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Modelling Productivity Shocks and Economic Growth Using the Bayesian Dynamic Stochastic General Equilibrium Approach

1. Introduction

Productivity has been one of the most important issues in macroeconomics since Douglas and Cobb first identified it in 1928 (Berndt and Triplett, 2008). According to neoclassical economics, economic growth can only be achieved by improving physical and human capital productivity and total factor productivity (Lucas, 1988). The benefit of increased productivity is that output grows without any extra input to the production process. From a national perspective, productivity growth can raise living standards and reduce poverty (Bechler, 1984).

Although numerous studies have focused on the impact of sector productivity on economic growth, such as Matsuyama's (1992) study of agriculture and Colecchia and Schreyer's (2002) study of information and communications technology, few have examined the relationship between productivity in tourism and national economic growth. An increasing number of tourism scholars are examining the influence of tourism development on economic growth (Song *et al*., 2012; Pablo-Romero and Molina, 2013), but most have adopted the demand perspective (Schubert *et al*., 2011; Pratt, 2015b) rather than considering supply issues such as the effect of productivity. Blake *et al*. (2006b) were among the few scholars to investigate the effect of tourism productivity on economic development. However, they compared the contribution of various types of productivity in different sectors of the tourism industry, rather than considering the mechanism that converts improvements in tourism productivity into economic growth.

To fill this research gap, this study uses a dynamic stochastic general equilibrium (DSGE) model estimated using the Bayesian method to explore the relationship between tourism development, which is driven by tourism productivity growth, and economic growth. A DSGE model, which Kydland and Prescott (1982) argued is suitable for exploring the impact of a productivity shock on economic fluctuations, is constructed based on the microeconomic assumption that households and firms maximise utility and profit, respectively. The model is composed of a series of dynamic equations with stochastic shocks to capture the behaviour of different representative agents in the economy, and is solved under the general equilibrium framework. Smets and Wouters (2003) developed a model for the European Central Bank in their pioneering application of the Bayesian method to a DSGE model. Subsequently, DSGE models have usually been estimated using the Bayesian method, which assumes that the parameters in a model are conditional probabilistic statements based on the dataset. This study examines whether tourism can lead to economic growth, and details a variable transmission mechanism that could help to achieve policy objectives in countries that treat tourism as a pillar industry of their economies.

The remainder of this paper is organised as follows. After briefly reviewing the studies examining the relationship between tourism and economic growth in Section 2, a two-sector DSGE model for an open economy is developed in Section 3, followed by the introduction of the selected tourism destination. The results of the Bayesian estimation and discussion of the simulation results are presented in Sections 5 and 6, respectively. Section 7 concludes the study by presenting its main findings and implications.

2. Literature Review

Scholars have been investigating the relationship between tourism and economic growth since the 1990s. Early studies examined the impact of tourism development on economic growth and national welfare using the international trade theory (e.g., Copeland, 1991; Hazari and Sgro, 1995; Nowak *et al*., 2003). Since Adams and Parmenter (1995) introduced the computable general equilibrium (CGE) model to the tourism field, more analyses have been conducted using the CGE model framework. Further, since Balaguer and Cantavella-Jordá (2002) advocated the econometric method, it has become a popular approach to examining the tourism-led economic growth (TLEG) hypothesis. The following subsections critically evaluate the published studies on TLEG from different perspectives.

2.1. International Trade Perspective

Taking tourism as a trade sector, Copeland (1991) constructed a static general equilibrium model and concluded that tourism development could stimulate economic growth. However, he noted that if foreign-owned input into the tourism industry was considered, tourism development could cause de-industrialisation. Thus, tourism expansion could have a negative effect on other industries or even the economy as a whole. Hazari and Sgro (1995) further developed a dynamic model and found that tourism expansion definitely stimulated economic growth in a small country or region; however, if the destination was a large country or region, the net effect of tourism on economic growth needed to be examined on a case by case basis. Nowak *et al*. (2003) used an international trade model with three industries – agriculture, manufacturing and tourism

– to study the effect of tourism. Consistent with Copeland (1991) and Hazari and Sgro (1995), they found that a tourism boom could have a negative effect on a destination's economies.

2.2. Computable General Equilibrium Modelling Perspective

As studies based on international trade theory have used conceptual models, their stylised frameworks cannot be empirically examined. Although the transmission mechanism between tourism development and economic growth is important for both academia and industry, a reliable simulation of economic growth boosted by tourism expansion is more meaningful for destinations' tourism industries and governments.

A CGE model is composed of a series of equations that capture the behaviour of different representative agents in various sectors and markets from both the demand and supply sides. The agents' behaviour is based on the optimisation principles of neoclassical microeconomics, and the effect of tourism on economic growth is analysed from a general equilibrium perspective based on the input-output table of the economy.

