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Lampiran 1. Data Aset

Tanggal	EURUSD	CHFUSD	WMT	IBM	RICE	ALUM
11/1/2013	1.3589	1.1033	81.01	171.62	15.96	2,251.50
12/1/2013	1.3745	1.1194	78.69	179.16	15.51	2,347.00
1/1/2014	1.3485	1.1028	74.68	168.76	15.4	2,208.00
2/1/2014	1.3802	1.1358	74.7	176.87	15.375	2,282.50
3/1/2014	1.377	1.1301	76.43	183.86	15.6	2,151.50
4/1/2014	1.3866	1.1352	79.71	187.66	15.615	2,246.00
5/1/2014	1.363	1.1171	76.77	176.09	14.985	2,356.00
6/1/2014	1.3691	1.1275	75.07	173.14	14.54	2,413.00
7/1/2014	1.3388	1.1004	73.58	183.08	12.985	2,373.00
8/1/2014	1.3132	1.0887	75.5	183.68	12.585	2,644.00
9/1/2014	1.2631	1.0467	76.47	181.32	12.745	2,378.00
10/1/2014	1.2524	1.0382	76.27	157.03	12.005	2,477.50
11/1/2014	1.245	1.0352	87.54	154.9	12.335	2,222.00
12/1/2014	1.2097	1.0056	85.88	153.25	11.49	2,162.00
1/1/2015	1.1286	1.0851	84.98	146.44	10.57	2,359.00
2/1/2015	1.1193	1.0487	83.93	154.68	10.47	2,488.50
3/1/2015	1.073	1.0281	82.25	153.3	10.875	2,445.50
4/1/2015	1.1222	1.0722	78.05	163.61	10.03	2,787.00
5/1/2015	1.0987	1.0634	74.27	162.04	9.51	3,052.50
6/1/2015	1.1135	1.0687	70.93	155.37	10.165	3,491.00
7/1/2015	1.0987	1.0347	71.98	154.73	11.515	3,368.50
8/1/2015	1.1211	1.034	64.73	141.26	11.88	3,021.00
9/1/2015	1.1176	1.027	64.84	138.47	13.2	2,807.50
10/1/2015	1.1005	1.0116	57.24	133.8	11.61	2,625.00
11/1/2015	1.0563	0.972	58.84	133.17	11.905	2,716.50
12/1/2015	1.086	0.9977	61.3	131.45	11.565	2,858.50
1/1/2016	1.0834	0.9768	66.36	119.19	11.35	2,718.00
2/1/2016	1.0871	1.001	66.34	125.16	10.495	2,590.00
3/1/2016	1.1378	1.0391	68.49	144.66	9.69	2,523.50
4/1/2016	1.1454	1.0418	66.87	139.4	10.84	2,483.00
5/1/2016	1.1129	1.0062	70.78	146.85	10.94	2,397.00
6/1/2016	1.1104	1.0243	73.02	144.97	10.505	2,212.00
7/1/2016	1.117	1.0311	72.97	153.42	9.94	2,154.50
8/1/2016	1.1156	1.0158	71.44	151.76	9.195	1,977.50
9/1/2016	1.1238	1.0291	72.12	151.73	9.885	1,979.50

10/1/2016	1.0979	1.0108	70.02	146.8	9.855	2,045.00
11/1/2016	1.0585	0.9825	70.43	154.95	9.705	1,848.50
12/1/2016	1.0513	0.9814	69.12	158.55	9.355	1,765.00
1/1/2017	1.0795	1.0106	66.74	166.7	9.535	1,800.00
2/1/2017	1.0575	0.994	70.93	171.76	9.285	1,713.50
3/1/2017	1.0649	0.9967	72.08	166.33	9.895	1,619.50
4/1/2017	1.0895	1.0046	75.18	153.1	9.13	1,548.00
5/1/2017	1.1241	1.0331	78.6	145.79	11.13	1,494.50
6/1/2017	1.1423	1.0433	75.68	146.93	11.505	1,526.00
7/1/2017	1.184	1.034	79.99	138.18	12.26	1,694.50
8/1/2017	1.1908	1.043	78.07	136.62	12.55	1,722.00
9/1/2017	1.1812	1.0326	78.14	138.58	11.995	1,810.00
10/1/2017	1.1644	1.0021	87.31	147.15	11.29	1,770.00
11/1/2017	1.1902	1.0165	97.23	147.07	12.53	1,755.00
12/1/2017	1.1996	1.0263	98.75	146.54	11.68	1,721.50
1/1/2018	1.242	1.0734	106.6	156.36	12.44	1,753.00
2/1/2018	1.2193	1.0584	90.01	148.84	12.39	1,799.00
3/1/2018	1.2321	1.0473	88.97	146.55	12.355	1,800.00
4/1/2018	1.2077	1.0091	88.46	138.46	12.785	1,794.50
5/1/2018	1.169	1.0143	82.54	134.97	11.56	1,797.00
6/1/2018	1.1683	1.0089	85.65	133.44	11.61	1,912.00
7/1/2018	1.1691	1.0096	89.23	138.43	11.915	1,911.00
8/1/2018	1.1599	1.0319	95.86	139.91	10.83	1,910.00
9/1/2018	1.1608	1.018	93.91	144.43	9.78	1,846.00
10/1/2018	1.131	0.9913	100.28	110.25	10.58	1,958.00
