**Journal of Tourism Theory and Research**
Online, http://dergipark.gov.tr/jttr
Volume: 4(1), 2018

ISSN: 2548-7583

# Fuzzy convergence in tourism economics

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***Abstract***

*Economic convergence has two meanings: the first refers to a more equitative system of wealth distribution (sigma-convergence), whereas Beta convergence is related to a higher rate of growth within poor countries than in rich ones. Assessing Neoclassical Growth through the convergence hypothesis has been catching the attention of the researchers since the 1950s. In order to test convergence, statistical methods such as regression analysis and panel data analysis are generally used. However, these methods are based on some strict assumptions that the practical problems do not support. This study purposes fuzzy convergence method that does not require any assumptions. Fuzzy convergence is based on fuzzy logic that is especially used to analyze problems including uncertainty, vagueness or impreciseness. Fuzzy convergence has been proposed for the first time in this study and has been used firstly to test whether fuzzy convergence is present or not in terms of international tourism receipts. This study aims to estimate which membership values of countries or regions are convergent or divergent, in the other words, introducing the part-convergence and part-divergence concept. The results suggest that fuzzy convergence exists within countries. The originality of this study is to use convergence concept based on fuzzy logic. Thus, we aim to estimate which membership values of countries or regions are convergent or divergent, in other words, introducing the part-convergence and part-divergence concept.*

***Keywords:*** *Fuzzy Logic, Convergence, Tourism*

**To cite this article:** Bozkurt, K., Güler, N., Bahar, O. (2018). Fuzzy convergence in tourism economics. *Journal of Tourism Theory and Research,* 4(1), 1-15. DOI: 10.24288/jttr.330951

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## 1. Introduction

During the last two decades, tourism has grown rapidly and the importance of the tourism sector within the world economy is increasing. Hence, for many countries, tourism absorbs a significant part of GDP and employment. Additionally, foreign currency incomes from tourism contribute significantly to the financing of current and foreign trade deficits. Locally, due to its labour-intensive structure, tourism is seen as a sector that may help to solve the unemployment problem within underdeveloped regions and re-establish the competitiveness that has been lost in the agriculture sector (Bahar & Kozak, 2007: 61) Also, tourism directly or indirectly affects other sectors such as agriculture, manufacture, transportation, trade, construction, accommodation, food-drink, communication, banking and health services due to the spillover effect (Soukiazi & Proença, 2008: 792). It is consensual that tourism affects economic growth positively as it regenerates domestic tourism demand. Tourism improves national economies through all the investments made to meet the service needs of tourists (Proença & Soukiazi, 2008: 44-45). Therefore, there is a strong relationship between tourism and other sectors.

Further tourism leads to convergence between the countries as it contributes to the distribution of income from wealthy and developed countries to poorer and less developed ones. Accordingly, tourism provides local development and enables the decline of regional economic disparities. Therefore, national/international investments in the tourism sector may show their effects in a short while and contribute to the development of underdeveloped regions (Soukiazis & Proença, 2008: 792-793).

On the other hand, developing countries consider international tourism demand as a political alternative to economic growth as demand is growing rapidly. In this regard, these countries support tourism to meet resource and currency needs as well as to satisfy and meet the increasing expectations of the increasing population. Accordingly, tourism is seen as a significant sector for economic development and growth due to its wide contribution to employment, production and balance of payments (Gökovalı & Bahar, 2006; Bahar & Kozak, 2007). Limited capital for the production of tourism product (supply) and the labour-intensive nature of the tourism sector increases the importance of tourism in terms of labour and ultimately of employment.

Tourism receipts are an alternative to exports as they have positive contributions to the balance of payments due to foreign currency incomes and the development of tourism is an important income resource for the national economy of a country (Kim, Chen & Jang, 2006: 925). This income earned from the tourism sector is used for importing goods and services that are required for other sectors for development and growth purposes (McKinnon, 1964: 388-409). From this point of view, the literature related to export and economic growth forms the theoretical basis for the assumption that as a development strategy, tourism leads to economic growth (Vanegas & Croes, 2003). This occurs in two different ways: Firstly, the competition between domestic sectors and foreign destinations increases efficiency. Secondly, local companies operate improving their economies of scale and thus production has a positive influence on economic growth (Proença & Soukiazi, 2008).

As a Mediterranean tourism country, Turkey has made efforts to develop its tourism sector and increase international tourism receipts, particularly since 1980. Therefore, it is known that parallel to the developments in the world, tourism in Turkey showed significant and rapid development particularly after 1980. This is mainly influenced by the encouragement of investments (including direct foreign investments) within the sector by 2634 "Law for the Encouragement of Tourism" of 1982. For instance, the tourism receipt ratio within Turkey's GNP, which was 0.6% in 1980, increased to 3.4% in 2009. For the same years, the share of tourism in Turkey's export revenue increased from 11.2% to 20.8% and its share in narrowing the foreign deficit increased from 6.5% to 54.79% respectively. In 1980, there existed 778 tourism operations and investment licensed facilities with 42,011 rooms and 82,332 beds. In 2009, these numbers reached 3,379, 392,502 and 840,221 increasing 334.3%, 834.2% and 920.5% respectively. Meanwhile, Turkey's tourism activities in the world, in Europe and particularly in the Mediterranean region are increasing fast. Although in the past Turkey was not capable of competing with other countries, currently Turkey is a blazing country that is competing side by side with these countries within every field of the tourism sector.

 ISSN: 2548-7583

Taking this point of view, the aim of the work is to examine whether or not there is a convergence between Turkey, one of the ten most developed tourism economies in the world, and other major competitors in international tourism. In this study, a new approach based on fuzzy logic has been proposed in order to determine whether convergence is present or not according to tourism receipts. Thus, we aim to estimate which membership values of countries or regions are convergent or divergent, in other words, introducing the part-convergence and part-divergence concept.

This study is organized as follows: the second part summarizes the literature view. The third part explains traditional convergence briefly and introduces the proposed fuzzy convergence concept. The fourth section covers the conclusions and experimental results.

## 2. Literature review

One of the major subjects of the economic growth literature is the main outcome of the Solow model that hypothesises convergence. According to this hypothesis, inter-country real income disparities per capita are decremented in due course due to the diminishing returns of capital in a closed economy. In other words, the Solow growth model provides that comparatively poor countries or regions grow faster and in due course different levels of income of these two groups converge on each other (Christopoulos & Tsionas, 2004). Although the convergence hypothesis is widely applied in 1980s due to the collection of long-term macroeconomic series and development of econometric techniques, this hypothesis is a quite old discussion topic that is still of concern for economists. It is suggested in the literature that there are three major sources for convergence hypothesis, which are technological diffusion, the neoclassical growth model and globalization (Rassekh, 1998).

In literature, there are several empirical studies on convergence of different countries or different regions within the countries, some proving the existence of convergence, others of divergence. Baumol (1986) was one of the first authors to test the convergence hypothesis. He used cross-section regression analysis and per capita real income series of 16 industrialized countries for the period 1870-1979 (1986) to show that there is a strong per capita real income convergence between the subject countries. In the same vein other researchers prove the existence of convergence within countries or inter-regions (Barro and Sala-i Martin, 1990, 1991, Kangasharju, 1998, Christopoulos & Tsionas, 2004, among others). The reasoning for the existence of convergence is the efficiency disparities that come about due to the asymmetric distribution of capital that is increasing, Christopoulos & Tsionas (2004).

On the other hand some authors found the non-existence of convergence. Benos & Karagiannis (2008) concluded that at a regional level, there exists beta but no sigma convergence. Although income level per capita converged between the cities, the analysis at regional level does not show beta convergence, suggesting that Greece has inter-regional income inequality and the reason for that is the intensification of production and population in certain places. Siriopoulos & Asteriou (1998) concluded that there exists no inter-regional convergence in Greece. Sachs, Bajpai & Ramiah (2002) could not find inter-state convergence in India. Dobson & Ramlogan (2002) concluded that there exists no convergence between the countries in South America. Also, Unger (2005) concluded that there is no inter-regional convergence in Mexico. Braga (2006) concluded that there exists no inter-regional sigma convergence in Portugal in terms of per capita GDP, whereas in industry-based regions a conditional beta convergence was shown. The consistence of these researches suggest that income inequality may lead to divergence, whereas intensification of capital in industries, regions or countries results in a more convergent world.