Adams and Parmenter (1995) built a CGE model based on the ORANI-F database that included 117 sectors of the Australian tourism industry, such as hotels, restaurants and air transport. They simulated a 10% expansion of inbound tourism and found that whereas the overall effect of tourism on the economy of Queensland, the Australian state most focused on tourism, was negative, a positive overall effect was observed in Victoria, which was less dependent on exports than Queensland but more reliant on air transport. These results supported Copeland's (1991) argument that tourism expansion could lead to the contraction of other industries and even have a negative effect on economic growth.

Zhou *et al*. (1997) used Hawaiian data to compare the results of the input-output (IO) multiplier and CGE model and found that the IO multiplier could overestimate the economic contribution of tourism by 20-30% due to its lack of consideration of interaction with other industries. Blake (2000) found that a 10% increase in tourism led to a 0.05% growth of gross domestic product (GDP) in Spain, and that appropriately raising the tax on foreign tourism could stimulate economic growth by improving the welfare of local residents. Sugiyarto *et al*. (2003) investigated the relationships between tariffs, tourism and economic growth in Indonesia using a CGE model with 18 sectors, including hotels and restaurants. Their simulation results showed that if tourism demand increased by 10%, even if both tariffs and indirect tax on domestic goods decreased by 20%, Indonesia's GDP would grow by 0.7%. Recent applications of CGE models have included Pratt's assessments of tourism's impact on 30 provinces of China (2015a) and small island economies (2015b). The latest development in CGE modelling techniques for tourism is Blake's (2009) attempt to expand the static CGE model into a dynamic version, and Pratt *et al*.'s (2013) introduction of uncertainty into the model. Both of these improvements have brought the model closer to reality and made simulations of tourism's effects on economic growth more accurate. More specific examples of the application of CGE models to tourism can be found in the studies by Dwyer *et al*. (2004) and Blake *et al*. (2006a).

2.3. Cointegration and Granger Causality Studies

Tourism scholars have also used the econometric method to examine the relationship between tourism and economic growth. Balaguer and Cantavella-Jordá (2002) tested the TLEG hypothesis using Spanish data. They investigated the long-term relationship between tourism expansion and economic growth using cointegration and Granger causality tests. As a prevailing method, the Granger causality approach is more convenient to implement than other methods such as regression discontinuity design. Subsequently, numerous studies have tested the TLEG hypothesis using data from various destinations and a variety of methods; some recent studies include Bilen *et al*. (2017) and Salifou and Haq (2017)'s use of panel data model, Chiu and Yeh (2017)'s study of cross-sectional data, Shahzad *et al*. (2017)'s application of quantile analysis and Zuo and Huang (2018)'s attempt with non-linear model. However, as argued by Song *et al*. (2012) and Pablo-Romero and Molina (2013) that cointegration and Granger causality tests were the most popular methods adopted in TLEG studies using time series or panel data. Despite inconclusive empirical findings, Song *et al*. (2012) further concluded that the relationship between tourism and economic growth identified by Granger causality tests only indicates a secessionist's view of causality, rather than a real cause-effect relationship. Thus, it is still necessary to explore the transmission mechanism from tourism development to economic growth.

2.4. Dynamic Stochastic General Equilibrium Modelling Perspective

The DSGE model also works under the general equilibrium framework and shares some behaviour equations with the CGE model. The main difference between them is that there are many more sectors in the CGE model than in the DSGE model. Thus, the CGE model can analyse interactions between sectors, whereas the DSGE model focuses more on the transmission mechanism of an economy.

DSGE models can be divided into two categories: real business cycle (RBC) and New Keynesian models. Kydland and Prescott (1982) advocated RBC theory in their investigation of productivity's impact on economic fluctuations based on neoclassical economic theory with flexible price. Rotemberg and Woodforld (1997) developed the New Keynesian School by introducing sticky price and other frictions into the model to shed light on the short-run effect. Smets and Wouters (2003) introduced the Bayesian method to estimate the parameters of the model they developed for the European Central Bank. Compared with the calibration method used by Kydland and Prescott (1982), the Bayesian estimated parameters should be more accurate because the calibration parameters can be used as the means for prior distribution, and the new information included in the data can be used to refine the parameters. There are usually tens of parameters and variables in a DSGE model, some of which are not observable. Another advantage of Bayesian estimation is that compared with the traditional econometric method, only a small number of variables are needed to estimate the whole model, making data collection more feasible.

DSGE models have become popular for explaining economic growth and fluctuation and simulating the effects of policies. However, the application of DSGE models in the tourism field is still underdeveloped. Using the DSGE model, Chao *et al*. (2006) calibrated the effect of tourism in a small, open economy with unemployment for Germany. They found that a tourism boom could increase employment but also decrease capital accumulation and lead to de-industrialisation. Álvarez-Albelo and Hernández-Martín (2007) used data from the Organization for Economic Co-operation and Development (OECD) and small tourism countries to represent capital and tourism export countries, respectively. They found that tourism could help small countries to achieve sustained economic growth. In addition, if tourism was considered a luxury good, economic growth would be much faster.

