Measuring the efficiency of tourism sector in Sri Lanka: An extension of the method to stochastic frontier analysis

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***Abstract:** The research was conducted to examine the performance of Sri Lanka's tourism industry. Secondary data was obtained from the annual reports of the Sri Lanka Tourism Development Authority. The inefficiency in tourist arrival, total annual receipts and per day receipt from a tourist were estimated using Stochastic Frontier Analysis (SFA) between the periods from 1970 to 2019. And the factors influencing on the above tree inefficiencies were estimated combined with Cobb–Douglas frontier function under the assumption of half-normal distribution. The study found that the efficiencies were 86.2 %, 78.4 %, and 89.6 % respectively in tourist arrival, tourist receipts and per day receipts. The productivity of both the number of tourist arrivals and the overall reception of tourists was significantly (p<0.05) increased by the number of indirect jobs involved in tourism activities and the number of beds available for accommodation. Tourist arrival inefficiency could be substantially (p<0.05) improved by embarkation tax. Similarly, the number of international conferences held in BMICH significantly (p<0.05) had a negative impacted on the inefficiency of Sri Lanka's tourist arrival and tourism receipts. The present study revealed that growing investment in conference halls will create an opportunity to start more international conferences and symposiums to increase the efficiency of the tourism industry in Sri Lanka instead of investing more in rooms and direct recruitment to the tourism sector.*

***Keywords:** Performance, technical efficiency, tourism industry, SFA, Sri Lanka.*

1. INTRODUCTION

Tourism is one of the fastest-growing sectors in developing countries in the world. The tourism industry could be a cluster of goods and services that includes numerous interrelated industries like infrastructure, transportation, hotels, food and beverages sector etc. which may create a spillover effect across all the sectors. Because of several reasons like shortage of capacity, poor efficiency of the economy and general unreliability of service delivery, the tourism-related organizations provide it services by via capital investment and skilled labour that alleviate the industry's efficiency on the local economy (Somano, 2008). Sri Lankan economic   development   is

mainly run by tourism, tea and textile exports (Ajith and Lelwala, 2020). The contribution of the tourism sector to Sri Lankan economy is remarkable as its input for GDP was 4.3 per cent and the industry provided 173,592 direct and 229,015 indirect job opportunity to the labour force in 2019 (Sri Lanka Tourism Development Authority, 2019).

In recent years, the estimation of efficiency in the tourism industry has been the subject of a substantial amount of study, reflecting both the growing economic importance of the tourism industry as a source of foreign currency earning, source of job opportunity and growing competition in global tourism markets around the globe (Somano, 2008). Therefore, it is quite relevant to study the performance of the tourism industry in developing countries.

Two main approaches have been found in the literature to evaluating the efficacy of entities, such as; the parametric approach, and the non - parametric approach (Ajith and Lelwala, 2020). The non-parametric approach or mathematical programming method developed by Charnes, Cooper, and Rhodes. The emphasis is mainly on the development of a linear piece-wise method using Data Envelopment Analysis (DEA). The key advantage of the DEA method is that the data is not presented in an explicit functional form and multiple outputs can be utilized in this approach. The Stochastic Frontier Analysis (SFA), which was initially proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van Den Broeck (1977), recognized random noise around the estimated frontier of output in the manufacturing environment. The major strength of the SFA is, its capacity to manage stochastic noises in the production system. This paper uses the parametric approach, known as SFA to estimate the technical efficiency of the tourism industry in Sri Lanka.

2. LITERATURE REVIEW

Quantity of studies conducted for tourism potential in terms of productivity and efficiency appears to be quite limited. Many of them were also targeting effectiveness of hotels and tourism companies (Akin Aksu and Deniz Köksal, 2005; Somano, 2008; Babacan and Özcan, 2009; Uyar and Alış, 2014; Yakut, Harbalıoğlu and Pekkan, 2015). Therefore, it's possible to precise that our study is an original one in the area of tourism efficiency.

