BUDT758K Spring 2022

Report for Team Assignment 2 Bike Share Project

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Introduction and Description of Data

Bike share provides free or affordable access to bicycles for short-distance trips in urban areas as an alternative to motorized vehicles. Therefore bike-share systems have become increasingly important for their environmentally friendly, convenient, and low-cost characteristics. In this project, we are studying the nation's largest bike-share program, Citi Bike, and building a simulation model to analyze and improve the daily operation of the Citi bike share system.

The dataset we are analyzing is the 'Citibike_6_Stations_Week-Days.xlsx' file, which is a modified version of the original Citi bike dataset. We are using the June 2017 part of the original dataset and weekend trips were removed. Moreover, we are only considering 4 stations out of 6 stations (out of 608 stations in the original dataset).

Input Model Analysis

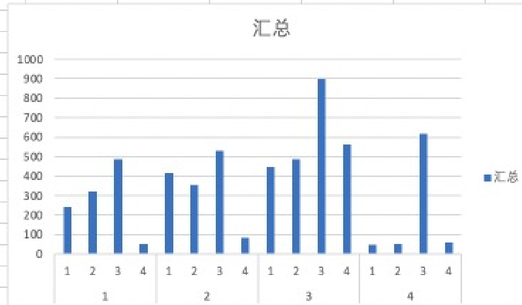
Since we are only considering 4 stations out of 6 stations, a filter was added to the dataset, and only stations 1-4 are selected. Therefore we are considering the trips in 4*4=16 routes. To implement model simulations, we need to do the input model analysis. Below shows the Input models for arrivals. We first create a timevalue column using Excel 'Timevalue()' equation and return the decimal number of the start time represented by a text string. Then a pivot table was inserted. From there we are able to count the Frequency of each time interval and calculate the arrival rate by using Frequency/2hr/22 days. Also, we use 5 times the arrival rates for simulation since the arrival rates that we are obtaining from the data are much lower than the actual arrival rate.

