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EXAMINING THE STABILITY OF THE LONG-RUN RELATIONSHIP BETWEEN TOURISM AND ECONOMIC GROWTH FOR PUERTO RICO

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This study empirically examines the stability of the long-run relationship between tourism and economic growth for Puerto Rico using annual data for 1960–2016. Robust results across several model specifications support the existence of a long-run equilibrium relationship between real GDP, real tourism receipts, and real exchange rate. Contrary to many previous studies that either explicitly or implicitly assume the stability of the cointegrated vector, the authors apply formal stability tests developed by Hansen and Johansen to investigate the long-run parameter constancy issue. Tests for long-run parameter stability reveal that the hypothesis of stable long-run parameters could not be rejected. The results indicate that tourism is a stable source of economic growth for Puerto Rico and Granger causality tests based on the error-correction model indicate a unidirectional causality from tourism receipts to real GDP.

Key words: Causality; Cointegration; Stability; Puerto Rico; Tourism-led growth

Introduction

Due to the evolving importance of the tourism industry for the Puerto Rican economy, this study investigates the impact of tourism on the island's economic growth. As a major tourist destination, Puerto Rico is overwhelmingly an understudied case in the literature when compared to other tourist destinations. Therefore, it is essential to empirically examine the significance of tourism for Puerto Rico, an economy that received over 5 million visitors in 2016, spending close to $4 billion, amounting for 6.2% of total export revenues and 3.9% of GDP (World Travel and Tourism Council [WTTC], 2018).

In addition to testing the validity of the tourism-led growth hypothesis (TLGH), this study also examines the stability of the cointegration relationship in the cointegrated vector autoregression model (henceforth CVAR). Unlike many previous studies that assume (either explicitly or implicitly) the stability of the long-run relationship in a CVAR, the authors formally assess the parameter-constancy issue by applying Hansen and Johansen's (1999)

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formal stability tests that are uniquely developed for CVAR models. If the results indicate that the TLGH is valid and stable for Puerto Rico, then private and public policies to promote the tourism industry should be considered.

Long-run stability ensures that the full sample period defines a constant parameter regime—that is, the parameters of the cointegration relationship do not excessively fluctuate over time. Hansen (1992) pointed out that, "model stability is necessary for prediction and econometric inference. While model instability generically makes it difficult to interpret regression results, it is of particular importance in policy analysis to know if econometric models are invariant to possible policy interventions" (p. 517).

The determination of the causality pattern between tourism receipts and economic growth has important policy implications concerning the appropriate growth and development strategies and policies a nation may pursue. As such, the present study contributes to the literature in the field of tourism-led growth in the following ways. First, to validate the TLGH for Puerto Rico, a system based cointegration test technique (Johansen, 1988) and a single equation bounds cointegration test method (Pesaran et al., 2001) are applied to ensure the robustness of the cointegration test results. Second, this study properly applies the ARDL bounds test by computing the F and the t tests, to determine the presence of a long-run relationship. If the F test rejects its null hypothesis, then, as suggested by Pesaran et al. (2001), computing the t test is essential to avoid the dependent variable degenerate case (i.e., no cointegration). Third, this study, to the best of our knowledge, is the first to apply the augmented ARDL bounds test proposed by Sam et al. (2019) to complement Pesaran et al.'s (2001) two tests. Sam et al. (2019) introduced an additional F test on the significance of the lagged independent variable(s) in order to avoid the degenerate lagged independent variable case discussed by Pesaran et al. (2001).

Fourth, long-run estimates based on Johansen's full information maximum likelihood (FIML) and Pesaran et al.'s (2001) ARDL approaches in addition to utilizing Stock and Watson's (1993) dynamic OLS (DOLS) are reported to ensure the consistency of the long-run estimates.

More importantly, despite the significant impact of the tourism industry on the island's economic growth, the authors found no recent time-series study that tested the validity and stability of the TLGH for Puerto Rico. Using the most up to date data (1960–2016), this study fills another gap in the literature in that regard. In addition to statistically establishing tourism as a "stable" source of economic growth for Puerto Rico, the authors propose, for the consideration of policymakers, a visa waiver program exclusive to Puerto Rico that may increase the relative competitiveness and diversity of tourism for the island. We hope that the findings from the present study may shape the posthurricane reconstruction effort, and policy discussions for the future of the island.

Literature Review

There has been an increasing number of studies investigating the validity of TLGH in recent years. A comprehensive literature survey on tourism growth is given in the study of Brida et al. (2016). Therefore, to preserve space, the authors discuss selected papers relevant to this study.

The validity of TLGH was examined for Puerto Rico's Caribbean competitors (i.e., the Bahamas, Barbados, and Jamaica) in a 2010 study (Singh et al., 2010). In this bivariate analysis of tourism receipts and GDP for the 1970–2008 period, Singh et al.'s panel cointegration test results revealed no long- or short-run support for the TLGH.

Using annual data (1972–2011) for Aruba and employing the Engle–Granger cointegration test, Ridderstaat, Croes, and Nijkamp (2014) found bilateral causality between tourism and economic growth. Vanegas (2012) investigated the TLGH for El Salvador for the period 1967–2010 using Johansen's approach, and found support for the TLGH.