Studies have been carried out using DEA approach to measure the efficiency of the tourism industry based on measuring the efficiency of micro-units such as resorts and restaurants, travel companies and websites for choosing a travel destination. Poldrugovac et al. (Poldrugovac, Tekavcic and Jankovic, 2016) and Sigala (Sigala, 2004) applied DEA for hotel productivity measurement and benchmarking. They obtained results present a high average efficiency, but not all hotels performed at their maximum efficiency. The efficiency of websites for tourism destinations was obtained by Alzua-Sorzabala et al. (Alzua-Sorzabal *et al.*, 2015) using DEA. Besides, a significant relationship was found between the dimensions of the hotels and their efficiency for instance; the performance of Portuguese-owned hotels was estimated by Barros (Barros, 2005) and Barros and Mascarenhas (Barros and José Mascarenhas, 2005). Further, Oliveira et al. (Oliveira, Pedro and Marques, 2013) evaluated the efficiency and its determinants in Portuguese hotels, the results showed that the number of hotel stars is a crucial factor for performance. There are other estimations methods can be extensively utilized for investigating the efficiency in the tourism industry. One such rarely used method is that SFA estimation method. The one-way SFA estimation approach was used by Wang et al. (Wang, Lee and Wong, 2007) to measure the comparative efficiency of 66 international hotels in Taiwan during 1992–2002. Similarly, the performance of key hotels and tour guiding organization were evaluated in the Asia Pacific region (George Assaf, 2012). The study implemented an innovative methodology such that, mixing DEA and SFA during a

Bayes system, the study found that compared to local hotels, international hotels have much higher efficiency. Further, the study found that compared to local hotels, international hotels have a much higher efficiency.

Empirical research is extensively available to evaluate the efficacy of the tourism industry using DEA or other parametric methods. Hadad et al. (Hadad *et al.*, 2012) tried to rank more than 100 countries based on their efficiency and productivity in the tourism industry. Similarly, Meng Chun et al. (Meng Chun *et al.*, 2011) investigated the tourism industry efficiency in 31 regions of China. Furthermore, using bootstrap-DEA, the efficiency in the Chinese tourism industry was calculated to be slightly advanced. (Song and Li, 2019). An investigation was carried out in China to estimate the eco-efficiency in the tourism industry by measuring CO_2 emission rate (Gössling *et al.*, 2005). In complement to that a worked on evaluating the tourism eco-efficiency in Chinese coastal cities was conducted using DEA-Tobit model (Liu, Zhang and Fu, 2017). The research was carried out to determine the efficiency of the international tourism industry in Sri Lanka by means of various DEA measurements pertaining to various combinations of tourism sector outcomes such as tree outputs (tourism receipts, tourism nights and direct employment) and three common inputs (tourist price index for all products, number of hotel rooms and number of beds) (Ajith and Lelwala, 2020). Similarly, the four inputs were used by Wang et al. (Wang, Lee and Wong, 2007); wages, the value of food and beverage, the number of rooms and other operating expenses, and also the three outputs, namely the number of rooms occupied, income from food and beverage, and other total revenues. The studies mentioned prominently used DEA for estimating tourism industry efficiency and a shortage can be observed in the application of SFA for estimating efficiency and studying the performance of the tourism industry. While SFA offers a richer specification, other formal statistical hypothesis testing and building confidence intervals (Hjalmarsson, Kumbhakar and Heshmati, 1996). Therefore, present study used SFA to estimate the efficiency of tourism industry from 1970 to 2019.