	A	B	C	D	E	F	G	H
1	end station id	(多项)						
2								
3	行标签	计数项:Time Value						
4	⊖1	1103		Time Interval		Frequency	Arrival Rate (Arrivals/2hr/22days)	Arrival Rate times 5
5	0-0.08332368833	3		0-2 am	0-0.083333	3	0.068181818	0.340909091
6	0.08332368833-0.16664737666	1		2-4 am	0.083333-0.166666	1	0.022727273	0.113636364
7	0.16664737666-0.24997106499	5		4-6 am	0.166666-0.249999	5	0.113636364	0.568181818
8	0.24997106499-0.33329475332	51		6-8 am	0.249999-0.333332	51	1.159090909	5.795454545
9	0.33329475332-0.41661844165	72		8-10 am	0.333332-0.416665	72	1.636363636	8.181818182
10	0.41661844165-0.49994212998	100		10am - 12pm	0.416665-0.499998	100	2.272727273	11.36363636
11	0.49994212998-0.58326581831	70		12-2pm	0.499998-0.583331	70	1.590909091	7.954545455
12	0.58326581831-0.66658950664	142		2-4pm	0.583331-0.666664	142	3.227272727	16.13636364
13	0.66658950664-0.74991319497	196		4-6pm	0.666664-0.749997	196	4.454545455	22.27272727
14	0.74991319497-0.8332368833	276		6-8pm	0.749997-0.83333	276	6.272727273	31.36363636
15	0.8332368833-0.91656057163	143		8-10pm	0.83333-0.916663	143	3.25	16.25
16	0.91656057163-0.99988425996	44		10pm - 12am	0.916663-0.999996	44	1	5
17	⊖2	1386		Time Interval		Frequency		
18	0-0.08332368833	22		0-2 am	0-0.083333	22	0.5	2.5
19	0.08332368833-0.16664737666	3		2-4 am	0.083333-0.166666	3	0.068181818	0.340909091
20	0.16664737666-0.24997106499	1		4-6 am	0.166666-0.249999	1	0.022727273	0.113636364
21	0.24997106499-0.33329475332	73		6-8 am	0.249999-0.333332	73	1.659090909	8.295454545
22	0.33329475332-0.41661844165	198		8-10 am	0.333332-0.416665	198	4.5	22.5
23	0.41661844165-0.49994212998	97		10am - 12pm	0.416665-0.499998	97	2.204545455	11.02272727
24	0.49994212998-0.58326581831	138		12-2pm	0.499998-0.583331	138	3.136363636	15.68181818
25	0.58326581831-0.66658950664	130		2-4pm	0.583331-0.666664	130	2.954545455	14.77272727
26	0.66658950664-0.74991319497	222		4-6pm	0.666664-0.749997	222	5.045454545	25.22727273
27	0.74991319497-0.8332368833	288		6-8pm	0.749997-0.83333	288	6.545454545	32.72727273
28	0.8332368833-0.91656057163	162		8-10pm	0.83333-0.916663	162	3.681818182	18.40909091
29	0.91656057163-0.99988425996	52		10pm - 12am	0.916663-0.999996	52	1.181818182	5.909090909
30	⊖3	2393		Time Interval		Frequency		
31	0-0.08332368833	37		0-2 am	0-0.083333	37	0.840909091	4.204545455
32	0.08332368833-0.16664737666	8		2-4 am	0.083333-0.166666	8	0.181818182	0.909090909
33	0.16664737666-0.24997106499	11		4-6 am	0.166666-0.249999	11	0.25	1.25
34	0.24997106499-0.33329475332	251		6-8 am	0.249999-0.333332	251	5.704545455	28.52272727
35	0.33329475332-0.41661844165	315		8-10 am	0.333332-0.416665	315	7.159090909	35.79545455
36	0.41661844165-0.49994212998	137		10am - 12pm	0.416665-0.499998	137	3.113636364	15.56818182
37	0.49994212998-0.58326581831	138		12-2pm	0.499998-0.583331	138	3.136363636	15.68181818
38	0.58326581831-0.66658950664	233		2-4pm	0.583331-0.666664	233	5.295454545	26.47727273
39	0.66658950664-0.74991319497	474		4-6pm	0.666664-0.749997	474	10.77272727	53.86363636
40	0.74991319497-0.8332368833	514		6-8pm	0.749997-0.83333	514	11.68181818	58.40909091
41	0.8332368833-0.91656057163	164		8-10pm	0.83333-0.916663	164	3.727272727	18.63636364
42	0.91656057163-0.99988425996	111		10pm - 12am	0.916663-0.999996	111	2.522727273	12.61363636
43	⊖4	779		Time Interval		Frequency		
44	0.16664737666-0.24997106499	1		0-2 am	0-0.083333	0	0	0
45	0.24997106499-0.33329475332	70		2-4 am	0.083333-0.166666	0	0	0
46	0.33329475332-0.41661844165	138		4-6 am	0.166666-0.249999	1	0.022727273	0.113636364
47	0.41661844165-0.49994212998	26		6-8 am	0.249999-0.333332	70	1.590909091	7.954545455
48	0.49994212998-0.58326581831	23		8-10 am	0.333332-0.416665	138	3.136363636	15.68181818
49	0.58326581831-0.66658950664	68		10am - 12pm	0.416665-0.499998	26	0.590909091	2.954545455
50	0.66658950664-0.74991319497	208		12-2pm	0.499998-0.583331	23	0.522727273	2.613636364

For the input model for the end station, we inserted another pivot table and calculated the start-end distribution. Below shows the start-end distribution and we can see that station 3 is more crowded compared to other stations.

行标签	计数项:end station id
1	1103
1	243
2	323
3	486
4	51
2	1386
1	416
2	356
3	529
4	85
3	2393
1	446
2	486
3	898
4	563
4	779
1	48
2	52
3	618
4	61
总计	5661

start-end	count	precentage
1-1	243	0.22030825
1-2	323	0.292837715
1-3	486	0.4406165
1-4	51	0.046237534
	1103	1
2-1	416	0.3001443
2-2	356	0.256854257
2-3	529	0.381673882
2-4	85	0.061327561
	1386	1
3-1	446	0.186376933
3-2	486	0.203092353
3-3	898	0.375261178
3-4	563	0.235269536
	2393	1
4-1	48	0.061617458
4-2	52	0.066752246
4-3	618	0.793324775
4-4	61	0.07830552
	779	1



For input models for trip durations, we first filtered the 16 routes' trip duration into a new tab. Then we are using @risk to generate the batch fit for the trip duration. The @Risk Batch Fit process is to fit trip duration data to a probability distribution and find the best fit according to the AIC ranking. We can see from the Batch Fit Summary that the best fit (ranked by AIC) is the lognormal distribution. With this Batch Fit summary we can use it as the input model for the trip duration for simulation model implementation.

