	20000	1000	1400	1400	1200	1	1
Dinotopia	10000	1200	4000	20000	40000	700	1300	14000	18000	1200	1000	1600	1200	0	1
Erewhon	14000	1600	28500	30000	40000	1500	1300	16000	16000	1400	1200	1600	1800	0	1
MyCountry	12000	1600	20000	25000	55000	1500	500	16000	14000	1200	1400	1200	1600	0	0.9

    - Output:

Name	population	metalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysW	housingWast	electronicsW	foodWaste	score
Atlantis	12000	1016	16409	16290.125	13600	1000	638	22000	10702.2135	1328	1600	1328	1800	-10107489
Brobdingnag	19000	1160	13410	23750	61500	1320	490	16500	18597.2222	1320	2000	2000	1800	-3576536.3
Carpania	12000	1232	22940	33250	17000	1402.36364	734.325581	18000	12244.4444	1128	1400	2512	1200	112101.827
Dinotopia	14440	1616	3432.64	25000	54400	1600	1618	9000	13683.1111	1128	1200	1728	1224	-760433.73
Erewhon	20000	304	8750	25000	66500	1061.63636	636.511628	12000	16000	2448	1400	1600	1600	376836.064
MyCountry	10000	704	2000	15000	45000	664	2107.16279	22000	14444.4444	1920	1600	1456	1400	-959260.21

- Test 4:
    - Description: All countries have a warAmbition of 1 except MyCountry which has an ambition of 0.5, representing having interest in war.
    - Parameters:
        - num_rounds = 7

- frontier_size = 100
- use_dynamic_solution_limit = False
- use_dynamic_depth_limit = False
- solution_limit = 100
- depth = 4
- interventions_on = True
- log_inequality = True
- seed = 123456654321
- initial_state_filename = "./input_files/war_ambition4.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/war_ambition4.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/war_ambition4.csv"
- trade_selectivity_parameters = [0, 100, 1, 200]

o Input:

Country	population	etalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	talAlloysWa	ousingWast	ctronicsWa	foodWaste	tradeSelectivity	warInclination
Atlantis	14000	1800	3000	15000	50000	1100	900	16000	16000	1600	2000	1000	1800	1	1
Brobdingnaj	18000	1400	5000	25000	35000	1300	500	20000	18000	2000	1400	2000	1600	1	1
Carpania	16000	1800	12000	15000	60000	900	1100	14000	18000	1000	1400	1200	1800	1	1
Dinotopia	20000	1000	16250	25000	45000	500	1300	18000	16000	1600	2000	1600	2000	0	1
Erewhon	20000	1400	8750	25000	55000	900	700	16000	22000	1400	1400	1200	1400	0	1
MyCountry	20000	1800	5000	10000	35000	1300	1100	12000	20000	1400	1200	1000	1000	0	0.5

o Output:

Name	population	metalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysW	housingWast	electronicsW	foodWaste	score
Atlantis	10000	616	23551	16290.125	47050	1015	617	12000	5062.5	2128	2000	1528	1600	-7801088.2
Brobdingnag	13300	360	25469	23750	4950	1325.8182	956.16279	13500	18958.333	2128	1400	1584	1000	-3823383.7
Carpania	20000	832	7000	19000	56500	910.18182	1718	16000	6875	1520	1000	2128	1600	-2186982.8
Dinotopia	15390	951.76	3611.5	35700	75050	2010.88	2444.1163	12300	26046.806	2120	1400	2000	1200	-2268813.8
Erewhon	20000	1000	9500	10000	40000	1376	1316	20000	3555.5556	1992	1600	2416	1400	2601201.6
MyCountry	9025	532.24	23628.5	24300	36450	102.12	1224.7209	16200	17175.417	1328	1200	2220	1800	-14454202

- Test 5:
  o Description: All countries have a warAmbition of 1 except MyCountry which has an ambition of 0, representing having no reservations towards war at all.
  o Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = False
    - use_dynamic_depth_limit = False

- solution_limit = 100
- depth = 4
- interventions_on = True
- log_inequality = True
- seed = 123456654321
- initial_state_filename = "./input_files/war_ambition5.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/war_ambition5.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/war_ambition5.csv"
- trade_selectivity_parameters = [0, 100, 1, 200]

○ Input:

Country	population	etalElemen	timber	landArea	water	metalAlloys	electronics	housing	food	talAlloysW	ousingWast	ctronicsWa	foodWaste	tradeSelectivity	warInclination
Atlantis	20000	1200	4000	20000	50000	1500	1300	14000	12000	1200	1800	1200	1600	1	1
Brobdingnag	20000	1800	13000	20000	35000	1300	900	14000	16000	1800	1800	1000	1200	1	1
Carpania	16000	1800	7000	35000	50000	1100	1100	14000	18000	1400	1000	1600	1000	1	1
Dinotopia	20000	2000	23750	25000	60000	900	1300	18000	22000	2000	1800	1600	1000	0	1
Erewhon	20000	1000	12250	35000	60000	500	1100	20000	22000	1200	1400	2000	1000	0	1
MyCountry	14000	1000	28500	30000	45000	700	500	12000	16000	1400	1600	1800	1200	0	0

○ Output:

Name	population	metalElemei	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysW	housingWast	electronicsW	foodWaste	score
Atlantis	14000	1216	26400	20362.6563	55000	320.545455	835.162791	18000	2564.0191	1000	1400	2184	1400	-9375538.5
Brobdingnag	24847.035	1258.60693	15218.4296	33859.531	63293.6705	1832.65874	3131.84033	24227.8608	19419.6895	1392	1000	1128	1832	1493958.74
Carpania	15200	1108.8	2707.5	21375	54000	246.4	1263	16200	6127.08333	2192	1400	2184	1600	-7689479.5
Dinotopia	16245	360	11104	30000	40000	1623.45455	328	12375	21166.6667	2256	1800	1528	1600	-589266.85
Erewhon	18000	304	12000	15000	45000	1648	348.837209	12000	20388.8889	1648	1600	1800	1600	812151.867
MyCountry	14726.7459	384.593069	1490.33957	6920.469	31706.3295	16.9412608	957.159668	10229.3442	278.011883	1864	1400	2240	1400	-7229490.9

- Results and Analysis:

Test case	1	2	3	4	5
Ambition	1	0.95	0.9	0.5	0
Quality change	871,594.473	1,181,768.05	-959,260.21	-14,454,202	-7,229,490.9

We can see that MyCountry performs best when it avoids war but is willing to attack if a really good opportunity comes along. Decreasing ambition(making MyCountry more aggressive) results in worse output schedules. This is because MyCountry is fighting too many wars. In the later test cases we can see that MyCountry's population decreases significantly during the simulation. A small amount of aggression is ideal in our world.

Trade Selectivity

- Description: we define the trade strategy in part 2, and it is about the willingness for countries to accept any proposed trades. These strategies influence the parameters that we pass into the participation probability function for countries in the trade successor function. These parameters include k and x_0 for trade selective countries and not selective countries. The change of these parameters can be done by changing the trade_selectivity_parameters parameter in Parameters.py. This parameter is a list containing 4 elements, which is [k for not selective countries, x_0 for not selective countries, k for selective countries, x_0 for selective countries]. We create different tests to see how changes in these things will influence countries' decisions.
- initial state:

Country	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	tradeSelectivity	warInclination
Atlantis	18000	1600	15000	30000	50000	1100	500	22000	18000	1400	1600	1400	1000	1	0.3
Brobdingnag	18000	1400	23750	25000	35000	1100	1100	14000	20000	1000	1200	1200	1200	0	0.99
Carpania	12000	1800	24000	30000	55000	900	1300	20000	22000	1000	1600	1600	2000	0	0.99
Dinotopia	18000	1400	16250	25000	50000	1300	500	22000	20000	1600	1600	1800	1000	1	0.3
Erewhon	20000	1000	50000	10000	40000	900	1500	20000	20000	1600	1800	1800	1200	1	0.99
MyCountry	18000	1600	17500	35000	40000	1100	900	20000	16000	1600	2000	1400	1600	0	0.3

- Test 1:
    - Description: this test is a control test which just uses the original standard parameters: k for not selective countries is 1, x_0 for not selective countries is 100, k for selective countries is 2, x_0 for selective countries is 200.
    - Parameters:
        - num_rounds = 7
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True
        - solution_limit = 1000
        - depth = 3
        - interventions_on = True
        - seed = 123456654321
        - trade_selectivity_parameters = [1, 100, 2, 200]

- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity original.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity original.csv"

