DAFTAR PUSTAKA

Aelst, S. Van, & Rousseeuw, P. (2009). Minimum Volume Ellipsoid. *John Wiley & Sons,Inc.*, *1*, 71–82.

BPS. (2023). *Provinsi Sulawesi Selatan Dalam Angka 2023*. Sulawesi Selatan: Badan Pusat Statistika

Draper, N. R., & Smith, H. (2011). *Applied Regression Analysis* (Third Edition). Canada: Wiley Series.

Filzmoser, P. (2005). Identification of Multivariate Outliers: A Performance Study. *Austrian Journal Of Statistics, 34*, 127–138.

Gujarati, D. N. (1995). *Basic Econometrics.* New York: McGraw-Hill.

Herdiani, E. T., Sunusi, N., & Sari, P. P. (2021). Minimum Vector Variance Estimator in Outlier Labeling of Multivariate Data: Application to HIV Patient in Indonesia. *Journal of Applied Science and Engineering (Taiwan)*, *25*(1), 13–18.

Hubert, M., Rousseeuw, P., & Branden, K. V. (2005). ROBPCA: A New Approach to Robust Principal. *Leuven, Belgium: Katholieke Universiteit*, *47(1)* : 64-79.

Jhonson, R. A., & Wichern, D. W. (2007). *Applied Multivarite Statistical Analysis, Sixth Edition.* New Jersey: United States of America.

Kurniawati, L. D. (2011). *Kekekaran Regresi Linear Ganda Dengan Estimasi MM (Method of Moment) Dalam Mengatasi Pencilan*. Universitas Negeri Yogyakarta, Yogyakarta.

Larasati, S. D., Nisa, K., & Setiawan, E. (2020). Analisis Regresi Komponen Utama Robust dengan Metode Minimum Covariance Determinant – Least Trimmed Square (MCD-LTS). *Jurnal Siger Matematika*, *1* : 1-9.

Montgomery, D. C., & Peck, E. A. (1992). *Introduction to Linear Regression Analysis, 2nd Edition.* New York: Wiley & Sons, Incorporated, John.

Mukhtar, N. (2019). *Analisis Komponen Utama Robust Dengan Metode Minimum Vector Variance*. Universitas Hasanuddin, Makassar.

Noeryanti. (2001). Detecting Multiple Outliers in Multivariate Samples With S-Estimation Method. *Jurnal Teknologi Industri*, *5* : 217-226.

Notiragayu, & Nisa, K. (2008). Analisis Regresi Komponen Utama Robust Untuk Data Mengandung Pencilan. *J. Sains MIPA*, *14*(1), 45–50.

Nurmiati, N., Raupong, & Islamiyati, A. (2014). Penggunaan Regresi Robust Pada Data Yang Mengandung Pencilan Dengan Metode Momen. *Jurnal Matematika, Statistika & Komputasi*, *10*(2), 114–123.

Putri, A. P. (2011). *Penggunaan Metode Ridge Trace dan Variance Inflation Factors (VIF) pada Regresi Ridge*. Universita Negeri Yogyakarta, Yogyakarta.

Ramadani, A. R. (2021). *Pemodelan Statistical Downscaling Menggunakan Regresi Komponen Utama Dengan Metode Minimum Vector Variance Untuk Pendugaan Curah Hujan (Studi Kasus:Data Curah Hujan Kabupaten Pangkep, Sulawesi Selatan)*. Universitas Hasanuddin, Makassar.

Siburian, J. N. J. O., Rahmaati, R., & Hoyyi, A. (2019). Regresi Komponen Utama Robust S-Estimator Untuk Analisis Pengaruh Jumlah Pengangguran DI Jawa Tengah. *Jurnal Gaussian*, *8*(4) : 439–450.

Yohai, V. J. (1987). High Breakdown Point and High Efficiency Robust Estimates for Regresion. *Annals of Statistics*, *15* : 642-656.

