

# On Technological Readiness of ASEAN Countries for Global Competitiveness

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## **Abstract**

*This study utilized exploratory data analysis or data mining using multivariate factor, cluster and principal components analyses in order to determine the technological readiness of the ASEAN member countries based on the World Economic Forum 2013-2014 edition. Factor analysis was able to identify three factors namely, technology competence, access to technology and technology users which were used as bases for clustering the ASEAN member Countries. The means of each cluster for each factor were further utilized to assess the extent of technological readiness of the ASEAN member states through a model obtained using the principal components analysis. With this model, Singapore, the only nation that belongs to Cluster 3, emerged as the most technologically ready among the ASEAN countries. Group 2 ASEAN nations comprising Thailand and the Philippines, are the next two countries with a very high technological readiness, respectively as compared to Cluster 1 ASEAN member states. On the other hand, ASEAN member states belonging to Cluster 1 are found to be relatively least technologically ready, except for Malaysia, Indonesia, and Vietnam that ranked fourth, fifth and sixth, respectively with a slightly competitive technological readiness. It was found out that technological readiness of an ASEAN country varies directly with the country's technological competence, access to technology, and level of technology utilization. More specifically, technological readiness is mainly determined by access to technology which is related to both culture and economy. Meanwhile, global competitiveness highly correlates with technological readiness. Thus, while economic productivity mainly drives global competitiveness, both culture and economic productivity determines technological readiness. The high correlation between technological readiness and global competitiveness is also limited with culture as much as it is driven by economic productivity.*

*Keywords: competitiveness, technological readiness, productivity, technology*

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## **1.0 Introduction**

Competitiveness determines the level of productivity of a country that is characterized by a set of institutions, policies, and other factors (Global Competitiveness Report, 2014-2015). The rates of return gained from different investments in an economy measures the level of productivity

of a country. Thus, an economy that grows faster over time tends to be more competitive.

There are several determinants which drive productivity and competitiveness. Understanding the factors behind this process has occupied the minds of economists for hundreds of years, creating theories ranging from Adam Smith's

focus on specialization and the division of labor to the neoclassical economists'. Recently, factors such as education and training, market efficiency, macroeconomic stability, good governance, firm sophistication, market efficiency and technological progress among others are considered indices of global competitiveness.

According to Global Competitiveness Report of 2013-2014, the technological readiness measures the agility with which an economy adapts existing technologies to enhance the productivity of their industry. The importance of technology adoption for national competitiveness has been growing in recent years. As such, it progressed to the dissemination of knowledge and the increasing use of information and communication technologies (ICT's) which has become increasingly considered.

This study tries to present the importance of technological readiness for the transition of economies from limited to innovative economies. Hence, this study will therefore analyze and assess the factors of technological readiness. More specifically the researchers would cluster, categorize and assess the extent of technological readiness of ASEAN countries.

## 2.0 Conceptual Framework

Global competitiveness of ASEAN Countries represents how countries respond to the challenges posed by global competition. In response to the challenges, technology is relatively needed for a country to compete and prosper. For a country to become technologically ready, key factors have been identified by the World Economic Forum. These includes (a) availability of latest technology (b) firm- level technology adoption (c) foreign direct investment and technology transfer (d) individuals using internet (e) broadband internet subscriptions (f) international internet bandwidth and (g) mobile broadband subscription. The factors

identified would be analyzed using multivariate factor, cluster, and principal components analysis to determine the extent of technological readiness of ASEAN member states.

## 3.0 Design and Methods

This study utilized exploratory data analysis or data mining using multivariate factor, cluster, and principal components of analyses. These treatments transform the available data to become meaningful in order to determine the extent of technological readiness of ASEAN member states and to generate a theory of technological readiness. Multivariate factor analysis will be used to unify the variables to form a concept out from the given factors of technological readiness. Cluster analysis then will be applied to cluster the ASEAN member countries based on the identified concepts and its corresponding factor loadings, respectively obtained using factor analysis. Then the principal components analysis determines the corresponding weights assigned to each of the factors identified from the cluster means of each group of ASEAN member states and its known index of competitiveness from the given factors of technological readiness. The resulting model based on the identified concepts generated using the principal components analysis will be utilized to assess the technological readiness of the ASEAN member countries.