Utilizing Johansen's approach, Croes and Rivera (2010) examined the bivariate relationship between tourism and the competitiveness of Puerto Rico using annual data from 1960–2004. Their Granger causality results reveal "short-run" unidirectional causality from tourism spending to competitiveness.

Jaforullah (2015) used Johansen procedure in a trivariate model for New Zealand (1972–2012). He found support for the TLGH, and Granger causality tests revealed a unidirectional causality, from tourism to economic growth. Using Johansen, Husein and Kara (2011) found a stable and significant long-run equilibrium relationship among GDP, exchange rate, and tourism receipts for Turkey for the 1964–2006 period. Granger causality tests based on the ECM indicated a unidirectional causality from tourism receipts to real GDP.

Alodadi and Benhim (2015) found no evidence supporting a causal relationship between religious tourism and economic growth in Saudi Arabia for the 1970–2011 period for the economy as a whole, based on Johansen technique. However, when isolating the non-oil sectors, religious tourism had a greater influence on economic growth.

The rest of the article is organized as follows. Section 3 presents an overview of tourism in Puerto Rico. Section 4 presents the data and unit root test results. Section 5 presents the methodology and empirical results. Section 6 is stability analysis and section 7 is the conclusion.

Tourism in Puerto Rico

Puerto Rico is a Caribbean Island with 3.41 million inhabitants in 2016. The US acquired Puerto Rico, a Spanish Colony for 400 years, at the end of the 1898 Spanish–American War. Although Puerto Ricans are citizens of the US, the island is not a state; it has the status of a commonwealth, without congressional representation. This administrative design is cited as a source of the island's poor economic performance resulting in a recession lasting for over 10 years (MacEwan, 2017; "The Puerto Rico Problem," 2015).

In 1996, the Clinton administration ended the long-standing tax breaks for the island with a 10-year phase-out period for existing firms. Notable was Section 936 of the US Tax Code, which had been the primary factor behind the flow of investments from the mainland, transforming Puerto Rico's manufacturing sector and her economy (Baver, 2000). Such removal of the tax incentives amplifies the importance of the tourism industry for the island's economy.

In 2017, travel and tourism's direct contribution to GDP ranked Puerto Rico 73rd in the world according to WTTC estimates, while competing destinations such as Bahamas, Jamaica, Dominican Republic, and Cuba were ranked at 86, 94, 60, and 75, respectively (WTTC, 2018). The travel and tourism's total contribution to GDP for the same year ranked Puerto Rico also at 73rd in the world, while same rival destinations ranking at 93, 90, 56, and 63, respectively. Puerto Rico ranked 55th out of 141 countries in tourism and competitiveness index (TTCI), while Jamaica and Dominican Republic ranked at 76th and 81st, respectively (World Economic Forum [WEF], 2015).

Puerto Rico does not compare well when it comes to travel and tourism's direct and total contributions to employment, relative to competing destinations. During 2017, Puerto Rico ranked 152nd and 135th in the world in travel and tourism's direct and total contributions to employment, respectively. However, Bahamas ranked 5th in both contributions, Jamaica ranked 25th and 21st, Dominican Republic 65th and 47th, and Cuba ranked 134th and 86th, respectively. Overall, Puerto Rico's reliance on manufacturing is listed as a major factor in the underperformance of Puerto Rican tourism industry relative to its potential: "The dominance of manufacturing in Puerto Rico, a dominance based on federal and local government support through tax incentives, has had an impact on the weakness of other economic activities on the island. A prime example is tourism" (MacEwan, 2017, p. 193).

As reported in the Comprehensive Economic Development Strategy (CEDS) document, tourism was identified as one of the five key sectors in the "Puerto Rico 2025 Initiative" (Government of Puerto Rico, 2004). Tourism and related industries are regarded as an integrated economic sector that must offer choice, competition, and quality to both residents and visitors in the *2025 Vision*. Based on the latest available visitor profile, approximately 40% of the visitors to the island classify themselves as vacationers, and due to the unique relationship with the mainland, 30% identify themselves as expats visiting family and friends ("Perfil de los Visitantes," 2012). Visitor profile indicates a need for diversification as 91% of the island's visitors originate from the mainland ("Perfil de los Visitantes," 2012).

At this juncture, a special visa waiver for non-US nationals visiting Puerto Rico needs to be considered. Currently, any non-US citizen willing to visit Puerto Rico is subject to the same visa requirements as the visitors to the mainland US. This is evident as WEF ranked Puerto Rico at 123 out of 130 destinations when it comes to visa requirements (WEF, 2015). This puts Puerto Rico at a considerable disadvantage against rival tourist destinations. For example, the Dominican Republic lists 95 countries that do not need a visa to land (ranked at 5 out of 130 in 2016), and Cuba lists only 15 countries that need visas. However, Puerto Rico requires travelers from some 160 countries to obtain a visa before landing on the island. A special visa waiver program, if granted, could significantly impact potential visitors' decisions, adding to the number and diversification of tourists visiting the island.

The structure of Puerto Rico's economy has been mostly shaped by the sectors benefiting from the revoked tax incentive programs, as indicated by MacEwan (2017). A result of this has been the relatively low level of public support for tourism (MacEwan, 2017). Therefore, it is necessary to demonstrate the significance of tourism for the island's economy. This study aims to provide empirical evidence regarding tourism and economic growth in order to inform policy makers, especially for posthurricane reconstruction planning by local and federal authorities.

