Spatial tourism supply: the case of ASEAN-5 countries

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Abstract. This article is the applied econometric analyses in estimating the spatial stochastic frontier (SSF) model. The heart of the modelling inference is Bayesian statistics with Gibbs sampling, which can provide flexible parametric distributions for capturing abnormal distributional observations. Yearly panel data between 2008 and 2018 regarding tourism supplies such as numbers of hotels, service rooms, and labour forces in ASEAN-5 countries (Vietnam, Indonesia, Malaysian, Singapore, and Thailand) is observed. The empirical results are divided into two major parts. The first section is the understanding of spatial effects which causally relate to the way for expanding tourism supplies is explained by the model validation using deviance information criterion (DIC). The panel spatial-error stochastic frontier (random-effect model) contains the minimum DIC which implies the parameters of locational effects is the minor, but it should be still considered for stimulating tourism supply sides in these five countries. The second section is the estimation of random parameters are processed to monitor technical efficiencies. Spatial effects are a specific impact on the group of connected borderline countries. On the other hand, this impact is dependently reduced when a country contains a remote area condition. Ultimately, this paper is the alternative to better analyse supply-chain management in the tourism sector without the restrictions of P-value, asymptotic struggling, and multicollinear problems. For further researches, subjective statistics (Bayesian) is the main issue that applies for modern econometrics.

1. Introduction
Tourism viability is not only relied on demands which are easily stimulated by short-term promotions, for example, price reductions, rewards, even privileged visa validations. A supply side of tourism industries has been defined as “mega-projects” producing wastages rather than benefits. This implies the beginning of development of tourism systems usually comes after the shift of tourism demands rather than preparing structures before tourists arrive. However, this is not sustainable stated by [1]. Consequently, the study of the supply-side tourism can be an interesting point of view that covers a footing idea for policy recommendations.

For sustainability in tourism, it goes closely with competitiveness since tourism growth needs to balance economic development with social, cultural and environmental goals to ensure a long-term future for the sector [2]. The fact is there is an enormous number of tourists fluctuated along seasonal periods. Tourism industries in ASEAN countries are presented like those trends. This causes the prediction of tourism demands to be not simple to find a stable composition in a long-run equilibrium. The solution is the findings of the supply-side tourism investigation. It is sensible to state demand levels vary according to the quality and quantity of tourism capacities in each country.
The efficiency of tourism industries has been considerably studied for several years. Commonly, calculative estimations are provided by using the traditional way – the objective statistics known as “P-value”. In 2006, Cracolici et.al. [3] computationally used a measure of tourist site competitiveness in terms of its technical efficiency, which are stochastic frontier and data envelopment analyses. Dmitry Pavlyuk [4] explored the relative regional efficiency levels of tourists’ attraction and spatially discovered factors affecting the efficiency for regions within the Baltic States. In 2019, Wu et.al. [5] applied the composition between a multiple-criteria decision-making and the stochastic frontier analysis technique to determine combination weights for individual tourism forecast models. Currently, Dapeng et.al. [6] deployed stochastic frontier analysis (SFA) to evaluate the efficiency of the hotel industry on a provincial level in China. Consequently, this paper is conducted to monitor and display the efficiency of tourism supplies in five major tourism countries in South East Asia. Bayesian statistics is technically combined with the stochastic frontier model. Additionally, spatial panel information is employed to improve the expression of efficiency relationships.

2. The Scope of Research
The framework of the paper is based on panel time-series information observed between 2008 and 2018. Variables searched from five ASEAN countries (Vietnam, Thailand, Singapore, Malaysia, and Indonesia) which stand for components of the tourism supply side are the numbers of hotels, available rooms for services, labour forces in the tourism sector, electricity assessments, and drinking water provisions. These are supposed to be an effect relating to tourism revenues in each country. Moreover, the factor of a spatial weight matrix is generated relied on geographic connections.