Furthermore, the following variables that characterized technological readiness were derived from the World Economic Forum 2013 - 2014:

1. Availability of latest technologies - to what extent are the latest technologies available in the country
2. Firm-level technology absorption - to what extent do businesses in the country absorb technology
3. Foreign Direct Investment (FDI) and

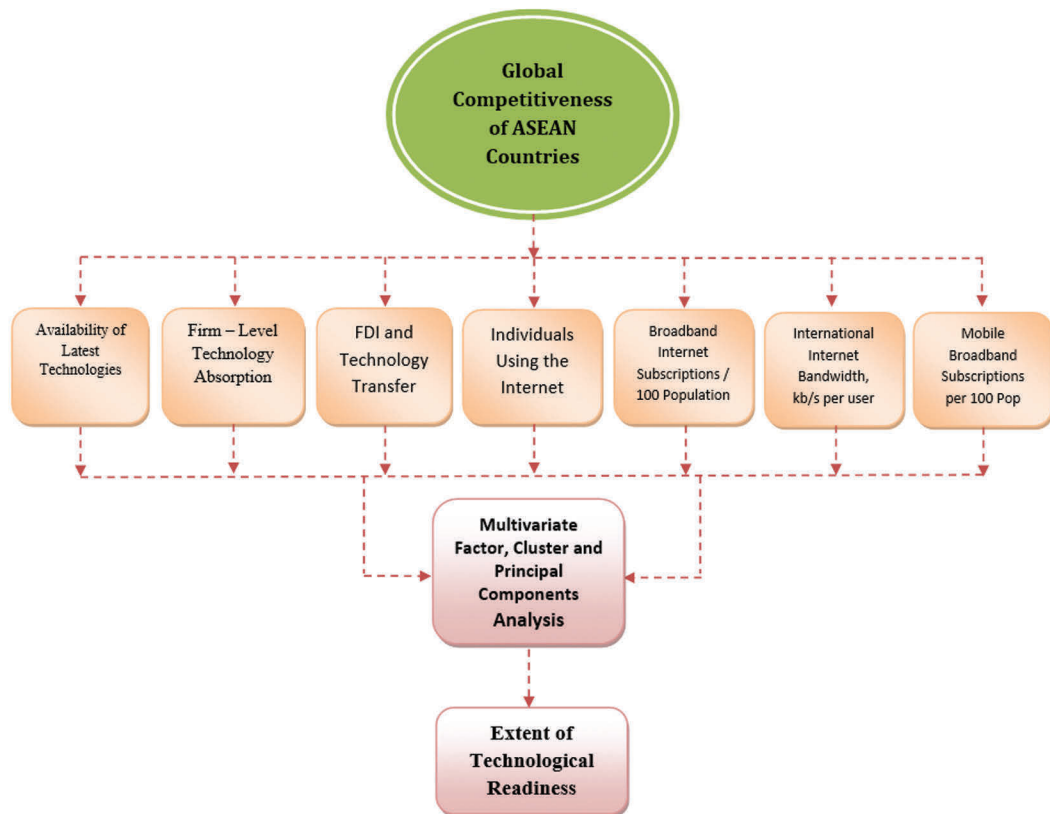


Figure 1: Conceptual Framework Diagram

technology transfer- to what extent does foreign direct investment bring new technology into the country

4. Internet users – percentage of individuals using the internet
5. Broadband internet subscription – number of fixed broadband Internet subscriptions per 100 population
6. Mobile Internet subscription- mobile broadband subscriptions per 100 population
7. Internet bandwidth - International Internet bandwidth (kb/s)/capita

#### 4.0 Results And Discussion

The following results present the factor analyses on the technological readiness of ASEAN Countries in terms of the availability of latest technologies, firm-level technology absorption, FDI and technology transfer, Internet users, broadband Internet subscriptions per 100 population, internet bandwidth, kb/s per user and mobile broadband subscriptions per 100 population. The ASEAN member countries in no particular order are composed of (1) Brunei Darussalam, (2) Cambodia, (3) Indonesia, (4) Lao PDR, (5) Malaysia, (6) Myanmar (7) Philippines, (8) Singapore, (9) Thailand and (10) Vietnam.

