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## Research Competitiveness among Higher Education Institutions in South East Asia: A Complex Adaptive System

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### *Abstract*

Research competitiveness among higher education institutions is vital for knowledge generation and innovation. It leads to international recognition and tertiary education quality that promotes the nation's sustainable growth and development. This has led the researchers to study the emergent behaviors of 63 higher education institutions in Southeast Asia through the data sets provided by the University Ranking of Academic Performance (URAP) in 2018. Data taken from URAP were on articles, citation and total documents, article impact total, citation impact total, and international collaborations that were categorized into three major dimensions through factor analysis of research productivity, research impact, and international collaboration. Cluster analysis was used to describe the ASEAN universities by cluster based on their characteristics. These features were then used as inputs to calculate the synergies. The study found that the research competitiveness of higher education institutions in Southeast Asia is high when there is an increase in research impact, research productivity, and international collaboration. As research productivity increases, HEIs can establish more research collaboration. The researches made have to make an impact in the fields of specialization to create more collaboration. The variations of research competitiveness in HEIs from progressive countries in Southeast Asia are less than the variations in the HEIs of developing countries.

*Keywords:* Research competitiveness, impact, productivity, internationalization, collaboration, higher education institutions.

### *Introduction*

Higher Education Institutions (HEIs) have become systems that place great value on the conduct and communication of scholarly research. They are prime movers in nation-building, knowledge generation, and innovation. They are linchpins of the countries' economy and society. Both instruction and research in colleges and universities contribute

significantly to the nations' economic activity, both directly and indirectly. Their impact on future growth, gains in government, communities, and individuals from learning and innovation are evident.

There are rapid changes in the roles of HEIs driven by globalization and internationalization.

Research and development, international competition, and collaboration have become high priority areas on the agenda of most universities worldwide. These areas are vital in terms of the institutions' performance and reputation, which would lead to promoting more students, stakeholders, and partners for resource generation and collaboration. These call for the institutions of higher education to become competitive in research and development.

In Asia, there is an expanding trend of regional and cross-border collaboration in higher education. Institutions are initiating and participating on this collaboration to strategize and strengthen their higher education systems. Asian Development Bank (2012) found that leaders in higher education generally believe that cross-border collaboration in higher education offers a promising mechanism for revenue generation, student recruitment, and quality enhancement, and sometimes a way to improve research. Moreover, regional cooperation and cross border collaborations can facilitate the operations of regional centers of research excellence, which can effectively enhance regional capacity and productivity. The collaborations across the Asian region have employed a wide variety of partnering arrangements such as twinning, franchising, dual degrees, joint degrees, and others.

The British Council (2015) conducted a study on the research performance in Southeast Asia. Thirty (30) institutions consisting of universities and research centers were selected across the five countries in SEA namely: Malaysia, Thailand, Indonesia, Vietnam, and the Philippines. The higher education institutions were chosen on the basis of their outputs and/or impact. Findings reveal that the ASEAN region as a whole is comparatively more active in the physical sciences, certain areas of the social sciences, a couple of life sciences fields, and computer sciences. It has relatively high output and impact levels in chemical engineering, engineering, material science, and energy. But

the UK collaborations with selected ASEAN countries show relatively more activity in the life and health sciences.

Moreover, the council reports that ASEAN produced 2.2% of world papers in 2009-2013. It has 1.19 field weighted citation impact, which is 19% above world average and an annual FWCI growth of 0.5%. ASEAN researches were more on energy which has the highest relative impact, a vibrant area that displays high output and high growth.

Moreover, based on the research performance of the ASEAN countries, Malaysia was found to have consistently increased its impact as well as shown strong output growth, reaching to a one percent share of the world's scholarly output in 2013. The increasing impact is attributed to the country's policy on investing aggressively into science and academic researches. In terms of citation impact, the country which remains significantly above the world average is the Philippines, but it has seen some decreases through time. Vietnam and Thailand's citation impacts are both approximately around the world average, due to stability over the past few years, while Indonesia has seen decreases in citation impact, remaining under and distancing itself further from the world average. Based on the report of the British Council, the HEIs in Southeast Asia have improved its research performance from 2009-2013. There are variations and differences in the performance of the five countries in many aspects.

