Marketing Research

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Ninth Edition

Chapter Twenty-one

Factor Analysis

Factor Analysis

- **Combines questions or variables to create new factors**
- **Combines objects to create new groups**

Uses in Data Analysis

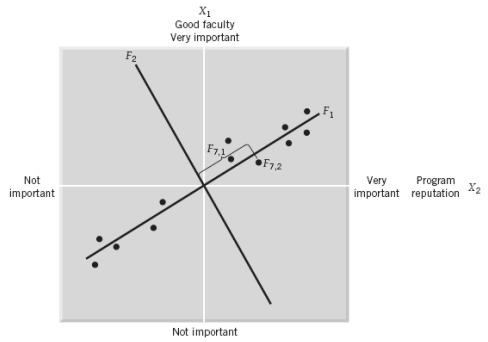
- **To identify underlying constructs in the data from the groupings of variables that emerge**
- **To reduce the number of variables to a more manageable set**

Factor Analysis (Contd.)

Methodology

- **Principal Component Analysis**
  - **Summarizes information in a larger set of variables to a smaller set of factors**

Factor Analysis- Example



Principal Component Analysis

- **Since the objective of factor analysis is to represent each of the variables as a linear combination of a smaller set of factors, it is expressed as**

$$X_1 = i_{11}F_1 + i_{12}F_2 + e_1$$
$$X_2 = i_{21}F_1 + i_{22}F_2 + e_2$$
$$\cdot$$
$$\cdot$$
$$X_n = i_{n1}f_1 + i_{n2}f_2 + e_n$$

Where

X_1, ... x_n represent standardized scores

F_1,F_2 are the two standardized factor scores

I_{11}, i_{12},....I_{52} are factor loadings

E_1,...E_5 are error variances

Export Data Set - Illustration

Respid	Will(y1)	Govt(y2)	Train(x5)	Size(x1)	Exp(x6)	Rev(x2)	Years(x3)	Prod(x4)
1	4	5	1	49	1	1000	5.5	6
2	3	4	1	46	1	1000	6.5	4
3	5	4	1	54	1	1000	6.0	7
4	2	3	1	31	0	3000	6.0	5
5	4	3	1	50	1	2000	6.5	7
6	5	4	1	69	1	1000	5.5	9
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
115	4	3	1	45	1	2000	6.0	6
116	5	4	1	44	1	2000	5.8	11
117	3	4	1	46	0	1000	7.0	3
118	3	4	1	54	1	1000	7.0	4
119	4	3	1	49	1	1000	6.5	7
120	4	5	1	54	1	4000	6.5	7

Description of Variables

Variable Description	Corresponding Name in Output	Scale Values
Willingness to Export ($Y_{1)}$	Will	1(definitely not interested) to 5 (definitely interested)
Level of Interest in Seeking Govt Assistance (Y_2)	Govt	1(definitely not interested) to 5 (definitely interested)
Employee Size (X_1)	Size	Greater than Zero
Firm Revenue (X_2)	Rev	In millions of dollars
Years of Operation in the Domestic Market (X_3)	Years	Actual number of years
Number of Products Currently Produced by the Firm (X_4)	Prod	Actual number
Training of Employees (X_5)	Train	0 (no formal program) or 1 (existence of a formal program)
Management Experience in International Operation ($X_{6)}$	Exp	0 (no experience) or 1 (presence of experience)

Factors

Factor

- A variable or construct that is not directly observable but needs to be inferred from the input variables
- All included factors (prior to rotation) must explain at least as much variance as an "average variable“

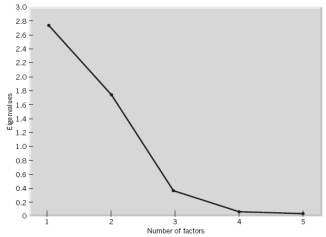
Eigenvalue Criteria

- Represents the amount of variance in the original variables that is associated with a factor
- Sum of the square of the factor loadings of each variable on a factor represents the eigen value
- Only factors with eigenvalues greater than 1.0 are retained

How Many Factors - Criteria

Scree Plot Criteria

- A plot of the eigenvalues against the number of factors, in order of extraction.
- The shape of the plot determines the number of factors



How Many Factors - Criteria (contd.)