There are a limited number of works in the tourism economics literature related to the convergence process in the international tourism sector, although tourism is an important service sector in the world that has an increasing share in world income. Also, current studies are mainly examining whether the tourism market is converging in general or not. It can be observed that the majority of the works in the field of tourism aim to measure the contributions of tourism to the economy. (Hazari & Sgro, 1993-1995; Modeste 1995; Balaguer & Jorda 2002; Durbarry 2004; Nowak et al. 2004; Gökovalı & Bahar, 2006; Bahar & Bozkurt, 2010).

 ISSN: 2548-7583

Hence, Narayan is the first scholar in tourism economics literature who examined the tourism-convergence relationship. Other works on the topic take Narayan's work as a basis. In his work covering the period of from 1991–2003, Narayan (2006) tested whether there is a convergence within the thirteen important source countries that send tourists to Australia (China, Hong-Kong, India, Indonesia, Japan, North Korea, Malaysia, New Zealand, Singapore, Taiwan, Thailand, Macao, Philippines). Univariate variance analysis and panel Lagrange Multiplier are used for testing and it is observed that there exists convergence in the Australian tourism sector. The work claims that Australian policies towards these thirteen countries aimed at attracting tourists will increase its tourism volume.

Hooi & Smyth (2006) conclude that tourism sector has been quite significant for the Malaysian economy during the last 25 years. In that work, it is examined whether there exists a convergence between 10 tourism centres that are quite significant for Malaysia during 1995-2005 (Singapore, Thailand, Indonesia, Japan, China, Brunei, Taiwan, Australia and USA) or not. That means that if the Malaysian government applies intense marketing strategies towards these markets this will increase the number of tourists. This work examined the reasons why tourists choose the country and whether there exists a convergence between these markets in terms of the number of tourists. Univariate variance analysis and panel Lagrange Multiplier are used in the work observing that there existed convergence in the Malaysian tourism sector. These findings indicate that Malaysian tourism strategies were successful and tourism contributes to economic development.

Narayan (2007) applies convergence analyses to assess the visitors arriving in the Fiji islands from various tourism centres (Australia, Canada, USA, New Zealand, UK, Europe, Japan, Pacific Islands). The work observed that tourists arriving in the Fiji islands from tourism centres converged and Fiji's tourism policies were successful. Another study taking Narayan's work as a basis is Lean & Smyth (2008), observing convergence in ten tourism centres of Malaysia. Lastly, Lee (2009) concluded that the number of tourists arriving to Singapore from Africa or Europe caught the ones from Asia and the tourists from America and Oceania converged with Asia. However, this work aims to test the convergence relationship between similar countries within the tourism market that are close to each other in terms of income and number of tourist arrivals.

Soukiazis & Proença (2008) corroborate the conditional convergence hypothesis for NUTS III regions of Portugal. Also, it is concluded that at NUTS II level, tourism activities have positive and significant impacts on regional growth. Moreover, it is concluded that improvement of both accommodation capacities and climatic conditions have significant impact on regional growth. Accordingly, the work states that policies towards tourism sector are important due to its contributions to regional per capita income growth and compensation for inter-regional development disparity.

Proença & Soukiazis (2008) show that conditional convergence hypothesis is valid for the growth model based on tourism. Besides, it is observed that tourism activities increase living standards and contribute to growth as an alternative resource. It is stated that the convergence process determined for these countries contributes to attenuated asymmetries between the countries in terms of "European Accession Policies". Additionally, it is underlined that the tourism sector has an important function not only for inter-state but also for inter-regional redistribution of wealth.

There are only two works in Turkey that show the tourism-convergence relationship in terms of tourism economy. The first is that of Samırkaş & Bahar (2011) measuring the effects of the tourism sector on compensating the inter-regional disparities in Turkey. Their findings show that the inter-city and inter-regional income disparities in Turkey for 1990-2000 period increased rather than decreased. Furthermore tourism activities intensified in certain cities of Turkey and this increase inter-regional disparities conditioning the existence of convergence. The second work is by Abbott, Vita & Altınay (2011), who observed that there is no convergence between the 20 emitting countries visiting Turkey.

The most important argument of economics literature where the above mentioned research is grounded is to investigate whether socio-economic differences between developed and underdeveloped countries will decrease in the course of time or not, that is to say the convergence hypothesis. The convergence

 ISSN: 2548-7583

hypothesis is the important inference of Solow's neoclassical growth (1956). According to this hypothesis, poor countries or regions have more growth potential than rich ones and thus convergence within rich countries or regions or economic sectors where capital is increasing may exist.

So far, numerous studies have been empirically carried out about the convergence hypothesis. Most of these studies are based on statistical methods such as statistical regression, panel data analysis and cross-sectional studies (Barro et. al., 1992; Mankiw et. al., 1992; Islam, 1995; Bernard et. al., 1996; Lee et. al., 1997). However, statistical methods cannot be used in some cases, because for example the number of observations is inadequate and the probability assumptions on error terms and dependent variables are not satisfied, the relationship between dependent variables and independent variables is complex, vague and uncertain. Besides, statistical methods assume that the relationship between dependent and independent variables is crisp or precise; on the other hand, these are based on classical logic. Contrary to this assumption of statistical methods, in real life, the relationship mostly contains some vagueness or uncertainty, especially in the case where the relationship is based on assumptions that are uncertain to happen. Since the convergence hypothesis is also based on uncertain assumptions such as technological levels of all countries being the same, or that technological growth rates between countries are the same, statistical methods can give misleading results. The other drawback of statistical methods is that coefficient or regression models obtained must be significant. Otherwise, one cannot make an interpretation about convergence or other statistical results.

In order to overcome the drawbacks of statistical methods, numerous methods based on fuzzy logic have been introduced in the literature (Tanaka et. al., 1982; Wang et. al., 2000; Chang et. al., 2001). The concept of fuzzy logic (FL) was first suggested at the beginning of the 70s by Zadeh (1965), and stated that the great majority of human thoughts are fuzzy, not precise or crisp and thus classical logic cannot express the human thought system capably. FL is considered as an version of classical or binary logic extended to many-value logic. As is known, in classical logic, propositions are either true or false, with nothing in between. It is often conventional to assign numerical values to truth of propositions with 1 representing true and 0 representing false. Like classical logic, FL is concerned with the truth of propositions. However, in FL, propositions may have a truth or falsity degree ranging between 0 and 1. These features of FL are widely used, especially in regression analysis. These methods are called fuzzy regression. In fuzzy regression, coefficients correspond to fuzzy numbers denoted with a membership function. In this way, large numbers of coefficients, each one having different membership values, are obtained. Thus, uncertainty in statistical regression that assumes that relationship between variables is crisp and precise and is based on hard assumptions has been annihilated.

In this study, we propose the concept of fuzzy convergence based on Fuzzy Linear Regression (FLR). FLR was first introduced by Tanaka et al. (1982) as a fuzzy type of statistical regression analysis, which is used to model the vague relationship between dependent and independent variables.

### 3. Convergence approaches

In traditional convergence, the convergence hypothesis can be tested in two main ways: β convergence, σ convergence. Generally, β convergence investigates the relationship of incomes and growth rates of countries. This kind of convergence assumes that poor countries have the faster growth rates than rich countries and thus will catch up to rich ones on the basis of personal income. β convergence is divided into two approaches: absolute β convergence and conditional β convergence. The main difference between these approaches is the initial assumption. While absolute β convergence asserts that some structural characteristics of countries such as human capital, government policy and technology are identical, conditional β convergence assumes that these characteristics are different.

