Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 57 (2012) 183 – 192

Procedia Social and Behavioral Sciences

International Conference on Asia Pacific Business Innovation and Technology Management

Exploring an Objective Weighting System for Travel & Tourism Pillars

L. W. Lan[a], W. W. Wu[b], Y. T. Lee[b,a*]

[a]*Department of Television & Internet Marketing Management, Ta Hwa Institute of Technology, Taiwan*
[b]*Department of International Trade, Ta Hwa Institute of Technology, Taiwan*

Abstract

The World Economic Forum employs Travel & Tourism Competitiveness Indexes (TTCI) to measure the travel & tourism (T&T) global competitiveness of a country. The TTCI overall scores are calculated with an arithmetic mean aggregation from the scores of the fourteen composite pillars with a subjective assumption of all the pillars having the same weights. This paper attempts to release such a subjective assumption by proposing a new solution framework to explore an objective weighting system for the pillars. The proposed solution framework employs the Expectation Maximization (EM) clustering algorithm to group the 139 ranked countries into three classes and then performs the Artificial Neural Network (ANN) analysis to explore the objective weighting system for the fourteen pillars. The results show that tourism infrastructure, ground transport infrastructure, air transport infrastructure, cultural resources, health and hygiene, and ICT infrastructure are the six most critical pillars contributing to the TTCI overall scores. Accordingly, the policy makers should allocate limited resources with priority to improve these six pillars to frog leap the T&T global competitiveness.

Keywords: Artificial Neural Network; Expectation Maximization clustering algorithm; objective weightings; travel & tourism.

1. Introduction

The World Economic Forum (WEF) defined Travel & Tourism Competitiveness Indexes (TTCI) to measure the travel & tourism (T&T) global competitiveness among different countries [1]. The TTCI framework consists of fourteen pillars within such subindexes as regulatory framework, business environment and infrastructure, and human, cultural and natural resources. Indeed, the TTCI rankings and scores have provided the policy makers and relevant stakeholders with comprehensive information to understand the global progresses and to realize each country's position in the global competitiveness in T&T sector. The information is especially useful for benchmarking, from which a nation can search out the best practices through systematic comparisons with the leaders. As such, it provides useful information to facilitate a nation not only to recognize its internal strengths and weaknesses but also to identify the obstacles hindering its competitiveness [2]. The policy makers should utilize the TTCI

* Corresponding author. Tel.: +886-3-592-7700 ext. 3210; fax: +886-2-2337-5755
E-mail address: lawrencelan@thit.edu.tw

1877-0428
doi:10.1016/j.sbspro.2012.09.1173

scores and rankings, together with the scores associated with different pillars, while allocating the national resources to advance the T&T global competitiveness.

Although the TTCI information is useful for benchmarking the global T&T competitiveness, the "subjective" weighting system associated with the pillars is debatable because the ranking trustworthiness can be affected by the subjective biases. In light of this, developing an "objective" weighting system deserves further exploration. With objective rankings, the policy makers can arrive at more prudent and informative decisions. Unfortunately, the TTCI overall scores have been measured by an arithmetic mean aggregation of the composite pillars' scores, which explicitly assumed that all the pillars must have identical weights. In other words, all the pillars must contribute equally to a country's T&T global competitiveness. To correct this problem, there is a need to find out an objective weighting system for the T&T pillars.

Some previous studies [3-5] have addressed the importance of objectively reflecting the relative contributions of a set of criteria, rather than subjectively assigning them with identical weights. Recently, Wu et al. [6] proposed a solution framework by using data mining techniques and partial least squares (PLS) path modeling to scrutinize the critical pillars within the Networked Readiness Indexes (NRI), which are also used by WEF to measure the global competitiveness of different countries' Information and Communication Technologies (ICT) diffusion. Their solution framework has satisfactorily fulfilled the following tasks: (1) explore the causal directions amongst the pillars without assigning subjective weights; (2) perform the hypotheses test to discover the foremost critical pillars affecting the overall NRI scores and rankings; and (3) disclose the causal knowledge from the pattern of critical pillars for better decision-making.

The purpose of this study is to explore the objective weighting system for the T&T pillars. We propose a new solution framework, which integrates the Expectation Maximization (EM) clustering algorithm and the Artificial Neural Network (ANN) analysis to unearth the objective weightings associated with the pillars for better decision making. The subsequent sections are organized as follows. Section 2 presents the proposed solution framework and briefly introduces the EM clustering algorithm and the ANN techniques. Section 3 carries out an empirical analysis based on the latest release of global TTCI rankings by WEF. Based on the findings, some policy implications are discussed in Section 4, followed by conclusion and directions for future studies.

2. Proposed Solution Framework

This paper proposes a solution framework to discover the relative importance (a weighting system) amongst the TTCI pillars for better decision making. The solution framework depicted in Fig. 1 intends to advance the T&T competitiveness as the decision-making problem. To solve such a problem, one requires finding out the objective weightings behind the TTCI scores. To this end, we employ the EM clustering algorithm to group all of the countries into appropriate classes. Based on the clustered results, we further utilize the ANN analysis to obtain objective weightings associated with the TTCI pillars. Both EM clustering algorithm and ANN are further explained below.

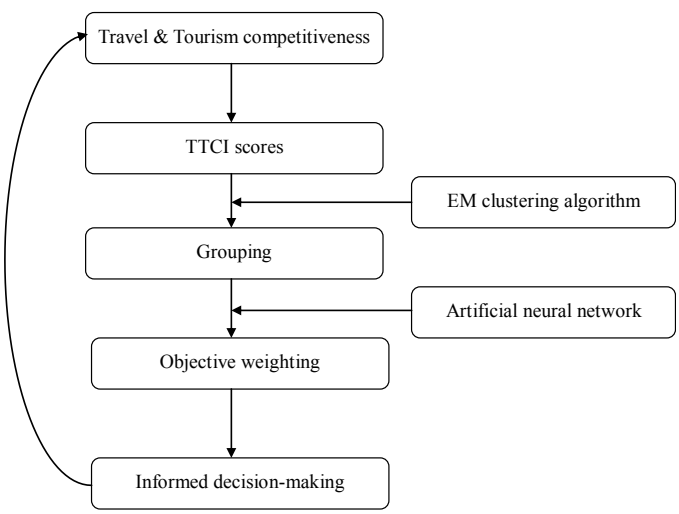

Fig. 1. The proposed solution framework

2.1. EM clustering algorithm

Clustering is a task to assign the objects into groups with similar characteristics. In general, clustering techniques can be divided into two categories: unsupervised clustering and supervised clustering [7]. Unlike the supervised clustering, the unsupervised clustering does not need to specify the number of clusters/classes beforehand. Although several developed clustering techniques require the users to know the number of clusters/classes in advance, it is usually difficult to know the exact number of clusters when the dataset is in high dimension [6]. Thus, the unsupervised clustering seems more useful.