Studies using DSGE models in tourism economics are still rare, and all simulations are based on calibration results. Although the objective of calibration is to capture the characteristics of an economy in equilibrium, the selection of parameters is subjective. To address these problems, this study applies Bayesian estimation to correct the calibrated parameters and bring the model closer to reality. The Bayesian method assumes that parameters are randomly distributed. The parameters of a particular model are the conditional probabilistic statements based on the dataset. One of the advantages of using the Bayesian method to estimate a calibrated DSGE model is that the values assigned to the parameters in calibration can be used as the means for prior distribution, and the new information included in the data can be used to refine the parameters. A framework grounded in solid economic theories and estimated using an advanced econometric method can not only obtain reasonable results, but also be expanded to different destinations and improve the generalisability of the results.

3. The Model

A circular flowchart of the model is presented in Figure 1. There are three types of representative agents in an open economy: households, firms and government. The economy can be divided into two sectors that produce tourism and non-tourism goods, respectively. In a tourism economy, the volume of inbound tourism is usually much larger than that of outbound tourism. Thus, only inbound and domestic tourism are considered in the model, and imports refer to non-tourism products. For convenience without loss of generality, it is assumed that a few members of each household work in the tourism sector, some work in non-tourism sectors and some are unemployed.

[Insert Figure 1 Here]

Based on classical microeconomics, it is assumed that households are infinitely lived and maximise the discounted value of their lifetime utility for consumption (C_t) and leisure, represented by unemployment (u_t) subject to budget constraints. In addition to wages, households invest in capital and treasury securities and obtain earnings as income. Households that are unemployed can access unemployment benefits from the government. All income in a period is used for consumption and investments, which will mature in the following period. Investment in capital can be considered as savings, which can be borrowed by companies as capital investment. To simplify the theoretical model, we assume that there is no banking sector in the economy. Thus, in a competitive market with complete information, households can find companies that need investments without any cost. The mathematical expression of the discounted utility of households is as follows:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \frac{[(C_t - hC_{t-1})\zeta_{C,t} + \frac{u_t^{1+\nu}}{1+\nu}]^{1-\sigma}}{1-\sigma} \tag{1}$$

where β is the discount factor, h is the parameter used to capture the habit persistence of consumption and σ and υ are the inverse of the elasticity of intertemporal substitution and leisure, respectively. $\zeta_{C,t}$ is the weight between consumption and leisure set by the households. As consumer age increases, preference for consumption or leisure may change; thus, $\zeta_{C,t}$ is set as a time-varying exogenous variable following an autoregressive process. Household consumption C_t is the aggregate of tourism goods ($C_{T,t}$), non-tourism goods ($C_{NT,t}$) and imported goods ($C_{M,t}$) by the constant elasticity of a substitution function with the corresponding prices of $P_{T,t}$, $P_{NT,t}$ and $P_{CM,t}$, respectively. P_t is the general price level of the economy. $P_{CM,t}$ is the numeraire; thus, the price of $C_{M,t}$ does not change explicitly, and $C_{M,t}$ is determined by the consumption of tourism and non-tourism goods. To capture the impact of the change of $C_{M,t}$, an exogenous shock $\zeta_{M,t}$ is introduced into the model.

The real added value of each sector ($Y_{i,t}$) is determined by the productivity ($A_{i,t}$), capital stock $K_{i,t}$ and labour input $n_{i,t}$ using a Cobb-Douglas function. To investigate the impact of improved tourism productivity on economic growth, productivity ($A_{i,t}$) is set as an exogenous variable. Firm profit is defined as the added value minus the costs of physical and labour capital after taxation. The objective of firms is to maximise the discounted value of profit as follows:

$$\Pr o(K_{it}, n_{it}) = P_{i,t}(1-\tau_Y)Y_{i,t} - r_t K_{i,t} - w_{i,t} n_{i,t} + \beta E_t \Lambda_{t,t+1} \Pr o(K_{i,t+1}, n_{i,t+1}) \quad (i = T, NT), \tag{2}$$

For convenience without loss of generality, according to classical microeconomics, government budget is assumed to be balanced in each period. Government revenue is composed of tax income from wages and production, plus treasury securities sold for the next period. Government expenditure is the payment of principal and interest that matures in a period.

