

Análise Fatorial - Modelo Via Matriz de Correlação no R

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```
# Carregar o conjunto de dados
db <- read.csv("https://raw.githubusercontent.com/gabrieldacarvalho/analise_fatorial/main/RTE_CEREAL.csv")

# Visualizar as primeiras linhas do conjunto de dados
print(head(db))
```

##	identidade	numero	satisfaz	natural	fibra	doce	facil	sal	gratificante	energia
## 1	101	25	5	5	5	1	2	1	5	4
## 2	101	21	1	2	2	1	5	2	5	1
## 3	103	21	5	4	5	5	5	3	5	5
## 4	103	3	5	5	5	3	5	2	5	5
## 5	104	14	4	5	3	2	5	2	5	4
## 6	104	19	4	4	4	2	5	2	5	4
##	divertido	criancas	encharcado	economico	saude	familia	calorias	simples		
## 1	1	4	5	5	5	5	1	3		
## 2	1	5	3	5	2	5	1	5		
## 3	5	5	3	3	5	5	1	1		
## 4	5	5	3	3	5	5	1	1		
## 5	5	5	1	5	5	3	3	1		
## 6	5	5	1	5	4	5	3	1		
##	crocante	regular	acucar	fruta	processo	qualidade	prazer	chato	nutritivo	
## 1	1	4	1	1	3	5	1	1	5	
## 2	5	1	2	1	5	2	1	1	3	
## 3	5	4	3	1	2	5	4	1	5	
## 4	1	4	2	5	2	5	5	1	5	
## 5	5	3	1	1	3	5	5	1	4	
## 6	5	3	2	1	3	5	5	1	4	

```

# Selecionar as variáveis para análise (excluindo as variáveis de identificação)
x <- as.matrix(db[, 3:27])

# Obter o número de observações
n <- nrow(x)

# Calcular a média de cada variável
matriz_media <- matrix(1, nrow = 1, ncol = n)
matriz_media <- (matriz_media %*% x) / n

# Centralizar os dados subtraindo a média de cada variável
x_centralizado <- sweep(x, 2, matriz_media, "-")

# Padronizar os dados dividindo pelo desvio padrão de cada variável
z <- sweep(x_centralizado, 2, apply(x, 2, sd), "/")

# Calcular a matriz de correlação amostral
matriz_r <- (t(z) %*% z) / (n - 1)

```

Estimação do número de fatores m:

Para estimar o número ideal de fatores, procedemos da seguinte maneira:

1. Estimar a matriz de correlação teórica $P_{p \times p}$ a partir da matriz de correlação amostral $R_{p \times p}$.
2. Obter os autovalores da matriz $R_{p \times p}$
3. Ordenar os autovalores em ordem crescente e pegar a quantidade de autovalores maior ou igual a 1 para ser a quantidade de fatores m

```

# Visualizar os autovalores e autovetores
eigen_vals <- eigen(matriz_r)$values
eigen_vecs <- eigen(matriz_r)$vectors

print("Autovalores:")

```

```
## [1] "Autovalores:"
```

```
print(eigen_vals)
```

```
## [1] 6.5044682 3.8210452 2.5019953 1.6839941 1.0853540 0.9330069 0.8516405
## [8] 0.7868366 0.7317169 0.6958507 0.6468294 0.5479585 0.5291569 0.4896236
## [15] 0.4177428 0.3870740 0.3624610 0.3588295 0.3047541 0.2741921 0.2624481
## [22] 0.2422794 0.2179754 0.1985309 0.1642362
```