LAMPIRAN

LAMPIRAN

Lampiran 1. Data Jumlah Pengangguran di Sulawesi Selatan Tahun 2022

Y	X_1	X_2	X_3	X_4	X_5	X_6
1091	16,74	68,35	64,99	49,89	8,09	139,1
2698	31,29	70,34	74,39	65,94	8,01	443,3
2991	17,22	69,69	56,81	51,17	6,81	199,4
4687	50,59	65,13	63,89	51,63	6,75	410,6
3942	24,75	68,31	65,99	58,79	7,64	305,1
14328	57,96	70,99	70,91	60,37	8,40	783,2
2113	21,67	68,33	71,72	69,45	7,79	263,8
8424	33,90	71,00	70,84	66,55	8,02	403,7
10103	47,53	69,79	66,43	58,27	8,05	351,4
4495	14,73	71,53	70,73	62,85	8,25	186,9
9019	80,34	67,01	63,44	53,19	7,36	813,2
3906	17,21	69,70	77,72	69,58	7,96	236,0
5092	26,75	70,26	62,81	54,71	7,16	379,7
4877	15,56	72,06	68,92	58,58	8,04	327,4
4658	33,64	71,97	73,59	61,58	8,04	411,8
641	26,15	73,39	78,86	69,67	8,93	230,6
7055	46,50	71,36	71,22	65,25	8,48	369,8
3441	29,31	69,88	77,36	52,62	8,52	291,0
4774	42,29	70,51	72,13	61,54	7,87	327,8
7230	20,89	73,92	70,11	61,95	8,92	305,5
2327	27,79	70,36	79,37	68,42	8,26	268,2
86267	71,83	83,12	73,03	59,64	11,55	1432,2
4025	8,01	78,54	73,05	64,27	10,66	154,8
7541	14,78	78,91	84,59	68,68	11,09	190,9

Keterangan:

Y : Jumlah pengangguran

X_1 : Jumlah penduduk miskin

X_2 : Indeks Pembangunan Manusia

X_3 : Angka Partisipasi Sekolah untuk umur 16-18 tahun

X_4 : Angka Partisipasi Murni untuk umur 16-18 tahun

X_5 : Rata-rata lama sekolah

X_6 : Jumlah penduduk

Lampiran 2. Deskriptif data sebelum standarisasi dan sesudah standarisasi

Sebelum Standarisasi

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
X1	24	72,33	8,01	80,34	32,3929	3,80293	18,63049	347,095
X2	24	17,99	65,13	83,12	71,4354	,80533	3,94528	15,565
X3	24	27,78	56,81	84,59	70,9542	1,27256	6,23426	38,866
X4	24	19,78	49,89	69,67	61,0246	1,29254	6,33214	40,096
X5	24	4,80	6,75	11,55	8,3604	,24418	1,19621	1,431
X6	24	1293,1	139,1	1432,2	384,392	56,6641	277,5964	77059,749
Valid N (listwise)	24							

Sesudah Standarisasi

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Zscore(X1)	24	3,88234	-1,30876	2,57358	,0000000	,20412415	1,00000000	1,000
Zscore(X2)	24	4,55988	-1,59822	2,96166	,0000000	,20412415	1,00000000	1,000
Zscore(X3)	24	4,45602	-2,26878	2,18724	,0000000	,20412415	1,00000000	1,000
Zscore(X4)	24	3,12374	-1,75842	1,36532	,0000000	,20412415	1,00000000	1,000
Zscore(X5)	24	4,01267	-1,34627	2,66641	,0000000	,20412415	1,00000000	1,000
Zscore(X6)	24	4,65820	-,88363	3,77457	,0000000	,20412415	1,00000000	1,000
Valid N (listwise)	24							

Lampiran 3. Hasil Standarisasi Data

Z1	Z2	Z3	Z4	Z5	Z6
-0,840177	-0,782054	-0,956676	-1,758422	-0,226061	-0,883627
-0,059200	-0,277653	0,551121	0,776264	-0,292939	0,212209
-0,814413	-0,442407	-2,268781	-1,556279	-1,296108	-0,666405
0,976737	-1,598220	-1,133121	-1,483634	-1,346266	0,094412
-0,410237	-0,792192	-0,796272	-0,352895	-0,602250	-0,285637
1,372325	-0,112899	-0,007085	-0,103375	0,033091	1,436648
-0,575557	-0,787123	0,122843	1,330579	-0,476853	-0,434414
0,080893	-0,110364	-0,018313	0,872598	-0,284579	0,069555
0,812490	-0,417060	-0,725694	-0,435016	-0,259500	-0,118848
-0,948065	0,023974	-0,035957	0,288278	-0,092305	-0,711435
2,573581	-1,121700	-1,205302	-1,237272	-0,836322	1,544719
-0,814950	-0,439872	1,085267	1,351109	-0,334738	-0,534559
-0,302886	-0,297930	-1,306357	-0,997227	-1,003517	-0,016901
-0,903514	0,158312	-0,326288	-0,386059	-0,267860	-0,205304
0,066938	0,135500	0,422798	0,087714	-0,267860	0,098734
-0,335091	0,495424	1,268127	1,365322	0,476157	-0,554012
0,757204	-0,019116	0,042641	0,667296	0,099969	-0,052564
-0,165477	-0,394248	1,027521	-1,327289	0,133408	-0,336430
0,531230	-0,234563	0,188608	0,081397	-0,409976	-0,203863
-0,617424	0,629762	-0,135408	0,146146	0,467797	-0,284196
-0,247064	-0,272583	1,349933	1,167917	-0,083946	-0,418563
2,116803	2,961665	0,332972	-0,218659	2,666409	3,774575
-1,308764	1,800783	0,336180	0,512530	1,922392	-0,827070
-0,945381	1,894566	2,187242	1,208977	2,281861	-0,697025