3. METHODOLOGY

The study was conducted to estimate the tourism sector efficiency in Sri Lanka using Stochastic Frontier Analysis (SFA) from a set of data entirely collected from Sri Lanka Tourism Development Authority reports. The analysis used labour and capital as input and used three outputs mentioned in Table 1. Stochastic frontier analysis (SFA) model was suggested by Aigner et al. (Aigner, Lovell and Schmidt, 1977) and Meeusen and Broeck (Meeusen and van Den Broeck, 1977) is given by;

$$Y_t = f(x_t, \beta)\exp(V_t - U_t) \qquad (1)$$

Where Y_t refers to the output obtained by the tourism sector at the time t, x_t is the vector of different inputs used and β is a coefficient of the variable to be estimated. The error components V_t captured the random error assumed to be distributed independently and identically as N $(0, \sigma_v^2)$. U_t represents the technical inefficiency of the chosen output, it can be defined as follows;

$$U_t = \sigma' z_t + \varepsilon_t \qquad (2)$$

Technical efficiency (TE) of the tourism output for t[th] year can be represented as:

$$TE_t = \exp(U_t) = \exp(-\sigma' z_t - \varepsilon_t) = \exp\left[-E\left(\frac{U_t}{W_t}\right)\right] = 1 - E\left(\left(\frac{U_t}{W_t}\right)\right) \qquad (3)$$

The above equation shows that the technical efficiency of Sri Lanka's tourism sector is set at between 1 and 0. The efficiency of each production calculated in each year by the Sri Lankan tourism industry using the estimation method based on the conditional expectation of U_i from composed error $W_t = V_t - U_t$. Whereby Inefficiency term can be determined by the conditional estimate on the total composed error term. The technical efficiency can be predicted either the expected value or following conditional distribution estimate of U:

$$E\left[\frac{U}{W}\right] = \sigma_*^2 \left[\left(\frac{f\left(\frac{w\rho}{\sigma}\right)}{1-F\left(\frac{w\rho}{\sigma}\right)}\right) - \left(\frac{w\rho}{\sigma}\right)\right] \qquad (4)$$

Where,
- f = standard normal density
- F = distribution function

Which were assessed at $\frac{w\rho}{\sigma}$, $\sigma_*^2 = \frac{\sigma_V^2 \sigma_U^2}{\sigma^2}$, $\rho = \frac{\sigma_U}{\sigma_V}$ and $\sigma^2 = \sigma_U^2 + \sigma_V^2$.

The mean TE was calculated based on the following equation 5.

$$Mean\,TE = E\left[exp\left\{-E\left(\frac{U_t}{W_t}\right)\right\}\right] = E\left[1 - E\left(\frac{U_t}{W_t}\right)\right] \qquad (5)$$

The input vector coefficients and factors influencing the technical inefficiency were estimated, along with the variance parameters expressed in the following equations. The value of γ is bounded between one and zero.

$$\sigma_*^2 = \frac{\sigma_V^2 \sigma_U^2}{\sigma_V^2 + \sigma_U^2} \qquad (6)$$

$$\gamma = \frac{\sigma_U^2}{\sigma_V^2 + \sigma_U^2} \qquad (7)$$

The present study used Cobb–Douglas (C-D) frontier function as it is the most common and simple model for the empirical estimation in estimating technical inefficiency or efficiency. Where Translog function was not chosen due to the multicollinearity and degrees of freedom issues (Coelli, 1995). The specified model is defined as follows;

$$lnY_{it} = \beta_0 + \beta_i lnX_{it} + \theta_0 t + V_i - U_i \qquad (8)$$

The present study selected three outputs (Y_{it}) and four inputs (X_{it}) to estimate the above used Cob-Doulas frontier function. The term t was included which are account for the technological improvements throughout the time (Sheng *et al.*, 2015). The inputs and outputs used to define the production frontier are indicated in Table 1.