The proposed solution in this study will adopt the EM clustering algorithm to assign the ranked countries into groups. The EM clustering algorithm is an unsupervised clustering technique that can perform automatic clustering without predetermining the number of clusters/classes [6]. According to Witten and Frank [8], users can specify how many clusters to use the mode of 10-fold cross-validation for the EM implementation. WEKA (Waikato Environment for Knowledge Analysis) is a useful suite of machine learning software, which provides the EM clustering algorithm to perform the automatic clustering. For more details about the EM clustering algorithm, one can refer to Witten and Frank [8].

2.2. Artificial neural network

The ANN, also known as Neural Network (NN), is a computational model aiming to emulate the biological neural systems. Liu et al. [9] indicated that ANN is a network with nodes analogous to the network of biological neurons, where the nodes are interconnected to the weighted links. The performance of an ANN depends upon the weights of its connections between the neurons, which store the knowledge. Walczak [10] viewed an ANN as the universal approximator, which can learn complex (non-linear) mappings between input and output variables. Many traditional statistical techniques (e.g., linear and logistic regression or discriminant analysis) require specific distributions for valid applications. However, ANN is a non-parametric technique where the input data are not required to fit a specific distribution, and relationships between variables do not have to be pre-specified. Moreover, ANN can handle the noises in both training and testing sets. It has been widely employed in different applications, such as simulation, modelling, classification, and prediction.

Unlike the conventional computing systems, ANN employs a parallel, distributed method of information processing. As such, it possesses good merits of robustness and fault tolerance [11]. Multi-Layer Perception (MLP) network and Radial Basis Function (RBF) network are the two popular feed-forward networks for ANN [12]. There are several dissimilarities between the MLP network and the RBF network. For instance, the MLP network can have one or more hidden layers, while the RBF network has only one hidden layer. In the MLP network, both the hidden layer and the output layer are nonlinear. In contrast, in the RBF network, the hidden layer is nonlinear while the output layer is linear. Moreover, the MLP network constructs the global approximations, while the RBF network constructs the local approximations. The proposed solution framework will employ both MLP and RBF networks to evaluate the objective weightings of the T&T pillars. The statistical software such as SPSS can be used to implement the ANN analysis. For more details, one can refer to the documentation of ‘‘SPSS Neural Networks.” [18]

3. Empirical Analysis

This paper explores the objective weightings associated with the fourteen pillars addressed in the 2011 Travel & Tourism Competitiveness Report [1]. In the Regulatory Framework (RF) subindex, there are five pillars which are denoted as RF1 (Policy rules and regulations), RF2 (Environmental sustainability), RF3 (Safety and security), RF4 (Health and hygiene), and RF5 (Prioritization of T&T), respectively. In the Business Environment and Infrastructure (BEI) subindex, there are five pillars which are denoted as BEI1 (Air transport infrastructure), BEI2 (Ground transport infrastructure), BEI3 (Tourism infrastructure), BEI4 (ICT infrastructure), and BEI5 (Price competitiveness in the T&T industry), respectively. In the Human, Cultural and Natural (HCN) resources subindex, there are four pillars which are denoted as HCN1 (Human resources), HCN2 (Affinity for Travel & Tourism), HCN3 (Natural resources), and HCN4 (Cultural resources), respectively.

First, we employ the EM clustering algorithm provided by WEKA to classify the 139 countries based on the TTCI scores and the results are detailed in Tables 1 through 3. Notice that the 139 ranked countries have been grouped into three classes (1, 2 and 3)—denoted as “Cluster” in Tables 1 through 3. Further looking into the geometric mean of the overall TTCI score in each cluster, we find that class 2 has the highest mean score (4.98), followed by class 3 (4.07), and then class 1 (3.27). It indicates that

class 2 represents the most developed countries while class 1 stands for the least developed countries in T&T sector.