Data and Unit Root Tests

Data and Definitions of Variables

Data used in this article are annual figures for the period 1960–2016 and the variables in the study are gross domestic product (GDP), tourism receipts (TR), and real effective exchange rate index (RER), 2010 = 100. We divide GDP and TR by the 2010 = 100 GDP deflator and the consumer price index, respectively, to obtain their real values. All variables in this study are expressed in natural logarithms (i.e., LGDP, LTR and LRER).

Data on GDP, GDP deflator, and consumer price index are obtained from Federal Reserve Bank Economic Data (FRED; https://fred.stlouisfed.org/), real effective exchange rate index is obtained from Bruegel datasets (http://bruegel.org/publications/datasets/), and tourism receipts data are collected from various issues of the "Apéndice Estadístico del Informe Económico al Gobernador" (http://jp.pr.gov/Economía/Apêndice).

Based on the above variable description and consistent with previous empirical studies that tested the TLGH (e.g., Gunduz & Hatemi, 2005; Husein & Kara, 2011; Mahalia, 2012; Tang, 2013), the following is the equation to be estimated:

$$LGDP_t = \mu_0 + \beta_1 LTR_t + \beta_2 LRER_t + \varepsilon_t \qquad (1)$$

where all variables are as defined above and the parameters, β_1 and β_2, are "long-run" coefficients, μ_0 is the intercept term, and ε is a random disturbance with the usual classical properties.

Unit Root Testing

Due to the importance of the integration properties of the time series data to Johansen's cointegration methodology, first the integration properties of the data are examined. If all variables in the data are integrated of order one, I(1), cointegration tests are performed using Johansen's approach and Pesaran et al.'s (2001) bounds test.

As Puerto Rico's LGDP, LTR, and LRER series may have been subject to structural breaks due to several natural disasters, and other possible disturbances to the island's economy, the authors apply the Perron unit root test that allows for a formal evaluation of the time-series properties in the presence of structural breaks at unknown points in time (Perron, 1997).

This unit root test allows the break date (TB) to be determined endogenously and proposes a class of test statistics that allow for two different forms of structural breaks, *i.e.,* the innovational outlier (IO) and the additive outlier (AO). The latter allows for a sudden change in the mean (crash model) while the former allows for more gradual changes. The two IO models studied by Perron (1997) (Models A and B) assume a gradual change in the intercept and a gradual change in the intercept and the slope, respectively. Under the third model, Model C, the change in the slope is allowed, but both segments of the trend function are joined at the time of the break. Under this model, the change is presumed to occur rapidly which corresponds to the AO model.

The results, reported in Table 1, suggest that the null hypothesis of a unit root is not rejected when the LGDP, LTR, and LRER series are in levels, and is rejected when the series are in first differences.

Methodology and Results

To test for the presence of a long-run equilibrium relationship between LGDP, LTR, and LRER, we employ the two most commonly used cointegration techniques, Johansen's system based, and Pesaran et

Table 1
Perron's (1997) Breakpoint Unit Root Tests

Variable	Model A	TB	Model B	TB	Model C	TB
LGDP	−2.73	2004	−3.21	2000	−2.87	2004
LTR	−4.80	2006	−4.47	1999	−3.87	2002
LRER	−3.89	1971	−3.85	1980	−3.65	1977
ΔLGDP	−6.28		−6.29		−5.70	
ΔLTR	−7.26		−7.36		−7.06	
ΔLRER	−5.21		−5.23		−4.97	

The 5% critical values for models A, B, and C are −5.23, −5.59, and −4.83, respectively. Break date suggested by the test, TB, is based on minimizing Dickey–Fuller t statistic.

al.'s (2001) single equation bounds test. Each cointegration test has its econometric advantages. Gonzalo (1994) showed that Johansen's cointegration procedure performs well even when the error distribution is nonnormal and the lag structure in the vector error-correction model (VECM) is incorrectly specified.

The bounds testing approach also has certain econometric advantages as well. The ARDL estimators have desirable small sample properties, and ARDL effectively corrects for potential endogeneity of explanatory variables (Caporale & Pittis, 2004; Panopoulou & Pittis, 2004). Moreover, Pesaran et al. (2001) demonstrated that within the ARDL framework, the ordinary least squares (OLS) estimators of the short-run parameters are consistent, and the ARDL-based estimators of the long-run coefficients are superconsistent, and provide valid t statistics in small sample sizes even if some of the regressors are endogenous.

Since Johansen and ARDL bounds cointegration procedures are widely known techniques, what follows is a brief description of each one.

The Johansen Approach

Following the notation in Johansen (1996), a CVAR of order k is expressed in a VECM as:

$$\Delta Y_t = \alpha\beta y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Phi D_t + \varepsilon_t \qquad (2)$$

where Δ is the first difference operator, Y_t is 3 × 1 vector of nonstationary variables (LGDP, LTR, and LRER), D_t is a deterministic vector, Φ is a matrix of deterministic parameters, Γ_i contains short-run parameters, and ε_t is a k-dimensional Gaussian error term. The cointegration rank, r, is given by the rank of $\Pi = \alpha\ \beta'$ where α matrix contains the weights (speed of adjustment) attached to the cointegrating relations in the individual equations of the model, and β' is the matrix of cointegrating parameters.

