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ECONOMIC GROWTH AND INTERNATIONAL VISITORS TO MEXICO: A VAR MODEL

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Mexico's momentum in economic growth recently has been lost, reporting 1.8% and 2.1% annual increases in total real gross domestic product (GDP) in 2013 and 2014, respectively. Policy reforms, particularly energy policy, intended to stimulate greater growth will need time to take hold. Increasingly, the tourism industry is viewed a potential growth driver of Mexico's economy. We estimate a vector autoregressive (VAR) model to explore the relationship between Mexico's GDP and the number of international visitors over time. Our results reveal a Granger causality relationship between GDP and the number of international tourists over the period of the study, which suggests that the promotion of tourism can generate significant support to the economic dynamism of the country.

Keywords: GDP, International tourism, VAR Model

INTRODUCTION

The review by Romero and Molina (2013) found that from a total of 87 studies, 55 demonstrated an unambiguous relationship linking tourism to economic growth, 16 of them identified an ambiguous causal relationship, and 9 of them found that the connection was flowing from the economic growth to tourism, while the rest (7) found no statistical relationship between the variables.

This body of research examines the various ways in which a flow of benefits from international tourism to national economies might be observed. Among others, we can deduce that tourism: i) increases (export) income from foreign exchange that could be used to finance imports; ii) encourages investment and creates incentives for local enterprises to improve quality and/or increase efficiency due to increased competition; iii) reduces unemployment, since tourism activities typically require relatively high levels of labor in the input mix; and, iv) generates economies of scale due to decreases in production costs for local enterprises.

Among the studies that found an unambiguous relationship, Lanza et al.(2003) and Seqyeruia and Nunes (2008) found that the size of a country is not important for verifying the tourism led growth hypothesis (TLGH). Adamou and Clorides (2010) and Holzner (2011) also argue in favor of the TLGH, but additionally emphasize that the level of tourism specialization in the national economy does matter.

Although empirical evidence suggests that tourism activities generate economic growth are abundant, the relevant literature can also point to a different conclusion; the most plausible being that economic growth positively affects tourism (reversing the hypothesized causality). For example, Payne and Mervar (2010) conclude the economic development of a country is dependent on a set of well-designed economic policies, government structure and investments in physical and human capital. In turn, these elements create a socioeconomic climate that encourages tourism activities.

Narayan (2004) employs a autogregressive distributed lag framework with cointigration and error modelling techniques and finds that an increase in per capita income among Fijians resulted in greater international tourism visits to the island nation from 1970 to 2000. Results showed that a 1% increase of the GDP in Australia, New Zealand and the USA implied an increase in tourist arrivals to Fiji of 3.6%; 3.1% and 4.3% respectively. Using a bivariate autoregressive vector on quarterly data from 1975 to 2001, Oh (2005) found that the economic expansion of South Korea had a positive effect on the number of international visitors. Similarly, using a Toda-Yamamoto causality test, Payne and Mervar (2010) found a positive effect of GDP on international tourism activity in Croatia from 2000-08. The autors followed the Toda-Yamamoto causality test.

In some cases statistically relevant correlation is found between international tourism and economy wide growth, but the direction of causality is not clear. Chen and Chiou (2009) use an EGARCH model, Riderstaat et al. (2013) employ cointegration and Granger causality analysis, and Apergis and Payne (2010) with a panel correction model, among others, all found evidence of bidirectional causality between tourism and economic growth, implying that the government should attend to general and sectoral stimulous policies simultaneously.

Finally, some studies conclude there is insufficient support of the hypothesis that general economic growth and growth of international tourism are connected. Although Figini and Vici (2009) find that a one standard deviation increase in the tourism specialization index would induce a 0.58% increase in national growth rates for the 1980-2005 period, they also argue that these results are problematic since endogeinity and lack of control variable may be important. Finals results, when using controls like investment or a tourism specialization coefficient, become relatively unconvincing or insignificant.

Here, the hypothesis is tested for the Mexican case using a vector autoregressive, or VAR, model. Our principal finding is evidence of the existence of Granger Causality from international tourism activity to national economic growth. This result is the most important because it demonstrates that public or private investments or policies to encourage the sectoral growth will influence the national growth trajectory.