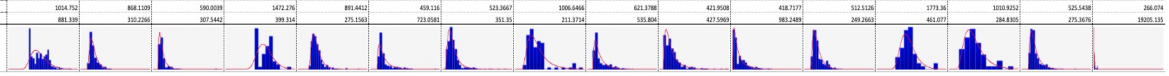
1-1Tripduration	1-2Tripduration	1-3Tripduration	1-4Tripduration	2-1Tripduration	2-2Tripdurat	2-3Tripdurat	2-4Tripdurat	3-1Tripdurat	3-2Tripdurat	3-3Tripdurat	3-4Tripdurat	4-1Tripdurat	4-2Tripdurat	4-3Tripdurat	4-4Tripdurati
1818	708	567	1019	836	61	472	859	340	173	179	319	1097	1116	376	1720
1025	638	1167	1444	870	110	599	1809	465	664	76	388	1646	1343	592	65
263	781	597	1913	803	1465	483	1817	496	805	2178	713	1598	1016	662	386
1518	873	743	980	740	385	258	1720	480	268	213	320	2750	1232	416	130
1615	754	452	1753	715	591	360	1154	495	615	1143	598	1405	1047	666	115
2362	938	848	1093	971	939	451	881	504	216	656	423	1079	1079	480	66
556	776	560	1466	679	77	645	883	641	411	192	1034	1527	768	378	173
181	950	548	1090	1095	361	1410	956	397	279	181	1291	1348	953	1126	160
375	952	480	1577	1305	1568	267	1023	602	466	339	394	1558	1000	517	102
1900	852	410	1068	1160	576	871	973	499	637	2921	312	1462	1456	519	86
1688	1154	414	2806	1124	70	315	1066	551	234	194	322	1323	899	557	733

OBJ

Batch Fit Summary: Batch Fit 1
Performed By: fzhao
Date: Friday, May 13, 2022 10:05:23 PM

