Clustering the Patterns of Program Cooperation Among Cross-Strait Universities

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Abstract
This study aims to evaluate the patterns of program cooperation among cross-strait universities for promoting mutual development in future. The data were collected from current cross-strait university cooperation and exchange programs in the selected universities. Fifty-eight leading universities have been reviewed by using their numbers of ongoing cooperation and exchange programs in their official web pages. The target group has been reviewed, which includes 31 universities in Taiwan and 27 universities in mainland China. This study transformed the data by applying mean, t-test, and cluster analysis for further interpretation. The result reveals the activities of cooperation are different among the universities by sectors and their locations. According to Euclidean distances in the cluster analysis, there are four significant clusters among the universities have been found. The different patterns of linkage among the universities provide more meaningful implications for university cooperation. Moreover, the SWOT analysis provides further information to interpret the strategy selection among the cross-strait universities to enhance their cooperation. Finally, this study proposes some suggestions for researchers to further expand the knowledge in this issue.

Keywords: cluster analysis, higher education, SWOT analysis, university cooperation

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Introduction

The relationships between China and Taiwan are changeable in the last decades. Political reasons and military tensions have impacted on the cross-strait interaction in culture and education activities. Cross-strait university cooperation has been initiated for a long period, while under the unique political issues the effect of proposed cooperation activities still unclear. Reviewing the current literature, this study also found it lacks of systematic studies in this field. Regarding the cross-strait contact and interactive experiences, this study explores the special phenomena among higher education institutions under political pressure. Basically, the cross-strait university cooperation is different from that of traditional notions of internationalization (Altbach and Knight, 2006; Altbach and de Wit, 2015; Jones and de Wit, 2012; Knight, 2015; Teichler, 2015). It is unequal to the format of internationalization at home (Beelen and Leask, 2011). Taking institutes to institutes models as examples, this study focuses on selected universities in mainland China and Taiwan to determine their effect of ongoing cross-strait cooperation.

Since 2009, the cross-strait business and culture cooperation activities are increasing. Korean media created a new word called "Chiwan" to address the new economic phenomena. Liu (2010) pointed that economic and educational interaction will initiate earlier than do other political related issues. Considered the unpredicted cross-strait relationships, Kuo (2009) argued the educational interaction in both areas will favor the mutual relationship and deepen the peace in that area. Actually, the Taiwan's authority has approved the mainland China's higher education accreditation lists in 2011. Following the lists of higher education institutes, Taiwanese students can enroll and graduate from those universities. Typically, the 41 accreditation listed universities in mainland China included 39 universities in 985 Project. The recognized lists have showed increased in 2011, the number of universities expanded from 41 to 111 which included the universities in 211 Project. In 2016, there are 155 universities in the new accreditation lists (Division of Higher education, MOE, 2016). Simultaneously, the Chinese students are welcome to study in Taiwan. This is a unique experience of cross-strait university cooperation under specific political reasons.

This study focuses on the universities cooperation and exchange activities by using the data collected from current cross-strait university interaction to answer the following research questions:

1. What is the current picture of cross-strait university cooperation and exchange?
2. Which factors are favored or disfavored in cross-strait university cooperation and exchange?
3. What's next step for cross-strait university cooperation and exchange?

Methods

Based on the cross-strait interactive activities in higher education institutes, this study collected the data from selected universities which include their locations, institutes ranking, sectors, and the numbers of MOU. The data were classified and interpreted by using t-test and cluster analysis respectively. In this study, the data collection is different from that of traditional questionnaire survey. Questionnaires represent one of the most practical cost effective methods to obtain large amounts of data, and produce

relatively robust evidence when adequate validation exercises are implemented. However, respondent bias remains an issue, especially regarding socially desirable responses (McDonald, 2008), which represents an inherent limitation of the method. By way of web data which the target universities have provided, this study transformed the data to fit the format of cluster analysis. Reviewing the method related literature, this study found previous studies have provided various examples for conducting cluster analysis (Battaglia, Paola & Fazio, 2016; Brusco, Singh, Cradit & Steinley, 2017; Crowe, LoPilato, Campbell, & Miller, 2015; Lankton, McKnight, & Tripp, 2017). In this study, the methodological section will follow the useful suggestions to determine the fittest classification for the current data.

Research target

Due to the time and resource constrain, this study selected 31 universities including research focusing, teaching oriented in terms of teaching excellence universities, and modeling technological universities in Taiwan. There are 27 leading universities in 985 Project were selected in mainland China, the other universities in 985 Project are omitted because of their data incomplete or not possible to search on web page at this time.