The models below are used for testing absolute β convergence and conditional β convergence respectively:

$$Ln\left(\frac{y_{it}}{y_{i0}}\right) = \alpha + \beta \ln\,(y_{i0}) + u_i \quad (1)$$

Equation (2) is formed by adding control variable ($x_{i0}$) representing the structural differentness to Equation (1):


ISSN: 2548-7583

$$Ln\left(\frac{y_{it}}{y_{i0}}\right) = \alpha + \beta \ln (y_{i0}) + \delta x_{i0} + u_i \quad (2)$$

Equation (1) and (2) indicate annual growth as a linear function of the log of the initial GDP, α, β and δ are coefficients, i is the country index, $y_{it}$ is the GDP in the time t, $y_{i0}$ is the GDP in the initial time, $u_i$ is the error term with mean zero and $\sigma^2$ variance. If β is negative, β convergence is present (Baumol ,1986, Barro et. al., 1992; Mankiw et. al. ,1992).

σ convergence is based on examining dispersion of per capita income of countries. According to (Permani, 2008), $\sigma$ convergence exists whenever dispersion of real per capita income across groups of economies is decreasing over time. $\sigma$ convergence can also refer to the catch up effect between richer and poorer countries (Permani 2008;Song et. al., 2012).

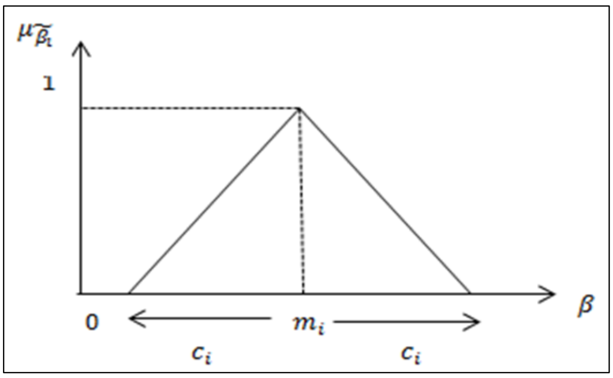
As mentioned before, all types of traditional convergence approaches cannot be used and can give misleading results in some cases. In this study, we propose the fuzzy convergence concept based on FLR to relax some strict assumptions of traditional methods and deal with cases of uncertainty.

Fuzzy convergence is based on examining the fuzzy coefficients and their membership values obtained from FLR. Basic FLR model is defined as follows:

$$\tilde{Y} = \widetilde{\beta_0}X_0 + \widetilde{\beta_1}X_1 + \cdots + \widetilde{\beta_p}X_p \quad (3)$$

Where $p$ is the number of independent variables, $X = [X_0, X_1, \ldots, X_p]$ is the vector of independent variables, $\widetilde{\boldsymbol{\beta}} = [\widetilde{\beta_0}, \widetilde{\beta_1}, \ldots, \widetilde{\beta_p}]$ is the fuzzy coefficients vector, and $\tilde{Y}$ is the fuzzy dependent variable. Each fuzzy coefficient $\widetilde{\beta_i} = (m_i, c_i)$ is defined as a symmetrical triangular fuzzy number with fuzzy center $m_i$ and fuzzy spread $c_i$ shown in Fig. 1.

Figure 1. Fuzzy coefficient defined as symmetrical triangular




As can be understood in Fig.1, coefficients estimated by FLR do not take an exact or crisp value, and can take infinite values between interval $[m_i - c_i, m_i + c_i]$ with different membership values. Membership value is calculated for any $\widetilde{\beta_i}$ coefficient as follows:

$$\mu_{\widetilde{\beta}} = \begin{cases} 1 - \frac{m_i - \widetilde{\beta_i}}{c_i} & m_i - c_i \leq \widetilde{\beta_i} \leq m_i + c_i \\ 0 & Otherwise \end{cases} \quad (4)$$

Equation (3) can be rewritten as follows:

$$\tilde{Y} = (m_0, c_0)X_0 + (m_1, c_1)X_1 + \cdots + (m_p, c_p)X_p \quad (5)$$

Different from statistical regression analysis, FLR is based on minimizing total spread as in:

$$F = \min \left(\sum_{j=1}^{p} \sum_{i=1}^{n} c_j x_{ij}\right) \quad (6)$$

This objective function leads to the following linear programming problem with different constraints according to:

<u>Case1: non-fuzzy output (X crisp, Y Crisp):</u>

$$y_i \geq \sum_{j=1}^{p} m_j x_{ij} - (1-h) \sum_{j=1}^{p} c_j x_{ij} \quad =1,2,\ldots,n \quad (7)$$

$$y_i \leq \sum_{j=1}^{p} m_j x_{ij} - (1-h) \sum_{j=1}^{p} c_j x_{ij} \quad i=1,2,\ldots,n \quad (8)$$

<u>Case 2: fuzzy output (X crisp, Y Fuzzy):</u>

$$y_i \geq \sum_{j=1}^{p} m_j x_{ij} - (1-h) \sum_{j=1}^{p} c_j x_{ij} + (1-h)e_i \quad i=1,2,\ldots,n \quad (9)$$

$$y_i \leq \sum_{j=1}^{p} m_j x_{ij} - (1h) \sum_{j=1}^{p} c_j x_{ij} - (1-h)e_i \quad i=1,2,\ldots,n \quad (10)$$

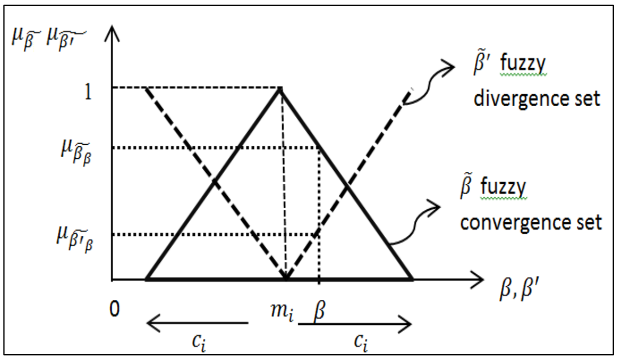
Where h is the fuzziness degree, that is the degree between interval [0 1] and is defined by user. In this study, the second case and Equation (1) will be used for fuzzy convergence. Note that all types of models used for convergence testing can be adjusted to FLR.

If Equation (1) is rewritten in the form of FLR, the equation below is obtained:

$$\widetilde{Ln\left(\frac{y_{\iota t}}{y_{\iota 0}}\right)} = \tilde{\alpha} + \tilde{\beta} y_{i0} \quad (11)$$

Where $\tilde{\beta}$ corresponds fuzzy convergence set. The complement of $\tilde{\beta}$ ($\tilde{\beta}'$) will be the fuzzy divergence set. Fig. 2 illustrates fuzzy convergence and divergence set.

Fig. 2. Fuzzy convergence, fuzzy divergence set and membership degree of for any crisp $\beta$ value.




The most important point in Fig. 2 is that the sum of $\mu_{\tilde{\beta}_\beta}$ and $\mu_{\tilde{\beta'}_\beta}$ is equal to 1. In other words, if the membership value of $\beta$ to fuzzy convergence set ($\tilde{\beta}$) is $\mu_{\tilde{\beta}_\beta}$ , its membership value to fuzzy divergence set ($\mu_{\tilde{\beta'}_\beta}$) is (1-$\mu_{\tilde{\beta}_\beta}$).

To sum up, we find FLR model for Equation (11) and constitute the fuzzy convergence set. Thus, instead of saying that there is convergence or divergence exactly, we try to find the membership value of convergence by calculating the membership value of the coefficient $\beta$ obtained from traditional convergence methods to fuzzy convergence or fuzzy divergence set.

## 4. Experimental results

In order to test fuzzy convergence, the data used in this study are international tourism receipts (ITR) (current USA dollars between 1995 and 2012 – 1995-2003 and 2004-2012 related to 10 countries: Australia, Austria, China, Germany, Spain, France, the United Kingdom, Italy, Turkey and the United States. Data set was obtained from the web site of the World Bank. We perform the analysis for all the period 1995-2012 and the second step was to divide data set in two parts: the period of 1995-2003 and the period of 2004-2012. The reason for this is to increase the number of experimental analyses, and to reinforce the reliability of our approach.

