Dynamic Inter-relationship among International Tourism, Economic Growth, and Energy Consumption in Taiwan

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Abstract — In 2010, due to government regulatory easing to mainland Chinese tourism, Taiwan's economic growth increased by 10.88% from the previous year, producing the highest real gross domestic product (GDP) growth rate since 1987. However, mass tourism can lead to possible degradation of the environment and exhaustion of natural resources. Facing the challenges of future energy scarcity and global warming, this study uses Granger causality analysis to examine the causal relationships among international tourism development, economic growth, and energy consumption in Taiwan from 1965 to 2010. The study presents three principal test results. First, there is no reciprocal causal relationship between economic growth and international tourism development. As a result, this study does not support the tourism-led growth hypothesis. Second, this study identifies bidirectional causality between economic growth and energy consumption. Third, this study shows bidirectional causality between international tourism development and energy consumption. In particular, one of the indicators for tourism development, the international tourist arrivals, Granger causes more with energy consumption than visitor expenditures. From an energy conservation perspective, these results suggest authorities to focus on increasing the volume of visitor expenditures rather than international tourist arrivals caused from operating low-budget travels when promoting international tourism.

Keywords - Energy consumption; Economic growth; Tourism development; Granger causality; Cointegration

I. INTRODUCTION

After the global financial crisis began in the United States in 2007, the unemployment rate in Taiwan rose to 5.9%, and its economic growth fell to -1.93% in 2009 [1]. Fortunately, Taiwan emerged from the global financial crisis in good shape due to the new international tourism market development. The government lifted the ban on mainland Chinese visits to Taiwan in July 2008. Although the legislation restricted inbound tourists from China to only 4,000 visitors per day at the beginning, and confined them to tour groups, the number of inbound Chinese tourists increased sharply to 967,000 in 2009 and then to 2.87 million in 2013[2]. In 2010, Taiwan's economic growth increased by 10.88% from the previous year, producing the highest real gross domestic product (GDP) growth rate since 1987 [3]. Mainland Chinese tourists has since then overtook Japanese tourists to become the largest group of inbound visitors to Taiwan. With the reported record high of 8.01 million inbound visitors, Taiwan's inbound tourism revenue topped US$12.3 billion in 2013 [2].

To continue enjoying the economic benefits of tourism growth, the administration should not overlook the sudden volume increase of inbound tourists. Even though the tourism industry has long been viewed as a non-smokestack industry, mass tourism can lead to possible degradation of the environment and exhaustion of natural resources [4,5]. In particular, Taiwan is a small island with limited natural resources, and a growing demand in energy consumption. From 1965 to 2010, Taiwan's energy consumption has increased from 6.2 million tons to 110.5 million tons of oil equivalent [6]. Based on Taiwan Bureau of Energy [7] statistics, Taiwan imported 99.39% of its required energy from abroad, and 91.29% of it in the form of fossil fuel (*e.g.*, coal, oil and natural gas). Under today's worsening global warming scenario, energy consumption and carbon fuels related issues are topics that should not be overlooked [8].

Facing the challenges of future energy scarcity and global warming, it is important to develop an effective framework to understand energy consumption issues from all economic facets including tourism. Few scholars have examined this topic in the past, including casinos' electricity consumption in Macao, estimation of tourism-induced electricity consumption in Balearics Islands, and local energy consumption associated with different travel modes in Australia [9-12]. Nonetheless, empirical studies on the topic in the tourism sector remain to be scarce.

The present study investigates the long-term causal relationships among tourism development, economic growth, and energy consumption in Taiwan; in an attempt to evaluate its contribution to the economy and its impact on energy consumption with the adoption of Granger causality analyses. The remainder of this paper is organized as follows: Section 2 to 4 present a review of various studies related to tourism development, economic growth, and energy consumption; Section 5 to 8 introduce the Granger causality tests, related procedures, and empirical results; and lastly, Section 9 offers a conclusion and delineates certain important policy implications.

II. TOURISM DEVELOPMENT AND ECONOMIC GROUTH

International tourism has advanced rapidly on a global scale since the late 1970s. Although some researchers have examined the relationship between economic growth and tourism development, the number of these publications cannot commensurate to the large body of literature on the export sector [13,14]. Several studies in the early 1980s have attempted to investigate the influence of international tourism on the economy in various countries by using demand or supply models. A number of authors adopted univariate and multivariate econometric techniques, input-output (I-O) models, the social accounting matrix (SAM), Granger causality tests, and computable general equilibrium (CGE) models [15,16,17].

Some empirical studies supported that tourism expansion boosts economic growth, which is frequently delineated as the tourism-led growth hypothesis (TLGH) [18-28]. Louca [24] examined the long-term relationships between tourism development and economic growth in Cyprus. His results suggested that the expansion of output growth in the tourism industry had effectively contributed to the economic growth and GDP in Cyprus. For more recent studies on the topic, Nissan *et al.* [17] conducted an empirical analysis for 11 countries (*i.e.*, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom, and the United States). Their findings indicated that tourism has a positive effect on economic growth and local entrepreneurship. Seetanah [29] assessed the economic effects of tourism on island economies by using panel data from 19 island economies with the generalized method of moments (GMM). Their results showed a bi-causal relationship between tourism and economic growth. Shubert *et al*. [30] studied the effects of a small tourism-driven economy on economic growth caused by an increase in the growth rate of international tourism demand. Their results confirmed the hypothesis that tourism was a driving factor in economic growth.

