

MANOVA & Multiple Linear Regression Analysis

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About The Data

- Was collected from several marketing research survey of a industrial supplier's customers
- Observe the effects and relationship of customers' perception and characteristics towards their purchasing outcomes
- 10 independent variables (x_1-x_{10})
- 2 dependent variables (y_1, y_2)
- 100 observations

Independent Variables (continuous)

- x_1 Delivery speed
amount of time it takes to deliver the product once an order has been confirmed
- x_2 Price level
perceived level of price charged by product suppliers
- x_3 Manufacturer's image
overall image of the manufacturer/supplier

Independent Variables (continuous)

- x_4 Service

overall level of service necessary for maintaining a satisfactory relationship between supplier and purchaser

- x_5 Salesforce's image

overall image of the manufacturer's sales force

- x_6 Product quality

- perceived level of quality of a particular product (e.g., performance or yield)

Independent Variables (categorical)

- x_7 Size of firm
1=large, and 0=small
- x_8 Purchase structure
1=centralized procurement,
0=decentralized procurement
- x_9 Type of industry
1=classic industry, and 0=other industries
- x_{10} Type of customer's buying situation
1=new task, 2=modified rebuy, and 3=straight rebuy

Response Variable

- y_1 Usage level

how much of the firm's total product is purchased from the supplier, ranging from 0 to 100 percent

- y_2 Satisfaction level

how satisfied the purchaser is with past purchases from the supplier, measured on the same graphic rating scale as the perceptions x_1 to x_7

MANOVA

- Test for x_7 main effect:

$$H_0: \tau_1 = \tau_2 = 0 \quad H_a: \text{at least one } \tau_i \neq 0$$

- Test for x_8 main effect

$$H_0: \alpha_1 = \alpha_2 = 0 \quad H_a: \text{at least one } \alpha_i \neq 0$$

- Test for x_9 main effect

$$H_0: \beta_1 = \beta_2 = 0 \quad H_a: \text{at least one } \beta_i \neq 0$$

- Test for x_{10} main effect

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = 0 \quad H_a: \text{at least one } \gamma_i \neq 0$$

MANOVA Table

SV	SSCP		df	Wilk's lambda	F	p-value
X ₇	118.178 1.802	1.802 0.027	1	0.946	2.64	0.0768
X ₈	1.522 1.05	1.05 0.724	1	0.977	1.1	0.3377
X ₉	124.6 9.166	9.166 0.674	1	0.941	2.89	0.0604
X ₁₀	4454.14 301.816	301.816 23.679	2	0.284	40.72	<0.0001
Error	2179.715 86.769	86.769 31.49	94			
Total	6878.155 400.603	400.603 56.594	99			

Reject $H_0: \mathbf{y}_1 = \mathbf{y}_2 = \mathbf{y}_3 = 0$
at $\alpha=0.05$.

Conclude that x_{10}
effects are significant.

Multivariate Regression

■ Model:

$$y_1 = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \varepsilon$$

$$y_2 = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \varepsilon$$

Multivariate Regression

應變數 y_1 :

變異數分析					
來源	自由度	平方和	平均值平方	F 值	Pr > F
模型	10	6999.16659	699.91666	62.30	<.0001
誤差	89	999.83341	11.23408		
已校正的總計	99	7999.00000			

根 MSE	3.35173	R 平方	0.8750
應變平均值	46.10000	調整 R 平方	0.8610
變異係數	7.27056		

應變數 y_2 :

變異數分析					
來源	自由度	平方和	平均值平方	F 值	Pr > F
模型	10	58.22753	5.82275	36.40	<.0001
誤差	89	14.23837	0.15998		
已校正的總計	99	72.46590			

根 MSE	0.39998	R 平方	0.8035
應變平均值	4.77100	調整 R 平方	0.7814
變異係數	8.38351		

Multivariate Regression

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$$

H_a : at least one $\beta_i \neq 0$

Multivariate Statistics and F Approximations					
S=2 M=3.5 N=43					
統計值	值	F 值	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.04936126	30.81	20	176	<.0001
Pillai's Trace	1.38318857	19.96	20	178	<.0001
Hotelling-Lawley Trace	10.49585965	45.76	20	145.03	<.0001
Roy's Greatest Root	9.58126880	85.27	10	89	<.0001
附註: Roy Greatest Root 的 F 統計值是上限。					
附註: Wilks Lambda 的 F 統計值是精確值。					