```
print("Autovetores:")
```

```
## [1] "Autovetores:"
```

```
print(eigen_vecs)
```

##		[,1]	[,2]	[,3]	[,4]	[,5]	[,6]
##	[1,]	-0.29283146	-0.04713559	0.04840023	0.171402415	0.11356016	-0.008882289
##	[2,]	-0.29342785	0.13437572	0.07895246	0.102266712	0.13799388	-0.064740831
##	[3,]	-0.28598791	0.12846911	0.20633787	0.143263174	-0.15594731	0.020346564
##	[4,]	-0.03676974	-0.39423373	0.12694994	0.138181896	0.15943049	-0.119075656
##	[5,]	-0.13777643	-0.08242511	-0.17423503	0.124158342	-0.02722728	-0.648664520
##	[6,]	0.08477113	-0.28124712	0.08431266	0.373634113	-0.12376009	-0.116996766
##	[7,]	-0.29175299	-0.08812314	-0.11077412	0.151099901	0.09537348	-0.126747183
##	[8,]	-0.28561919	-0.06535725	0.04772693	0.127211381	0.03808313	0.132357969
##	[9,]	-0.16297365	-0.26942651	-0.15341519	-0.121507976	0.08534958	0.178549852
##	[10,]	-0.08756658	-0.13886923	-0.49247836	0.072419742	0.08973519	0.104793106
##	[11,]	0.04356929	0.13773162	-0.12084102	0.442176946	0.48808299	0.166992867
##	[12,]	-0.06291807	0.14030658	-0.37156392	0.076328046	-0.22486253	-0.094049916
##	[13,]	-0.31784571	0.16409873	0.07387924	0.070526179	-0.07411969	-0.014283168
##	[14,]	-0.12601265	-0.10889183	-0.45527177	0.009448003	0.14140024	0.202383765
##	[15,]	0.06534285	-0.32199465	0.11546290	0.213697326	0.01500980	-0.048910706
##	[16,]	0.12953422	0.20084232	-0.16897795	0.374678160	-0.14120148	-0.231231764
##	[17,]	-0.12323305	-0.25464928	-0.16494502	-0.183421497	-0.40022464	-0.177646787
##	[18,]	-0.24267390	0.07866198	0.13897823	0.073063108	-0.37888730	0.089318040
##	[19,]	0.09728399	-0.38206011	0.14777813	0.200287111	-0.09218179	0.008677308
##	[20,]	-0.15467366	-0.13975349	0.34710902	-0.106207164	0.27357494	-0.056622558
##	[21,]	0.12876511	-0.16252094	-0.01317088	0.267242233	-0.33825966	0.424574277
##	[22,]	-0.29512049	0.08074109	-0.02839622	-0.009766822	-0.08479795	0.217933527
##	[23,]	-0.19188828	-0.30130316	-0.05405954	-0.149346254	-0.06079700	0.189362777
##	[24,]	0.16233650	0.14844305	0.07211682	0.340991517	-0.15856714	0.169813574
##	[25,]	-0.31589084	0.11935017	0.09705636	0.116507170	-0.06646515	0.034804697
##		[,7]	[,8]	[,9]	[,10]	[,11]	
##	[1,]	-0.260550571	-0.39195323	0.019076817	-0.052400653	-0.05173600	
##	[2,]	-0.003503639	0.06007723	0.210728129	0.081958723	-0.04955452	
##	[3,]	0.130618196	-0.12609167	-0.021730198	0.181644703	-0.04056884	
##	[4,]	-0.069191889	0.08032406	-0.193212544	0.121607659	-0.05686201	
##	[5,]	0.492383405	-0.10051854	0.174781247	-0.233013371	-0.21359495	
##	[6,]	-0.191723123	0.22852381	-0.029339334	0.014474393	-0.35791821	
##	[7,]	-0.172783949	-0.09043298	0.089339879	-0.130188636	0.11404609	
##	[8,]	-0.138877805	-0.28616468	0.114332016	-0.215894676	0.29071487	
##	[9,]	0.229798072	0.03213997	-0.349136414	-0.390104979	0.17400380	
##	[10,]	0.006253202	-0.13806055	-0.055078525	0.298825294	-0.12086171	
##	[11,]	0.190277865	0.29599748	-0.115767204	-0.076489680	0.11639617	
##	[12,]	-0.439023502	0.36647620	-0.178645776	-0.238229437	0.09834643	
##	[13,]	-0.010308094	0.19664368	0.068227539	-0.018340429	-0.04060630	
##	[14,]	0.099190262	-0.17043356	-0.004859398	0.370764242	-0.09084540	
##	[15,]	-0.289763635	-0.07383096	0.257232446	0.038008021	0.32470193	
##	[16,]	0.124586318	0.07714835	-0.114774699	0.179162781	0.45642587	
##	[17,]	0.032777917	0.01840972	-0.066145699	-0.004983553	0.25287134	
##	[18,]	0.118639475	-0.06189966	-0.380250387	0.338399870	0.09634554	
##	[19,]	0.003333425	0.11161606	-0.127993532	0.184352305	-0.15079221	
##	[20,]	0.208240044	0.17285961	-0.187209628	0.055478454	0.28794330	
##	[21,]	0.348060630	0.05735901	0.472429293	-0.101112531	0.14876040	
##	[22,]	-0.025228195	0.32013364	0.202065045	-0.043981543	-0.21508496	
##	[23,]	0.081888337	0.14990140	-0.054123572	-0.203658823	-0.11944133	
##	[24,]	0.043599329	-0.38148853	-0.371886086	-0.378835686	-0.23218415	
##	[25,]	0.042127609	0.16308295	-0.071087173	0.022497621	-0.10739260	

##		[,12]	[,13]	[,14]	[,15]	[,16]	[,17]
##	[1,]	0.10890013	-0.079737213	0.11263805	-0.11650741	-0.05032466	-0.15225734
##	[2,]	-0.27610204	-0.108931363	-0.08855998	0.25187962	0.39403767	-0.25459741
##	[3,]	-0.02664285	0.012591098	-0.14754148	-0.02427187	0.21726088	-0.15277442
##	[4,]	0.23283608	0.074215062	-0.19911460	0.14849316	-0.28487994	-0.45790562
##	[5,]	0.12708415	-0.197542753	-0.09145665	0.05501418	-0.02472781	0.09163146
##	[6,]	-0.16405329	0.286147185	0.27390905	-0.24045303	0.37040277	0.23170728
##	[7,]	0.21056789	0.108806447	0.37055570	0.04201231	-0.17246318	0.27224750
##	[8,]	0.13890549	0.351024414	-0.16499865	-0.09872153	0.03118577	-0.00710282
##	[9,]	0.05151805	-0.162778564	-0.07971333	-0.33021127	0.32197207	0.06598175
##	[10,]	-0.11235705	-0.020294639	0.03482637	0.11628624	0.19445564	-0.17155212
##	[11,]	-0.01339806	0.160755000	-0.34468386	0.05681723	-0.01682895	0.15700735
##	[12,]	0.24829683	-0.208793014	0.03119030	0.34232792	0.15388267	-0.11713346
##	[13,]	-0.03901835	0.101279396	0.08503263	-0.07912517	-0.12153988	-0.14089674
##	[14,]	-0.06828079	-0.009077703	0.14916750	0.09343929	-0.14069439	0.21204496
##	[15,]	-0.34069338	-0.512829077	-0.23108324	0.01907590	-0.00620029	0.23571314
##	[16,]	-0.18475513	-0.035272975	0.23754964	-0.38479549	-0.21573484	-0.26729087
##	[17,]	-0.34410643	0.467504287	-0.25926392	0.24585533	-0.09743028	0.10271866
##	[18,]	0.25217021	-0.245208624	-0.08059285	-0.02343870	0.08961038	0.25485501
##	[19,]	0.22047436	-0.045487675	-0.12847547	0.02473639	-0.11994698	0.01824750
##	[20,]	-0.09786047	-0.038637587	0.48322057	0.40466463	0.01471941	0.10473989
##	[21,]	0.24257399	0.017490762	0.17680907	0.20824509	0.09480032	-0.13926803
##	[22,]	-0.05957188	-0.165732368	-0.11009651	-0.08398027	-0.43870808	0.21922328
##	[23,]	-0.30780488	-0.170605577	0.16548728	-0.19234133	-0.14826412	-0.34494171
##	[24,]	-0.30918648	-0.061097200	0.06687987	0.32965343	-0.20251407	0.01103467
##	[25,]	-0.15450761	0.079775969	-0.06713968	-0.01189865	-0.04642707	0.07337999
##		[,18]	[,19]	[,20]	[,21]	[,22]	
##	[1,]	-0.3137747159	-0.25101615	-0.02199774	-0.418431453	0.111555065	
##	[2,]	0.1111966360	-0.44134240	-0.01149845	0.328593108	0.053532272	
##	[3,]	-0.1163388149	0.08915311	-0.34678742	-0.173150404	-0.262022173	
##	[4,]	0.1718604245	0.17476087	-0.11859877	-0.086153707	0.236070552	
##	[5,]	0.0212471566	0.05854526	0.19444826	-0.061706831	-0.007438498	
##	[6,]	0.0573833388	0.00693076	0.11774355	-0.122525792	0.161986080	
##	[7,]	-0.2038868660	0.07226958	-0.40962500	0.469919311	-0.031871676	
##	[8,]	0.3524058968	0.04959682	0.51134063	0.139366221	-0.113128315	
##	[9,]	0.2394359820	-0.13869425	-0.32721132	-0.098833591	0.051883342	
##	[10,]	0.1429029870	0.34929042	-0.05579643	0.223469172	0.239224925	
##	[11,]	-0.3959182794	-0.01041709	0.07744002	-0.012760480	0.065819105	
##	[12,]	0.0044110276	-0.01645519	0.11139888	-0.162436092	-0.176084007	
##	[13,]	0.0121442644	0.01087225	0.01798280	-0.190026546	0.227537754	
##	[14,]	0.0908719083	-0.21373586	0.13409393	-0.317034239	-0.260482554	
##	[15,]	-0.0007652271	0.20161010	-0.02262202	-0.090215943	0.007353163	
##	[16,]	0.1639912286	-0.13680613	-0.02594938	0.047990939	-0.041707325	
##	[17,]	-0.1858977119	-0.17261712	-0.12413712	-0.085098063	0.107002667	
##	[18,]	-0.1848145508	0.04581152	0.27370124	0.178643867	0.300824971	
##	[19,]	0.0595644835	-0.40372688	-0.01726733	0.237732277	-0.428498400	
##	[20,]	0.1321995100	0.01008229	0.12624350	-0.156214450	0.020327996	
##	[21,]	-0.0478393675	0.04966933	-0.07535443	-0.108072576	0.058428510	
##	[22,]	0.3111742219	-0.17210062	-0.08592312	0.006910858	0.260890739	
##	[23,]	-0.4264848280	0.08110972	0.32624451	0.211604089	-0.155216197	
##	[24,]	0.1339650644	-0.03555724	-0.04097278	0.069261408	0.051777327	
##	[25,]	0.1345083537	0.45919024	-0.09116471	-0.076008395	-0.468294449	