On the other hand, certain empirical studies have failed to show that tourism expansion contributes directly to economic growth [13,31-33]. Using the Granger causality test, Oh [31] found only a unidirectional relationship from economic growth to tourism development, but not vice versa, for South Korea. Oh argued that in South Korea, value-added revenue from tourism-associated activities accounted for only 3.5% of the country's GDP, much less than those double-digit-number figures of highly tourism developed countries. Tang and Jang [33] studied the causality between sales of four tourism-related industries (*i.e.*, airlines, casinos, hotels, and restaurants) and the overall economic growth in the United States. Their study showed no cointegration between GDP and sales of all four tourism industries. More recently, Arslanturk *et al.* [13] found no Granger causality between tourism receipts and GDP in Turkey. Tang [32] investigated the validity of the TLGH for Malaysia based on a data set of 12 tourism markets from 1995 to 2009. Their results demonstrated that not all international tourism markets Granger cause economic growth. Based on previous studies, contradictions in the causal link between tourism development and economic growth can be observed; for that reason, the generalization of the TLGH to a larger extent is still uncertain.

Some researchers studied the long-term relationships between tourism expansion and economic growth in Taiwan. Kim *et al.* [23] adopted vector autoregressive model (VAR) and Granger causality test to explore the long-term bidirectional relationship between the two factors. Their study results showed cointegration and suggested a bidirectional relationship between the two variables. However, according to Granger [34], vector error correction model (VECM) was deemed to be more appropriate for long-term causality relations analysis when variables were cointegrated. Chen and Chiou-Wei [35] by using the Exponential Generalised Autoregressive Conditional Heteroskedasticity-Mean (EGARCH-M) model to consider the uncertainty (volatility) of variables, examined the long-term causal relationship between tourism expansion and economic growth over the period of 1975:Q1 - 2007:Q1. Their study reported no cointegrating between the two variables and supported the TLGH; while a reciprocal causal relationship was not found. However, whilst taking care of the uncertainty issues with the EGARCH-M model, it cannot take care of the seasonality characteristic of quarterly data [36]. This study attempts to re-examine the long-term relationships between the two variables with a longer annual data set which legitimately avoid the seasonality matter. Therefore, the following alternative hypotheses are proposed:

Hypothesis 1. A long-term equilibrium relationship exists between tourism development and economic growth in Taiwan.

Hypothesis 2a. Tourism development leads to economic growth (tourism-led economic growth).

Hypothesis 2b. Economic growth leads to tourism

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development (economy-led tourism growth).

Hypothesis 2c. Tourism development and economic growth Granger causes each other.

III. ECONOMIC GROUTH AND ENERGY CONSUMPTION

The relationship between energy consumption and economic growth is an essential subject in energy economics. Previous studies on the relationship have focused on different countries, periods, proxy variables, and econometric methodologies [37]. Several studies have used multivariate modeling and the cointegration approach. However, Granger energy-GDP nexus remain inconsistent, stimulating arguments regarding the role of energy in economic growth [38-42].

Bartleet and Gounder [38] observed the causal relationship between energy consumption and economic growth using trivariate demand-side and multivariate production models for the period 1960-2004 in New Zealand. The results of their demand model showed a long-term relationship among energy consumption, GDP, and energy prices; whereas the production model showed a long-term relationship among real GDP, energy consumption, and employment. The Granger causality appeared to be running from GDP to energy consumption. Lean and Smyth [41] used data from 1971 to 2006 to test the causal relationship among aggregate output, electricity consumption, exports, labor, and capital in a multivariate model for Malaysia. Result demonstrated bidirectional Granger causality between aggregate output and electricity consumption. Chang [43] used multivariate cointegration Granger causality tests to examine the correlations among energy consumption, economic growth, and carbon dioxide emissions in China. The results showed that electricity consumption and GDP exhibit a feedback causality relationship. This in turn indicated that economic growth generates a higher level of energy consumption. Pao and Tsai [42] studied the effects of economic growth and financial development on environmental degradation in the BRIC (Brazil, Russian Federation, India, and China) countries using a panel cointegration method. Their results showed strong bidirectional causality between GDP and energy consumption.

Some researchers studied the long-term relationship between energy consumption and economic growth in Taiwan. Lee and Chang [44] investigated the linear and nonlinear effects of energy consumption on economic growth. Their evidence confirmed an inverse U-shape between energy consumption and economic growth. Chiou-Wei *et al.* [45] investigated the linear and nonlinear Granger causality relationships between energy consumption and economic growth for a sample of newly industrialized Asian countries and the U.S. Results demonstrated that energy consumption might have influenced economic growth in Taiwan. Pao [46] examined the causality relationship between electricity consumption and economic growth in Taiwan from 1980-2007 using cointegration, error-correction models, and Granger causality. Results showed that electricity consumption and GDP were cointegrated, and there existed unidirectional short- and long-term Granger causality from economic growth to electricity consumption. Yang *et al.* [47] explored the linear and nonlinear causality between total electricity consumption and real GDP in Taiwan by using quarterly data from the periods 1982 to 2008. Results supported bidirectional causality between total electricity consumption and real GDP in both linear and nonlinear models.