11/1/2018	1.1315	1.0009	97.65	118.7	10.885	1,953.50
12/1/2018	1.1469	1.0185	93.15	108.57	10.095	2,062.00
1/1/2019	1.1444	1.0054	95.83	128.39	10.61	2,125.00
2/1/2019	1.137	1.0015	98.99	131.94	10.395	2,081.00
3/1/2019	1.1217	1.0045	97.53	134.77	10.85	2,133.00
4/1/2019	1.1215	0.981	102.84	133.98	10.275	2,292.00
5/1/2019	1.1167	0.9989	101.44	121.3	11.455	2,255.00
6/1/2019	1.1368	1.0242	110.49	131.72	11.275	2,004.50
7/1/2019	1.1074	1.0058	110.38	141.59	11.945	2,132.00
8/1/2019	1.0989	1.0098	114.26	129.45	11.67	2,219.50
9/1/2019	1.0898	1.0018	118.68	138.9	12.015	2,268.00
10/1/2019	1.115	1.0135	117.26	127.73	11.73	2,048.00

11/1/2019	1.1015	0.9996	119.09	128.42	12.485	2,160.00
12/1/2019	1.121	1.0328	118.84	128.03	13.135	2,102.00
1/1/2020	1.1093	1.038	114.49	137.29	13.61	2,117.00
2/1/2020	1.1025	1.0356	107.68	124.31	13.515	1,918.00
3/1/2020	1.1029	1.0404	113.62	105.96	14.035	1,919.00
4/1/2020	1.0955	1.0356	121.55	119.93	17.155	1,928.00
5/1/2020	1.1098	1.04	124.06	119.3	17.215	1,911.50
6/1/2020	1.1231	1.0555	119.78	115.36	14.505	1,962.50
7/1/2020	1.1774	1.0952	129.4	117.43	11.595	1,924.00
8/1/2020	1.1936	1.1063	138.85	117.78	12.49	1,819.00
9/1/2020	1.1718	1.0855	139.91	116.21	12.475	1,693.00
10/1/2020	1.1647	1.0904	138.75	106.65	12.525	1,732.00
11/1/2020	1.1928	1.0997	152.79	117.98	12.555	1,734.00
12/1/2020	1.2213	1.1293	144.15	120.24	12.4	1,673.00
1/1/2021	1.2136	1.1228	140.49	113.77	13.46	1,614.00
2/1/2021	1.2074	1.1006	129.92	113.6	12.75	1,644.00
3/1/2021	1.1728	1.0595	135.83	127.29	13.18	1,649.00
4/1/2021	1.2018	1.0945	139.91	135.52	13.385	1,556.00
5/1/2021	1.2225	1.1116	142.03	137.3	13.3	1,679.00
6/1/2021	1.1855	1.0807	141.02	140.02	13.175	1,520.00
7/1/2021	1.187	1.104	142.55	134.64	13.68	1,573.00
8/1/2021	1.1807	1.0924	148.1	134.05	13.13	1,519.00
9/1/2021	1.1581	1.0731	139.38	132.7	13.715	1,507.00
10/1/2021	1.1561	1.0917	149.42	119.49	13.28	1,446.00
11/1/2021	1.1336	1.088	140.63	117.1	14.035	1,478.50
12/1/2021	1.1368	1.0958	144.69	133.66	14.63	1,577.00
1/1/2022	1.1233	1.0782	139.81	133.57	15.06	1,603.00
2/1/2022	1.1219	1.0905	135.16	122.51	15.365	1,618.00
3/1/2022	1.1065	1.0834	148.92	130.02	16.01	1,691.00
4/1/2022	1.0541	1.027	152.99	132.21	17.09	1,740.00
5/1/2022	1.0733	1.0421	128.63	138.84	17.545	1,925.00
6/1/2022	1.0482	1.0468	121.58	141.19	16.425	1,785.00
7/1/2022	1.0218	1.0506	132.05	130.79	16.885	1,815.00
8/1/2022	1.0057	1.0228	132.55	128.45	17.505	1,864.00
9/1/2022	0.9799	1.013	129.7	118.81	17.17	1,852.50
10/1/2022	0.9883	0.9985	142.33	138.29	16.56	2,004.00
11/1/2022	1.0405	1.057	152.42	148.9	18.14	2,039.00

12/1/2022	1.0702	1.0813	141.79	140.89	18.05	1,960.00
1/1/2023	1.0862	1.0912	143.87	134.73	17.825	2,097.00
2/1/2023	1.0576	1.061	142.13	129.3	16.97	1,988.00
3/1/2023	1.0839	1.0928	147.45	131.09	17.415	1,891.00
4/1/2023	1.102	1.1181	150.97	126.41	17.375	1,838.00
5/1/2023	1.0688	1.0978	146.87	128.59	17.29	1,800.00
6/1/2023	1.091	1.1164	157.18	133.81	18.055	1,785.00
7/1/2023	1.0993	1.1467	159.86	144.18	15.47	1,754.00
8/1/2023	1.0841	1.1319	162.61	146.83	16.79	1,706.00
9/1/2023	1.057	1.0925	159.93	140.3	15.91	1,800.00
10/1/2023	1.0576	1.0982	163.41	144.64	16.12	1,755.00

Sumber : *investing.com*, 2023.