The external demand for tourism and non-tourism products is determined by the price adjusted by the real exchange rate and the global income level, following a Cobb-Douglas function as follows:

$$EX_{i,t} = \left(\frac{P_{i,t}}{RER_t}\right)^{\theta_{ex_i}} Yrow_t^{\omega_i} \quad (i = T, NT), \tag{3}$$

where $EX_{i,t}$ represents the exports of tourism and non-tourism products, RER_t represents the real exchange rate to US dollars and $Yrow_t$ is the global income level. A small economy in the global economic system exerts very little impact on the global income level; thus, $Yrow_t$ is considered to be exogenous. As there is no banking sector in the model, the exchange rate is also set as exogenous. ω_i and $\theta_{ex,i}$ are the income and price elasticities in the two sectors, respectively. The exponential tourism demand function has been widely used in tourism studies such as those of Song *et al*. (2003), Song *et al*. (2009), Song and Lin (2010) and Lin *et al*. (2015). In most tourism demand studies, the relative price has been calculated as the price level of the destination divided by the price of the original market, adjusted by the exchange rate (Song *et al*., 2009; Wu *et al*., 2017). In this study, as the international tourism demand is not separated into various source markets, $\frac{P_{T,t}}{RER_t}$ is used to represent the relative price of the destination to the world. In a small economy, the global price level could be taken as a constant. A similar assumption is used for determinants of non-tourism exports.

The balance of an international payment is composed of the balance of the current account, which is the sum of exports minus imports, minus net foreign direct investment in the economy. The Taylor rule, which is an empirical monetary policy function that takes historical interest, the inflation rate and the economic growth rate into consideration, is introduced to close the model. Due to space limitations, the mathematical description of the full model is available upon request.

The model uses 33 endogenous variables in 33 equations that describe the optimal behaviour of households, firms and governments under the general equilibrium framework. Another six exogenous variables, including the total factor productivities of the two sectors, follow an autoregression form of $X_{j,t} = \rho_j X_{j,t-1} + \varepsilon_{j,t}$, where $X_{j,t}$ represents the exogenous variables and

ρ_j represents the autoregression coefficients. $\varepsilon_{j,t}$ represents exogenous stochastic shocks, including the shock to productivity in the tourism sector.

To solve the model, non-linear equations are transformed into linear equations using the log-linear method. The log-linear method has an advantage: after transformation, the initial values of all of the variables can be set to zero. This significantly simplifies the model-solving process, as one of the most difficult steps in solving a non-linear model is finding the initial values of the variables. The log-linearised model can be estimated using the Bayesian method.

4. Selected Destination and Data

4.1. The Island of Mauritius

Mauritius was selected as the case study destination for investigating tourism's impact on economic growth using the developed DSGE model. Mauritius is a typical island economy that started to transform from a sugar-export-oriented economy into a tourism-oriented economy in the 1970s. In 2014, the number of international arrivals to Mauritius exceeded 1 million for the first time, reaching 1.04 million and representing an average annual growth rate of 4.85% since 1995. Tourism has enjoyed more rapid growth, increasing by US$1 billion in the last two decades to US$1.442 billion in 2014. On average, Mauritian tourism experienced a 6.58% growth rate per annum from 1995 to 2014 (Statistics Mauritius, 2015).

According to the Mauritian tourism satellite account (TSA), tourism's direct contribution to the Mauritian GDP was 9.5% in 2010, making it the highest of the five pillar industries, which include the sugar, tourism, textile, financial services and information and communication technology industries (Statistics Mauritius, 2015). Driven by its sustained tourism development, the World Bank re-categorised Mauritius from a low-income country to an upper-middle-income country (Durbarry, 2002).

The success of Mauritius has also attracted the interest of tourism scholars. Durbarry (2004) examined the TLEG hypothesis in Mauritius using cointegration and the Granger causality test. He concluded that tourism development in Mauritius led to economic growth. Mauritius has also often been used in panel data models to test the TLEG hypothesis, such as by Lee and Chang (2008) and Fayissa *et al*. (2008).

4.2. Data

As the model includes six exogenous shocks, to avoid the stochastic singularity issue, six variables – GDP, tourism value added, final consumption, total fixed capital formation, imports and Consumer Price Index (CPI) – are selected as observables for the estimation. Quarterly data from 1999 to 2014 are collected from Statistics Mauritius, except for CPI, which is based on the 2010 price and collected from the *International Financial Statistics* of the International Monetary Fund (IMF).

The TSA can be used to compressively measure the tourism value added from a statistical accounting perspective (Dwyer *et al*., 2007; Song *et al.*, 2012). However, as the Mauritian TSA was only compiled for 2005 and 2010, the input-output tables from 1997, 2002 and 2007 are used to calculate the tourism value added for Mauritius in this study. According to the 2005 and 2010 TSAs, the aggregation of the lodging, food and beverage and transport services sectors accounts for 79-84% of the tourism value added. As other sectors' contributions to tourism cannot be disaggregated without the support of the TSA, these three sectors are selected to represent the Mauritian tourism sector. As the data used in the Bayesian estimation are deviations from the steady state, if the added value calculated from the input-output table is highly correlated with the figures in the TSA, it does not influence the estimation results. The output multipliers are calculated based on the input-output tables to estimate the indirect and induced effects. To show the dynamic trend of tourism development, the average multiplier of 1997 and 2002 is calculated to represent the multipliers from 1999 to 2001, and the average multiplier of 2002 and 2007 is used to represent the multipliers from 2003 to 2006. The multipliers from 2007 onward are kept the same due to data availability.