Research competitiveness among higher education institutions is varied and intricate depending on the institution's system and culture. It is a complex adaptive system because each HEI has varied characteristics. The complexity is inherent in the HEI's system as it relates to more than a large number of interacting agents. The actions and interactions that these agents perform are often independent and unpredictable. These agents are influenced by the following factors:

institutional characteristics, leadership, and individual faculty members' characteristics (Bland et al., 2005). Institutional characteristics may include academic environment, organizational structure, and access to resources and organizational networks and linkages. Leadership may include leaders' characteristics, and organizational management. The faculty members' characteristics may include individual researchers' position, research motivation and personality which are found to affect research performance (Kyvik, 1991).

Competitiveness in research calls for institutions to promote research productivity, research impact and international collaboration (URAP, 2019). These features are important in sustaining quality research which is the lifeblood of any scientific discipline. Without it, disciplines would stagnate, failing to advance past their current limits and understanding (Wann, 1997). As such, higher education institutions must learn to understand its complexities and be able to manage the factors that influence the research competitiveness in the academe. Hence, this study aims at determining the emergent behaviors resulting from the interactions of the three elements namely: research productivity, research impact and international collaboration among higher education institutions in Southeast Asia.

### *Framework of the Study*

Competitiveness is an ability to achieve a high standard of living through productivity growth in the new global environment, where knowledge becomes a critical factor (Lee & Karpova, 2018). Research competitiveness is the degree to which an institution may produce researches and publications that pass the test of international competition and at the same time maintain and develop its profits at a national level, in the conditions of market liberalization (OECD Programme on Technology and the Economy, 1992). This means that a higher education institution is competitive in research when it is able to

produce and publish researches that generate income contributing to the nation's productivity and economy. Global Competitiveness Index, defined competitiveness as a "set of institutions, policies, and factors that determine the level of productivity of a country" (World Economic Forum, 2015).

The economic literature reveals that the competitiveness concept is very complex, difficult, and amorphous (Anca, 2012). There is still not a commonality to the concept of competitiveness. There are confusion surrounding competitiveness concept but literature shows some of the important aspects: Competitiveness has qualitative and quantitative factors and conditions. It has several dimensions: national, regional and local. It is explained by composite factors. These composite factors can be clear goals for coordination, research emphasis, distinctive culture, positive group climate, decentralized organization, participative governance, frequent communication, resources (particularly human resources), group age, size and diversity, appropriate rewards, recruitment emphasis, and leadership with both research skill and management practice (Bland & Ruffin, as cited in Pratt, Margaritis, & Coy, 1999). Dunder and Lewis (1998) also stated these composite factors: individual attributes, institutional and departmental attributes, as well as departmental culture and working conditions affect research productivity or in the context of this paper research competitiveness. Hence, with all these complex factors, competitiveness may comprise a complex adaptive system.

Complex Adaptive Systems (CAS) is composed of a large number of components called agents that interact and adapt or learn (Holland, 2006). CAS involves many components that adapt or learn as they interact – is at the heart of important contemporary problems. The agents in the context of this study are the universities that compete and adapt to each other as they work for research competitiveness.

A higher education institution is a complex adaptive system consisting of several components or agents, interacting with each other according to set of rules called schema in such a manner as to improve their behavior and the behavior of the system, which they comprise (Stacey, 1996). CAS is adequate to understand the change in the institutions especially in research. The change can be brought about by the institution's agenda, priorities, and systems, change in leadership, and the composition and characteristics of its individual faculty members. Figure 1 shows the dimensions of research competitiveness in HEIs through interactions that may result to an emergent behavior of research competitiveness.

Research competitiveness can be explained by the interaction between the higher education institutions across the countries in Southeast Asia. The research competitiveness of these institutions are measured in terms of research productivity, research impact, and international collaboration. Research productivity refers to the number of scientific researches and documents generated by higher education institutions. Research impact is the influence of the produced publications and researches to the field or disciplines. International collaboration is the global acceptance of the university.