Table 1: Factor Analysis: Rotated Factor Loadings and Communalities with Varimax Rotation

Variables	Factor 1	Factor 2	Factor 3	Communality
1. Availability of Latest Tech	0.896	0.290	0.305	0.980
2. Firm-Level Tech Absorption	0.932	0.198	0.288	0.980
3. FDI and Technology Transfer	0.884	0.397	0.155	0.963
4. Internet Users	0.438	0.328	0.836	0.998
5. Broadband Internet Subscriptions	0.310	0.824	0.464	0.991
6. Internet Bandwidth	0.210	0.940	0.199	0.967
7. Mobile Broadband Subscriptions	0.350	0.917	0.112	0.975
Variance	2.9076	2.7909	1.1665	6.8651
% Var	0.415	0.399	0.167	0.981

Factor analysis was used to group variables to form a factor. These factors can be computed by multiplying the loadings of the variables on a factor.

The set of variables 1,2, and 3 have a relatively high positive loadings on Factor 1 while a relatively low loadings on Factors 2 and 3, respectively. These variables pertain to technological competence readiness of ASEAN countries that will be characterized as “technology competence”. Meanwhile, the set of variables 5,6 and 7 load higher on Factor 2 than on Factors 1 and 3 respectively. This set of variables will be identified as “access to technology”. Variable 4, on the other hand, has a load on Factor 3 greater than on Factors 1 and 2, respectively and hence will be determined as “Technology Users”. These findings suggest that for the ASEAN countries to be technologically ready, one has to adopt technological competence, wide access to technology and must be an optimum user of the advancement of technology. These results are well explained through factor analysis of a cumulative variance of 98.10%.

Moreover, the succeeding findings depict the multivariate cluster analysis considering the three identified factors that determine the technological readiness of the ASEAN member states.

#### Cluster Analysis of ASEAN Countries in the Aspect of Technology Competence, Access to Technology, and Technology Users

The following figure shows the Dendrogram of the ASEAN countries depicting the groupings of the member states.

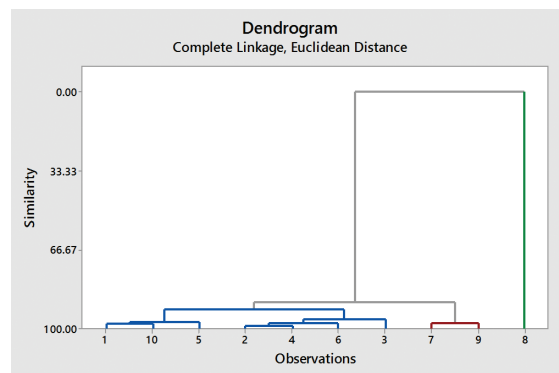


Figure 2: Cluster Dendrogram of the Member States of the ASEAN

Table 2: Final Partition Number of Clusters: 3

	<b>Number of Countries</b>	<b>Within Cluster Sum of Squares</b>	<b>Average Distance from Centroid</b>	<b>Maximum Distance from Centroid</b>
Cluster 1	7	3442.29	21.3770	34.5933
Cluster 2	2	125.40	7.9183	7.9183
Cluster 3	1	0.0000	0.0000	0.0000

Table 2 determines the number of ASEAN countries that belongs to a particular group of ASEAN nations.

The clustering of ASEAN member countries was based on the countries similarities on the level of the three indentified concepts, namely, technology adoption, technology competence and technology users obtained through factor analysis.

Cluster 1 ASEAN countries are composed of seven member states. These include (1) Brunei Darussalam, (2) Cambodia, (3) Indonesia, (4) Lao PDR, (5) Malaysia, (6) Myanmar and (10) Vietnam. These countries in cluster 1 shared a common level

on technology competence, access to technology, and technology users, factors of technological readiness. On the other hand, two member states, the (7) Philippines and (9) Thailand both belong to cluster 2 while (8) Singapore is the only ASEAN nation that comprise group 3. These two clusters also possess a distinct level with respect to the three identified factors of technological readiness.