Table 1. The TTCI scores for class 1

Country/Economy	RF1	RF2	RF3	RF4	RF5	BEI1	BEI2	BEI3	BEI4	BEI5	HCN1	HCN2	HCN3	HCN4	Overall	Cluster
Algeria	3.68	4.00	4.38	4.21	3.07	2.44	2.96	1.72	2.30	5.02	4.62	3.98	2.59	2.21	3.37	1
Angola	2.83	4.02	4.05	1.81	2.64	2.14	2.03	2.33	1.86	5.24	3.09	2.90	3.41	1.04	2.80	1
Bangladesh	3.70	3.65	4.17	2.63	3.07	2.23	3.92	1.31	1.80	4.83	4.15	3.88	2.70	1.5	3.11	1
Benin	3.68	4.92	4.22	1.85	3.73	2.16	3.07	2.05	1.96	4.52	4.42	4.70	3.36	1.42	3.30	1
Bolivia	2.81	3.90	4.02	2.74	3.34	2.47	2.38	2.09	2.35	5.05	4.43	3.87	4.51	2.45	3.35	1
Botswana	4.45	4.71	4.46	3.54	4.47	2.61	3.43	2.85	2.33	5.45	3.92	4.49	4.22	1.61	3.74	1
Burkina Faso	3.82	4.36	4.39	1.96	4.01	1.85	2.87	1.91	1.74	4.13	3.44	4.52	2.71	1.26	3.07	1
Burundi	3.09	4.23	3.40	2.21	2.48	2.06	3.21	1.29	1.60	4.46	3.60	4.33	2.33	1.03	2.81	1
Cambodia	3.42	4.34	4.57	1.47	5.83	2.30	3.01	1.36	1.92	5.07	4.31	5.30	3.50	1.57	3.44	1
Cameroon	3.60	4.20	4.25	2.51	2.88	2.06	2.86	2.02	1.95	4.16	4.24	4.49	3.91	1.17	3.18	1
Chad	2.69	4.24	3.33	1.07	3.08	1.76	2.39	1.30	1.53	3.49	3.22	4.05	2.51	1.04	2.56	1
Côte d'Ivoire	3.62	4.16	3.83	2.01	2.47	2.29	3.28	2.23	1.97	3.55	3.73	4.25	4.23	1.21	3.08	1
Ethiopia	4.12	4.26	4.20	1.03	3.52	2.70	3.07	1.59	1.54	5.14	3.88	4.30	4.11	1.95	3.26	1
Gambia, The	4.30	4.88	4.44	3.31	5.36	2.75	4.22	1.63	2.27	5.66	4.33	5.10	2.49	1.48	3.71	1
Ghana	4.37	4.87	4.30	2.16	3.41	2.46	3.10	2.34	2.05	5.10	4.20	4.86	3.42	1.49	3.44	1
Guyana	3.89	4.98	4.07	3.98	4.31	2.29	2.97	2.61	2.79	4.86	5.04	4.29	3.35	1.32	3.62	1
Iran, Islamic Rep.	3.74	4.33	3.86	2.19	3.05	2.59	3.18	1.11	2.73	5.53	4.60	3.94	3.05	2.96	3.37	1
Kenya	3.83	5.12	3.17	1.64	5.56	2.94	3.18	2.05	2.14	4.33	4.35	4.61	4.42	1.61	3.52	1
Kyrgyz Republic	3.99	4.18	3.90	5.43	3.53	1.96	2.55	1.16	2.70	4.58	4.49	5.41	2.62	1.65	3.45	1
Lesotho	3.63	4.15	4.01	2.39	3.49	1.70	2.86	2.03	1.74	5.17	3.19	4.30	1.88	1.14	2.96	1
Libya	2.98	3.69	4.22	4.27	3.07	2.50	2.59	2.19	2.39	4.93	4.19	4.16	1.92	2.47	3.25	1
Madagascar	3.88	4.16	3.26	1.24	4.91	2.39	2.62	2.53	1.80	4.46	4.30	4.68	2.88	1.32	3.18	1
Malawi	3.84	4.89	4.67	2.73	3.54	1.94	3.14	1.50	1.81	4.32	3.89	4.43	3.80	1.55	3.30	1
Mali	3.48	4.17	4.08	1.53	4.07	2.04	2.84	1.93	1.73	3.56	3.65	4.72	2.52	2.15	3.05	1
Mauritania	3.74	4.13	3.50	1.13	3.32	1.74	2.62	1.69	1.96	4.17	3.54	4.52	2.48	1.25	2.85	1
Mongolia	4.21	3.29	4.85	4.46	4.17	2.83	2.39	1.75	2.44	4.69	4.52	4.99	2.88	2.23	3.56	1
Mozambique	3.76	4.99	3.76	1.15	4.55	2.30	2.57	2.57	1.85	4.37	3.24	4.42	3.47	1.47	3.17	1
Nepal	3.71	4.32	3.61	3.33	4.89	2.28	2.35	1.43	1.74	5.28	3.71	4.84	4.20	1.36	3.37	1
Nicaragua	3.80	4.76	4.41	2.89	4.08	2.33	2.70	3.03	1.97	5.11	4.70	4.34	4.00	1.61	3.56	1
Nigeria	3.46	4.69	3.38	1.61	2.98	2.45	2.45	2.27	2.32	4.31	3.78	4.06	3.52	1.84	3.09	1
Pakistan	3.80	3.79	3.19	2.99	3.49	2.52	3.47	1.92	2.10	5.27	3.89	3.48	2.88	2.58	3.24	1
Paraguay	3.75	3.99	3.78	3.64	4.61	1.79	2.19	2.37	2.43	4.80	4.40	3.69	2.73	1.6	3.26	1
Rwanda	4.72	5.68	5.37	2.36	4.19	2.32	3.72	1.05	1.95	4.59	4.50	4.72	3.42	1.06	3.54	1
Senegal	3.77	4.30	4.71	2.15	4.58	2.60	3.16	2.65	2.35	3.81	4.02	4.94	3.96	1.75	3.50	1
Swaziland	4.17	4.71	4.67	2.63	4.72	2.16	3.81	2.10	2.02	5.24	2.89	4.61	2.72	1.03	3.35	1
Syria	3.61	3.92	4.83	4.07	4.44	2.31	3.13	1.99	2.31	4.82	4.32	5.27	2.11	1.85	3.49	1
Tajikistan	3.67	4.23	5.13	4.95	3.43	2.27	2.80	1.08	2.17	4.70	4.73	3.99	2.35	1.43	3.34	1
Tanzania	3.92	4.89	4.00	1.28	4.26	2.19	2.69	1.68	1.80	4.75	3.83	4.50	5.86	1.7	3.42	1
Timor-Leste	3.74	3.80	4.44	2.47	3.76	2.42	2.49	1.10	1.66	4.41	3.96	4.41	2.24	1.01	2.99	1
Uganda	3.89	4.90	3.93	2.07	3.94	2.25	2.73	1.66	1.90	4.71	4.22	4.75	4.38	1.35	3.36	1
Venezuela	3.07	4.17	3.36	4.46	3.31	2.72	2.33	3.25	3.13	4.31	4.29	3.25	4.91	1.75	3.46	1
Zambia	4.70	4.84	4.56	2.16	3.81	2.26	2.88	1.71	1.95	4.19	3.89	4.25	4.73	1.46	3.40	1
Zimbabwe	2.93	4.52	4.38	2.98	3.72	2.16	3.21	1.93	1.92	3.99	3.38	4.46	4.77	1.68	3.31	1
Geometric mean	3.69	4.35	4.09	2.39	3.76	2.27	2.88	1.84	2.04	4.62	3.99	4.36	3.23	1.54	3.27	