- outputs:
  - End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	12570.07	484.5169	3239.571	11687.27	150014.3	133.3885	59.93457	10522.53	8259.701	1528	1600	1528	1000	-4.1E+07
Brobdingnag	13231.65	383.6183	14460.34	14024.14	2066.715	157.7128	488.3848	6200.145	6650.403	1064	1200	1712	1200	-2.9E+07
Carpania	30094.09	2952.741	54673.18	74235.87	35348.25	3332.019	3922.489	50658.67	41093.08	1256	1600	1856	2000	1528459
Dinotopia	11344.49	220.6189	1436.477	11957.42	23914.85	188.2391	345.4133	5918.924	8656.169	1792	1600	2056	1000	-3.1E+07
Erewhon	20000	104	4900	100000	50000	1448	1597.674	20000	16444.44	2048	1800	1800	1200	262663.5
MyCountry	14400	494.505	12627.33	23739.51	8655.86	820.6411	986.1041	14191.1	6149.254	1792	2000	1848	1600	-1.6E+07

  - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity original.txt"

- Test 2:
  - Description: this test changes the x_0 for selective countries to 400000 and remain other parameters as the original standard parameters: k for not selective countries is 1, x_0 for not selective countries is 100, k for selective countries is 2, x_0 for selective countries is 400000.
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - seed = 123456654321

- trade_selectivity_parameters = [1, 100, 2, 400000]
- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity x_0_s.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity x_0_s.csv"

  o outputs:
  - End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	12570.07133	458.1361368	5379.089567	12302.39414	23914.845	58.559692 8	98.793457 03	1052.531 8	8396.0921 8	1464	1600	1720	1000	-40075907.36
Brobdingnag	19942.75181	851.9041376	26260.582 84	30967.682 77	158626.934	153.8 179375	1629.3335 86	1522.3.323 12	19958.773 77	1000	1200	1840	1200	11796524.24
Carpania	25158.37097	2737.39732	42782.259 78	65065.180 53	5911.5	3253.5701 53	3931.7473 66	4560 4.857 5	3740 7.056 99	1256	1600	1856	2000	1498334.3 6
Dinotopia	12294.48938	241.4989368	3716.4766 29	12857.422 5	37414.845	409.6 7905 28	661.0 3191 43	7718.9241 38	7499.3133 28	1792	1600	2056	1000	-29392664.65
Erewhon	19000	80.8	4750	9000	25000	1079.2	1251.2558 14	18000	14969.444 44	1984	1800	1928	1200	-1908743.1 82
MyCountry	12570.07133	206.2634688	8223.0134 3	16740.391 5	19131.876	293.1 7316 42	403.8 3786 37	9565.938	1518.6108 59	1728	2000	1976	1600	-33838436.74

  - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity x_0_s.txt"

- Test 3:
  o Description: this test changes the x_0 for both not selective and selective countries and remain other parameters as the original standard parameters: k for not selective countries is 1, x_0 for not selective countries is 200000, k for selective countries is 2, x_0 for selective countries is 400000.
  o Parameters:
  - num_rounds = 7
  - frontier_size = 100
  - use_dynamic_solution_limit = True
  - use_dynamic_depth_limit = True

- solution_limit = 1000
- depth = 3
- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [1, 200000, 2, 400000]
- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity x_0.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity x_0.csv"

○ outputs:
- End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	13341.18	644.5313	10840.24	14738.7	29763.98	626.4635	266.3104	12808.84	3840.766	1592	1600	1400	1000	-3.7E+07
Brobdingnag	13928.06	455.3154	19665.29	15582.38	22963.5	4.943127	630.7031	6889.05	5738.637	1000	1200	1840	1200	-2.6E+07
Carpania	30415.89	3014.941	40245.62	76427.34	134225.8	3659.54	4617.35	52025.12	42674.53	1256	1600	1856	2000	1564457
Dinotopia	11344.49	278.2189	6943.291	11957.42	23914.85	57.16705	60.05347	5918.924	13225.64	1728	1600	2120	1000	-3E+07
Erewhon	20000	104	5000	10000	40000	1152.545	1600	20000	20000	2048	1800	1800	1200	557288.1
MyCountry	12570.07	254.9931	7434.464	16740.39	19131.88	115.3409	497.5825	9565.938	935.403	1664	2000	2056	1600	-3.4E+07

- To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity x_0.txt"

- Test 4:
  ○ Description: this test changes the x_0 for both not selective and selective countries and remain other parameters as the original standard parameters: k for not selective countries is 1, x_0 for not selective countries is 20000, k for selective countries is 2, x_0 for selective countries is 40000.
  ○ Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True

- solution_limit = 1000
- depth = 3
- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [1, 20000, 2, 40000]
- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity x_0_1.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity x_0_1.csv"

○ outputs:
   ▪ End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	13341.18	644.5313	9762.079	14738.7	29763.98	385.116	251.6034	12808.84	8299.361	1528	1600	1528	1000	-3.7E+07
Brobdingnag	13231.65	388.9327	14282.92	14024.14	20667.15	142.5855	486.0117	6200.145	6603.814	1064	1200	1712	1200	-2.9E+07
Carpania	31152.91	3106.006	53990.27	77899.01	1365 22.2	3638.256	4329.667	52997.52	42239.67	1320	1600	1728	2000	1564254
Dinotopia	11344.49	220.6189	2506.608	11957.42	23914.85	188.2391	354.51	5918.924	7419.304	1792	1600	2056	1000	-3.1E+07
Erewhon	20000	168	5000	10000	40000	1423.455	1589.674	20000	17611.11	1920	1800	1992	1200	462153.9
MyCountry	12570.07	287.9115	4823.21	16740.39	19131.88	94.3489	468.5332	9565.938	3462.442	1728	2000	1864	1600	-3.4E+07

   ▪ To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity x_0_1.txt"

- Test 5:
  ○ Description: this test changes the k for selective countries and remain other parameters as the original standard parameters: k for not selective countries is 1, x_0 for not selective countries is 100, k for selective countries is 100, x_0 for selective countries is 200.
  ○ Parameters:
    ▪ num_rounds = 7
    ▪ frontier_size = 100
    ▪ use_dynamic_solution_limit = True

- use_dynamic_depth_limit = True
- solution_limit = 1000
- depth = 3
- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [1, 100, 100, 200]
- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity k_s.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity k_s.csv"

○ outputs:
- End state and score for all countries:

Name	population	metalElements	timber	land Area	water	metal Alloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	food Waste	score
Atlantis	12570.07	419.563	3239.571	11687.27	150014.3	133.3885	59.93457	10522.53	8598.842	1528	1600	1528	1000	-4.1E+07
Brobdingnag	13231.65	442.0768	14534.08	14024.14	2066.715	157.7128	477.8379	6200.145	6137.923	1064	1200	1712	1200	-2.9E+07
Carpania	30094.09	2958.652	54583.44	74235.87	35348.25	3332.019	3931.058	50658.67	40882.67	1256	1600	1856	2000	1528471
Dinotopia	11344.49	220.6189	1436.477	11957.42	23914.85	188.2391	345.4133	5918.924	8656.169	1792	1600	2056	1000	-3.1E+07
Erewhon	20000	104	4900	10000	50000	1448	1597.674	20000	16444.44	2048	1800	1800	1200	262663.5
MyCountry	14400	495.0895	12622.91	23739.51	8655.86	820.6411	988.0816	14191.1	6127.397	1792	2000	1848	1600	-1.6E+07

- To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity k_s.txt"

- Test 6:
  ○ Description: this test changes the k for not selective countries and remain other parameters as the original standard parameters: k for not selective countries is 0.01, x_0 for not selective countries is 100, k for selective countries is 2, x_0 for selective countries is 200.
  ○ Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True

- use_dynamic_depth_limit = True
- solution_limit = 1000
- depth = 3
- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [0.01, 100, 2, 200]
- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity k_not_s.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity k_not_s.csv"

○ outputs:
  ▪ End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	12570.07	485.173	4648.828	11687.27	69998.35	209.7521	238.6836	10522.53	3908.099	1464	1600	1656	1000	-4.1E+07
Brobdingnag	18001.83	1055.271	17288.13	28962.96	13756.89	1401.749	1870.077	15378.46	20677.06	1128	1200	1520	1200	894173 2
Carpania	25133.3	2504.47	49946.28	61908.87	5107.87	2605.406	2831.65	42114.2	32775.88	1192	1600	1984	2000	149407 0
Dinotopia	12941.57	298.6182	4593.008	14286.03	41572.05	424.725	762.8753	8576.582	11590.67	1792	1600	2056	1000	-2.7E+07
Erewhon	19000	93.6	4750	9000	135000	922.0364	1236.628	18000	14969.44	2048	1800	1800	1200	-227 238 0
MyCountry	13828.73	314.8675	10046.01	19929.04	4564.845	52.33132	732.0853	11286.48	2701.72	1664	2000	2056	1600	-2.6E+07