Statistics analysis

Cluster analysis is a popular statistical method. It is also called segmentation analysis or taxonomy analysis, partitions sample data into groups or clusters. Tryon (1939), the first time initiated the notion, indicated there are various algorithms and methods in cluster analysis. Clusters are formed such that objects in the same cluster are very similar, and objects in different clusters are very distinct. Basically, cluster evaluation determines the optimal number of clusters for the data using different evaluation criteria in diverse settings. In this study, the data selection was the first step; then we applied hierarchical clustering with SPSS to determine the clusters; the verified the clusters by using k-means clustering in SPSS.

Hierarchical Clustering

Typically, hierarchical clustering groups data over a variety of scales by creating a cluster tree or dendrogram. The tree is not a single set of clusters, but rather a multilevel hierarchy, where clusters at one level are joined as clusters at the next level. The dendrogram function plots the cluster tree. Based on the dendrogram, this study decides the level or scale of clustering that is most appropriate for the data application. The agglometrative methods in this study include single linkage, average, centroid and Ward. The single linkage method calculated the distances are as follows:

$$d_{A,B} = \underset{\substack{i \in A \\ j \in B}}{Min} d_{ij}$$

The average linkage method calculated the distances are as follows:

$$d_{A,B} = \Sigma\Sigma d_{ij} / n$$

n in terms of the numbers of distances;
The centroid method calculated distances are as the follows:

$$d_{A,B} = d(\bar{\bar{x}}_A, \bar{\bar{x}}_B) = \| \bar{x}_A - \bar{x}_B \|^2$$

While the Ward method transformed the data according to the following format:

$$d_{A,B} = n_A \| \bar{x}_A - \bar{\bar{x}} \|^2 + n_B \| \bar{x}_B - \bar{\bar{x}} \|^2$$

K-Means Clustering

K-means clustering is a partitioning method. The function *k*-means partitions data into *k* mutually exclusive clusters, and returns the index of the cluster to which it has assigned each observation. Unlike hierarchical clustering, *k*-means clustering operates on actual observations (rather than the larger set of dissimilarity measures), and creates a single level of clusters. The distinctions mean that *k*-means clustering is often more suitable than hierarchical clustering for large amounts of data. In this study, *k*-means treats each observation in the data set as an object having a location in space. It finds a partition in which objects within each cluster are as close to each other as possible, and as far from objects in other clusters as possible. In SPSS process, the *k*-means provides more meaningful statistical test information. Taken the advantage of this method, each cluster in the partition is defined by its member objects and by its centroid, or center. The centroid for each cluster is the point to which the sum of distances from all objects in that cluster is minimized. *K*-means computes cluster centroids differently for each distance measure, to minimize the sum with respect to the measure that we specify. Basic *k*-means algorithms are as follows:

1. Select *k* point as initial centroids,
2. Repeat
3. From *k* clusters by assigning each point to its closest centroids,
4. Re-compute the centroids of each cluster,
5. Until centroids do not change.

SWOT analysis

The effect of cross-strait cooperation has been evaluated by using SWOT model. First, the study listed the strong and weak conditions based on the collected data. Second, this study taken into account opportunities and threatens to develop improving strategies. Finally, the information was synthesized from SWOT to SWOTS in terms of using SWOT framework to find strength, opportunity, threat and weakness information in the field, after that this study created active, utilized, controlling, and improving strategies for suggestions.

Result

The result will present the current real pictures of cross-strait university interaction in the selected universities. First, this study reviewed the selected 10 leading universities from mainland China and Taiwan to compare their cooperation formats. Then, the cumulated university cooperation and exchange activities will be addressed. Finally, the favor or disfavor factors will be evaluated for enhancing the cross-strait university cooperative activities in future.

Selected 10 leading universities' cross-strait cooperation activities

Table 1 shows the political limited areas in terms of 8 provinces or cities in mainland China still create more cooperative opportunities for Taiwan's 5 leading universities compared to the other unlimited provinces or cities. Regarding the cooperation with cross-strait and world-wide universities, this study found the cross-strait cooperative activities are only a small part of the whole universities' cooperative activities. The proportions share of cross-strait cooperation among these universities are: NCKU 10.55%, NTU 10.78%, NCTU 15.23%, NTHU 19.33%, and TKU 17.59%.

Table 1. Current universities cooperation with selected 5 leading universities in Taiwan

Name of university	Type	Research U.	Sector	Number of cooperation with universities in eight provinces or cities	Number of cooperation with universities not in the eight provinces or cities	Total number of cooperation with mainland China's university (A)	Total number of cooperation with world-wide universities (B)	A/B (%)
NCKU	1	1	1	19	6	25	237	10.55
NTU	1	1	1	41	21	62	575	10.78
NCTU	1	1	1	25	14	39	256	15.23
NTHU	1	1	1	28	24	52	269	19.33
TKU	2	0	0	22	13	35	199	17.59

Note: Type 1 represents the research funding universities, 2 represents the teaching excellence funding universities; Sector 1 represents the public universities, sector 0 represents the private universities;

The numbers of cooperation activities in selected 5 leading universities in mainland China with Taiwan's universities are different. There are only 6 Taiwan's universities cooperation with SJTU, while 25 Taiwan's universities have created cooperation with SYSU. Basically, PKU only 4.21％ of her total cooperation programs with Taiwan's universities, while RUC has shown 34％ of her cooperation programs with Taiwan's universities, see Table 2.