3. Methodology
3.1 Panel spatial model specification
The panel spatial model is justified by the short-term relationship between tourism revenues and supply-side factors. The expectation is that unobserved spatial heterogeneity is existed as well as spatial interdependence demonstrates the spatial autocorrelation for many variables. The fundamental model is as follows [7]:

\[ y_{it} = \alpha + \tau_i + \eta_t + \sum_{k=1}^{K} \beta X_{k,ij,t} + \rho Wy_{i,t-1} + \mu_{it} + \mu_{it} = \gamma Wu_{it} + \epsilon_{it}. \]  

(1)

The panel spatial regression model explained by the formula (1) contains the spatial weights matrix \( W \), with \( \rho Wy_{i,t-1} \) being the “substantive spatial dependence” model which is the weights matrix affecting to lags of \( y_{i,t} \). \( \gamma Wu_{it} \) refers to as the panel spatial error regression, alternatively named “spatial random effect”. The error terms, \( \mu_{it} \), are weighted and they are parametrically correlated to \( y_{i,t} \). \( \beta X_{k,ij,t} \) is the term expressing the panel pooled regression. With this model, the spatial weights matrix is supposed to be ineffective on estimated parameters. \( \tau_i \) and \( \eta_t \) are specific effects in space (i) and time (t), and \( \epsilon_{it} \) is the random error.

3.2 Bayesian inference in the panel spatial stochastic frontier model with Gibbs sampling
With respect to multidimensional covariates and spatial weights, Bayesian inference with MCMC simulations is a computationally efficient manner [8]. In Bayesian econometrics, the theoretical framework for Bayes’ rule is relied on the conditional probability expressed in the formula as follows:

\[ p(A,B) = p(A|B)p(B) = p(B|A)p(A). \]  

(2)

For the linear relationship that holds for every individual effect, the demand function model is given by
\[ y_{it} = X_{it}\beta + \varepsilon_{it}, \quad i = 1,...,n. \] (3)

In this case, all elements of \( X_{it} \) are fixed or independent of \( \varepsilon_{it} \), which is assumed to be the multivariate normal distribution \((\sigma^2 = 1/h)\) with a probability function \( p(X_{it} | \lambda) \), where \( \beta, h \neq \lambda \). With suggesting a Normal-Gamma prior \( (\beta \sim N(\beta, h^{-1}V)) \) and \( h \sim G(s^{-2}, v) \) the formula (3) is processed to a likelihood function of the form as follows:

\[
p(y_{it} | \beta, h) = \prod_{i=1}^{N} \frac{h^2}{2\pi} \exp \left\{ -\frac{h}{2}(y_{it} - X_{it}\beta) (y_{it} - X_{it}\beta) \right\} \]
\[
= \frac{1}{2\pi^{T/2}} \left\{ h^{\frac{K}{2}} \exp \left[ -\frac{h}{2} (\beta - \hat{\beta})' X_{it}' X_{it} (\beta - \hat{\beta}) \right] \right\} \left\{ \frac{h}{2s^{-2}} \right\} \] (4)

With the numerical analytics by the Markov Chain Monte Carlo (MCMC) which contains the Gibbs sampling process followed by [9], the estimated results in \( \beta, h | y \sim NG(\hat{\beta}, \hat{\psi}, \hat{s}^{-2}, \hat{\nu}) \) can be mathematically derived as follows:

\[
\hat{\psi} = (V^{-1} + X_{it}'X_{it})^{-1} \] (5)

\[
\hat{\beta} = \hat{\psi} (V^{-1} + X_{it}'X_{it}) \hat{\beta} \] (6)

\[
\hat{\nu} = \nu + NT. \] (7)

To apply to the production for the supply-side tourism, the model called stochastic production function displayed in Figure 1 is the graphical expression of the output bounded above by the stochastic random variable, which is the exponential function of \( Y_i' = \beta X_i + V_i \). The residual term, \( V_i \), can be both positive \((v_i)\) or negative \((-v_i)\) since it is assumed “two sided” [10]. Consequently, the stochastic output varies about the deterministic part of the frontier model, \( \exp(\beta X_i) \).