### *4.1. Traditional convergence results*

The log of ITR in 1995-2012, illustrated in Figure 3, suggests that the ten countries under analysis have convergence in the long term. The plot of log of ITR between 1995 and 2003 and between 2004 and 2012, illustrated in Fig. 4.5 also suggests convergence, which means that convergence may be verified even in shorter periods.

Fig. 3. Log of ITR between 1995 and 2012 related to 10 countries.

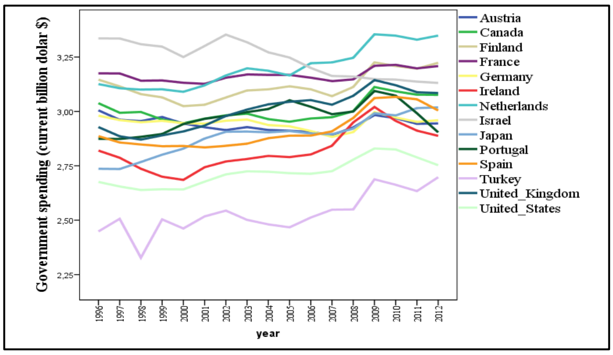



Fig. 4. Log of ITR between 1995 and 2003

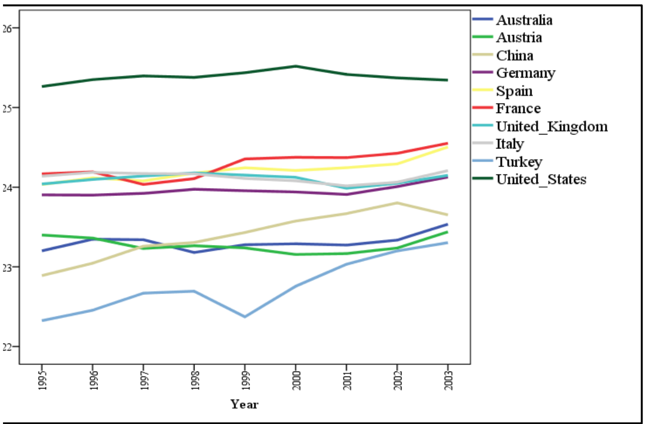
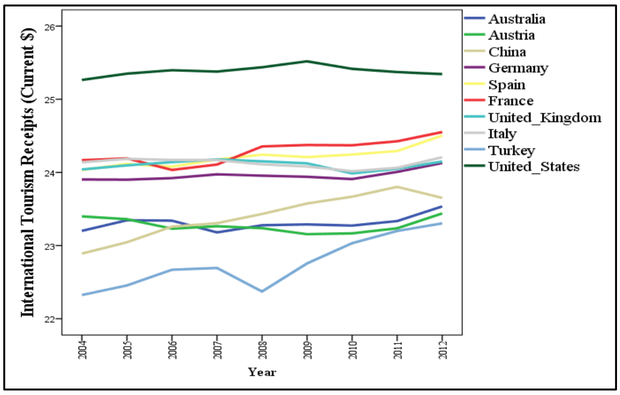



Fig. 5. Log of ITR between 2004 and 2012




Algebraically convergence was verified for the three periods with equation 12, for the period of 1995-2012, equation 13 for the period of 1995-2003 and equation 14 for 2004-2012.

Accordingly, Equation 12 shows the absolute β convergence model in 1995-2012


ISSN: 2548-7583

$$\ln(\frac{y_{it}}{y_{i0}}) = 11.832 - 0.460\ln\,(y_{i0}) \tag{12}$$

From Equation12, it is verified that the value of β=-0.460 is smaller than 0. Also Equation 13: estimated for the period of 1995-2003 suggests convergence as β<0.

$$\ln(\frac{y_{it}}{y_{i0}}) = 7.0498 - 0.2825\ln\,(y_{i0}) \tag{13}$$

The period of 2004-2012 also suggests convergence as in equation 14

$$\ln(\frac{y_{it}}{y_{i0}}) = 2.205 - 0.075\ln\,(y_{i0}) \tag{14}$$

As mentioned before, coefficient $\beta$(-0.075) and the regression model in Eq. (14) are statistically significant suggesting convergence.

Table1. The results of absolute β Convergence Test for ITR

| | Constant | β | R |
|---|---|---|---|
| **1995-2012** | | | |
| **Coefficients and R** | 11.832 | **-0.460** | |
| **Two-way significant** | 0.019 | **0.026** | 0,692 |
| **1995-2003** | | | |
| **Coefficients and R** | 70.498 | **-0.2825** | 0.727 |
| **Two-way significant** | 0.014 | **0.017** | |
| **2004-2012** | | | |
| **Coefficients and R** | 2.205 | -0.075 | 0.208 |
| **Two-way significant** | 0.489 | 0.564 | |

The existence of a β<0 only ensures convergence if the coefficient and the regression model are statistically significant. Table 1 and Table 2 show the results of absolute β convergence test and ANOVA test respectively, for each of the periods under analysis.

Table 2. The One Way ANOVA test results

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **1995-2012** | | | | | |
| **Regression** | 1.271 | 1 | 1.271 | 7.371 | 0.026 |
| **Residual** | 1.379 | 8 | 0.172 | | |
| **Total** | 2.650 | 9 | | | |
| **1995-2003** | | | | | |
| Regression | 0.479 | 1 | 0.479 | 8.992 | **0.017** |
| Residual | 0.426 | 8 | 0.053 | | |
| Total | 0.904 | 9 | | | |
| **2004-2012** | | | | | |
| Regression | 0.018 | 1 | 0.018 | 0.362 | 0.564 |
| Residual | 0.400 | 8 | 0.050 | | |
| Total | 0.418 | 9 | | | |

As per reference to 1995-2012, table 1 shows that coefficient β is statistically significant since the two-way significant value (0.026) is smaller than 0.05. Besides, there is a positive and moderate correlation between $\ln\left(\frac{y_{it}}{y_{i0}}\right)$ and $y_{i0}$ higher than 0.5. ANOVA (table 2) tests the statistical significance of regression models. In the case of the estimated regression of 1995-2012 it may be confirmed that the regression model is statistically significant since the sig. value (0.026) is smaller than 0.05. Considering these statistical results, we can say that there is a significant convergence between countries in terms of international tourism receipts (current $).

As mentioned before, exact convergence is present in traditional convergence. In other words, each β is smaller than zero and statistical significance indicates the existence of convergence.

For the period of 1995-2003, table 1, it can be seen that coefficients are significant since their two-way significant values are smaller than 0.05. In Table 2, the sig. value is smaller than 0.05. Therefore, we can say that absolute β model is statistically significant. In brief, we can say that convergence is present in this period as well.

For 2004-2013, table 1 and table 2 illustrate that convergence between countries is not statistically significant since both two sig. values are bigger than 0.05.

Constraint equations and solution vector for these data sets are in Appendix C (for 1995-2012), C (for 1995-2003) and C (for 2004-2012). The coefficient matrix and coefficient vector of objective function are similar to the first ones.

When statistical significance is not confirmed, the significance of fuzzy convergence may be manifested in such circumstances. Because, while it is difficult to say that convergence is present or not according to statistical methods, fuzzy convergence gives a chance of investigating whether there is convergence or not (Siriopoulos & Asteriou, 1998; Dobson & Ramlogan, 2002; Unger, 2005;). As such, the analysis follows with estimation of fuzzy convergence, for the three periods.

 ISSN: 2548-7583

### *4.2. Fuzzy convergence*

When there is no difference between β being -1 and β being -0.0000001. Fuzzy convergence allows that each β between -1 and 1 belongs to fuzzy convergence or a fuzzy divergence set with different membership value.