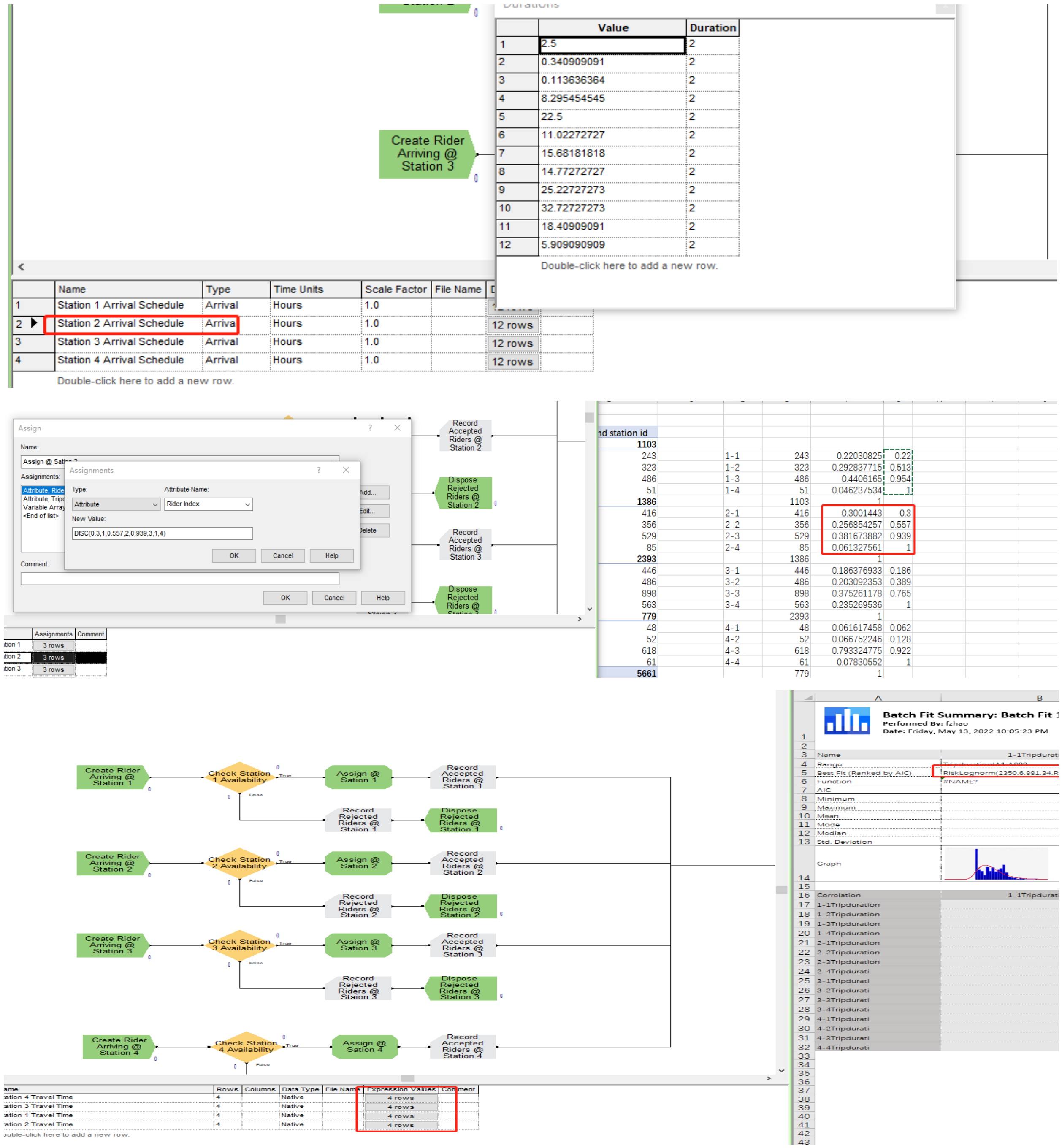
Name	1-1Tripduration	1-2Tripduration	1-3Tripduration	1-4Tripduration	2-1Tripduration	2-2Tripduration	2-3Tripduration	2-4Tripdurati
Range	Tripduration!A1:A899	Tripduration!B1:B899	Tripduration!C1:C899	Tripduration!D1:D899	Tripduration!E1:E899	Tripduration!F1:F899	Tripduration!G1:G899	Tripduration!H1:H899
Best Fit (Ranked by AIC)	RiskLognorm(2350.6,881.34,	RiskLognorm(556.11,310.23,	RiskLognorm(361.11,307.54,	RiskLognorm(1750.5,399.31,	RiskLognorm(475.29,275.16,	RiskLognorm(670.77,723.06,	RiskLognorm(510.68,351.35,	RiskLognorm(354.37,211.37,
Function	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?
AIC	3943.3652	4496.749	6549.8514	758.3106	5678.4303	5283.298	7398.2261	1118.4953
Minimum	-1186.243	382.4571	315.0887	-234.417	480.1083	2.9203	102.6491	702.3026
Maximum	+∞	+∞	+∞	+∞	+∞	+∞	+∞	+∞
Mean	1164.373	938.5673	676.196	1516.116	955.3984	673.6938	613.3244	1056.6739
Mode	743.473	752.8466	474.4283	1387.863	788.1878	213.9296	388.1992	926.7823
Median	1014.752	868.1109	590.0039	1472.276	891.4412	459.116	523.3667	1006.6466
Std. Deviation	881.339	310.2266	307.5442	399.314	275.1563	723.0581	351.35	211.3714
Graph								