Since Johansen's λ_{Trace} test is sensitive to the lag length, k, and deterministic components in the VAR model, the authors perform λ_{Trace} test for different lag orders (k = 1, 2, and 3), and for the three deterministic components (known as Models 2, 3, and 4). It is also known that λ_{Trace} test is biased towards rejecting the null of no cointegration in small samples (Johansen, 1996); hence, all reported λ_{Trace} tests are corrected for small sample properties using the Bartlett correction factor given in Corollary 1 of Johansen (Johansen, 2002).

Table 2 presents Johansen's cointegration test results. It can be seen that the null hypothesis of no cointegration can be rejected, at least at the 5% level of significance, for nearly all lags and all models, in favor of one cointegrating relationship.

ARDL Approach

The unrestricted ECM of the ARDL model for equation 1 can be written as:

$$\Delta y_t = c_0 + \pi_{yy} y_{t-1} + \pi_{yx,x}\mathbf{x}_{t-1} + \sum_{i=1}^{p-1} \psi_i' \Delta Z_{t-i} + \omega' \Delta \mathbf{x}_t + \mu_t \qquad (3)$$

where $z_t = (y_t, x_t')'$, c_0 and c_1 are drift and trend components, Δ is the first difference operator, π_{yy} and $\pi_{yx,x}$ are the long-run coefficients defining the cointegrating relation between y_t and $\mathbf{x}_t$, ψ_i is short-run matrix, ω' contains coefficients on $\Delta\mathbf{x}_t$. Pesaran et al. (2001) presented two tests that must be applied to establish a long-run relation between y_t and $\mathbf{x}_t$ in equation 3. First, an overall F statistic for testing the significance of all lagged levels of the variables in equation 3 (i.e., H0: $\pi_{yy} = \pi_{yx,x} = 0$). The second is the t statistic of the coefficient of the lagged dependent variable (i.e., H0: $\pi_{yy} = 0$). Pesaran et al. (2001) provided two sets of bounds critical values, one set assumes that all variables in the ARDL are $I(0)$, and the other assumes all variables

Table 2
Bartlett Corrected Johansen's Trace, λ^{C}_{trace}, Cointegration Tests (LGDP, LTR, LRER)

Null Hyp.(H0)	VAR Lag 1	Asymp. *p* Value	Bartlett Factor	VAR Lag 2	Asymp. *p* Value	Bartlett Factor	VAR Lag 3	Asymp. *p* Value	Bartlett Factor
Model 2									
None ($r = 0$)	74.83	0.00	1.08	33.05	0.08	1.26	27.13	0.28	1.36
At most 1 ($r \leq 1$)	4.44	0.99	1.89	12.45	0.40	1.40	9.94	0.64	1.89
At most 2 ($r \leq 2$)	2.07	0.76	1.45	3.92	0.42	1.54	3.85	0.43	1.43
Model 3									
None ($r = 0$)	38.92	0.00	1.10	29.72	0.05	1.25	26.02	0.12	1.28
At most 1 ($r \leq 1$)	3.50	0.93	2.17	11.23	0.19	1.30	10.05	0.27	1.75
At most 2 ($r \leq 2$)	0.86	0.35	2.54	1.95	0.16	2.89	2.22	0.13	2.13
Model 4									
None ($r = 0$)	46.25	0.02	1.10	36.46	0.19	1.25	33.49	0.31	1.28
At most 1 ($r \leq 1$)	2.42	1.00	4.79	17.97	0.34	1.27	7.77	0.98	2.72
At most 2 ($r \leq 2$)	1.74	0.98	2.49	4.38	0.68	1.85	3.37	0.82	2.40

Note. r = cointegration rank. Asymptotic and bootstrap p values for the Bartlett corrected Trace test agree with essentially equal values for all models. Test results and p values are computed using SVAR 0.45 program created by Anders Warne and CATS in RATS 2.0.

are $I(1)$. This provides a band covering all possible classifications of the variables into $I(0)$, $I(1)$, or mutually cointegrated.

Many previous TLGH studies, utilizing the ARDL bounds procedure, relied solely on the F test to determine the presence of cointegration among the variables (e.g., Aslan, 2016; Ertugrul & Mangir, 2015; Jalil et al., 2013; Perles-Ribes et al., 2017; Saayman & Saayman, 2015; Shahbaz et al., 2019; Tang, 2013; Tang & Ozturk, 2017). To avoid two degenerate cases (i.e., no level relationship), cointegration using bounds test is confirmed only if the F and t tests individually reject their respective null hypotheses together with the condition that the dependent variable is integrated of order one. Regressors, however, can be integrated of a mixture of $I(0)$ and $I(1)$.

The first degenerate case arises when the lagged level of the dependent variable in equation 3 is insignificant (i.e., when $\pi_{yy} \neq \pi_{yx,x} \neq 0$ but $\pi_{yy} = 0$). Therefore, the t test for the lagged level of the dependent variable is required to rule out this degenerate lagged dependent variable case. Suspect cointegration conclusions may be drawn when the t test is not performed. The second case is when lagged levels of the independent variables are insignificant (i.e., when $\pi_{yy} \neq 0$ but $\pi_{yx,x} = 0'$). This degenerate lagged independent variables case implies that the dependent variable, y_t, is (trend) stationary or $I(0)$.