Based on previous empirical studies, the causal relationship between economic growth and energy consumption can be concluded into four hypotheses:

1) Conservation hypothesis: There is unidirectional Granger causality running from economic growth to energy consumption. This hypothesis implies that the policy of conserving energy consumption has little or no adverse effect on economic growth.
2) Growth hypothesis: There is unidirectional Granger causality running from energy consumption to economic growth. This hypothesis suggests that a reduction or limitation in the use of energy consumption may harmfully affect economic growth, and that an increase in energy consumption may improve economic growth.
3) Feedback hypothesis: There is bidirectional Granger causality between economic growth and energy consumption. This hypothesis infers that economic growth and energy consumption are mutually affected.
4) Neutrality hypothesis: There is no Granger causality between economic growth and energy consumption. This hypothesis indicates that energy consumption is not connected with economic growth. The conservative or growth

policy of energy consumption has no influence on economic growth.

Therefore, this study proposes the following alternative hypotheses:

Hypothesis 3. There is a long-term equilibrium relationship between economic growth and energy consumption in Taiwan.

Hypothesis 4a. Economic growth leads to energy consumption.

Hypothesis 4b. Energy consumption leads to economic growth.

Hypothesis 4c. Economic growth and energy consumption cause each other.

IV.TOURISM DEVELOPMENT AND ENERGY CONSUMPTION

Energy consumption is indispensable to all economic activities including tourism, and several other related businesses that fall under the sector's umbrella. A range of tourism activities depend on energy. In particular, the transportation subsector is generally considered as the major energy consumer of the industry [48,49]. Not only do tourists rely on different transport means to be transported between and within destinations, different travel modes within the transport, accommodation, attraction, and activity subsectors demand varying amounts of energy [50]. Gössling [51] estimated that tourism-related global energy consumption was approximately 14,000 Petajoule (PJ). Of this total, the transport sector was expected to consume 94%, the accommodation sector 3.5%, and the remainder was consumed by the activities sector. Previous study showed that the total energy consumption by international tourists was four times that of domestic tourists; however, the energy used per day did not differ significantly between the two groups [10,52].

Apart from international and domestic transportation, tourism industry also relies on energy for other activities; including recreational activities that depend mostly on fossil fuels to power the equipment [48]. Other industry sectors, counting hotels, casinos, and shopping malls, also consume a significant amount of electricity for lighting, heating, ventilating, air-conditioning, and powering IT mainstays [53]. Becken and Simmons [48] found that entertainment attractions, followed by tourist attractions, were the major consumers of domestic energy consumption. However, on a per capita basis, these attractions consumed much less energy than tourist activities. Previous research indicated that the gaming industries in Macao and Las Vegas required a substantial amount of electricity to operate and illuminate infrastructures day and night [11]. Other domestic tourism studies had examined energy consumption patterns in different divisions [12,48,50]. Martín-Cejas and Sanchez [49] attempted to estimate the contribution of tourism road travel to the total energy consumption per tourist in Lanzarote by using ecological footprint indicator analysis. Liu *et al.* [54] studied the energy requirements of the tourism industry of Chengdu, China. Results indicated that from 1999 to 2004, the energy consumption of the tourism industry in Chengdu increased from 1.8×10^7 GJ (Gigajoule) to 2.3×10^7 GJ. Transportation was the major contributor to energy consumption in the industry.

Compared to the vast amount of long-term causality studies between economic growth and energy consumption [38,40-42,43], research in the long-term causality studies between tourism development and energy consumption is rather limited [9,11,49,51]. Bakhat and Rosello [9] assessed the electricity demand pattern and investigated the aggregated contribution of tourism to electricity consumption using a case study of the Balearic Islands, Spain. The study adopted a conventional daily electricity demand model, including data for daily stocks of tourists, to show that tourism cannot be considered an energy-intensive sector in electricity consumption. Lai *et al.* [11] investigated the relationship between electricity consumption and economic growth in Macao, where the majority of GDP (62.25%) depends on gaming and associated hospitality services. Study results showed that electricity consumption and economic growth in GDP were cointegrated for the period of 1999 Quater1 - 2008 Quarter 4.

Although tourism industry cannot be considered as an energy-intensive sector compare to other energy guzzling industries, as an integrated part of the global economy, it is important to understand its dynamics within the overall energy consumption framework. Based on previous literature review, this study proposes the following alternative hypotheses to investigate the relationship between tourism development and energy consumption:

Hypothesis 5. There is a long-term equilibrium relationship between tourism development and energy consumption in Taiwan.

Hypothesis 6a. Tourism development leads to energy consumption.

Hypothesis 6b. Energy consumption leads to tourism development.

Hypothesis 6c. Tourism development and energy consumption cause each other.

