Konstantinos N. Konstantakis, George Soklis, Panayotis G. Michaelides

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Article (Accepted version)
(Refereed)

Original citation: Konstantakis, Konstantinos N. and Soklis, George and Michaelides, Panayotis G. (2017) *Tourism expenditures and crisis transmission: a general equilibrium GVAR analysis with network theory*. Annals of Tourism Research, 66. pp. 74-94. ISSN 0160-7383
DOI: 10.1016/j.annals.2017.06.006

Tourism Expenditures and Crisis Transmission: A General Equilibrium GVAR analysis with Network Theory

Konstantinos N. Konstantakis

National Technical University of Athens

George Soklis

Greek Research Institute for Tourism

& National Technical University of Athens

Panayotis G. Michaelides*

National Technical University of Athens

& Systemic Risk Centre, London School of Economics

ABSTRACT: According to the World Tourism Organization, during the last decades, tourism has become one of the largest and most dynamic economic industries in the world. In this work, we employ a Network General Equilibrium GVAR model to analyze the impact of tourism expenditures on GDP and our approach allows for the existence of dominant economies in the system. The model is estimated simultaneously as a system of equations for a large panel of world economies and the results show that the less developed economies are quite vulnerable to changes in the tourism expenditures of the dominant economies. Meanwhile, USA is found to be largely unaffected by shocks in the tourism expenditures of the less developed economies.

Keywords: GVAR, USA, world economy.

JEL classification: B51, C62, C67, E32

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1. INTRODUCTION

During the last decades, tourism has become one of the largest and most dynamic economic sectors in the world. According to the World Tourism Organization (UNWTO), "International tourist arrivals have increased from 25 million globally in 1950, to 278 million in 1980, 527 million in 1995, and 1133 million in 2014. Likewise, international tourism receipts earned by destinations worldwide have surged from US$ 2 billion in 1950 to US$ 104 billion in 1980, US$ 415 billion in 195 and US$ 1245 billion in 2014" (UNWTO, 2015). Moreover, UNWTO estimates that tourism accounts for about 9% of world GDP and employment, and about 1.5 trillion US dollars exports, which constitutes 6% of total world's exports and 30% of services exports. Now, it is estimated that the emerging economies account for about 45% of world's international arrivals and 35% of international tourist receipts, while the BRICs account for about 13% of world's international arrivals and 16% of international tourist receipts.

Moreover, tourism in EU constitutes the third largest economic activity after the trade and construction sectors. The European Commission estimates that tourism accounts for more than 10% of GDP and more than 12% of employment in EU. Also, EU constitutes the most popular tourist destination in the world and one of the top source regions of outbound tourism. Finally, the US account for about 7% of world's tourism arrivals and about 14% of international tourist receipts. On the expenditure side, the BRICs contribute about 21% of international tourism expenditures, whilst the EU contributes about 34% and the US contributes about 11%. Thus, it follows that BRIC's, EU and US account for more than two thirds of international tourism expenditures.

After all, in the globalized era, the growth of the tourism sector depends on its ability to overcome the increasing obstacles that arise from the perceived cultural distance and intercultural competence of various travelers who influence inter-role congruence, interaction comfort, adequate and perceived service levels, and satisfaction, Sharma et *al.* (2009). Nevertheless, the ongoing crises around the globe set another important obstacle for the tourism sector. In this context, for tourism sector it is apparent that the prevailing question in terms of the tourist industry is how it will be affected by the ongoing crisis, especially since the number of incoming visitors is likely to be strongly determined by the business cycles in the countries of origin (Dekimpe et *al.* 2016). In other words, what would the impact of a potential slowdown of the emerging economies' tourist activity be on other major economies (e.g. US, EU)? And what is the impact of the recent economic crisis (US, EU)in the emerging markets' tourist activity? Despite early efforts made by Kim et *al.* (2009) on identifying and assessing the evolution of consumers' differential reactions to major service attribute classes that resulted from and were propagated by a severe financial crisis, thus far no adequate research attention has been paid to the impact of economic activity on the service sector, and more specifically, on tourism.

In the field of tourism, in recent years there are a growing number of studies investigating the relationship between tourism and economic activity. These studies have used different methodologies. For example, Lee and Chien (2008), Chen and Chiou-Wei (2009), Arslaturk et *al.* (2011), Schubert et *al.* (2011) and Arslaturk and Atan (2012) have based their investigation on time-series analysis; Lee and Chang (2008), Chou (2013) and Tugcu (2014) have used panel data; Po and Huang (2008), Ivanov and Webster (2013), and Webster and Ivanov (2014) have based their research on cross-section analysis; Atanand Arslaturk (2012) have used the tool of input-output analysis; Zhou et *al.* (1997) investigated the impact of tourism on the economy of a region on the basis of a computable general equilibrium model;[1] while De Vita and Kyaw (2016) use a generalized methods-of-moments for a panel of 129 countries, over the period 1995-2011, and find evidence in favour of economic growth from tourism activities. From the aforementioned studies as well as from other relevant studies,[2] we may say that there is a rather no unambiguous relationship between tourism development and economic growth. For example, Dekimpe et *al.* (2016), in a prominent paper, provides evidence in favour of the sensitivity of the tourism sector to macroeconomic business cycles, while Chen (2013) analyzes the tourism cycle in the US economy using a Markov Switching Model. In the meantime, Antonakakis et *al.* (2016), in a prominent work, explore the relationship between tourism and economic activity using a panel VAR approach attributing the heterogeneity of their findings to the role of democratic institutions.

In a different approach, Tugcu (2014) concludes that the European countries in the Mediterranean region are better able to generate growth from tourism than the other countries in the same region while Lee and Chang (2008) conclude that tourism development has a higher impact on GDP in non OECD countries than in OECD countries. Moreover, Po and Huang (2008) noticed that the contribution of tourism on economic growth depends on the degree of specialization of a country in tourism activities, while, more recently, De Vita and Kyaw (2016) found a statistically significant contribution of tourism development on growth only for the middle- and high-income countries but not for the lower-income countries. Thus, it seems that the relationships between tourism activities and economic growth are rather complex and further investigation on the subject would be of great interest.

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[1] For arguments in favor of the use of computable general equilibrium models in evaluating tourism's economic effects, see, for instance, Dwyer et *al.* (2004).

[2] For a detailed review of all the relevant studies, see Pablo-Romero and Molina (2013).

The aim of this paper is to investigate the impact of shocks in tourism expenditures on GDP among a panel of countries that include: China, Russia, Brazil, India, Japan, Australia, Canada, US and EU17.[3] The selection of the countries is based on the fact that they account for more that 90% of global production, and about two thirds of international tourism expenditures and, therefore, we may assume that the results of our analysis will have general validity.

The present work builds on the prominent work of Acemoglu et *al.* (2012) and Pesaran and Yang (2016) and, more specifically, we utilize the network system structure proposed by Acemoglou et *al.*(2012) in order to model the interdependencies among a selected panel of world economies using a general equilibrium framework. Additionally, we investigate the pervasiveness of each economy in the network using the δ-value characterization established by Pesaran and Yang (2016), while we extend the modeling choice of Spartial Vector Autoregressive schemes proposed by these authors, by using a GVAR process, which acts as an infinite approximation of the global factor augmented process. Finally, based on the selection of dominant entities proposed in Tsionas et *al.* (2016) and Konstantakis et *al.* (2016), we provide a robustness analysis for the dominance characterization each economy (node) in the network, without ignoring at the same time the estimation results of the general equilibrium equation that characterizes the network through the estimation of the respective GVAR model as a system of equations.

The present paper contributes to the literature in the following ways: (a) It develops a novel network-theoretic model, which builds on general equilibrium theory and the GVAR framework, in order to investigate the dynamics of global tourism; (b) It is the

[3] In this paper, the EU17 economy is considered as a single economy and includes the economies of: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovak Republic, Slovenia and Spain.

first work in the literature, to the best of our knowledge, which investigates the dynamic interdependencies between tourism and the real economy, by accounting for the interconnection among economies that account for more than 90% of the global production; (c) It is the first article in the literature that cross validates the existence of dominant entities in a SGVAR scheme, using state-to-the-art quantitative and econometric techniques such as δ-pervasiveness; and (d) The results of the analysis have significant policy implications since they cast light on the dependency of each economy on potential shocks in tourism expenditures from other countries and, therefore, will provide a useful tool for development planning.

The rest of the paper is structured as follows: Section 2 sets out the methodological framework upon which our model is structured; Section 3 provides the empirical analysis of the results; Section 4provides a brief discussion of the main results, while Section 5 concludes.

2. METHODOLOGY

In what follows, an overview of procedures and methodology to be implemented in this study is presented.