Table 2. The TTCI scores for class 2

Country/Economy	RF1	RF2	RF3	RF4	RF5	BEI1	BEI2	BEI3	BEI4	BEI5	HCN1	HCN2	HCN3	HCN4	Overall	Cluster
Australia	4.87	4.70	5.76	5.13	4.95	5.84	4.22	6.31	5.08	4.07	5.54	4.76	5.56	5.25	5.16	2
Austria	4.95	5.78	6.14	6.92	5.67	4.37	5.64	7.00	5.03	3.93	5.47	5.42	3.87	5.76	5.40	2
Bahrain	4.53	3.96	5.47	5.00	4.35	4.36	5.78	5.61	4.39	5.18	5.27	4.86	1.93	2.67	4.47	2
Barbados	4.36	5.06	5.46	5.95	6.41	4.40	5.92	5.18	4.96	4.49	5.11	6.53	2.11	2.54	4.84	2
Belgium	5.00	5.53	5.87	6.55	4.44	4.30	6.03	4.24	5.26	3.45	5.59	4.67	2.19	6.09	4.93	2
Canada	5.40	4.98	5.73	5.38	4.91	6.68	4.77	5.89	5.38	4.19	5.84	4.80	4.86	5.36	5.29	2
Croatia	4.33	4.87	5.47	5.97	4.47	3.09	4.12	6.96	4.47	4.24	4.73	5.30	3.00	3.9	4.61	2
Cyprus	4.33	4.81	5.71	5.59	6.19	4.69	5.26	7.00	4.63	4.17	5.49	5.74	2.34	3.18	4.89	2
Czech Republic	4.60	5.06	5.36	6.81	4.47	3.59	5.15	5.30	4.29	4.48	5.20	4.30	2.84	5.56	4.77	2
Denmark	5.16	5.88	6.22	5.87	4.40	4.93	6.13	5.73	5.66	3.10	5.93	4.26	2.99	4.93	5.05	2
Estonia	5.00	5.19	5.72	6.20	5.38	3.47	4.96	6.69	5.45	4.86	5.22	5.09	3.40	2.52	4.88	2
Finland	5.39	5.69	6.48	6.60	4.53	4.94	5.19	4.81	5.20	3.62	5.75	4.49	3.33	4.65	5.01	2
France	5.03	5.66	5.76	6.84	5.26	5.50	6.45	6.19	5.46	3.15	5.44	4.90	4.34	6.02	5.41	2
Germany	5.09	5.84	6.19	6.80	4.39	5.48	6.52	6.33	5.72	3.80	5.54	4.50	4.68	6.34	5.50	2
Greece	4.32	4.54	4.70	6.41	5.57	4.76	4.00	6.89	4.29	3.82	4.98	4.85	3.38	4.73	4.78	2
Hong Kong SAR	5.69	4.13	6.32	7.00	5.85	5.10	6.74	3.68	5.90	4.53	5.76	5.89	3.30	3.4	5.19	2
Hungary	4.90	5.04	5.32	6.46	4.71	2.86	4.63	5.15	4.35	4.40	5.13	4.35	2.60	4.17	4.54	2
Iceland	4.83	5.42	6.34	6.91	6.00	4.87	4.79	6.72	5.93	4.50	6.01	5.46	2.93	2.85	5.19	2
Ireland	5.33	5.53	6.10	6.19	5.26	4.42	4.56	6.71	4.89	3.84	5.67	5.08	2.39	4.32	4.98	2
Israel	4.47	4.49	5.26	6.52	4.46	3.59	4.25	4.57	5.15	4.07	5.24	4.75	3.03	2.47	4.41	2
Italy	4.31	4.69	5.23	6.16	4.62	4.35	4.54	7.00	4.47	3.59	5.13	4.43	3.69	6.06	4.87	2
Japan	4.61	4.79	5.76	6.29	4.75	4.61	6.14	4.53	4.90	3.40	5.51	3.92	4.15	5.88	4.94	2
Korea, Rep.	4.59	4.35	5.05	6.08	4.22	4.00	5.49	4.30	5.70	4.32	5.19	4.17	2.55	6.18	4.72	2
Luxembourg	5.37	5.40	6.14	6.32	4.32	4.18	5.77	6.55	5.86	4.40	5.57	5.60	3.33	2.97	5.08	2
Malta	4.39	4.79	6.27	6.76	6.24	4.37	4.87	6.09	5.18	4.16	5.32	5.84	1.82	3.09	4.88	2
Netherlands	5.11	5.62	5.86	6.42	4.50	4.99	6.09	5.13	5.76	3.53	5.69	4.50	3.32	5.59	5.13	2
New Zealand	5.40	5.21	5.88	6.03	5.46	5.17	4.22	5.05	5.14	4.42	5.64	5.38	4.36	3.02	5.00	2
Norway	5.18	5.70	6.39	6.23	5.04	5.25	3.91	5.78	5.53	3.49	5.57	4.48	3.40	4.34	4.98	2
Portugal	4.79	5.36	5.74	5.95	5.49	4.15	5.11	6.34	4.61	4.00	5.16	5.02	2.85	5.89	5.01	2
Qatar	4.75	4.55	5.69	5.52	4.61	4.70	4.66	5.10	3.99	4.93	5.55	4.21	2.14	2.68	4.45	2
Singapore	6.00	4.90	6.10	5.19	6.42	5.01	6.56	5.12	5.16	5.09	6.13	5.68	2.64	3.91	5.23	2
Slovenia	4.44	5.19	5.65	5.81	4.88	2.90	5.08	6.27	4.96	4.28	5.14	4.83	3.34	2.82	4.64	2
Spain	4.30	4.99	5.44	6.08	5.90	5.28	5.72	6.71	4.70	4.18	5.11	4.99	4.19	6.58	5.29	2
Sweden	5.31	6.26	6.27	5.93	4.58	5.23	5.58	5.01	5.99	3.94	5.64	4.77	3.81	6.63	5.34	2
Switzerland	5.11	6.06	6.42	6.58	5.80	5.08	6.45	6.71	5.96	3.68	6.17	5.00	4.70	6.03	5.68	2
Taiwan, China	5.29	4.11	5.39	5.48	4.49	3.75	5.64	3.66	5.38	5.21	5.51	4.61	2.57	3.33	4.56	2
United Arab Emirates	4.74	3.98	5.13	4.88	5.09	5.83	4.86	5.79	5.18	4.93	5.65	5.25	2.35	3.73	4.78	2
United Kingdom	5.19	5.54	5.63	5.57	4.81	5.51	5.54	6.16	5.70	3.46	5.70	4.48	4.51	6.42	5.30	2
United States	5.18	4.15	5.01	5.58	5.11	6.17	4.97	6.54	5.16	4.25	5.66	4.31	5.81	6.15	5.30	2
Geometric mean	4.90	5.04	5.74	6.08	5.04	4.58	5.23	5.68	5.12	4.10	5.48	4.88	3.21	4.33	4.98	