METHODOLOGY

The VAR Model is a tool of multivariate time series, originally proposed by Sims (1980) for macroeconomic analysis. For a system with two variables, the causality can be analyzed in three ways: X causes Y; Y causes X; or X causes Y at the same time that Y causes X. Finally, analysis of the data may reveal no causal link between the focal variables; they are statistically independent. According to Lutkepohl (2005, 2011) and Enders (2004), the object of interest in the VAR Model (p), represented as:

$$y_t = v + A_i y_t - 1 + \cdots + u_t, t = 0, \pm 1, \pm 2, \dots,$$

Where $y_t = (y_{1t}, \dots, y_{Kt})'$ is a random vector (Kx1), A_i is represented by a matrix of the size (k x k) and the coefficient vector is specified as $\nu = (\nu_1, \dots, \nu_K)'$, that represents a vector of the size (k x 1). Finally, $u_t = (u_{1t}, \dots, u_{Kt})'$, is a k-dimensional matrix, of white noise or innovation process, that is the same to $E(u_t) = 0$, $E(u_t u'_t) = \Sigma u$ and $E(u_t u'_s) = 0$ for s ‡ t.

The covariance matrix Σ_u is assumed to be nonsingular. The first step for modeling a time series through a VAR model requires a stable Ai matrix that can be inverted. To test these properties, it is convenient to represent a VAR model with only one lag as:

$$y_t = v + A_1 y_{t-1} + u_t.$$

Assuming that the dynamic process starts at t=1, then we have:

$$y_1 = v + A_1 y_0 + u_{t1},$$
$$y_2 = v + A_1 y_1 + u_2 = v + A_1(v + A_1 y_0 + u_1) + u_2$$
$$(I_K + A_1)v + A_1^2 y_0 + A_1 u_1 + u_2,$$
$$y_t = (I_K + A_1 + \cdots + A_1^{t-1})v + A_1^t y_0 + \sum_{i=0}^{t-1} A_l^i \, u_{t-i}$$

and, the vectors $y_1 \dots y_t$ are only determined by $u_0, u_1, \dots, u_t$. Also, the union of the distribution of $y_1 \dots y_t$ is determined by the union of the distribution of y_0, u_1, u_t.

Although the process began at a specific time, it is convenient to assume that it began in the infinite past. To find to find a process consistent with this assumption, we have to consider the VAR (1) process again, with the following representation:

$$y_t = v + A_1 y_{t-1} + u_t.$$
$$= \left(I_K + A_1 + \cdots + A_1^j\right)v + A_1^{j+1} y_{t-j-1} + \textstyle\sum_{i=0}^{j} A_1^i \, u_{t-i}$$

If all the eigenvalues of A_1 have a modulus of less than 1, the sequence

$$A_l^i, i = 0,1, \ldots,$$

In absolute terms, the sum of the elements is infinite and it can be represented as:

$$\sum_{i=1}^{\infty} A_1^i \, u_{t-i}$$

However, considering the next expression:

$$\left(I_K + A_1 + \cdots + A_1^j\right)v \underset{j\to\infty}{\rightarrow} (I_K - A_1)^{-1}\, v$$

Where, $A_l{}^{j+l}$ converge from zero quickly as $j \to \infty$, and the term $A_l{}^{j+l}y_{t-j-l}$ is represented at the limit. Thus, all the values of A_1 have the modula of less than 1, and if y_t is a VAR (1) process, then y_t is well defined like a stochastic process:

$$y_t = \mu + \sum_{i=0}^{\infty} A_l^i u_{t-i,}\; t = 0, \pm 1, \pm 2, \dots,$$

Where: $\mu \coloneqq (I_K - A_1)^{-1}v$

The distributions and united distributions of y_t's are only determined because of the distribution of processes u_t. If these processes are satisfied, then we are in position to guarantee the stability of the VAR process and we can continue with its representation, its bounding and its estimation. To ascertain the bounding, the estimation and the identification properties, is necessary to identify the optimal lag length according to the following criteria:

i) Akaike Criterion (AIC) establishes an optimal lag at the minimum value of:

Det $\ln\left|\hat{\sum}(p)\right| + K^2\, p\,\frac{2}{T}$

Where $\hat{\sum}$ represents the covariance matrix obtained by applying OLS (Ordinary Least Squares) to the VAR model; P is the number of lags, K represents the number of variables and T is the sample size.

ii) Hannan and Orwin Criterion (HQC) estimates the minimum value of:

Det $\ln\left|\hat{\sum}(p)\right| + K^2\, p\,\frac{2\ln(lnT)}{T}$

iii) Schwarz / Bayes Criterion (SBIC) establishes the minimum determinant corresponding to:

$$\text{Det} \ln\left|\hat{\Sigma}\,(p)\right| + K^2\, p \text{ - } \frac{lnT}{T}$$

Where $\hat{\Sigma}$ is the covariance matrix in obtained by Ordinary Least Squares (OLS). Then, the length of the lag has to be chosen according to the minimum value of these criteria.

When these techniques do not generate a concensus choice of the optimal lag, we can resort to a Likelihood Ratio (LR) test, to find the appropriate criterion to choose the number of optimal lags. This test consists of comparing the result of a VAR (0) model with the result of a VAR (1) model, and with the result of a VAR (2) model and so on. The LR Criterion is obtained from estimating the determinant in the next equation:

$$(T - P_2K^2)Det \ln\left|\hat{\Sigma}\,(P_1)\right| - \ln\left|\hat{\Sigma}\,(P_2)\right|$$

Where, P_1= 1 is the restricted model lag, and, P_2 = 2 is the unrestricted model lag. In a restricted VAR a value and/or a defined structure is included (like in Granger Causality). A general VAR does not present this kind of restriction, so it is known as an *unrestricted VAR*. Then, the results of the LR Criterion of the VAR (0) restricted with the VAR (1) unrestricted (more generally) will be compared and the one with the higher value of $p \leq 0.05$ is chosen.

GRANGER CAUSALITY

Granger Causality is a concept exclusive to VAR with no counterpart in the Theory of Univariate Series. It represents a standard method of determining when a variable predicts another and, also, it provides a means to reach a decision of when a VAR model is appropriate.

Granger Causality is defined when a random scalar variable {Xt}. It is said that does not demonstrate causality –in Granger sense – when the variable {yt} is:

$$E[y_t x_{t-1}; y_{t-1}; x_{t-2}; \dots] = E[y_t y_{t-1}; y_{t-2}; \dots]$$

This means that the variation of the value of y_t only depends on the values of that same variable y_t at the time t-1, t-2, etc.… and does not depend on the values of x_t. This formulation is appropriate to evaluate Granger Causality at the mean.

Lütkepohl (2005) indicates that the definition can be explained as a definition at the mean in the variance or in the distribution of probabilities. However, Enders (2004) explains that the definition at the mean variance is easier to understand because it uses scalar vectors that are easier to compare among them, than the variance of distributions. For this reason, we have adopted Enders' Criterion as follows.

Generalizing Granger Causality, we have that for a VAR (p) k-dimensional:

$$y_t = \emptyset_0 + \emptyset_1 y_{t-1} + \emptyset_2\, y_{t-2} +, \ldots + \emptyset_k y t_p + \in t$$

or

$$y_t = VA_1 y_{t-1} + A_2 y_{t-2} +, \ldots + A_p y t_p + \in t$$

if:

$\emptyset_{ij,1} = \emptyset_{ij,2} = \emptyset_{ij,3}, \ldots.. \emptyset_{ij,p} = 0$

Thus, the quotient or verisimilitude test can be calculated as:

$$(T - (PK^2 - K)\ (\ln|\widehat{\Sigma r}| - \ln|\hat{\Sigma}\, u|))$$

Where, $\hat{\Sigma}_r$: the estimated residual covariance of the restricted VAR y $\hat{\Sigma}_\upsilon$: the estimated residual covariance of the unrestricted VAR. This expression is similar to the verisimilitude test (Likelihood Ratio) for optimal lags, but with the following differences: a) It no longer depends on P (number of lags) and, b) The covariance of the restricted VAR model and the unrestricted VAR model ($\hat{\Sigma}$) can be extracted from this new residual model.