2.1 The GVAR System

The model

Consider a network with $i = 1, \dots, N$ nodes, where each node represents an economy. Each node in the network communicates with the rest of the nodes through the edges of the network, which can be represented by the input output (IO) Leontief weights. The network evolves in time, i.e. the position of each node (economy) changes over time as a result of a change in the IO weights. In this context, each time stamp $t \in T$ represents a snapshot of the network in time. For the sake of simplicity we assume that the number of network nodes remain fixed over time i.e. no node can neither exit nor enter the network. Following the seminal work of Pesaran and Young (2016), which builds on Acemoglu et *al.* (2012), we assume, without loss of generality, that each node (economy) produces one good whereas the production process is characterized by a Cobb-Douglas production function:

$$x_{it} = e^{a_{ii}v_{it}} l_{it}^{a_{ii}} \prod_{j=1}^{m-1} x_{ij,t}{}^{a_{ij}w_{ijt}}, i = 1, \ldots, N, \ t \in T \ \textbf{(1)}$$

where:x_{it} is the produced good of each economy$i = 1, .., N$,a_{ij}, $j, i = 1, .., N$ denote the output elasticities such that $\sum_{j=1}^{J} a_{ij} = 1$, i.e. the production of each economy is characterized by constant returns to scale, $a_{ij}w_{ijt} \geq 0$, $\forall t \in T$ denotes the share of the $j - th$ good used in the production of $i - th$ economy (intermediate good) and v_{it} denotes a productivity shock for economy $i \in I$, which is composed of an economy specific shock ε_{it}, and a common technological factor f_t such that:

$$v_{it} = \varepsilon_{it} + \gamma_i f_t \ \textbf{(2)}$$

whereγ_i is a factor loading which expresses how the common factor influences each economy $i = 1, \ldots, N$. Following, Pesaran and Yang (2016), we assume that the cross-section exponent of the factor loadings is δ_γ such that the following sequence converges to a positive constant i.e.:

$$N^{\delta_\gamma} \sum_{i \in I} |\gamma_i| \to c_\gamma > 0 \ \textbf{(3)}$$

In this set up, if $\delta_\gamma = 1$ then the common factor is pervasive in the sense that it affects all economies (nodes) in the network, otherwise if $\delta_\gamma < 1$ then the common factor is not pervasive i.e. it does not affect all the economies in the network. Of course, if the factor loadings are random then we will assume that they follow a random walk pattern i.e. $E(\gamma_i) = 0$ and $Var(\gamma_i) = \sigma_\gamma^2$.

Additionally we will assume that the economy-specific shocks are cross-sectionally independent with zero mean such that $E(\varepsilon_{it}) = 0$ and $Var(\varepsilon_{it}) = \sigma_i^2$.

Turning back to the network structure we will assume that each economy (node) is endowed with one unit of labor, supplied in-elastically and has Cobb-Douglas preferences over the N goods produced in the network:

$$u_{it}(c_{1t}, \dots, c_{Nt}) = A \prod_{i=1}^{N} c_{it}{}^{1/m}, i = 1, \dots, N \quad \textbf{(4)}$$

In this set up, the goods produced in the network could be either final goods, c_{it}, or intermediate goods, x_{ijt}, which are used in the production process of at least one economy (node). Therefore, the amount of final goods in the network is defined as:

$$c_{it} = x_{it} - \sum_{j=1}^{N} x_{ijt} \quad \textbf{(5)}$$

Now, we will assume that labor markets clear:

$$l_t = \sum_{i \in I} l_{it} \quad \textbf{(6)}$$

In this context, the competitive equilibrium solution for a given vector of prices, $p = (p_{1t}, \dots, p_{Nt})$ and a wage rate h_t is given by:

$$x_{ijt} = \frac{a_{ij} w_{ij} P_{it}}{P_{jt}} \quad \textbf{(7)}$$

and

$$l_{it} = \frac{a_{ii} P_{it} x_{it}}{H_t} \quad \textbf{(8)}$$

Therefore, by substituting in (1) the above expressions and by simplifying we get:

$$p_{it} = a_{ij}\sum_{j=1}^{M} w_{ij}p_{it} + a_{ii}h_t - b_i - a_{ii}(\varepsilon_{it} + \gamma_i f_t) \quad \textbf{(9)}$$

Where $p_{it} = \ln(P_{it})$, $h_t = \ln(H_t)$

and $b_i = a_{ii}\ln(a_{ii}) + a_{ij}\ln\left(a_{ij}\right) + a_{ij}\sum_{i\in I} w_{ij}\ln(w_{ij})$

We rewrite equation (9) using matrix notation as:

$$\boldsymbol{p_t} = a_{ij}\boldsymbol{W}\boldsymbol{p_t} + a_{ii}h_t\boldsymbol{1} - (\boldsymbol{b} + a_{ii}\boldsymbol{\gamma}f_t + \alpha_{ii}\boldsymbol{\varepsilon_t}) \textbf{(10)}$$

and by solving for the ln-ized price vector we get:

$$\boldsymbol{p_t} = a_{ii}h_t[\boldsymbol{I} - a_{ij}\boldsymbol{W'}]^{-\boldsymbol{1}}\boldsymbol{1} + a_{ii}\left[\boldsymbol{I} - a_{ij}\boldsymbol{W'}\right]^{-\boldsymbol{1}}(-a_{ii}{}^{-1}\boldsymbol{b} + \boldsymbol{\gamma}f_t + \boldsymbol{\varepsilon_t}) \quad \textbf{(11)}$$

$$\boldsymbol{p_t} = a_{ii}h_t\boldsymbol{IO1} + a_{ii}\boldsymbol{IOu_t} \textbf{(12)}$$

where: $\boldsymbol{IO} = [\boldsymbol{I} - a_{ij}\boldsymbol{W'}]^{-\boldsymbol{1}}$and $\boldsymbol{u_t} = -a_{ii}{}^{-1}\boldsymbol{b} + \boldsymbol{\gamma}f_t + \boldsymbol{\varepsilon_t}$

The price system described in (12), characterizes a network system of economies, where each economy is represented by a node, and the interconnections between the economies, i.e. edges, are represented by the inverse Leontief matrix.

In this context, Pesaran and Yang (2016), propose writing the price equation in (9) as a Spartial Vector Autoregressive (SAR) scheme of the form:

$$\boldsymbol{y_t} = a_{ij}\boldsymbol{W}\boldsymbol{y_t} - \boldsymbol{b}\left(a_{ij}, \boldsymbol{W}\right) - a_{ij}(\boldsymbol{\gamma}f_t + \boldsymbol{\varepsilon_t}) \quad \textbf{(13)}$$

where: $\boldsymbol{y_t} = \boldsymbol{p_t} - \boldsymbol{H_t}\boldsymbol{1}$

which represents a SAR(1) scheme with an unobserved common factor, where the price specific interests captured by the vector $\boldsymbol{b}$, depend on the weight matrix $\boldsymbol{W}$and on a_{ij}. In this context, $\boldsymbol{y_t}$ is captured by a GDP measure according to the related literature.

Pesaran and Yang (2016) characterize the network in terms of strongly and weakly dominant units based on the out degree measure proposed in Acemoglu et *al.* (2012). In detail, a unit in the network is δ_j dominant if its weighted out-degree, is of order N^{δ_j}. In other words, if $\delta_j = 1$ the unit is considered to be strongly dominant, otherwise, if $\delta_j \in (0,1)$, it is considered to be weakly dominant, while non-dominant are the units with$\delta_j = 0$. In this context, following Pesaran and Yang (2016), we characterize the various economies (nodes) of the network in terms of their dominance using the following scheme:

$$d_{it} = \kappa N^{\delta_i} \exp(v_{it}),\ i = 1, \dots, N \quad \textbf{(14)}$$

$$\kappa = \frac{\exp\left(-\frac{\sigma_v^2}{2}\right)}{lim_{N\to\infty} N^{-1} \sum_{i=1}^{N} N^{\delta_i}} \quad \textbf{(15)}$$

Of course, equation (14) that characterizes the dominance of each economy(node) in the network could be consistently estimated using a log transformation.