Percentage of Variance Criteria

- The number of factors extracted is determined so that the cumulative percentage of variance extracted by the factors reaches a satisfactory level

Significance Test Criteria

- Statistical significance of the separate eigenvalues is determined, and only those factors that are statistically significant are retained

Common Terms

Factor Scores

- Values of each factor underlying the variables

Factor Loadings

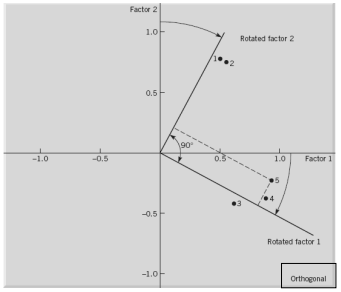
- Correlations between the factors and the original variables

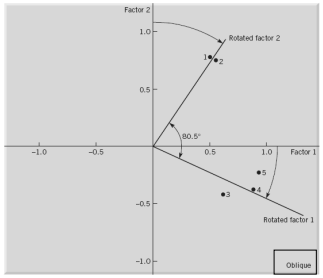
Communality

- The amount of the variable variance that is explained by the factor

Factor Rotations

- **Solutions generated by factor analysis for a data set.**





Factor Rotations (contd.)

- **Varimax (orthogonal) rotation**
  - **Each factor tends to load high (1 or 1) on a smaller number of variables and low, or very low (close to zero), on other variables, to make interpretation of the resulting factors easier.**
  - **The variance explained by each unrotated factor is simply rearranged by the rotation, while the total variance explained by the rotated factors still remains the same.**
  - **The first rotated factor will no longer necessarily account for the maximum variance and the amount of variance each factor accounts for has to be recalculated.**
- **Promax (oblique) rotation**
  - **The factors are rotated for better interpretation, such that the orthogonality is not preserved anymore**.

Extraction using Principal Component Method - Unrotated

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.326	38.761	38.761	2.326	38.761	38.761
2	1.567	26.109	64.870	1.567	26.109	64.870
3	.918	15.306	80.175			
4	.594	9.894	90.069			
5	.362	6.035	96.104			
6	.234	3.896	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix(a)

Factor Loading

	Component	
	1	2
Train	.566	.724
Size	.880	.022
Exp	.695	-.344
Rev	-.100	.503
Years	-.297	.809
Prod	.806	.124

Extraction Method: Principal Component Analysis.
a 2 components extracted.

Component Score Coefficient Matrix

Factor Score Coefficient

	Component	
	1	2
Train	.244	.462
Size	.378	.014
Exp	.299	-.220
Rev	-.043	.321
Years	-.128	.517
Prod	.347	.079

Extraction Method: Principal Component Analysis.
Component Scores.

Extraction using Principal Component Method - Factor Rotation

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.326	38.761	38.761	2.326	38.761	38.761	2.309	38.479	38.479
2	1.567	26.109	64.870	1.567	26.109	64.870	1.583	26.391	64.870
3	.918	15.306	80.175						
4	.594	9.894	90.069						
5	.362	6.035	96.104						
6	.234	3.896	100.000						

Extraction Method: Principal Component Analysis.

Rotated Component Matrix(a)

Not significantly different from unrotated values

	Component	
	1	2
x5	.668	.632
x1	.873	-.110
x6	.636	-.444
x2	-.023	.512
x3	-.173	.844
x4	.816	.002

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 3 iterations.

Component Score Coefficient Matrix

	Component	
	1	2
x5	.310	.421
x1	.376	-.043
x6	.263	-.262
x2	.006	.324
x3	-.049	.530
x4	.355	.027

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Component Scores.