Table 2. Universities cooperation with selected 5 leading universities in mainland China

Area/city	Name of university	Located in 8 provinces and cities	985 project	Recognized by Taiwan	Number of cooperation with Taiwan (A)	Number of cooperation with world-wide universities (B)	A/B (%)
Peking	RUC	1	1	1	17	50	34.00
Peking	PKU	1	1	1	16	380	4.21
Shanghai	SJTU	1	1	1	6	68	8.82
Zhejiang	ZJU	1	1	1	16	117	13.68
Guangdong	SYSU	1	1	1	25	158	15.82

Taiwan's effort of cross-strait university cooperation

Compare 12 research-oriented with 19 non-research-oriented universities in Taiwan, this study found their cooperation activities with mainland China's universities did not shown significant differences. While various sector's universities make differences in their cooperation activities with mainland China's universities. The private universities have shown actively in connect with the universities in mainland China, the details have been presented in Table 3.

Table 3. Compare the number of cooperation activities with mainland China by different types and sector of Taiwan's universities

Type and sector	Universities	Number of universities	Average cooperation activities with mainland China	t	p
Research-oriented or not	Yes	12	40.0	1.403	.171
	No	19	50.8		
Sector	Public	21	39.2	-2.83	.008
	Private	10	62.2		

Mainland China's effort to cross-strait university cooperation

The study collected 27 universities in the list of 985 Project. There are 10 universities located in cities, while 17 universities located in the limited 8 provinces or cities which for political reasons. According to our classification, there are 15 universities located in the limited 8 provinces or cities, 12 universities located in the other area. Their average of cooperation activities with Taiwan's universities is 16.3. The range of cooperation activities is from 4 to 34 in different universities. Based on the limited 8 provinces or cities for opening to study in Taiwan, this study did not find significant difference regarding to those leading universities' cooperation activities with Taiwan, see Table 4.

Table 4. Compare the effect of cooperation in mainland China's universities by different areas and limitations

University's cooperation activities	Types	N	Average number of cooperation with Taiwan	t	p
City or provinces	Cities	10	13.1	-1.54	.135
	Provinces	17	18.2		
Within 8 provinces/ cities or not	Within 8 provinces or cities	15	17.3	.67	.509
	With other areas	12	15.1		

Classified the different types of cross-strait university cooperation

Types of cross-strait university cooperation in Taiwan

Based on the attributes of universities (types, research-oriented or not, and sector) and cooperative activities with the universities in mainland China, the hierarchical cluster analysis suggests that the types of Taiwan's universities can be classified 4 different groups by considered the data's Euclidean distance and average linkage, see Figure 1.
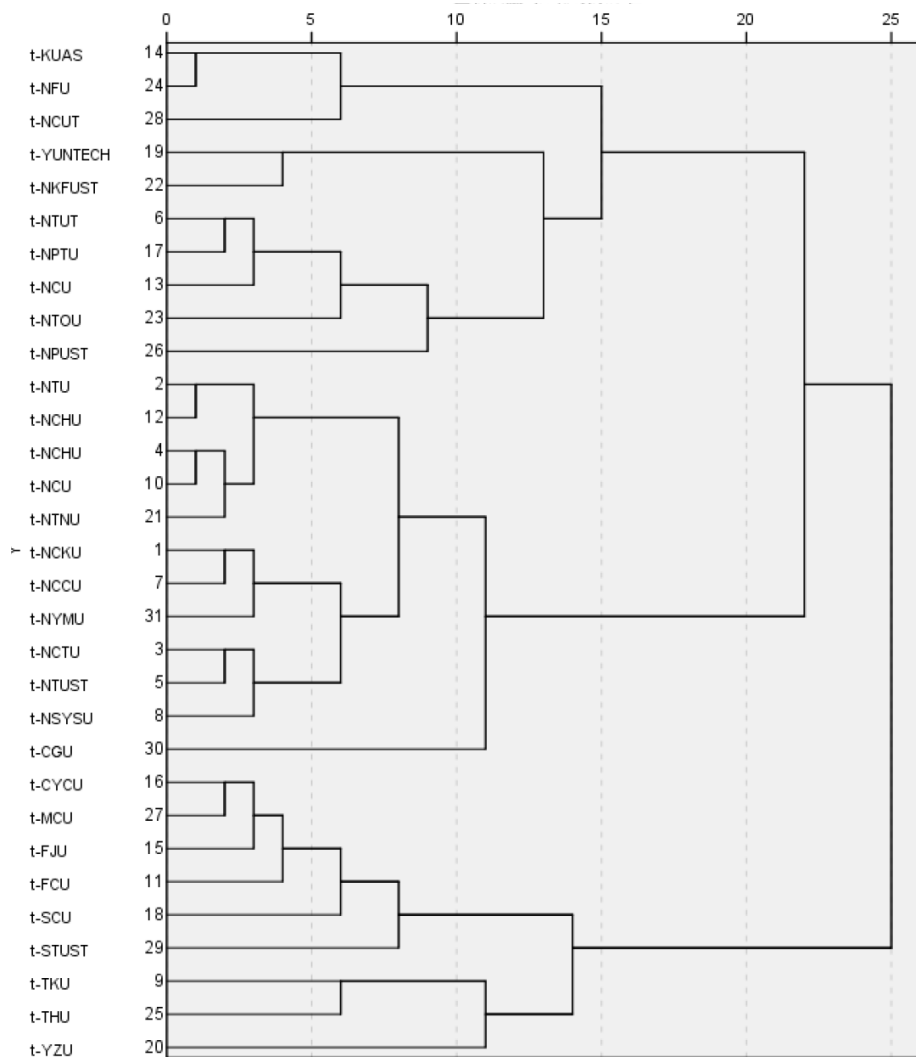