Name	3-1Tripdurati	3-2Tripdurati	3-3Tripdurati	3-4Tripdurati	4-1Tripdurati	4-2Tripdurati	4-3Tripdurati	4-4Tripdurati
Range	Tripduration!I1:I899	Tripduration!J1:J899	Tripduration!K1:K899	Tripduration!L1:L899	Tripduration!M1:M899	Tripduration!N1:N899	Tripduration!O1:O899	Tripduration!P1:P899
Best Fit (Ranked by AIC)	RiskLognorm(483.00,535.80,	RiskLognorm(417.25,427.60,	RiskLognorm(670.90,983.25,	RiskLognorm(341.82,249.27,	RiskLognorm(1379.0,461.08,	RiskLognorm(577.24,284.83,	RiskLognorm(344.70,275.37,	RiskLognorm(1987.7,19205.1
Function	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?
AIC	6328.251	6740.0303	13337.1005	7453.2493	723.9334	724.7664	8240.013	921.1012
Minimum	297.9822	130.5493	40.5838	236.3245	465.494	493.277	256.2286	61.445
Maximum	+∞	+∞	+∞	+∞	+∞	+∞	+∞	+∞
Mean	780.9817	547.7959	711.4814	578.1479	1844.526	1070.5141	600.9288	2049.137
Mode	442.9638	272.6806	160.7063	416.6311	1641.856	909.5667	420.6277	63.613
Median	621.3788	421.9508	418.7177	512.5126	1773.36	1010.9252	525.5438	266.074
Std. Deviation	535.804	427.5969	983.2489	249.2663	461.077	284.8305	275.3676	19205.135
Graph								

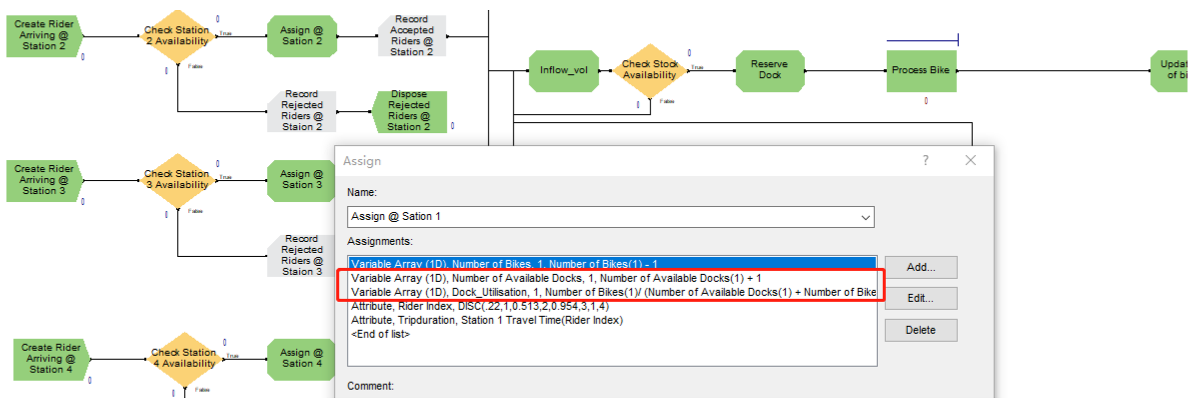


Implementation of Simulation Model

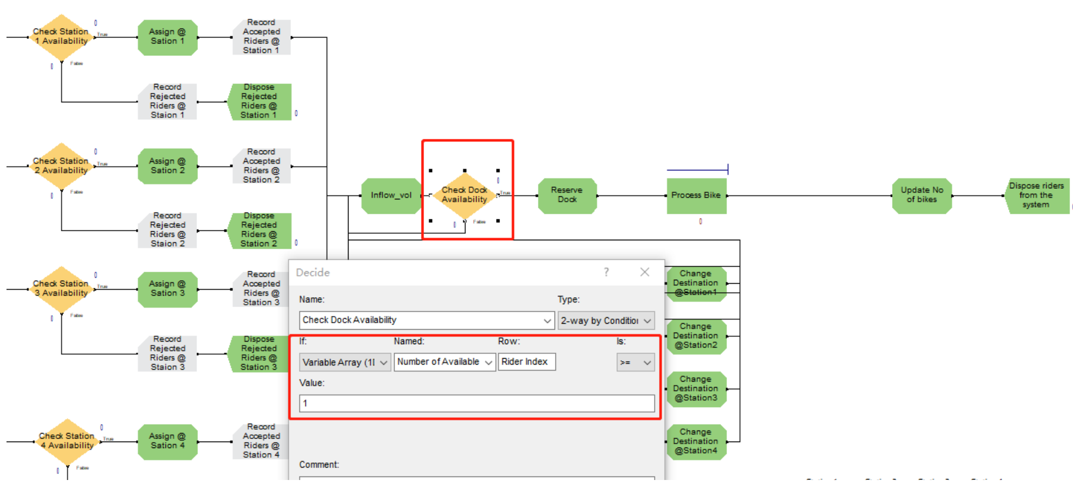
Since the Arena model ‘BikeShare_Basic.doe’ is not complete, we need to add input models for arrivals, end stations, and trip duration based on the previous input model analysis session. The following picture shows the parameter editing of station 2 based on the input model of arrivals and destination distribution. When changing the parameter of station travel time, we edited the expression value based on the Batch Fit Summary.