V. MODEL SPECIFICATION

This study investigates the long-term causal relationship among tourism development, economic growth, and energy consumption. Following previous studies, GDP is considered the indicator of economic growth [55]. Previous studies have used various proxies for international tourism development. One of these proxies is international tourism receipts, defined as the total amount of personal spending by tourists in the country in addition to fees paid to travel agencies by inbound visitors during their travel in the country [56]. Other proxies include the expenditures in transport and communication, hotels and restaurants, advertising and promotion [24], and total tourist arrivals [23]. This study also uses international tourist arrivals and visitor expenditures to measure tourism development. Data sources include the BP Statistical Review of World Energy

2011 [6], the Taiwan Tourism Bureau [2], and the Taiwan Directorate-General of Budget, Accounting and Statistics [1], respectively. Energy consumption data are expressed in million tons of oil equivalent. Visitor expenditures and GDP are both measured in million U.S. dollars. This study uses annual time series data for the period 1965-2010. To avoid both a spurious regression result and overestimating the importance of variables, lnVIS, lnEXP, lnGDP, and lnENE representing natural logarithms of international tourist arrivals, visitor expenditure, GDP, and energy consumption, respectively were adopted for analyses.

This study presents six sets of hypotheses concerning the relationship between any two variables from tourist arrivals, visitor expenditures, GDP, and energy consumption. For example, the fourth set of hypotheses concerns the relationship between energy consumption and tourist arrivals. These hypotheses state that there is unidirectional Granger causality running from energy consumption to tourist arrivals, unidirectional Granger causality running from tourist arrivals to energy consumption, bidirectional Granger causality between these two variables, or no Granger causality in either direction. The remaining sets of hypotheses, except for two variables in the fourth set of hypotheses, consider the relationship between any two variables from energy consumption, tourist arrivals, visitor expenditures, and GDP.

The following equations present the corresponding specifications for the tourism- GDP-energy models:

$$lnVISt = \alpha_{20} + \alpha_{21}\, lnENEt + \alpha_{22}\, lnEXPt + \alpha_{23} lnGDPt + \varepsilon_{2t}. \quad (1)$$

$$lnEXPt = \alpha_{30} + \alpha_{31}\, lnENEt + \alpha_{32}\, lnVISt + \alpha_{33} lnGDPt + \varepsilon_{3t}. \quad (2)$$

$$lnGDPt = \alpha_{40} + \alpha_{41}\, lnENEt + \alpha_{42}\, lnVISt + \alpha_{43} lnEXPt + \varepsilon_{4t}. \quad (3)$$

$$lnENEt = \alpha_{10} + \alpha_{11} lnVISt + \alpha_{12}\, lnEXPt + \alpha_{13} lnGDPt + \varepsilon_{1t}. \quad (4)$$

where ε_{it} is the error term, i=1,2,3,4.

VI. UNIT ROOT AND COINTEGRATION TESTS

Because most macroeconomic variables are trended, the spurious regression problem is highly likely to be present in most macroeconomic models [57]. By definition, cointegration requires that variables of the same order be integrated. Therefore, the first step is to test the variables for their order of integration. This study uses augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to examine the unit root and to determine if all series are of the same order, which is a precondition of cointegration. We applied the Johansen approach for cointegration to test for the existence of a long-term relationship among the variables [36]. Unit roots were tested without drift, with drift, and with both drift and time trends. The significance of drift and time trend terms were checked to see if they should be included in the unit root tests [58].

If the null hypothesis of no cointegration cannot be rejected, a short-term relationship is estimated in a vector error correction model (VECM) framework with the lagged error correction term (ECT) to incorporate long-term dynamics. There are five possible cases for the VECM model, including a constant and/or a trend in the long-term model (the cointegrating equation), and a constant and/or a trend in the short-term model (the VAR model). The Pantula principle justifies which of the five cases is appropriate for testing cointegration. The model selection procedure comprises moving from the most restrictive model (Case 1), at each stage comparing the trace test statistics to its critical value, and stopping only when the null hypothesis of no integration is not rejected [57].

VII. GRANGER CAUSALITY TESTS

This study uses the Granger Test [34] to further assess the causal relationship between variables. This method assumes that the information relevant to the prediction of the respective variables is contained solely in the time-series data on these variables. The forms of the Granger-causality model in the first differences are as follows:

$\Delta lnENE_t = \gamma_1 +$ **Error! Reference source not found.**$_{11i}\Delta lnENE_{t-i} +$ **Error! Reference source not found.**$_{12i}\Delta lnVIS_{t-i} +$ **Error! Reference source not found.**$_{13i}\Delta lnEXP_{t-i}$ $+$**Error! Reference source not found.**$_{14i}\Delta lnGDP_{t-i} + \theta_1\Delta\, ECT_{t-1} + \tau_{1t}$ (5)

$\Delta lnVIS_t = \gamma_2 +$ **Error! Reference source not found.**$_{21i}\Delta lnENE_{t-i} +$ **Error! Reference source not found.**$_{22i}\Delta lnVIS_{t-i} +$ **Error! Reference source not found.**$_{23i}\Delta lnEXP_{t-i}$ $+$ **Error! Reference source not found.**$_{24i}\Delta lnGDP_{t-i} + \theta_2 ECT_{t-1} + \tau_{2t}$ (6)

$\Delta lnEXP_t = \gamma_3 +$**Error! Reference source not found.**$_{31i}\Delta lnENE_{t-i} +$**Error! Reference source not found.**$_{32i}\Delta lnVIS_{t-i} +$**Error! Reference source not found.**$_{33i}\Delta lnEXP_{t-i} +$**Error! Reference source not found.**$_{34i}\Delta lnGDP_{t-i}$ $+$ $\theta_3 ECT_{t-1} + \tau_{3t}$ (7)