Lampiran 2. Return masing-masing aset

EURUSD	CHFUSD	WMT	IBM	RRICE	RALUM
0.0115	0.0146	-0.0286	0.0439	-0.0282	0.0424
-0.0189	-0.0148	-0.0510	-0.0580	-0.0071	-0.0592
0.0235	0.0299	0.0003	0.0481	-0.0016	0.0337
-0.0023	-0.0050	0.0232	0.0395	0.0146	-0.0574
0.0070	0.0045	0.0429	0.0207	0.0010	0.0439
-0.0170	-0.0159	-0.0369	-0.0617	-0.0403	0.0490
0.0045	0.0093	-0.0221	-0.0168	-0.0297	0.0242
-0.0221	-0.0240	-0.0198	0.0574	-0.1069	-0.0166
-0.0191	-0.0106	0.0261	0.0033	-0.0308	0.1142
-0.0382	-0.0386	0.0128	-0.0128	0.0127	-0.1006
-0.0085	-0.0081	-0.0026	-0.1340	-0.0581	0.0418
-0.0059	-0.0029	0.1478	-0.0136	0.0275	-0.1031
-0.0284	-0.0286	-0.0190	-0.0107	-0.0685	-0.0270
-0.0670	0.0791	-0.0105	-0.0444	-0.0801	0.0911
-0.0082	-0.0335	-0.0124	0.0563	-0.0095	0.0549
-0.0414	-0.0196	-0.0200	-0.0089	0.0387	-0.0173
0.0459	0.0429	-0.0511	0.0673	-0.0777	0.1396
-0.0209	-0.0082	-0.0484	-0.0096	-0.0518	0.0953
0.0135	0.0050	-0.0450	-0.0412	0.0689	0.1437
-0.0133	-0.0318	0.0148	-0.0041	0.1328	-0.0351
0.0204	-0.0007	-0.1007	-0.0871	0.0317	-0.1032
-0.0031	-0.0068	0.0017	-0.0198	0.1111	-0.0707
-0.0153	-0.0150	-0.1172	-0.0337	-0.1205	-0.0650
-0.0402	-0.0391	0.0280	-0.0047	0.0254	0.0349
0.0281	0.0264	0.0418	-0.0129	-0.0286	0.0523
-0.0024	-0.0209	0.0825	-0.0933	-0.0186	-0.0492
0.0034	0.0248	-0.0003	0.0501	-0.0753	-0.0471
0.0466	0.0381	0.0324	0.1558	-0.0767	-0.0257
0.0067	0.0026	-0.0237	-0.0364	0.1187	-0.0160
-0.0284	-0.0342	0.0585	0.0534	0.0092	-0.0346
-0.0022	0.0180	0.0316	-0.0128	-0.0398	-0.0772
0.0059	0.0066	-0.0007	0.0583	-0.0538	-0.0260
-0.0013	-0.0148	-0.0210	-0.0108	-0.0749	-0.0822
0.0074	0.0131	0.0095	-0.0002	0.0750	0.0010
-0.0230	-0.0178	-0.0291	-0.0325	-0.0030	0.0331

-0.0359	-0.0280	0.0059	0.0555	-0.0152	-0.0961
-0.0068	-0.0011	-0.0186	0.0232	-0.0361	-0.0452
0.0268	0.0298	-0.0344	0.0514	0.0192	0.0198
-0.0204	-0.0164	0.0628	0.0304	-0.0262	-0.0481
0.0070	0.0027	0.0162	-0.0316	0.0657	-0.0549
0.0231	0.0079	0.0430	-0.0795	-0.0773	-0.0441
0.0318	0.0284	0.0455	-0.0477	0.2191	-0.0346
0.0162	0.0099	-0.0372	0.0078	0.0337	0.0211
0.0365	-0.0089	0.0570	-0.0596	0.0656	0.1104
0.0057	0.0087	-0.0240	-0.0113	0.0237	0.0162
-0.0081	-0.0100	0.0009	0.0143	-0.0442	0.0511
-0.0142	-0.0295	0.1174	0.0618	-0.0588	-0.0221
0.0222	0.0144	0.1136	-0.0005	0.1098	-0.0085
0.0079	0.0096	0.0156	-0.0036	-0.0678	-0.0191
0.0353	0.0459	0.0795	0.0670	0.0651	0.0183
-0.0183	-0.0140	-0.1556	-0.0481	-0.0040	0.0262
0.0105	-0.0105	-0.0116	-0.0154	-0.0028	0.0006
-0.0198	-0.0365	-0.0057	-0.0552	0.0348	-0.0031
-0.0320	0.0052	-0.0669	-0.0252	-0.0958	0.0014
-0.0006	-0.0053	0.0377	-0.0113	0.0043	0.0640
0.0007	0.0007	0.0418	0.0374	0.0263	-0.0005
-0.0079	0.0221	0.0743	0.0107	-0.0911	-0.0005
0.0008	-0.0135	-0.0203	0.0323	-0.0970	-0.0335
-0.0257	-0.0262	0.0678	-0.2367	0.0818	0.0607
0.0004	0.0097	-0.0262	0.0766	0.0288	-0.0023
0.0136	0.0176	-0.0461	-0.0853	-0.0726	0.0555
-0.0022	-0.0129	0.0288	0.1826	0.0510	0.0306
-0.0065	-0.0039	0.0330	0.0277	-0.0203	-0.0207
-0.0135	0.0030	-0.0147	0.0214	0.0438	0.0250
-0.0002	-0.0234	0.0544	-0.0059	-0.0530	0.0745
-0.0043	0.0182	-0.0136	-0.0946	0.1148	-0.0161
0.0180	0.0253	0.0892	0.0859	-0.0157	-0.1111
-0.0259	-0.0180	-0.0010	0.0749	0.0594	0.0636
-0.0077	0.0040	0.0352	-0.0857	-0.0230	0.0410
-0.0083	-0.0079	0.0387	0.0730	0.0296	0.0219
0.0231	0.0117	-0.0120	-0.0804	-0.0237	-0.0970
-0.0121	-0.0137	0.0156	0.0054	0.0644	0.0547

0.0177	0.0332	-0.0021	-0.0030	0.0521	-0.0269
-0.0104	0.0050	-0.0366	0.0723	0.0362	0.0071
-0.0061	-0.0023	-0.0595	-0.0945	-0.0070	-0.0940
0.0004	0.0046	0.0552	-0.1476	0.0385	0.0005
-0.0067	-0.0046	0.0698	0.1318	0.2223	0.0047
0.0131	0.0042	0.0206	-0.0053	0.0035	-0.0086
0.0120	0.0149	-0.0345	-0.0330	-0.1574	0.0267
0.0483	0.0376	0.0803	0.0179	-0.2006	-0.0196
0.0138	0.0101	0.0730	0.0030	0.0772	-0.0546
-0.0183	-0.0188	0.0076	-0.0133	-0.0012	-0.0693
-0.0061	0.0045	-0.0083	-0.0823	0.0040	0.0230
0.0241	0.0085	0.1012	0.1062	0.0024	0.0012
0.0239	0.0269	-0.0565	0.0192	-0.0123	-0.0352
-0.0063	-0.0058	-0.0254	-0.0538	0.0855	-0.0353
-0.0051	-0.0198	-0.0752	-0.0015	-0.0527	0.0186
-0.0287	-0.0373	0.0455	0.1205	0.0337	0.0030
0.0247	0.0330	0.0300	0.0647	0.0156	-0.0564
0.0172	0.0156	0.0152	0.0131	-0.0064	0.0790
-0.0303	-0.0278	-0.0071	0.0198	-0.0094	-0.0947
0.0013	0.0216	0.0108	-0.0384	0.0383	0.0349
-0.0053	-0.0105	0.0389	-0.0044	-0.0402	-0.0343
-0.0191	-0.0177	-0.0589	-0.0101	0.0446	-0.0079