Additionally, in this paper, we propose a more general representation of the price system described by (13) using a Global Vector Autoregressive scheme, so as to directly estimate the influence of each and every economy (node) in the network to the rest of the economies (nodes). To do so, based on the prominent work of Dees et *al.* (2007), equation (13) can be represented by a canonical global factor model of the form:

$$y_{it} = \Gamma_i f_t + \xi_{it},\ i = 1, \dots, N \quad \textbf{(16)}$$

where:Γ_i is a matrix of factor loadings which is uniformly bounded i.e. $\|\Gamma_i\| < K < \infty$ and ξ_{it} is a vector of economy (node) specific shocks, whereas the factors and the economy (node) specific shocks assume to satisfy:

$$\Delta f_t = \Lambda_f(L)\eta_f, \eta_f \sim IID(0, I) \textbf{ (17)}$$

$$\Delta \xi_{it} = \Xi_i(L)\omega_{it}, \omega_{it} \sim IID(0, I) \textbf{ (18)}$$

whereΛ_f and Ξ_i are uniformly absolute summable, so as to ensure the existence of $Var(\Delta f_t)$ and $Var(\Delta \xi_{it})$. Under these assumptions, Dees et *al.* (2007) showed that the unobserved common factors could be consistently estimated by linear combinations of cross section averages of the observable variables y_{it} given as:

$$y_{it}{}^* = W_i{}' y_{it} = \Gamma_i^* f_t + \xi_{it}{}^* \textbf{ (19)}$$

Therefore, they obtained the economy specific VAR augmented models with $y_{it}{}^*$:

$$\Phi_i(L, p_i)(y_{it} - \widetilde{\delta_\iota} - \widetilde{\Gamma_\iota^*} y_{it}{}^*) \approx \omega_{it} \textbf{ (20)}$$

which corresponds to a conditional VARX model for each economy (node) in the network of the form:

$$y'_{i,t} = a_{i0} + \Phi(L_1)y'_{j,t} + \Phi(L_2)y'_{i,t}{}^* + \Phi(L_3)g'_{i,t} + u_{i,t}, j\epsilon\{1, .., N, N+1, \dots N+k\} \textbf{ (21)}$$

where: a_{i0}isa$(1xm)$ vector of m intercepts, $y'_{i,t} = [y_{i_1,t}, \dots, y_{i_m,t}]$is the transpose of a $(1xm)$ vector $y_{i,t}$of m variables for each economic entity$i = 1, .., N$, which expresses the entityspecific variables; $y'_{j,t} = [y_{i_1,t}, \dots, y_{i_m,t}, y_{i_{k_1},t}, \dots, y_{i_{k_m},t}, \dots, y_{i_{k_K}.t}, \dots, y_{i_{k_K}.t}]$ is the transpose of an$((m + Km)x1)$endogenous variables. Notice that the$m$ endogenous variables are augmented by the km variables of the dominant entities, and $\Phi(L_1)$ is the $\left((m + Km)xL_1\right)$ matrix of the associated lag polynomial; $y'_{i,t}{}^* = \left[y_{i_1,t}{}^*, \dots, y_{i_m,t}{}^*\right]$ is the transpose of a $(mx1)$ vector $y^*{}_{i,t}$, of m foreign-specific variables for each entity $i = 1, \ldots, N-1$ and $\Phi(L_2)$ is an (mxL_2) matrix of the associated lag polynomial; $g'_{i,t} = [g_{i_1}, \ldots, g_{i_p}]$ is the transpose of a $(px1)$ vector of $p$global variables for each economy $i = 1, .., N$, while $\Phi(L_3)$ is an (pxL_3) matrixof the associated lag polynomial. In general, m and p may be allowed to vary between entities.

Following the system estimation procedure proposed in Konstantakis et *al.* (2016), we estimate the GVAR as a system of simultaneous equations, i.e. System GVAR or simply SGVAR. The results of the proposed SGVAR estimation are assessed using the Generalized Impulse Response Functions (GIRFs). The GIRFs are expressed by the following formula (Koop et *al.* 1996, Pesaran and Shin 1998):

$$I_{j\,(n)} = \sigma_{jj}{}^{-1/2} + B_n \Sigma e_j \forall n = 1, 2, \ldots \quad \textbf{(22)}$$

where: $I_{j\,(n)}$denotes the Impulse Response Function *n* periods after a positive standard error unit shock; σ_{jj}denotes the *j*th row and *j*th column element of the variance–covariance matrix of the lower Cholesky decomposition matrix of the error term which is assumed to be normally distributed; B denotes the coefficients' matrix when inversely expressing the VAR model as an equivalent MA process and $e_j$denotes the column vector of a unity matrix.

2.2 Robustness Analysis

Number of dominant entities in the network

Following Konstantakis et *al.* (2016) and Tsionas et *al.* (2016), we investigate the eigenvalue distribution of a matrix (*Q*) that accounts for the exchangeable quantities between the economies:

$$Q \equiv \begin{pmatrix} q_{11} & \cdots & q_{1(N+K)} \\ \vdots & \ddots & \vdots \\ q_{(N+K)1} & \cdots & q_{(N+k)(N+K)} \end{pmatrix} \equiv Wx_t = \begin{pmatrix} 0\ w_{1,2} \dots w_{1,N+K} \\ w_{2,1}\ 0\ \dots w_{2,N+K} \\ \vdots \ddots \dots \vdots \\ w_{N+k,1} \cdots \quad 0 \end{pmatrix} \begin{pmatrix} x_{1,t} \\ x_{2,t} \\ \vdots \\ x_{N+K,t} \end{pmatrix} \quad \textbf{(23)}$$

where: $x_t$denotes a (N+K)x1 vector of outputs and Wdenotes the (N+K)x(N+K) trade weight matrix, and the q_{ij} element of matrix Q expresses the quantity of output that flows from economy $i$to economy j. The row elements express the quantities supplied by one economy to all others. Column elements express quantities obtained by an economy from all others. Hence: $q_{ii} = 0$.

Based on the work of Bródy (1997), the behavior of systems describing economic interconnections depends on the ratio of the modulus of the subdominant eigenvalues to the dominant one, so that a ratio close to zero implies negligible power of this economy.In this context, if$\lambda(pf) = \lambda(1)$ denotes the dominant eigenvalue of *Q* and the normalized eigenvalues: $\rho(i) \equiv \frac{\lambda(i)}{\lambda(pf)}, i = 1, \dots, N + K$ are the *non*-dominant normalized eigenvalues. The number of dominant economies is i*, such that $\rho(i\,*) > 0.4$, since values <0.40 are considered to be negligible (Bródy, 1997; Mariolis and Tsoulfidis, 2014).

2.3 Node / Vertex Theory for selecting the Dominant Economies

Having selected the number of dominant entities in the universe of our model, we need to determine which of the economies that enter the model act as dominant entities, following Konstantakis et *al.* (2016) and Tsionas et *al.* (2016). In this work, based on the concept of centrality (Freeman 1979), we examine which economies are dominant by using the main vertex theory measures, namely degree centrality, alter-based centrality, and beta centrality.

(i) The degree centrality of a node indicates how connected a node is to the rest of the nodes in the graph, (see Ying et *al.* 2014, and Bates et *al.* 2014). The centrality, c_i, of each node is given by the following formula:

$$c_i = d(i) \sum_{j=1}^{N+K} z_{ij} \quad \textbf{(24)}$$

where $d(i)$ is the degree of each node, which represents the number of ties with the rest of the nodes (Fagiolo et *al.* 2008), and z_{ij} represent the respective flows between the various nodes that come from the Input Output matrix of Leontief. The dominant entities are those which exhibit the largest centrality.

Nevertheless, degree centrality ignores how the neighbors of each node interact with the rest of the nodes of the vertex. Therefore, we apply two more measures of node centrality namely, alter-based power and beta power, that take into consideration both the nearby and the distant neighbors of a node (Bonacich and Lloyd, 2001).

(ii) Altered based power of a node i, identifies the most central nodes of a vertex by considering both the degree centrality of the neighboring nodes, and their respective weights. Alter-based centrality is given by the following scheme:

$$AC_i = \sum_{i=1}^{N+K} (z_{ij} * \ c(i)^{-1}) \quad \textbf{(25)}$$

where: $z_{ij}, i, j \in \{1, \dots, N+K\}$ are the weights between each node, i, with the rest of the j nodes and $c(i)^{-1}$ is the inverse degree centrality of each node in the vertex. The larger value of alter based power of a node corresponds to the first dominant economy, the second largest to the second dominant and so on.

(iii) **Beta based power** of a node, i, was introduced by Bonacich (1987) as an extension of the eigenvector centrality (Bonacich 1972), and can identify the centrality power of a node based on either their distant neighbors or their nearby neighbors of the specific node. It is given by the following scheme:

$$BC_i = (I - \beta R)^{-1} R \quad \textbf{(26)}$$

where: I is the indentity matrix, β is a discount parameter and $R = [z_{ij}], i, j \in \{1, \dots, N + K\}$ is the adjacency matrix. Different values of the discount parameter βyielddifferent centrality powers for the node $\boldsymbol{i}$. More precisely, according to the value of β the following casesarise: (a) if $\beta \gg 0$ or $\beta \ll 0$ then the power centrality of a node, i, is based on the distant neighbors of the specific node and approaches the eigenvector centrality; and (b) if $\beta > 0$ or $\beta < 0$ then the power centrality of a node, i, is based on the nearby neighbors of the specific node and it approaches the alter-based power of a node. Apparently, dominant economies are those with the greater values of beta based centrality power.