### Methodology

This is a descriptive-analytical type of research, utilizing new methodologies of data mining, factor analysis, cluster analysis and complex adaptive system. Data sets used in this study are from the University Ranking by Academic Performance (URAP) in 2018. The data on research articles, citation, total documents, article impact total, citation impact total, and international collaboration of the 63 universities in Southeast Asia were taken from the said data sets. These data were analyzed, summarized and processed in determining the emergent feature.

Factor analysis was utilized in reducing the six (6) dimensions or factors into three dimensions: research productivity index, research impact index, and international collaboration. Research productivity index is composed of articles, citation, and total documents.

Article is a measure of current scientific productivity which includes articles published in journals that are listed within the first, second, and third quartiles in terms of their journal impact factor. Articles that include more than 1000 authors are excluded.

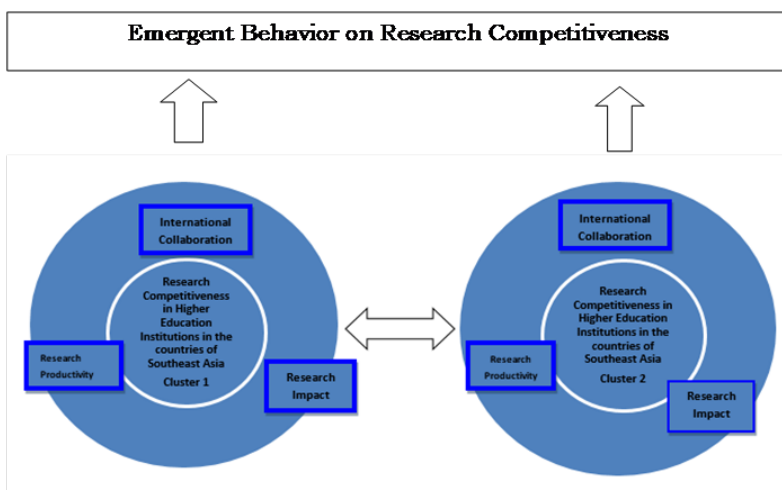


Figure 1. Dimensions of research competitiveness that may result to emergent behaviors.

Citation is a measure of research impact and scored according to the total number of citations received in 2013-2017 for the articles published in 2013-2017 in journals that are listed within the first, second, and third quartiles in terms of their journal impact factor. Articles that include more than 1000 authors are excluded.

Total document is the measure of sustainability and continuity of scientific productivity and presented by the total document count which covers all scholarly output of the institutions, including conference papers, reviews, letters, discussions, and scripts in addition to journal articles published during 2013-2017 period. The total document counts are not subjected to any filtering.

Research Impact Index is composed of article impact total (AIT) and citation impact total.

Article impact total (AIT) is a measure of scientific productivity corrected by the institution's normalized citation per publication (CPP) (1) concerning the world CPP in 23 subject areas between 2013 and 2017. The ratio of the institution's CPP and the world CPP indicates whether the institution is performing above or below the world average in that field. This ratio is multiplied by the number of publications in that field and then summed across the 23 fields. This indicator aims to balance the institution's scientific productivity with the field normalized impact generated by those publications in each field.

Citation impact total (CIT) is a measure of research impact corrected by the institution's normalized CPP with respect to the world CPP in 23 subject areas between 2013 and 2017. The ratio of the institution's CPP and the world CPP indicates whether the institution is performing above or below the world average in that field.

The third dimension is the international collaboration. International collaboration is a measure of global acceptance of a university.

International collaboration data, which is based on the total number of articles published in collaboration with foreign universities, is obtained from citations for the years 2013-2017. The weight of this indicator is 15 % in the overall ranking.

Factor analysis was used to determine the features described by the variables. Cluster analysis was used to describe the ASEAN universities by cluster based on their characteristics. These features were then used as inputs to calculate the synergies. Positive synergies imply feature similarities. In calculating the synergy, a program or application from Northwestern Mindanao State College of Science and Technology (NMSCST) was utilized. A histogram is shown to summarize the synergy generated. A scatter plot was also generated to look at emerging patterns. The results were then analyzed and discussed.

### *Results and Discussions*

There were 63 ASEAN universities involved in the study which were identified in URAP as top-performing academe in Southeast Asia. Using the factor analysis the Eigen analysis of the correlation matrix was done. The predictors on articles, citation, and total documents were grouped into research productivity index.