Table 3. The TTCI scores for class 3

Country/Economy	RF1	RF2	RF3	RF4	RF5	BEI1	BEI2	BEI3	BEI4	BEI5	HCN1	HCN2	HCN3	HCN4	Overall	Cluster
Albania	4.65	4.52	5.27	4.87	4.67	2.52	3.08	3.35	3.20	4.33	5.00	6.33	2.38	1.99	4.01	3
Argentina	4.17	3.84	4.62	5.71	4.23	2.90	2.91	4.35	3.62	4.51	4.95	4.56	4.63	3.51	4.19	3
Armenia	4.12	4.12	5.18	5.88	4.46	2.59	2.96	2.77	2.52	4.61	4.77	4.94	2.21	1.94	3.77	3
Azerbaijan	4.37	4.22	5.10	5.22	4.68	2.73	4.08	2.61	2.76	4.48	5.07	4.37	2.46	2.05	3.85	3
Bosnia and Herzegovina	3.55	4.14	5.37	4.99	3.18	1.87	2.27	4.12	3.22	4.22	4.81	4.74	2.25	2.17	3.62	3
Brazil	3.72	5.06	4.67	4.61	3.95	3.91	2.80	3.49	3.49	4.07	4.88	4.40	6.35	4.88	4.36	3
Brunei Darussalam	3.65	3.56	5.73	4.73	3.31	4.00	4.22	2.84	3.87	5.75	5.11	4.51	4.05	1.83	4.07	3
Bulgaria	4.10	4.18	4.55	6.65	4.48	2.66	3.15	6.82	4.12	4.85	4.88	4.80	2.98	3.52	4.39	3
Cape Verde	4.37	4.72	4.47	3.22	4.85	3.66	3.83	4.11	2.70	3.75	4.55	6.03	1.84	1.13	3.78	3
Chile	5.20	4.49	5.70	4.65	4.53	3.50	4.11	3.84	3.61	4.91	5.15	4.47	2.99	2.97	4.26	3
China	4.33	4.21	5.09	3.89	5.08	4.24	4.05	2.62	3.15	5.12	5.18	4.05	5.48	5.53	4.47	3
Colombia	4.50	4.41	3.74	3.93	4.28	2.99	2.73	3.05	3.34	4.37	4.91	4.43	4.81	3.3	3.94	3
Costa Rica	4.43	5.14	4.94	4.55	5.52	3.85	3.12	4.98	3.19	4.60	5.53	5.23	5.11	1.84	4.43	3
Dominican Republic	4.84	4.22	3.95	4.13	6.15	3.63	3.26	4.12	2.80	4.50	4.62	5.15	2.98	1.83	3.99	3
Ecuador	3.60	4.47	4.41	4.31	4.40	2.84	2.75	2.93	2.79	4.97	4.48	4.29	4.51	2.21	3.79	3
Egypt	4.62	4.09	3.35	5.17	5.45	3.47	3.37	2.87	2.66	5.59	4.61	5.11	2.87	2.48	3.96	3
El Salvador	4.74	4.63	3.93	3.95	4.51	2.80	3.55	3.14	2.92	5.02	4.89	4.23	2.10	1.53	3.68	3
Georgia	4.58	4.54	5.26	5.99	5.16	2.40	3.57	2.89	2.81	4.36	5.25	4.86	2.30	2.07	3.98	3
Guatemala	4.54	4.03	3.47	3.93	4.44	2.97	3.05	2.99	2.91	5.09	4.63	4.62	4.46	2.14	3.81	3
Honduras	4.61	4.56	4.10	3.33	4.72	3.01	3.20	3.13	2.66	5.07	4.61	4.66	3.67	1.8	3.79	3
India	3.56	4.15	4.62	2.64	4.24	4.11	4.30	2.86	2.16	5.09	4.58	4.23	4.94	4.86	4.07	3
Indonesia	4.18	3.90	4.70	2.59	5.68	3.35	3.22	1.96	2.54	5.59	5.04	4.17	4.70	3.5	3.96	3
Jamaica	5.22	4.07	4.18	4.12	6.36	3.23	5.14	3.53	3.37	4.36	4.63	5.96	2.40	1.62	4.12	3
Jordan	4.63	4.78	4.92	5.14	5.91	3.30	3.41	4.01	2.79	4.55	4.77	5.83	2.57	1.75	4.14	3
Kazakhstan	4.02	3.89	4.08	6.74	4.22	2.71	3.08	3.11	3.35	4.34	4.77	4.03	2.49	1.47	3.70	3
Kuwait	3.56	2.95	5.59	4.99	2.61	3.08	4.09	3.96	3.23	5.25	5.01	4.02	1.80	1.87	3.68	3
Latvia	4.51	5.20	5.16	6.17	4.30	3.25	4.31	5.07	4.40	4.78	4.98	4.26	3.03	2.39	4.36	3
Lebanon	3.91	3.93	3.82	5.52	4.91	3.46	3.06	5.15	2.88	4.76	4.92	6.79	1.76	1.75	4.03	3
Lithuania	4.32	5.22	5.06	7.00	4.09	2.38	5.03	4.51	4.63	4.50	4.94	4.49	2.37	2.83	4.34	3
Macedonia, FYR	4.33	4.58	5.36	5.65	3.99	2.11	3.17	3.82	3.53	4.83	4.82	4.77	2.70	2.18	3.96	3
Malaysia	5.07	4.61	4.50	4.53	4.85	4.25	4.65	3.58	3.68	5.60	5.20	5.39	4.53	3.75	4.59	3
Mauritius	4.99	4.64	5.27	4.83	6.44	3.27	4.49	4.54	3.27	5.20	5.03	6.11	1.97	1.59	4.35	3
Mexico	4.56	4.08	3.60	4.93	5.24	3.72	3.28	4.62	3.09	4.85	4.86	4.56	4.89	5.31	4.43	3
Moldova	4.32	4.39	4.91	5.50	3.72	2.10	2.65	2.73	3.30	4.78	4.57	4.53	1.96	1.42	3.60	3
Montenegro	5.25	4.87	5.40	5.32	4.89	3.26	2.88	5.67	4.13	4.84	5.21	5.92	3.23	3.18	4.56	3
Morocco	4.62	4.95	4.50	3.22	5.44	3.02	3.46	3.68	2.89	4.43	4.63	5.27	2.15	2.9	3.93	3
Namibia	4.56	5.20	4.47	3.06	4.56	3.34	4.29	3.85	2.21	4.84	3.83	4.81	3.78	1.36	3.84	3
Oman	4.72	4.46	5.78	4.45	3.94	3.47	4.51	4.24	3.47	5.20	4.72	4.58	3.28	2.16	4.18	3
Panama	5.01	4.94	4.70	4.16	5.39	4.29	3.65	3.92	3.48	5.08	4.69	4.89	4.67	1.64	4.30	3
Peru	4.67	4.38	3.91	3.70	4.84	2.81	2.70	4.24	2.80	4.46	4.89	4.55	4.95	3.29	4.04	3
Philippines	4.38	4.21	4.07	3.76	4.49	2.79	2.83	2.59	2.52	5.19	4.69	4.64	3.26	2.17	3.68	3
Poland	4.48	4.94	5.21	5.59	4.09	2.67	3.30	4.47	4.07	4.54	5.14	3.89	3.49	5.41	4.38	3
Puerto Rico	5.19	5.43	5.05	4.74	4.83	4.30	5.48	5.12	3.34	4.51	5.21	5.16	2.40	1.81	4.42	3
Romania	4.46	4.82	5.45	5.10	4.43	2.76	3.06	4.99	3.75	4.46	4.93	4.42	2.69	3.33	4.16	3
Russian Federation	3.57	4.18	4.01	6.62	4.04	4.32	3.09	4.57	3.87	4.48	4.78	3.65	4.44	3.72	4.24	3
Saudi Arabia	4.70	3.82	5.17	3.94	4.29	3.77	4.18	4.55	3.68	5.56	5.21	4.34	3.77	1.75	4.17	3
Serbia	4.39	3.95	4.85	5.65	4.01	2.31	2.82	4.51	3.35	3.96	4.81	4.62	2.23	2.72	3.85	3
Slovak Republic	4.78	5.09	5.23	6.53	3.64	2.17	4.27	4.89	4.23	4.23	5.04	4.27	3.93	2.92	4.35	3
South Africa	4.85	4.86	3.52	4.10	4.53	3.89	3.73	4.27	2.59	4.94	3.73	4.87	4.76	2.89	4.10	3
Lanka	4.14	4.06	4.41	4.33	5.12	2.62	4.76	2.28	2.64	4.68	5.02	4.37	3.84	2	3.87	3
Thailand	4.35	4.19	4.39	4.40	4.93	4.49	4.09	4.94	2.88	5.21	4.82	5.26	4.59	3.86	4.47	3
Trinidad and Tobago	4.70	3.34	4.19	4.63	4.04	3.40	5.02	3.61	3.75	4.90	4.98	4.18	2.79	1.74	3.91	3
Tunisia	5.01	5.31	5.11	4.41	6.02	3.17	4.24	4.48	3.05	5.30	5.39	5.30	2.64	2.44	4.39	3
Turkey	4.80	4.30	4.37	4.86	4.58	4.16	4.03	4.38	3.38	4.17	4.88	5.00	2.91	5.23	4.37	3
Ukraine	3.78	4.24	4.54	6.51	4.06	2.60	3.41	4.43	3.25	3.95	4.88	4.23	2.31	1.9	3.83	3
Uruguay	4.38	4.52	5.75	5.94	5.34	2.52	4.26	3.10	3.75	4.45	5.01	4.89	2.57	3.25	4.25	3
Vietnam	4.41	4.07	4.84	4.07	3.98	2.72	3.31	2.07	3.25	5.21	4.86	4.48	3.57	3.57	3.90	3
Geometric mean	4.42	4.39	4.65	4.68	4.57	3.12	3.57	3.73	3.20	4.74	4.86	4.74	3.17	2.47	4.07	