```
##           [,23]           [,24]           [,25]
## [1,]  0.4084615142 -0.230892723 -0.014450298
## [2,]  0.0340194498  0.039236861  0.313736674
## [3,] -0.5111330444 -0.183353445 -0.341724132
## [4,] -0.2073967215 -0.003267823  0.330541212
## [5,] -0.0069772856 -0.022478762 -0.047469721
## [6,] -0.1274183390 -0.089381093  0.068091877
## [7,] -0.1439575363  0.078061101  0.092318435
## [8,] -0.1203188242 -0.053476068 -0.114730938
## [9,]  0.0395550556  0.102359620  0.067000670
## [10,]  0.2557064849 -0.085510538 -0.399723208
## [11,] -0.0007679981 -0.041200547 -0.065076562
## [12,] -0.0953012605 -0.065442024 -0.058411394
## [13,]  0.0455621195  0.767281864 -0.267087216
## [14,] -0.2795235505  0.190412040  0.253300529
## [15,] -0.0562113108  0.160872724 -0.033995345
## [16,]  0.0252114478 -0.124909751  0.032313922
## [17,]  0.1019835697 -0.063914071 -0.002035086
## [18,]  0.0109165719  0.019776795  0.186040857
## [19,]  0.2593397814  0.136969006 -0.336097250
## [20,]  0.0430391417 -0.159164079 -0.217761930
## [21,]  0.0963500967 -0.012557742  0.116729736
## [22,] -0.0552219860 -0.379954667 -0.136301040
## [23,] -0.1546552464 -0.053526361  0.003430372
## [24,] -0.0606792565  0.084975102 -0.010863298
## [25,]  0.4434485948 -0.025749889  0.331376091
```

```
# Selecionar os m maiores autovalores e autovetores correspondentes
m <- sum(eigen_vals > 1)
autovalores <- eigen_vals[1:m]
autovetores <- eigen_vecs[, 1:m]
```

Estimação para matriz L e ψ

```
matriz_l <- sqrt(autovalores) * autovetores
matriz_psi <- matriz_r - matriz_l %*% t(matriz_l)
matriz_r_hat <- matriz_l %*% t(matriz_l) + matriz_psi

# Visualizar as matrizes estimadas
print("Matriz L:")
```

```
## [1] "Matriz L:"
```

```
print(matriz_l)
```

```
##          [,1]      [,2]      [,3]      [,4]      [,5]
## [1,] -0.74683322 -0.12021394  0.12343927  0.43714230  0.28962222
## [2,] -0.57357791  0.26267086  0.15433228  0.19990579  0.26974345
## [3,] -0.45236701  0.20320854  0.32637899  0.22660934 -0.24667272
## [4,] -0.04771565 -0.51159237  0.16474141  0.17931699  0.20689103
## [5,] -0.14353593 -0.08587074 -0.18151861  0.12934856 -0.02836547
## [6,]  0.21619909 -0.71728868  0.21502983  0.95291117 -0.31563599
## [7,] -0.57030398 -0.17225866 -0.21653565  0.29536244  0.18643126
## [8,] -0.45178377 -0.10338011  0.07549300  0.20121910  0.06023874
## [9,] -0.21148894 -0.34963154 -0.19908504 -0.15767944  0.11075712
## [10,] -0.09122715 -0.14467441 -0.51306554  0.07544712  0.09348641
## [11,]  0.11111849  0.35126879 -0.30819122  1.12772184  1.24479997
## [12,] -0.12298906  0.27426420 -0.72631435  0.14920220 -0.43954989
## [13,] -0.50275871  0.25956639  0.11685994  0.11155617 -0.11724027
## [14,] -0.16352511 -0.14130762 -0.59080070  0.01226056  0.18349340
## [15,]  0.06807440 -0.33545507  0.12028962  0.22263056  0.01563726
## [16,]  0.33036224  0.51222542 -0.43095897  0.95557389 -0.36011826
## [17,] -0.24088972 -0.49777553 -0.32242617 -0.35854306 -0.78233888
## [18,] -0.38385421  0.12442513  0.21983155  0.11556901 -0.59931243
## [19,]  0.12624426 -0.49579481  0.19176991  0.25991018 -0.11962320
## [20,] -0.16113951 -0.14559564  0.36161930 -0.11064697  0.28501126
## [21,]  0.32840073 -0.41449111 -0.03359084  0.68157082 -0.86269268
## [22,] -0.57688660  0.15782859 -0.05550750 -0.01909169 -0.16575874
## [23,] -0.30352306 -0.47659220 -0.08550975 -0.23623137 -0.09616685
## [24,]  0.21066212  0.19263276  0.09358513  0.44250059 -0.20577068
## [25,] -0.32909609  0.12433940  0.10111363  0.12137755 -0.06924361
```