2.4 Information Criterion for selecting the Dominant Economies

In this sub-section, we will use the Schwartz-Bayes Information criterion (SBIC) introduced by Schwartz (1978) in order to econometrically validate the selected dominant entities uncovered by the eigen-value distribution of the system. Let $L_T(o)$ be the maximum likelihood of the SGVAR system, from the eigen-value distribution of the system, we have that there exist k^* dominant entities in our system. In order to test which of the $i = 1, .., N + K$ economies are dominant we need to calculate the BIC criterion for the different combinations of k^* dominant economies regarding the system of equations **[21]**.

Let $\widehat{\Sigma_{k^*_i}}$, be the estimated variance of the above system of equations. The BIC criterion for each $k^*_i, i = 1,..,N+K$ combination of dominant entities will be given by the following formula:

$$c_T{}^{3-SLS}(k^*_i) = \ln\left(\det\left(\widehat{\Sigma_{k^*_i}}\right) + o\,\frac{ln(T)}{T}\right. \quad \textbf{(27)}$$

The dominant combination of $\overline{k^*_i}$ economies is the combination that optimizes the BIC, i.e. in mathematical terms: $\overline{k^*_i} = argmin\ \{c_T{}^{3-SLS}(i)\}$.

Of course, the same selection strategy could easily be followed using some other relevant information criterion, e.g. AIC, etc. However, we have decided to use BIC over other criteria following Breiman and Freedman (1983) and Speed and Yu (1992) who provided evidence in favor of the superiority of the BIC criterion when used in finite samples.

Finally, a number of fairly standard tests need to be carried out. To begin with, following standard econometric practice, in order to avoid spurious regression effects that could be caused by the explosive behavior of the time series, all the variables are tested against the existence of a unit root, using the Phillips-Perron unit root test. Next, we investigate the potential existence of long-run equilibrium relationships among the various time series, using the Johansen cointegration test. In case of cointegration, the various VARXs models of the SGVAR need to be corrected, using the relevant error correction method (ECM). Finally, in order to determine the optimum lag length for each VARX model, we make use of Bayes Information Criterion (BIC), which performs best when the dataset is relatively small. The stability of the SGVAR is checked based on the system's eigenvalue distribution and the relevant asymptotic properties (see, e.g. Konstantakis et *al.* 2016).

3. EMPIRICAL RESULTS

3.1 Data and Variables

We use data in a quarterly frequency for the period 1992(Q1)-2015(Q4), so as to capture the various crises, for each economy in the universe of our model, i.e. China, Russia, Brazil, India, Japan, Australia, Canada, US and EU17. In order to consistently estimate the general equilibrium price equation of the network system of economies we make use of (2) economy-specific variables for each economy: GDP and Tourism Expenditures, which can capture the log difference of prices and wages in the economy. More specifically, we use data[4] regarding Tourism Expenditures, GDP in current prices, GDP deflator and Exchange rate to the dollar. The data come from the main economic indicators of OECD's database, with the exception of EU17 GDP data that come from the National Accounts of Eurostat while Tourism Expenditures data come from the World Data Bank. The variables of Global Credit, i.e. Worldwide Total Credit, and Global Trade, i.e. Worldwide Total Trade are in millions of dollars in constant 2005 prices and also come from the World Data Bank. These variables constitute the main transmission channels of the crises in our model. See,*inter alia,* Xu (2012), Cesa-Bianchi (2013), Eickmeier and Ng (2015). Moreover, in order to avoid any structural instability in our findings, in every country specific VARX model we make use of exogenous key dummy variables that capture the global financial crisis of 2007-2009 as well as for local-regional crises that some countries experienced during the period under investigation, like the Russian crisis of 1998, the crisis of the Japanese economy, the Real crisis in Brazil etc.

[4] When data were missing, following Pesaran et *al.* (2004) we have intra/extra-polated the missing values.

In order to express all the variable in constant prices, we will make use of the GDP deflator of each economy's, $i = 1, .., 9$, $GDP_i\, deflator$, we calculated the GDP and Tourism Expenditures in constant 2005 prices using the formula:

$$X_{2005_i} = \frac{X_i\, current\, prices}{GDP_i\, deflator}$$

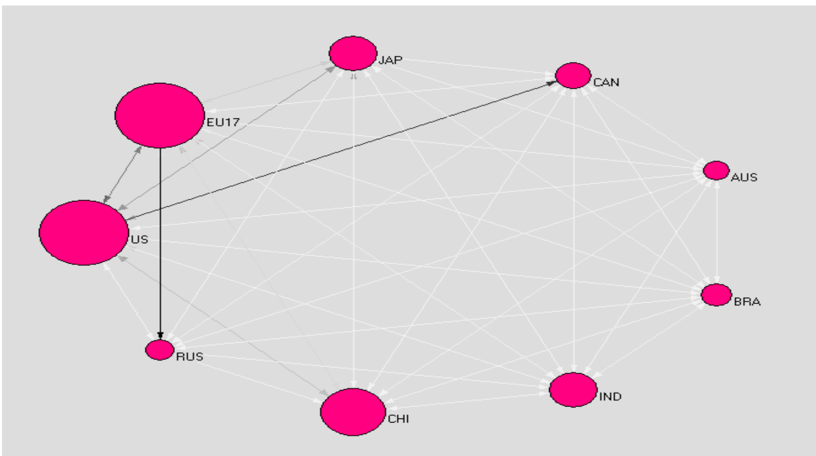
where $X_i = \{GDP_i, Tourism\ Expenditures_i\}$, while using the exchange rate of each economy's, $i = 1, .., 9$, we transformed, X_{2005_i}, into dollars, using the formula:

$$X_{i,2005\, in\, \$} = X_{2005_i} * exchange\, rate_i$$

3.2 Network structure of the Economy

The network structure of our model is depicted in Figure 1. According to our analysis, the network has a cyclical structure since all economies interact with each other. Additionally, the Economies of US and EU17 are depicted as the largest economies in the network based on their centrality.

Figure 1: Diagram of centrality between the economies



3.3 Degree of Pervasiveness

Following Pesaran and Yang (2016), we characterize each and every economy (node) in the network in terms of its pervasiveness based on its δ-value.

Table 1: Degree of pervasiveness

Economies (Nodes)	**δ-value**
US	0.812
EU17	0.831
JAP	0.412
RUS	0.452
CAN	0.213
CHI	0.415
BRA	0.399
AUS	0.461
IND	0.256

Based on our findings, the economies of US and EU17 are the only economies that exhibit a δ-value characterization that exceeds 0.5, which in turn, based on Pesaran and Yang (2016), implies that they should be considered as being (weakly) dominant in the model.

3.4 Robustness Analysis

In order to cross validate the findings obtained through the degree of pervasiveness of each node in the network, we employ the methodologies for the selection of dominant entities proposed in Tsionas et *al.* (2016), and Konstantakis et *al.* (2016). In this context, we construct matrix *Q* and calculate the normalized eigenvalues of the respective matrix, see Table 2.

Table 2: Normalized Eigenvalues of matrix *Q*

Eigenvalue	ρ_i
1	1.00
2	0.72
3	0.33
4	0.18
5	0.08
6	0.04
7	0.02
8	0.00
9	0.00

According to our findings there exist two dominant economies for which: $\varrho(i^*)>0.4$ ($\rho_1 = 1, \rho_2 = 0.72$).

Next, in order to determine the dominant economies in the model, we use the various centrality measures introduced in the previous section, see Table 3. Based on our findings, all measures agree with the selection of US and EU17 as dominant in the model.

Table 3: Centrality measures

Economy (i)	Degree Centrality, $c(i)$	Alter power, AC_i	Beta power, BC_i
US	1.321	1.724	0.445
EU17	1.831	1.757	2.498
JAP	0.754	1.014	0.370
RUS	0.806	0.595	0.172
CAN	0.170	0.171	0.059
CHI	0.139	0.093	-0.021
BRA	0.658	0.576	-0.203
AUS	0.894	0.906	0.097
IND	1.184	0.607	-1.530

Finally, in order to econometrically validate the selection of the dominant entities, we estimated the BIC for the system as described earlier, see Table 4.

Table 4: Bayes Information criterion

Dominant Pairs of Economies	*BIC*
US and EU17	171.53
US and China	321.15
EU17 and China	291.26
US and Japan	356.31
EU and Japan	362.35
Japan and China	425.32

According to the results in Table 4, the pair of dominant economies US - EU17 exhibits the lowest BIC value, compared to the rest of the pairs, which are the most likely alternative pairs for dominant economies in the universe of our model.

3.5 Relevant Tests

In what follows, we present the results of the various tests.