Multivariate Regression

$$H_0: \beta_1 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.99408403	0.26	2	88	0.7702
Pillai's Trace	0.00591597	0.26	2	88	0.7702
Hotelling-Lawley Trace	0.00595117	0.26	2	88	0.7702
Roy's Greatest Root	0.00595117	0.26	2	88	0.7702

$$H_0: \beta_2 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.97521943	1.12	2	88	0.3315
Pillai's Trace	0.02478057	1.12	2	88	0.3315
Hotelling-Lawley Trace	0.02541025	1.12	2	88	0.3315
Roy's Greatest Root	0.02541025	1.12	2	88	0.3315

$$H_0: \beta_3 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.58769658	30.87	2	88	<.0001
Pillai's Trace	0.41230342	30.87	2	88	<.0001
Hotelling-Lawley Trace	0.70155832	30.87	2	88	<.0001
Roy's Greatest Root	0.70155832	30.87	2	88	<.0001

$$H_0: \beta_4 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.97519393	1.12	2	88	0.3311
Pillai's Trace	0.02480607	1.12	2	88	0.3311
Hotelling-Lawley Trace	0.02543707	1.12	2	88	0.3311
Roy's Greatest Root	0.02543707	1.12	2	88	0.3311

Multivariate Regression

$$H_0: \beta_5 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.84964899	7.79	2	88	0.0008
Pillai's Trace	0.15035101	7.79	2	88	0.0008
Hotelling-Lawley Trace	0.17695662	7.79	2	88	0.0008
Roy's Greatest Root	0.17695662	7.79	2	88	0.0008

$$H_0: \beta_6 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.95643671	2.00	2	88	0.1409
Pillai's Trace	0.04356329	2.00	2	88	0.1409
Hotelling-Lawley Trace	0.04554749	2.00	2	88	0.1409
Roy's Greatest Root	0.04554749	2.00	2	88	0.1409

$$H_0: \beta_7 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.69035303	19.74	2	88	<.0001
Pillai's Trace	0.30964697	19.74	2	88	<.0001
Hotelling-Lawley Trace	0.44853423	19.74	2	88	<.0001
Roy's Greatest Root	0.44853423	19.74	2	88	<.0001

$$H_0: \beta_8 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.76368637	13.62	2	88	<.0001
Pillai's Trace	0.23631363	13.62	2	88	<.0001
Hotelling-Lawley Trace	0.30943806	13.62	2	88	<.0001
Roy's Greatest Root	0.30943806	13.62	2	88	<.0001

Multivariate Regression

$$H_0: \beta_9 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.79227353	11.54	2	88	<.0001
Pillai's Trace	0.20772647	11.54	2	88	<.0001
Hotelling-Lawley Trace	0.26219034	11.54	2	88	<.0001
Roy's Greatest Root	0.26219034	11.54	2	88	<.0001

$$H_0: \beta_{10} = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=43					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.34709859	82.77	2	88	<.0001
Pillai's Trace	0.65290141	82.77	2	88	<.0001
Hotelling-Lawley Trace	1.88102582	82.77	2	88	<.0001
Roy's Greatest Root	1.88102582	82.77	2	88	<.0001

Multivariate Regression

–Reduced Model

■ Model:

$$y_1 = \beta_0 + \beta_3 x_3 + \beta_5 x_5 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \varepsilon$$

$$y_2 = \beta_0 + \beta_3 x_3 + \beta_5 x_5 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \varepsilon$$

Multivariate Regression

應變數 y_1 :

變異數分析					
來源	自由度	平方和	平均值平方	F 值	Pr > F
模型	6	6530.31134	1088.38522	68.92	<.0001
誤差	93	1468.68866	15.79235		
已校正的總計	99	7999.00000			

根 MSE	3.97396	R 平方	0.8164
應變平均值	46.10000	調整 R 平方	0.8045
變異係數	8.62030		

應變數 y_2 :

變異數分析					
來源	自由度	平方和	平均值平方	F 值	Pr > F
模型	6	53.73510	8.95585	44.47	<.0001
誤差	93	18.73080	0.20141		
已校正的總計	99	72.46590			