-0.0017	0.0173	0.0720	-0.0995	-0.0317	-0.0405
-0.0195	-0.0034	-0.0588	-0.0200	0.0569	0.0225
0.0028	0.0072	0.0289	0.1414	0.0424	0.0666
-0.0119	-0.0161	-0.0337	-0.0007	0.0294	0.0165
-0.0012	0.0114	-0.0333	-0.0828	0.0203	0.0094
-0.0137	-0.0065	0.1018	0.0613	0.0420	0.0451
-0.0474	-0.0521	0.0273	0.0168	0.0675	0.0290
0.0182	0.0147	-0.1592	0.0501	0.0266	0.1063
-0.0234	0.0045	-0.0548	0.0169	-0.0638	-0.0727
-0.0252	0.0036	0.0861	-0.0737	0.0280	0.0168
-0.0158	-0.0265	0.0038	-0.0179	0.0367	0.0270
-0.0257	-0.0096	-0.0215	-0.0750	-0.0191	-0.0062
0.0086	-0.0143	0.0974	0.1640	-0.0355	0.0818
0.0528	0.0586	0.0709	0.0767	0.0954	0.0175
0.0285	0.0230	-0.0697	-0.0538	-0.0050	-0.0387

0.0150	0.0092	0.0147	-0.0437	-0.0125	0.0699
-0.0263	-0.0277	-0.0121	-0.0403	-0.0480	-0.0520
0.0249	0.0300	0.0374	0.0138	0.0262	-0.0488
0.0167	0.0232	0.0239	-0.0357	-0.0023	-0.0280
-0.0301	-0.0182	-0.0272	0.0172	-0.0049	-0.0207
0.0208	0.0169	0.0702	0.0406	0.0442	-0.0083
0.0076	0.0271	0.0171	0.0775	-0.1432	-0.0174
-0.0138	-0.0129	0.0172	0.0184	0.0853	-0.0274
-0.0250	-0.0348	-0.0165	-0.0445	-0.0524	0.0551
0.0006	0.0052	0.0218	0.0309	0.0132	-0.0250

Sumber : Data diolah, 2023.

Lampiran 3. Sintaks Phyton

```
#memanggil paket
import math as mt
import numpy as np
import pandas as pd

#load the data
from google.colab import files
files.upload()

#memanggil data
data=pd.read_csv("data^5.csv")
print(data)

      REURUSD   RCHFUSD      RWMT      RIBM     RRICE     RALUM
0    0.011480  0.014593 -0.028638  0.043934 -0.028195  0.042416
1   -0.018916 -0.014829 -0.050959 -0.058049 -0.007092 -0.059225
2    0.023508  0.029924  0.000268  0.048056 -0.001623  0.033741
3   -0.002319 -0.005018  0.023159  0.039521  0.014634 -0.057393
4    0.006972  0.004513  0.042915  0.020668  0.000962  0.043923
..        ...       ...       ...       ...       ...       ...
114  0.020771  0.016943  0.070198  0.040594  0.044245 -0.008333
115  0.007608  0.027141  0.017051  0.077498 -0.143174 -0.017367
116 -0.013827 -0.012907  0.017203  0.018380  0.085326 -0.027366
117 -0.024998 -0.034809 -0.016481 -0.044473 -0.052412  0.055100
118  0.000568  0.005217  0.021760  0.030934  0.013199 -0.025000
[119 rows x 6 columns]

#Rata-rata R
# Menghitung rata-rata untuk setiap kolom
rata_rata_kolom = data.mean()

print("Rata-rata setiap kolom:")
print(rata_rata_kolom)
meanr=np.array(rata_rata_kolom)
print("mean", meanr)

Rata-rata setiap kolom:
REURUSD   -0.001878
RCHFUSD    0.000203
RWMT       0.007288
RIBM       0.000633
RRICE      0.002220
RALUM     -0.000663
dtype: float64
```

```
mean [-0.00187811  0.00020279  0.00728818  0.00063339
0.00222043 -0.00066276]

#pendefinisian data
x1=data["REURUSD"]
x2=data["RCHFUSD"]
x3=data["RWMT"]
x4=data["RIBM"]
x5=data["RRICE"]
x6=data["RALUM"]
i=1j
N=len(data)

#menghitung transformasi hilbert
exp = [np.cos(2*np.pi*(k/N)) + 1j*np.sin(2*np.pi*(k/N)) for k in
range(N)]
print("exp=", exp)

sgn1=-i*np.sign(1-N/2)
rk1=x1*exp
sig1=sum(rk1)
hdr1=sgn1*sig1
z1t=x1+i*hdr1

sgn2=-i*np.sign(2-N/2)
rk2=x2*exp
sig2=sum(rk2)
hdr2=sgn2*sig2
z2t=x2+i*hdr2

sgn3=-i*np.sign(3-N/2)
rk3=x3*exp
sig3=sum(rk3)
hdr3=sgn3*sig3
z3t=x3+i*hdr3

sgn4=-i*np.sign(4-N/2)
rk4=x4*exp
sig4=sum(rk4)
hdr4=sgn4*sig4
z4t=x4+i*hdr4

sgn5=-i*np.sign(5-N/2)
rk5=x5*exp
sig5=sum(rk5)
hdr5=sgn5*sig5
```

```
z5t=x5+i*hdr5

sgn6=-i*np.sign(6-N/2)
rk6=x6*exp
sig6=sum(rk6)
hdr6=sgn6*sig6
z6t=x6+i*hdr6

zt=(z1t,z2t,z3t,z4t,z5t,z6t)
print(zt)

exp= [(1+0j), (0.9986064103215336+0.05277534713046237j),
(0.9944295254705184+0.10540359990284776j),
(0.9874809871741873+0.15773807393743752j),
(0.9777801622550408+0.20963290366854653j),
(0.9653540886520386+0.26094344889801674j),
(0.950237400061015+0.31152669793339155j),
(0.9324722294043558+0.3612416661871529j),
(0.9121080913989877+0.40994978912605357j),
(0.8892017445499812+0.457515308475323j),
(0.8638170329544163+0.5038056506013295j),
(0.8360247083564339+0.5486917960180738j),
(0.8059022329494349+0.5920486389876383j),
(0.7735335634750531+0.6337553362123162j),
(0.7390089172206591+0.6736956436465572j),
(0.7024245205675985+0.711758240489971j),
(0.6638823407910085+0.7478370394583644j),
(0.6234898018587336+0.7818314824680298j),
(0.58135948502146+0.8136468209091601j),
(0.5376088150285774+0.8431943797272186j),
(0.4923597328443421+0.8703918045762196j),
(0.4457383557765383+0.8951632913550623j),
(0.3978746259649208 5+0.9174397974871563j),