Figure 1. Dendrogram of hierarchical cluster analysis with Euclidean distance and average linkage

K-means presents the details of ANOVA test for three groups' differences in Taiwan's universities with their specific variables, see Table 5.

Table 5. ANOVA test for cluster differences in the three groups

	Cluster		Error		F	Sig. (P)
	Mean square	df	Mean square	df		
Type	.733	2	.620	28	1.182	.322
Number of cooperation	7137.658	2	82.001	28	87.043	.000
Research-oriented or not	.308	2	.241	28	1.280	.294
Sector	.618	2	.198	28	3.122	.060

Regarding to the number of cooperation activities, location in limited 8 provinces and cities or not, this study with square Euclidean distance and centroid method to linkage the result reveal there are three significant groups among the 31 universities in Taiwan, see Figure 2.
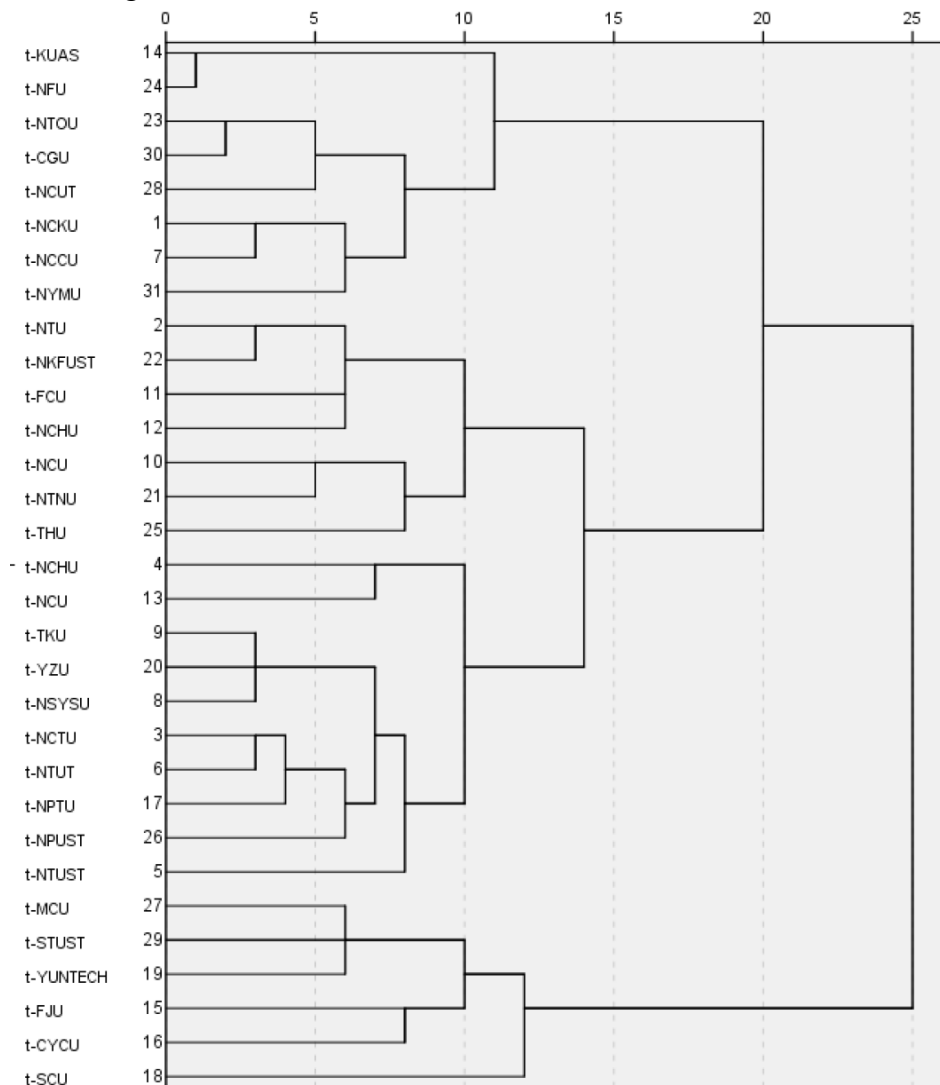