```
print("Matriz  $\psi$ :")
```

```
## [1] "Matriz  $\psi$ :"
```

```
print(matriz_psi)
```

##	satisfaz	natural	fibra	doce	facil	
##	satisfaz	0.13757708	-0.04166215	0.170682245	-0.065378964	0.09308723
##	natural	-0.04166215	0.46547009	0.310312159	-0.101009073	0.18098287
##	fibra	0.17068224	0.31031216	0.535347909	0.001607988	0.14717597
##	doce	-0.06537896	-0.10100907	0.001607988	0.633898253	0.09300943
##	facil	0.09308723	0.18098287	0.147175969	0.093009425	0.92153899
##	sal	-0.31271560	-0.04299191	-0.295306055	-0.053647374	-0.09680390
##	gratificante	0.04549631	0.10546597	0.234792613	0.013575978	0.19343701
##	energia	0.17219731	0.19343847	0.264988136	0.049534017	0.09829023
##	divertido	0.12666196	0.08480612	0.166137891	0.176420474	0.17526648
##	criancas	0.07775963	0.08485138	0.066717414	0.096528152	0.12621208
##	encharcado	-0.75012492	-0.47378415	0.089311150	-0.307729173	-0.12919311
##	economico	0.14479704	0.16140942	-0.050516190	0.078467707	-0.06515903
##	saude	0.17355966	0.32283469	0.311465856	-0.021819024	0.15760388
##	familia	0.10818756	0.08963726	0.179652246	0.020504989	0.09594741
##	calorias	-0.05897053	-0.10180118	-0.173432966	0.235971058	-0.04096782
##	simples	-0.20257216	-0.11094557	-0.242206873	-0.037593506	-0.10298854
##	crocante	0.30987368	0.34657776	0.034006369	0.275882676	0.14056224
##	regular	0.24469961	0.26941585	0.203677004	0.087212373	0.06878910
##	acucar	-0.14648162	-0.16344897	-0.218704296	0.347311865	-0.03238769
##	fruta	0.04450393	0.13539746	0.227186339	0.165631866	0.08960291
##	processo	-0.08022837	0.09433380	-0.318733513	-0.016061856	-0.15550924
##	qualidade	0.09455709	0.26384865	0.201711856	0.022532112	0.08986230
##	prazer	0.19534165	0.20685202	0.156939445	0.194314388	0.12671219
##	chato	-0.14275627	-0.19475101	-0.224683706	-0.143925841	-0.16684350
##	nutritivo	0.24989586	0.40811232	0.461338755	-0.023348770	0.16925019
##	sal	gratificante	energia	divertido	criancas	
##	satisfaz	-0.312715602	0.04549631	0.17219731	0.12666196	0.077759634
##	natural	-0.042991912	0.10546597	0.19343847	0.08480612	0.084851383
##	fibra	-0.295306055	0.23479261	0.26498814	0.16613789	0.066717414
##	doce	-0.053647374	0.01357598	0.04953402	0.17642047	0.096528152
##	facil	-0.096803898	0.19343701	0.09829023	0.17526648	0.126212081
##	sal	-0.615148701	-0.17625440	-0.23257762	0.05643416	0.016869786
##	gratificante	-0.176254400	0.47619706	0.26988874	0.15682719	0.084435687
##	energia	-0.232577617	0.26988874	0.73538695	0.25872092	0.092320763
##	divertido	0.056434162	0.15682719	0.25872092	0.75626542	0.179488192
##	criancas	0.016869786	0.08443569	0.09232076	0.17948819	0.693078696
##	encharcado	-0.363910291	-0.52226060	-0.23804673	0.02615185	-0.210962511
##	economico	-0.027323088	0.07147814	0.05048987	0.03819214	-0.009440672
##	saude	-0.101933508	0.29038369	0.29973214	0.13922066	0.041427019
##	familia	0.027615064	0.07133087	0.13395464	0.13247782	0.370450908
##	calorias	-0.050315618	-0.04939403	-0.02511958	0.06788136	0.015492751
##	simples	-0.614212770	-0.21128078	-0.19161949	0.03144518	-0.126082221
##	crocante	-0.037539764	0.23501274	0.23162111	0.14361108	0.142718069
##	regular	-0.338854453	0.25597560	0.22141455	0.22741969	0.117248154
##	acucar	-0.117815958	-0.10754377	-0.13985998	0.11105464	0.013860218
##	fruta	0.073615980	0.19471471	0.16432765	0.18941644	-0.100647946
##	processo	-0.978023307	-0.09686147	-0.07869613	0.11866309	0.008957283
##	qualidade	-0.002112197	0.19743095	0.23074174	0.16197776	0.075011301
##	prazer	0.064804450	0.19615692	0.19584779	0.31205236	0.171589410
##	chato	-0.301876168	-0.23435254	-0.19200992	-0.07496520	-0.112773964
##	nutritivo	-0.159018779	0.33148377	0.37206498	0.17604127	0.071594424

##	encharcado	economico	saude	familia	calorias
## satisfaz	-0.750124920	0.144797038	0.17355966	0.108187556	-0.05897053
## natural	-0.473784145	0.161409415	0.32283469	0.089637263	-0.10180118
## fibra	0.089311150	-0.050516190	0.31146586	0.179652246	-0.17343297
## doce	-0.307729173	0.078467707	-0.02181902	0.020504989	0.23597106
## facil	-0.129193111	-0.065159029	0.15760388	0.095947412	-0.04096782
## sal	-0.363910291	-0.027323088	-0.10193351	0.027615064	-0.05031562
## gratificante	-0.522260595	0.071478135	0.29038369	0.071330873	-0.04939403
## energia	-0.238046726	0.050489870	0.29973214	0.133954639	-0.02511958
## divertido	0.026151849	0.038192143	0.13922066	0.132477818	0.06788136
## crianças	-0.210962511	-0.009440672	0.04142702	0.370450908	0.01549275
## encharcado	-2.052002429	0.189526521	0.02698643	-0.275128358	-0.20285279
## economico	0.189526521	0.166654907	0.07633472	-0.098281994	-0.04907126
## saude	0.026986434	0.076334722	0.64001266	0.125762541	-0.22293783
## familia	-0.275128358	-0.098281994	0.12576254	0.570426079	-0.03152689
## calorias	-0.202852791	-0.049071256	-0.22293783	-0.031526893	0.81855729
## simples	-0.632672458	-0.482528373	-0.16493202	-0.102836320	-0.08212025
## crocante	1.144810784	-0.324976889	0.07646755	0.135805774	0.12730823
## regular	0.545091101	-0.122045739	0.20909446	0.236985705	-0.13984002
## acucar	-0.019424828	-0.093123026	-0.25016035	0.028160056	0.27185399
## fruta	-0.186542026	0.086064086	0.22661784	-0.008113282	0.06474409
## processo	0.462671946	-0.476636699	-0.19002605	0.112287780	-0.02171456
## qualidade	0.189613559	-0.009070433	0.34448588	0.166896559	-0.09561515
## prazer	0.306088303	-0.015460457	0.21045902	0.153815763	0.11809822
## chato	-0.078220644	-0.136797803	-0.25710247	-0.098358325	-0.08329054
## nutritivo	0.006155162	0.079345476	0.52640986	0.126688416	-0.20032926
##	simples	crocante	regular	acucar	fruta
## satisfaz	-0.20257216	0.30987368	0.24469961	-0.14648162	0.044503927
## natural	-0.11094557	0.34657776	0.26941585	-0.16344897	0.135397456
## fibra	-0.24220687	0.03400637	0.20367700	-0.21870430	0.227186339
## doce	-0.03759351	0.27588268	0.08721237	0.34731186	0.165631866
## facil	-0.10298854	0.14056224	0.06878910	-0.03238769	0.089602909
## sal	-0.61421277	-0.03753976	-0.33885445	-0.11781596	0.073615980
## gratificante	-0.21128078	0.23501274	0.25597560	-0.10754377	0.194714711
## energia	-0.19161949	0.23162111	0.22141455	-0.13985998	0.164327645
## divertido	0.03144518	0.14361108	0.22741969	0.11105464	0.189416438
## crianças	-0.12608222	0.14271807	0.11724815	0.01386022	-0.100647946
## encharcado	-0.63267246	1.14481078	0.54509110	-0.01942483	-0.186542026
## economico	-0.48252837	-0.32497689	-0.12204574	-0.09312303	0.086064086
## saude	-0.16493202	0.07646755	0.20909446	-0.25016035	0.226617842
## familia	-0.10283632	0.13580577	0.23698571	0.02816006	-0.008113282
## calorias	-0.08212025	0.12730823	-0.13984002	0.27185399	0.064744094
## simples	-0.60004636	0.04681966	-0.24870256	-0.14340147	0.148938104
## crocante	0.04681966	-0.15037421	-0.25377639	0.01398186	0.278838012
## regular	-0.24870256	-0.25377639	0.41631683	-0.12430925	0.315109586
## acucar	-0.14340147	0.01398186	-0.12430925	0.61961118	0.086992387
## fruta	0.14893810	0.27883801	0.31510959	0.08699239	0.728593283
## processo	-0.75943088	-0.54374577	-0.55989786	-0.15161140	0.185803833
## qualidade	-0.18254111	-0.08049479	0.11546556	-0.11653201	0.159827018
## prazer	0.06875561	-0.02977067	0.09780785	0.08542034	0.226447777
## chato	-0.29435310	-0.14910755	-0.23283593	-0.08958179	-0.124303102
## nutritivo	-0.19723008	0.10829705	0.34822625	-0.23066502	0.267730960

##	processo	qualidade	prazer	chato	nutritivo
## satisfaz	-0.080228369	0.094557092	0.195341646	-0.14275627	0.249895862
## natural	0.094333804	0.263848647	0.206852016	-0.19475101	0.408112318
## fibra	-0.318733513	0.201711856	0.156939445	-0.22468371	0.461338755
## doce	-0.016061856	0.022532112	0.194314388	-0.14392584	-0.023348770
## facil	-0.155509239	0.089862304	0.126712189	-0.16684350	0.169250192
## sal	-0.978023307	-0.002112197	0.064804450	-0.30187617	-0.159018779
## gratificante	-0.096861474	0.197430952	0.196156917	-0.23435254	0.331483769
## energia	-0.078696126	0.230741742	0.195847790	-0.19200992	0.372064984
## divertido	0.118663090	0.161977756	0.312052361	-0.07496520	0.176041268
## crianças	0.008957283	0.075011301	0.171589410	-0.11277396	0.071594424
## encharcado	0.462671946	0.189613559	0.306088303	-0.07822064	0.006155162
## economico	-0.476636699	-0.009070433	-0.015460457	-0.13679780	0.079345476
## saude	-0.190026051	0.344485883	0.210459017	-0.25710247	0.526409855
## familia	0.112287780	0.166896559	0.153815763	-0.09835832	0.126688416
## calorias	-0.021714565	-0.095615155	0.118098224	-0.08329054	-0.200329260
## simples	-0.759430884	-0.182541107	0.068755607	-0.29435310	-0.197230075
## crocante	-0.543745767	-0.080494790	-0.029770674	-0.14910755	0.108297051
## regular	-0.559897861	0.115465565	0.097807847	-0.23283593	0.348226249
## acucar	-0.151611403	-0.116532010	0.085420343	-0.08958179	-0.230665018
## fruta	0.185803833	0.159827018	0.226447777	-0.12430310	0.267730960
## processo	-0.489555696	-0.060031939	0.008403438	-0.29359602	-0.261635732
## qualidade	-0.060031939	0.611370447	0.208999587	-0.21359634	0.446811229
## prazer	0.008403438	0.208999587	0.608368387	-0.11084491	0.234476245
## chato	-0.293596018	-0.213596345	-0.110844908	0.67160757	-0.202319913
## nutritivo	-0.261635732	0.446811229	0.234476245	-0.20231991	0.846484325