$\Delta lnGDP_t = \gamma_4 +$ **Error! Reference source not found.**$_{41i}\Delta lnENE_{t-i} +$ **Error! Reference source not found.**$_{42i}\Delta lnVIS_{t-i} +$ **Error! Reference source not found.**$_{43i}\Delta lnEXP_{t-i} +$ **Error! Reference source not found.**$_{44i}\Delta lnGDP_{t-i} +$ $\theta_4 ECT_{t-1} + \tau_{4t}$ (8)

where Δ represents the first difference, and ECT $_{t-1}$ is the long-term effect term. The terms Θ_l , l = 1, 2, 3, 4 are the corresponding long-term impact coefficients, which are also

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known as the speed of adjustment parameter, for models of energy consumption, international tourist arrivals, visitor expenditure, and real GDP, respectively. τ_{lt} is the error term. The short-term effects between the independent and dependent variables are inferred by the size of β_{lji}, j = 1, 2, 3, 4, and l = 1, 2, 3, 4. If H_0: $\beta_{lji} = 0$ (j = 2, 3, 4, l = 1, 2, 3, 4) is rejected, the independent variable Granger causes the dependent variable. The null hypothesis is tested by a standard F-statistics or chi-square statistics.

The optimal lag length n is determined according to Akaike information and Schwarz Bayesian criteria. The short-term Granger-causality direction is tested with the Wald F-statistic pertaining to each of the lagged explanatory variables. The long-term speed of adjustment can be inferred from the estimated coefficient of the lagged ECT [57].

VIII. EMPIRICAL RESULTS

The following figures (Fig. 1 to 4) present the trend plots for energy consumption, international tourist arrivals, visitor expenditure, and GDP in log scale (lnENE, lnARR, lnEXP, lnGDP, respectively).