5. Model Estimation

5.1. Prior Distribution and Calibration

Three types of parameters are used in the model: structural, shock and steady state parameters. Structural parameters determine the properties of the model, such as the discount rate β , and are not easily observable (Wickens, 2007). Shock parameters include the autoregressive coefficients and stochastic error terms of the exogenous variables. Steady state parameters are the values of the variables in equilibrium. Only the structural and shock parameters are used in the Bayesian estimation, as they are difficult to observe, and most of the steady state parameters can be calculated based on the real tourism and macroeconomic data.

As few economic studies have examined the Mauritian economy, the parameters for this study are drawn from the DSGE literature, including Smets and Wourters (2003) and Orrego and Vega (2013) for the conventional parameters, and Gertler *et al*. (2008) for the shock parameters. Although these parameters are not valued based on real data or studies of Mauritius, they are the best available data, and are further corrected by the Bayesian estimation. The distribution of each parameter follows Guerrón-Quintana and Nason (2013). Some of the variables, such as the price elasticities of tourism and non-tourism demands, are estimated by auto-regressive distributed lagged models using real tourism and economic data from 1999 to 2014. The calibrations of variables in steady states are based on the means of the corresponding variables in the sample period, and are listed in the appendices.

5.2. Estimation Results

The posterior modes of the parameters are estimated using the Monte Carlo-based optimisation routine, and five parallel Markov chains are drawn from the posterior kernel to simulate the posterior distributions of the parameters. Because the posterior probabilities of the estimated coefficients are determined by the prior probabilities and the likelihood functions derived from the observations, this is applicable for estimations with small sample sizes. To evaluate the estimation results, convergence diagnostic tests are carried out before the simulations are conducted.

5.2.1. Convergence Diagnostic Tests

As five parallel chains are generated and used to simulate the posterior distributions, it is assumed that they converge in a good estimation. The multivariate and univariate convergence diagnostics developed by Brooks and Gelman (1998) are introduced to assess the convergence of all of the estimated parameters. The basic idea of the Brooks and Gelman (1998) test is that the draws from all of the chains should converge to the mean of the draws from the individual chains. Following Brooks and Gelman (1998), the 80% interval of pooled draws from all of the sequences and the mean of the draws from each individual sequence are selected to test the convergence. To enhance the test's reliability, the convergence of the second and third central moments of the preceding sequences are also examined. If the five chains converge, the two lines should remain horizontally stable or be close to each other.

The multivariate convergence diagnostic is used to test the convergence of all of the parameters simultaneously, representing the overall convergence of the model. The multivariate diagnostic sequences are calculated based on the posterior likelihood function, which means the posterior kernel is used to aggregate the parameters. The absolute mean sequences and the second and third moments of the multivariate convergence diagnostic are shown in Figure 3. The top chart shows the absolute mean sequences, and the middle and bottom charts show the second and third moments, respectively. In Figure 2, the dotted lines are the statistics that are calculated from the pooled draws from all of the sequences, and the solid lines represent the means of the draws from individual sequences. The lines based on the pooled draws converge and even overlap the lines based on the individual draws in all three figures. Overall, the five chains of parameters converge and the simulations of the posterior distributions are reliable. Individual convergence diagnostic tests of the 27 parameters are also carried out, and the estimation of all of the parameters converges. Due to space limitations, the results of the univariate convergence diagnostic tests are available upon request.

[Insert Figure 2 Here]

5.2.2. Estimation Results

Twenty-seven parameters are estimated using the Bayesian method, with the results presented in Table 1. In addition to the estimation of the mean posterior distribution, the 90% interval estimation is provided for more robust results.

[Insert Table 1 Here]

The priors of the parameters are drawn from the general literature instead of studies focusing on Mauritius. Table 1 shows that the priors of most of the parameters differ from the posterior distributions, indicating that the estimation results have been corrected using real tourism and economic data.

Most of the estimation results are consistent with expectations. The output elasticities of capital in the tourism and non-tourism sectors (α_T and α_{NT}) change to around 0.436 and 0.585, respectively, indicating that the non-tourism sector in Mauritius is more capital-intensive than the tourism sector.

The leisure elasticity parameter (υ) and the intertemporal substitute elasticity parameter (σ) are estimated as 2.021 and 2.051, respectively, yielding leisure elasticity and substitute elasticity of 0.495 ($\frac{1}{\upsilon}$) and 0.488 ($\frac{1}{\sigma}$), respectively. The results are supported by the findings of previous studies focused on estimations of the two parameters, such as Domeij and Flodén (2001) for leisure elasticity and Havranek *et al*. (2015) for intertemporal substitute elasticity.