**Figure 1.** The conceptual framework of the stochastic frontier model following the basis of the contribution by Coelli et.al. 2005, p 244 [10].

For the measurement of efficiencies, the technical efficiency (TE) output is mathematically derived from the formula as follows:
4. Empirical Result

4.1 Descriptive information
In this section, Table 1 represents basic statistical results for tourism supply indicators. Each variable is transformed into the log-return formation for stationary. The Jarque-Bera test reports an interesting point that there is only the observation set of tourism revenues are the normal distribution. Others are calculated and shown the null hypothesis of normality is significantly rejected. The numbers of hotels, service rooms, and labor forces therefore contains various types of distributions. Figure 2 confirms the complexity of panel data. The best way to solve this problem is to apply a flexible statistical inference. Thus, the subjective “Bayesian” inference is used to empower the panel spatial stochastic frontier estimation.

\[ TE = \frac{Y_i}{Y_i^*} = \frac{f(X_i, \beta) \exp(v_i - u_i)}{f(X_i, \beta) \exp(v_i)} = \exp(U_i) \]  
\[ (8) \]

Figure 2. The panel observations of the indicators regarding the tourism supply sector. The yearly data is between 2008 and 2018 observed from Indonesia, Malaysia, Singapore, Thailand, and Vietnam.

| Table 1: General details and normality testing for observed variables |
|----------------------|----------------------|----------------------|----------------------|
|                      | LN_TOUR_IN           | LN_HOTEL             | LN_ROOM              |
| Mean                 | 23.43926             | 8.286827             | 12.06814             |
| Median               | 23.60969             | 9.196748             | 12.62200             |
| Maximum              | 24.90137             | 10.12327             | 13.48909             |
| Minimum              | 21.83841             | 4.682131             | 9.322597             |
| Jarque-Bera          | 0.185403             | 10.37923*            | 13.49288*            |
| Probability          | 0.911466             | 0.005574             | 0.001175             |
| Distribution         | Normal Distribution  | Non-normal Distribution | Non-normal Distribution |
| Panel unit root test | Levin, Lin & Chu     | -6.16881*            | 5.99845*             |
|                      |                      | -4.42966*            | -3.34462*            |

* / a significance level of 0.01, **/ a significance level of 0.05,
4.2 The parameters of Bayesian spatial stochastic frontier

With the complexity of spatial econometrics and random parameters estimated by Gibbs sampling simulations, the deviance information criterion (DIC) is introduced to fill a crucial gap in the practical Bayesian calculations and used to compare the goodness fit of a set of Bayesian hierarchical models [11]. Table 2 represents the modelling comparison between three types of panel stochastic frontier estimations. The empirical result indicates the panel spatial-error frontier model is the most accurate estimation. This spatial nuisance dependence implies the tourism supply-side adjustment in ASEAN-5 countries is probably caused by their neighbors because of the ASEAN integration, which fundamentally promotes human rights and social justice, not the economic association as similar as European nations [12].

Table 2. The model accuracy comparison by deviance information criterion

|                      | Panel non-spatial stochastic frontier | Panel spatial-lag stochastic frontier | Panel spatial-error stochastic frontier |
|----------------------|--------------------------------------|--------------------------------------|----------------------------------------|
| Log(ML)              | -78.3176                             | -82.1274                             | -77.5647                               |
| DIC                  | 133.8894                             | 137.7414                             | 131.3964**                             |

Note: ** stands for the most precise estimation. Source: authors

Table 3 demonstrates randomly estimated parameters. γ refers to as the spatial matrix weighted through error terms in the stochastic frontier regression model. With the advantage of Bayesian statistics and Gibbs sampling, the parameters in the 2.5% quantile interval stand for the case of inefficient supply-side management. Conversely, the 97.5% quantile interval’s parameters explain the situation that the tourism supply sectors in ASEAN-5 countries are nearly efficient. This interval is focused to be the baseline for analyzing technical efficiencies. Expressly, the numbers of hotels, available rooms, and tourism employment are positive for the increment of tourism revenues in each country. The spatial factor is also a positive effect on the change of revenues from tourism activities. This implies the effective development of supply sides shall be benefits for the countries spatially contain borderlines.