  ▪ To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity k_not_s.txt"

- Test 7:
  ○ Description: this test changes the k for both selective and not selective countries and remain other parameters as the original standard parameters: k for not selective countries is 0.01, x_0 for not selective countries is 100, k for selective countries is 100, x_0 for selective countries is 200.
  ○ Parameters:

- num_rounds = 7
- frontier_size = 100
- use_dynamic_solution_limit = True
- use_dynamic_depth_limit = True
- solution_limit = 1000
- depth = 3
- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [0.01, 100, 100, 200]
- initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/trade_selectivity k_both.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/trade_selectivity k_both.csv"
  - outputs:
    - End state and score for all countries:

Name	population	metalElements	timber	land Area	water	metal Alloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	food Waste	score
Atlantis	12570.07	419.563	3239.571	11687.27	150014.3	133.3885	59.93457	10522.53	8598.842	1528	1600	1528	1000	-4.1E+07
Brobdingnag	13231.65	442.0768	13586.45	14024.14	2066.715	193.7855	492.3223	6200.145	6123.253	1064	1200	1712	1200	-2.9E+07
Carpania	30094.09	2958.652	53734.87	74235.87	35348.25	3401.776	3949.008	50658.67	40253.37	1256	1600	1856	2000	1528563
Dinotopia	11344.49	220.6189	1436.477	11957.42	23914.85	188.2391	344.9914	5918.924	8670.839	1792	1600	2056	1000	-3.1E+07
Erewhon	20000	104	4900	10000	50000	1348	1597.674	20000	17666.67	2048	1800	1800	1200	480216.8
MyCountry	14400	495.0895	14419.11	23739.51	8655.86	814.8113	956.0689	14191.1	5624.815	1792	2000	1848	1600	-1.6E+07

      - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity k_both.txt"

- Test 8:
  - Description: this test changes all parameters: k for not selective countries is 0.01, x_0 for not selective countries is 200000, k for selective countries is 2, x_0 for selective countries is 400000.

- Parameters:
  - num_rounds = 7
  - frontier_size = 100
  - use_dynamic_solution_limit = True
  - use_dynamic_depth_limit = True
  - solution_limit = 1000
  - depth = 3
  - interventions_on = True
  - seed = 123456654321
  - trade_selectivity_parameters = [0.01, 200000, 100, 400000]
  - initial_state_filename = "./input_files/countries_trading_strategy.xlsx"
  - initial_resource_filename = "./input_files/Resources.xlsx"
  - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
  - output_schedule_filename = "./output_files/trade_selectivity all.txt"
  - game_state_print = True
  - game_state_filename = "./game_output_files/trade_selectivity all.csv"
- outputs:
  - End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	13341.18	580.1679	10840.24	14738.7	29763.98	626.4635	166.3104	12808.84	6560.146	1592	1600	1400	1000	-3.7E+07
Brobdingnag	13928.06	514.3644	19665.29	15582.38	22963.5	4.943127	630.7031	6889.05	5190.531	1000	1200	1840	1200	-2.6E+07
Carpania	30415.89	3020.256	40245.62	76427.34	134225.8	3659.54	4642.35	52025.12	42124.23	1256	1600	1856	2000	1564485
Dinotopia	11344.49	278.2189	6943.291	11957.42	23914.85	57.16705	135.0535	5918.924	11195.09	1728	1600	2120	1000	-3E+07
Erewhon	20000	104	5000	10000	40000	1152.545	1600	20000	20000	2048	1800	1800	1200	557288.1
MyCountry	12570.07	254.9931	7434.464	16740.39	19131.88	115.3409	497.5825	9565.938	935.403	1664	2000	2056	1600	-3.4E+07

  - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/trade_selectivity all.txt"

- Results and Analysis:

First, if we compare the schedules generated for each test, we can find that the differences between searches in these 7 tests are not very big. All of them look similar in terms of the timing and frequencies for wars, transfer proposals, and transforms. The reason behind the fact that the differences are not big can just be because the way we do

calculation for probability. When the power of e, which is determined by the value of k and x_0, in the denominator of the function gets larger than 100, we would just set probability to be -1. This rules out a very large proportion of the TRANSFER operations, which decreases the possibility for variance in transfers in the final schedules.

Since the output schedules are too long, we do not include them in this summary. Because our trading strategy is defined to be only related to the probability of countries accepting trade proposals from other countries, we went through all the output schedule files and count the number of accepting trades for each country in the resulting schedule for every test. Below are summaries of data for the number of times that each country accepts trade proposals in the generate schedule:

	Atlantis	Brobdingnag	Carpania	Dinotopia	Erewhon	MyCountry
Test1	14	8	9	3	4	4
Test2	7	17	6	2	5	5
Test3	18	12	4	6	2	0
Test4	8	13	12	3	3	3
Test5	14	8	9	3	4	4
Test6	10	9	12	5	3	3
Test7	14	8	8	4	5	3
Test8	19	12	3	6	2	0

Below is the sketched plot with the data from the above table:

Change of Trade Acceptance Number
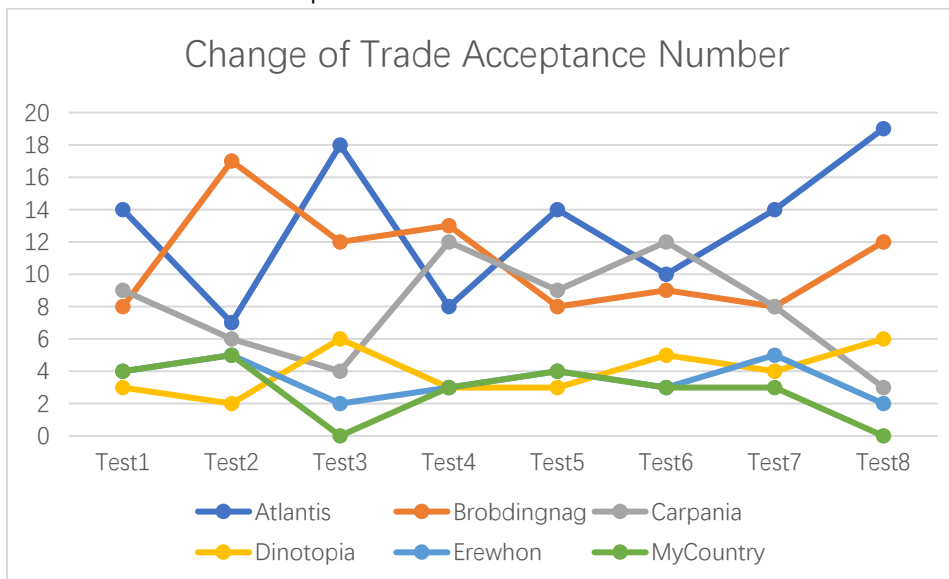
According to our definition of the start state for each country, Atlantis, Dinotopia, and Erewhon are the three countries that are selective in trading, which means not inclined to accept trades. For all of the Tests, we expect to see changes in countries that are selective in trading strategy, so we have more interest to look at them than other countries. Since Dinotopia and Erewhon are not very engaging in all tests, let's just focus on the changes for Atlantis. Test 1 uses the original standard parameters, which is used as the control test. We see that Atlantis shows decrease in the number of acceptance in Test 2 (only change

x_0 for selective countries to 400000), Test 4 (change x_0 for not selective countries to 20000 and selective countries to 40000), and Test 6 (only change k for not selective countries to 0.001). These results show to us that the changes in x_0 for both selective and not selective countries give the most influence on countries' willingness to accept trades. Decreasing k for not selective countries can also have some influence on the results, but not as big as changing x_0. This can be because of the way the power of e is calculated in the probability calculation function, which is -k*(discounted reward-x_0). We think that x_0 controls the difference in the parentheses, and this difference sets the base for the magnitude of the power. Also, discounted reward can be vastly different for different operators, so any changes to the x_0 will have influences on all the types of operators. Therefore, change in x_0 can impose more changes to countries' willingness to accept trades. For other cases, Atlantis's inclination for accepting trades either increases (Test 3 and test 8) or remains the same (Test 5 and Test 7). Test 3 and 8 both have the x_0 for not selective and selective countries to be 200000 and 400000. Since Test 2 shows decrease in acceptance for Atlantis, their increase may indicate that x_0 for not selective countries is set too high and makes countries become even more willing to accept trades than originally. Since Test 5 and Test 7 both have k for selective countries set to 100, we think that the results of remaining the same level of willingness of accepting trades for Atlantis may just be because the k for selective countries' original value (2) is already high enough, and any more increases in it cannot really change anything for the results.