Table 1 shows the result of the factor analysis performed to extract the underlying features of the variables of the study which is the combined effect of the research productivity, research impact and international collaboration as drivers for research competitiveness. With the three variables under investigation, it makes sense that only factor 1 is used after the factor analysis was performed especially because 98.4% of this feature in factor 1 can be explained by the variables of this study. This feature refers to research competitiveness of the higher education institutions in Southeast Asia included in the analysis.

Table 1  
Factor Analysis of the Three Dimensions of Research Competitiveness

Variable	Factor 1	Factor 2	Factor 3
Research Productivity Index	0.996	-0.024	0.083
Research Impact Index	0.988	0.149	-0.031
International Collaboration	0.991	-0.124	-0.052
Variance	2.9513	0.0381	0.0105
% Var	0.984	0.013	0.004

The research competitiveness feature of the higher education institutions in Southeast Asia was used to calculate their positive synergy. Using this feature, the synergies were computed for pairs of HEIs that form positive interaction. Positive synergy implies similarities in this feature. Figure 1 shows the synergistic analysis of this feature where the blue connections imply institutions that share similar features. In contrast red connections imply dissimilar features in terms of research productivity index, research quality, and international collaboration.

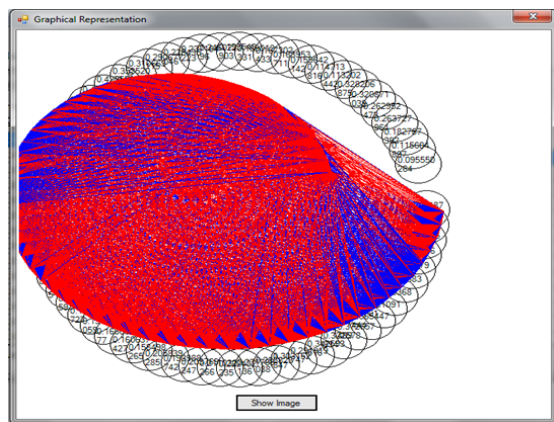


Figure 1. Synergy computation results of the HEIs research competitiveness.

At a glance, Figure 1 shows the extensiveness of the red rather than the blue colors, which signify that dissimilarities are prevalent than similarities among higher education institutions. This means that there are only few HEIs interacting with other HEIs that share the same characteristics of research competitiveness. Majority of the HEIs interacting or cooperating have different characteristics in

terms of research competitiveness. Synergies refer to the interaction or cooperation of two or more organizations, and other agents to produce a combined effect greater than the sum of their separate effects. In the context of this paper, interactions are done or conducted by institutions in Southeast Asia that have different systems and contexts of research competitiveness. The universities investigated were disaggregated to underscore their positive synergy which is shown in Table 2.

Table 2 presents the synergies of the 63 higher education institutions.

Table 2.  
Resulting Synergies of the 63 Higher Education Institutions

Higher Education Institutions	Synergy	Higher Education Institutions	Synergy
University 1	0	University 31	17
University 2	0	University 32	19
University 3	2	University 33	19
University 4	2	University 34	19
University 5	2	University 35	19
University 6	2	University 36	20
University 7	3	University 37	20
University 8	3	University 38	20
University 9	3	University 39	20
University 10	3	University 40	20
University 11	3	University 41	24
University 12	4	University 42	28
University 13	9	University 43	28
University 14	9	University 44	29
University 15	9	University 45	30
University 16	9	University 46	30
University 17	9	University 47	30
University 18	9	University 48	33
University 19	9	University 49	34
University 20	9	University 50	36
University 21	11	University 51	41
University 22	11	University 52	41
University 23	11	University 53	49
University 24	11	University 54	49
University 25	11	University 55	49
University 26	12	University 56	49

Institute			
Technology 1	12	University 57	49
University 27	13	University 58	50
Institute			
Technology 2	14	University 59	55
University 28	14	University 60	59
University 29	14	University 61	60
University 30	16		

This denotes that there are more universities in Southeast Asia that have diverse characteristics and interactions in terms of research competitiveness. The scores of the HEIs are varied and extreme in research productivity, research impact, and international collaboration. As seen in the table there are more universities with synergies ranging from 0-20 and only few universities have synergies higher than 20.