Table 3. The estimated parameters of Bayesian panel spatial-error stochastic frontier

|                      | Mean of estimated parameter | Standard deviation of estimated parameter | Parameter at 2.5% quantile interval | Parameter at 97.5% quantile interval |
|----------------------|-----------------------------|-------------------------------------------|-------------------------------------|-------------------------------------|
| Intercept            | 13.649                      | 3.398                                     | 4.549                               | 18.414                              |
| Hotels               | -0.042                      | 0.056                                     | -0.119                              | 0.099                               |
| Service rooms        | -0.048                      | 0.058                                     | -0.126                              | 0.093                               |
| Labour forces        | -0.038                      | 0.055                                     | -0.117                              | 0.102                               |
| γ                    | -0.025                      | 0.029                                     | -0.067                              | 0.046                               |
| Residuals            | 149.783                     | 296.432                                   | 50.390                              | 394.755                             |

Source: authors

4.3 The technical efficiency for tourism supplies in ASEAN

Based on the spatial nuisance dependence (panel random-effect estimations), tourism supply management in Malaysia and Singapore is the case that spatial effects may cause a technical efficiency in each country. Figure 2 displays the alike trend of the efficiency graphs. It is sensible that these two neighborhoods’ tourism supplies are spatially parallel. For Vietnam and Indonesia, these two countries are remoted, and borderlines are not connected. This comparison is the case that spatial effects still affect the efficiency trends of tourism supply developments. The detail is pictured in Figure 3.

According to the tourism supply side in Thailand, this case is the example of the non-spatial effect, even though the country contains the borderline areas connected with Malaysia and its location is positioned
on the map of Indochina. The country contains the most efficiency level of tourism supply productions. The efficiency graph shown in Figure 4 demonstrates the dissimilar trend compared with others.

Figure 3. The comparison of tourism supply efficiencies between Malaysia and Singapore

Figure 4. The comparison of tourism supply efficiencies between Vietnam and Indonesia

Figure 5. The case of technical efficiencies for the tourism supply side in Thailand, the country is located in the mainland Indochina with Vietnam, Malaysia, and Singapore.

5. Conclusion
With the usefulness of random parameters provided by Bayesian statistics, updated information by Gibbs simulations, the empowered observations by panel analyzing, and spatial econometrics for reality, this paper represents the empirical result to clarify that tourism policies to develop supply sides in Thailand, Vietnam, Indonesia, Malaysia, and Singapore should be separately mentioned. In other words, rapid expansions of hotel quantities and employments in Malaysia probably impact on borderline tourism activities in Thailand and then possibly stimulate its internal tourism supplies positively or
negatively. However, the positive spatial effect should be strongly linked with the whole continent. For example, Thailand is located at the center of the Indochina map and indicated to have the best efficiency rates of tourism supply management. This seems to be well organized if tourism supplies can gain profits from border lines connections between Malaysia and Thailand, although the comparison of DIC obviously points that the spatial effect randomly influences tourism supplies through shocks of residuals in productivities. In conclusion, the parametric interval of Bayesian statistics is also the key for clearly distinguishing the efficient and inefficient zones of the stochastic regression model. The frontier parameters are efficiently updated by Gibbs sampling. This paper is the alternative to better monitor technical efficiencies in supply-management researches without the restrictions of P-value, asymptotic struggling, and multicollinear problems.

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