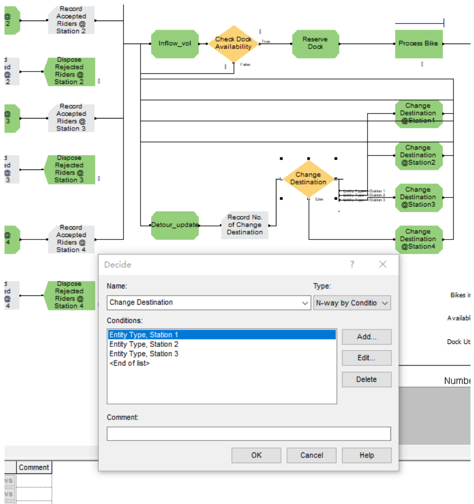
As for the operation of docks (parking space) implementation, we added an assignment to update the dock and stats for dock utilization. In the basic model, there was no dock and only bikes, now there are bikes and docks. The number of docks is set to be greater than the number of bikes. For example, the initial number of bikes per station is 20, and the available dock is 10. So there are 30 docks in total. When a station has enough bikes, the rider gets to choose the destination station.



A decide module is used to check availability and to determine whether the destination station dock is sufficient (>1) or not. If it is sufficient, the rider would reserve a dock to the reserved dock; otherwise, the rider needs to re-select the destination station.



When the destination station dock does not have enough space, we need to re-select the destination station. The probability of re-selecting the destination still obeys the probability that the tourists take each destination in the previous analysis.



After the selection, the new-selected destination is judged whether it is free or not. We are hoping to make the detour percentage smaller to avoid inconvenience for the rider; in other words the smaller proportion of the re-selection the better.

Model Simulation Report Analysis

The following picture shows the average cycle time of the riders in each station.

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Station 1	16.0149	0.35	13.7235	18.4060	0.00	100.87
Station 2	8.3738	0.22	7.1808	9.4472	0.00	95.7587
Station 3	8.4850	0.19	7.6831	9.5184	0.00	305.29
Station 4	8.4534	0.49	6.6650	11.7098	0.00	565.20

The next table shows the number in and out and the WIP of each station.

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Station 1	2.7661	0.09	2.2920	3.1080	0.00	21.0000
Station 2	1.8177	0.06	1.5446	2.1942	0.00	13.0000
Station 3	3.2060	0.08	2.6252	3.5628	0.00	20.0000
Station 4	1.0638	0.08	0.7348	1.5462	0.00	13.0000