In fuzzy convergence, the level of h is firstly determined. For this data, we set this as 0.1. Thus, the interval of fuzzy convergence set will be narrow. In the second step, constraints are constructed for lower and upper boundaries. For the fuzzy absolute β model, we must find two $m_i$ and $c_i$. Obtained constraint equations and the coefficient matrix, A, solution vector, b, and coefficient vector of objective function, z, are in Appendix C. After obtaining z, A and b, the solution is obtained as follows:

$$[z]_4 = [b^{-1}]_{20}x[A]_{20x4}$$

Solutions are obtained with the above command

[X, fval, exitflag, output] = linprog(z, A, b)

Where X indicates the solution vector as follows:

X = [11.000 -0.4268  0.15 0.2598]

Based on these results, fuzzy absolute β model is obtained via linear programming, as outlined in equation 15,16, 17 for 1995-2012, 1995-2003 and 2004-2012, respectively:

$$Ln\left(\frac{y_{it}}{y_{i0}}\right) = (11.00{,}0.15) + (-0.4268{,}0.2598)\ln{(y_{i0})}$$

$$Ln\left(\frac{y_{it}}{y_{i0}}\right) = (7.1495{,}0.4546) + (-0.2102{,}0.1649)\ln{(y_{i0})}$$

$$Ln\left(\frac{y_{it}}{y_{i0}}\right) = (2.0139{,}0.1141) + (-0.0591{,}0.0242)\ln{(y_{i0})}$$

(17)

Where y indicates $\ln(\frac{y_{it}}{y_{i0}})$ and x is $\ln{(y_{i0})}$. The membership value of coefficient β estimated from traditional convergence approach is calculated as in equation 18, 19 and 20. This membership can be calculated even if traditional coefficient β is not statistically significant. Because traditional β is not considered directly, a membership value is calculated for it

$$\mu_\beta = 1 - \frac{-0.4268 + 0.460}{0.2598} = 0.871 \quad (18)$$

$$\mu_\beta = 1 - \frac{-0.2102 + 0.283}{0.1649} = 0.559 \quad (19)$$

$$\mu_\beta = 1 - \frac{-0.0591 + 0.075}{0.0242} = 0.343 \quad (20)$$

Fig. 6 Fuzzy convergence and fuzzy divergence set for 1995-2012

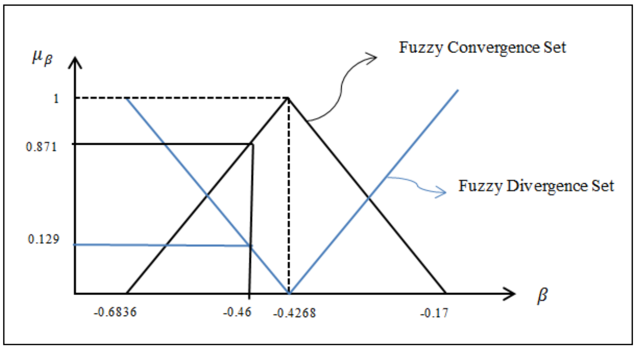



Fig. 7. Fuzzy convergence and fuzzy divergence set for 1995-2003

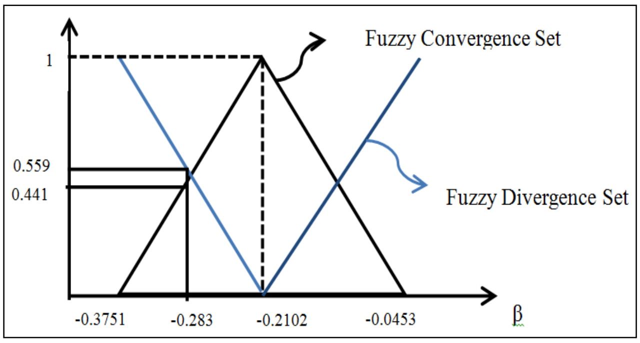
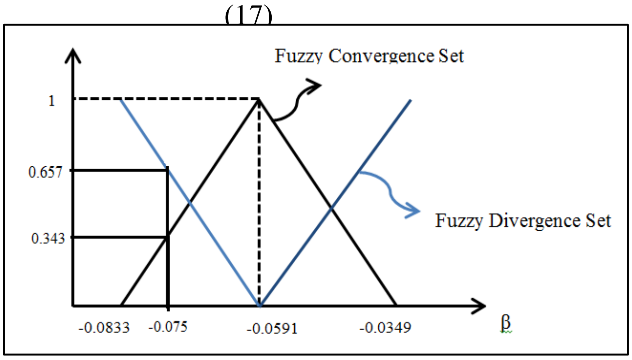



Fig. 8. Fuzzy convergence and fuzzy divergence set for 2004-2012




From Fig. 6, 7 and 8, it can be said that the convergence is present for each y, since y's converge


ISSN: 2548-7583

at a constant value in the period 1995-2012 (figure 6). In the period 1995-2012, equation 15 and figure 6, it may be suggested that there is convergence within countries with a coefficient of 0.871 of membership and divergence with 0.129 of membership.

Concerning 1995-2003, Eq. (16), it can be said that there is a fuzzy convergence based on the interval of coefficient $\beta$. Equation 19 shows that convergence stays at 0.559 of membership, whereas divergence relies on 0.441, suggesting that for short periods the level of convergence weakens. Figure 7 illustrates the y's convergence with a constant value.

In the period of 2004-2012, eq. 17 suggests that there is convergence since left, middle and right points of β coefficient are negative. Fig. 8 shows that series of y_low, y_mid and y_high tend to converge on a constant value. Therefore, we can say that fuzzy convergence with 0.343 of membership.is present for this data set.

Fig. 9. The log of Fuzzy Regression Interval from 1995-2012

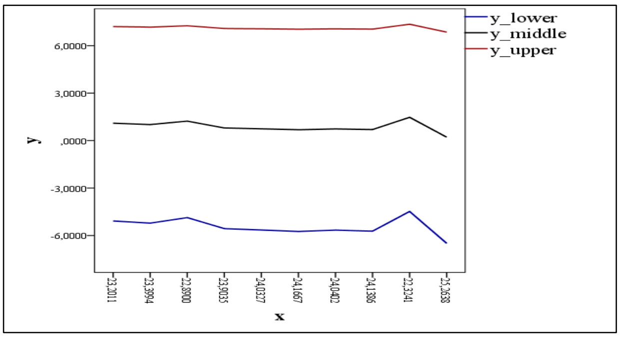



Fig. 10. The Interval of Fuzzy Regression for 1995-2003

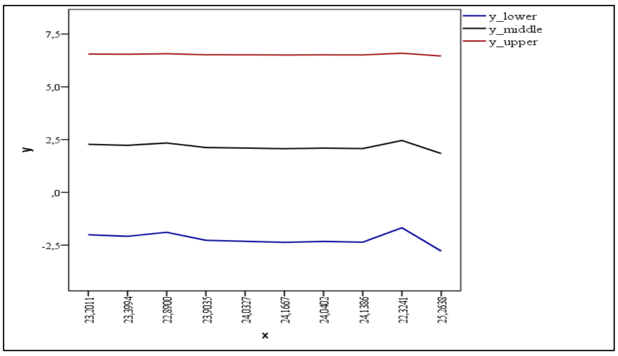
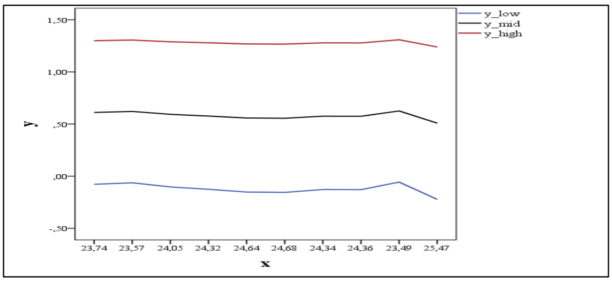



Fig. 11. The Interval of Fuzzy Regression for 2004-2012




Figures 9, 10 and 11 show the fuzzy convergence and divergence set for the three periods.

For the whole period 1995-2012 (fig. 9) the countries belong to a fuzzy convergence of 0.871, suggesting that convergence is very strong in the countries with high membership. In the period 1995-2004, Fig. 10 suggests that the countries belong to a fuzzy convergence set with 0.559 membership and a fuzzy divergence set with 0.441 membership. This highlights that there is convergence within the countries with high membership, even if in this period the convergence is not so strong. In 2004-2012 Fig. 11 illustrates that the left and right bound of convergence coefficient are negative. Hence, it is possible to say that there is fuzzy convergence with 0.343 membership degree.