Lampiran 4. Model Regresi Linear Berganda

```
> rm(list = ls())
> library(readxl)
> library(openxlsx)
> Data<-read_excel("C:/Data.xlsx")
> #regresi linear berganda
> analisis_regresi<-lm(formula =
Data$Y~Data$X1+Data$X2+Data$X3+Data$X4+Data$X5+Data$X6, data = Data)
> summary(analisis_regresi)

Call:
lm(formula = Data$Y ~ Data$X1 + Data$X2 + Data$X3 + Data$X4 +
    Data$X5 + Data$X6, data = Data)

Residuals:
   Min     1Q Median     3Q    Max
-11174  -3112   1020   3504   9765

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -45541.22   65990.13  -0.690 0.499432
Data$X1       -241.93     171.06  -1.414 0.175328
Data$X2        525.92    1243.40   0.423 0.677622
Data$X3       -310.73     419.73  -0.740 0.469204
Data$X4        -79.15     332.61  -0.238 0.814741
Data$X5       3462.53    4100.28   0.844 0.410139
Data$X6         58.04      12.33   4.707 0.000203 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6244 on 17 degrees of freedom
Multiple R-squared:  0.8983,   Adjusted R-squared:  0.8625
F-statistic: 25.04 on 6 and 17 DF,  p-value: 1.5e-07

> ##multikolienaritas
> library(car)
> vif(analisis_regresi)
  Data$X1   Data$X2   Data$X3   Data$X4   Data$X5   Data$X6
 5.991163 14.195103  4.038908  2.616571 14.190639  6.910780
> ##uji normalitas
> sisa<-residuals(analisis_regresi)
> sisa
          1           2           3           4           5           6
7
  2793.8590  -6313.7433   2596.8461   4949.9039    542.0911 -11174.4970
2459.4929
          8           9          10          11          12          13
14
   905.6175   7424.4943   3520.1970 -10005.6883   5352.6181  -2828.6170  -
4503.9700
         15          16          17          18          19          20
21
 -3511.6964   -374.0122   2785.6703   1134.6500   4472.1914  -2979.0533
3499.3175
         22          23          24
  9765.2766  -7910.4856  -2600.4625
> lillie.test(sisa)

        Lilliefors (Kolmogorov-Smirnov) normality test

data:  sisa
D = 0.13491, p-value = 0.3114
```

Lampiran 5. Tabel distribusi Chi-Square

Df	0,1	0,05	0,025	0,001	0,005
1	2,705543	3,841459	5,023886	6,634897	7,879439
2	4,605170	5,991465	7,377759	9,210340	10,596635
3	6,251389	7,814728	9,348404	11,344867	12,838156
4	7,779440	9,487729	11,143287	13,276704	14,860259
5	9,236357	11,070498	12,832502	15,086272	16,749602
6	10,644641	12,591587	14,449375	16,811894	18,547584
7	12,017037	14,067140	16,012764	18,475307	20,277740
8	13,361566	15,507313	17,534546	20,090235	21,954955
9	14,683657	16,918978	19,022768	21,665994	23,589351
10	15,987179	18,307038	20,483177	23,209251	25,188180
11	17,275009	19,675138	21,920049	24,724970	26,756849
12	18,549348	21,026070	23,336664	26,216967	28,299519
13	19,811929	22,362032	24,735605	27,688250	29,819471
14	21,064144	23,684791	26,118948	29,141238	31,319350
15	22,307130	24,995790	27,488393	30,577914	32,801321
16	23,541829	26,296228	28,845351	31,999927	34,267187
17	24,769035	27,587112	30,191009	33,408664	35,718466
18	25,989423	28,869299	31,526378	34,805306	37,156451
19	27,203571	30,143527	32,852327	36,190869	38,582257
20	28,411981	31,410433	34,169607	37,566235	39,996846
21	29,615089	32,670573	35,478876	38,932173	41,401065
22	30,813282	33,924438	36,780712	40,289360	42,795655
23	32,006900	35,172462	38,075627	41,638398	44,181275
24	33,196244	36,415029	39,364077	42,979820	45,558512
25	34,381587	37,652484	40,646469	44,314105	46,927890
26	35,563171	38,885139	41,923170	45,641683	48,289882
27	36,741217	40,113272	43,194511	46,962942	49,644915
28	37,915923	41,337138	44,460792	48,278236	50,993376
29	39,087470	42,556968	45,722286	49,587884	52,335618
30	40,256024	43,772972	46,979242	50,892181	53,671962