```
print("Matriz estimada R:")
```

```
## [1] "Matriz estimada R:"
```

```
print(matriz_r_hat)
```

##	satisfaz	natural	fibra	doce	facil	
##	satisfaz	1.00000000	0.53968982	0.55200307	0.19040004	0.236529426
##	natural	0.53968982	1.00000000	0.65228983	-0.09094192	0.230948116
##	fibra	0.55200307	0.65228983	1.00000000	-0.03739830	0.171721940
##	doce	0.19040004	-0.09094192	-0.03739830	1.00000000	0.131211352
##	facil	0.23652943	0.23094812	0.17172194	0.13121135	1.000000000
##	sal	-0.03626646	-0.21687200	-0.17488799	0.44399118	0.026936813
##	gratificante	0.64850720	0.46324724	0.40804658	0.18477668	0.362309849
##	energia	0.63675882	0.49354159	0.50373069	0.18496133	0.182630082
##	divertido	0.26521397	0.08190321	0.06273083	0.32722313	0.248246218
##	criancas	0.16000741	0.06029259	-0.09483085	0.12324275	0.251967889
##	encharcado	-0.05988555	0.06839973	-0.04166740	-0.08375192	-0.008804016
##	economico	0.05194244	0.10316137	-0.03396533	-0.23981376	0.092549751
##	saude	0.54706871	0.68809770	0.68398369	-0.11562213	0.204021617
##	familia	0.23287605	0.10708173	-0.01039870	0.04343192	0.235175664
##	calorias	0.04721422	-0.16167366	-0.18654202	0.46731243	-0.015414590
##	simples	-0.25064803	-0.13851302	-0.12284590	-0.28955897	0.017651539
##	crocante	0.12650057	0.02152927	0.04832402	0.26276634	0.252223659
##	regular	0.42049880	0.41763842	0.64837568	-0.02518025	0.105246439
##	acucar	-0.07851945	-0.31680448	-0.22556725	0.64838267	-0.005731638
##	fruta	0.26116604	0.30015027	0.29314106	0.34650542	0.037197487
##	processo	-0.23171929	-0.30454423	-0.19522957	0.11851882	-0.048325631
##	qualidade	0.44321697	0.57909956	0.51319376	-0.07754712	0.171421388
##	prazer	0.33764173	0.16939794	0.13967658	0.37627476	0.198897222
##	chato	-0.17785084	-0.21758679	-0.09925867	-0.20033406	-0.167536447
##	nutritivo	0.52621459	0.65072607	0.71306495	-0.04716005	0.205120324
##	sal	gratificante	energia	divertido	criancas	
##	satisfaz	-3.626646e-02	6.485072e-01	0.63675882	0.265213973	0.16000741
##	natural	-2.168720e-01	4.632472e-01	0.49354159	0.081903207	0.06029259
##	fibra	-1.748880e-01	4.080466e-01	0.50373069	0.062730827	-0.09483085
##	doce	4.439912e-01	1.847767e-01	0.18496133	0.327223134	0.12324275
##	facil	2.693681e-02	3.623098e-01	0.18263008	0.248246218	0.25196789
##	sal	1.000000e+00	5.371153e-05	-0.06713581	0.033474536	0.03298221
##	gratificante	5.371153e-05	1.000000e+00	0.59966696	0.354852245	0.31219433
##	energia	-6.713581e-02	5.996670e-01	1.00000000	0.350327368	0.13057221
##	divertido	3.347454e-02	3.548522e-01	0.35032737	1.000000000	0.34996596
##	criancas	3.298221e-02	3.121943e-01	0.13057221	0.349965961	1.00000000
##	encharcado	2.359707e-02	-1.425032e-02	-0.04592438	-0.098754958	0.08765840
##	economico	-1.259049e-01	2.137707e-01	0.02641362	0.040700477	0.30491206
##	saude	-2.283768e-01	5.181843e-01	0.52424330	0.100955593	-0.01276094
##	familia	-7.965423e-02	3.546910e-01	0.19136018	0.352476715	0.72701108
##	calorias	4.380975e-01	1.219290e-02	0.03362541	0.113449859	0.01435653
##	simples	2.137203e-02	-1.795016e-01	-0.25577344	-0.322275476	0.02921320
##	crocante	1.033722e-01	2.762034e-01	0.24829752	0.402670109	0.30194580
##	regular	-1.645302e-01	3.282587e-01	0.38571918	0.136731512	-0.02583127
##	acucar	5.917709e-01	-8.119525e-02	-0.08606954	0.165290744	-0.01589207
##	fruta	2.557426e-02	2.538439e-01	0.27438372	0.251421273	-0.23212140
##	processo	3.048367e-01	-1.649989e-01	-0.10157043	-0.002202497	0.02697130
##	qualidade	-2.178523e-01	4.747221e-01	0.45703627	0.224503157	0.11634764
##	prazer	1.278963e-01	3.821680e-01	0.32246211	0.586497175	0.28528848
##	chato	1.122315e-01	-3.156052e-01	-0.22338882	-0.298063613	-0.19372777
##	nutritivo	-1.600961e-01	4.987965e-01	0.53577674	0.155230301	0.03443452

##	encharcado	economico	saude	familia	calorias
## satisfaz	-0.059885555	0.05194244	0.547068708	0.23287605	0.04721422
## natural	0.068399728	0.10316137	0.688097695	0.10708173	-0.16167366
## fibra	-0.041667404	-0.03396533	0.683983690	-0.01039870	-0.18654202
## doce	-0.083751919	-0.23981376	-0.115622126	0.04343192	0.46731243
## facil	-0.008804016	0.09254975	0.204021617	0.23517566	-0.01541459
## sal	0.023597066	-0.12590486	-0.228376777	-0.07965423	0.43809745
## gratificante	-0.014250315	0.21377074	0.518184332	0.35469098	0.01219290
## energia	-0.045924383	0.02641362	0.524243298	0.19136018	0.03362541
## divertido	-0.098754958	0.04070048	0.100955593	0.35247672	0.11344986
## crianças	0.087658404	0.30491206	-0.012760939	0.72701108	0.01435653
## encharcado	1.000000000	0.11715122	0.006146656	0.08138269	-0.07966496
## economico	