Table 5a: Phillips Perron unit root test (original variables)

REGION	Variables	Lags	P-value	Stationarity
AUS	GDP	3	0.53	No
	Tourism expeditures	3	0.81	
BRA	GDP	3	0	
	Tourism expeditures	3	0.98	
CAN	GDP	3	0.25	
	Tourism expeditures	3	0.98	
CHN	GDP	3	0.12	
	Tourism expeditures	3	0.97	
EU17	GDP	3	0.68	
	Tourism expeditures	3	0.70	
IND	GDP	3	0.25	
	Tourism expeditures	3	0.36	
JPN	GDP	3	0.69	
	Tourism expeditures	3	0.95	
RUS	GDP	3	0.70	
	Tourism expeditures	3	0.76	
USA	GDP	3	0.98	
	Tourism expeditures	3	0.71	
WORLD	Trade	3	0.98	
	Credit	3	0.45	

Table 5b: Phillips Perron unit root test (first differences)

REGION	Variables	Lags	P-value	Stationarity
AUS	GDP	3	0	Yes
	Tourism expeditures	3	0.01	
BRA	GDP	3	0	
	Tourism expeditures	3	0.04	
CAN	GDP	3	0	
	Tourism expeditures	3	0	
CHN	GDP	3	0	
	Tourism expeditures	3	0	
EU17	GDP	3	0	
	Tourism expeditures	3	0	
IND	GDP	3	0	
	Tourism expeditures	3	0	
JPN	GDP	3	0	
	Tourism expeditures	3	0.01	
RUS	GDP	3	0	
	Tourism expeditures	3	0	
USA	GDP	3	0	
	Tourism expeditures	3	0.05	
WORLD	Trade	3	0	
	Credit	3	0	

All GDP and Tourism expenditures variables were found to be stationary in their first differences (Table 5b), i.e. I(1), except for the GDPs of Brazil, that is stationary in levels (Table 5a), i.e. I(0).

Next, in the presence of I(1) variables, we tested for cointegration using the Johansen and Juselius (1990) methodology. The results in Table 6 suggested that cointegration was present in the VARX of Australia, Japan, Canada, Brazil and India.

Table 6: Johansen Cointegration test

Economies	Cointegration Rank	Log Likelihood	Trace statistics	5% Critical value	Cointegration
US	0	-1191.78	162.43	64.64	No
EU17	0	-1184.97	162.43	64.64	No
BRA	3	-1495.18	34.51	34.55	Yes
RUS	0	-1183.12	162.43	64.64	No
IND	3	-1202.06	29.67	34.55	Yes
CHN	0	-1183.54	162.43	64.64	No
JPN	2	-1204.5	162.43	64.64	Yes
CAN	1	-1265.31	51.12	54.64	Yes
AUS	3	1581.32	32.11	34.55	Yes

We, then, determined the lag length of each VARX and VECX using the BIC (1978), see Table 7.

Table 7: Lag Length Selection

Economies	Optimum Lag Selected	BIC
US	1	21.21
EU17	1	23.56
JAP	2	22.32
CAN	2	24.26
AUS	1	25.21
BRA	1	24.65
IND	2	22.31
CHI	2	23.54
RUS	1	21.64

Having determined the VECX(p,q)/VARX(p) specification for each economy in the GVAR model we proceed by estimating the system of VECX models simultaneously using 3-SLS estimation. Next, we computed the GIRFs, following Pesaran and Shin (1998).

3.6 Generalized Impulse Response Functions

Our analysis will be based on the Generalized Impulse Response Function (GIRFs) and, on the robust confidence intervals that were calculated using 10.000 bootstrapped iterations, instead of mere point estimates. We focus on the impact of a unit shock in Tourism Expenditures of BRICs on the GDP of the dominant economies, i.e. EU17 (Figure 2) and US (Figure 3).

Figure 2: Response of GDP EU17 to BRICs Tourism Expenditures

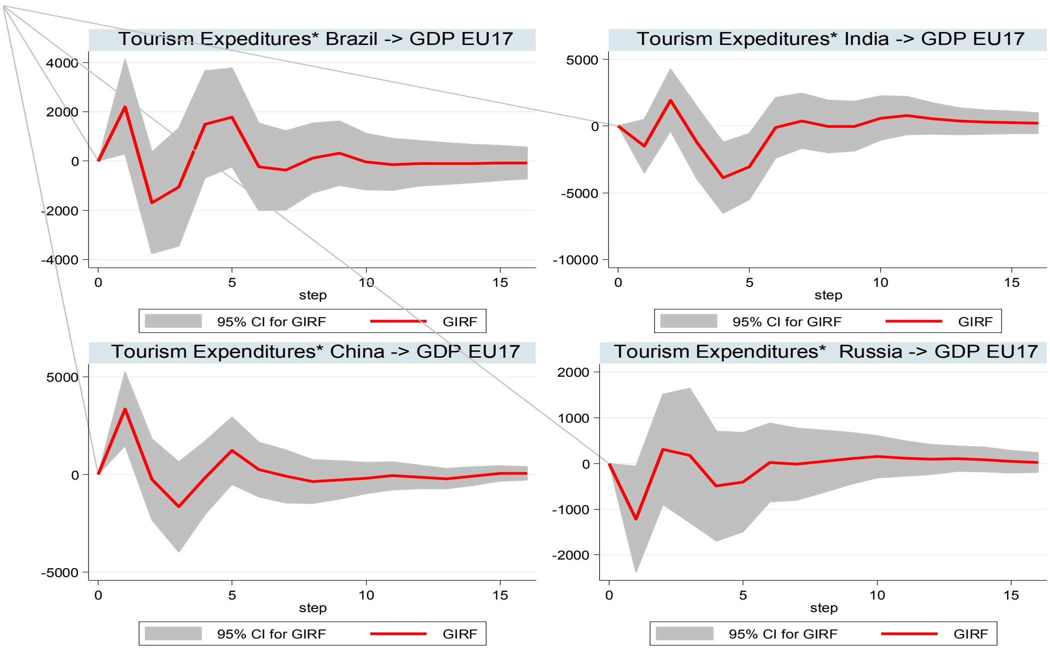
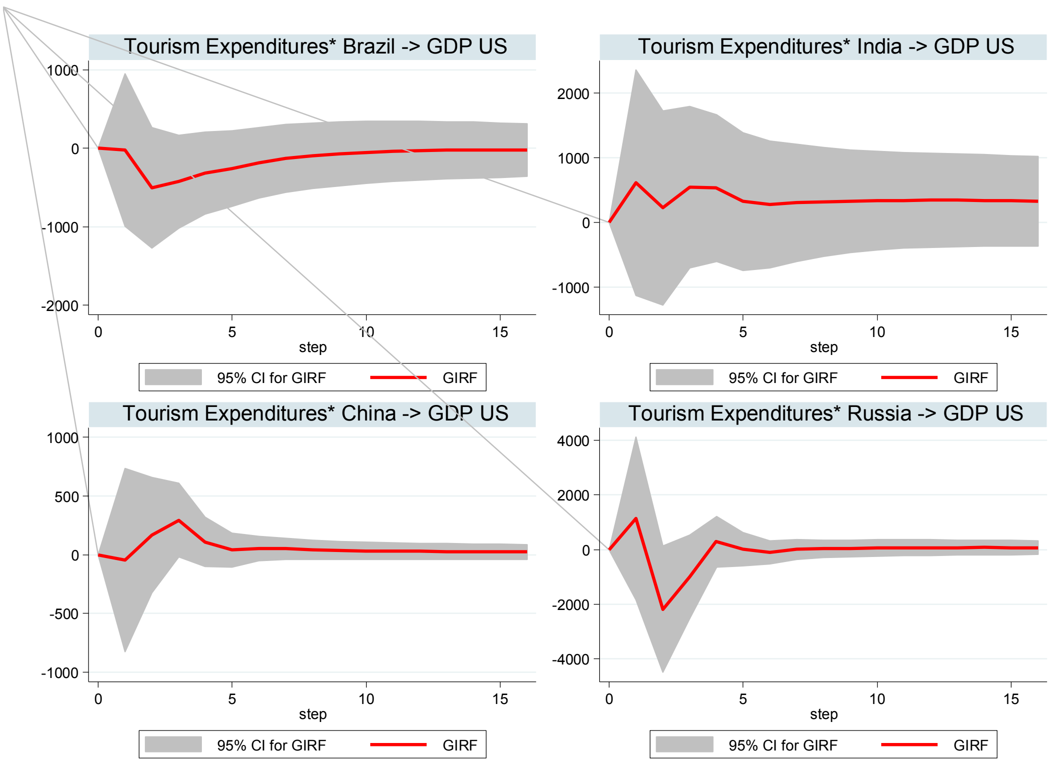


Figure 3: Response of GDP US to BRICs Tourism Expenditures



According to our findings, a shock in the Tourism Expenditures of Brazil and China has a positive and statistically significant effect on the GDP of EU17, which dies out in the medium run i.e. less than six (6) quarters when the GDP of EU17 returns back to its initial equilibrium position. The opposite picture is in force regarding the effect of a unit shock in the Tourism Expenditures of India, while Russian's Tourism Expenditures do not seem to have any statistically significant effect on the EU17 GDP. On the other hand, the US GDP seems to be unaffected by shock in the Tourism expenditures of the BRIC economies.