The habit persistent coefficient (*h*) decreased to 0.441 from its prior of 0.552, which was obtained from Smets and Wouters's (2003) study of European countries. Thus, the change represents the effect of the new information obtained from real Mauritian data.

The real data also affect the estimation of income elasticities (ω_{T} and ω_{NT}). The income elasticities of the tourism and non-tourism sectors change to 0.852 and 0.212, respectively. Although the posterior values differ from the priors, the major characteristic of the products is the same: both Mauritian tourism and non-tourism goods are inelastic in terms of income. The estimated price elasticities of the tourism and non-tourism sectors are 0.398 and 0.237, respectively; the changes are not as significant as those in income elasticities.

The insensitivity of tourists to changes in income and price in the Mauritian tourism sector is due to the country's historical and geographic background. According to Statistics Mauritius (2015), the largest inbound market to Mauritius is the United Arab Emirates (UAE), followed by Reunion Island, France and South Africa. These four source markets accounted for a 65.35% market share in 2014. The UAE is one of the richest countries in the world, making its tourists insensitive to price changes. As Reunion Island and South Africa are closer to Mauritius than the other source markets, tourists from these markets may not be sensitive to changes in income and price. Mauritius was a French colony for 100 years, and although French is not the official language, it is still widely used. French tourists may thus prefer the country due to the familiar culture and environment, and may for this reason not be sensitive to changes in income and price.

The estimated substitute elasticity between tourism and non-tourism goods (θ_1) is 0.223. In one of the few empirical studies of the substitute elasticity between tourism and non-tourism products, Lanza *et al*. (2004) estimated the elasticity for 13 OECD countries and found that although all of the substitute elasticities were less than unit, four were not significant. Although no studies have directly supported this study's estimation for Mauritius, the results of studies of OECD countries have suggested that the substitute elasticity between tourism and non-tourism products is likely to be insensitive. As domestic tourism consumption accounts for 2.58% of household consumption (Statistics Mauritius, 2015), the low substitute elasticity is reasonable.

In terms of the shock parameters, the autoregressive coefficient of world output (ρ_{Yrow}) is only 0.280, which is lower than expected, perhaps due to the small sample size. Furthermore, as the simulation is driven by a shock in tourism productivity rather than global output, which is assumed to be constant, the estimation result of the parameter does not affect the simulation used to examine tourism's contribution to the economic growth of Mauritius.

6. Findings and Discussion

In macroeconomics, impulse response functions (IRFs) are usually used to measure an economy's reaction to an exogenous shock. The IRFs of selected variables in the Mauritian model are presented in Figure 3, which shows the response of each variable to a 1% positive shock in tourism productivity. The bold lines in Figure 4 are the IRFs, and the space between the two black lines for each variable is the 90% highest posterior density interval. The vertical axis is the percentage by which the variable fluctuates, and the horizontal axis is the quarterly timeline.

[Insert Figure 3 Here]

6.1. Effect of a Productivity Shock on the Product Market

With a 1% positive productivity shock, tourism value added increases by 0.516%. Due to the increased supply, tourism product price decreases by 1.86%, whereas little change is observed in non-tourism price relative to import price, which is taken as the numeraire. Thus, domestic consumption of tourism products increases by 0.43% and tourism exports increase by 0.73%. Due to the improvement in productivity, less investment is needed to maintain the same production level. To finance the expanded domestic tourism demand, investment in the tourism sector decreases by 1.35% in the first period. However, to further expand production and obtain a higher return rate, investment starts to increase from the second period. As tourism and non-tourism have the same long-term nominal return rate and wage index, the improved benefit leads to simultaneous capital and labour inflow to the non-tourism sector. However, compared to the tourism sector, the boom in the non-tourism sector is not significant. As tourism accounts for around 10% of the Mauritian GDP, the tourism expansion caused by a 1% productivity improvement may boost the GDP by 0.09%. Although tourism's contribution to economic growth appears marginal, as the Mauritian GDP's average annual growth rate is 3-4% (Statistics Mauritius, 2015), tourism can be seen as a long-term driving force boosting the economic growth of Mauritius.

The implication of this finding is straightforward. In an island economy, tourism development can lead to economic growth. This is consistent with most empirical studies of the TLEG hypothesis. In addition, the simulation results demonstrate the mechanism through which tourism development leads to economic growth, which complements previous studies.

From a practical perspective, these findings can be used to help policymakers further tourism development in Mauritius. However, it should be noted that investment growth starts to fall again after the second period, indicating that households do not have enough resources to support further production expansion. GDP growth thus begins to slow after the first period. The government could consider subsidising investment in tourism or inviting more foreign direct investment (FDI) to extend the expansion period of the tourism sector, leading to more sustained GDP growth.