Lampiran 6. Tabel Uji F

α = 0,05	df2=(k-1)							
df2=(n-k-1)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	161.448	199.500	215.707	224.583	230.162	233.986	236.768	238.883
2	18.513	19.000	19.164	19.247	19.296	19.330	19.353	19.371
3	10.128	9.552	9.277	9.117	9.013	8.941	8.887	8.845
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726
8	5.318	4.459	4.066	3.838	3.687	3.581	3.500	3.438
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447
21	4.325	3.467	3.072	2.840	2.685	2.573	2.488	2.420
22	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397
23	4.279	3.422	3.028	2.796	2.640	2.528	2.442	2.375
24	4.260	3.403	3.009	2.776	2.621	2.508	2.423	2.355
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337
26	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321
27	4.210	3.354	2.960	2.728	2.572	2.459	2.373	2.305
28	4.196	3.340	2.947	2.714	2.558	2.445	2.359	2.291
29	4.183	3.328	2.934	2.701	2.545	2.432	2.346	2.278

30	4.171	3.316	2.922	2.690	2.534	2.421	2.334	2.266
31	4.160	3.305	2.911	2.679	2.523	2.409	2.323	2.255
32	4.149	3.295	2.901	2.668	2.512	2.399	2.313	2.244
33	4.139	3.285	2.892	2.659	2.503	2.389	2.303	2.235
34	4.130	3.276	2.883	2.650	2.494	2.380	2.294	2.225
35	4.121	3.267	2.874	2.641	2.485	2.372	2.285	2.217
36	4.113	3.259	2.866	2.634	2.477	2.364	2.277	2.209
37	4.105	3.252	2.859	2.626	2.470	2.356	2.270	2.201
38	4.098	3.245	2.852	2.619	2.463	2.349	2.262	2.194
39	4.091	3.238	2.845	2.612	2.456	2.342	2.255	2.187
40	4.085	3.232	2.839	2.606	2.449	2.336	2.249	2.180

Lampiran 7. Tabel Uji t

	0,25	**0,10**	**0,05**	**0,025**	**0,01**	**0,005**	**0,001**
	0,50	**0,20**	**0,10**	**0,050**	**0,02**	**0,010**	**0,002**
df	***α***						
1	1,00000	3,07768	6,31375	12,70620	31,82052	63,65674	318,30884
2	0,81650	1,88562	2,91999	4,30265	6,96456	9,92484	22,32712
3	0,76489	1,63774	2,35336	3,18245	4,54070	5,84091	10,21453
4	0,74070	1,53321	2,13185	2,77645	3,74695	4,60409	7,17318
5	0,72669	1,47588	2,01505	2,57058	3,36493	4,03214	5,89343
6	0,71756	1,43976	1,94318	2,44691	3,14267	3,70743	5,20763
7	0,71114	1,41492	1,89458	2,36462	2,99795	3,49948	4,78529
8	0,70639	1,39682	1,85955	2,30600	2,89646	3,35539	4,50079
9	0,70272	1,38303	1,83311	2,26216	2,82144	3,24984	4,29681
10	0,69981	1,37218	1,81246	2,22814	2,76377	3,16927	4,14370
11	0,69745	1,36343	1,79588	2,20099	2,71808	3,10581	4,02470
12	0,69548	1,35622	1,78229	2,17881	2,68100	3,05454	3,92963
13	0,69383	1,35017	1,77093	2,16037	2,65031	3,01228	3,85198
14	0,69242	1,34503	1,76131	2,14479	2,62449	2,97684	3,78739
15	0,69120	1,34061	1,75305	2,13145	2,60248	2,94671	3,73283
16	0,69013	1,33676	1,74588	2,11991	2,58349	2,92078	3,68615
17	0,68920	1,33338	1,73961	2,10982	2,56693	2,89823	3,64577
18	0,68836	1,33039	1,73406	2,10092	2,55238	2,87844	3,61048
19	0,68762	1,32773	1,72913	2,09302	2,53948	2,86093	3,57940
20	0,68695	1,32534	1,72472	2,08596	2,52798	2,84534	3,55181
21	0,68635	1,32319	1,72074	2,07961	2,51765	2,83136	3,52715
22	0,68581	1,32124	1,71714	2,07387	2,50832	2,81876	3,50499
23	0,68531	1,31946	1,71387	2,06866	2,49987	2,80734	3,48496
24	0,68485	1,31784	1,71088	2,06390	2,49216	2,79694	3,46678
25	0,68443	1,31635	1,70814	2,05954	2,48511	2,78744	3,45019