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Estimation of the VAR Model by OLS (Ordinary Least Squares)

Now, to describe the process of the technique of the Ordinary Least Squares in a VAR model, we proceed to find the estimator on the next expressions:

$$Y = (y_1, \dots y_T)(K * T)$$
$$B_1 = \left(V, A_1, \dots A_p\right)[K * (Kpt)]$$
$$Ƶ_i = \begin{bmatrix} 1 \\ yt \\ y - p - t \end{bmatrix} [\left(K_{p+1}\right) * T]$$
$$Ƶ = [Z_0, \dots Z_{T-1}]\ [(Kp + 1) * T]$$
$$u_i = (u_i \dots u_T)(K * T)$$

We assume that we have y_1,….. y_T, time series of a sample of the size T for each one of the K variables. Now, considering P lags, we can rewrite the VAR (p) as:

$$y_t = VA_1 y_{t-1} + A_2 y_{t-2} +, \dots + A_p yt_p + Ut$$

Using these expressions, we can show the VAR as: Y = BZ + U. To find the size of the matrix B, we have to re-express the VAR model in matrix terms, as:

$$Y = BZ + U$$

Now, to estimate the value of B, we take the expression Yt= BƵt_{-1} Ƶ$^1t_{-1}$ + Ut and we multiply it by Ƶt_{-1}, to obtain:

$$Y_t = BZ_{t-1} Z_{t-1}^1 + U_t Z_{t-1}^1$$

Where Ƶ$^\circ t_{-1}$ is the transposed matrix of Ƶt_{-1}. Once the multiplication is complete, we obtain the expected value of each member of the equation:

$$E(y_t Z_{t-1}^1) = \frac{1}{T} \sum_{t=r}^{T} yt\ \ Ƶ^1 t_{-1}$$

The main interest in obtaining the expected values is to convert a vector expression in a scalar expression. Thus, the expectation of B is equal to:

$$E(BZ_{t-1}\, Z_{t-1}^1) = BE(Z_{t-1}\ \ Z_{t-1}^1)$$

Assuming that B is a constant value matrix:

$$= B\,\frac{1}{T}\sum_{t}^{T} Z_{t-1}\;Z_{t-1}^{1}$$

Then, obtaining the expected value of:

$$E(BZ_{t-1}\,Z_{t-1}^{1}) = \frac{1}{T}\sum_{t=r}^{T} Z_{t-1}\;Z_{t-1}^{1}$$

This expression represents the expected value of only one product. Finally, we obtain the expected value of Shock UƵt-1, where, $E(U + Z_{t-1}) = 0$ y Ƶt-1= $\begin{pmatrix} 1 \\ yt \end{pmatrix}$

Therefore, we have:

$$E(Y + Z_{t-1}) = E(BZ_{t-1}\,Z_{t-1}^{1})$$

$\frac{1}{T}\sum_{t=r}^{T}$ Ƶ¹t-1 = $B\;\frac{1}{T}\sum_{t=r}^{T}\;Z_{t-1}\,Z_{t-1}^{1}$

This expression can be rewritten as:

$\frac{1}{T}$ YƵ¹ = $\frac{1}{T}$ B Ƶ Ƶ¹

Since $\frac{1}{T}$ represents a scalar number, the expression can be reduced, which yields:

$$YZ = BZ\,Z^{1}$$

As with the other matrix expressions, the problem reduces in only the inverse matrix of Ƶ Ƶ¹, to finally get the B value:

(Y Ƶ¹) (Ƶ Ƶ¹)⁻¹ = B (Ƶ Ƶ¹) (Ƶ Ƶ¹)⁻¹

This multiplication gives us a result, the identity matrix:

$$(Y\,Z^{1})(ZZ^{1}) = B * I = B$$

To finally get to:

$$(YZ^1)(ZZ^1) = B$$

RESULTS

The analysis presents the unit root test for the time series of the variables that were used in the model using Augmented Dickey-Fuller (ADF), Phillis-Perron (PP) Kwiatowski-Phillips-Smicht-Shin (KPSS) tests. The ADF and PP Tests are based on the fact that the null hypothesis establishes that the respective time series are stationary in difference while the unit root test of KPSS is based on the fact that the null hypothesis establishes that the time series are stationary in tendency.