6.2. Effect of Price Elasticity on Economic Growth

The 1% increased tourism value added (Y_T) is aggregated by domestic tourism consumption (C_T), tourism investment purchases (I_T) and exports (EX_T). As the increased margin of Y_T is fixed, if the aggregated expansion of domestic and inbound consumption is larger than the increased value added, the producer is unable to purchase further fixed asset investment; however, if the expansion is smaller, the producer can further expand the investment. To obtain a full picture of the investment response, IRFs with different elasticities are presented in Figure 4.

[Insert Figure 4 Here]

In Figure 4, the darker solid lines are the IRFs of the baseline model with an estimated price elasticity of 0.398 in absolute value. The lighter dotted line, lighter solid line and black dotted line represent the IRFs with absolute values of posterior elasticity at 0.989, 1.461 and 1.971, respectively.

When the tourism product is inelastic in terms of price (e.g., the baseline model and scenario with price elasticities of 0.398 and 0.989 in absolute value, respectively), the increase in tourism exports is much smaller than in the scenarios with price elasticities that are larger than unity. As a result, more products are left for domestic consumption in the inelastic scenarios. As discussed in Section 6.1, producers decrease investment in the first period to finance the increased domestic consumption. To further increase production and obtain a higher return rate, they start to increase investment from the second period.

In contrast, as international tourists become more sensitive to price changes, tourism exports increase. When the price elasticity is close to -2, the growth in tourism exports reaches 1.827%, which is more than double the rate of expansion in the baseline model with an elasticity of only -0.398. To earn a higher return rate, producers increase investment from the first period. When the price elasticity is -1.461, investment is stimulated by 0.251%, and it further increases to 0.637% when the elasticity is -1.971. However, as the increase in exports consumes too much of the increased tourism value added, the resources left for domestic consumption and investment become insufficient. Households thus begin to reduce investment from the second period. Hence, domestic consumption is less in scenarios with larger elasticities in absolute value than in scenarios with inelasticities.

Based on the estimation results, the threshold for the absolute value of the model for Mauritius ranges from 0.989 to 1.461. When the price elasticity is 0.989, all of the demand variables are stimulated by a productivity shock. In contrast, when price elasticity equals 1.461, investment negatively responds to the shock. Obviously, similar to previous research findings, a positive shock to tourism productivity would lead to increased investment in the sector, and therefore to increased GDP. However, this study contributes more than this. By introducing an innovative method – the Bayesian DSGE model – the transmission mechanism from a productivity shock in the tourism industry to economic growth, which is a black box in econometric models, has been unlocked. When tourism practitioners and governments understand the mechanism, it is easier for them to make decisions or policies with a view to influencing tourism development.

7. Conclusions and Implications

7.1 Conclusions

In this study, a two-sector open economy is modelled under the DSGE framework. The model is estimated using the Bayesian method, based on real tourism and macroeconomic data from Mauritius for the 1999-2014 period. The convergence diagnostics show that the estimation results are robust, and the prior and posterior distributions indicate that most of the parameters are significantly influenced by the information from the data. The IRFs show that the Mauritian GDP would increase by 0.09% if tourism productivity improved by 1%, indicating that tourism growth could lead to economic growth. Considering that the average annual growth rate of the Mauritian GDP is 3-4% (Statistics Mauritius, 2015), the contribution of tourism to its economic growth is significant.

7.2 Theoretical Implications

The findings and framework developed by this study can benefit academia, governments and tourism practitioners. Methodologically, this is the first study in the tourism economics field to use Bayesian estimation in a DSGE model. The Bayesian method is a combination of calibration and traditional econometric methods, and integrates information from both prior published studies and real data. The introduction of a Bayesian DSGE model brings the simulation results closer to reality. Thus, the study's conclusions are more robust. Previous econometric models have confirmed the correlation between tourism and economic growth, which is illustrated by the TLEG hypothesis. The framework developed in this study discloses the transmission mechanism from productivity shocks in the tourism industry to economic growth using a macroeconomic model. The transmission logic is grounded in microeconomic behaviour equations, which are more rigorous than the reduced econometrics models used by other researchers. It provides a theoretical framework that can be further applied to other destinations in order to examine the impact of tourism development on economic growth for academia and policymakers.

7.3 Practical Implications

A few practical implications can also be obtained from this study. As international tourists are insensitive to changes in the tourism price of Mauritius, productivity improvements result in more products for domestic consumption. In this scenario, investment first declines to finance this consumption and then starts to increase to further expand production and earn a higher return rate. However, it should be noted that investment growth starts to decline in the second period, indicating that Mauritian residents do not have enough resources to further increase investment. Thus, the Mauritian government could invite more foreign capital to boost tourism development and sustain economic growth.

Furthermore, the estimated elasticity of the labour output is 0.564, which is relatively low for a labour-intensive industry. The simulation results also show that a 1% improvement in tourism productivity causes an increase in tourism value added of only 0.589%, indicating the low efficiency of the tourism sector in Mauritius. The Mauritian government should attract more experienced tourism and hospitality professionals to Mauritius to enhance the human capital of the tourism sector. Providing professional training to employees should be effective for improving labour productivity in the sector.