Table 1: Inputs and outputs used in Cob-Douglas frontier estimation

Outputs (Y_{it})	Inputs (X_{it})
Total tourist arrival per year (TA_t)	Number of direct labours (LD_t)
Total tourist receipt per year ($TRec_t$)	Number of indirect labours (LID_t)
Per day receipt per tourist ($TRPDPT_t$)	Number of rooms ($Room_t$)
	Number of beds (Bed_t)
Note: Three C-D models were run each output, all three models used four inputs	

A linear inefficiency model was estimated combined with C-D frontier functional model under the half-normal distribution assumption. The parameters (δ_i) was estimated in maximum likelihood estimation technique. The model is specified as follows;

$$TE(U_t) = \delta_0 + \delta_1 \text{EMBTAX}_t + \delta_2 \text{NTVMUS}_t + \delta_3 \text{NTVCLTR}_t + \delta_4 \text{NTVZGN}_t + \delta_5 \text{NLCBMICH}_t + \delta_6 \text{NICBMICH}_t + \delta_7 \text{ADN}_t + \delta_8 \text{AROR}_t + \varepsilon_t \qquad (9)$$

Where,
$TE(U_t)$ = Technical inefficiency of tourism output in year t
EMBTAX_t = Embark tax per tourist in year t
NTVMUS_t = Number of tourist visited to museum in year t
NTVCLTR_t = Number of tourist visited to cultural triangle in year t
NTVZGN_t = Number of tourist visited to zoological garden in year t
NLCBMICH = Number of local conferences held in BMICH in year t
NICBMICH = Number of international conferences held in BMICH in year t
ADN_t = Average duration of night spent by tourist in year t
AROR_t = Average room occupancy rate in year t
ε_t = Random error

The above estimations and post estimations such as Kernel density estimation, Link test and Likelihood ratio test was carried out using STATA 15.

4. RESULTS AND DISCUSSION

Table 2 indicates the estimated efficiency of each selected outputs to measure the Sri Lankan tourist sector efficiency from SFA. The stochastic frontier estimate indicated that the efficiency in tourist arrival, tourist receipts and per day receipts per tourist from 1970 to 2019 were 86.2%, 78.4% and 89.6% respectively. Similar results were found by Ajith and Lelwala (2020) using a non-parametric approach (DEA). The results reveal that the tourism sector did not gain maximum out of selected inputs such as number of labour and capital. Therefore, the Sri Lankan tourism industry still need to use the labour and capital even more effectively to achieve desired selected outputs.

This research analyzed the tourism sector efficiency in Sri Lanka by investigating the efficiency of total tourist arrival, official tourist receipts and per day tourist receipts. Table 3 presents the findings and the coefficient values of selected output and input models from the SFA model. It shows two efficiency models out of three supported to accept the alternative hypothesis thus, there was inefficiency in SFA – 01 and SFA – 02.

Table 2: Estimation of technical efficiency in tourism industry

Efficiency Variable	Mean	Standard Deviation	Minimum Efficiency	Maximum Efficiency
Total Tourist Arrival Efficiency	0.862	0.081	0.650	0.971
Total Tourist Receipts Efficiency	0.784	0.172	0.394	0.999
Per day receipts per	0.896	0.072	0.629	0.981

tourist efficiency				

Further, the value of lambda (λ) was greater than 1 in those two efficiency models, it reveals that there was a significant inefficiency in tourist arrival to Sri Lanka and per day income generated from a tourist. Furthermore, the value of gamma (γ) shows that 86.2% of the variation in the total arrival of tourist to the country was impacted by the inefficiency in the system. Similarly, inefficiency caused 92.4% in the per day receipt from a tourist. This test reveals that output selected for the models had a significant impact by the inefficiency in the tourism sector in Sri Lanka during 1970 to 2019.

The generalized probability ratio test suggested that in all three models outlined in Table 3, variables comprised in production function were all highly significant together. It says the null hypothesis for the response variables that the coefficient estimates; $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ was rejected at 1% significant level. The individual z-value and the probability value of several individual tourism production factors were also highly significant in different efficiency models. The unexpected negative signs were observed in the number of direct labours ($lnLD_t$) and the number of rooms available in the country on a particular period ($lnRoom_t$). This could occur due to the seasonal impact on tourist arrival to the country (Perera, 2017).