These synergies are summarized in the form of a histogram as shown in Figure 2. Figure 2 shows the histogram of the positive synergies of the 63 universities. It shows that there are more universities with less than 24 synergies. There are 42 universities with synergy ranging from 0-23 and only 21 universities with synergy ranging from 24-60. The synergy analysis indicated positive connections along 0 to 60.

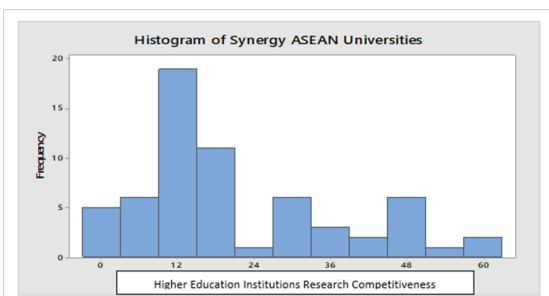


Figure 2. Histogram of HEIs’ research competitiveness.

From the derived histogram, two (2) clusters are formed. The first cluster is the institutions with 24 to 60 positive synergies and the second cluster has 0 to 23 positive synergies. Then using a software, the data of the two clusters were transformed to scatter plot to determine their emergent behavior concerning

research productivity index, research impact, and international collaboration, which are the dimensions for research competitiveness.

The scatter plot that is used to describe the emergent behavior of the universities along the research competitiveness features in cluster 1 is shown in Figure 3 and cluster 2 in Figure 4.

Figure 3 shows that the universities under this cluster have high research competitiveness. Meaning, the HEIs in this cluster have intensive research productivity, research impact and have conducted many international collaborations. The universities belonging to this cluster also have high positive synergies, signifying they have strong interactions and cooperation with other institutions on research and development undertakings. The research competitiveness in this cluster shows an upward drift, which is the emergent behavior of these institutions. This signifies that increase in research impact, research productivity, and international collaboration are vital elements for research competitiveness.

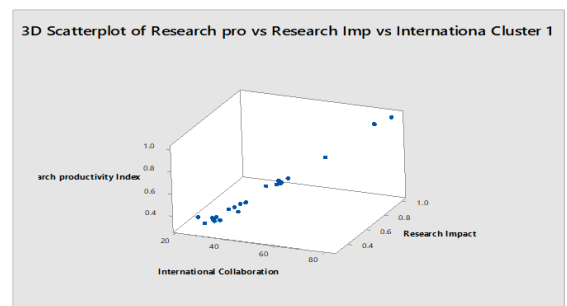


Figure 3. Scatter plot of HEIs’ research competitiveness in cluster 1.

The average research competitiveness index of the institutions in cluster one is 45.26, ranging from 83.17 to 23.36. This means that these HEIs are doing relatively well in their research productivity, research impact, and international collaborations. They are highly prolific in terms of generated scientific researches and publications, citations and research impact to the areas of specializations. They are known to have international collaboration and linkages. There are 8 universities which are performing

way above the 50% on research competitiveness index.

It can be seen in the scatter plot that there are two universities with high amplitude in terms of research productivity, research impact, and international collaboration. These universities are known to rank first and second in the university ranking academic performance in Southeast Asia. These universities are very superior on their research performance (British Council, 2015). Six (6) universities in cluster one have a moderate amplitude in terms of research productivity ranging from 0.59 to 0.70 with .60 research impact. Several higher education institutions fall below this range except one whose research productivity is 0.40 and research impact is 0.50.

The 21 universities in cluster 1 have an average research productivity index of 0.58. This means that these HEIs have generated scientific researches and documents above 50%. It has an average research impact of 0.52 and the average international collaboration is 44.23. This means that their research citations and applications to the fields of specialization were above 50%. It can be inferred that research productivity and research impact in which the number of researches produced, published, cited, and utilized in the field of specializations and disciplines are essential for international collaboration. These universities have very high research competitiveness. They can compete globally and at the same time maintain and develop its capacity to collaborate in various levels: local, national and international.