Figure 2. Hierarchical cluster analysis with square Euclidean distance and centroid method

K-means presents the details of ANOVA test for the three groups regarding to the number of cooperation activities, location in limited 8 provinces and cities or not, see Table 6.

Table 6. ANOVA test for the group's differences with number of cooperation activities and political limitation in 8 provinces

	Cluster		Error			
	Mean square	*df*	Mean square	*df*	*F*	Sig. (*p*)
Number of cooperation	7137.658	2	82.001	28	87.043	.000
Within 8 provinces or cities	2519.981	2	41.073	28	61.354	.000
The other provinces or cities	1178.400	2	27.948	28	42.163	.000

Types of cross-strait university cooperation in mainland China

What is the feature of the cross-strait cooperation among 27 universities in mainland China? According to hierarchical cluster analysis, this study conducted Ward method with square Euclidean distance and z transformation found there are three significant groups with their cooperation activities with Taiwan's universities under the constrain of location in provinces or cities and location in limited 8 provinces and cities or not. The details have been presented in Figure 3.
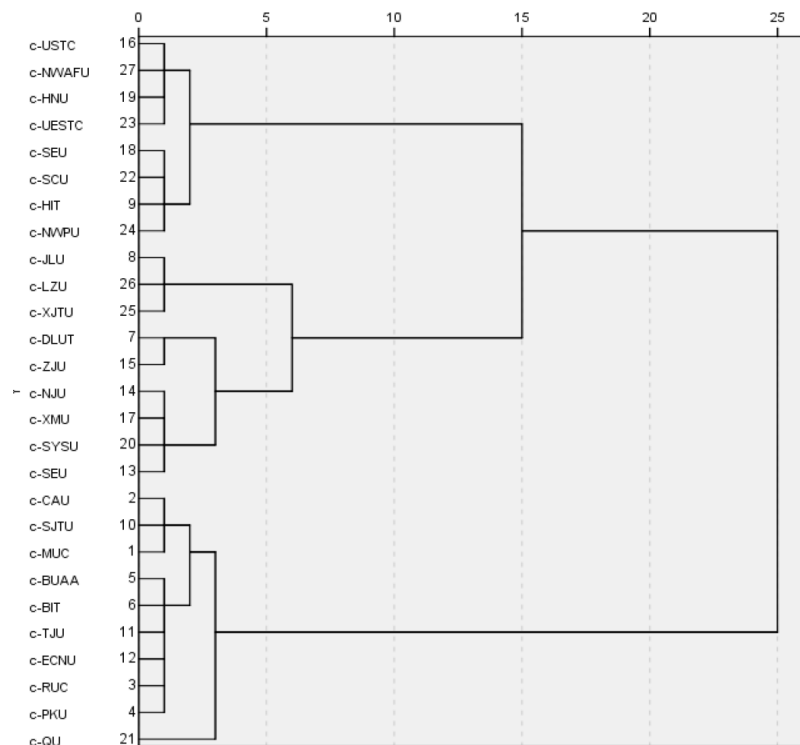

Figure 3. Clustering the cross-strait cooperation among 27 universities in mainland China

K-means presents the details of ANOVA test with the number of cooperation activities under constrains: "location in provinces or cities" and "location in limited 8 provinces and cities or not".