Lampiran 8. Output Penduga MVE Pada Rstudio

```
> #minimum volume ellipsoid
> mve<- DataStandarisasi
> c1 <- CovMve(mve)
> c1

Call:
CovMve(x = mve)
-> Method:  Minimum volume ellipsoid estimator

Robust Estimate of Location:
[1]  -0.1649  -0.2498  -0.1009   0.1720  -0.3515  -0.2360

Robust Estimate of Covariance:
      [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
[1,]  0.55188  -0.15895  -0.05185  -0.14706  -0.05517   0.16537
[2,] -0.15895   0.38191   0.27713   0.26396   0.29494  -0.03496
[3,] -0.05185   0.27713   1.27919   1.14922   0.49724  -0.02819
[4,] -0.14706   0.26396   1.14922   1.27338   0.48987  -0.06879
[5,] -0.05517   0.29494   0.49724   0.48987   0.36598  -0.03008
[6,]  0.16537  -0.03496  -0.02819  -0.06879  -0.03008   0.11480
```

Lampiran 9. Skor Komponen Utama

Pengamatan	K_1	K_2	K_3
1	-1,5601	0,7126	-1,3599
2	0,3447	0,3797	0,8636
3	-2,6620	0,7908	-1,6111
4	-2,8040	-0,5008	0,3180
5	-1,2215	0,6671	-0,1390
6	-0,3350	-1,5793	0,7419
7	0,0516	1,3248	1,0518
8	0,1022	0,2543	0,6687
9	-1,0399	-0,6066	0,1024
10	0,2139	1,0950	-0,3238
11	-2,5669	-2,4677	0,9151
12	0,9225	1,4753	1,0765
13	-1,7553	0,2568	-0,7915
14	-0,2603	0,7103	-0,7748
15	0,2116	-0,0079	0,2314
16	1,8183	0,6246	0,6695
17	0,2061	-0,4445	0,7095
18	0,0563	0,0090	-0,3364
19	-0,2335	-0,1709	0,5375
20	0,6006	0,3304	-0,7025
21	1,1355	0,8229	1,1741
22	2,3885	-4,4768	-0,8568
23	2,4170	0,4853	-1,6351
24	3,9697	0,3154	-0,5291

Lampiran 10. Nilai Eigen dan Vektor Eigen

```
> c1@cov
            [,1]        [,2]        [,3]        [,4]        [,5]
[,6]
[1,]  0.55188080 -0.15894881 -0.05184926 -0.14706228 -0.05517267
0.16537033
[2,] -0.15894881  0.38191107  0.27713460  0.26395865  0.29493893 -
0.03496264
[3,] -0.05184926  0.27713460  1.27919440  1.14922196  0.49724330 -
0.02819383
[4,] -0.14706228  0.26395865  1.14922196  1.27338056  0.48987112 -
0.06879397
[5,] -0.05517267  0.29493893  0.49724330  0.48987112  0.36597673 -
0.03007570
[6,]  0.16537033 -0.03496264 -0.02819383 -0.06879397 -0.03007570
0.11479802
> ev<-eigen(c1@cov)
> ev$values
[1] 2.74528209 0.65482553 0.36029343 0.11567822 0.06464268 0.02641964
> ev$vectors
            [,1]        [,2]        [,3]         [,4]        [,5]
[,6]
[1,]  0.08389544  0.85800038  0.34170380 -0.180302966 -0.21875177
0.24428243
[2,] -0.19403407 -0.36015585  0.71337819  0.007872574  0.21087554
0.52839344
[3,] -0.65730443  0.21977786 -0.08335794  0.712024332 -0.06611385
0.03674704
[4,] -0.65762722  0.05276344 -0.30228605 -0.649699337  0.17645490
0.14184513
[5,] -0.29921253 -0.09223674  0.49988306 -0.183886943 -0.33729399 -
0.71028130
[6,]  0.03551799  0.27300036  0.16162175  0.067279849  0.87086426 -
0.36763644
```