Table 1. Unit Root Test

Variable	**ADF (C)**	**ADF (C+T)**	**PP (C)**	**PP (C+T)**	**KPSS (C)**	**KPSS (C+T)**
GPIB	-0-10	-2.55	-0.37	-2.46	0.65	0.12
ΔPIB	-5.87	-5.92	-5.94	-6.05	0.09	0.06
Int Tourists	-0.59	-2.19	-0.56	-2.41	0.89	0.11*
Δ Int Tourists	-5.57	-5.48	-5.58	-5.50	0.09	0.08

Notes: Critical values for the ADF(C) and PP(C) unit root tests which include only a constant: a(1%) -3.66, b(5%), -2.96, and c(10%) -2.61. Critical value for the KPSS(C) unit root test which includes only a constant: a(1%) 0.739, b(5%) 0.463, and c(10%) 0.347. Critical values for the ADF(C + T) and PP(C + T) unit root tests which include both a constant and trend: a(1%) -3.66, b(5%) -2.96, and c(10%) -2.61. Critical values for the KPSS(C + T) unit root test which includes both a constant and trend: a(1%) 0.21, b(5%) 0.14, and c(10%) 0.11.

The evidence shows that the time series are stationary again when it has generated the first differences and that is why we can suspect that the order of integration is equal to one (1). If the long-run relationships remains stable during the time period's sample, it is possible to assure that a structural change does not exist, and the outcomes will be more robust. The structural change test, suggested by Bai and Perron (2003) was implemented for the log series individually. No breaks were found using the minimum parameter value of the Schwartz information criterion.

Empirically, we follow the proposal used by Toda & Yamamoto (1995) to apply the asymptotic distribution theory. Basically, the proposal uses a VAR model (p+d) to generate the Granger Causality Test, if the variables are integrated (*p* presents the order of lags of the VAR and *d* the order of integration of the incorporated variables).

Table 2 shows the Akaike (AIC); Hanna (HQ); Schwarz (SC) and Final Predictor (FPE) criteria to estimate the optimal lag of the series.

Table 2. Optimal lags of the VAR model series

Lag	**AIC**	**HQ**	**SC**	**FPE**
1	0.0724	0.07257	0.07271	0.0003071
2	0.0719	0.07207	0.07228*	0.0001748
3	0.0718	0.07201	0.07296	0.0001575
4	0.07173	0.07196*	0.07231	0.0001429
5	0.07170*	0.07198	0.07240	0.0001390*
6	0.07174	0.07206	0.07255	0.0001442
7	0.07176	0.07213	0.07269	0.0001483
8	0.07182	0.07223	0.07286	0.0001573
9	0.07183	0.07230	0.07229	0.0001608
10	0.07173	0.07225	0.07301	0.0001468

* indicates lag order selected by the criterion
AIC: Akaike information criterion; HQ: Hanna-Quartz information criterion; SC: Schwarz information criterion; FPE: Final prediction error

In the table we can see that under the AIC and FPE criteria the optimal number lags is five. However, using the HQ criterion, the optimal number of lags is four and two based on the SC. As a result, the number of lags terms to use is inconclusive. We used the Portmanteau test on the three models under consideration (five, four and two lags) to test the null hypothesis that the residuals of these models are not correlated with obtaining the results.

Table 3. Serial Correlation Test

Model	Chi-square	p-value
Two Lags	82.7751	0.01153
Four Lags	57.9368	0.1542
Five Lags	53.0608	0.1644

Clearly, the models with four and five lags stop being seriously correlated. Following the Toda & Yamamoto (1995) criterion, we choose the five lag model, due to its superior p-value.

According to the Toda & Yamamoto (1995) process, a VAR model (p+d) should be considered. Therefore, with five lags in total and taking into account that the order of the co-integration is one, the VAR model to be estimated becomes part of a bi-dimensional model with six optimal lags.