Considered the cross-strait political factor, the university cooperation activities are still interfered by current situation. This study assumed mainland China only opened 8 provinces' or cities' students can study in Taiwan, whether this political limitation will impact on cross-strait university cooperation activities? According to hierarchical cluster analysis, this study conducted Ward method with square Euclidean distance and z transformation found there are three significant groups with their cooperation activities with Taiwan's universities under the only constrain of location in limited 8 provinces and cities or not. The result reveals the universities located in the 8 provinces or cities have shown more university cooperation activities with Taiwan's universities than that of others, see Figure 4.
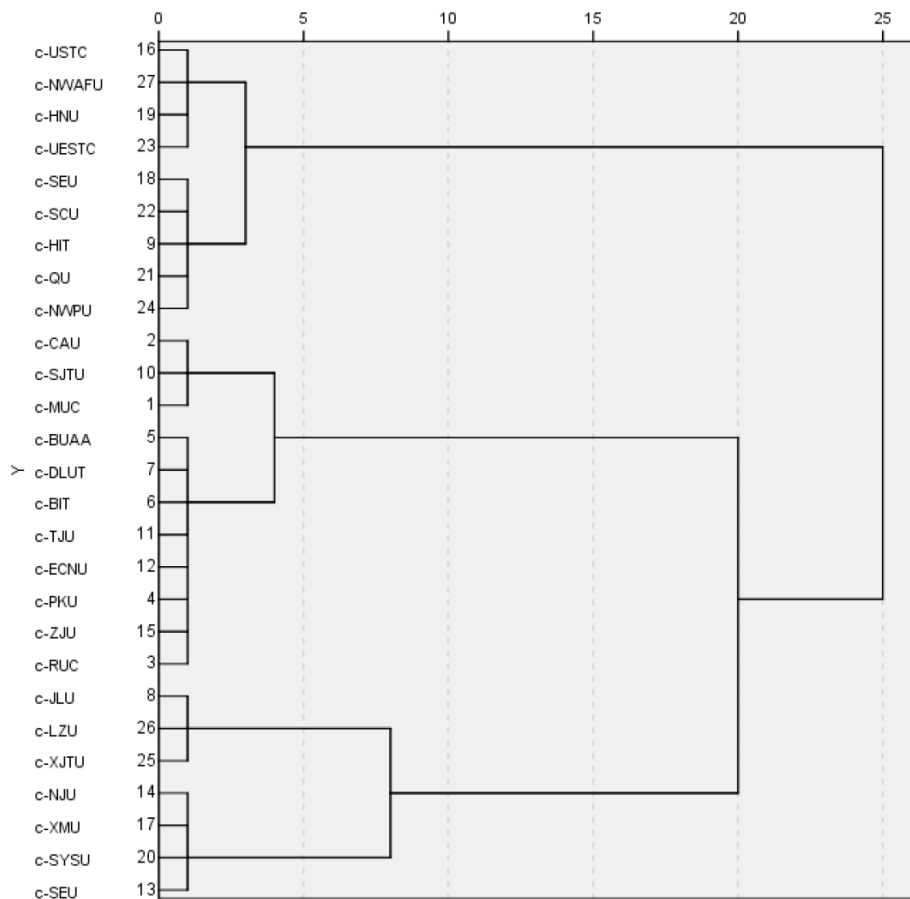

Figure 4. University cooperation activities clustered by 8 provinces' or cities' limitation with Ward method

K-means presents the ANOVA test to verify the clustering with the number of universities' cooperation activities under the political constraints. The details of three significant groups have been presented in Table 7.

Table 7. ANOVA test the group differences of cooperative activities with political constraint

	Cluster		Error		F	Sig. (p)
	Mean square	df	Mean square	df		
Number of cooperation	820.419	2	11.215	24	73.153	.000
Within provinces or cities	.076	2	.271	24	.281	.758

Similarity or dissimilarity of cross-strait university cooperation

Based on the simple linkage with z transform the data, this study found there are four significant groups classified by considered the universities' location, research-oriented type of universities or not, and number of current cooperation activities. First, figure 5 displays cross-strait universities with similarity group will create more opportunities of cooperation. For example, the NTCU in Taiwan may take advantage of similarities with the following universities in mainland China in terms of their deepen cooperation activities: Zhejiang University (ZJU)、University of Science and Technology of China (USTC)、Xiamen University (XMU)、Southeast University (SEU)、Central South University (CSU)、Hunan University (HNU)、Nanjing University (NJU)、Sun Yat-sen University (SYSU)、Sichuan University (SCU)、University of Electronic Science and Technology of China (UESTC)、Northwestern Polytechnical University (NWPU) 、 Xi'an Jiaotong University (XJTU)、Lanzhou University (LZU)、Northwest A&F University (NWAFU)、Dalian University of Technology (DLUT)、Harbin Institute of Technology (HIT)、Jilin University (JLU).

Second, National Cheng Kung University (NCKU)、National Taiwan University (NTU)、National Chung Hsing University (NCHU)、National Taiwan University of Science and Technology (NTUST)、National Taipei University of Technology (NTUT)、National Chengchi University (NCCU)、National Sun Yat-sen University (NSYSU)、National Central University (NCU)、Chang Gung University (CGU)、National Yang Ming University (NYMU)、National Taiwan Normal University (NTNU)、Shanghai Jiao Tong University (SJTU)、Tongji University (TJU)、East China Normal University (ECNU)、Renmin University of China (RUC)、Peking University (PKU)、Beijing Institute of Technology (BIT)、Beihang University (BUAA)、Central University of Nationalities (CUN)、China Farmer University (CFU)、Chongqing University (CQU) are similar group. These universities are located in cities areas.