Lampiran 11. Output Regresi Komponen Utama

```
> ##Regresi Komponen Utama
> PC1<- 0.0839*Z1-0.1940*Z2-0.6573*Z3-0.6576*Z4-0.2992*Z5+0.0355*Z6
> PC2<- 0.8580*Z1-0.3602*Z2+0.2198*Z3+0.0528*Z4-0.0922*Z5+0.2730*Z6
> PC3<- 0.3417*Z1+0.7134*Z2-0.0834*Z3-0.3023*Z4+0.4999*Z5+0.1616*Z6
> Y<-Data$Y
> model_regresi<-lm(Y~PC1+PC2+PC3)
> summary(model_regresi)

Call:
lm(formula = Y ~ PC1 + PC2 + PC3)

Residuals:
     Min       1Q   Median       3Q      Max 
-14502.6  -4424.3    201.9   4352.7  19942.4 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   8571.9     1724.9   4.969 7.37e-05 ***
PC1            512.4     1274.9   0.402   0.6920    
PC2           3423.6     1764.2   1.941   0.0665 .  
PC3          10975.1     1533.1   7.159 6.21e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8450 on 20 degrees of freedom
Multiple R-squared:  0.781,	Adjusted R-squared:  0.7481 
F-statistic: 23.77 on 3 and 20 DF,  p-value: 8.421e-07

> #multikolienaritas
> library(car)
> vif(model_regresi)
     PC1      PC2      PC3 
1.266230 1.194980 1.207481 
```

Lampiran 12. Hasil Transformasi dari Variabel baru ke Variabel asal pada Model PCR:

$$Z_j = \frac{X_j - \bar{X}_J}{\sigma_j}$$

$$Z_1 = \frac{X_1 - 32{,}3929}{3{,}8029}$$

$$Z_2 = \frac{X_2 - 71{,}4354}{0{,}8053}$$

$$Z_3 = \frac{X_3 - 70{,}9542}{1{,}2757}$$

$$Z_4 = \frac{X_4 - 61{,}0246}{1{,}2925}$$

$$Z_5 = \frac{X_5 - 8{,}3604}{0{,}2442}$$

$$Z_6 = \frac{X_6 - 384{,}3917}{56{,}6641}$$

$$\begin{aligned} Y_{RKU} = {} & 8571{,}9 + 3750{,}1917\left(\frac{X_1 - 32{,}3929}{3{,}8029}\right) + 7829{,}6363\left(\frac{X_2 - 71{,}4354}{0{,}8053}\right) \\ & - 915{,}3233\left(\frac{X_3 - 70{,}9542}{1{,}2757}\right) - 3317{,}7727\left(\frac{X_4 - 61{,}0246}{1{,}2925}\right) \\ & + 5486{,}4525\left(\frac{X_5 - 8{,}3604}{0{,}2442}\right) + 1773{,}5762\left(\frac{X_6 - 384{,}3917}{56{,}6641}\right) \end{aligned}$$

$$\begin{aligned} Y_{RKU} = {} & 8571{,}9 + 986{,}1400X_1 - 31943{,}9335 + 9722{,}6330X_2 - 694540{,}1725 \\ & - 717{,}5067X_3 + 50910{,}1140 - 2566{,}9421X_4 + 156646{,}6166 \\ & + 22467{,}0455X_5 - 187833{,}4868 + 31{,}2998X_6 - 12031{,}3915 \end{aligned}$$

$$\begin{aligned} Y_{RKU} = {} & -710220{,}3355 + 986{,}1400X_1 + 9722{,}6330X_2 - 717{,}5067X_3 - 2566{,}9421X_4 \\ & + 22467{,}0455X_5 + 31{,}2998X_6 \end{aligned}$$

Lampiran 13. Penduga MVE Berdasarkan Skor Komponen Utama

```
> #minimum volume ellipsoid
> mve1<-read_excel("C:/AKU.xlsx")
> c2 <- CovMve(mve1)
> c2

Call:
CovMve(x = mve1)
-> Method:  Minimum volume ellipsoid estimator

Robust Estimate of Location:
     K1       K2       K3
-0.1792   0.3497   0.0941

Robust Estimate of Covariance:
    K1        K2        K3
K1   1.74519   0.14374   0.97479
K2   0.14374   0.78840  -0.09056
K3   0.97479  -0.09056   1.08064
```