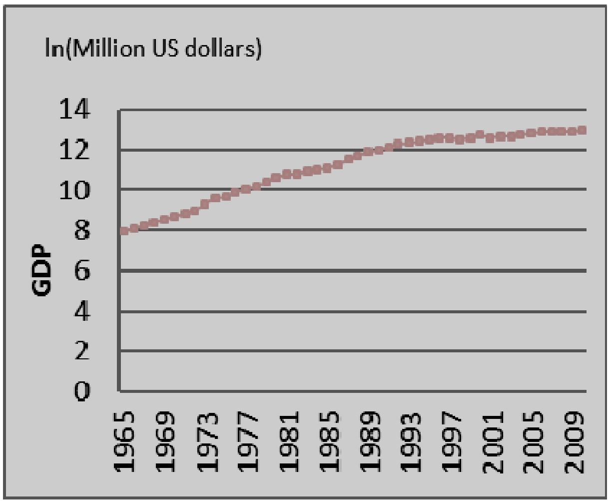

Fig.1 Trend Plot for GDP

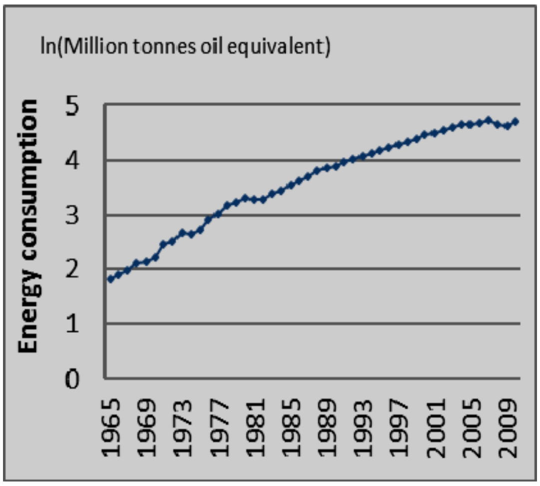

Fig.2 Trend Plot for Energy Consumption

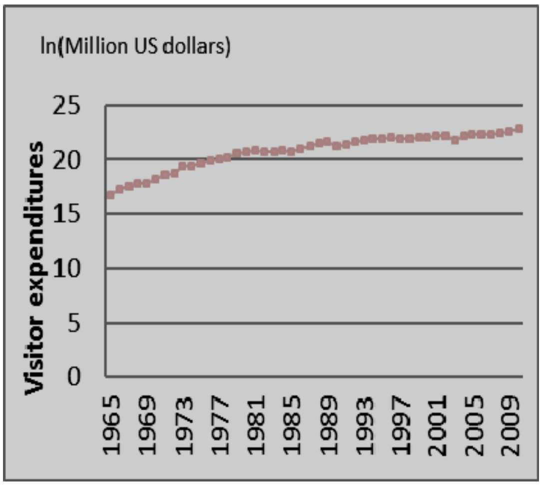

Fig.3 Trend Plot for Visitor Expenditures

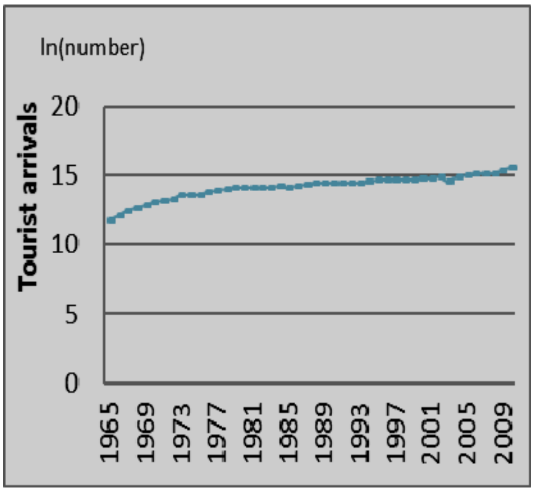

Fig.4 Trend Plot for Tourist Arrivals

The plots in Fig. 1 to 4 show that the trends of energy consumption, tourist arrivals, visitor expenditure, and GDP in log scale have similar patterns. The increasing trends may imply the characteristics of non-stationary in all four data series. For the precondition of cointegration, this study uses the ADF and PP tests to determine the order of integration for all variables in the model. Results were presented in Table 1.

As shown in Table 1, all four variables are non-stationary in level, but are stationary after the first difference. When the order of integration for all four variables is I (1), the Johansen approach can be used to test cointegration. The optimal lag length is determined with the Akaike information criterion [59] and Schwartz Bayesian criterion [60] in various VAR models with lags from 1 to 9, and the appropriate lag length is Lag 1 for all tested VAR models. This diagnostic checking, including the AR roots table, Granger causality, and lag exclusion test for VAR with Lag 1, confirms the appropriateness of this lag selection. Next, all five possible cases for Johansen cointegration with Lag 1 were estimated. Table 2 presents the results.

The Pantula principle with the cointegration rank test selected Case 5 with two cointegrating equations. After establishing the number of cointegrating vectors, it is possible to estimate the VECM. Table 3 shows the estimated results.

Two cointegrating equations were estimated as:

$$\ln ENE_{t-1} = -0.7939 + 0.0389t + 0.0314 \ln VIS_{t-1} + 0.2084 \ln GDP_{t-1} - 0.0000 \ln EXP_{t-1} \quad (9)$$

$$\ln EXP_{t-1} = -3.6817 - 0.0389\, t + 0.9426 \ln GDP_{t-1} + 0.8135 \ln VISt\text{-}1 \quad (10)$$

The first cointegrating equation shows that energy consumption has a long-term equilibrium relationship with GDP, tourist arrivals, and visitor expenditures. The second cointegrating equation shows that the visitor expenditures variable has a long-term equilibrium relationship with GDP and tourist arrivals. These results support Hypotheses 1, 3, and 5. Because energy consumption deviates from the equilibrium level, lnENEt-1 decreases and returns to the equilibrium level when $\ln ENE_{t-1} > -0.7939 + 0.0389t + 0.0314 \ln VIS_{t-1} + 0.2084 \ln GDP_{t-1} - 0.0000 \ln EXP_{t-1}$ or increases to the equilibrium level when $\ln ENE_{t-1} < -0.7939 + 0.0389t + 0.0314 \ln VIS_{t-1} + 0.2084 \ln GDP_{t-1} - 0.0000 \ln EXP_{t-1}$. Likewise, if visitor expenditures $\ln EXP_{t-1}$ deviates from the equilibrium level, it returns to the fundamental level: $-3.6817 - 0.0389t + 0.9426 \ln GDP_{t-1} + 0.8135 \ln VIS_{t-1}$. The signs of the coefficients in the cointegrating equations indicate that GDP and total tourist arrivals are positively related to energy consumption and visitor expenditures. Although visitor expenditures are negatively related to energy consumption, this relationship is weak because its coefficient estimate is almost 0.

The empirical results of Granger causality in Table 4 showed bidirectional Granger causality between GDP and energy consumption, total tourist arrivals, and energy consumption, and between visitor expenditures and energy consumption. These results support Hypotheses 4c and 6c. Results also show unidirectional Granger causality from visitor expenditures to international tourist arrivals. However, there is no any significant Granger causality in either direction between GDP and total tourist arrivals, GDP, and visitor expenditures. Thus, GDP and total tourist arrivals and GDP and visitor expenditures are not mutually associated, failing to support Hypotheses 2a, 2b, and 2c. Additionally, the effect of tourist arrivals on energy consumption (p = 0.0011) is substantially greater than that from visitor expenditures (p = 0.0139). This implies that an increase in tourist arrivals may result in greater energy consumption compared to visitor expenditures.

TABLE I. ADF AND PP TESTS

	Level		1st difference	
	ADF	PP	ADF	PP
LnARR	1.0000[a] (0)	. 9997[a](4)	.0002[b]***(0)	.0002 [b]***(0)
LnEXP	1.0000[a] (0)	.9999[a](3)	.0000[b]***(0)	.0000 [b]***(0)
LnGDP	.9993[b](0)	.9991[b](2)	.0002[b]***(0)	.0002 [b]***(0)
LnENE	.9874[b](0)	.9972[b](5)	.0000[b]***(0)	.0000 [b]***(0)

Notes: Values in ( ) are optimal lags for ADF and truncated lags for the PP based on AIC and SBC.
*: significant at 10%; **: significant at5%; ***: significant at 1%;
a. Neither drift nor trend is included in the unit root test.
b. Both drift and time trend is included in the unit root test.