To examine the classification accuracies of classifiers, we use the “Cluster” as the outcome variable and the scores of fourteen pillars as the explanatory/independent variables. Table 4 presents the results of classification accuracies using several classifiers through implementations of WEKA. Note that the EM clustering algorithm has reached an overall satisfactory level of high classification accuracy with a geometric mean of 93.46%. Specifically, the two popular ANN models (MLP and RBF) have also reached satisfactorily high classification accuracies of 94.96% and 94.24%, respectively.

Table 4. The classification accuracies of classifiers

	EM clustering
NaiveBayes	97.12%
BN-TAN	95.68%
BN-TabuSearch	95.68%
BN-SimulatedAnnealing	92.81%
Logistic (Multinomial logistic regression)	85.61%
MLP (Multilayer Perception)	94.96%
RBFNetwork	94.24%
SMO	96.40%
IBk (K-nearest neighbours)	93.53%
J48 (the Weka version of C4.5)	89.21%
Geometric mean	93.46%

After confirming the classification accuracies, we then proceed to disclose the objective weightings associated with the fourteen TTCI pillars by using the SPSS statistical software. Note that selecting a proper architecture and tweaking parameters is an important task before applying any ANN analysis because the performance of ANN can be greatly influenced by the parameters. Without proper tweaking parameters, the resulted performance may not be favorable [13]. To this end, we use the ‘‘automatic architecture selection’’ with default parameter values in the SPSS statistical software in order to select the best architecture or parameter automatically. For the MLP network, the hyperbolic tangent function is used for the hidden layer and the softmax function is for the output layer. As for the RBF network, the normalized radial basis function is used for the hidden layer and the identity function is for the output layer. Table 5 and Fig. 2 display the normalized importance for the independent variables resulted from the MLP model, while Table 6 and Fig. 3 exhibit the normalized importance resulted from the RBF model.