根 MSE	0.44878	R 平方	0.7415
應變平均值	4.77100	調整 R 平方	0.7248
變異係數	9.40648		

Multivariate Regression

$$H_0: \beta_3 = \beta_5 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$$

H_a : at least one $\beta_i \neq 0$

Multivariate Statistics and F Approximations					
S=2 M=1.5 N=45					
統計值	值	F 值	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.08920760	36.00	12	184	<.0001
Pillai's Trace	1.27194623	27.08	12	186	<.0001
Hotelling-Lawley Trace	6.16134229	46.88	12	140.06	<.0001
Roy's Greatest Root	5.41349560	83.91	6	93	<.0001
附註: Roy Greatest Root 的 F 統計值是上限。					
附註: Wilks Lambda 的 F 統計值是精確值。					

Multivariate Regression

$$H_0: \beta_3 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=45					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.63120299	26.88	2	92	<.0001
Pillai's Trace	0.36879701	26.88	2	92	<.0001
Hotelling-Lawley Trace	0.58427641	26.88	2	92	<.0001
Roy's Greatest Root	0.58427641	26.88	2	92	<.0001

$$H_0: \beta_5 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=45					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.69938804	19.77	2	92	<.0001
Pillai's Trace	0.30061196	19.77	2	92	<.0001
Hotelling-Lawley Trace	0.42982141	19.77	2	92	<.0001
Roy's Greatest Root	0.42982141	19.77	2	92	<.0001

$$H_0: \beta_7 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=45					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.86240393	7.34	2	92	0.0011
Pillai's Trace	0.13759607	7.34	2	92	0.0011
Hotelling-Lawley Trace	0.15954944	7.34	2	92	0.0011
Roy's Greatest Root	0.15954944	7.34	2	92	0.0011

$$H_0: \beta_8 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=45					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.82602777	9.69	2	92	0.0002
Pillai's Trace	0.17397223	9.69	2	92	0.0002
Hotelling-Lawley Trace	0.21061305	9.69	2	92	0.0002
Roy's Greatest Root	0.21061305	9.69	2	92	0.0002

Multivariate Regression

$$H_0: \beta_9 = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=45					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.84404515	8.50	2	92	0.0004
Pillai's Trace	0.15595485	8.50	2	92	0.0004
Hotelling-Lawley Trace	0.18477075	8.50	2	92	0.0004
Roy's Greatest Root	0.18477075	8.50	2	92	0.0004

$$H_0: \beta_{10} = 0$$

Multivariate Statistics and Exact F Statistics					
S=1 M=0 N=45					
統計値	値	F 値	分子自由度	分母自由度	Pr > F
Wilks' Lambda	0.25087741	137.36	2	92	<.0001
Pillai's Trace	0.74912259	137.36	2	92	<.0001
Hotelling-Lawley Trace	2.98601051	137.36	2	92	<.0001
Roy's Greatest Root	2.98601051	137.36	2	92	<.0001

Multivariate Regression

Predicted Model:

參數估計值					
變數	自由度	參數估計值	標準誤差	t 值	Pr > t
Intercept	1	20.15442	2.26844	8.88	<.0001
x3	1	-1.86517	0.65006	-2.87	0.0051
x5	1	5.35325	0.89983	5.95	<.0001
x7	1	5.53318	1.49361	3.70	0.0004
x8	1	-1.10633	1.56326	-0.71	0.4809
x9	1	-3.42254	0.82808	-4.13	<.0001
x10	1	10.75937	0.65518	16.42	<.0001

參數估計值					
變數	自由度	參數估計值	標準誤差	t 值	Pr > t
Intercept	1	1.94675	0.25618	7.60	<.0001
x3	1	0.42516	0.07341	5.79	<.0001
x5	1	-0.05014	0.10162	-0.49	0.6229
x7	1	0.33673	0.16867	2.00	0.0488
x8	1	-0.77688	0.17654	-4.40	<.0001
x9	1	-0.13072	0.09352	-1.40	0.1655
x10	1	0.52285	0.07399	7.07	<.0001

- $\hat{y}_1 = 20.15 - 1.87x_3 + 5.35x_5 + 5.53x_7 - 1.11x_8 - 3.42x_9 + 10.76x_{10}$
- $y_2 = 1.95 + 0.43x_3 - 0.05x_5 + 0.34x_7 - 0.78x_8 - 0.13x_9 + 0.52x_{10}$

THE END