Generally, it can be construed that these universities are academically research-oriented with a sustained research culture; have high research competitiveness which can further be inferred that as the research productivity increases on the universities in this cluster, the research impact and international collaboration also move within the ideal boundary of more than 50%.

The scatter plot in Figure 3 reveals that universities with research productivity ranging from 0.80-1.00 have high international collaboration. This signifies that the institutions' ability to generate and produce scientific researches and documents enable them to have more international collaborations. Collaboration is a critical element of research productivity among higher education institutions enabling them to become competitive in research. Collaboration provides for funding resources, ability to share resources, and opportunity to learn from other disciplines. This offers universities opportunity to lead with credibility and validity in any conducted research projects.

Universities in cluster 1 are mostly located in SEA countries known to have sustained economy and are known to be premier national universities. This confirms the report of Asian Development Bank (2012) that research collaboration tends to focus on the "high-flying" universities. These universities are role models in building research capability and productivity. These academic institutions are known to be partnering with industries that effectively transfer whatever knowledge is produced and generated. The experiences of the HEIs belonging to cluster 1 on cross-border collaboration in research and publication have improved their research competitiveness by participating actively in joint and multi-country research. They have increased research productivity, as indicated by an increase in the number of internationally indexed publications (some coauthored with foreign partners) produced during the last 10 years by researchers based in HEIs with international linkages. Their international research partnerships were collaborated around research issues of importance to all the partners (ADB, 2012).

Figure 4 reveals the emergent behaviors of higher education institutions in cluster 2 which has different features compared to cluster 1. The institutions in cluster 2 have an average

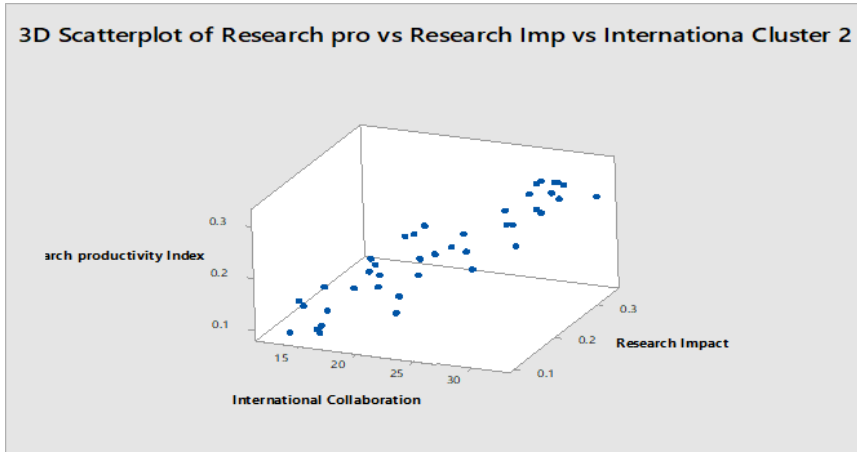


Figure 4. Scatter plot of HEIs' research competitiveness in cluster 2.

research competitiveness index of 22.78 with a maximum of 32.82 and a minimum of 12.59.

The 3D scatter plot in Figure 4 shows an erratic behavior with upward and downward drift. The cluster is composed of 42 universities with varied characteristics in terms of research competitiveness. There are 19 HEIs that fall above the average research competitiveness index (22.78 RCI to 32.82) and 23 institutions below the average (below 22.78). This would mean that majority of the institutions in cluster 2 are still growing institutions when it comes to research competitiveness. They are still beginning to implement their research culture as an institution; capacitating its faculty and students to generate scientific researches and documents.

Generally, the universities in this cluster have an average research productivity index of 0.20, ranging from 0.09 to 0.32. They have an average research impact of 0.23, ranging from 0.10 to 0.34. The average for international collaboration is 22.35 with a minimum of 12.32 and maximum of 32.22. This means that the HEIs in this cluster have produced and generated limited number of scientific researches and documents that were utilized and applied in the field of specializations. There

are a number of researches cited with research impact.