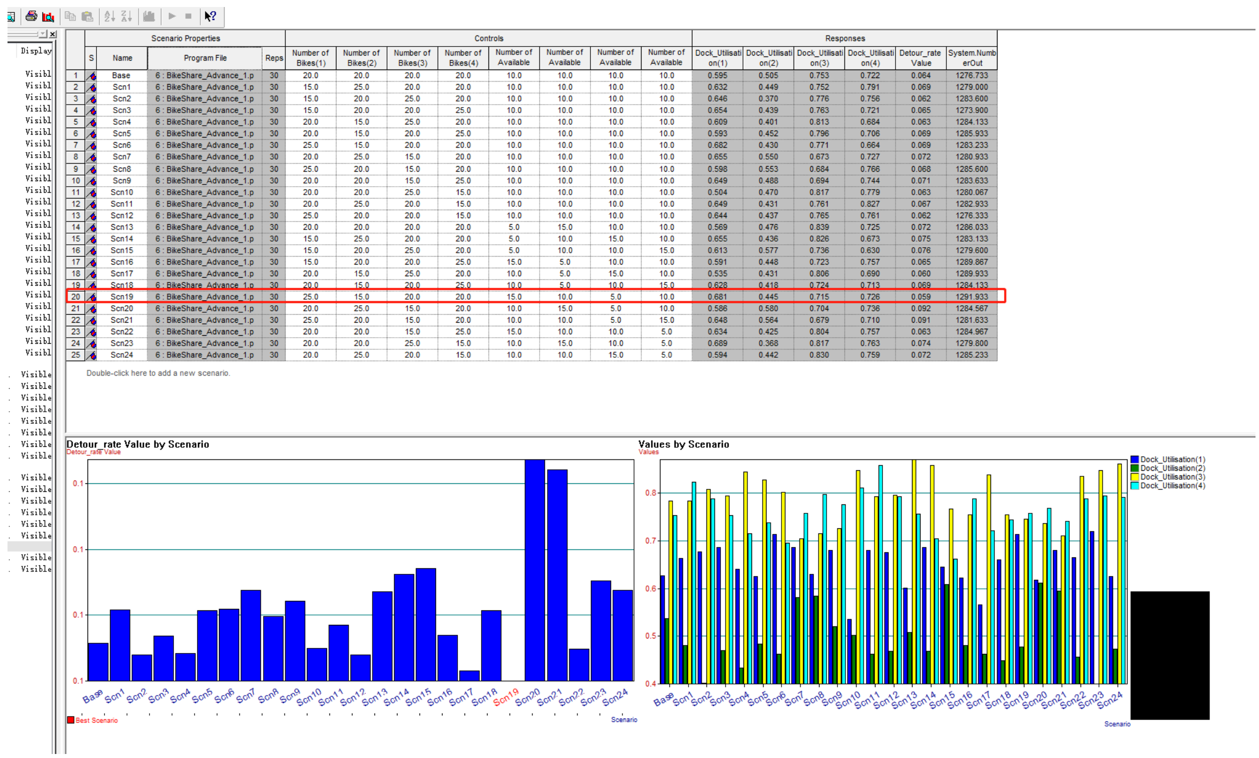
From the time persistent part, the detour_cnt means the number of riders who re-select their destination because of lack of dock. The average detour rate is 6.4%. Since we designed the model to use reservations, therefore it works as a way to rebalance.

Time Persistent

Variable	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Detour_cnt	54.0878	8.27	16.0416	106.91	0.00	326.00
Detour_rate	0.06423710	0.01	0.02178425	0.1334	0.00	0.3248

PAN Analysis

After importing the original BikeShare_Advance_1.doe file, we set the parameters that need to pass the PAN test. The control parameters include the number of bikes in each station and the number of docks. As for the response, we are aiming for a somewhat in-between utilization rate; that means not too high and not too low, lower detour rate, and higher system number out. According to the PAN analysis, we found that scenario 19 performs the best on detour rate and system number out. Scenario 19's dock utilization rate in each station is quite balanced, not exceeding 80%. Therefore we are using scenario 19 to update the simulation model for optimization.