Table 3 shows the cluster centroids for the three different groups of ASEAN member countries across the three identified factors namely, technology competence, access to technology and technology users.

Table 3: Cluster Centroids

<b>Variables</b>	<b>Cluster 1</b>	<b>Cluster 2</b>	<b>Cluster 3</b>	<b>Grand Centroid</b>
Technology Competence	12.1494	13.5588	16.083	12.825
Access to Technology	27.6995	82.0571	690.922	104.893
Technology Users	23.4558	27.5462	61.028	28.031

Table 4: Distances Between Cluster Centroids

	<b>Cluster1</b>	<b>Cluster2</b>	<b>Cluster 3</b>
<b>Cluster 1</b>	0.000	54.530	664.297
<b>Cluster 2</b>	54.530	0.000	609.790
<b>Cluster 3</b>	664.297	609.790	0.000

Table 4 depicts the distances between cluster centroids for the three different groups of ASEAN member states across the three identified factors, technology competence, access to technology and technology users.

The clustering of ASEAN countries is characterized mainly by competence of the technological advancement of the country. Cluster 3 is classified as the most technologically sophisticated group of ASEAN nations as evidenced by the most positive competitive index on technology competence. Moreover, the technological readiness of a cluster of member

states of the ASEAN are also greatly influenced by wide access to technology and a high proportion of technology users of the country.

The following table reveals the extent of competitiveness on technological readiness among member states of the ASEAN in terms of technology competence. This is obtained through multiplying the loadings of the variables on this identified factor, namely, availability of latest technology, firm – level technology absorption and FDI and technology transfer for this identified factor.

**Table 5: Index of Technological Readiness Among Member States of ASEAN in the Aspect of Technology Competence**

ASEAN Countries	Cluster #	Technology Competence Index	Rank	Interpretation
1. Brunei Darussalam	1	13.0248	6	Highly Competitive
2. Cambodia	1	12.2828	7	Moderately Competitive
3. Indonesia	1	13.7440	3	Highly Competitive
4. Lao PDR	1	11.7476	8	Moderately Competitive
5. Malaysia	1	15.1884	2	Highly Competitive
6. Myanmar	1	8.2160	10	Slightly Competitive
7. Philippines	2	13.7428	4	Highly Competitive
8. Singapore	3	16.0832	1	Highly Competitive
9. Thailand	2	13.3748	5	Highly Competitive
10. Vietnam	1	10.8420	9	Moderately Competitive

**Legend: Hypothetical Range**

16.10 and Above  
 12.88 - 16.09  
 9.66 - 12.87  
 6.44 - 9.65  
 6.43 and Below

**Interpretation**

Very Highly Competitive  
 Highly Competitive  
 Moderately Competitive  
 Slightly Competitive  
 Least Competitive

Singapore, the only ASEAN nation belonging to Cluster 3, is found to be the most highly competitive in terms of technology competence as compared from among other ASEAN countries. On the other hand, Malaysia and Indonesia ranked second and third, respectively, among ASEAN countries, which are categorized as highly competitive as to the technological competence in the region. The competitiveness index on technological competence of these countries seems to surpass the Philippines and Thailand's index of competitiveness that ranked fourth and fifth, respectively, in the same category. Although, the Philippines and Thailand belong to Cluster 2,

having a cluster centroid of 13.5588 higher than in group 1 with a cluster centroid of 12.1494 where Malaysia and Indonesia belong, the latter exceeded the extent of competitiveness on technology competence by the member states in Group 2. This is evidenced by the minimal deviation of the corresponding competitiveness index and a relatively high index of these countries in Cluster 1 than each of the member states in Group 2. The other ASEAN member states in Group 1, includes Brunei Darussalam which ranked 6th in the list and categorized as a highly competitive nation in terms of technology competence. The remaining countries in Group 1, namely Cambodia (7th), Lao

Table 6: Index of Technological Readiness Among ASEAN Countries in Terms of Access to Technology