We continue by presenting the impact of a unit shock in the Tourism Expenditures of either US (Figure 5) or EU17 (Figure 4) and their respective GIRFs.

Figure 4: Response of GDP EU17 to US Tourism Expenditures

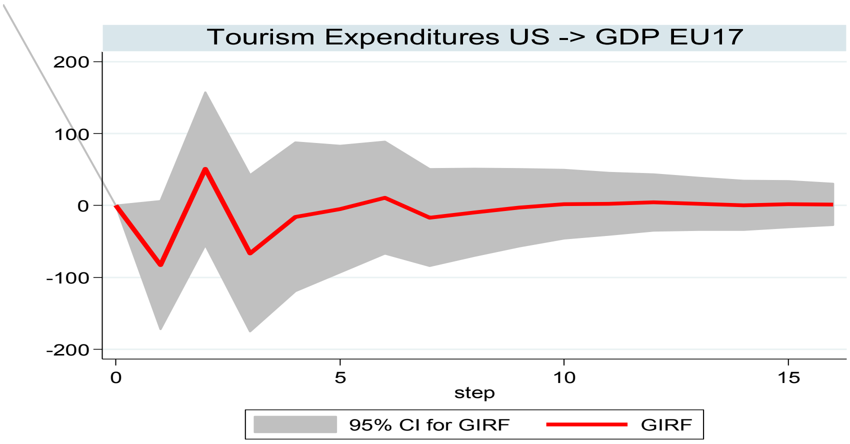
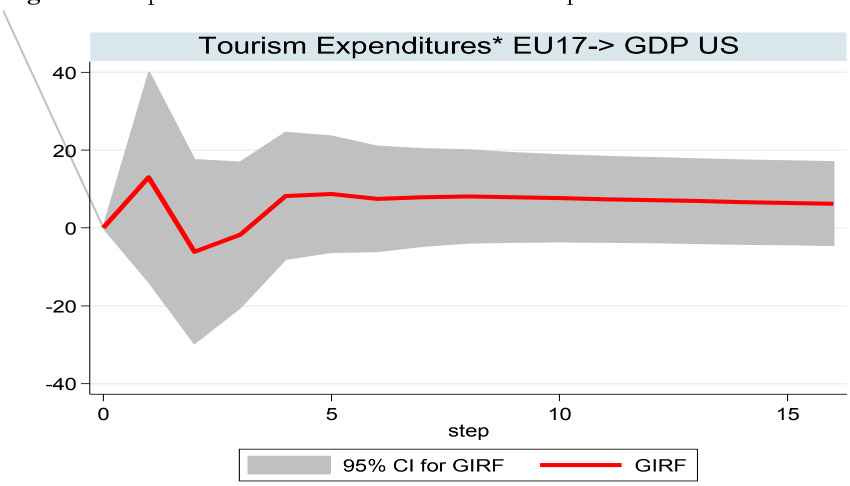


Figure 5: Response of GDP US to EU17 Tourism Expenditures



We do not witness any statistically significant deviations from equilibrium.

Next, we present the impact of both US (Figure 6) and EU17 (Figure 7) economies to the GDPs of the rest of the economies in our model.

Figure 6: Response of GDP US to Japan, Canada and Australia Tourism Expenditures

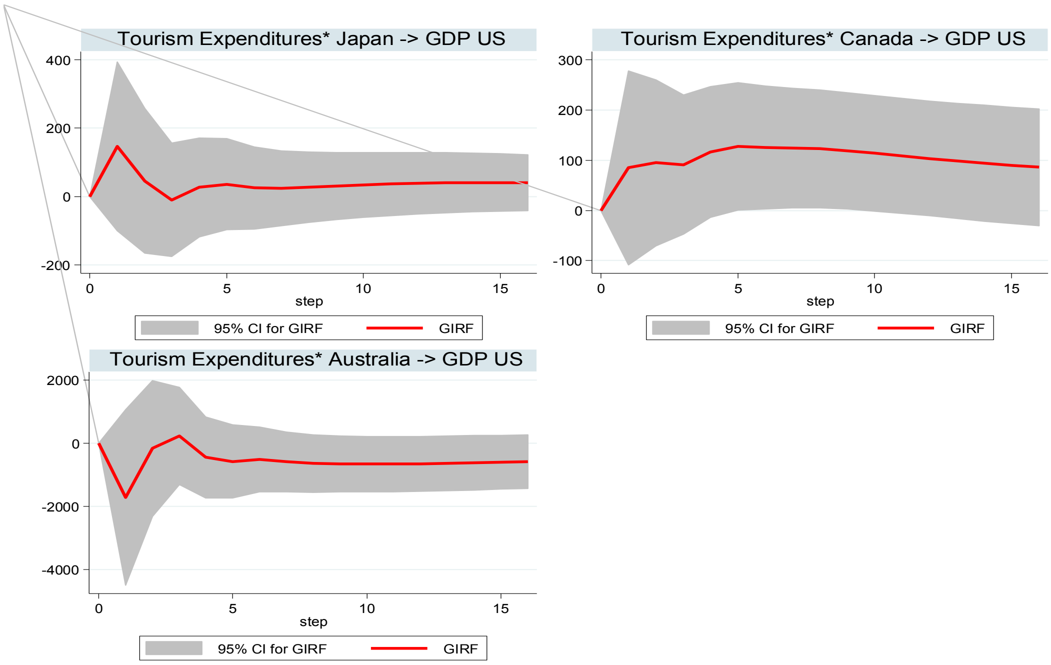
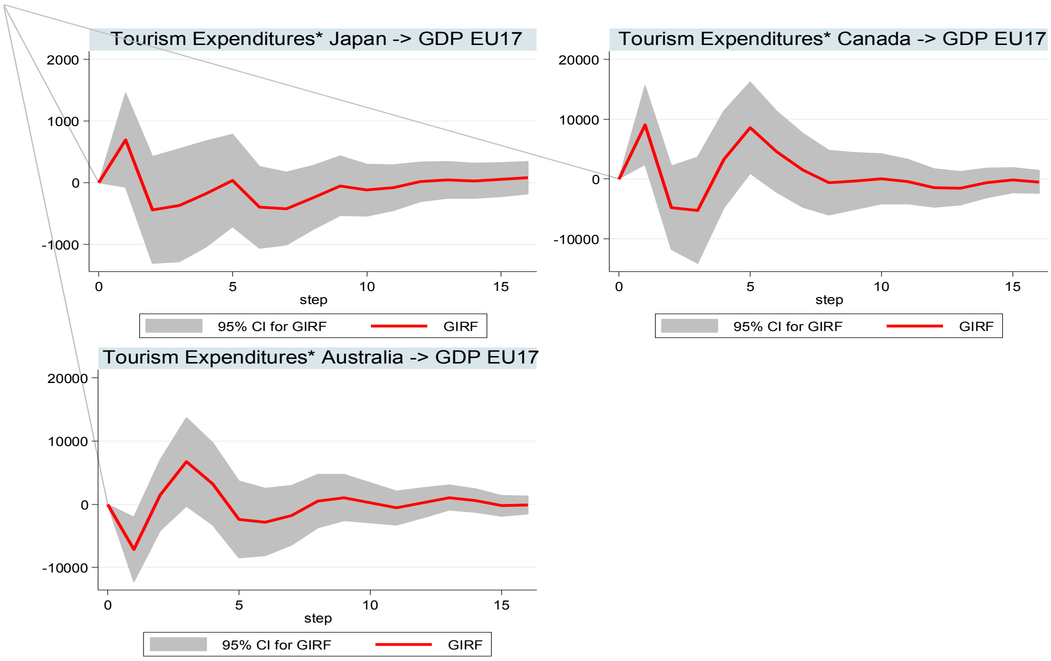


Figure 7: Response of GDP EU17 to Japan, Canada and Australia Tourism Expenditures



The GIRFs show that the US GDP is unaffected by all shocks while the EU17 is statistically significantly affected by shocks in the Tourism Expenditures of Australia and Canada.

We continue by focusing on the GIRFs of each BRIC economy separately. In this context, Figure 8 shows the response of the Brazilian GDP, while Figure 9 shows the response of the India's GDP to unit shocks in the Tourism Expenditures of EU17 and US.