According to the MLP model, BEI3 (Tourism infrastructure) has the highest normalized importance of 100.00, followed by BEI2 (Ground transport infrastructure) of 95.16, and BEI1 (Air transport infrastructure) of 94.25. In contrast, the results of RBF model reveal that BEI3 (Tourism infrastructure) also has the highest normalized importance of 100.00, but followed by HCN4 (Cultural resources) of 99.59, RF4 (Health and hygiene) of 99.06, and BEI4 (ICT infrastructure) of 97.52. Based on these results, we conclude that BEI3 (Tourism infrastructure) is the foremost critical TTCI pillar no matter which models are employed. The remaining imperative TTCI pillars include BEI2 (Ground transport infrastructure), BEI1 (Air transport infrastructure), HCN4 (Cultural resources), RF4 (Health and hygiene) and BEI4 (ICT infrastructure).

Table 5. Importance of 14 pillars (MLP model)

Independent variable	Importance	Normalized Importance
RF1	0.0765	61.03
RF2	0.0693	55.24
RF3	0.0450	35.85
RF4	0.0566	45.15
RF5	0.0436	34.80
BEI1	0.1182	94.25
BEI2	0.1193	95.16
BEI3	0.1254	100.00
BEI4	0.0606	48.35
BEI5	0.0670	53.44
HCN1	0.0932	74.35
HCN2	0.0439	35.02
HCN3	0.0298	23.79
HCN4	0.0514	41.02

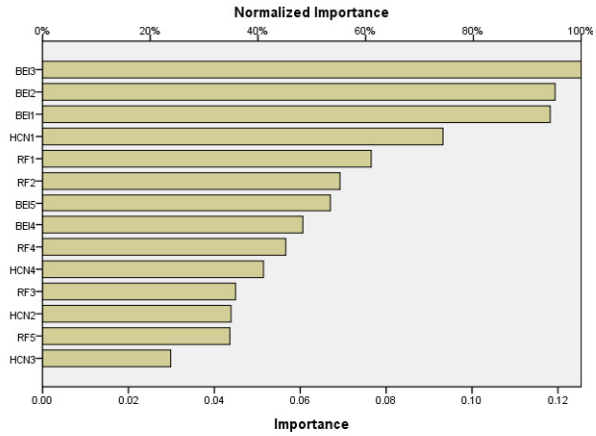

Fig. 2. Distribution of normalized importance of 14 pillars (MLP model)

Table 6. Importance of 14 pillars (RBF model)

Independent variable	Importance	Normalized Importance
RF1	0.0712	61.76
RF2	0.0254	22.07
RF3	0.0516	44.77
RF4	0.1141	99.06
RF5	0.0620	53.78
BEI1	0.1013	87.91
BEI2	0.0777	67.39
BEI3	0.1152	100.00
BEI4	0.1124	97.52
BEI5	0.0338	29.35
HCN1	0.0670	58.16
HCN2	0.0195	16.89
HCN3	0.0341	29.58
HCN4	0.1148	99.59

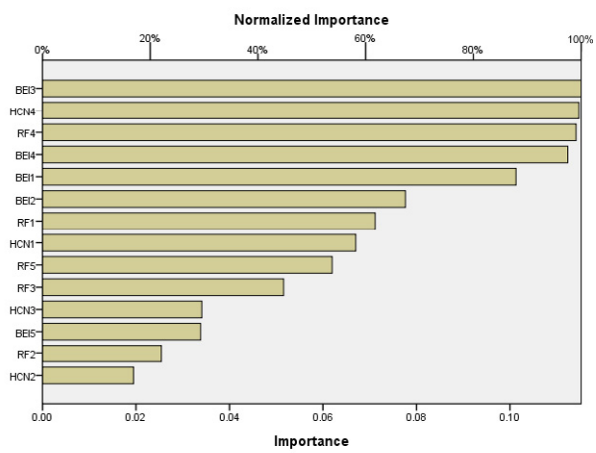

Fig. 3. Distribution of normalized importance of 14 pillars (RBF model)

4. Discussion

The WEF Report [1] has provided basic knowledge for benchmarking the best practices in each of the fourteen pillars in the T&T sector worldwide. This Report, however, offered insufficient information as to which pillar(s) would be the most critical enablers to the overall T&T global competitiveness. Our proposed solution framework has successfully tackled this challenging issue. According to the aforementioned findings, some policy implications are discussed as follows.

First, the foremost critical TTCI pillar should be BEI3 (Tourism infrastructure). This pillar mainly contains Hotel rooms, Presence of major car rental companies, and ATMs accepting Visa cards. It indicates that the policymakers should place absolute emphases on ameliorating the fundamental hospitality facilities with top priority.

Second, the policymakers should highlight BEI2 (Ground transport infrastructure), which mainly includes Quality of roads, Quality of railroad infrastructure, Quality of port infrastructure, Quality of domestic transport network, and Road density. With sound ground transport infrastructure, the movements of people and goods would become efficient.

Third, BEI1 (Air transport infrastructure) is also a crucial pillar in addition to the ground transport infrastructure because both pillars constitute a "seamless" network for ease of travelling. The air transport infrastructure mainly includes Quality of air transport infrastructure, Available seat kilometers, domestic, Available seat kilometers, international, Departures per 1,000 population, Airport density, Number of operating airlines, and International air transport network. Therefore, the policy makers should also place emphases on these components to facilitate the travel and tourism.