ASEAN Countries	Cluster #	Access to Technology Index	Rank	Interpretation
1.Brunei Darussalam	1	23.1688	8	Least Competitive
2. Cambodia	1	17.7100	9	Least Competitive
3. Indonesia	1	39.5424	4	Slightly Competitive
4. Lao PDR	1	11.9721	10	Least Competitive
5. Malaysia	1	38.9933	5	Slightly Competitive
6. Myanmar	1	25.7098	7	Least Competitive
7. Philippines	2	74.9015	3	Highly Competitive
8. Singapore	3	690.9215	1	Very Highly Competitive
9. Thailand	2	89.2127	2	Very Highly Competitive
10. Vietnam	1	36.8000	6	Slightly Competitive

Legend: **Hypothetical Range**

89.20 and Above  
 71.36 - 89.19  
 53.52 - 71.35  
 35.68 - 53.51  
 35.67 and Below

**Interpretation**

Very Highly Competitive  
 Highly Competitive  
 Moderately Competitive  
 Slightly Competitive  
 Least Competitive

PDR (8th), Vietnam (9th), and Myanmar (10th), are the ASEAN member states that assumes the last four ranks among ten ASEAN countries. These nations are determined to have a moderately competitive technology competence lower than the rest of the ASEAN countries. These finding supports the fact that cluster 1 ASEAN countries, except for Malaysia and Indonesia, had a relatively low technology competence than the other two clusters. Group 3 composed of only one ASEAN state, Singapore seemed to be the leading cluster that dominates in terms of the competence of the technological advancement. This is because Singapore is considered by many multinational companies as a regional base for testing the markets in Asia. Also, since Singapore offers a good environment for investors to establish their businesses, many expatriates go to Singapore bringing with them the technology and giving them chance to innovate, introduce a better and new technology. Singapore is also becoming a digital hub of the world made possible through the presence of the best education, technology and infrastructures that it can offer ([www.npr.org](http://www.npr.org)).

Table 6 shows the extent of competitiveness concerning the technological readiness of ASEAN member countries in terms of access to technology.

Singapore, the only ASEAN state that composed Cluster 3, is still deduced to be the most highly competitive in terms of wide access to technology as compared to other ASEAN countries. On the other hand, Cluster 2 ASEAN countries, made up of Thailand and the Philippines, occupy the second and third ranks among ASEAN member states, respectively. These countries are categorized as very highly and highly competitive states, respectively in terms of access to technology. Cluster 1 ASEAN countries, namely; Indonesia (4th), Malaysia (5th), and Vietnam (6th) assumes the

succeeding three ranked positions with a slightly competitive access to technology. All other ASEAN countries in Cluster 1, namely, Myanmar (7th), Brunei Darussalam (8th), Cambodia (9th) and Lao PDR (10th) ultimately determines the remaining ranks in the list. These countries are classified as least competitive for the same aspect relative to other ASEAN nations. These facts imply that Singapore, as the sole ASEAN country belonging to Cluster 3, remains as the most highly competitive in terms of wide access to technology than the rest of the ASEAN states. Group 2, on the other hand, are composed of Thailand and the Philippines which revealed a highly competitive access to technology greater than those ASEAN countries belonging to Group 1. The access to technology of either groups of the ASEAN nations are mainly characterized by the number of fixed broadband Internet subscriptions per 100 population, mobile broadband subscriptions per 100 population and international internet bandwidth (kb/s) per capita.

Table 7 reveals the extent of competitiveness on technological readiness among ASEAN member countries in terms of technology users.