Table 3: Maximum Likelihood estimates of the Cobb Douglas stochastic production frontier function with half normal distribution of inefficiency term

Variables		Tourist arrival efficiency SFA-01		Tourist receipts efficiency SFA – 02		Per day tourist receipts efficiency SFA - 03	
		Cof	SE	Cof	SE	Cof	SE
$lnLD_t$		-1.92	1.46	-2.07	0.03***	0.37	0.51
$lnLID_t$		3.35	1.45**	3.92	0.03***	0.27	0.52
$lnRoom_t$		2.32	1.20*	2.28	0.01***	0.59	0.65
$lnBed_t$		2.33	1.23*	2.73	0.00***	-0.52	0.67
$Year$		0.021	0.01***	0.02	0.00***	0.01	0.01**
$\_cons$		38.62	11.96***	22.07	0.25***	-21.13	6.87**
$/lnsig2v$		-4.98	0.89***	-37.82	12.72	-6.41	1.32***
$/lnsig2u$		-3.26	0.60***	-2.95	0.20	-3.81	0.49***
$sigma\_v$		0.08	0.04	0.00	0.00	0.04	0.03
$sigma\_u$		0.20	0.06	0.22	0.04	0.14	0.04
$sigma2$		0.04	0.02	0.05	0.03	0.02	0.01
$Lambda\ (\lambda0$		2.35	0.09	0.00	0.04	3.68	0.06
		Number of Obs = 50 Wald chi2 (5) = 2217 Prob > chi2 = 0.00 Likelihood Ratio test of sigma_u = 0 Log likelihood = 130.46895 chibar2(01) = 0.85		Number of Obs = 50 Wald chi2 (5) = 0.00 Prob > chi2 = 0.00 Likelihood Ratio test of sigma_u = 0 chibar2(01) = 24.45 Prob >= chibar2 =		Number of Obs = 50 Wald chi2 (5) = 4.48e+08 Prob > chi2 = 0.00 Likelihood Ratio test of sigma_u = 0 chibar2(01) = 30.66 Prob >= chibar2 = 0.00	

		Prob >= chibar2 = 0.18		0.00		

Cof: Coefficient; SE: Standard Error; *,** and *** = Significant at 10%, 5% and 1% level of significance respectively

Table 4 elaborates the results of the combined estimation of SFA function and technical inefficiency effects in all three efficiency models. Based on the generalized likelihood test, all the variables used in the models were jointly significant. In brief, the null hypothesis ($\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$, with respect to the case of stochastic production frontier and $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$ in the case of inefficiency function) was rejected at 1% significant level.

The combination estimation results show that direct labour ($lnLD_t$) involved in the tourism sector had no significant impact on the three terms of efficiency selected to the present study. Apart from that, the other inputs selected for the total tourist arrival efficiency model were significantly impacted. The technological improvement was the only factor which significantly (p<0.01) impacted the tourism receipt of the country. Similarly, one per cent in the number of rooms for accommodating tourist impacted the per day tourist receipt by 0.83 at 5% significant level.

From the explanatory variables designed into the inefficiency model, the embark tax ($EMBTAX_t$) had a positive impact on inefficiency in total tourist arrival to the country at 5% significant level. In another word, 1% increment in embark tax on tourist caused the 0.02% reduction in total tourist arrival efficiency. Embark tax is an act that is being controlled by the Sri Lankan government charge a payment who leave from the country by ship or aircraft. Government need to be vigilant while setting the value of embarking tax since it influences the tourist arrival efficiency of the country. The number of international conferences had a significant impact on all three selected tourism efficiency measures. One per cent increase in the number of the international conference at BMICH had reduced the inefficiency in the arrival of tourist to the country, total tourist receipts and per day tourist receipt by 0.02%, 0.01% and 0.001% respectively and the impact was significant at less than 5% significant level. This disclosed that Sri Lanka could increase the efficiency in tourist arrival and income earn from tourism sector can be raised through the implementation of more international conferences and symposium which are demanded in the present world situation. Simply saying that the Sri Lankan museum contributed more in increasing the efficiency of per day income generated from a tourist at 5% significant level.