## 5. Conclusions

In this study, we propose the fuzzy convergence method based on fuzzy logic that are especially used to analyse problems including uncertainty, vagueness or imprecision. Fuzzy convergence has been proposed *for the first time* in this study and firstly has been used to test whether fuzzy convergence is present or not in terms of *international tourism receipts*.

Fuzzy logic gives successful results especially in solving problems including uncertainty, vagueness and imprecision. The objective of fuzzy convergence is to suggest the concept of partial convergence or partial divergence, instead of exact convergence for each coefficient β that is smaller than 0. To introduce the concept of fuzzy convergence, the absolute β convergence model is preferred as a first step.

In fuzzy convergence, coefficient β corresponds to an interval representing a triangular membership function instead of a crisp value. We call this function a fuzzy convergence set. How much countries or regions converge is determined by calculating the membership value of traditional coefficient β to this fuzzy convergence. The superiority of the fuzzy convergence method from statistical methods is that it can be used even though the number of data points is very small and statistical assumptions do not satisfy. Besides, fuzzy convergence does not require a significant test on the coefficients.

To illustrate our proposed method, we carried out three experimental analyses. Experimental analyses are carried on three parts of a data set consisting of international tourism receipts (current $ billion) of 10 countries in a period between 1995 and 2012. The first data involves the period between 1995 and 2012. In terms of this data, statistical regression is found that there is convergence within countries since coefficient β is negative and statistically significant. Besides, it is found that countries have fuzzy convergence with 0.871 membership value and fuzzy divergence with 0.129 membership value.

The second data set consists of international tourism receipts of the period between 1995 and 2003. For this data set traditional convergence is also found. According to fuzzy convergence, it belongs to a fuzzy convergence set with 0.559 membership value and fuzzy divergence set with 0.441 membership value.

The period of 2004 and 2012 do not suggest convergence since the coefficient β is negative, and not statistically significant. To sum up, fuzzy convergence has some advantages by comparison with other statistical methods:

The concept of convergence is based on some human assumptions such as technological levels of all countries being the same, and technological growth rates between countries being equivalent. These assumptions are uncertain to happen. Statistical methods are not appropriate to model problems including uncertainty since these methods produce single, in the other words, exact solutions such as exact β coefficient. Yet, infinitely many solutions at specified intervals are obtained in fuzzy methods and each of these solutions has the membership value between 0 and 1. Therefore, fuzzy methods are more successful in solving problems including uncertainty. Statistical methods are based on some statistical assumptions such as that errors follow the normal distribution with 0 mean and a constant variance. The observations also come from normal distributions. However, in real life, it is very difficult to verify these assumptions. Fuzzy methods do not require any assumptions. In traditional convergence, coefficient β must be statistically significant to say whether convergence is present or not. However, fuzzy convergence does not require any significant test.

In economic terms the results of this essay suggest that in the period of 1995-2003 countries visiting Turkey have convergence, which means that the economic distribution of welfare is equivalent. However in the period of 2004-2012 the paths of growth across the countries are not equitative. Further research should seek to understand where the differences lie. Furthermore, due to the robustness of fuzzy convergence, further research should rely on testing this method across other countries to extend the stream of this line of research.

**References**

Abbott, A., Vita, G. D. & Altınay, L. (2011). Revisiting the Convergence Hypothesis for Tourism Markets: Evidence from Turkey Using the Pairwise Approach. *Tourism Management*, (Article in Press).

Bahar, O. & Kozak M. (2007). Advancing Destination Competitiveness Research: Comparison Between Tourists and Service Providers. *Journal of Travel and Tourism Marketing*, 22 (2): 61-71.

Bahar, O. & Kozak M. (2008). *Tourism Economics Concepts and Practices*. New York: Nova Science Publishers, Inc.

Balaguer, J., & Jorda, M. C. (2002). Tourism as a Long-run Economic Growth Factor: the Spanish Case. *Applied Economics*, 34: 877-884.

Barro, R & Sala-i-Martin, X. (1990). Economic Growth and Convergence Across United States. www.nber.org/papers/w3419.

Barro, R & Sala-i-Martin, X. (1995). *Economic Growth*. Eastern Economy Edition, Second Edition, Prentice Hall of India.

Barro, R., J., & Xavier, X. S. (1992). Convergence. *Journal of Political Economy,* 100, 223-51.

Baumol, W. J. (1986). Productivity Growth, Convergence and Welfare: What the LongRun Data Show. *The American Economic Review*, 76 (5): 1072-85.

 ISSN: 2548-7583

Benos, N. & Karagiannis, S. (2008). Convergence and Economic Performance in Greece: Evıdence at Regıonal and Prefecture Level. *Review of Urban & Regional Development Studies*, 20 (1): 52-69.

Bernard, A.B. & Jones ,C., I. (1998). Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries. *American Economic Review 86*, 1216-1238.

Braga, V. (2006). Regional Growth an Local Convergence: Evidence for Portugal. http://www.ersa.org/ersaconfs/ersa03/cdrom/papers/323.pdf.

Chang, Y. O., Ayyup, B., M. (2001). Fuzzy Regression Methods-A Comparative Assessment. *Fuzzy Sets and Systems*, 119, 187-203.

Cho, V. (2003). A Comparison of Three Different Approaches to Tourist Arrival Forecasting. *Tourism Management,* 24 (3): 323–330.

Christopoulos, D. K. & Tsionas, E. G. (2004). Convergence and Regional Productivity Differences: Evidence from Greek Prefectures. *The Annals of Regional Science*, 38: 387-396.

Dobson, S. & Ramlogan, C. (2002). Convergence and Divergence in Latin America, 1970-1998. *Applied Economics*, 34 (4): 465-470.

Durbarry, R. (2004). Tourism and Economic Growth: the Case of Mauritius. *Tourism Economics*, 10(4): 389-401.

Gökovalı, U. & Bahar, O. (2006). Contribution of Tourism to Economic Growth in Mediterrranean Countries: A Panel Data Approach. *Anatolia An International Journal of Tourism And Hospitality Research*, 17 (2): 155-168.

Hazari, B. R., & Ng, A. (1993). An Analysis of Tourists' Consumption of Non-traded Goods and Services on the Welfare of the Domestic Consumers. *International Review of Economics and Finance*, 2: 3-58.

Hazari, B. R., & Sgro, P. M. (1995). Tourism and Growth in a Dynamic Model of Trade. *The Journal of International Trade and Economic Development*, 4 (2): 243-252.

Hooi, L. H. & Smyth, R. (2006). Marketing, Malaysia Welcomes the World: Are Malaysia's Tourism Markets Converging?. *Monash University Business and Economics, ABERU Discussion*, Paper 26.

Islam, N. (1995). Growth Empirics: A Panel Data Approach. *Quarterly Journal of Economics*, 110, 1127-1170.

Issa, I. A. & Altınay, L. (2006). Impacts of Political Instability on Tourism Planning and Development: the Case of Lebanon. *Tourism Economics*, 12 (3): 361-381.

Kangasharju, A. (1998). Β convergence in Finland: Regional Differences in Speed of Convergence. *Applied Economics*, 30 (5): 679-687.

Kim, H. J., Chen, M. H. & Jang S. (2006). Tourism Expansion and Economic Development: The case of Taiwan. *Tourism Management*, 27 (5): 925-933.

Kozak, M., Baloğlu, Ş. & Bahar O. (2010). Measuring Destination Competitiveness: Multiple Destinations Vs Multiple Nationalities. *Journal of Hospitality Marketing & Management*, 19 (1):56-71.

Lean, H. H & Smyth, R. (2008). Are Malaysia's Tourism Markets Converging? Evidence From Univariate and Panel Unit Root Tests with Structural Breaks. *Tourism Economics*, 14 (1): 97-112.

Lee, C. G. (2009). The Convergence Hypothesis For Tourism Markets: Evidence From Singapore. *Tourism Economics*, 15 (4): 875–881.

Lee, J. (2009). Trade, FDI, and Productivity Convergence: A dynamic Panel Data Approach in 25 Countries. *Japan and the World Economy*, 21: 226–238.

Lee, K., M. H. Pesaran & R. Smith (1998). Growth Empirics: A Panel Data Approach { A Comment, Quarterly Journal of Economics, 113, 319-323.