Using a statistical series for GDP and international tourists from the World Bank, we can estimate a VAR model that is both a stable system and is invertible, as we can see in Table 4 of the roots of the characteristic polynomial. Table 4 illustrates that all numbers are greater unity, implying that time series of the VAR model does not diverge.

Table 4. Stability of the models test

Model	GDP	International visitors
Root of the characteristic polynomial with two lags	1.2300	1.2300
Root of the characteristic polynomial with two lags	1.1646	1.1818
Root of the characteristic polynomial with two lags	1.065	1.1990

Finally, the Wald test establishes that there is only one causal relationship, and this goes from the tourism to the GDP, with $p < 0.033$ in the first panel of the next table

Table 5. Wald Test

Dependent Variable: Logarithm of GDP			
	Chi-square	Grades of freedom	P-value
L international visitors	12.2	5	0.033
Could not be rejected (X2=8.6; p=0.2)			
Dependent Variable: L international visitors			
	Chi-square	Grades of freedom	P-value
LPIB	6.3	5	0.28
Could be rejected at 10% (X2=12.3; p=0.056)			

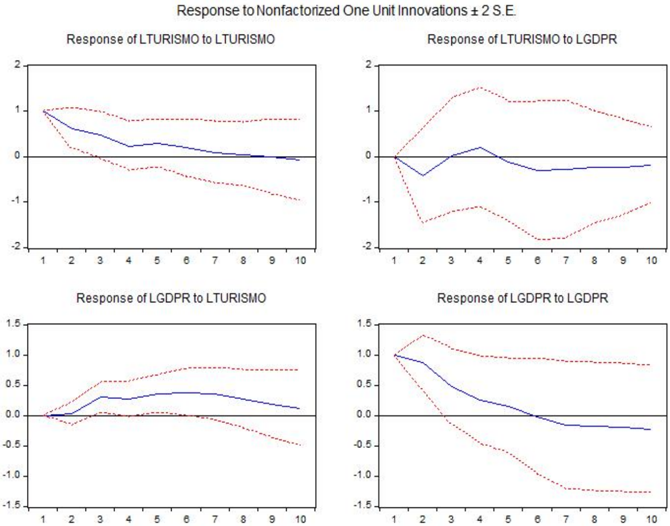
The Wald Test results we obtained establish that there is only one causal relationship in the long term between the tourist expenditure and GDP variables and that the causality goes from tourist expenditure to GDP. With all former test results it is possible to have an empirical convergence vector estimation of the time series, as highlighted in Table 6. Our results indicate a 10% increase in international tourists arrivals to Mexico results in an almost 2% increase in GDP per capita using one period lag of the explanatory variable.

Table 6. Convergence vector estimation

Variable	Coeficient	Standard deviation	T-stat
LGDPR (-1)	0.165324	0.023	7.18
LTURISMO (-1)	0.0189	0.0093	2.03

In order to look at the dynamic path of a tourist shock per capita GDP in Mexico an impulse response analysis was undertaken (Figure 1).

Figure 1. Impulse response of GDP to Tourism shocks.



Focusing on the response of LGDPR to LTURISMO, we show that a positive shock to the tourism sector results in a positive response to GDP after the second term and this effect remains positive over the next five terms (second graph to the bottom left).

Despite the knowledge that Mexico is a developing country with a relatively low level of tourist specialization and considering that the variable representing tourism was used in an unstructured VAR model, this study shows that there is solid empirical evidence that tourism activity has a positive impact on per capita income in Mexico over the study period. Exploring the vulnerability or sensitivity of tourist activities to additional variables potentially correlated with GDP levels or growth rates, such as lower crime rates, good transport network, good tourism infrastructure, low levels of poverty, public health events, etc., should be viewed as potentially useful future directions to research expansion in this area of inquiry.

Our conclusions support the results obtained by Brida (2008); Gallegos (2010); Nonthapot and Ueasin (2014) and Zeren (2015) in the direction of causality of the variables, but not in the magnitudes of the effects. Potentially, a different time series and different tourism variable specification may be responsible for these differences. Therefore, we find that supporting economic growth through increased investment in the tourism sector is a good idea, especially since the effects of recent energy policy reform will take some years to consolidate.

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