Figure 8: Response of GDP Brazil to EU17 and US Tourism Expenditures

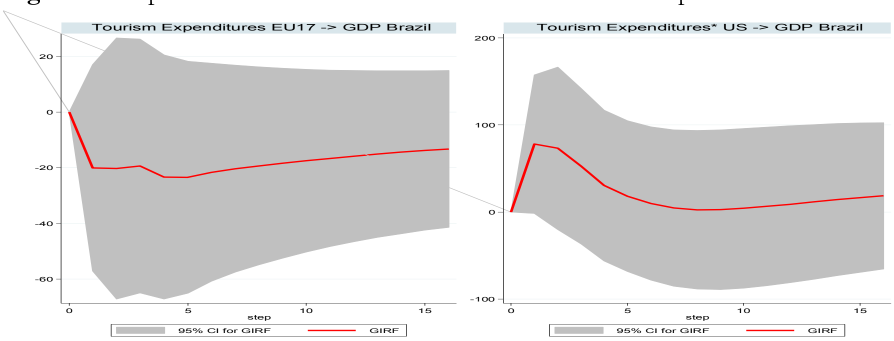
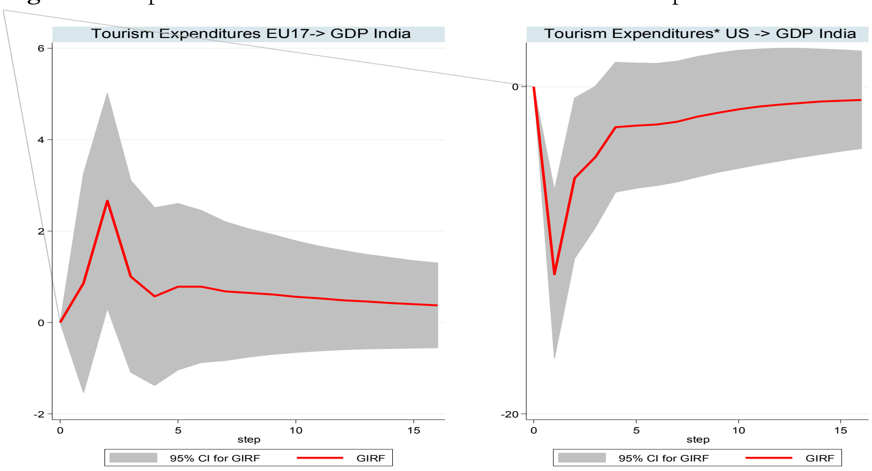


Figure 9: Response of GDP India to EU17 and US Tourism Expenditures



The results show the a unit shock in the US Tourism expenditures has a statistically significantly negative effect on the Brazilian and the Indian GDP, while a shock in the EU17 Tourism expenditures also has a statistically significant negative effect on the Indian GDP.

Next, Figures10 and 11 show the response of Russia's and China's GDP, respectively, to unit shock in the tourism expenditures of either EU17 or US.

Figure 10: Response of GDP Russia to EU17 and US Tourism Expenditures

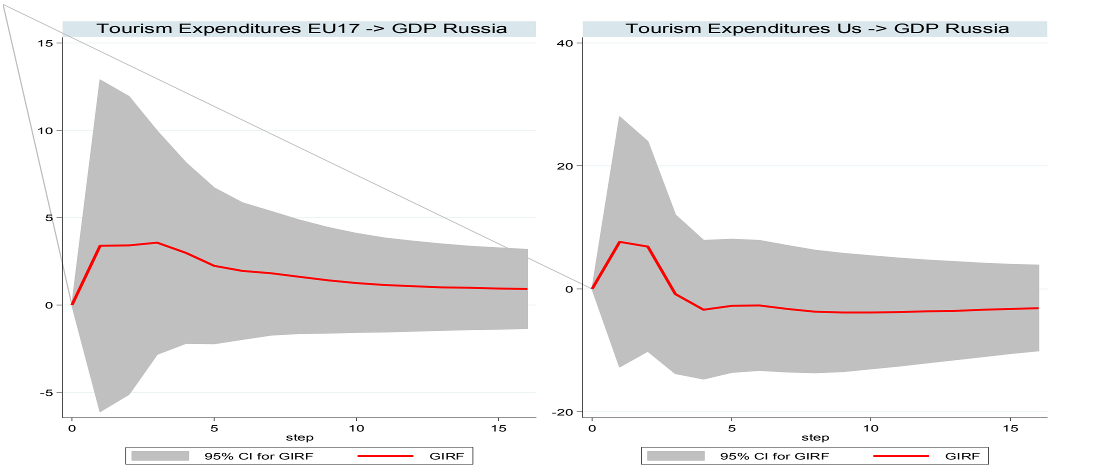
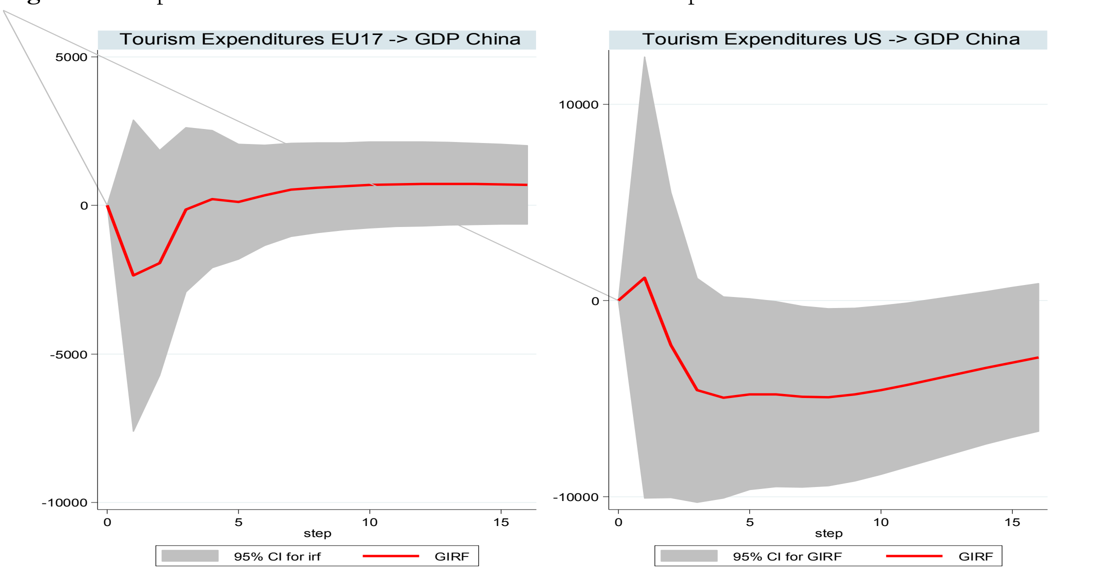


Figure 11: Response of GDP China to EU17 and US Tourism Expenditures



The results show that a unit shock in the Tourism Expenditures of US has a negative effect on the Chinese GDP, while EU 17 Tourism Expenditures do not have any statistically significant effect.

Next, we turn to the impact of a unit shock in the Tourism expenditures of the BRIC economies to their respective GDPs, Figures 12-15.

Figure 12: Response of GDP Brazil to India, China and Russia Tourism Expenditures

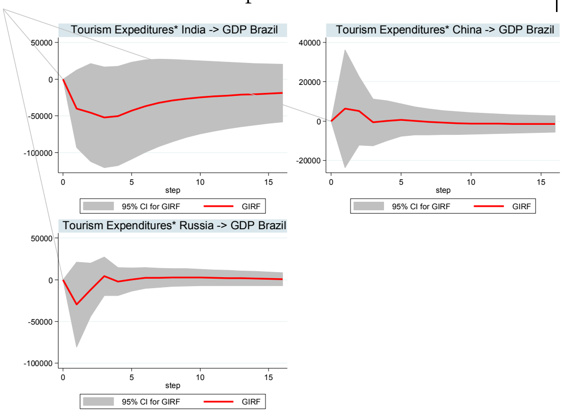


Figure 13: Response of GDP India to Brazil, China and Russia Tourism Expenditures

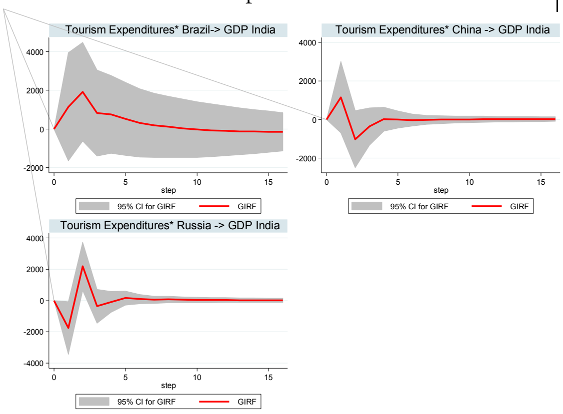


Figure 14: Response of GDP China to Brazil, India and Russia Tourism Expenditures