Different Threshold
- Description: Like what we do for part 1 tests, we also want to see how the games is simulated when we change the thresholds to different values. For different tests in this, we give different resources' input files.
- initial state:

Country	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	tradeSelectivity	warInclination
Atlantis	110000	1900	19000	10000	50000	700	1400	13000	21000	1100	1200	1300	1500	1	0.3
Brobdingnag	110000	1900	19000	15000	3750	1100	500	12000	2000	1900	2000	1100	1500	0	0.99
Carpania	130000	2000	7000	30000	5250	700	700	20000	1900	1600	1500	1800	1300	0	0.99
Dinotopia	110000	1200	17000	35000	3750	900	1200	21000	1700	1100	1600	1700	1500	1	0.3
Erewhon	110000	2000	15000	20000	50000	1400	1300	20000	1800	1600	1500	2000	1600	1	0.99
MyCountry	130000	1800	13000	30000	40000	800	900	16000	1900	1700	1800	1800	1300	0	0.3

- Test 1:
    - Description: In this test, the input resources file contains the original thresholds for materials and wastes. Specifically, it is min + n for materials' 1st threshold, min + 4n for materials' 2nd threshold, and min + 5n for wastes' threshold.
    - Parameters:
        - num_rounds = 7
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True
        - solution_limit = 1000
        - depth = 3
        - interventions_on = True
        - seed = 123456654321
        - trade_selectivity_parameters = [1, 100, 2, 200]
        - initial_state_filename = "./input_files/ countries_threshold.xlsx"
        - initial_resource_filename = "./input_files/ Resources_Different_Threshold original.xlsx"
        - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"

- output_schedule_filename = "./output_files/change_threshold original.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/change_threshold original.csv"

○ outputs:
- End state and score for all countries:

Name	population	metalElements	timber	land Area	water	metal Alloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	food Waste	score
Atlantis	13268.41	114.2141	2841.349	5125.998	23914.85	244.3829	179.4563	9087.641	4797.637	1928	1800	1256	1300	-1.1E+07
Brobdingnag	271050.51	2368.368	40596.34	390740.46	129342.7	2928.931	3946.921	32044.84	39534.28	1520	1200	1700	1800	6033710
Carpania	170000	532	6400	23750.0	42500	1306.909	1612	12000	13541.67	1228	2000	2012	1500	-818485
Dinotopia	12604.99	15.30338	1881.045	4782.969	19131.88	165.1825	380.8066	4035.63	1453.411	2128	1200	2216	1100	-8314910
Erewhon	170000	804	18800	15000.0	50000	860.5455	1528	18000	20777.78	2084	1100	1128	1400	575459.3
MyCountry	6983.373	246.115	579.8207	10761.68	25110.59	214.0488	312.8159	9087.641	8299.711	1892	1900	2148	1400	-2.2E+07

- To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/change_threshold original.txt"

- Test 2:
  ○ Description: In this test, the input resources file contains the changed 1st thresholds for materials, the same 2nd threshold for materials and same threshold for wastes, compared with the original thresholds. Specifically, it is min + 2n for materials' 1st threshold, min + 4n for materials' 2nd threshold, and min + 5n for wastes' threshold.
  ○ Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]

- initial_state_filename = "./input_files/ countries_threshold.xlsx"
- initial_resource_filename = "./input_files/ Resources_Different_Threshold 1st.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/change_threshold 1st.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/change_threshold 1st.csv"
- outputs:
  - End state and score for all countries:

Name	popul ation	metalEl ements	timb er	land Area	wate r	metal Alloys	electr onics	hous ing	food	metalAllo ysWaste	housin gWaste	electroni csWaste	food Wast e	scor e
Atlanti s	1326 8.41	114.214 1	5637 .751	5125 .998	2391 4.85	52.35 658	266.6 943	9087 .641	3580 .702	1928	1800	1256	1300	- 9752 576
Brobdi ngnag	2710 0.51	2321.48	3830 4.12	3907 0.46	1293 42.7	3143. 33	4108. 953	3204 4.84	3781 1.24	1520	1200	1700	1800	6034 121
Carpa nia	1700 0	532	7450	2375 0	4250 0	1208	1535. 163	1200 0	1411 1.11	1292	2000	1884	1500	- 4120 87
Dinoto pia	1260 4.99	15.5349 3	87.5 6331	4782 .969	1913 1.88	150.7 094	333.7 646	4035 .63	4167 .502	2112	1200	2312	1100	- 7643 482
Erewh on	1700 0	804	1880 0	1500 0	5000 0	956	1428	1800 0	2200 0	2084	1100	1128	1400	4508 78.3
MyCo untry	6983. 373	292.771	821. 2572	1076 1.68	2511 0.59	161.6 037	319.4 253	9087 .641	7690 .704	1828	1900	2212	1400	- 1.8E +07

  - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/change_threshold 1st.txt"

- Test 3:
  - Description: In this test, the input resources file contains the changed 2nd thresholds for materials, the same 1st threshold for materials and same threshold for wastes, compared with the original thresholds. Specifically, it is min + n for materials' 1st threshold, min + 8n for materials' 2nd threshold, and min + 5n for wastes' threshold.
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3

- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [1, 100, 2, 200]
- initial_state_filename = "./input_files/ countries_threshold.xlsx"
- initial_resource_filename = "./input_files/ Resources_Different_Threshold 2nd.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/change_threshold 2nd.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/change_threshold 2nd.csv"

○ outputs:
  ▪ End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	13268.41	38.63138	3002.232	5125.998	34914.85	232.3343	239.6299	9087.641	2028.652	1864	1800	1512	1300	-1.2E+07
Brobdingnag	26376.28	2211.253	25739.03	37561.04	124257.1	3015.651	4492.789	30749.64	36015.63	1520	1200	1700	1800	30142254
Carpania	17000	532	15180	23750	10000	830.5455	1212	12000	19515.28	1228	2000	2012	1500	-1744020
Dinotopia	13324.91	212.0293	9240.564	6292.389	24217.47	15.87401	543.3457	5243.396	3278.986	2000	1200	2376	1100	-6303818
Erewhon	17000	804	16915	15000	71500	372	1864	18000	22000	1956	1100	1384	1400	-780530
MyCountry	6983.373	282.0868	409.8137	10761.68	25110.59	101.5951	376.2356	9087.641	5818.024	1828	1900	2244	1400	-2.9E+07

  ▪ To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/change_threshold 2nd.txt"

- Test 4:
  ○ Description: In this test, the input resources file contains the changed 1st and 2nd thresholds for materials and the same threshold for wastes, compared with the original thresholds. Specifically, it is min + 2n for materials' 1st threshold, min + 8n for materials' 2nd threshold, and min + 5n for wastes' threshold.
  ○ Parameters:
    ▪ num_rounds = 7
    ▪ frontier_size = 100
    ▪ use_dynamic_solution_limit = True

- use_dynamic_depth_limit = True
- solution_limit = 1000
- depth = 3
- interventions_on = True
- seed = 123456654321
- trade_selectivity_parameters = [1, 100, 2, 200]
- initial_state_filename = "./input_files/ countries_threshold.xlsx"
- initial_resource_filename = "./input_files/ Resources_Different_Threshold 1st + 2nd.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/change_threshold 1st + 2nd.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/change_threshold 1st + 2nd.csv"
  - outputs:
    - End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	13268.41	38.63138	6839.217	5125.998	31131.95	93.63099	136.3252	9087.641	2687.308	1928	1800	1384	1300	-1E+07
Brobdingnag	26376.28	2178.837	37607.79	37561.04	137987.1	3020.273	3879.698	30749.64	37667.02	1520	1200	1700	1800	3014 1611
Carpania	17000	532	12850	23750	10000	1026	1422	12000	14708.33	1228	2000	2012	1500	-2243 678
Dinotopia	13324.91	154.4293	4735.829	6292.389	35770.41	113.1511	694.5897	5243.396	1267.048	2000	1200	2440	1100	-6111 754
Erewhon	17000	804	8100	15000	50000	564	2156	18000	22000	2020	1100	1256	1400	-2460 699
MyCountry	6983.373	212.1028	239.0729	10761.68	25110.59	166.9449	215.387	9087.641	11369.06	1892	1900	2212	1400	-2.6E +07

    - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/change_threshold 1st + 2nd.txt"

- Test 5:
  - Description: In this test, the input resources file contains the same 1st and 2nd thresholds for materials and the changed threshold for wastes, compared with the original thresholds. Specifically, it is min + n for materials' 1st threshold, min + 4n for materials' 2nd threshold, and min + 7.5n for wastes' threshold.