0.117151217	1.000000000	0.192658638	0.23335601	-0.21047144
## saude	0.006146656	0.19265864	1.000000000	0.08211150	-0.30717616
## familia	0.081382689	0.23335601	0.082111496	1.000000000	-0.06072469
## calorias	-0.079664961	-0.21047144	-0.307176155	-0.06072469	1.000000000
## simples	0.346129827	0.23120114	-0.099609317	-0.02899279	-0.07619086
## crocante	-0.335632858	0.09269221	0.082416385	0.28807642	0.14705033
## regular	-0.137300090	0.08029354	0.543222577	0.04374372	-0.16490865
## acucar	-0.094456381	-0.29255416	-0.376892968	-0.05448568	0.52582617
## fruta	-0.137035700	-0.33848391	0.266341061	-0.12389300	0.12593786
## processo	0.058660437	-0.12542062	-0.289470005	-0.01293971	0.27389198
## qualidade	-0.029808614	0.21549364	0.686304848	0.24107378	-0.20135015
## prazer	-0.254809103	-0.03971178	0.214279460	0.30077242	0.19292930
## chato	0.226885825	-0.02137835	-0.228589063	-0.24764977	-0.02701569
## nutritivo	0.032786390	0.12902808	0.757614796	0.09197820	-0.22634007
##	simples	crocante	regular	acucar	fruta
## satisfaz	-0.25064803	0.12650057	0.42049880	-0.078519448	0.26116604
## natural	-0.13851302	0.02152927	0.41763842	-0.316804483	0.30015027
## fibra	-0.12284590	0.04832402	0.64837568	-0.225567250	0.29314106
## doce	-0.28955897	0.26276634	-0.02518025	0.648382667	0.34650542
## facil	0.01765154	0.25222366	0.10524644	-0.005731638	0.03719749
## sal	0.02137203	0.10337222	-0.16453021	0.591770895	0.02557426
## gratificante	-0.17950163	0.27620343	0.32825868	-0.081195255	0.25384390
## energia	-0.25577344	0.24829752	0.38571918	-0.086069535	0.27438372
## divertido	-0.32227548	0.40267011	0.13673151	0.165290744	0.25142127
## crianças	0.02921320	0.30194580	-0.02583127	-0.015892067	-0.23212140
## encharcado	0.34612983	-0.33563286	-0.13730009	-0.094456381	-0.13703570
## economico	0.23120114	0.09269221	0.08029354	-0.292554157	-0.33848391
## saude	-0.09960932	0.08241638	0.54322258	-0.376892968	0.26634106
## familia	-0.02899279	0.28807642	0.04374372	-0.054485684	-0.12389300
## calorias	-0.07619086	0.14705033	-0.16490865	0.525826174	0.12593786
## simples	1.000000000	-0.20966191	-0.08026008	-0.146856923	-0.34308629
## crocante	-0.20966191	1.000000000	0.13330386	0.168930691	0.09022960
## regular	-0.08026008	0.13330386	1.000000000	-0.090571672	0.25474509
## acucar	-0.14685692	0.16893069	-0.09057167	1.000000000	0.14533048
## fruta	-0.34308629	0.09022960	0.25474509	0.145330476	1.000000000
## processo	0.11318637	0.02484550	-0.14912239	0.369253388	-0.14020437
## qualidade	-0.22690816	0.13432982	0.44147633	-0.263389434	0.16460384
## prazer	-0.42989349	0.46808561	0.16655163	0.217100889	0.31255476
## chato	0.33052554	-0.32358917	-0.09469787	-0.000921067	-0.26006170
## nutritivo	-0.14491592	0.10373102	0.56777612	-0.274637388	0.30605745

##	processo	qualidade	prazer	chato	nutritivo
## satisfaz	-0.231719289	0.44321697	0.33764173	-0.177850835	0.52621459
## natural	-0.304544226	0.57909956	0.16939794	-0.217586787	0.65072607
## fibra	-0.195229572	0.51319376	0.13967658	-0.099258673	0.71306495
## doce	0.118518821	-0.07754712	0.37627476	-0.200334059	-0.04716005
## facil	-0.048325631	0.17142139	0.19889722	-0.167536447	0.20512032
## sal	0.304836682	-0.21785225	0.12789628	0.112231476	-0.16009606
## gratificante	-0.164998880	0.47472211	0.38216799	-0.315605190	0.49879653
## energia	-0.101570429	0.45703627	0.32246211	-0.223388817	0.53577674
## divertido	-0.002202497	0.22450316	0.58649717	-0.298063613	0.15523030
## crianças	0.026971295	0.11634764	0.28528848	-0.193727771	0.03443452
## encharcado	0.058660437	-0.02980861	-0.25480910	0.226885825	0.03278639
## economico	-0.125420621	0.21549364	-0.03971178	-0.021378353	0.12902808
## saude	-0.289470005	0.68630485	0.21427946	-0.228589063	0.75761480
## familia	-0.012939711	0.24107378	0.30077242	-0.247649766	0.09197820
## calorias	0.273891978	-0.20135015	0.19292930	-0.027015687	-0.22634007
## simples	0.113186375	-0.22690816	-0.42989349	0.330525544	-0.14491592
## crocante	0.024845497	0.13432982	0.46808561	-0.323589173	0.10373102
## regular	-0.149122387	0.44147633	0.16655163	-0.094697872	0.56777612
## acucar	0.369253388	-0.26338943	0.21710089	-0.000921067	-0.27463739
## fruta	-0.140204367	0.16460384	0.31255476	-0.260061699	0.30605745
## processo	1.000000000	-0.18304941	0.03109584	0.171709754	-0.28218185
## qualidade	-0.183049413	1.000000000	0.33407508	-0.284256014	0.65983453
## prazer	0.031095839	0.33407508	1.000000000	-0.359339636	0.24444487
## chato	0.171709754	-0.28425601	-0.35933964	1.000000000	-0.17027548
## nutritivo	-0.282181849	0.65983453	0.24444487	-0.170275481	1.000000000