Lorde, T. & Moore, W. (2008). Co-movement in Tourist Arrivals in the Caribbean. *Tourism Economics*, 14 (3), 631–643

Lundberg, E. D. et al. (1995). *Tourism Economics*. Canada: John Wiley&Sons,Inc.

Mankiw, N. G. (2007). *Macroeconomics*. Sixth Edition, New York: Worth Publishers.

Mankiw, N. G., Romer, D. & Weil, D. N. A. (1992). Contribution to the Empirics of Economic Growth. *Quantitative Journal of Economics,* 407-437.

McKinnon, T. (1964). Foreign Exchange Constraint in Economic Development and Efficient Aid Allocation. *Economic Journal*, 74: 388–409.

Modeste, N. C. (1995). The Impact of Growth in the Tourism Sector on Economic Development: the Experience of Selected Caribbean Countries. *Economia Internazionale*, 48: 375-385.

Narayan, P. K. (2006). Are Australia's Tourism Markets Converging?. *Applied Economics*, 38 (10): 1153–1162.

Narayan, P. K. (2007). Testing Convergence of Fiji's Tourism Markets. *Pacific Economic Review*, 12 (5): 651–663.


 ISSN: 2548-7583

Nowak, J., Sahli, M. & Sgro, P. M. (2004). Tourism, Trade and Domestic Welfare. *FEEM Working Paper Series*, No: 24.

Permani, R. (2008). Education as a determinant of economic growth in East Asia: historical trends and empirical evidences (1965-2000). *In Asia-Pacific Economic and Business History Conference*, 13-15.

Pizam, A. (1999). Life and Tourism in the Year 2050. *International Journal of Hospitality Management*, 18 (4): 331–343.

Proença, S. & Soukiazi, E. (2008). Tourism as an Alternative Source of Regional Growth in Portugal: a Panel Data Analysis at NUTS II and III Levels. *Portuguese Economic Journal*, 7 (1): 43-61.

Rassekh, F. (1998). The Convergence Hypothesis: History, Theory, and Evidence. *Open Economies Review*, 9: 85-105.

Rassekh, F., Panik, M. J. & Kolluri, B. R. (2001). A test of the Convergence Hypothesis: the OECD Experience, 1950-1990. *International Review of Economics and Finance*, 10: 147-157.

Sachs, J. D., Bajpai, N. & Ramiah, A. (2002). Understanding Regional Economic Growth in India. *Harvard CID Working Paper*, No: 88.

Sala-i-Martin, X. (1996). The Classical Approach to Convergence Analysis. *The Economic Journal*, 106 (437): 1019–1036.

Siriopoulos, C. & Asteriou, D. (1998). Testing for Convergence Across The Greek Regions. *Regional Studies*, 32 (6): 537–546.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, 70 (1): 65-94.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, 3 (3): 312-320.

Solow, Robert M. (1956). A Contribution to Theory of economic Growth. *The Quarterly Journal of Economics*, 70, No. 1, 65-94.

Song, P., C., Sek, S., K., Har, W., M. (2012). Investigating The Convergence of Growth: A Comparative Study. *International Conference on Economics, Business Innovation*, vol. 38, 34-38.

Soukiazi, E. & Proença, S. (2008). Tourism as an Economic Growth Factor: a Case Study for Southern European Countries. *Tourism Economics*, 14 (4): 791–806.

Tanaka, H., Uejima, S., Asal, K. (1982). *Linear regression analysis with fuzzy model*. IEEE Transactions on Systems, Man and Cybernetics 12 (1982): 903–907.

Tse, R. Y. C. (2001). Estimating the Impact of Economics Factors on Tourism: Evidence from Hong Kong. *Tourism Economics*, 7 (3): 277–297.

Unger, K. (2005). Regional Economic Development and Mexican out-Migration. http://www.nber.org/papers/W11432.

Vanegas, M. & Croes, R. R. (2003). Growth, Development and Tourism in a Small Economy: Evidence from Aruba. *The International Journal of Tourism Research*, 5 (5): 315-330.

Wang, H., F., Tsaur, R., C. (2000). Insight of a Fuzzy Regression. *Fuzzy Sets and Systems*, 112, 355-369.

WTO. (2010). *Tourism Highlights 2010 Edition*, Spain.

Zadeh, L., A. (1965). Fuzzy Sets. *Information and Control*, 8, 338:353.

 ISSN: 2548-7583

**APPENDIX**
**C Solutions**

**For 1995-2012**
**Constraint Equations**

$m_0$ +(23.2011)$m_1$-(0.1)$c_0$-(2.3201)$c_1$ ≤1.0524
$m_0$ +(23.3994)$m_1$-(0.1)$c_0$-(2.3399)$c_1$ ≤0.3894
$m_0$ +(22.8900)$m_1$-(0.1)$c_0$-(2.2890)$c_1$ ≤ 1.8394
$m_0$ +(23.9035)$m_1$-(0.1)$c_0$-(2.3903)$c_1$ ≤0.7629
$m_0$ +(24.0327)$m_1$-(0.1)$c_0$-(2.4033)$c_1$ ≤ 0.8369
$m_0$ +(24.1667)$m_1$-(0.1)$c_0$-(2.4167)$c_1$ ≤0.8421
$m_0$ +(24.0402)$m_1$-(0.1)$c_0$-(2.4040)$c_1$ ≤ 0.5109
$m_0$ +(24.1396)$m_1$-(0.1)$c_0$-(2.4139)$c_1$ ≤ 0.3467
$m_0$ +(22.3241)$m_1$-(0.1)$c_0$-(2.2324)$c_1$ ≤1.8727
$m_0$ +(25.2638)$m_1$-(0.1)$c_0$-(2.5264)$c_1$ ≤0.7582
- $m_0$ -(23.2011)$m_1$-(0.1)$c_0$-(2.3201)$c_1$ ≤-1.0524
- $m_0$ -(23.3994)$m_1$-(0.1)$c_0$-(2.3399)$c_1$ ≤-0.3894
-$m_0$ -(22.8900)$m_1$-(0.1)$c_0$-(2.2890)$c_1$ ≤-1.8394
- $m_0$ -(23.9035)$m_1$-(0.1)$c_0$-(2.3903)$c_1$ ≤-0.7629
-$m_0$ -(24.0327)$m_1$-(0.1)$c_0$-(2.4033)$c_1$ ≤ -0.8369
- $m_0$ -(24.1667)$m_1$-(0.1)$c_0$-(2.4167)$c_1$ ≤-0.8421
-$m_0$ -(24.0402)$m_1$-(0.1)$c_0$-(2.4040)$c_1$ ≤-0.5109
-$m_0$ -(24.1396)$m_1$-(0.1)$c_0$-(2.4139)$c_1$ ≤ -0.3467
-$m_0$ -(22.3241)$m_1$-(0.1)$c_0$-(2.2324)$c_1$ ≤-1.8727
- $m_0$ -(25.2638)$m_1$-(0.1)$c_0$-(2.5264)$c_1$ ≤-0.7582

**Coefficient Matrix**

A =

| | | | |
|---|---|---|---|
| 1 | 23.20106 | -0.1 | -2.32011 |
| 1 | 23.39941 | -0.1 | -2.33994 |
| 1 | 22.89003 | -0.1 | -2.289 |
| 1 | 23.90348 | -0.1 | -2.39035 |
| 1 | 24.03268 | -0.1 | -2.40327 |
| 1 | 24.16672 | -0.1 | -2.41667 |
| 1 | 24.04025 | -0.1 | -2.40402 |
| 1 | 24.13856 | -0.1 | -2.41386 |
| 1 | 22.32407 | -0.1 | -2.23241 |
| 1 | 25.26382 | -0.1 | -2.52638 |
| -1 | -23.2011 | -0.1 | -2.32011 |
| -1 | -23.3994 | -0.1 | -2.33994 |
| -1 | -22.89 | -0.1 | -2.289 |
| -1 | -23.9035 | -0.1 | -2.39035 |
| -1 | -24.0327 | -0.1 | -2.40327 |
| -1 | -24.1667 | -0.1 | -2.41667 |
| -1 | -24.0402 | -0.1 | -2.40402 |
| -1 | -24.1386 | -0.1 | -2.41386 |
| -1 | -22.3241 | -0.1 | -2.23241 |
| -1 | -25.2638 | -0.1 | -2.52638 |