In addition, as the Mauritian inbound market is dominated by tourists from the UAE, Reunion Island, France and South Africa, which are closer either geographically or culturally to Mauritius than other source markets, both the income and price elasticities of that market are insensitive. Insensitive visitors are more loyal to their destinations. Thus, the Mauritian government could increase the tourism price to earn more tourism revenue. Meanwhile, more effort could be made to promoting Mauritius to emerging countries in Asia that have higher income and price elasticities (Peng *et al*., 2015). According to the simulation results, driven by stronger exports, tourism's contribution to economic growth is more significant when international tourists become more sensitive to price changes.

In summary, as an island economy, Mauritius illustrates how tourism can lead to economic growth. However, caution is necessary when generalising this conclusion to other destinations, as various inbound price elasticities may result in tourism having different effects on economic growth. Thus, governments should implement specific policies to stimulate fixed capital investment and domestic tourism consumption if inbound price elasticity is very sensitive.

7.4 Limitations and Future Research

The main limitation of this study is the unavailability of TSA data for Mauritius. Although the aggregation of particular sectors in an input-output table can act as a substitute for tourism value added, quarterly TSA data would provide more information about the characteristics of the tourism sector that could be included in the Bayesian estimation.

It would be valuable and important to apply the emerging DSGE framework with Bayesian estimation to more destinations and to examine the generalisability of this study's findings. With the support of tourism employment data provided in TSAs, it would also be interesting to investigate the effect of tourism on employment, specifically under the framework incorporated in the DSGE model.

Appendices

Table A. 1 Calibration of Selected Variables

Variable		Value in Steady State	Time Period/Source
GDP/GDP	$\bar{Y}$	1.000	-
Tourism Value Added/GDP	$\bar{Y}_T$	0.172	1999-2014
Non-tourism Value Added/GDP	$\bar{Y}_{NT}$	0.827	1999-2014
Final Consumption/GDP	$\bar{C}$	0.821	1999-2014
Total Investment/GDP	$\bar{I}$	0.237	1999-2014
Imports/GDP	$\overline{CM}$	0.354	1999-2014
Tourism Exports/GDP	$\overline{EX_T}$	0.137	2005-2010
Non-tourism Exports/GDP	$\overline{EX_{NT}}$	0.702	2005-2010
Tourism Investment/GDP	$\bar{I}_T$	0.004	2005-2010
Non-tourism Investment/GDP	$\bar{I}_{NT}$	0.233	2005-2010
Tourism FDI/GDP	$\bar{I}_T^F$	0.003	1999-2014
Non-tourism FDI/GDP	$\bar{I}_{NT}^F$	0.020	1999-2014
Balance of Payment/GDP	$\overline{BP}$	0.485	1999-2014
Treasury Security/GDP	$\bar{B}$	0.250	-
Unemployment	$\bar{u}$	0.084	1999-2014
Tourism Consumption/(Final Consumption + Imports)	γ_1	0.036	2005-2010
Non-tourism Consumption /(Final Consumption + Imports)	γ_2	0.532	2005-2010
Tourism Employment /Employment	$\bar{n}_T$	0.116	2010
Non-tourism Employment/ Employment	$\bar{n}_{NT}$	0.804	2010
CPI	$\bar{P}$	1.000	-
Tourism Price	$\bar{P}_T$	1.000	-
Non-tourism Price	$\bar{P}_{NT}$	1.000	-
Average Growth Rate of GDP	g_y	Log(1.032)	1999-2014
Average Growth Rate of Non-tourism Value Added	g_{yt}	Log(1.026)	1999-2014
Production Tax Rate	τ_Y	0.150	Mauritius Revenue Authority
Wage Tax Rate	τ_W	0.150	

Table A.2 Estimated Priors of Selected Parameters

	Ex_t		Ex_nt		RER
Log(RP(-2))	-0.346 (-1.877)*	**Log(RP)**	-0.478 (-7.766)***	**Log(RER(-1))**	0.996 (144.357)***
Log(WGDP(-1))	0.883 (6.483)***	**Log(WGDP(-1))**	0.512 (141.860)***		
D09	-0.218 (-4.029)***	**D09**	-0.260 (-5.720)***		
D14	0.143 (2.611)**	**D14**	0.302 (5.483)***		
Constant	-7.471 (-3.322)***				
R^2	0.965		0.856		-0.723

Notes: 1. Log is the operator of nature logarithm; 2. Figures in parentheses after the variables are the lagged order; 3. *, ** and *** represent the 10%, 5% and 1% significance levels, respectively; 4. D09 and D14 are dummies representing the Global Financial Crisis in 2009 and currency depreciation in 2014, respectively.

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