(0.3489019482091668+0.9371592343544655j),
(0.2989568181457703 5+0.954266640349623j),
(0.2481784418102239 4+0.9687143340637885j),
(0.196708347644828 1+0.9804620471832867j),
(0.1446899920335405+0.9894770367246195j),
(0.0922683594633020 2+0.9957341762950345j),
(0.0395895584262695 86+0.9992160261242876j), (-
0.013199585810758838+0.9999128816724107j), (-
0.06595194043469546+0.9978228006780053j), (-
0.11852047517170261+0.9929516085716734j), (-
0.17075867208693757+0.9853128822394974j), (-
0.22252093395631434+0.9749279121818236j), (-
0.27366299007208 29+0.9618256431728 19j), (-
```

```
0.32404229835116566+0.9460425935861948j), (-
0.3735184426255116+0.9276227536119478j), (-
0.42195352400713765+0.9066174626478126j), (-
0.4692125452370662+0.8830852662071507j), (-
0.5151637869468961+0.8570917527421046j), (-
0.559679174784308+0.8287093708368187j), (-
0.6026346363792563+0.7980172272802396j), (-
0.6439104471559156+0.7651008665813082j), (-
0.6833915640265487+0.7300520325410701j), (-
0.7209679460372246+0.692968412546247j), (-
0.7565348610716958+0.6539533652969682j), (-
0.7899931777585879+0.6131156327275371j), (-
0.8212496417683136+0.570569036923155j), (-
0.850217135729614+0.5264321628773561j), (-
0.8768149220412986+0.48082802797435953j), (-
0.900968867902419+0.43388373911755823j), (-
0.9226116519336829+0.38573013845977966j), (-
0.9416829518142116+0.33650143872273913j), (-
0.958129612410668+0.2863348491221129j), (-
0.9719057939301476+0.23537019294084263j), (-
0.9829730996839018+0.18374951781657037j), (-
0.9913006831057968+0.13161669982939342j), (-
0.996865333727226+0.0791170424934248j), (-
0.9996515418688489+0.026396871769836513j), (-0.9996515418688489-
0.02639687176983627j), (-0.9968653337272261-
0.07911704249342412j), (-0.9913006831057968-0.1316166998293936j),
(-0.9829730996839018-0.18374951781657012j), (-
0.9719057939301476-0.23537019294084238j), (-0.9581296124106682-
0.28633484912211227j), (-0.9416829518142115-
0.33650143872273935j), (-0.922611651933683-0.3857301384597794j),
(-0.9009688679024191-0.433883739117558j), (-0.8768149220412987-
0.4808280279743593j), (-0.8502171357296141-0.5264321628773558j),
(-0.8212496417683137-0.5705690369231547j), (-0.7899931777585883-
0.6131156327275366j), (-0.7565348610716959-0.653953365296968j),
(-0.7209679460372248-0.6929684125462469j), (-0.6833915640265489-
0.7300520325410699j), (-0.6439104471559158-0.7651008665813081j),
(-0.6026346363792565-0.7980172272802395j), (-0.5596791747843082-
0.8287093708368186j), (-0.5151637869468959-0.8570917527421047j),
(-0.469212545237066-0.8830852662071508j), (-0.4219535240071375-
0.9066174626478127j), (-0.37351844262551204-0.9276227536119476j),
(-0.32404229835116627-0.9460425935861946j), (-
0.2736629900720831-0.9618256431728l9j), (-0.2225209339563146-
0.9749279121818236j), (-0.1707586720869376-0.9853128822394974j),
(-0.11852047517170351-0.9929516085716733j), (-
0.06595194043469525-0.9978228006780053j), (-0.01319958581075864-
0.9999128816724107j), (0.0395895584262689-0.9992160261242876j),
```

```
(0.09226835946330154-0.9957341762950346j), (0.14468999203354002-
0.9894770367246195j), (0.19670834764482786-0.9804620471832867j),
(0.2481784418102237-0.9687143340637886j), (0.29895681814577035-
0.954266640349623j), (0.34890194820916676-0.9371592343544655j),
(0.397874625964921-0.9174397974871562j), (0.4457383557765377-
0.8951632913550626j), (0.4923597328443425-0.8703918045762195j),
(0.537608815028577-0.8431943797272188j), (0.5813594850214596-
0.8136468209091604j), (0.6234898018587334-0.7818314824680299j),
(0.6638823407910084-0.7478370394583645j), (0.7024245205675984-
0.711758240489971j), (0.7390089172206585-0.6736956436465578j),
(0.7735335634750533-0.6337553362123161j), (0.8059022329494351-
0.592048638987638j), (0.8360247083564337-0.5486917960180743j),
(0.863817032954416-0.5038056506013299j), (0.889201744549981-
0.45751530847532335j), (0.9121080913989877-0.40994978912605373j),
(0.9324722294043558-0.36124166618715303j), (0.9502374000610148-
0.3115266979333923j), (0.9653540886520388-0.26094344889801663j),
(0.9777801622550408-0.2096329036685463j), (0.9874809871741872-
0.15773807393743808j), (0.9944295254705183-0.1054035999028482j),
(0.9986064103215336-0.05277534713046272j)]
(0      0.239889+0.012500j
1      0.209493+0.012500j
2      0.251917+0.012500j
3      0.226091+0.012500j
4      0.235381+0.012500j
              ...