Fourth, HCN4 (Cultural resources) is a critical pillar because many people traveled to distant lands in order to see historic monuments or to have cultural adventures. The pillar of Cultural resources comprises Number of World Heritage cultural sites, Sports stadiums, Number of international fairs and exhibitions, and Creative industries exports. Therefore, the policy makers should in any circumstances endeavor to maintaining the historical heritages and, furthermore, occasionally hosting world-class events to be a magnet for the inbound tourists.

Fifth, RF4 (Health and hygiene) has been found a critical pillar as it influences the health of tourists while travelling in distant lands where the hygiene in lodging, eating and drinking is of particular importance. The Health and hygiene pillar mainly includes Physician density, Access to improved sanitation, Access to improved drinking water, and Hospital beds. Therefore, the policy makers should educate the residents to keep the environmental hygiene at an international standard.

Last, BEI4 (ICT infrastructure) has also been indentified as one of the critical pillars for T&T competitiveness. Indeed, ICT in today's society has proven to empower individuals with unprecedented access to information and knowledge, with important consequences in providing education, doing business, linking social interactions and among others. ICT has also played a formidable role in helping sustain a country's global competitiveness in the medium to long term. The ICT global competitiveness of a country is determined by three compositions: environment (including market environment, political and regulatory environment, and infrastructure environment), readiness (including individual readiness, business readiness, and government readiness), and usage (including individual usage, business usage, and government usage), according to Dutta and Mia [14]. Among which, business usage, business readiness, market environment and government usage are the most imperative components that the policy makers should focus upon, according to Wu et al. [6].

5. Conclusion

In the Travel & Tourism Competitiveness Report released by the World Economic Forum, the final TTCI overall scores were calculated via an arithmetic mean aggregation of the fourteen composite pillars, which have been subjectively assigned with identical weights. This paper proposes a solution framework to explore the objective weighting system for the fourteen T&T pillars, from which one can clearly identify the most critical pillars for better decision making. The proposed solution framework employs the EM clustering algorithm to group the 139 ranked countries into three classes and then performs the ANN analysis to disclose the relative importance (also regarded as the objective weighting system) of the fourteen pillars. According to the normalized importance associated with each pillar, one can easily identify the most critical pillars for use.

Our findings show that BEI3 (Tourism infrastructure), BEI2 (Ground transport infrastructure), BEI1 (Air transport infrastructure), HCN4 (Cultural resources), RF4 (Health and hygiene) and BEI4 (ICT infrastructure) are the six most critical pillars that have contributed to T&T overall scores denoting a country's global competitiveness in T&T sector; particularly, BEI3 (Tourism infrastructure) is the foremost one. Based on these findings, the policy makers should allocate limited resources to

ameliorate the components within these six imperative pillars to frog leap the T&T global competitiveness.

In the future study, we can attempt another solution framework suggested by Wu et al. [6] to tackle the same issue. If obtaining the same results, we may confirm the robustness of the six critical pillars. Moreover, we can also compare the proposed solution framework with other methods [15-17] to identify the significant pillars and causal knowledge for better decision making.

References

[1] Blanke J, Chiesa T. *The Travel & Tourism Competitiveness Report 2011*. Geneva: World Economic Forum; 2011.

[2] Wu WW, Lan LW, Lee YT. Benchmarking hotel industry in a multi-period context with DEA approaches: A case study. *Benchmarking: An International Journal* 2012a (in press).

[3] Cerulli G, Filippetti A. Substitutability vs. complementarity: Rethinking STI composite indicators building with an application of sensitivity analysis. *Procedia - Social and Behavioral Sciences* 2010, 2 (6):7633-35.

[4] Grupp H, Mogee ME. Indicators for national science and technology policy: How robust are composite indicators? *Research Policy* 2004, 33 (9):1373-84.

[5] Grupp H, Schubert T. Review and new evidence on composite innovation indicators for evaluating national performance. *Research Policy* 2010, 39 (1):67-78.

[6] Wu WW, Lan LW, Lee YT. Exploring the critical pillars and causal relations within the NRI: An innovative approach. *European Journal of Operational Research* 2012b, 218(1):230-38.

[7] Karaboga D, Ozturk C. A novel clustering approach: Artificial Bee Colony (ABC) algorithm. *Applied Soft Computing* 2011, 11 (1):652-57.

[8] Witten I, Frank E. *Data Mining: Practical Machine Learning Tools and Techniques* (Second Edition), San Francisco: Morgan Kaufmann; 2005.

[9] Liu D, Yuan Y, Liao S. Artificial neural network vs. nonlinear regression for gold content estimation in pyrometallurgy. *Expert Systems with Applications* 2009, 36(7):10397-400.

[10] Walczak S. Neural networks as a tool for developing and validating business heuristics. *Expert Systems with Applications* 2001, 21(1):31-36.

[11] Eickhoff R, Ruckert U. Robustness of radial basis functions. *Neurocomputing* 2007, 70(16–18):2758-2767.

[12] Bovis K, Singh S, Fieldsend J, Pinder C. Identification of masses in digital mammograms with MLP and RBFnets. *Proceedings of the IEEE-INNSENNS International Joint Conference on Neural Networks* 2000, 1(1): 342-47.

[13] Hu HY, Lee YC, Yen TM, Tsai CH. Using BPNN and DEMATEL to modify importance–performance analysis model: A study of the computer industry. *Expert Systems with Applications* 2009, 36(6):9969-79.

[14] Dutta S, Mia I. *The Global Information Technology Report 2009-2010*. Geneva: World Economic Forum and INSEAD, SRO-Kundig; 2010.

[15] Wu WW. Linking Bayesian networks and PLS path modeling for causal analysis. *Expert Systems with Applications* 2010, 37 (1):134-39.

[16] Wu WW. Beyond travel & tourism competitiveness ranking using DEA, GST, ANN and Borda count. *Expert Systems with Applications* 2011a, 38(10):12974-82.

[17] Wu WW. Improving classification accuracy and causal knowledge for better credit decisions. *International Journal of Neural Systems* 2011b, 21(4):297-309.

[18] Tseng, M.L., An assessment of cause and effect decision making model for firm environmental knowledge management capacities in uncertainty. Environmental Monitoring and Assessment, 161, 549-564; 2010