Lampiran 14. Jarak Mahalanobis dan Q-Q Plot

```
> #mahalanobis
> c2@cov
          K1          K2          K3
K1 1.7451894  0.14374164  0.97478765
K2 0.1437416  0.78840255 -0.09055549
K3 0.9747877 -0.09055549  1.08063604
> c2@center
         K1          K2          K3
-0.17916942  0.34971049  0.09409813
> Sx<-c2@cov
> z<-c2@center
> D2<-mahalanobis(mve1,z,Sx)
> D2
 [1]  2.0548174  0.6080471  4.1312409  9.2879841  1.2165935  4.9391392
3.3736756
 [8]  0.3706214  1.6078750  1.2063784 17.1063118  2.7840239  1.4252769
1.2842746
[15]  0.3388423  2.8361040  1.0592595  1.0235736  0.6049232  3.4938933
1.5257305
[22] 60.9390846 24.3637201 28.3777538
> qqplot(qchisq(ppoints(24), df=3),D2,
+        main=expression("Q-Q plot of Mahalanobis"*~D^2*
+                        "vs. quantiles of"*~chi[3]^2))
> abline(0,1,col='green')
```

Lampiran 15. Analisis Regresi Komponen Utama *Robust* dari software R

```
> #input data
> rm(list = ls())
> library(readxl)
> library(openxlsx)
> Data<-read_excel("C:/AKU1.xlsx")
> data=data.frame(k1=Data$K1,k2=Data$K2,k3=Data$K3,y=Data$Y)
> #model MM
> summary( m1 <- lmrob(y ~ k1+k2+k3, data = data) )

Call:
lmrob(formula = y ~ k1 + k2 + k3, data = data)
 \--> method = "MM"
Residuals:
    Min      1Q  Median      3Q     Max 
-4084.3 -1544.3   220.2  1642.1 67519.9 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   5718.0      593.3   9.637 5.87e-09 ***
k1             415.4      218.4   1.902  0.07168 .  
k2           -2664.9      788.2  -3.381  0.00297 ** 
k3            -124.9      455.4  -0.274  0.78673    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Robust residual standard error: 2485 
Multiple R-squared:  0.4847,	Adjusted R-squared:  0.4075 
Convergence in 11 IRWLS iterations

Robustness weights: 
 observation 22 is an outlier with |weight| = 0 ( < 0.0042); 
 2 weights are ~= 1. The remaining 21 ones are summarized as
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
 0.7084  0.9267  0.9622  0.9318  0.9809  0.9988 
Algorithmic parameters: 
       tuning.chi                bb        tuning.psi        refine.tol 
        1.548e+00         5.000e-01         4.685e+00         1.000e-07 
          rel.tol         scale.tol         solve.tol          zero.tol 
        1.000e-07         1.000e-10         1.000e-07         1.000e-10 
      eps.outlier             eps.x warn.limit.reject warn.limit.meanrw 
        4.167e-03         8.143e-12         5.000e-01         5.000e-01 
     nResample         max.it       best.r.s       k.fast.s          k.max 
           500             50              2              1            200 
   maxit.scale      trace.lev            mts     compute.rd fast.s.large.n 
           200              0           1000              0           2000 
                  psi           subsampling                   cov 
           "bisquare"         "nonsingular"         ".vcov.avar1" 
compute.outlier.stats 
                 "SM" 
seed : int(0) 
> ## Nowadays **strongly recommended** for routine use:
> summary(m2 <- lmrob(y ~ k1+k2+k3, data = data, setting = "KS2014") )

Call:
lmrob(formula = y ~ k1 + k2 + k3, data = data, setting = "KS2014")
 \--> method = "SMDM"
Residuals:
    Min      1Q  Median      3Q     Max 
-4087.5 -1543.4   216.6  1655.6 67437.9 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   5728.4      529.2  10.825 8.21e-10 ***
k1             413.3      344.0   1.202   0.2436    
k2           -2684.5      647.5  -4.146   0.0005 ***
k3            -111.6      607.3  -0.184   0.8560    
---
```

```
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Robust residual standard error: 2392
Multiple R-squared:  0.4928,  Adjusted R-squared:  0.4168
Convergence in 8 IRWLS iterations

Robustness weights:
 observation 22 is an outlier with |weight| = 0 ( < 0.0042);
 19 weights are ~= 1. The remaining 4 ones are
     6      8      9     16
0.7686 0.9297 0.9531 0.8427
Algorithmic parameters:
      tuning.chi1       tuning.chi2       tuning.chi3       tuning.chi4
       -5.000e-01        1.500e+00                NA        5.000e-01
               bb       tuning.psi1       tuning.psi2       tuning.psi3
        5.000e-01       -5.000e-01        1.500e+00        9.500e-01
      tuning.psi4        refine.tol           rel.tol         scale.tol
               NA        1.000e-07         1.000e-07        1.000e-10
        solve.tol          zero.tol       eps.outlier             eps.x
        1.000e-07        1.000e-10         4.167e-03        8.143e-12
warn.limit.reject warn.limit.meanrw
        5.000e-01        5.000e-01
     nResample         max.it       best.r.s       k.fast.s          k.max
          1000            500             20              2           2000
   maxit.scale      trace.lev            mts     compute.rd      numpoints
           200              0           1000              0             10
fast.s.large.n
          2000
              setting                  psi           subsampling
             "KS2014"                "lqq"         "nonsingular"
                  cov compute.outlier.stats
            ".vcov.w"                "SMDM"
seed : int(0)
> ##--- 'init' argument -----------------------------------
> ## 1)  string
> set.seed(0)
> m3 <- lmrob(y ~ k1+k2+k3, data = data, init = "S")
> stopifnot(all.equal(m1[5], m3[5]))
> ## 2) function
> initFun <- function(x, y, control, ...) { # no 'mf' needed
+   init.S <- lmrob.S(x, y, control)
+   list(coefficients=init.S$coef, scale = init.S$scale)
+ }
> set.seed(0)
> m4 <- lmrob(y ~ k1+k2+k3, data = data, method = "M", init = initFun)
> ## list
> m5 <- lmrob(y ~ k1+k2+k3, data = data, method = "M",
+             init = list(coefficients = m3$init$coef, scale = m3$scale))
> stopifnot(all.equal(m4[4], m5[4]))
> m3

Call:
lmrob(formula = y ~ k1 + k2 + k3, data = data, init = "S")
 \--> method = "MM"
Coefficients:
(Intercept)           k1           k2           k3
     5718.0        415.4      -2664.9       -124.9

> m4

Call:
lmrob(formula = y ~ k1 + k2 + k3, data = data, method = "M", init =
initFun)

Coefficients:
(Intercept)           k1           k2           k3
     5718.0        415.4      -2664.9       -124.9

> m5
```

```
Call:
lmrob(formula = y ~ k1 + k2 + k3, data = data, method = "M", init =
list(coefficients = m3$init$coef,     scale = m3$scale))

Coefficients:
(Intercept)           k1           k2           k3
     5718.0        415.4      -2664.9       -124.9
```