114    0.249180+0.012500j
115    0.236017+0.012500j
116    0.214582+0.012500j
117    0.203411+0.012500j
118    0.228977+0.012500j
Name: REURUSD, Length: 119, dtype: complex128, 0
0.090345+0.097655j
1      0.060923+0.097655j
2      0.105676+0.097655j
3      0.070734+0.097655j
4      0.080265+0.097655j
              ...
114    0.092695+0.097655j
115    0.102893+0.097655j
116    0.062846+0.097655j
117    0.040944+0.097655j
118    0.080970+0.097655j
Name: RCHFUSD, Length: 119, dtype: complex128, 0
0.457414+0.141290j
1      0.435093+0.141290j
2      0.486320+0.141290j
```

```
3      0.509212+0.141290j
4      0.528968+0.141290j
              ...
114    0.556251+0.141290j
115    0.503103+0.141290j
116    0.503255+0.141290j
117    0.469571+0.141290j
118    0.507812+0.141290j
Name: RWMT, Length: 119, dtype: complex128, 0     -
0.054289+0.244842j
1     -0.156272+0.244842j
2     -0.050167+0.244842j
3     -0.058703+0.244842j
4     -0.077555+0.244842j
              ...
114   -0.057629+0.244842j
115   -0.020725+0.244842j
116   -0.079844+0.244842j
117   -0.142697+0.244842j
118   -0.067290+0.244842j
Name: RIBM, Length: 119, dtype: complex128, 0
0.507472+0.432836j
1      0.528575+0.432836j
2      0.534044+0.432836j
3      0.550302+0.432836j
4      0.536629+0.432836j
              ...
114    0.579913+0.432836j
115    0.392494+0.432836j
116    0.620994+0.432836j
117    0.483256+0.432836j
118    0.548867+0.432836j
Name: RRICE, Length: 119, dtype: complex128, 0     -
0.150110+0.180316j
1     -0.251751+0.180316j
2     -0.158786+0.180316j
3     -0.249920+0.180316j
4     -0.148604+0.180316j
              ...
114   -0.200860+0.180316j
115   -0.209893+0.180316j
116   -0.219892+0.180316j
117   -0.137427+0.180316j
118   -0.217526+0.180316j
Name: RALUM, Length: 119, dtype: complex128)
```

```
# membentuk matriks diagonal E[z1t-E(z1t)]*[(z1t-E(z1t))*]
e1=sum(z1t)/N
ze1=z1t-e1
z1tk=np.conj(z1t)
ze1k=np.conj(ze1)
z1tot=ze1*ze1k
ez1t=sum(z1tot)/N
z1=complex(round(ez1t.real,18),round(ez1t.imag,18))

e2=sum(z2t)/N
ze2=z2t-e2
z2tk=np.conj(z2t)
ze2k=np.conj(ze2)
z2tot=ze2*ze2k
ez2t=sum(z2tot)/N
z2=complex(round(ez2t.real,18),round(ez2t.imag,18))

e3=sum(z3t)/N
ze3=z3t-e3
z3tk=np.conj(z3t)
ze3k=np.conj(ze3)
z3tot=ze3*ze3k
ez3t=sum(z3tot)/N
z3=complex(round(ez3t.real,18),round(ez3t.imag,18))

e4=sum(z4t)/N
ze4=z4t-e4
z4tk=np.conj(z4t)
ze4k=np.conj(ze4)
z4tot=ze4*ze4k
ez4t=sum(z4tot)/N
z4=complex(round(ez4t.real,18),round(ez4t.imag,18))

e5=sum(z5t)/N
ze5=z5t-e5
z5tk=np.conj(z5t)
ze5k=np.conj(ze5)
z5tot=ze5*ze5k
ez5t=sum(z5tot)/N
z5=complex(round(ez5t.real,18),round(ez5t.imag,18))

e6=sum(z6t)/N
ze6=z6t-e6
z6tk=np.conj(z6t)
ze6k=np.conj(ze6)
z6tot=ze6*ze6k
```

```
ez6t=sum(z6tot)/N
z6=complex(round(ez6t.real,18),round(ez6t.imag,18))

#membentuk matriks non diagonal
z7tot=ze1*ze2
ez7t=sum(z7tot)/N
z7=complex(round(ez7t.real,18),round(ez7t.imag,18))

z12tot=ze2*ze1
ez12t=sum(z12tot)/N
z12=complex(round(ez12t.real,18),round(ez12t.imag,18))

z8tot=ze1*ze3
ez8t=sum(z8tot)/N
z8=complex(round(ez8t.real,18),round(ez8t.imag,18))

z17tot=ze3*ze1
ez17t=sum(z17tot)/N
z17=complex(round(ez17t.real,18),round(ez17t.imag,18))

z9tot=ze1*ze4
ez9t=sum(z9tot)/N
z9=complex(round(ez9t.real,18),round(ez9t.imag,18))

z22tot=ze4*ze1
ez22t=sum(z22tot)/N
z22=complex(round(ez22t.real,18),round(ez22t.imag,18))

z10tot=ze1*ze5
ez10t=sum(z10tot)/N
z10=complex(round(ez10t.real,18),round(ez10t.imag,18))

z27tot=ze5*ze1
ez27t=sum(z27tot)/N
z27=complex(round(ez27t.real,18),round(ez27t.imag,18))

z11tot=ze1*ze6
ez11t=sum(z11tot)/N
z11=complex(round(ez11t.real,18),round(ez11t.imag,18))

z32tot=ze6*ze1
ez32t=sum(z32tot)/N