Third, the other two groups show more numbers of cooperation activities with each other and most of universities in Taiwan belong to teaching-oriented purposes or

technological universities. For better cross-strait universities cooperation, the suggestion goes to looking for similar universities to be partners in mainland China.

In this study, *k*-means presents the ANOVA test to verify the four clusters with the number of universities' cooperation activities under the political constraints. The details of four significant groups have been presented in Table 8.

Table 8. ANOVA test the group differences of cooperative activities with type and location of universities

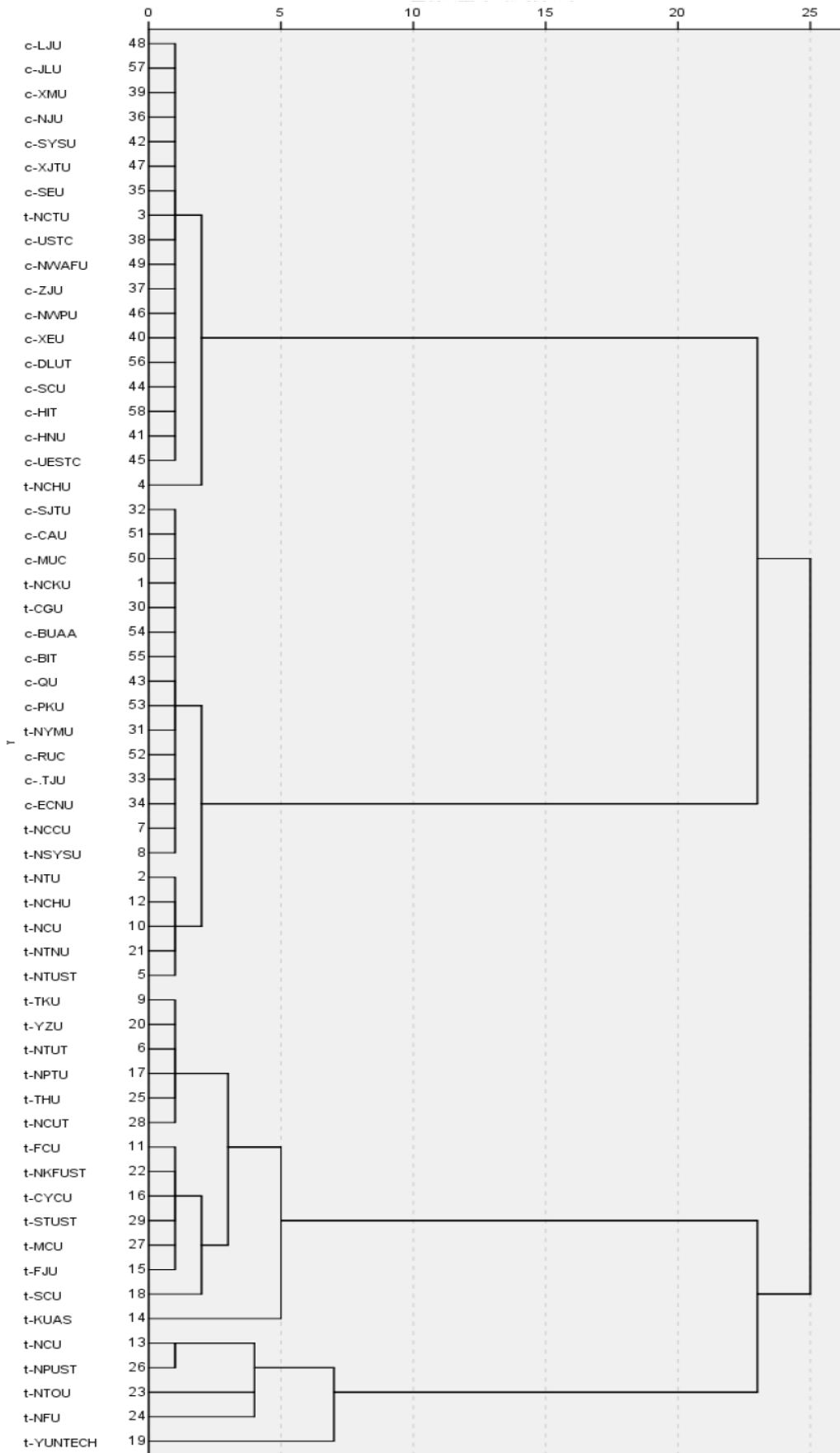|	Cluster		Error			
	Mean square	*df*	Mean square	*df*	*F*	Sig. (*p*)
Research-oriented U.	.968	3	.183	54	5.296	.003
Provinces or cities	.398	3	.238	54	1.668	.185
Number of cooperation	9503.125	3	59.317	54	160.210	.000