In essence as defined by Pesaran et al. (2001) "to test for the absence of a level relationship between y_t and $\mathbf{x}_t$, the emphasis in this paper is a test of the *joint* hypothesis $\pi_{yy} = 0$ and $\pi_{yx,x} = 0'$ in equation 3" (p. 295).

Previous empirical studies did not test for the significance of the lagged independent variables but rather relied on unit root tests to confirm that the dependent variable is $I(1)$. However, Sam et al. (2019) introduced an augmented ARDL bounds test that involves an additional F test on the lagged levels of the independent variables in equation 3. Computing this third test, in conjunction with Pesaran et al.'s (2001) F and t tests, will provide a clearer conclusion on cointegration status, given the low power associated with some unit root tests. Therefore, we supplement this article with this third F test (F_{IDV}), and utilize the upper bound critical values provided by Sam et al. (2019).

The authors compute the three tests, Pesaran et al.'s (2001) overall F and t tests and Sam et al.'s (2019) F_{IDV} test, based on an optimal lag order chosen by Schwarz Criterion (SC). Table 3 reports the values of these tests under 3 different cases, depending on whether the model contains a linear trend and whether the trend coefficients are restricted (using LGDP, LTR and LRER as the dependent variable, respectively). Table 4 reports the upper bound critical values used in these tests and their sources. The null hypothesis of no cointegration is rejected if the three tests, Pesaran et al.'s (2001) F_{all} and t test, and Sam et al.'s (2019) F_{IDV} are all above their respective 10%.

Table 3
Results of ARDL Cointegration Tests (F and t Statistics)

	With Deterministic Trends				Without Deterministic Trends		
	$F_{\text{all}}^{\text{IV}}$	$F_{\text{all}}^{\text{V}}$	t_{DV}^{V}	$F_{\text{IDV}}^{\text{V}}$	$F_{\text{all}}^{\text{III}}$	$t_{\text{DV}}^{\text{III}}$	$F_{\text{IDV}}^{\text{III}}$
F_{LGDP} (LGDP/LTR, LRER)	16.2*	4.74***	−3.06	7.09**	18.17*	−4.34*	5.24***
F_{LTR} (LTR/LGDP, LRER)	4.58	5.98***	−3.72***	2.43	1.56	−1.80	1.95
F_{LRER} (LRER/LGDP, LTR)	3.05	3.81	−3.33	0.73	3.83	−3.31***	0.42

Note. F^{iv} is the F statistic of the unrestricted intercept and restricted trend model. F^{V} is the F statistic of the unrestricted intercept and unrestricted trend model. F^{III} is the F statistic of the unrestricted intercept and no trend model. F_{all}^{IV} is the F statistic of the unrestricted intercept and restricted trend model. F_{all}^{V} and F_{all}^{III} test overall significance of lagged levels of all variables in equation 3 ($\pi_{yy} = \pi_{yx.x} = 0$). $F_{\text{IDV}}^{\text{III}}$ and $F_{\text{IDV}}^{\text{V}}$ test the significance of lagged independent variables ($\pi_{yx.x} = 0$). t_{DV}^{V} and $t_{\text{DV}}^{\text{III}}$ are the t statistics for the significance of the lagged dependent variable ($\pi_{yy} = 0$), with and without a deterministic linear trend, respectively. Maximum order of ARDL lags is 4.
*Significant at 1%, **significant at 5%, ***significant at 10%.

The two F and the t statistics in Table 3 are larger than critical value bounds for model III when LGDP is the dependent variable [denoted as F_{LGDP} (LGDP| LTR, LRER)]. The two computed F and/or the t statistics are less than critical value bounds for all cases when LTR and LRER are the dependent variables [denoted as F_{LTR} (LTR| LGDP, LRER) and F_{LRER} (LRER| LGDP, LTR), respectively]. Therefore, the null hypothesis of no cointegration is rejected only when LGDP is the dependent variable indicating that it is variable that ought to be normalized.

Estimated Long-Run Relations

The existence of one cointegration vector implies that an economic interpretation of the long-run impact of tourism receipts on economic growth can be made by normalizing the estimates of the unconstrained cointegrating vector on LGDP. A VECM lag length of two lagged differences was sufficient to describe the dynamics in the data, as suggested by AIC and FPE information criterion. Table 5 reports Johansen's FIML estimates, normalized on LGDP. Empirical results show that tourism receipts, LTR, has a positive and significant long-run impact on economic growth. The results also indicate that real effective exchange rate is significant and has its expected negative sign, an indication that an increase in RER results in reducing the island's economic growth in the long-run.