Looking at the scatter plot, there are 14 higher education institutions of the 42 institutions clustered together. These universities have a research competitiveness index of 32.82 to 27.37. Specifically, these academes have a research productivity of 0.26 to 0.32, research impact of 0.34 to 0.27 and international collaboration of 32.22 to 26.97. These universities are performing well in terms of research competitiveness but still below the 50% when compared to the institutions in cluster 1. This means that that these institutions work and collaborate with the other partners to come up with scientific research publications and citations applied to their field of specializations. They revisit the priorities of their institutions and work on improving their research performance.

Eleven (11) institutions in cluster 2 have a research competitiveness index of 20.72 to 26.46 and 17 have a research competitiveness of 12.59-19.99. These universities have a research productivity below 0.25, research impact of below 0.26 and international collaboration below 25. This means that majority of the HEIs in cluster 2 do not do very well in research.

They have generated and produced researches but may not have significantly impacted their institutions and research areas. They also have limited international collaboration and linkages. A factor that drives international partners to collaborate is the institutions' performance in terms of research productivity and research impact.

The results signify that these institutions in cluster 2 have devoted more time to instruction or have put more emphasis to teaching outcomes which could lead to reduction in the generation and production of researches (Toutkoushian, Porter, Danielson, & Hollis, 2003). There are researches indicating that faculty who devoted more time to teaching have lower research outputs (Fox, 1992); Bellas & Toutkoushian, 1999; Porter & Umbach, 2001). Institutional priorities, institutional contexts, and working environment of higher education organizations have to be revisited in order for the HEIs in cluster 2 to improve their research competitiveness.

These connote that the universities under this cluster to become more competitive in research have to produce more researches and publications to establish collaborations. They can improve their context: faculty composition; institutional characteristics-leadership, priorities, access to resources and working environment in order to increase research productivity, research impact and international collaboration. Contextual factors have the greatest impact on the indicator considered to be the most essential when assessing research performance: published scientific articles (Smeby & Try, 2005).

### *Emergent Features*

1. The research competitiveness of higher education institutions is high when there is an increase in research impact, research productivity and international collaboration. As research productivity increases, HEIs can establish more research collaboration. The researches have to make an impact in the fields of specialization to create more collaboration. This feature implies that research competitiveness is concerned with producing researches with impact that drives more international collaboration. For an institution to gain more international partners or linkages and to access more resources, it has to generate more scientific research, publications, and citations deemed useful and relevant to the subject areas or fields of focus.
2. The variations of research competitiveness in higher education institutions from progressive countries in Southeast Asia are less than the variations in the HEIs of developing countries. This feature indicates that when there are researches which are conducted, disseminated, and published in prestigious universities with selective and competitive research faculty they have high research competitiveness index. This further implies that there is greater participation in research among faculty and students in cluster 1 because access to resources, working environment support, and having high research competencies are better in cluster 1 than in cluster 2, giving wider opportunities for collaboration. The HEIs in cluster 1 have a high complementarity in teaching, research and public service. There is a greater emphasis on research activities complementing teaching and extension undertakings.
3. The research competitiveness of universities and higher education institutions is low when there is a decrease in research productivity and research impact which could lead to lesser international collaboration. This feature illustrates that when HEIs put more emphasis to instruction and extension undertakings with less priority on the production of researches would result

to low research competitiveness index. Although the institutions in cluster 2 are producing scientific researches and doing international collaborations, these have significantly less impact to their institutions and research areas of focus.

### Conclusion

In conclusion, the research competitiveness among higher education institutions in Southeast Asia is a complex adaptive system wherein the interplay of the essential elements namely, research productivity, research impact and international collaboration among the 63 universities have led to emergent features or behaviors on research performance. The top universities in Southeast Asia as found in cluster 1 generally are academically research-oriented institutions with sustained research cultures that have led to high impact research publications and citations that have paved the way for more international collaborations. The institutions in cluster 2 belonging to the developing countries in SEA are diverse in terms of their research competitiveness. There are disparities in their research performance: research productivity, impact and international collaborations. These variations can change when HEIs in progressing countries start to revisit their priorities by putting emphasis on the complementarity of research, instruction and public service. Contextual factors of the organization including its institutional characteristics-policies, structures, resources, faculty characteristics and attributes have to be assessed and reexamined in order to sustain research culture and improve research competitiveness.

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