TABLE II. THE JOHANSEN COINTEGRATION TEST RESULTS (BASED ON PANTULA PRINCIPAL)

Hypothesized number.of cointegrating equations	Casel 1	Case 2	Case 3	Case 4	Case 5
0	93.44939*** (0.0000)	117.5852*** (0.0000)	87.21709*** (0.0000)	118.2329*** (0.0000)	101.4282*** (0.0000)
1	37.64029*** (0.0006)	54.24768** (0.0002)	39.97232*** (0.0024)	65.05792*** (0.0001)	48.25425*** (0.0012)
2	15.57183** (0.0138)	27.19192*** (0.0047)	14.60888* (0.0677)	30.04781** (0.0142)	14.27909 (0.1715)
3	5.318226** (0.0251)	7.907237* (0.0861)	3.735139* (0.0533)	5.023781 (0.5930)	4.68E-05 (0.9961)

Notes: Numbers in cells are the trace statistic of Cointegration Rank Test. Values in ( ) are *p* values.
*: significant at 10%; **: significant at 5%; ***: significant at 1%;

TABLE III. COEFFICIENT ESTIMATES OF VECM

Error Correction:	$\Delta(LnENE)_t$	$\Delta(LnEXP)_t$	$\Delta(LnGDP)_t$	$\Delta(LnARR)_t$
ECT1	-0.793056	-12.65020	-1.053186	-7.156682
	[-1.09167]	[-3.10505]	[-1.17319]	[-3.50300]
ECT2	-0.295108	3.406552	0.852221	2.452298
	[-1.11334]	[2.29163]	[2.60180]	[3.28972]
$\Delta(LnENE)_{t-1}$	0.714995	11.31775	1.027862	6.249476
	[1.13764]	[3.21102]	[1.32346]	[3.53576]
$\Delta(LnENE)_{t-2}$	0.945814	11.42167	1.014229	6.399337
	[1.56938]	[3.37937]	[1.36187]	[3.77570]
$\Delta(LnENE)_{t-3}$	0.438088	8.736805	1.175033	4.545558
	[0.77126]	[2.74268]	[1.67404]	[2.84555]
$\Delta(LnENE)_{t-4}$	0.248890	6.024011	0.083548	3.079759
	[0.53520]	[2.30982]	[0.14538]	[2.35486]
$\Delta(LnENE)_{t-5}$	0.421751	3.161905	-0.031196	1.768085
	[1.02514]	[1.37043]	[-0.06136]	[1.52816]
$\Delta(LnENE)_{t-6}$	-0.196288	2.214917	0.370614	1.336759
	[-0.64814]	[1.30412]	[0.99031]	[1.56953]
$\Delta(LnEXP)_{t-1}$	0.148281	-3.464257	-0.767907	-2.237838
	[0.61224]	[-2.55054]	[-2.56580]	[-3.28554]
$\Delta(LnEXP)_{t-2}$	0.275227	-3.171152	-0.653822	-1.989487
	[1.20259]	[-2.47075]	[-2.31187]	[-3.09107]
$\Delta(LnEXP)_{t-3}$	0.253697	-1.940040	-0.361137	-1.099652
	[1.64306]	[-2.24044]	[-1.89272]	[-2.53241]
$\Delta(LnEXP)_{t-4}$	0.208732	-0.873000	-0.208582	-0.617844
	[2.37837]	[-1.77373]	[-1.92328]	[-2.50328]
$\Delta(LnEXP)_{t-5}$	0.204940	-0.260486	-0.048749	-0.380043
	[2.96520]	[-0.67204]	[-0.57078]	[-1.95524]
$\Delta(LnEXP)_{t-6}$	0.112886	-0.254260	-0.019983	-0.122113
	[1.79333]	[-0.72025]	[-0.25689]	[-0.68980]
$\Delta(LnGDP)_{t-1}$	-0.618048	0.359952	0.307963	0.324946
	[-2.65075]	[0.27528]	[1.06886]	[0.49556]
$\Delta(LnGDP)_{t-2}$	-0.298419	1.941519	0.037646	0.952542
	[-1.38848]	[1.61078]	[0.14174]	[1.57593]