Table 4
Summary of Upper Bound Critical Values and Sources

Reference/Model	1%	5%	10%
Narayan (2005) ($k = 2$, $n = 55$)			
$F_{\text{all}}^{\text{V}}$	8.34	6.22	5.30
$F_{\text{all}}^{\text{III}}$	6.99	5.09	4.27
$F_{\text{all}}^{\text{IV}}$	6.58	4.96	4.24
Pesaran et al. (2001) ($k = 2$)			
t_{DV}^{V}	−4.53	−3.95	−3.63
$t_{\text{DV}}^{\text{III}}$	−4.10	−3.53	−3.21
Sam et al. (2019) ($k = 2$, $n = 55$)			
$F_{\text{IDV}}^{\text{V}}$	8.43	5.55	4.32
$F_{\text{IDV}}^{\text{III}}$	8.31	5.54	4.37

Note. See Table 3. k is number of regressors and n is the sample size.

Similar to FIML, ARDL long-run point estimates, reported in Table 5, reveal that LTR long-run parameter is positive and highly significant, and LRER's parameter is negative and significant, albeit at the 8% level. Moreover, the reported error-correction term carries its expected negative sign and is significant at least at the 5% level, which is expected if there is cointegration between the variables in the ARDL model. DOLS results reported in Table 5 confirm those of FIML and ARDL.

FIML based estimates reported in Table 5 describe the following long-run relationship between:

$$LGDP = 9.51 + 0.62LTR - 0.80LREER \qquad (4)$$

Granger Causality

In the presence of cointegration, Granger causality concerns the influence of the Γ and α parameters

Table 5
FIML, ARDL, and DOLS Long-Run Estimation Results

	FIML (*t* Statistic)	ARDL (*t* Statistic)	DOLS (*t* Statistic)
LGDP–	–	–	
LTR	0.69 (12.77)	0.63 (9.86)	0.74 (31.92)
LRER	−0.80 (−2.18)	−0.61 (−1.77)	−0.67 (−2.01)
C	9.5	9.3 (5.13)	8.6 (5.38)
$ec_{t\text{-}1}$	−0.10 (−2.85)	−0.14 (−12.9)	–

Note. VECM estimates pass the standard diagnostic tests: the Lagrange multiplier (LM) test statistic for residual correlation at lags 1, 2, and 3, multivariate normality test and White's residual Heteroskedasticity joint test; ARDL estimates pass the standard diagnostic tests (LM serial correlation, Jarque–Bera normality test, Breusch–Pagan–Godfrey heteroskedasticity test, and Ramsey RESET/functional form test).

on LGDP, LTR, and LRER and can be investigated in using VECM in equation 2. The existence of cointegration suggests that a Granger causality exists in at least one direction, but it does not indicate the exact temporal or direction of that causality. The estimates of the VECM in equation 2 are applied to detect the direction of short- and long-run Granger causality among the variables through the influence of Γ and α parameters—whether the TLGH or growth led tourism (GLTH), or both hold true for Puerto Rico. For example, the VECM in equation 2 with *k*-level lags and one cointegration relation, has the following short-run parameter matrices, Γ_j, and long-run parameter matrix, $\alpha\beta'$:

$$\begin{bmatrix} \Gamma_{j,11} & \Gamma_{j,12} & \Gamma_{j,13} \\ \Gamma_{j,21} & \Gamma_{j,22} & \Gamma_{j,23} \\ \Gamma_{j,31} & \Gamma_{j,32} & \Gamma_{j,33} \end{bmatrix} \; and$$

$$\alpha\beta` = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \end{bmatrix} \times \left[\beta_{11}\beta_{12}\beta_{13} \right] = \begin{bmatrix} \alpha_{11}ec_{1,t-1} \\ \alpha_{21}ec_{1,t-1} \\ \alpha_{31}ec_{1,t-1} \end{bmatrix}$$

where subindex *j* is the lag length of the VECM ($j = 1, \ldots, k-1$), and $ec_{1,t\text{-}1}$ is the error-correction term lagged one period. Granger causality from LTR to *LGDP* (i.e., TLGH) in the presence of cointegration is determined by first computing a "joint" test on the following null hypothesis:

$$\Gamma_{1,12} = \Gamma_{2,12} = \cdots = \Gamma_{j,12} = \alpha_{11} = 0$$

if the above null is rejected, we proceed to test if $\alpha_{11} = 0$ to establish the presence of long-run Granger causality from LTR to LGDP. Cointegration among the variables indicates Granger causality in at least one direction (i.e., one of the error-correction terms must be significantly different from zero). The above test differs from standard Granger causality test since it includes the error-correction term, $ec_{1,t\text{-}1}$, that accounts for cointegration among the variables. Similarly, Granger causality from LGDP to LTR (i.e., GLTH) can be determined by first testing the following null hypothesis:

$$\Gamma_{1,21} = \Gamma_{2,21} = \cdots = \Gamma_{j,21} = \alpha_{21} = 0$$

if the above null is rejected, then we proceed to test if $\alpha_{21} = 0$ to establish the presence of long-run Granger causality from LGDP to LTR.

Table 6 provides joint Wald statistics of the lagged differenced variables and the error-correction term that tests the significance of the short-run causal effects among the variables, while long-run causality is assessed via the significance of the error-correction terms. In the short-run, LTR and LRER Granger cause LGDP as the *F* statistics indicate that the null hypotheses ΔLTR ≠> ΔLGDP and ΔLRER ≠> ΔLGDP in the ΔLGDP equation are rejected ($p < 0.05$). We can also see that none of the lagged differences and error-correction terms in the ΔLTR and ΔLRER equations are significant implying no short-run causality from LGDP to LTR and LRER. This implies that in the short-run there is only unidirectional causality from tourism receipts and real exchange rate to economic growth in Puerto Rico.