Lampiran 16. Hasil Transformasi dari Variabel baru ke Variabel asal pada Model ROBPCA

$$Z_j = \frac{X_j - \bar{X}_J}{\sigma_j}$$

$$Z_1 = \frac{X_1 - 32,3929}{3,8029}$$

$$Z_2 = \frac{X_2 - 71,4354}{0,8053}$$

$$Z_3 = \frac{X_3 - 70,9542}{1,2757}$$

$$Z_4 = \frac{X_4 - 61,0246}{1,2925}$$

$$Z_5 = \frac{X_5 - 8,3604}{0,2442}$$

$$Z_6 = \frac{X_6 - 384,3917}{56,6641}$$

$$\begin{aligned} Y_{ROBPCA} = 5718,0 &- 2286,4842\left(\frac{X_1 - 32,3929}{3,8029}\right) + 959,8970\left(\frac{X_2 - 71,4354}{0,8053}\right) \\ &- 585,7450\left(\frac{X_3 - 70,9542}{1,2757}\right) - 140,7067\left(\frac{X_4 - 61,0246}{1,2925}\right) \\ &+ 245,7038\left(\frac{X_5 - 8,3604}{0,2442}\right) - 727,5177\left(\frac{X_6 - 384,3917}{56,6641}\right) \end{aligned}$$

$$\begin{aligned} Y_{ROBPCA} = 5718,0 &- 601,2475X_1 + 19476,1508 + 1191,9744X_2 - 85149,1694 \\ &- 459,1558X_3 + 32579,0295 - 108,8640X_4 + 6643,3811 + 1006,1581X_5 \\ &- 8411,8839 - 12,8391X_6 + 4935,2547 \end{aligned}$$

$$\begin{aligned} Y_{ROBPCA} = -24209,2372 &- 601,2475X_1 + 1191,9744X_2 - 459,1558X_3 - 108,8640X_4 \\ &+ 1006,1581X_5 - 12,8391X_6 \end{aligned}$$