

國立清華大學 107 學年度碩士班考試入學試題

系所班組別：服務科學研究所 甲組（服務管理組）

考試科目（代碼）：統計學（5102）

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Please answer all 10 questions. In each question, select the correct answer(s).

HaoCafe's Bonus Program Effectiveness

HaoCafe sells coffee beans to large restaurants and cafes in Taiwan. The company markets in three regions of Taiwan: Kaohsiung, Taipei, and Taichung.

HaoCafe's management started a bonus program for the sales managers and would like to evaluate its effectiveness. This program provides bonuses to salespeople based on performance. Management wants to know if the bonuses paid in 2016 affected sales, and expect this relationship to be positive. When studying this relationship, they also want to take into account the effects of advertising and region.

HaoCafe's data include information for a sample of 25 customers in 2016:

CUST# = Customer number

SALES = HaoCafe's sales from the customer (in thousands of NTD)

ADV = Amount HaoCafe spent on advertising to that customer (in hundreds of NTD)

BONUS = Amount of bonuses paid to the manager handling the customer (in hundreds of NTD)

REGION = the region in which the client is located

CUST#	SALES	ADV	BONUS	REGION
1	963.50	374.27	230.98	kaohsiung
2	893.00	408.50	236.28	kaohsiung
3	1057.25	414.31	271.57	kaohsiung
4	1183.25	448.42	291.20	taichung
5	1419.50	517.88	282.17	taipei
6	1547.75	637.60	321.16	taipei
7	1580.00	635.72	294.32	taipei
8	1071.50	446.86	305.69	kaohsiung
9	1078.25	489.59	238.41	kaohsiung
10	1122.50	500.56	271.38	taichung
11	1304.75	484.18	332.64	taipei
12	1552.25	618.07	261.80	taipei
13	1040.00	453.39	235.63	kaohsiung

CUST#	SALES	ADV	BONUS	REGION
14	1045.25	440.86	249.68	taichung
15	1102.25	487.79	232.99	taichung
16	1225.25	537.67	272.20	taichung
17	1508.00	612.21	266.64	taipei
18	1564.25	601.46	277.44	taipei
19	1634.75	585.10	312.35	taipei
20	1159.25	524.56	292.87	kaohsiung
21	1202.75	535.17	268.27	taichung
22	1294.25	486.03	309.85	taichung
23	1467.50	540.17	291.03	taipei
24	1583.75	583.85	289.29	taipei
25	1124.75	499.15	272.55	taichung

Suppose this sample is representative of all HaoCafe's sales since 2016.

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We wish to test whether, in general, the average bonus amount for managers in Taipei is higher than bonuses in other regions

1. **[10%]** Which of the following set of hypotheses is appropriate for answering this question? We use μ to denote the average bonus amount in the population (all HaoCafe's customers since 2016).
 - a. $H_0: \mu_{\text{Taipei}} = \mu_{\text{Taichung+Kaohsiung}}$ and $H_1: \mu_{\text{Taipei}} \neq \mu_{\text{Taichung+Kaohsiung}}$
 - b. $H_0: \mu_{\text{Taipei}} \geq \mu_{\text{Taichung+Kaohsiung}}$ and $H_1: \mu_{\text{Taipei}} < \mu_{\text{Taichung+Kaohsiung}}$
 - c. $H_0: \mu_{\text{Taipei}} > \mu_{\text{Taichung+Kaohsiung}}$ and $H_1: \mu_{\text{Taipei}} \leq \mu_{\text{Taichung+Kaohsiung}}$
 - d. $H_0: \mu_{\text{Taipei}} < \mu_{\text{Taichung+Kaohsiung}}$ and $H_1: \mu_{\text{Taipei}} \geq \mu_{\text{Taichung+Kaohsiung}}$
 - e. $H_0: \mu_{\text{Taipei}} \leq \mu_{\text{Taichung+Kaohsiung}}$ and $H_1: \mu_{\text{Taipei}} > \mu_{\text{Taichung+Kaohsiung}}$
2. **[10%]** Which of the following data are **necessary** for computing the test statistic? (choose all that apply)
 - a. Average sales across the 25 customers
 - b. Average bonus across the 25 customers
 - c. Average bonus of Taipei customers
 - d. Bonus for each of the 25 customers
 - e. Standard deviation of sales for Taipei customers
3. **[10%]** Compute the test statistic (assume equal variances of bonuses for customers in Taipei and outside Taipei). The value of the test statistic is:
 - a. lower than -3
 - b. in the interval $[-3, -1)$
 - c. in the interval $[-1, 1)$
 - d. in the interval $[1, 3]$
 - e. higher than 3

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Below is a linear regression model estimated for SALES as a function of BONUS, and two region dummy variables. Use the output to answer the following questions.

	Coefficients	Std Error	t Stat	P-value
Intercept	884.183102	197.715461	4.471997776	0.000210215
BONUS	1.027058089	0.720776657	1.424932508	0.168870158
REGION_taipei	331.2580167	43.91122646	7.543811535	2.08335E-07
REGION_kaohsiung	-112.4250783	45.57968394	-2.466561165	0.022331028