z32=complex(round(ez32t.real,18),round(ez32t.imag,18))

z13tot=ze2*ze3
ez13t=sum(z13tot)/N
```

```
z13=complex(round(ez13t.real,18),round(ez13t.imag,18))

z18tot=ze3*ze2
ez18t=sum(z18tot)/N
z18=complex(round(ez18t.real,18),round(ez18t.imag,18))

z14tot=ze2*ze4
ez14t=sum(z14tot)/N
z14=complex(round(ez14t.real,18),round(ez14t.imag,18))

z23tot=ze4*ze2
ez23t=sum(z23tot)/N
z23=complex(round(ez23t.real,18),round(ez23t.imag,18))

z15tot=ze2*ze5
ez15t=sum(z15tot)/N
z15=complex(round(ez15t.real,18),round(ez15t.imag,18))

z28tot=ze5*ze2
ez28t=sum(z28tot)/N
z28=complex(round(ez28t.real,18),round(ez28t.imag,18))

z16tot=ze2*ze6
ez16t=sum(z16tot)/N
z16=complex(round(ez16t.real,18),round(ez16t.imag,18))
z33tot=ze6*ze2
ez33t=sum(z33tot)/N
z33=complex(round(ez33t.real,18),round(ez33t.imag,18))

z19tot=ze3*ze4
ez19t=sum(z19tot)/N
z19=complex(round(ez19t.real,18),round(ez19t.imag,18))

z24tot=ze4*ze3
ez24t=sum(z24tot)/N
z24=complex(round(ez24t.real,18),round(ez24t.imag,18))

z20tot=ze3*ze5
ez20t=sum(z20tot)/N
z20=complex(round(ez20t.real,18),round(ez20t.imag,18))

z29tot=ze5*ze3
ez29t=sum(z29tot)/N
z29=complex(round(ez29t.real,18),round(ez29t.imag,18))

z21tot=ze3*ze6
```

```
ez21t=sum(z21tot)/N
z21=complex(round(ez21t.real,18),round(ez21t.imag,18))

z34tot=ze6*ze3
ez34t=sum(z34tot)/N
z34=complex(round(ez34t.real,18),round(ez34t.imag,18))

z25tot=ze4*ze5
ez25t=sum(z25tot)/N
z25=complex(round(ez25t.real,18),round(ez25t.imag,18))

z30tot=ze5*ze4
ez30t=sum(z30tot)/N
z30=complex(round(ez30t.real,18),round(ez30t.imag,18))

z26tot=ze4*ze6
ez26t=sum(z26tot)/N
z26=complex(round(ez26t.real,18),round(ez26t.imag,18))

z35tot=ze6*ze4
ez35t=sum(z35tot)/N
z35=complex(round(ez35t.real,18),round(ez35t.imag,18))

z31tot=ze5*ze6
ez31t=sum(z31tot)/N
z31=complex(round(ez31t.real,18),round(ez31t.imag,18))

z36tot=ze6*ze5
53
ez36t=sum(z36tot)/N
z36=complex(round(ez36t.real,18),round(ez36t.imag,18))

#matriks varians-kovarianss dan menghitung invers
matrix=np.matrix([[z1,z7,z8,z9,z10,z11],[z12,z2,z13,z14,z15,z16],
[z17,z18,z3,z19,z20,z21],[z22,z23,z24,z4,z25,z26],[z27,z28,z29,z
30,z5,z31],[z32,z33,z34,z35,z36,z6]])
invers=np.linalg.inv(matrix)
print("matriks kovarians", matrix)
print("invers matriks kovarians", invers)

matriks kovarians [[ 4.51714469e-04-0.j  3.04742715e-04+0.j
1.64678276e-04-0.j
   2.20069505e-04+0.j  4.13778612e-05+0.j  5.21569703e-05+0.j]
 [ 3.04742715e-04+0.j  4.85263473e-04+0.j  6.59976497e-05+0.j
   1.18797109e-04-0.j -1.04961404e-04-0.j  8.94736666e-05-0.j]
 [ 1.64678276e-04-0.j  6.59976497e-05+0.j  2.73397780e-03+0.j
```

```
   6.78417029e-04+0.j  5.70632624e-04+0.j -2.17727954e-04+0.j]
 [ 2.20069505e-04+0.j  1.18797109e-04-0.j  6.78417029e-04+0.j
   4.09983060e-03+0.j -1.89340040e-05+0.j  1.79183409e-04-0.j]
 [ 4.13778612e-05+0.j -1.04961404e-04-0.j  5.70632624e-04+0.j
  -1.89340040e-05+0.j  4.28672124e-03+0.j  7.76095266e-05-0.j]
 [ 5.21569703e-05+0.j  8.94736666e-05-0.j -2.17727954e-04+0.j
   1.79183409e-04-0.j  7.76095266e-05-0.j  2.86811920e-03+0.j]]
invers matriks kovarians [[ 4006.29451209+0.j -2486.65606042+0.j
-133.60214033+0.j
   -121.45990558-0.j   -82.38879955+0.j     4.39412919+0.j]
 [-2486.65606042+0.j  3649.40511497-0.j    26.05942245+0.j
     27.05267523+0.j   111.30149995+0.j   -71.35017007+0.j]
 [ -133.60214033+0.j    26.05942245+0.j   402.55545203-0.j
    -62.07720877+0.j   -52.61174118+0.j    37.47773245-0.j]
 [ -121.45990558+0.j    27.05267523-0.j   -62.07720877+0.j
    260.84640712-0.j    11.61174599-0.j   -19.95802528+0.j]
 [  -82.38879955+0.j   111.30149995+0.j   -52.61174118+0.j
     11.61174599+0.j   244.09456152+0.j   -13.29831253+0.j]
 [    4.39412919+0.j   -71.35017007+0.j    37.47773245+0.j