5. CONCLUSION

Define The present study was carried out to evaluate the efficiency of the tourism sector for the period from 1970 to 2019. While the tourism sector contributes to earning foreign currency for Sri Lankan economic development prominently. Tourism industry did not reach its maximum potential outputs from selected input. After the existence of inefficiency was confirmed, the combined estimation of SFA function and technical efficiency function revealed that mean efficiency in tourism arrival, total tourist receipt and per day tourist per tourist was 86.2%, 78.4% and 89.6% respectively. The number of tourist arrival to Sri Lanka and the total tourist receipt were significantly and positively impacted by the number of indirect labours involved in tourism sector and number of beds available in Sri Lanka for accommodation. However, unexpected negative impacts were observed via the number of

direct labour employed in the tourism sector and the rooms available to accommodate tourists. Only the technological progress was significantly impacted the per day income from a tourist visited Sri Lanka. Therefore, further recruitments of direct workers and investment on construction work in the tourism sector are wastage of resources as far as the selected outputs for this study is a concern.

Inefficiency in tourist arrival to the country was positively affected significantly by embarking tax implemented by the Sri Lankan government. Further, the number of international conferences held in BMICH had a significant negative impact on inefficiency in tourist arrival and tourism receipts to Sri Lanka. The number of tourists visited the museum reduced the inefficiency in per day receipt generated from a tourist. Investment on public conference halls with the capacity of arranging the international conference would increase the tourism sector performance by enhancing the efficiency of tourist arrival and income-generating from a tourist is the main recommendation derived from the findings of the study. Further, the conference arranging bodies such as state universities, government organizations and private campus should be motivated to arrange more conferences and symposium. The direct investment and recruitment control should be implemented in the tourism sector where resources were wasted without getting optimum outputs. Meanwhile, the investment which is indirectly related to tourism activities should be improved and increase its labour force for enhancing the performance of the tourist industry in Sri Lanka.

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APPENDIX

The following section describes frontier post estimation test to confirm the distribution and significance of model specification

A. *Likelihood ratio test*

The tourist arrival efficiency model was significance at less than 1% significant level. Thus, the restricted and the structural model were not significantly different. However, the other two efficiency models showed no differences in its restricted and structural models (Table II).

Table I: Results of likelihood ratio test

Likelihood test	Tourist arrival efficiency	Total tourist receipts efficiency	Per day tourist receipts per tourist efficiency
LR chi2(4)	18.70	-0.37	6.45
Prob > chi2	0.0009	1.000	0.17