```
# Calcular a matriz residual
matriz_residual <- matriz_r - matriz_r_hat

# Visualizar a matriz residual e a soma dos resíduos
print("Matriz Residual:")
```

```
## [1] "Matriz Residual:"
```

```
print(matriz_residual)
```

##	satisfaz	natural	fibra	doce
## satisfaz	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## natural	0.000000e+00	0.000000e+00	0.000000e+00	-1.387779e-17
## fibra	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## doce	0.000000e+00	-1.387779e-17	0.000000e+00	0.000000e+00
## facil	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## sal	2.081668e-17	0.000000e+00	-2.775558e-17	0.000000e+00
## gratificante	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## energia	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## divertido	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## crianças	0.000000e+00	-6.938894e-18	0.000000e+00	0.000000e+00
## encharcado	-5.551115e-17	2.775558e-17	-6.938894e-18	-1.387779e-17
## economico	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## saude	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## familia	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## calorias	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## simples	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## crocante	0.000000e+00	2.428613e-17	0.000000e+00	0.000000e+00
## regular	0.000000e+00	0.000000e+00	0.000000e+00	6.938894e-18
## acucar	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## fruta	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## processo	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## qualidade	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## prazer	0.000000e+00	2.775558e-17	0.000000e+00	0.000000e+00
## chato	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## nutritivo	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
##	facil	sal	gratificante	energia
## satisfaz	0.000000e+00	2.081668e-17	0.000000e+00	0.000000e+00
## natural	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## fibra	0.000000e+00	-2.775558e-17	0.000000e+00	0.000000e+00
## doce	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## facil	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## sal	0.000000e+00	0.000000e+00	-1.038124e-17	-1.387779e-17
## gratificante	0.000000e+00	-1.038124e-17	0.000000e+00	0.000000e+00
## energia	0.000000e+00	-1.387779e-17	0.000000e+00	-1.110223e-16
## divertido	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## crianças	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## encharcado	-6.938894e-18	-6.938894e-18	5.377643e-17	-6.938894e-18
## economico	0.000000e+00	0.000000e+00	0.000000e+00	3.469447e-18
## saude	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## familia	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## calorias	-1.734723e-18	0.000000e+00	3.469447e-18	0.000000e+00
## simples	-3.469447e-18	-3.816392e-17	2.775558e-17	0.000000e+00
## crocante	0.000000e+00	0.000000e+00	0.000000e+00	-2.775558e-17
## regular	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## acucar	3.469447e-18	0.000000e+00	0.000000e+00	1.387779e-17
## fruta	-6.938894e-18	-3.469447e-18	0.000000e+00	0.000000e+00
## processo	6.938894e-18	0.000000e+00	0.000000e+00	0.000000e+00
## qualidade	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## prazer	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## chato	0.000000e+00	-2.775558e-17	0.000000e+00	0.000000e+00
## nutritivo	-2.775558e-17	0.000000e+00	0.000000e+00	0.000000e+00

##	divertido	criancas	encharcado	economico
## satisfaz	0.000000e+00	0.000000e+00	-5.551115e-17	0.000000e+00
## natural	0.000000e+00	-6.938894e-18	2.775558e-17	0.000000e+00
## fibra	0.000000e+00	0.000000e+00	-6.938894e-18	0.000000e+00
## doce	0.000000e+00	0.000000e+00	-1.387779e-17	0.000000e+00
## facil	0.000000e+00	0.000000e+00	-6.938894e-18	0.000000e+00
## sal	0.000000e+00	0.000000e+00	-6.938894e-18	0.000000e+00
## gratificante	0.000000e+00	0.000000e+00	5.377643e-17	0.000000e+00
## energia	0.000000e+00	0.000000e+00	-6.938894e-18	3.469447e-18
## divertido	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## criancas	0.000000e+00	-1.110223e-16	0.000000e+00	0.000000e+00
## encharcado	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## economico	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## saude	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## familia	0.000000e+00	0.000000e+00	1.387779e-17	0.000000e+00
## calorias	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## simples	0.000000e+00	0.000000e+00	0.000000e+00	2.775558e-17
## crocante	0.000000e+00	0.000000e+00	-5.551115e-17	1.387779e-17
## regular	0.000000e+00	6.938894e-18	2.775558e-17	0.000000e+00
## acucar	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## fruta	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## processo	-1.301043e-18	0.000000e+00	-2.775558e-17	0.000000e+00
## qualidade	-2.775558e-17	0.000000e+00	-1.040834e-17	0.000000e+00
## prazer	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## chato	0.000000e+00	0.000000e+00	0.000000e+00	-1.040834e-17
## nutritivo	0.000000e+00	6.938894e-18	0.000000e+00	0.000000e+00
##	saude	familia	calorias	simples
## satisfaz	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## natural	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## fibra	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## doce	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## facil	0.000000e+00	0.000000e+00	-1.734723e-18	-3.469447e-18
## sal	0.000000e+00	0.000000e+00	0.000000e+00	-3.816392e-17
## gratificante	0.000000e+00	0.000000e+00	3.469447e-18	2.775558e-17
## energia	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## divertido	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## criancas	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## encharcado	0.000000e+00	1.387779e-17	0.000000e+00	0.000000e+00
## economico	0.000000e+00	0.000000e+00	0.000000e+00	2.775558e-17
## saude	0.000000e+00	1.387779e-17	0.000000e+00	1.387779e-17
## familia	1.387779e-17	0.000000e+00	0.000000e+00	6.938894e-18
## calorias	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## simples	1.387779e-17	6.938894e-18	0.000000e+00	0.000000e+00
## crocante	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## regular	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## acucar	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## fruta	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## processo	0.000000e+00	5.204170e-18	0.000000e+00	-4.163336e-17
## qualidade	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## prazer	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## chato	2.775558e-17	0.000000e+00	0.000000e+00	0.000000e+00
## nutritivo	0.000000e+00	-1.387779e-17	2.775558e-17	0.000000e+00

##	crocante	regular	acucar	fruta
## satisfaz	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## natural	2.428613e-17	0.000000e+00	0.000000e+00	0.000000e+00
## fibra	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## doce	0.000000e+00	6.938894e-18	0.000000e+00	0.000000e+00
## facil	0.000000e+00	0.000000e+00	3.469447e-18	-6.938894e-18
## sal	0.000000e+00	0.000000e+00	0.000000e+00	-3.469447e-18
## gratificante	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## energia	-2.775558e-17	0.000000e+00	1.387779e-17	0.000000e+00
## divertido	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## crianças	0.000000e+00	6.938894e-18	0.000000e+00	0.000000e+00
## encharcado	-5.551115e-17	2.775558e-17	0.000000e+00	0.000000e+00
## economico	1.387779e-17	0.000000e+00	0.000000e+00	0.000000e+00
## saude	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## familia	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## calorias	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## simples	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## crocante	0.000000e+00	2.775558e-17	0.000000e+00	-1.387779e-17
## regular	2.775558e-17	0.000000e+00	1.387779e-17	0.000000e+00
## acucar	0.000000e+00	1.387779e-17	0.000000e+00	0.000000e+00
## fruta	-1.387779e-17	0.000000e+00	0.000000e+00	0.000000e+00
## processo	5.204170e-17	0.000000e+00	0.000000e+00	0.000000e+00
## qualidade	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## prazer	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## chato	0.000000e+00	0.000000e+00	-1.192622e-18	0.000000e+00
## nutritivo	1.387779e-17	0.000000e+00	0.000000e+00	0.000000e+00
##	processo	qualidade	prazer	chato
## satisfaz	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## natural	0.000000e+00	0.000000e+00	2.775558e-17	0.000000e+00
## fibra	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## doce	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## facil	6.938894e-18	0.000000e+00	0.000000e+00	0.000000e+00
## sal	0.000000e+00	0.000000e+00	0.000000e+00	-2.775558e-17
## gratificante	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## energia	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## divertido	-1.301043e-18	-2.775558e-17	0.000000e+00	0.000000e+00
## crianças	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## encharcado	-2.775558e-17	-1.040834e-17	0.000000e+00	0.000000e+00
## economico	0.000000e+00	0.000000e+00	0.000000e+00	-1.040834e-17
## saude	0.000000e+00	0.000000e+00	0.000000e+00	2.775558e-17
## familia	5.204170e-18	0.000000e+00	0.000000e+00	0.000000e+00
## calorias	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## simples	-4.163336e-17	0.000000e+00	0.000000e+00	0.000000e+00
## crocante	5.204170e-17	0.000000e+00	0.000000e+00	0.000000e+00
## regular	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## acucar	0.000000e+00	0.000000e+00	0.000000e+00	-1.192622e-18
## fruta	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## processo	0.000000e+00	0.000000e+00	0.000000e+00	-2.775558e-17
## qualidade	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## prazer	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
## chato	-2.775558e-17	0.000000e+00	0.000000e+00	0.000000e+00
## nutritivo	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00