Note: REGION_taipei=1 if REGION=taipei, otherwise REGION_taipei=0

REGION_kaohsiung=1 if REGION=kaohsiung, otherwise REGION_kaohsiung=0

4. [10%] Using the regression model, predict the average sales expected for a new customer in Kaohsiung whose sales manager received a bonus of NT\$25,000. Choose the appropriate predicted range:
- < NT\$900,000
 - NT\$900,000 to NT\$1,000,000
 - NT\$1,000,001 to NT\$1,100,000
 - NT\$1,100,001 to NT\$1,200,000
 - > NT\$1,200,000
5. [10%] The coefficient REGION_taipei=331.26 indicates that (choose all the correct statements)
- on average, sales in Taipei are higher than outside Taipei
 - on average, sales in Taipei are higher than in Taichung
 - on average, sales in Taipei are higher than in Kaohsiung
 - for the same bonus level, average sales in Taipei are higher than outside Taipei
 - for the same bonus level, average sales in Taipei are higher than in Taichung

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6. [10%] Based on the estimated regression model, what can we say about the relationship between sales and bonus? Use a 5% significance level. (Choose all that apply)
- a. Sales are positively correlated with bonus in each of the 3 regions
 - b. Sales are uncorrelated with bonus in each of the 3 regions
 - c. Sales are negatively correlated with bonus in Kaohsiung
 - d. Sales are uncorrelated with bonus in Taichung
 - e. Sales are positively correlated with bonus in Taipei
7. [10%] For a specific bonus amount, what is the difference between the average sales in Taipei and Kaohsiung? (Choose the correct interval)
- a. < NT\$100,000
 - b. NT\$100,000 - 200,000
 - c. NT\$200,001 - 300,000
 - d. NT\$300,001 - 400,000
 - e. > NT\$400,000

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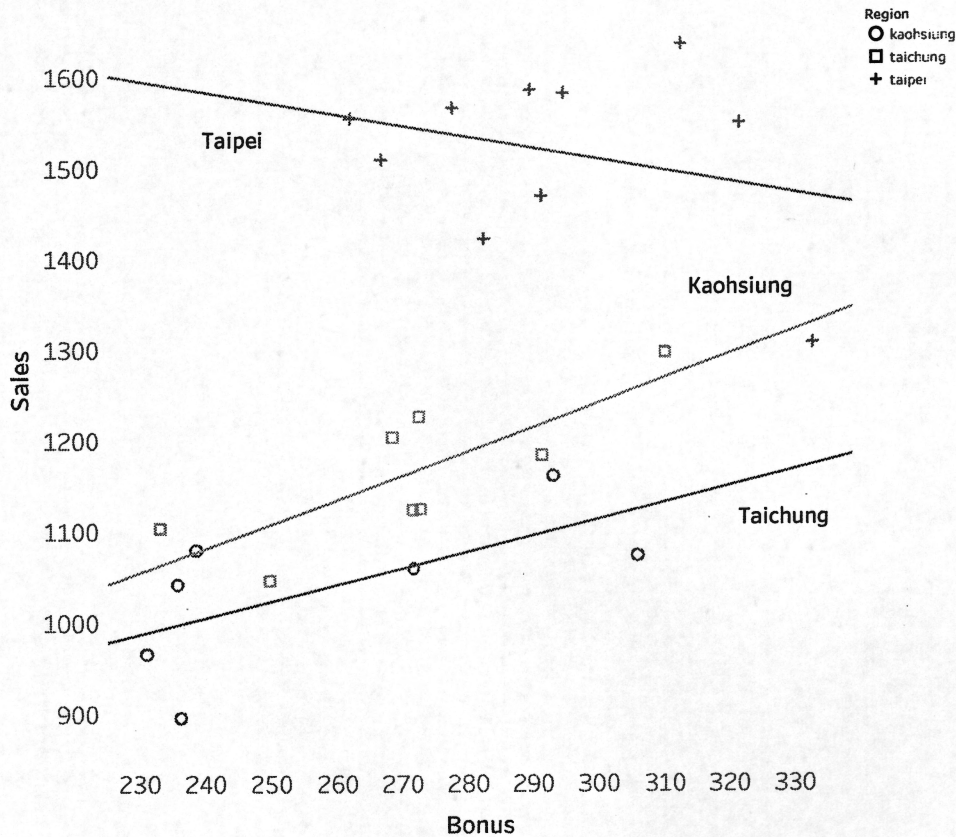
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When fitting separate regression models of SALES as a function of BONUS for each Region, we get the following result:

SALES as a function of BONUS, for each city



8. [10%] Suppose that all 3 slopes in the above chart are statistically significant at a reasonable level. And suppose there are no other factors affecting sales. What can we say about the effectiveness of bonus amount on sales by just considering the slopes? (Choose all correct answers)

- a. The bonus program seems most effective in Taipei
- b. The bonus program seems most effective in Kaohsiung
- c. The bonus program seems most effective in Taichung
- d. The bonus program should be stopped in Taipei
- e. The bonus program should be stopped in Taichung

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9. [10%] Based on the above chart, we can potentially improve our original regression model, which modeled all 3 cities together, by:
(Choose all the correct statements):
- a. adding a predictor that is a dummy variable for Taichung
(REGION_taichung=1 if REGION=Taichung, otherwise 0)
 - b. removing REGION_taipei from the original model
 - c. adding a predictor that is an interaction term REGION_taipei * BONUS
 - d. adding a predictor that is an interaction term REGION_kaohsiung *
REGION_taipei * BONUS
 - e. removing BONUS from the original model
10. [10%] The residuals from the original model are shown in the chart below, as a function of advertising expenditure (ADV). From this chart, we can say
(Choose all the correct statements):
- a. Advertising should be included in the original model
 - b. The highest under-prediction is for a Taipei customer
 - c. On average, advertising expenditure is highest in Taipei
 - d. The coefficient for BONUS from the original model can become larger
(>1.02) if we add ADV into the model.
 - e. The coefficient for BONUS from the original model might become
statistically insignificant if we add ADV into the model.

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Residuals as a function of ADV