- o Parameters:
  - num_rounds = 7
  - frontier_size = 100
  - use_dynamic_solution_limit = True
  - use_dynamic_depth_limit = True
  - solution_limit = 1000
  - depth = 3
  - interventions_on = True
  - seed = 123456654321
  - trade_selectivity_parameters = [1, 100, 2, 200]
  - initial_state_filename = "./input_files/ countries_threshold.xlsx"
  - initial_resource_filename = "./input_files/ Resources_Different_Threshold waste.xlsx"
  - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
  - output_schedule_filename = "./output_files/change_threshold waste.txt"
  - game_state_print = True
  - game_state_filename = "./game_output_files/change_threshold waste.csv"
- o outputs:
  - End state and score for all countries:

Name	population	metalElements	timber	land Area	water	metal Alloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	food Waste	score
Atlantis	13268.41	114.2141	2841.349	5125.998	23914.85	244.3829	179.4563	9087.641	4797.637	1928	1800	1256	1300	-1.1E+07
Brobdingnag	27100.51	2368.368	40596.34	39070.46	129342.7	2928.931	3946.921	32044.84	39534.28	1520	1200	1700	1800	6033710
Carpania	17000	532	6400	23750	42500	1306.909	1612	12000	13541.67	1228	2000	2012	1500	-818485
Dinotopia	12604.99	15.30338	1881.045	4782.969	19131.88	165.1825	380.8066	4035.63	1453.411	2128	1200	2216	1100	-8314910
Erewhon	17000	804	18800	15000	50000	860.5455	1528	18000	20777.78	2084	1100	1128	1400	575459.3
MyCountry	6983.373	246.115	579.8207	10761.68	25110.59	214.0488	312.8159	9087.641	8299.711	1892	1900	2148	1400	-2.2E+07

  - To check all the performed operations and expected utility for each operation in the schedule, please see "./output_files/change_threshold waste.txt"

- Test 6:

- o Description: In this test, the input resources file contains the changed 1st and 2nd thresholds for materials and the changed threshold for wastes, compared with the original thresholds. Specifically, it is min + 2n for materials' 1st threshold, min + 8n for materials' 2nd threshold, and min + 7.5n for wastes' threshold.
- o Parameters:
  - num_rounds = 7
  - frontier_size = 100
  - use_dynamic_solution_limit = True
  - use_dynamic_depth_limit = True
  - solution_limit = 1000
  - depth = 3
  - interventions_on = True
  - seed = 123456654321
  - trade_selectivity_parameters = [1, 100, 2, 200]
  - initial_state_filename = "./input_files/ countries_threshold.xlsx"
  - initial_resource_filename = "./input_files/ Resources_Different_Threshold 1st+2nd+waste.xlsx"
  - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
  - output_schedule_filename = "./output_files/change_threshold 1st+2nd+waste.txt"
  - game_state_print = True
  - game_state_filename = "./game_output_files/change_threshold 1st+2nd+waste.csv"
- o outputs:
  - End state and score for all countries:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	13268.41	38.63138	6839.217	5125.998	31131.95	93.63099	136.3252	9087.641	2687.308	1928	1800	1384	1300	-1E+07
Brobdingnag	26376.28	2178.837	37607.79	37561.04	137987.1	3020.273	3879.698	30749.64	37667.02	1520	1200	1700	1800	3014 1611
Carpania	170000	532	12850	23750	10000	1026	1422	12000	14708.33	1228	2000	2012	1500	-2243678
Dinotopia	13324.91	154.4293	4735.829	6292.389	35770.41	113.1511	694.5897	5243.396	1267.048	2000	1200	2440	1100	-6111754
Erewhon	170000	804	8100	15000	50000	564	2156	18000	22000	2020	1100	1256	1400	-2460699
MyCountry	6983.373	212.1028	239.0729	10761.68	25110.59	166.9449	215.387	9087.641	11369.06	1892	1900	2212	1400	-2.6E+07

- Results and Analysis:

Below is the number of transforms, number of trades, and number of wars count from the output schedules of all 6 tests.

	transform	trade	war
test1	102	42	41
test2	105	42	41
test3	114	42	43
test4	106	42	41
test5	102	42	43
test6	106	42	43

Number of Operators
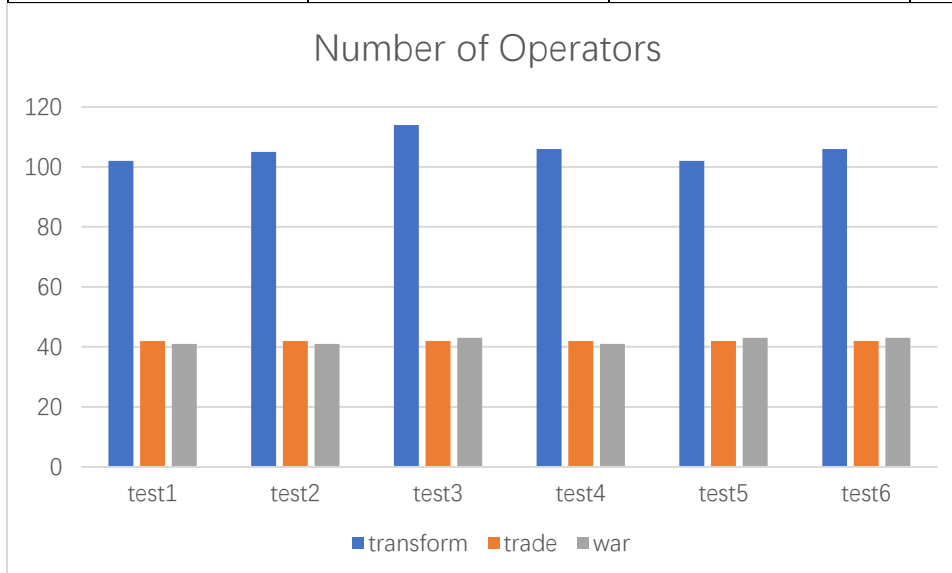
Unlike the results we gain from the threshold tests in part 1, these tests for part 2 seem to show more differences between tests. We find that the schedules get changed when we change 1st threshold for materials, 2nd threshold for materials, or change both 1st and 2nd thresholds. The change to schedules as the result of 2nd threshold also happened in part 1 tests and can be understood in the same way. A lot of countries have resources with amount between min + 4n and min + 8n, so when the 2nd threshold is increased to min + 8n, these resources will suddenly be in the range of 1st threshold and 2nd threshold. Then these countries will change their strategies, and when some countries make decisions different from what they make in test 1 in the same world state, the subsequent decisions can also be different from test 1 as a result of chain reactions. The reason behind the change of schedules after changing 1st threshold can be similar to this. In part 1, we only consider MyCountry, which does not have any resources below min + 2n, which is the

changed value of 1st threshold. So when we increase 1st threshold from min + n to min + 2n, nothing really changes. But now, the game manager needs all countries to involve, and there are some countries with resources below min + 2n but above min + n. These countries' decisions will be influenced as we increase 1st threshold for materials because some of their resources that were above the survival threshold can suddenly get below the survival threshold. The only thing that never changes is when we change the threshold for wastes because we do not see any difference between test 5 (only changes threshold for wastes) and test 1. This can be because of the same reasons as what we conclude in part 1's tests. So based on our definition, the amount and weights for wastes in all countries are not significant, so wastes cannot play any important roles in any types of operations we define right now. So any changes to their thresholds will not influence countries' decisions.

Interventions Tests Summary

- Description: To test the nature of interventions as implemented in our project, we wanted to analyze the impact interventions have on the evolution of the game. We developed a testing strategy to test the impact of interventions on the game (compared to no interventions), the variance introduced by interventions, and finally, the different impacts when altering the intervention settings. This strategy fixes the resource file and country file and varies the interventions file. The "MLD 0.5 ARQ 2" input case from part was chosen as the country file due to the variance in resource distributions used for that test case. The "Resources" input case, a file defined specifically for part 2, was chosen to represent the resources. Finally, we used 5 different files to represent different input scenarios. These are summarized in the table below.
  - Name of Case/File   Notes

Name of Case/File	Notes
Interventions Off – No File	"Base Case" for comparison
Case 0	Case 0 of Interventions
Case 1	Case 0 + Added new intervention w/ fixed prob
Case 2	Case 0 + Increased prob. chances
Case 3	Case 2 + Increased Impacts

A summary of the test cases that were run for interventions is included below.