    -19.95802528+0.j   -13.29831253+0.j   355.25822974+0.j]]

# Menghitung bobot mean-variance portfolio
# Mengatur return saham atau aset dalam portofolio
exreturns = meanr
# Mengatur matriks kovarians antar return saham atau aset dalam
portofolio
cov_matrix = matrix

# Menghitung inverse dari matriks kovarians
inv_cov_matrix = np.linalg.inv(cov_matrix)

#vektor e
e=np.array([1,1,1,1,1,1])

# Inisialisasi list untuk menyimpan bobot, expected return,
standar deviasi, dan rasio
bobot_list = []
erpc_list = []
sdpc_list = []
rc_list = []

# Inisialisasi variabel untuk menyimpan erpc dan sdpc terbaik
best_erpc = None
best_sdpc = None
best_index = None
```

```
# Definisikan nilai c yang akan digunakan dalam perulangan
c_values = [0, 0.01, 0.02, 0.03, 0.04]

# Perulangan untuk menghitung bobot, expected return, standar
deviasi, dan rasio
for i, c in enumerate(c_values):
    bobot = np.dot(inv_cov_matrix, e) / np.dot(np.dot(e.T,
inv_cov_matrix), e) + (c * ((np.dot(inv_cov_matrix, exreturns))
- (((np.dot(np.dot(e.T, inv_cov_matrix), exreturns)) /
(np.dot(np.dot(e.T, inv_cov_matrix), e))) *
(np.dot(inv_cov_matrix, e)))))

# Memeriksa apakah ada bobot negatif
if np.any(bobot < 0):
        print("Bobot negatif ditemukan. Iterasi dihentikan.")
        break

    bobot_list.append(bobot)

    erpc = np.dot(bobot, exreturns.T)
    erpc_list.append(erpc)

    sdpc = np.dot(np.dot(bobot, cov_matrix), bobot.T)
    sdpc_list.append(sdpc)

    rc = erpc / sdpc
    rc_list.append(rc)

    # Menyimpan erpc dan sdpc terbaik
    if best_erpc is None or erpc > best_erpc:
        best_erpc = erpc
        best_sdpc = sdpc
        best_index = i

    # Menampilkan hasil
    print(f"Bobot C {i} Mean-Variance Portfolio:", bobot)
    print(f"Expected Return Portfolio Compleks {i} =", erpc)
    print(f"Risiko Portfolio Compleks {i} =", sdpc)
    print(f"Rasio Bobot {i} =", rc)
    print()

# Mencari bobot terbaik
if best_index is not None:
    best_bobot = bobot_list[best_index]
    print("Bobot terbaik adalah", best_bobot)
```

```
# Menampilkan erpc dan sdpc terbaik
if best_erpc is not None and best_sdpc is not None:
    print("Expected Return Portfolio Terbaik adalah", best_erpc)
    print("Risiko Portfolio Terbaik adalah", best_sdpc)
```

```
Bobot C 0 Mean-Variance Portfolio: [[0.3631529 +0.j
0.38434094+0.j 0.06665807+0.j 0.02938557+0.j
  0.06693579+0.j 0.08952673+0.j]]
Expected Return Portfolio Compleks 0 = [[-1.03799301e-05+0.j]]
Risiko Portfolio Compleks 0 = [[0.00030605+0.j]]
Rasio Bobot 0 = [[-0.03391584+0.j]]

Bobot C 1 Mean-Variance Portfolio: [[0.27062565+0.j
0.44358901+0.j 0.09677192+0.j 0.02924953+0.j
  0.07047875+0.j 0.08928514+0.j]]
Expected Return Portfolio Compleks 1 = [[0.00040283+0.j]]
Risiko Portfolio Compleks 1 = [[0.00031018+0.j]]
Rasio Bobot 1 = [[1.29868276+0.j]]

Bobot C 2 Mean-Variance Portfolio: [[0.17809841+0.j
0.50283708+0.j 0.12688576+0.j 0.02911349+0.j
  0.07402171+0.j 0.08904354+0.j]]
Expected Return Portfolio Compleks 2 = [[0.00081604+0.j]]
Risiko Portfolio Compleks 2 = [[0.00032258+0.j]]
Rasio Bobot 2 = [[2.52973039+0.j]]

Bobot C 3 Mean-Variance Portfolio: [[0.08557117+0.j
0.56208515+0.j 0.15699961+0.j 0.02897745+0.j
  0.07756466+0.j 0.08880195+0.j]]
Expected Return Portfolio Compleks 3 = [[0.00122924+0.j]]
Risiko Portfolio Compleks 3 = [[0.00034324+0.j]]
Rasio Bobot 3 = [[3.58130991+0.j]]

Bobot negatif ditemukan. Iterasi dihentikan.
Bobot terbaik adalah [[0.08557117+0.j 0.56208515+0.j
0.15699961+0.j 0.02897745+0.j
  0.07756466+0.j 0.08880195+0.j]]
Expected Return Portfolio Terbaik adalah [[0.00122924+0.j]]
Risiko Portfolio Terbaik adalah [[0.00034324+0.j]]
```