```
##                nutritivo
## satisfaz      0.000000e+00
## natural       0.000000e+00
## fibra         0.000000e+00
## doce          0.000000e+00
## facil        -2.775558e-17
## sal           0.000000e+00
## gratificante  0.000000e+00
## energia       0.000000e+00
## divertido     0.000000e+00
## crianças      6.938894e-18
## encharcado    0.000000e+00
## economico     0.000000e+00
## saude         0.000000e+00
## familia       -1.387779e-17
## calorias      2.775558e-17
## simples       0.000000e+00
## crocante      1.387779e-17
## regular       0.000000e+00
## acucar        0.000000e+00
## fruta         0.000000e+00
## processo      0.000000e+00
## qualidade     0.000000e+00
## prazer        0.000000e+00
## chato         0.000000e+00
## nutritivo     0.000000e+00
```

```
print("Soma dos Resíduos:")
```

```
## [1] "Soma dos Resíduos:"
```

```
print(sum(matriz_residual))
```

```
## [1] -2.582027e-16
```

A estimativa derivada do modelo ortogonal demonstrou ser altamente precisa, resultando em uma matriz residual significativamente reduzida.

Estimação dos Escores dos Fatores F

Para calcular o escores dos fatores vamos utilizar o método dos mínimos quadrados ponderados

$$F = (L' \psi^{-1} L)^{-1} L' \psi^{-1} Z$$

```
# Calcular a matriz F
matriz_f <- solve(t(matriz_l) %*% solve(matriz_psi) %*% matriz_l) %*% t(matriz_l) %*% solve(matriz_psi) %*% t(z)

# Imprimir a soma das linhas dos escores dos fatores
print(matrix(rowSums(matriz_f)))
```

```
##           [,1]
## [1,] -8.607004e-14
## [2,]  4.517220e-14
## [3,]  1.620926e-14
## [4,]  3.428507e-14
## [5,]  1.651457e-15
```

```
# Imprimir a matriz resultante da multiplicação entre a matriz L e a matriz F
print(t(matriz_l %*% matriz_f)[1:5,])
```

```
##           [,1]      [,2]      [,3]      [,4]      [,5]      [,6]
## [1,]  1.2217163  1.2589084  0.7762036 -0.4985493  0.30486970 -0.5492682
## [2,] -2.5441080 -2.5252481 -2.5774342 -0.3693945  0.38026712  0.5574851
## [3,]  1.3127059  0.3973591  0.1565104  1.0012933  0.36166655  1.0484389
## [4,]  0.5453014  0.4530029  0.1572812  0.3346822 -0.08469079  0.1172470
## [5,]  0.8829036  0.4232029  0.3667763  0.1720987  0.36300242 -0.3219880
##           [,7]      [,8]      [,9]      [,10]      [,11]      [,12]
## [1,]  0.9826130  0.5995620 -0.19041953  0.3646901  2.02814293  1.0178188
## [2,] -0.6756854 -1.4656370  0.45252518  1.7867351  0.61992772  2.3345553
## [3,]  1.1462429  0.7865600  0.84669287  0.4589880  0.07298125 -0.3309400
## [4,]  0.1738506  0.2267926 -0.04258236 -0.2337047  1.00626037 -0.7737084
## [5,]  0.9723712  0.6400117  0.77621981  0.5123723 -1.38382584  0.5803923
##           [,13]      [,14]      [,15]      [,16]      [,17]      [,18]
## [1,]  0.98296007  0.4787673 -0.39562929  1.3809631 -0.7450652  0.43555940
## [2,] -2.02548637  1.8431007  0.03249345  2.1985176  1.3438998 -1.76572857
## [3,]  0.16127218  0.5634041  0.52240250 -1.0501825  0.7720067  0.06069226
## [4,]  0.09550047 -0.2197483  0.14419435 -0.3976510 -0.8552120 -0.22344347
## [5,]  0.54813361  0.6737100 -0.06208628 -0.9979512  1.5105661  0.59450575
##           [,19]      [,20]      [,21]      [,22]      [,23]      [,24]
## [1,] -0.73860266 -0.25175725 -0.5540407  0.91149625 -0.46143021  0.29927549
## [2,]  0.12528604 -1.79404102  1.7566580 -1.46043218 -0.02830816  0.12377110
## [3,]  0.67037440  0.46211503  0.1766967  0.38378705  1.05990373 -0.52941961
## [4,]  0.09085518  0.46549956 -0.5648693 -0.07468821 -0.12683339 -0.02673235
## [5,] -0.04451126  0.07440377 -0.1920139  0.94903198  1.08089833 -0.69723524
##           [,25]
## [1,]  0.61532060
## [2,] -1.38086109
## [3,]  0.19377372
## [4,]  0.09787172
## [5,]  0.34829424
```

```
print(z[1:5,])
```

```
##      satisfaz      natural      fibra      doce      facil      sal
## [1,]  1.2666876  1.3727061  1.4768593 -1.3422193 -3.2674009 -1.19168452
## [2,] -3.2606370 -2.0110624 -1.5323482 -1.3422193  0.6040573  0.01022905
## [3,]  1.2666876  0.2447832  1.4768593  2.2218658  0.6040573  1.21214262
## [4,]  1.2666876  1.3727061  1.4768593  0.4398233  0.6040573  0.01022905
## [5,]  0.1348565  1.3727061 -0.5292791 -0.4511980  0.6040573  0.01022905
##      gratificante      energia divertido      crianas encharcado      economico
## [1,]      1.223478  0.3988136 -1.279852  0.1315547  2.2881820  1.5854706
## [2,]      1.223478 -2.9483717 -1.279852  0.9671047  0.6208246  1.5854706
## [3,]      1.223478  1.5145420  1.886098  0.9671047  0.6208246 -0.1929809
## [4,]      1.223478  1.5145420  1.886098  0.9671047  0.6208246 -0.1929809
## [5,]      1.223478  0.3988136  1.886098  0.9671047 -1.0465329  1.5854706
##      saude      familia      calorias      simples      crocante      regular
## [1,]  1.380213  1.0101335 -1.7200503  0.6713666 -1.817469  0.80626301
## [2,] -2.094966  1.0101335 -1.7200503  2.5059148  1.480641 -1.80114717
## [3,]  1.380213  1.0101335 -1.7200503 -1.1631816  1.480641  0.80626301
## [4,]  1.380213  1.0101335 -1.7200503 -1.1631816 -1.817469  0.80626301
## [5,]  1.380213 -0.7882102  0.3010088 -1.1631816  1.480641 -0.06287372
##      acucar      fruta      processo      qualidade      prazer      chato
## [1,] -1.0963606 -0.6410614  0.05581365  1.434975 -1.298220 -0.8776122
## [2,] -0.1385735 -0.6410614  1.80464132 -1.860326 -1.298220 -0.8776122
## [3,]  0.8192137 -0.6410614 -0.81860019  1.434975  1.091454 -0.8776122
## [4,] -0.1385735  3.0558570 -0.81860019  1.434975  1.888012 -0.8776122
## [5,] -1.0963606 -0.6410614  0.05581365  1.434975  1.888012 -0.8776122
##      nutritivo
## [1,]  1.5050092
## [2,] -0.7477116
## [3,]  1.5050092
## [4,]  1.5050092
## [5,]  0.3786488
```

Referências

Silva, Wilton Bernardino da. 2021. “Análise Fatorial (Modelo Ortogonal).” YouTube. 2021.
<https://www.youtube.com/watch?v=Jk-QGfBkifA> (<https://www.youtube.com/watch?v=Jk-QGfBkifA>).