- No Interventions Case:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = False
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/MLD0.5_ARQ2.xlsx"
    - initial_resource_filename = "./input_files/Resources.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/interventions_no.txt"

- game_state_print = True
- game_state_filename = "./game_output_files/interventions_no.csv"
    - o End State:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	10,475.06	30.55	424.25	717.45	1,434.89	32.27	194.12	4,663.39	320.58	5,160.00	8,000.00	4,512.00	6,000.00	(942,577.24)
Brobdingnag	16,131.65	190.28	17,198.65	4,368.29	21,536.58	7.70	937.60	13,093.88	1,534.24	3,064.00	6,000.00	3,496.00	2,500.00	3,156,835.98
Carpania	16,253.91	973.78	1,430.23	10,207.77	8,415.53	1,720.18	2,592.32	14,350.47	2,670.42	4,448.00	5,000.00	4,500.00	4,000.00	412,382.32
Dinotopia	10,475.06	258.76	253.06	9,565.94	4,782.97	156.39	390.73	7,174.45	961.73	2,256.00	1,600.00	1,720.00	1,500.00	(20,262,319.42)
Erewhon	15,000.00	1,104.00	33.50	24,000.00	15,000.00	3,448.00	5,231.00	15,000.00	5,000.00	2,448.00	1,600.00	1,400.00	1,500.00	(495,938.54)
MyCountry	21,664.32	2,366.63	60.30	37,840.56	3,830.03	5,131.46	8,582.24	28,467.80	10,813.03	2,448.00	1,800.00	1,600.00	1,500.00	6,170,944.38

- Case 0:
    - o Parameters:
        - num_rounds = 7
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True
        - solution_limit = 1000
        - depth = 3
        - interventions_on = True
        - log_inequality = False
        - seed = 123456654321
        - trade_selectivity_parameters = [1, 100, 2, 200]
        - initial_state_filename = "./input_files/MLD0.5_ARQ2.xlsx"
        - initial_resource_filename = "./input_files/Resources.xlsx"
        - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
        - output_schedule_filename = "./output_files/interventions_c0.txt"
        - game_state_print = True
        - game_state_filename = "./game_output_files/interventions_c0.csv"
    - o End State:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	10,475.06	141.85	230.22	647.49	1,434.89	342.12	68.31	4,663.39	180.32	5,000.00	8,000.00	4,640.00	6,000.00	(1,040,330.06)
Brobdingnag	15,352.64	383.50	11,835.37	4,141.88	4,336.58	4.23	1,023.24	9,949.95	530.37	3,000.00	6,000.00	3,464.00	2,500.00	2,178,906.17
Carpania	16,253.91	1,136.46	2,075.23	9,683.07	8,415.53	1,043.29	2,849.48	14,350.47	1,959.85	4,384.00	5,000.00	4,500.00	4,000.00	(690,763.18)
Dinotopia	9,453.74	258.76	1,340.81	9,565.94	4,782.97	107.15	380.02	4,035.63	961.73	2,256.00	1,600.00	1,720.00	1,500.00	(20,155,089.77)
Erewhon	15,000.00	1,104.00	55.00	24,000.00	15,000.00	3,448.00	5,230.00	15,000.00	5,000.00	2,448.00	1,600.00	1,400.00	1,500.00	(493,789.63)
MyCountry	21,362.25	2,379.43	141.01	37,834.49	21,030.03	5,167.22	8,472.94	26,181.31	10,785.94	2,448.00	1,800.00	1,600.00	1,500.00	6,196,133.61

- Case 1:
    - o Parameters:
        - num_rounds = 7
        - frontier_size = 100
        - use_dynamic_solution_limit = True
        - use_dynamic_depth_limit = True

- solution_limit = 1000
- depth = 3
- interventions_on = True
- log_inequality = False
- seed = 123456654321
- trade_selectivity_parameters = [1, 100, 2, 200]
- initial_state_filename = "./input_files/MLD0.5_ARQ2.xlsx"
- initial_resource_filename = "./input_files/Resources.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case1.xlsx"
- output_schedule_filename = "./output_files/interventions_c1.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/interventions_c1.csv"
  - End State:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	10,475.06	86.43	286.21	797.16	1,594.32	87.86	229.16	3,886.16	377.15	5,128.00	8,000.00	4,512.00	6,000.00	(864,316.85)
Brobdingnag	15,352.64	480.72	11,991.30	4,386.99	2,223.98	0.01	1,002.40	9,791.63	1,555.97	3,000.00	6,000.00	3,368.00	2,500.00	2,391,948.31
Carpania	15,643.03	947.46	1,178.58	10,109.35	8,218.70	1,821.87	2,453.31	13,710.78	2,592.12	4,448.00	5,000.00	4,500.00	4,000.00	275,666.41
Dinotopia	9,951.31	258.76	1,112.31	9,565.94	4,782.97	81.13	404.72	5,380.84	961.73	2,256.00	1,600.00	1,720.00	1,500.00	(20,177,768.36)
Erewhon	14,250.00	1,616.00	22.50	20,577.00	15,000.00	3,192.00	5,131.00	11,250.00	3,901.04	2,192.00	1,600.00	1,400.00	1,500.00	(8,200,093.35)
MyCountry	21,475.57	1,980.96	843.29	35,948.53	23,180.03	3,564.17	7,035.82	24,423.11	6,318.11	2,256.00	1,800.00	1,600.00	1,500.00	6,265,464.71

- Case 2:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/MLD0.5_ARQ2.xlsx"
    - initial_resource_filename = "./input_files/Resources.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case2.xlsx"
    - output_schedule_filename = "./output_files/interventions_c2.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/interventions_c2.csv"
  - End State:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	11,026.38	310.01	4,994.91	934.94	1,968.30	203.70	106.88	3,598.30	391.50	5,064.00	8,000.00	4,384.00	6,000.00	(239,022.40)
Brobdingnag	14,061.25	381.11	6,075.52	3,894.38	4,218.70	7.47	1,084.28	6,974.89	2,206.59	3,000.00	6,000.00	3,496.00	2,500.00	1,227,718.22
Carpania	13,953.52	1,468.88	1,438.35	9,256.49	8,513.00	1,524.28	2,604.66	10,687.83	2,051.91	4,256.00	5,000.00	4,500.00	4,000.00	(660,634.25)
Dinotopia	9,453.74	447.31	194.27	9,087.64	4,782.97	52.47	400.06	4,035.63	548.70	2,128.00	1,600.00	1,696.00	1,500.00	(20,808,849.86)
Erewhon	13,537.50	1,488.00	233.00	22,800.00	15,000.00	3,256.00	5,210.00	8,437.50	3,750.00	2,256.00	1,600.00	1,400.00	1,500.00	(3,177,970.00)
MyCountry	20,154.67	2,452.69	1,786.23	35,410.82	20,517.03	4,868.07	8,370.12	25,986.60	6,085.26	2,384.00	1,800.00	1,600.00	1,500.00	6,358,862.91

- Case 3:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/MLD0.5_ARQ2.xlsx"
    - initial_resource_filename = "./input_files/Resources.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case3.xlsx"
    - output_schedule_filename = "./output_files/interventions_c3.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/interventions_c3.csv"
  - End State:

Name	population	metalElements	timber	landArea	water	metalAlloys	electronics	housing	food	metalAlloysWaste	housingWaste	electronicsWaste	foodWaste	score
Atlantis	11,048.48	528.53	393.31	1,804.28	2,697.30	30.04	581.45	3,413.50	456.06	5,000.00	8,000.00	4,452.00	6,000.00	284,037.14
Brobdingnag	13,939.61	433.75	10,320.91	3,281.85	4,632.70	244.99	1,192.14	5,627.33	1,780.67	3,064.00	6,000.00	3,384.00	2,500.00	1,639,278.47
Carpania	12,311.94	1,255.20	1,103.06	7,692.47	8,270.00	1,469.85	2,570.49	8,820.74	1,707.88	4,320.00	5,000.00	4,500.00	4,000.00	(2,456,399.20)
Dinotopia	8,962.72	492.53	71.91	7,891.90	4,782.97	51.72	417.83	3,031.21	625.13	2,064.00	1,600.00	1,792.00	1,500.00	(22,166,410.25)
Erewhon	12,834.38	1,488.00	360.25	19,800.00	15,000.00	3,256.00	5,120.00	6,337.50	3,250.00	2,256.00	1,600.00	1,400.00	1,500.00	(9,916,193.10)
MyCountry	19,383.07	2,297.99	2,158.07	28,888.02	19,617.03	4,807.40	7,946.09	24,338.93	4,883.47	2,384.00	1,800.00	1,600.00	1,500.00	3,873,433.33

- Results and Analysis

The experiment involved analyzing each case of the intervention inputs to determine a mean impact of interventions relative to the base case. The findings are included below.