Cluster 3, composed of one ASEAN nation, Singapore is deduced to have the largest proportion of technology users as compared from among other ASEAN countries. Meanwhile, Malaysia, Brunei Darussalam, and Vietnam, which belong to Cluster 1, ranked second, third and fourth, respectively in the list of ASEAN countries, with a relatively high proportion of technology users. These ASEAN countries are a part of Cluster 1 with a cluster centroid of 23.4558 lower than 27.5462, the cluster centroid of Group 2, comprising the Philippines and Thailand ranked fifth and sixth, respectively. These countries are known to have a relatively lesser proportion of technology users in the region. The former ASEAN nations are found to be superior



Table 7: Index of Technological Readiness Among ASEAN Member States in Terms of Technology Users

ASEAN Countries	Cluster #	Technology Users Index	Rank	Interpretation
1. Brunei Darussalam	1	41.8000	3	Moderately Competitive
2. Cambodia	1	5.0160	9	Least Competitive
3. Indonesia	1	13.2088	7	Least Competitive
4. Lao PDR	1	10.4500	8	Least Competitive
5. Malaysia	1	56.0120	2	Highly Competitive
6. Myanmar	1	1.0032	10	Least Competitive
7. Philippines	2	30.9320	5	Slightly Competitive
8. Singapore	3	61.0280	1	Highly Competitive
9. Thailand	2	24.1604	6	Least Competitive
10. Vietnam	1	36.7004	4	Moderately Competitive

Legend: **Hypothetical Range**

61.05 and Above  
 48.84 - 61.04  
 36.63 - 48.83  
 24.42 - 36.62  
 24.41 and Below

**Interpretation**

Very Highly Competitive  
 Highly Competitive  
 Moderately Competitive  
 Slightly Competitive  
 Least Competitive

to those countries belonging to Cluster 2 in terms of the percentage of technology users in the area. This is because each of these countries are a part of group 1 having the relatively high index than each of the member states in Cluster 2. Other ASEAN countries found in Group 1 namely; Indonesia, Lao PDR, Cambodia, and Myanmar are all categorized to have a relatively least proportion of technology users in the country. These findings suggest the fact that Cluster 1 ASEAN countries, except for

Malaysia, Brunei Darussalam, and Vietnam had a relatively least percentage of technology users in the region. On the other hand, Singapore, the only ASEAN nation in Cluster 3 remains on top with the highest proportion of technology users in the area than the rest of the countries of the other two groups. Technology user is a factor identified that determines the percentage of individuals using the internet.

**Principal Components Analysis: Technology Competence, Access to Technology, and Technology Users**

The following results determine the principal components analysis for the three identified factors in technological readiness namely, technology competence, access to technology, and technology users across ASEAN member countries:

**Table 8: Eigenanalysis of the Covariance Matrix**

Eigenvalue	43149	294	2
Proportion	0.993	0.007	0.000
Cumulative	0.993	1.000	1.000

Results reveal that the first eigenvector or principal component represents 99.30% of the total variance. This finding is sufficient to represent all three identified factors of technological readiness, namely, technology competence, access to technology, and technology users.

Hence, the index of the extent of technological readiness of an ASEAN member state can be modeled by the equation

$$\text{Index of Technological Readiness} = 0.006 \text{ Technology Competence} + 0.998 \text{ Access to Technology} + 0.058 \text{ Technology Users}$$

**Table 9: Principal Components Analysis Results Across Three Identified Factors of Technological Readiness**

Factors	PC1	PC2	PC3
Technology Competence	0.006	0.064	-0.998
Access to Technology	0.998	-0.059	0.002
Technology Users	0.058	0.996	0.064

**Table 10: Competitiveness Index of the Extent of Technological Readiness Among ASEAN Member States**

ASEAN Countries	Cluster #	Extent of Technological Readiness Index	Rank	Interpretation
1. Brunei Darussalam	1	25.6250	8	Least Competitive
2. Cambodia	1	18.0392	9	Least Competitive
3. Indonesia	1	40.3119	5	Slightly Competitive
4. Lao PDR	1	12.6247	10	Least Competitive
5. Malaysia	1	42.2551	4	Slightly Competitive
6. Myanmar	1	25.7659	7	Least Competitive
7. Philippines	2	76.6282	3	Highly Competitive
8. Singapore	3	693.176	1	Very Highly Competitive
9. Thailand	2	90.5158	2	Very Highly Competitive
10. Vietnam	1	38.9201	6	Slightly Competitive

<b>Legend:</b>	<b>Hypothetical Range</b>	<b>Interpretation</b>
	90.50 and Above	Very Highly Competitive
	72.40 - 90.49	Highly Competitive
	54.30 - 72.39	Moderately Competitive
	36.20 - 54.29	Slightly Competitive
	36.19 and Below	Least Competitive

Thus, the higher the technology competence of an ASEAN country, the greater is the index of technological readiness, the greater access to technology, the higher is the index. Moreover, the more technology users of an ASEAN nation, the greater is the index of technological readiness.