	Scenario Properties				Controls								Responses					
	S	Name	Program File	Reps	Number of Bikes(1)	Number of Bikes(2)	Number of Bikes(3)	Number of Bikes(4)	Number of Available	Number of Available	Number of Available	Number of Available	Dock_Utilisation(1)	Dock_Utilisation(2)	Dock_Utilisation(3)	Dock_Utilisation(4)	Detour_rate Value	System.NumberOut
1		Base	6 : BikeShare_Advance_1.p	30	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	0.595	0.505	0.753	0.722	0.064	1276.733
2		Scn1	6 : BikeShare_Advance_1.p	30	15.0	25.0	20.0	20.0	10.0	10.0	10.0	10.0	0.632	0.449	0.752	0.791	0.069	1279.000
3		Scn2	6 : BikeShare_Advance_1.p	30	15.0	20.0	25.0	20.0	10.0	10.0	10.0	10.0	0.646	0.370	0.776	0.756	0.062	1283.600
4		Scn3	6 : BikeShare_Advance_1.p	30	15.0	20.0	20.0	25.0	10.0	10.0	10.0	10.0	0.654	0.439	0.763	0.721	0.065	1273.900
5		Scn4	6 : BikeShare_Advance_1.p	30	20.0	15.0	25.0	20.0	10.0	10.0	10.0	10.0	0.609	0.401	0.813	0.684	0.063	1284.133
6		Scn5	6 : BikeShare_Advance_1.p	30	20.0	15.0	20.0	25.0	10.0	10.0	10.0	10.0	0.593	0.452	0.796	0.706	0.069	1285.933
7		Scn6	6 : BikeShare_Advance_1.p	30	25.0	15.0	20.0	20.0	10.0	10.0	10.0	10.0	0.682	0.430	0.771	0.664	0.069	1283.233
8		Scn7	6 : BikeShare_Advance_1.p	30	20.0	25.0	15.0	20.0	10.0	10.0	10.0	10.0	0.655	0.550	0.673	0.727	0.072	1280.933
9		Scn8	6 : BikeShare_Advance_1.p	30	25.0	20.0	15.0	20.0	10.0	10.0	10.0	10.0	0.598	0.553	0.684	0.766	0.068	1285.600
10		Scn9	6 : BikeShare_Advance_1.p	30	20.0	20.0	15.0	25.0	10.0	10.0	10.0	10.0	0.649	0.488	0.694	0.744	0.071	1283.633
11		Scn10	6 : BikeShare_Advance_1.p	30	20.0	20.0	25.0	15.0	10.0	10.0	10.0	10.0	0.504	0.470	0.817	0.779	0.063	1280.067
12		Scn11	6 : BikeShare_Advance_1.p	30	20.0	25.0	20.0	15.0	10.0	10.0	10.0	10.0	0.649	0.431	0.761	0.827	0.067	1282.933
13		Scn12	6 : BikeShare_Advance_1.p	30	25.0	20.0	20.0	15.0	10.0	10.0	10.0	10.0	0.644	0.437	0.765	0.761	0.062	1276.333
14		Scn13	6 : BikeShare_Advance_1.p	30	20.0	20.0	20.0	20.0	5.0	15.0	10.0	10.0	0.569	0.476	0.839	0.725	0.072	1286.033
15		Scn14	6 : BikeShare_Advance_1.p	30	15.0	25.0	20.0	20.0	5.0	10.0	15.0	10.0	0.655	0.436	0.826	0.673	0.075	1283.133
16		Scn15	6 : BikeShare_Advance_1.p	30	15.0	20.0	25.0	20.0	5.0	10.0	10.0	15.0	0.613	0.577	0.736	0.630	0.076	1279.600
17		Scn16	6 : BikeShare_Advance_1.p	30	15.0	20.0	20.0	25.0	15.0	5.0	10.0	10.0	0.591	0.448	0.723	0.757	0.065	1289.867
18		Scn17	6 : BikeShare_Advance_1.p	30	20.0	15.0	25.0	20.0	10.0	5.0	15.0	10.0	0.535	0.431	0.806	0.690	0.060	1289.933
19		Scn18	6 : BikeShare_Advance_1.p	30	20.0	15.0	20.0	25.0	10.0	5.0	10.0	15.0	0.628	0.418	0.724	0.713	0.069	1284.133
20		Scn19	6 : BikeShare_Advance_1.p	30	25.0	15.0	20.0	20.0	15.0	10.0	5.0	10.0	0.681	0.445	0.715	0.726	0.059	1291.933
21		Scn20	6 : BikeShare_Advance_1.p	30	20.0	25.0	15.0	20.0	10.0	15.0	5.0	10.0	0.586	0.580	0.704	0.736	0.092	1284.567
22		Scn21	6 : BikeShare_Advance_1.p	30	25.0	20.0	15.0	20.0	10.0	10.0	5.0	15.0	0.648	0.564	0.679	0.710	0.091	1281.633
23		Scn22	6 : BikeShare_Advance_1.p	30	20.0	20.0	15.0	25.0	15.0	10.0	10.0	5.0	0.634	0.425	0.804	0.757	0.063	1284.967
24		Scn23	6 : BikeShare_Advance_1.p	30	20.0	20.0	25.0	15.0	10.0	15.0	10.0	5.0	0.689	0.368	0.817	0.763	0.074	1279.800
25		Scn24	6 : BikeShare_Advance_1.p	30	20.0	25.0	20.0	15.0	10.0	10.0	15.0	5.0	0.594	0.442	0.830	0.759	0.072	1285.233

Conclusion and Potential Improvements

This bike share model use reservation to solve the problem when riders' destination stations are unavailable to be dropped off. There could be more potential solutions to deal with the destination rejection.