Case	Δ Quality - Atlantis	Δ Quality - Brobdingnag	Δ Quality - Carpania	Δ Quality - Dinotopia	Δ Quality - Erewhon	Δ Quality - MyCountry
no	(942,577)	3,156,836	412,382	(20,262,319)	(495,939)	6,170,944
c0	(1,040,330)	2,178,906	(690,763)	(20,155,090)	(493,790)	6,196,134
c1	(864,317)	2,391,948	275,666	(20,177,768)	(8,200,093)	6,265,465

c2	(239,022)	1,227,718	(660,634)	(20,808,850)	(3,177,970)	6,358,863
c3	284,037	1,639,278	(2,456,399)	(22,166,410)	(9,916,193)	3,873,433
Mean Interventions	(464,908)	1,859,463	(883,033)	(20,827,030)	(5,447,012)	5,673,474
Std Dev Interventions	606,240	526,994	1,140,832	942,924	4,367,913	1,201,878
CI Lower	(1,394,399)	1,051,473	(2,632,164)	(22,272,726)	(12,143,924)	3,830,747
CI Higher	464,583	2,667,453	866,099	(19,381,333)	1,249,901	7,516,200

The findings show that the interventions generally impact the game evolution by lowering the change in state quality change after 7 rounds and introducing variance. This is in-line with our original goal for adding interventions. Only in Case 3, which involved numerous high-probability, high-impact events did we notice a substantial drop in quality from beginning to end of game for most of the countries. This confirms that our implementation is flexible enough to alter the game either gently or substantially depending on the input parameters for interventions.

The second part of the experiment involves generating confidence intervals from the data used in experiment 1. Using a t-distribution and alpha of 0.1 (two-tailed), we determined the 80% confidence interval for the intervention impact for each country. Country B was the only country to show a statistically significant reduction in game outcome because of interventions. However, using our domain knowledge and the fact Case 3 had a substantially higher impact than the other cases, we believe our interventions implementation is producing meaningful results in the intended manner (reducing quality only slightly while increasing variance).

Resource Weight Scaling:
Similar to some the scaling we did in part one, we increase the resource weights in the resource dictionary.   We tested a 50% and 75% upscale on raw materials, produced materials and waste to watch how the preferences shift from transfers to transforms and to war. Some expectations we had in part 1. These weight changes were also applied to war weights which decided the war power or deterrence score and the warfare quality score. The scaling of the war weights was on the premise that countries will show more inclination to war since their deterrence score compare to others might increase as we scaled the war weights

- raw-mat 0.5:
  - o Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources – raw 0.5.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/raw -mat 0.5.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/raw -mat 0.5csv"
  - o End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingWa	electronics	foodWaste	score
Atlantis	21897.84	1407.096	12326.46	24545.38	81920.39	2132.281	4051.24	24619.11	21648.86	2128	1600	1200	1832	33020679
Brobdingna	13032.1	701.496	8569.635	17313.75	40824	7.226182	790.875	9841.5	7196.058	1800	2000	2416	2008	-3E+07
Carpania	18000	632	14250	14250	45000	1479.455	200	12000	18902.78	1584	1800	1400	1400	62363.36
Dinotopia	14728.17	162.3173	2658.624	8461.978	36718.84	796.3047	958.8748	8187.596	4004.366	1256	1400	1584	1600	-3582241
Erewhon	18000	1232	6500	10000	50000	1400	1456	12000	8388.889	1656	1400	1456	1200	891665.3
MyCountr	11731.54	425.0907	8430.609	14586.93	40536.77	8.733901	1007.01	9845.437	3615.048	1064	1600	1608	1800	-2.1E+07

- raw-mat 0.75:
  - o Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"

- initial_resource_filename = "./input_files/Resources – raw 0.75.xlsx"
- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/raw -mat 0.75.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/raw -mat 0.75csv"
  - End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingW;	electronic;	foodWast	score
Atlantis	22759.26	1588.134	13871	25426.12	70555.89	2258.623	4304.865	25731.63	22785.01	2128	1600	1200	1864	42529096
Brobdingn;	13032.1	701.496	8569.635	17313.75	40824	202.6807	690.875	9841.5	7196.058	1800	2000	2416	2008	-3.4E+07
Carpania	18000	632	14250	14250	45000	1479.455	100	12000	21291.67	1584	1800	1400	1400	47631.46
Dinotopia	14766.75	258.0788	3027.585	8531.233	37083.34	798.7623	962.2498	8275.076	5130.192	1192	1400	1584	1600	-3818348
Erewhon	17100	955.2	4132.5	9000	45000	1075.745	1399	10800	3519.444	1720	1400	1456	1200	-2016322
MyCountr	11731.54	425.0907	8430.609	14586.93	40536.77	8.733901	1007.01	9845.437	3615.048	1064	1600	1608	1800	-2.4E+07

- raw-prod 0.5:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -prod 0.5.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/ raw-prod 0.5.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/ raw-prod 0.5csv"
  - End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingW;	electronic;	foodWast	score
Atlantis	19855.18	1283.804	9040.719	20213.68	20377.25	1594.542	3157.246	21374.03	21571.97	2128	1600	1200	1928	11576410
Brobdingn;	13718	650.16	14408.57	19237.5	45360	19.54909	679.6221	10935	12172.34	1800	2000	2576	2008	-1.7E+07
Carpania	18000	888	9890	14250	5000	1351.455	500	12000	16705.89	1456	1800	1400	1480	-359689
Dinotopia	14726.45	161.4834	2650.64	8445.53	36678.01	732.6981	968.8256	8174.474	4175.525	1256	1400	1584	1600	-3249634
Erewhon	18775.08	1249.943	10939.51	10938.39	54075.33	1591.175	1806.942	12908.27	4292.413	1592	1400	1584	1200	3125005
MyCountr	12314.93	262.6105	6490.896	16084.8	45509.4	86.58199	1671.365	11101.86	4083.675	1128	1600	1640	1800	-1.1E+07

- raw-prod 0.75:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -prod 0.75.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/ raw-prod 0.75.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/ raw-prod 0.75csv"

  End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingW	electronics	foodWaste	score
Atlantis	20590.26	1419.586	15588.57	20914.58	7892.587	1835.088	3049.34	22102.31	21003.7	2064	1600	1200	1960	14457725
Brobdingn	15200	1016	6502.4	23750	12000	312.5455	1756	13500	12899.11	1864	2000	2256	2096	-4238903
Carpania	18000	888	12040	14250	5000	1451.455	300	12000	16678.11	1456	1800	1400	1480	294918.2
Dinotopia	14726.45	161.4834	2742.808	8445.53	36678.01	673.7774	870.5857	8174.474	7402.22	1256	1400	1584	1600	-4338570
Erewhon	18000	1232	12950	10000	50000	1408	1384	12000	3555.556	1592	1400	1584	1200	2670582
MyCountr	10832.93	282.9305	3437.809	11809.8	35429.4	7.13472	1048.074	8266.86	628.6659	1064	1600	1584	1800	-2E+07

- raw-waste 0.5:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -waste 0.5.xlsx"

- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/ raw-waste 0.5.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/ raw-waste 0.5csv"

End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingWa	electronics	foodWast	score
Atlantis	22724.96	1429.797	14548.96	25233.75	102305.3	2274.917	3934.212	25622.28	28465.97	2192	1600	1200	1800	24016270
Brobdingna	13718	749.36	18502.2	19237.5	48600	9.949091	711.25	10935	7080.972	1800	2000	2464	2000	-1.5E+07
Carpania	18000	632	15350	14250	45000	1206.909	1212	12000	3583.333	1328	1800	1912	1400	1812511
Dinotopia	14766.75	173.0716	180.0288	8531.233	37086.25	762.2337	919.4608	8275.076	8316.095	1320	1400	1456	1600	-3080422
Erewhon	17100	955.2	667.5	9000	45000	1191.2	1234	10800	10200	1720	1400	1456	1200	-1382472
MyCountr	11079.93	436.5718	1396.303	12855.55	37008.41	2.790977	765.0769	8861.287	7019.519	1064	1600	1488	1800	-1.8E+07

- raw-waste 0.75:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -waste 0.75.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/ raw-waste 0.75.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/ raw-waste 0.75csv"