**Solution vector**

b = [1.0524 0.3894 1.8394 0.7629 0.8369 0.8421 0.5109 0.3467 1.8727 0.7582 -1.0524-0.3894 -1.8394 -0.7629 -0.8369 -0.8421 -0.5109 -0.3467 -1.8727 -0.7582]

**The coefficient vector of objective function**

z =[0.1 23.7360 10 237.3601]

**For 1995-2003**

**Constraint Equations**

$m_0$ +(23.2011)$m_1$-(0.1)$c_0$-(2.3201)$c_1$ ≤0.3344
$m_0$ +(23.3994)$m_1$-(0.1)$c_0$-(2.3399)$c_1$ ≤0.0404
$m_0$ +(22.8900)$m_1$-(0.1)$c_0$-(2.2890)$c_1$ ≤ 0.7621
$m_0$ +(23.9035)$m_1$-(0.1)$c_0$-(2.3903)$c_1$ ≤0.2244
$m_0$ +(24.0327)$m_1$-(0.1)$c_0$-(2.4033)$c_1$ ≤ 04717
$m_0$ +(24.1667)$m_1$-(0.1)$c_0$-(2.4167)$c_1$ ≤0.3850
$m_0$ +(24.0402)$m_1$-(0.1)$c_0$-(2.4040)$c_1$ ≤ 0.1085
$m_0$ +(24.1396)$m_1$-(0.1)$c_0$-(2.4139)$c_1$ ≤ 0.0687
$m_0$ +(22.3241)$m_1$-(0.1)$c_0$-(2.2324)$c_1$ ≤0.9796
$m_0$ +(25.2638)$m_1$-(0.1)$c_0$-(2.5264)$c_1$ ≤0.0798
- $m_0$ -(23.2011)$m_1$-(0.1)$c_0$-(2.3201)$c_1$ ≤-0.3344
- $m_0$ -(23.3994)$m_1$-(0.1)$c_0$-(2.3399)$c_1$ ≤-0.0404
-$m_0$ -(22.8900)$m_1$-(0.1)$c_0$-(2.2890)$c_1$ ≤-0.7621
- $m_0$ -(23.9035)$m_1$-(0.1)$c_0$-(2.3903)$c_1$ ≤-0.2244
-$m_0$ -(24.0327)$m_1$-(0.1)$c_0$-(2.4033)$c_1$ ≤ -0.4717
- $m_0$ -(24.1667)$m_1$-(0.1)$c_0$-(2.4167)$c_1$ ≤-0.3850
-$m_0$ -(24.0402)$m_1$-(0.1)$c_0$-(2.4040)$c_1$ ≤-0.1085
-$m_0$ -(24.1396)$m_1$-(0.1)$c_0$-(2.4139)$c_1$ ≤ -0.0687
-$m_0$ -(22.3241)$m_1$-(0.1)$c_0$-(2.2324)$c_1$ ≤-0.9796
- $m_0$ -(25.2638)$m_1$-(0.1)$c_0$-(2.5264)$c_1$ ≤-0.0798

**Solution vector**

b = [0.3344 0.0404 0.7621 0.2244 0.4717 0.3850 0.1085 0.0687 0.9796 0.0798 -0.3344-0.0404 -0.7621 -0.2244 -0.4717 -0.3850 -0.1085 -0.0687 -0.9796 -0.0798]

**For 2004-2012**

**Constraint Equations**
$m_0$ +(23.7414)$m_1$-(0.5)$c_0$-(11.8707)$c_1$ ≤0.5120
$m_0$ +(23.5711)$m_1$-(0.5)$c_0$-(11.7856)$c_1$ ≤0.2177

 ISSN: 2548-7583

$m_0$ +(24.0467)$m_1$-(0.5)$c_0$-(12.0233)$c_1$ ≤ 0.6828
$m_0$ +(24.3176)$m_1$-(0.5)$c_0$-(12.1588)$c_1$ ≤0.3489
$m_0$ +(24.6352)$m_1$-(0.5)$c_0$-(12.3176)$c_1$ ≤ 0.2343
$m_0$ +(24.6766)$m_1$-(0.5)$c_0$-(12.3383)$c_1$ ≤0.1982
$m_0$ +(24.3387)$m_1$-(0.5)$c_0$-(12.1693)$c_1$ ≤ 0.2125
$m_0$ +(24.3574)$m_1$-(0.5)$c_0$-(12.1787)$c_1$ ≤ 0.1279
$m_0$ +(23.4888)$m_1$-(0.5)$c_0$-(11.7444)$c_1$ ≤0.7079
$m_0$ +(25.4742)$m_1$-(0.5)$c_0$-(12.7371)$c_1$ ≤0.5479
- $m_0$ -(23.7414)$m_1$-(0.5)$c_0$-(11.8707)$c_1$ ≤-0.5120
- $m_0$ -(23.5711)$m_1$-(0.5)$c_0$-(11.7856)$c_1$ ≤-0.2177
-$m_0$ -(24.0467)$m_1$-(0.5)$c_0$-(12.0233)$c_1$ ≤-0.6828
- $m_0$ -(24.3176)$m_1$-(0.5)$c_0$-(12.1588)$c_1$ ≤-0.3489
-$m_0$ -(24.6352)$m_1$-(0.5)$c_0$-(12.3176)$c_1$ ≤ -0.2343
- $m_0$ -(24.6766)$m_1$-(0.5)$c_0$-(12.3383)$c_1$ ≤-0.1982
-$m_0$ -(24.3387)$m_1$-(0.5)$c_0$-(12.1693)$c_1$ ≤-0.2125
-$m_0$ -(24.3574)$m_1$-(0.5)$c_0$-(12.1787)$c_1$ ≤ -0.1279
-$m_0$ -(23.4888)$m_1$-(0.5)$c_0$-(11.7444)$c_1$ ≤-0.7079
- $m_0$ -(25.4742)$m_1$-(0.5)$c_0$-(12.7371)$c_1$ ≤-0.5479

**Solution vector**

b = [0.512047192 0.217668035 0.682771070 0.348859376 0.234329653 0.198193747 0.212507628 0.127877733 0.707922928 0.547871705 -0.512047192 -0.217668035 -0.682771070 -0.348859376 -0.234329653 -0.198193747 -0.212507628 -0.127877733 -0.707922928 -0.547871705]

**The coefficient vector of objective function**

z =[0.1 24.2648 10 242.6477]

**Coefficient Matrix**

$$A = \begin{bmatrix} 1 & 23.7414 & -0.5 & -11.8707 \\ 1 & 23.57114 & -0.5 & -11.7856 \\ 1 & 24.04668 & -0.5 & -12.0233 \\ 1 & 24.31756 & -0.5 & -12.1588 \\ 1 & 24.63521 & -0.5 & -12.3176 \\ 1 & 24.67658 & -0.5 & -12.3383 \\ 1 & 24.33866 & -0.5 & -12.1693 \\ 1 & 24.35743 & -0.5 & -12.1787 \\ 1 & 23.48883 & -0.5 & -11.7444 \\ 1 & 25.47417 & -0.5 & -12.7371 \\ -1 & -23.7414 & -0.5 & -11.8707 \\ -1 & -23.5711 & -0.5 & -11.7856 \\ -1 & -24.0467 & -0.5 & -12.0233 \\ -1 & -24.3176 & -0.5 & -12.1588 \\ -1 & -24.6352 & -0.5 & -12.3176 \\ -1 & -24.6766 & -0.5 & -12.3383 \\ -1 & -24.3387 & -0.5 & -12.1693 \\ -1 & -24.3574 & -0.5 & -12.1787 \\ -1 & -23.4888 & -0.5 & -11.7444 \\ -1 & -25.4742 & -0.5 & -12.7371 \end{bmatrix}$$

 ISSN: 2548-7583