B. Kernel density estimation for the half normal distributional assumption

A kernel density functions were plotted against the technical inefficacy terms of each models (Fig 01). The estimated density diagram proves that inefficiency error term (U_i) was non-negatively distributed with half-normal distribution.
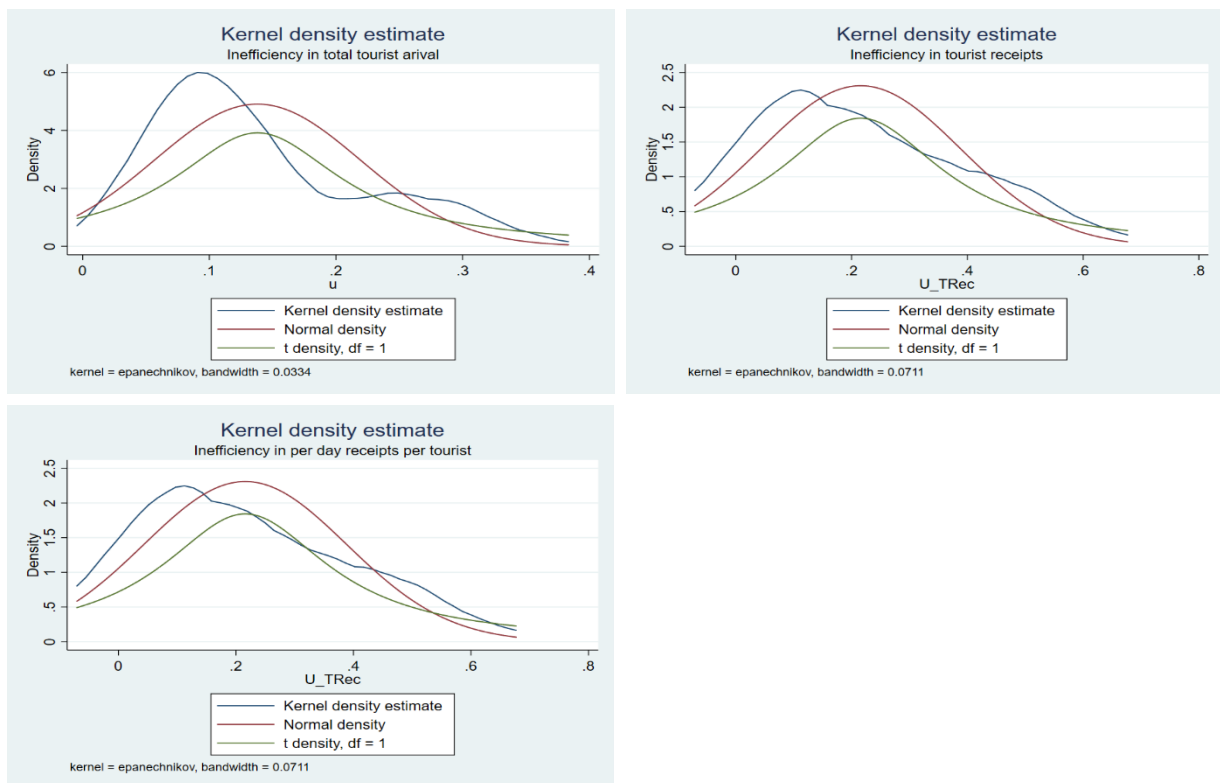

Fig 01: Kernel density estimation of error term, U_i under half normal distribution for three models

C. Link test

The results of link test for three models are summarized in Table II. This suggests that the models did not have misspecification problem where values of _hat were significant at 1% significant level and _hatsq were insignificant for all three models.

Table II: Results of link test

Variables		Tourist arrival efficiency SFA-01			Tourist receipts efficiency SFA - 02			Per day tourist receipts efficiency SFA - 03	
		Cof	SE		Cof	SE		Cof	SE
_hat		1.52	0.41***		1.03	0.08***		1.14	0.16***
_hatsq		-0.02	0.02		-0.003	0.008		-0.012	0.020
_cons		-3.59	2.60		-0.03	0.21		-0.41	0.34
lnsig2v		-5.11	0.50***		-5.17	0.87***		-4.74	0.21***
lnsig2u		-3.14	0.34***		-2.03	0.30***		-11.26	99.19
sigma_v		0.07	0.02		0.08	0.03		0.09	0.01
sigma_u		0.21	0.04		-0.36	0.05		0.004	0.17
sigma2		0.05	0.01		0.14	0.04		0.009	0.002
lambda		2.68	0.05		4.80	0.08		0.04	0.18
		Number of Obs = 50 Wald chi2 (5) = 2625.78 Prob > chi2 = 0.00 Likelihood Ratio test of sigma_u = 0 Log likelihood = 26.39 chibar2(01) = 4.30 Prob >= chibar2 = 0.02			Number of Obs = 50 Wald chi2 (5) = 4058.27 Prob > chi2 = 0.00 Likelihood Ratio test of sigma_u = 0 Log likelihood = 6.18 chibar2(01) = 8.25 Prob >= chibar2 = 0.002			Number of Obs = 50 Wald chi2 (5) = 3158.34 Prob > chi2 = 0.00 Likelihood Ratio test of sigma_u = 0 Log likelihood = 47.54 chibar2(01) = 0.00 Prob >= chibar2 = 0.00	
Cof: Coefficient; SE: Standard Error; *,** and *** = Significant at 10%, 5% and 1% level of significance respectively									