  End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingWa	electronics	foodWast	score
Atlantis	22724.96	1429.797	14548.96	25233.75	102305.3	2274.917	3934.212	25622.28	28465.97	2192	1600	1200	1800	24016271
Brobdingna	13718	749.36	18502.2	19237.5	48600	9.949091	711.25	10935	7080.972	1800	2000	2464	2000	-1.5E+07
Carpania	18000	632	15350	14250	45000	1206.909	1212	12000	3583.333	1328	1800	1912	1400	1812511
Dinotopia	14766.75	173.0716	180.0288	8531.233	37086.25	762.2337	919.4608	8275.076	8316.095	1320	1400	1456	1600	-3080423
Erewhon	17100	955.2	667.5	9000	45000	1191.2	1234	10800	10200	1720	1400	1456	1200	-1382473
MyCountr	11079.93	436.5718	1396.303	12855.55	37008.41	2.790977	765.0769	8861.287	7019.519	1064	1600	1488	1800	-1.8E+07

- wwr 0.5:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -ww raw 0.5.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/ wwr 0.5.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/ wwr 0.5csv"

    End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingWa	electronics	foodWast	score
Atlantis	9776.722	293.8543	8731.167	5843.637	26306.33	632.3032	56.82504	6696.157	2231.517	2192	1600	1200	1800	-1.6E+07
Brobdingn	26506.62	1811.252	14749.8	35818.12	118756.8	2795.047	3991.076	24813.98	33452.6	2120	2000	2000	2000	13953125
Carpania	17100	684	26102.5	12825	40500	39.63636	777.5	10800	6056.25	1200	1800	2040	1400	-639184
Dinotopia	18111.45	683.8724	1568.475	18595.92	63884.01	1887.202	2248.337	13967.64	22603.33	1320	1400	1328	1600	16407522
Erewhon	14661.11	784.8072	512.4775	6561	32805	119.7475	835.5447	7873.2	5626.067	1464	1400	1784	1200	-6959848
MyCountry	10631.72	342.2137	700.3283	10848.44	32747.81	6.063704	770.7173	7776.157	4977.708	1064	1600	1528	1800	-2.1E+07

- wwr 0.75:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -ww raw 0.75.xlsx"

- initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
- output_schedule_filename = "./output_files/ wwr 0.75.txt"
- game_state_print = True
- game_state_filename = "./game_output_files/ wwr 0.75csv"

End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingWa	electronics	foodWast	score
Atlantis	9776.722	293.8543	8731.167	5843.637	26306.33	632.3032	56.82504	6696.157	2231.517	2192	1600	1200	1800	-1.6E+07
Brobdingn:	26506.62	1811.252	14749.8	35818.12	118756.8	2795.047	3991.076	24813.98	33452.6	2120	2000	2000	2000	13953125
Carpania	17100	684	26102.5	12825	40500	39.63636	777.5	10800	6056.25	1200	1800	2040	1400	-639184
Dinotopia	18111.45	683.8724	1568.475	18595.92	63884.01	1887.202	2248.337	13967.64	22603.33	1320	1400	1328	1600	16407522
Erewhon	14661.11	784.8072	512.4775	6561	32805	119.7475	835.5447	7873.2	5626.067	1464	1400	1784	1200	-6959848
MyCountry	10631.72	342.2137	700.3283	10848.44	32747.81	6.063704	770.7173	7776.157	4977.708	1064	1600	1528	1800	-2.1E+07

- wwp 0.5:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -ww prod 0.5.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/ wwp 0.5.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/wwp 0.5csv"

End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingWa	electronics	foodWast	score
Atlantis	22724.96	1429.797	14548.96	25233.75	102305.3	2274.917	3934.212	25622.28	28465.97	2192	1600	1200	1800	24016267
Brobdingn:	13718	749.36	18502.2	19237.5	48600	9.949091	711.25	10935	7080.972	1800	2000	2464	2000	-1.5E+07
Carpania	18000	632	15350	14250	45000	1206.909	1212	12000	3583.333	1328	1800	1912	1400	1812512
Dinotopia	14766.75	173.0716	180.0288	8531.233	37086.25	762.2337	919.4608	8275.076	8316.095	1320	1400	1456	1600	-3080420
Erewhon	17100	955.2	667.5	9000	45000	1191.2	1234	10800	10200	1720	1400	1456	1200	-1382471
MyCountry	11079.93	436.5718	1396.303	12855.55	37008.41	2.790977	765.0769	8861.287	7019.519	1064	1600	1488	1800	-1.8E+07

- wwp 0.75:
  - Parameters:
    - num_rounds = 7
    - frontier_size = 100
    - use_dynamic_solution_limit = True
    - use_dynamic_depth_limit = True
    - solution_limit = 1000
    - depth = 3
    - interventions_on = True
    - log_inequality = False
    - seed = 123456654321
    - trade_selectivity_parameters = [1, 100, 2, 200]
    - initial_state_filename = "./input_files/countries_for_test.xlsx"
    - initial_resource_filename = "./input_files/Resources -ww prod 0.75.xlsx"
    - initial_interventions_filename = "./input_files/Interventions_case0.xlsx"
    - output_schedule_filename = "./output_files/ wwp 0.75.txt"
    - game_state_print = True
    - game_state_filename = "./game_output_files/ wwp 0.75csv"

End State:

Name	population	metalElem	timber	landArea	water	metalAlloy	electronics	housing	food	metalAlloy	housingW	electronics	foodWaste	score
Atlantis	22724.96	1429.797	14548.96	25233.75	102305.3	2274.917	3934.212	25622.28	28465.97	2192	1600	1200	1800	24016267
Brobdingna	13718	749.36	18502.2	19237.5	48600	9.949091	711.25	10935	7080.972	1800	2000	2464	2000	-1.5E+07
Carpania	18000	632	15350	14250	45000	1206.909	1212	12000	3583.333	1328	1800	1912	1400	1812512
Dinotopia	14766.75	173.0716	180.0288	8531.233	37086.25	762.2337	919.4608	8275.076	8316.095	1320	1400	1456	1600	-3080420
Erewhon	17100	955.2	667.5	9000	45000	1191.2	1234	10800	10200	1720	1400	1456	1200	-1382471
MyCountry	11079.93	436.5718	1396.303	12855.55	37008.41	2.790977	765.0769	8861.287	7019.519	1064	1600	1488	1800	-1.8E+07

Results:

resource weight scaling

Country	Trial					
	raw-waste 0.5	raw-waste 0.75	raw-prod 0.5	raw-prod 0.75	raw-mat 0.5	raw-mat 0.75
Atlantis	24,016,269.53	24,016,270.66	11,576,409.58	14,457,725.41	33,020,678.52	42,529,096.27
Brobdingnag	(14,539,833.87)	(14,539,834.65)	(16,816,171.06)	(4,238,903.02)	(29,584,708.17)	(34,498,726.19)
Carpania	1,812,511.32	1,812,510.89	(359,688.79)	294,918.18	62,363.36	47,631.46
Dinotopia	(3,080,422.12)	(3,080,423.16)	(3,249,633.60)	(4,338,570.05)	(3,582,240.79)	(3,818,348.45)
Erewhon	(1,382,472.13)	(1,382,472.93)	3,125,004.67	2,670,581.83	891,665.28	(2,016,321.82)
MyCountry	(18,282,476.20)	(18,282,477.48)	(11,185,459.28)	(19,788,779.54)	(20,597,638.29)	(23,612,571.21)
Mean	(1,909,403.91)	(1,909,404.45)	(2,818,256.41)	(1,823,837.87)	(3,298,313.35)	(3,561,539.99)
Variance	223,049,478,883,035.00	223,049,502,602,624.00	102,942,220,168,502.00	124,934,757,077,747.00	467,648,210,094,300.00	699,795,972,422,834.00

war weight scaling

Name	T1	T2	T3	T4
Atlantis	-15567227.4	-1.6E+07	24016267	24016267
Brobdingnag	13953125.36	13953125	-14539832	-1.5E+07
Carpania	-639184.053	-639184	1812512.2	1812512
Dinotopia	16407522.37	16407522	-3080420	-3080420
Erewhon	-6959847.88	-6959848	-1382470.5	-1382471
MyCountry	-20589882.4	-2.1E+07	-18282474	-1.8E+07
Mean	-2232582.33	-2232582	-1909402.8	-1909403
Variance	2.29824E+14	2.3E+14	2.23E+14	2.23E+14

After analyzing the output text files, we recognized that for a for the scaling of 0.5 and 0.75 of raw material resources for just resource weight we saw a drop in transforms compared to the control run just as we expected in the part 1. However, for 0.5 and 0.75 scaling for waste the transfers and transforms did not change in value too much in number. This was surprising because we set up the war weight to steer countries to step up for war when they can. We saw that this result may be because we do not have any resource increase apart from transfer and transforms. This means our world is in perpetual spending with no renewal of resources.