Δ(LnGDP) $_{t-3}$	0.134532	0.305869	0.165085	-0.003277
	[0.61699]	[0.25013]	[0.61268]	[-0.00534]
Δ(LnGDP) $_{t-4}$	-0.004002	-1.571730	-0.123929	-0.340664
	[-0.01767]	[-1.23752]	[-0.44283]	[-0.53488]
Δ(LnGDP) $_{t-5}$	-0.239799	-1.107545	-0.950679	-1.243835
	[-1.07263]	[-0.88338]	[-3.44122]	[-1.97836]
Δ(LnGDP) $_{t-6}$	0.268348	-2.568117	-0.344785	-1.427073
	[0.87644]	[-1.49562]	[-0.91127]	[-1.65733]
Δ(LnARR) $_{t-1}$	-0.261793	0.963600	0.465967	0.607740
	[-1.58673]	[1.04141]	[2.28547]	[1.30979]
Δ(LnARR) $_{t-2}$	-0.428796	0.026679	0.310015	0.087971
	[-2.96837]	[0.03293]	[1.73670]	[0.21654]
Δ(LnARR) $_{t-3}$	-0.404806	-1.225658	0.110770	-0.712236
	[-3.06081]	[-1.65250]	[0.67777]	[-1.91493]
Δ(LnARR) $_{t-4}$	-0.443997	-1.833826	-0.129093	-1.065882
	[-2.66612]	[-1.96355]	[-0.62731]	[-2.27588]
Δ(LnARR) $_{t-5}$	-0.234164	-2.170484	-0.151093	-0.886727
	[-1.53552]	[-2.53790]	[-0.80178]	[-2.06759]
Δ(LnARR) $_{t-6}$	-0.025038	-0.632993	-0.133004	-0.328215
	[-0.17935]	[-0.80848]	[-0.77095]	[-0.83596]
Constant	-0.135137	-0.747492	0.545141	-0.164775
	[-0.69460]	[-0.68510]	[2.26750]	[-0.30116]
TREND	0.002693	-0.004061	-0.013505	-0.006494
	[0.74636]	[-0.20070]	[-3.02881]	[-0.63994]
R-squared	0.905756	0.803522	0.932039	0.819509
Adj. R-squared	0.674431	0.321259	0.765226	0.376486
F-statistic	3.915512	1.666149	5.587317	1.849812
Log likelihood	108.4433	41.19892	100.1884	68.11732
Akaike AIC	-4.125297	-0.676868	-3.701971	-2.057298
Schwarz SC	-2.930945	0.517484	-2.507619	-0.862946
Mean dependent	0.057679	0.112123	0.100830	0.059835
S.D. dependent	0.049508	0.192294	0.072044	0.100609

Notes: *t*-statistics in [ ]

TABLE IV. SUMMARY OF THE MULTIVARIATE GRANGER CAUSALITY TESTS BASED ON THE VECM

		Y			
		ΔLnENE	ΔLnARR	ΔLnEXP	ΔLnGDP
X	ΔLnENE		23.22081*** (0.0007)	18.09976*** (0.0060)	15.67978* (0.0156)
	ΔLnARR	22.19498*** (0.0011)		10.22276 (0.1156)	5.794509 (0.4466)
	ΔLnEXP	15.96602** (0.0139)	13.36456** (0.0376)		9.837708 (0.1317)
	ΔLnGDP	16.13422** (0.0131)	8.127565 (0.2289)	8.043900 (0.2349)	

Notes: Null Hypothesis: "X" does not Granger Cause "Y". Figures in the cell are Chi-square statistics. *: significant at 10%; **: significant at 5%; ***: significant at 1%; Values in () are *p* values.

IX. DISCUSSION AND CONCLUSIONS

This study investigates the causal relationships among tourism development, economic growth, and energy consumption using Granger causality analysis for the period of 1965 to 2010 in Taiwan. A longer time span and the adoption of annual data instead of quarterly data were applied to avoid possible volatility caused by seasonality. Based on the Granger causality tests, three major study results have emerged. Firstly, there is no long-term reciprocal causal relationship between tourism development and economic growth. Neither tourism development indicators (i.e., visitor expenditures and international tourist arrivals) Granger causes with GDP; suggesting that the TLGH is not supported in this study. Contrary to previous Taiwan studies by Kim *et al*. [23] which suggested a bidirectional relationship between economic growth and tourism development, and Chen and Chiou-Wei [35], which implied a unidirectional relationship from tourism development to economic growth. Kim's study inappropriately adopted VAR for long-term Granger causality analysis as discussed previously. As to Chen and Chiou-Wei's study, it misused EGARCH-M model to handle quarterly data with seasonality. Main reasons for no long-term reciprocal causal relationship between tourism development and economic growth are twofold: first, according to the World Travel & Tourism Council (WTTC) [61], tourism contributed to only 3.6% of Taiwan's GDP in 2010. Based on Oh's [31] arguments, the tourism industry in South Korea contributed to 3.5% GDP, and their study did not support the TLGH. Considering the similarity of tourism industry share of GDP in Taiwan and Korea, it is suggested the TLGH is not valid in Taiwan. Second, Kim and Chiou-Wei's studies conducting Granger causality tests in a bivariate framework are likely to be biased due to the omission of relevant variables affecting aggregate output and energy consumption [41].

Secondly, this study supports the feedback hypothesis by observing bidirectional causality between economic growth and energy consumption. This result is consistent with Yan's study [62] in Taiwan, but differs from the findings of Cheng and Lai [40] which suggested a unidirectional causality running from GDP to total energy consumption.

Thirdly, the test results indicate a long-term equilibrium relationship and bidirectional causality between energy consumption and tourism development. Specifically, international tourist arrivals Granger causes more significantly with energy consumption than visitor expenditures. Since based on our first finding, neither total tourist arrivals nor visitor expenditures are significantly associated with GDP, limiting the number of visitors may be an appropriate strategy for reducing energy consumption without harming tourism development. Therefore, we suggest promoting tourism activities with higher expenditures instead of operating low-budget travels to help balance tourism development and energy consumption. Thus, policymakers and industry leaders should focus on developing high-value, high-profit tourism products, such as medical tourism, to increase visitor expenditures rather than international tourist arrivals.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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