Figure 5. The features of cross-strait university cooperation

SWOT analysis

Based on the previous SWOT analysis, this study provides suggestions for Taiwan:

1. The research-oriented universities with 985 project universities in mainland China have high feasible to create substantive cooperation opportunities. Supported by MOST, related cooperative projects will promote the cross-strait university cooperation.
2. Most of private universities have created more cross-strait cooperation activities in terms of their percentage share. These phenomena might reflect the fact that the private universities lack of international cooperation activities or need to reinvent their internationalization.
3. Long-term strategies in most of universities did not show so clear. It might impact on the effect of university cooperative activities.
4. Under current political constrains, how to break through the impasse to attract students or faculty from mainland China is important strategy. More active university cooperative activities are welcome to eliminate the boundary of cross-strait political reasons.
5. Clarify the fittest cooperative programs in different type of universities are necessary; then the effect of long-term university cooperation will achieve.
6. Teaching-oriented universities may focus their cooperative partners on the other 985 Project universities. Currently, the location of universities in mainland China is very important to create cooperative opportunities. The suggested 8 provinces or cities by mainland China is the best choice for Taiwan's teaching-oriented universities to seeking cooperative partners.

Table 9. SWOT analysis for Taiwan with cross-strait university cooperation and exchange

Opportunities	Threats
O1. Cross-strait cultural and education interaction still active O2. MOE and MOST support the cross-strait activities O3. Competitive resources are relative fair to acquire O4. Mechanism for personnel are still encourage	T1. China rising and her competition in different fields T2. China's attraction for academic talents T3. Chin's strong policy intervention for higher education T4. China's classification of higher education is effective T5. Competitions come from the outside never ended
Strengths	Weaknesses
S1. Well-developed universities in Taiwan S2. Democratic mechanism in campuses S3. Universities focus on professionalism S4. Law and regulation are well-established	W1. Over expanded higher education and resource limited W2. Low salary cannot attract academic talents W3. Incentive of university-industry cooperation is not sufficient W4. Focusing on since and technology result neglected in the humanity innovation W5. Lack of cross-strait cooperation office in universities W6. Lack of resource for promoting cross-strait cooperation and exchange

Conclusion

What kinds of benefit already shared among the higher education institutes of cross-strait interaction? Because of insufficient precisely information in previous studies, this study evaluated the effect of cooperation and exchange by using the current web data. The result reveals both the number of interactive activities and the participated cross-strait cooperation universities in Taiwan are more than that of mainland China. Suggestions for further development will prompt to how to deepen interaction with institutes and wider the cooperation activities. This study also perceived the only approved 8 provinces or cities to study in Taiwan by mainland China, while this limitation did not constrain the cooperative activities with individual universities. From the view of Taiwan, how to enhancing the strategies for effective district cooperation has become more important in next stage cross-strait cooperation. Too wide or various institute interactive activities have exited for a long period, however it did not utilize the limited resources for effectiveness. For long term purposes, it is disfavored to Taiwan's universities. In mainland China, there are various planned activities for university cooperation and interaction have been found. The China's universities still directed by the central government or the campus's delegate of ruling party, while the universities perceived more institutional autonomy in Taiwan. Because of the cross-strait managerial principle did not fit well, how to

delimitate the dissimilarity toward the similarity is the new challenge for both sides of universities in future. Furthermore, the resources in universities are limited, to widen the cooperative activities is challenged. Therefore, creating union organizations or enhancing university cooperation in specific areas is an important strategy for Taiwan to face the new challenges of cross-strait university cooperation.

Finally, this study proposes the following suggestions to further developing cross-strait university cooperation:

- The strategies for active strengths and grasp the opportunities are: Based on current development, high quality human resources, government supported resources to create further moment of cross-strait university cooperation.
- Strategies for utilizing strengths to eliminate threatens are: Based on democratic and fair system, campus culture of respect on profession to diminish threaten from mainland China to attract Taiwan's academic talents.
- Strategies for grasping opportunities to improving weakness are: Based on government initiatives the industry-university cooperation and provide competitive resources for universities, the universities should reconsider their innovative entrepreneurship system to diminish the low salary and brain-drain issues.
- Strategies for improving weakness and diminish threatens are: The industry-university cooperation is inactive and the related encourage strategy is not enough in Taiwan. Lack of cross-strait university cooperation units or offices to implement and lack of interactive budgets are current problems that the universities confront with. Whether the weakness and threaten can be diminished or not? It will impact on the effect of cross-strait university cooperation directly.

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