The following table reveals the extent of competitiveness on technological readiness among ASEAN member countries using the above model that considers the three identified factors namely, technology competence, access to technology and technology users.

The overall results revealed that Singapore, the only ASEAN nation in cluster 3, is found to be the most highly globally competitive in terms of technological readiness among other ASEAN countries. Group 2 ASEAN nations comprising Thailand and the Philippines are deduced as the next two countries with a very highly and highly

globally competitive technological readiness, respectively as compared to cluster 1 ASEAN member states. These two succeeding ASEAN countries ranked second and third, respectively, in terms of technological readiness among other ASEAN nations. On the other hand, ASEAN countries belonging to group 1 are found to be relatively least competitive as to its technological readiness, except for Malaysia, Indonesia, and Vietnam that ranked fourth, fifth and sixth, respectively. These member states were determined to have a slightly globally competitive technological readiness.

Singapore which was a third world country in the mid twentieth century is an example of how the government can change the economic tract of a country. Singapore found its wealth not through oil deposits, or diamond and gold but through its government which capitalized its geographical location that makes its port a busy stopover for

**Table 11: Competitiveness Index of the Extent of Technological Readiness and Global Competitiveness Index Among ASEAN Member Countries**

ASEAN Countries	Cluster #	Extent of Technological Readiness Index	Global Competitiveness Index
1. Brunei Darussalam	1	25.6250	4.95
2. Cambodia	1	18.0392	4.01
3. Indonesia	1	40.3119	4.53
4. Lao PDR	1	12.6247	4.08
5. Malaysia	1	42.2551	5.03
6. Myanmar	1	25.7659	3.23
7. Philippines	2	76.6282	4.29
8. Singapore	3	693.176	5.61
9. Thailand	2	90.5158	4.54
10. Vietnam	1	38.9201	4.18

many ships. The government also made sure that its airport would attract airline passengers who would want to consider going to Singapore en route to other Asian destinations. Singapore does not also tax its constituents that high which allows its people to spend more money and help its own economy ([www.servcorp.com.sg](http://www.servcorp.com.sg)). These actions plus the presence of very good education, best technology and best infrastructures make Singapore at the top of the ASEAN in terms of many things and specifically in technology advancement ([www.npr.org](http://www.npr.org)).

The following correlational analysis determines the relationship between the extent of competitiveness on technological readiness and global competitiveness index among ASEAN member countries.

The results revealed that there is a very strong positive correlation between the extent of technological readiness index and the global competitiveness index ( $r_s = 0.661$ ,  $P\text{-Value} = 0.038$ ) among ASEAN member states that is statistically significant at 0.05 level of significance. That is, as the

technological readiness index of an ASEAN country increases, likewise, its global competitiveness index increases as well. Thus, global competitiveness can be determined through the three identified factors of technological readiness, namely, technological competence, access to technology and technology users.

### 5.0 Conclusion

For a country to become globally competitive one has to possess the three aspects of technological readiness, namely access to technology, technology competence and technology users. Technological readiness is mainly determined by access to technology. On the other hand, access to technology exhibited a relationship to culture and economy. Thus, global competitiveness highly correlates with technological readiness. Likewise, global competitiveness determines the productivity while culture and economy has an impact on technological readiness. Therefore, global competitiveness is also culture bound.

**Table 12: Correlation Between Competitiveness Index of the Extent of Technological Readiness and Global Competitiveness Index Among ASEAN Member Countries**

Variables Correlated	Spearman Rho Correlation Coefficient, $r_s$	$P$ - Value	Interpretation
Extent of Technological Readiness Index and Global Competitiveness Index	0.661	0.038*	Significant Very Strong Positive Correlation

\* Significant at  $\alpha = 0.05$

<sup>ns</sup>Not Significant at  $\alpha = 0.05$

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