Looking at the *F* statistics associated with testing the significance of the error-correction terms in each of the three equations, we find that the coefficient

Table 6
Granger Causality Test Results for the Cointegrated VAR Model ($r = 1$)

	Short-Run Causality: Estimated Wald Test		Long-Run Causality	
Dep. Variable/Null Hypothesis	*F* Statistic	*P* Value	*F* Statistic	*p*-value
ΔLGDP			8.13	0.00
ΔLTR ≠> ΔLGDP	5.06	0.00		
ΔLRER ≠> ΔLGDP	6.20	0.00		
ΔLTR			0.49	0.49
ΔLGDP ≠> ΔLTR	1.44	0.24		
ΔLRER ≠> ΔLTR	0.74	0.54		
ΔLRER			1.78	0.19
ΔLGDP ≠> ΔLRER	0.93	0.43		
ΔLTR ≠> ΔLRER	0.94	0.43		

Note. y ≠> x implies that y does not Granger cause x.

of the error-correction term is significant only in the LGDP equation. This indicates that tourism receipts and real effective exchange rate long-run Granger cause economic growth. For Puerto Rico, Granger causality test results provide empirical support for the existence of "pure" causality from tourism to economic growth, and not vice versa. In other words, the TLGH hypothesis is empirically validated for the island.

Stability Analysis

To examine the stability of the underlying cointegrated VAR model, we apply Hansen and Johansen's (1999) formal stability tests. A notable strength of these tests is that they do not require a prespecified break date, but rather test the null hypothesis of structural change against the alternative that there are one or more structural breaks at some unknown point in the sample. As we note in the introduction, several TLGH studies "assume" stability of their underlying models and they either did not perform or report any formal or informal parameter stability test results (e.g., Aslan, 2016; Belloumi, 2010; Brida & Giuliani, 2013; Brida et al., 2010; Croes & Rivera, 2010; Jalil, 2013; Pavlić et al., 2014; Perles-Ribes et al., 2017; Surugiu & Surugiu, 2013; Tang, 2013; Tang & Ozturk, 2017; Trang et al., 2014). Because "the instability of the economic system may be reflected in the parameters of the models which try to describe it, their use of inference, policy simulation and forecasting may lead to very misleading results" (de A. Gabriel et al., 2003, p. 893).

CVAR Long-Run Structural Stability

Having found a cointegration relation among LGDP, LTR, and LRER, it is prudent to examine whether the long-run parameters are stable. Long-run stability ensures that the full sample period defines a constant parameter regime—that is, the parameters of the cointegration relationship do not excessively fluctuate overtime. To this end, we study the stability of the non-zero eigenvalue(s) used in Johansen's cointegration analysis first.

For CVAR models, Hansen and Johansen (1999) suggest applying a fluctuation test to the non-zero eigenvalues of the reduced rank matrix. It is considered a recursive check on both β_i and α_i ($i = 1, \ldots r$). The fluctuation test rejects stability when the recursively estimated eigenvalues fluctuate excessively. It may be applied to the eigenvalues themselves, λ_i, giving rise to the test statistic Sup λ_i, or to the transformation $\xi_i = \log(\lambda_i/(1 - \lambda_i))$, giving rise to the test statistic Sup ξ_i.

Secondly, if the estimated eigenvalues in the above tests appear to fluctuate, it is of interest to examine if it is α_i or β_i that is changing over time. By utilizing two Nyblom tests, studied by Hansen and Johansen (1999), we are able to examine the constancy of the cointegrated vector, β_i (Nyblom, 1989). The two Nyblom test statistics, MeanQ and SupQ, are obtained by applying the mean and supremum operators, respectively, to the recursively estimated likelihood maximum (LM) statistics, for structural stability of the cointegration parameters over the experimentation period.

The LM-type statistic for the two Nyblom tests can be calculated using two methods. The first suggested by Hansen and Johansen (1999) involves a first-order Taylor expansion of the score function; the other, suggested by Brüggemann et al. (2003), uses the scores directly. Brüggemann et al. suggested that the score version to computing the Nyblom (1989) LM-type statistic is superior to that of Hansen and Johanson (1999) since the latter suffers from numerical problems in simulation exercises, leading to small sample distributions that are far away from the limit distributions.

Two versions of all the above stability tests may be applied. The first one is to leave the deterministic and short-run parameters, Φ and Γ_1, fixed at full sample estimates (conditional on $\widehat{\Phi}^{(T)}$ and $\widehat{\Gamma}_1^{(T)}$) and the second is to update them at each observation during recursion (updating of $\widehat{\Phi}^{(t)}$ and $\widehat{\Gamma}_1^{(t)}$). These two versions may produce different stability test results. According to Juselius (2006), a situation may arise when a CVAR model suffers from nonconstant parameters in the short-run structure, but not in the long-run. In this case, the recursive tests based on the conditional version will look more "stable" than the updating one. The conditional version of the stability test will "correctly" accept the parameter stability of the long-run structure, whereas the instability in the updated version is likely influenced by the instability in the short-run parameters. Note that Hansen and Johansen's (1999) formal stability tests do not require trimming of the sample; however, similar to Brüggemann et al. (2003) and Hansen and Johansen, we use about 30% of the sample as a base period and examine constancy over the remainder.