Case 21-1 Store Image Study (p.586)

- **Label the factors in table 21-6.**
- **Compare these factors with those found in the discount store analysis of table 21-5.**

BLE 21-5
ctor Loadings for a Discount Store (Varimax Rotation)

ale	Factor I	II	III	IV	V	Communality
Good service	.79	−.15	.06	.12	.07	.67
Helpful salespersons	.75	−.03	.04	.13	. 31	.68
Friendly personnel	.74	−.07	.17	.09	−.14	.61
Clean	.59	−.31	.34	.15	−.25	.65
Pleasant store to shop in	.58	−.15	.48	.26	.10	.67
Easy to return purchases	.56	−.23	.13	−.03	−.03	.39
Too many clerks	.53	−.00	.02	.23	.37	.47
Attracts upper-class customers	.46	−.06	.25	−.00	.17	.31
Convenient location	.36	−.30	−.02	−.19	.03	.26
High quality products	.34	−.27	.31	.12	.25	.36
Good buys on products	.02	−.88	.09	.10	.03	.79
Low prices	−.03	−.74	.14	.00	.13	.59
Good specials	.35	−.67	−.05	.10	.14	.60
Good sales on products	.30	−.67	.01	−.08	.16	.57
Reasonable value for price	.17	−.52	.11	−.02	−.03	.36
Good store	.41	−.47	.47	.12	.11	.63
Low pressure salespersons	−.20	−.30	−.28	−.03	−.05	.18
Bright store	−.02	−.10	.75	.26	−.05	.61
Attractive store	.19	.03	.67	.34	.24	.66
Good displays	.33	−.15	.61	.15	−.20	.57
Unlimited selections of products	.09	.00	.29	−.03	.00	.09
Spacious shopping	.00	.20	.00	.70	.10	.54
Easy to find items you want	.36	−.16	.10	.57	.01	.49
Well-organized layout	−.02	−.05	.25	.54	−.17	.39
Well-spaced merchandise	.20	.15	.27	.52	.16	.43
Neat	.38	−.12	.45	.49	−.34	.72
Big store	−.20	.15	.06	.07	−.65	.49
Ads frequently seen by you	.03	.00	.07	.10	.06	.02

						Communality
1. Well-spaced merchandise	.73	.10	−.11	.02	.12	.57
2. Bright store	.63	−.08	.45	−.11	.06	.62
3. Ads frequently seen by you	−.04	.08	−.02	−.12	.58	.36
4. High-quality products	.50	.32	.24	.01	−.03	.41
5. Well-organized layout	.70	.08	.05	−.00	.12	.51
6. Low prices	−.09	.64	−.02	.19	.18	.49
7. Good sales on products	.27	.73	−.00	−.10	−.01	.62
8. Pleasant store to shop in	.63	.36	.09	.12	.01	.55
9. Good store	.73	.37	.26	.19	−.06	.78
10. Convenient location	.18	.01	.59	−.10	.36	.52
11. Low pressure salespersons	−.15	.05	.40	−.06	−.11	.20
12. Big store	.08	−.02	.42	−.00	.14	.20
13. Good buys on products	.35	.73	.04	.18	−.10	.70
14. Attractive store	.68	.28	.38	.10	−.10	.70
15. Helpful salespersons	.43	.16	.34	.34	.45	.64
16. Good service	.60	.19	.21	.35	.01	.56
17. Too many clerks	−.06	.03	−.01	.62	−.08	.40
18. Friendly personnel	.48	.11	.17	.47	.36	.62
19. Easy to return purchases	.39	.10	.01	−.10	.43	.36
20. Unlimited selection of products	.10	.09	.48	.17	−.18	.31
21. Reasonable prices for value	.24	.71	.04	.01	.13	.58
22. Neat	.87	−.00	.11	.07	.04	.78
23. Spacious shopping	.72	.02	−.26	−.01	.18	.62
24. Attracts upper-class customers	.38	−.37	−.17	−.06	.06	.32
25. Clean	.83	.11	.16	.12	.03	.74
26. Fast checkout	.22	.12	−.07	.68	−.13	.55
27. Good displays	.73	.19	.07	.14	.13	.61
28. Easy to find items you want	.57	.23	−.08	.03	−.01	.39
29. Good specials	.37	.62	.08	.06	.32	.63