Constancy of the Non-Zero Eigenvalues

Part A of Table 7 reports the Hansen and Johansen (1999) eigenvalue fluctuation tests, Sup λi and Sup ξi, conditional on the full sample estimates of the deterministic and lagged parameters. As can be seen, the null hypothesis of constant Sup λi and Sup ξi cannot be rejected, at the 5% level, using asymptotic and bootstrapped *p* values. If instead the Φ and the Γ_i parameters are updated over the experimentation period, we obtain the results reported in part B of Table 7. This is where recursion analysis is expected to show more inconstancy as pointed out by Juselius (2006). As can be seen in part B of Table 7, the null hypothesis of constant Sup λi and Sup ξi is rejected, at the 5% level, using asymptotic but not bootstrapped *p* values. Juselius pointed out that "It is not uncommon to see a rejection of constancy, i.e. in connection with an intervention or a new regime, but after a short period the graphs return back to the acceptance region. In this case, one may not need to be utterly concerned about

Table 7
Hansen–Johansen Fluctuation tests of the Non-Zero Eigenvalue and Nyblom Tests for the Constancy of β for the Cointegrated VAR Over the Period 1979–2016

	Supλi	Supξi	MeanQs	SupQs
A: Conditional on $\widehat{\Phi}^{(T)}$ and $\widehat{\Gamma}_1^{(T)}$				
Specification	0.85	0.74	0.21	0.46
Asymptotic *p* value	0.46	0.64	0.56	0.93
Bootstrap *p* value	0.54	0.59	0.46	0.75
B: Updating $\widehat{\Phi}^{(t)}$ and $\widehat{\Gamma}_1^{(t)}$				
Specification	1.91	1.54	0.14	0.65
Asymptotic *p* value	0.01	0.02	0.74	0.78
Bootstrap *p* value	0.42	0.69	0.84	0.78

Note. MeanQ_s and SupQ_s are H-J Nyblom tests computed based on the score function suggested by Brüggemann *et al*. (2003). Sup λ_i and Sup ξ_i are the fluctuation tests based on the largest eigenvalue, λ_i, and the transformation $\xi = \log(\lambda_l/(1 - \lambda_l))$ as proposed by Hansen and Johansen (1999). All stability tests are computed from a VECM with 2 lagged differences and $r = 1$. Stability tests and corresponding asymptotic and bootstrap *p* values are calculated using Anders Warne SVAR 0.45 program.

accounting for such a temporary change in the model parameters" (p. 151).

Since the estimated recursive eigenvalues Sup λi and Sup ξi appear to fluctuate overtime based on the conditional model, the following two Nyblom (1989) constancy tests can help us determine if it is α_i or β_i that is constant.

Nyblom Tests for the Constancy of the Cointegration Space

Table 7A and B reports the Nyblom type tests based on Brüggemann et al. ($SupQ_S$ and $MeanQ_S$) for testing the stability of the cointegrating vector, β. Part A of Table 7 reports asymptotic and bootstrap *p* values for the constancy of β, conditional on full sample estimates of Φ and Γ_i. Here the null hypothesis of constant cointegrated vector, β, cannot be rejected at the 5% level using asymptotic and bootstrap *p* values.

Similarly, part B of Table 7 reports the results of the two Nyblom (1989) tests when the Φ and Γi parameters are updated. As can be seen, the null hypothesis, based on asymptotic and bootstrap *p* values, of constant cointegrated vector, β, cannot be rejected. In sum, based on the Nyblom-type tests reported, the authors conclude that the cointegration space or the long-run parameters demonstrate remarkable stability. We also applied the cumulative sum and cumulative sum of squares of recursive residuals (CUSUM and CUSUMSQ) to the estimated ARDL model as suggested by Pesaran et al. (2001). CUSUM and CUSUMSQ figures suggest that the ARDL regression coefficients are stable over the sample period. CUSUM and CUSUMSQ figures can be supplied upon request.

Conclusions

The present study employs Johansen's (1988) system based cointegration technique and properly apply the single equation ARDL bounds test to ascertain the presence of level relationships between LGDP, LTR, and LRER over the period 1960–2016 for Puerto Rico. Because of the importance of the tourism industry to the island's economic well-being, particularly after the removal of tax incentives, we examine whether tourism for Puerto Rico has been a stable source of economic growth and whether promoting the island's tourism industry is a key strategy to enhancing economic growth. The empirical results, based on the two techniques applied, suggest that real GDP, tourism receipts, and real exchange rate are cointegrated. The empirical evidence from Granger causality tests reveals that the causal link between tourism receipts and real GDP is unidirectional, indicating that tourism causes economic growth for Puerto Rico. Hansen and Johansen's (1999) formal stability tests confirm the stability of the cointegration relationship; hence, tourism can be considered a stable source of economic growth to the island.

From the findings of this study, public and private policies that emphasize tourism growth and expansion are recommended. Controversial as this may be, a visa waiver program for non-US visitors to Puerto Rico also should be considered. Such a waiver can be accompanied by a "Discover Puerto Rico" advertising campaign to promote and increase the island's tourism demand.

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