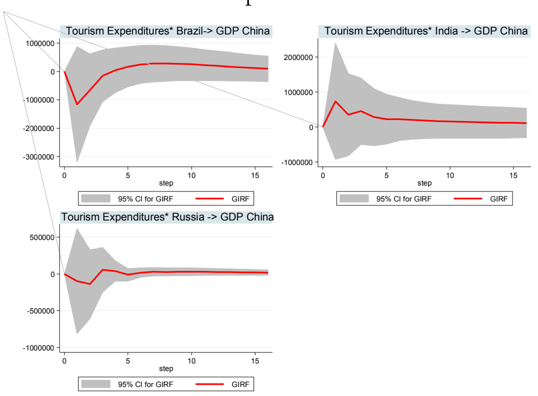
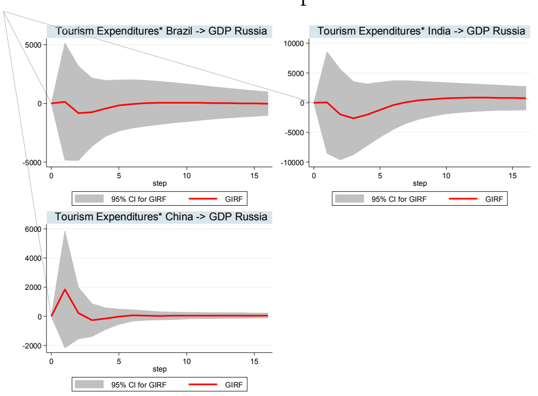


Figure 15: Response of GDP Russia to Brazil, India and China Tourism Expenditures



Based on the results, Russia's Tourism Expenditures have a positive and statistically significant impact on India's GDP, while we do not witness any other statistically significant impact.

Lastly, Figures 16-19 present the response of the BRIC economies to the rest of the economies that enter the model, i.e. Australia, Canada and Japan.

Figure 16: Response of GDP Brazil to Japan, Canada and Australia Tourism Expenditures

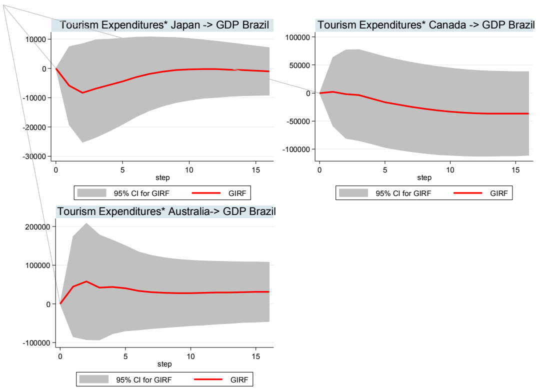


Figure 17: Response of GDP India toJapan, Canada and Australia Tourism Expenditures

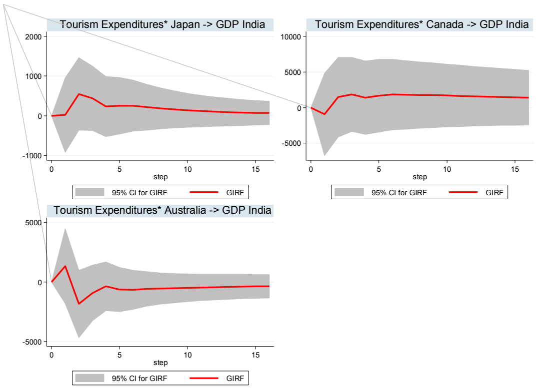


Figure 18: Response of GDP China to Japan, Canada and Australia Tourism Expenditures

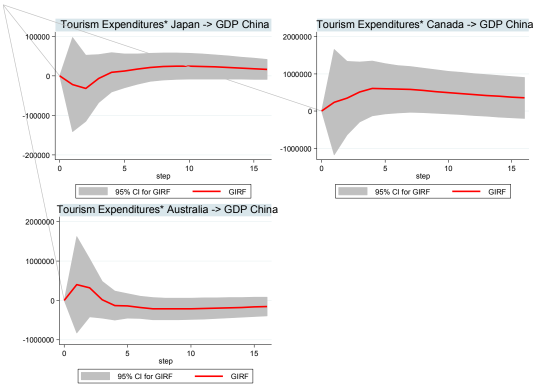
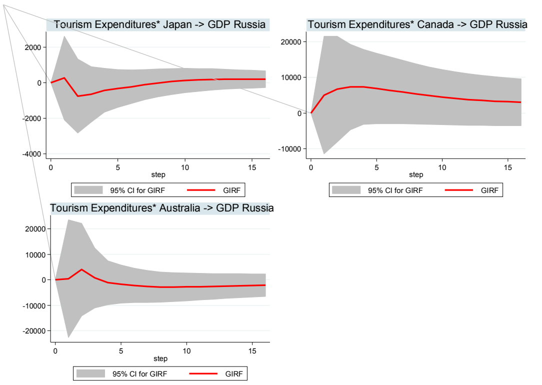


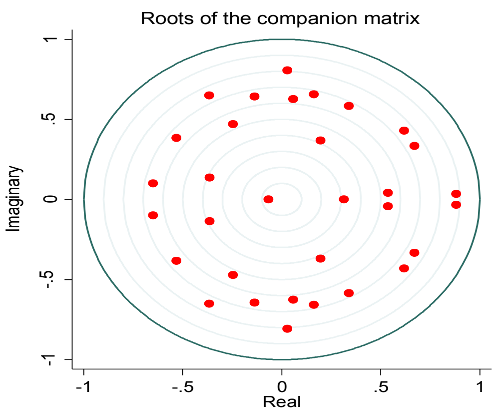
Figure 19: Response of GDP Russia to Japan, Canada and Australia Tourism Expenditures



According to our findings, we do not witness any statistically significant effects.

The robustness of the results is confirmed by the stability of the system (Figure 20).

Figure 20: Stability of GVEC System



4. DISCUSSION AND POLICY IMPLICATIONS

Our discussion will be based on the results of the Generalized Impulse Response Functions (GIRFs) taking into consideration the respective 95% confidence intervals that were calculated using 10,000 iterations. The general picture is that most of the GIRFs are found to be stable to unexpected/unanticipated shocks, which in turn suggests that the economies entering the model are characterized by increased stability, a finding which is largely consistent with the GVAR literature. See, among others, Dées et *al.* (2005, 2007a) and Pesaran et *al.* (2006).

Regarding the impact of a unit shock in tourism expenditures of the BRIC's economies on the GDP of the dominant economies of our model, i.e. EU 17 and US, it has been found that the US's economy is unaffected of shocks in tourism expenditures of all the BRIC economies, while the EU17 economy is initially positively affected by shocks in tourism expenditures of Brazil and China, negatively affected by shocks in tourism expenditures of India, and is unaffected by shocks in tourism expenditures of Russia. Also, our analysis indicates that there is no statistically significant impact of the unit shocks in tourism expenditures of BRIC's on the GDP of the rest of the economies of our analysis, i.e. Australia, Canada and Japan. Moreover, it has been found that one of the two dominant economy in our model, i.e. the US, is not only unaffected by shocks in tourism expenditures of the BRIC economies but is also unaffected by shocks of all the economies that entered our model, including the other dominant economy, i.e. EU. On the other hand, EU seems to be positively affected by unit shocks in the tourism expenditures of Canada and negatively affected by unit shocks of Australia. Now, although US's GDP is not affected by unit shocks in tourism expenditures of any of the countries examined, US' s tourism expenditures negatively affect the GDP of Brazil, China and India. Moreover, a unit shock in EU's tourism expenditures negatively affects India's GDP. Finally, it has also been found that a unit shock in Russia's tourism expenditures has a statistically significant positive impact on India's GDP, while unit shocks in Australia's (Canada's) tourism expenditures negatively (positively) affect EU's GDP.

From the previous analysis, it follows that unit shocks in tourism expenditures of the BRIC economies do not have any statistically significant impact on the economies of US, Australia, Canada and Japan. Brazil's and China's tourism expenditures seem to positively affect EU's GDP, whilst Russia's tourism expenditures do not affect EU17. The only negative impact on the GDP of the dominant economies is that of India's tourism expenditures on the EU's GDP. On the other hand, it is interesting that the only statistically significant effects of unit shocks in tourism expenditures of the dominant economies we detected have negative effects on the GDP of three of the BRIC economies, i.e. Brazil, China and India. Thus, it seems that the dominant economies are more likely to benefit from an increase in tourism expenditures of the non-dominant economies, while the latter are more likely not to benefit from an increase in tourism expenditures of the dominant economies. These results seem to be in line with some of the findings in the relevant literature. More specifically, the research of Lee and Chang (2008) concluded that tourism development has a higher impact on GDP in non-OECD countries than in OECD countries. Also, the finding of Tugcu (2014) that the European countries of the Mediterranean region are better able to generate growth from tourism than the other countries in the region does not contradict the findings of our analysis. Furthermore, our general findings are consistent with the work of Antonakakis et *al.* (2015) who suggest that the tourism–economic growth relationship does not remain constant over time in terms of both its magnitude and direction and, on the contrary, tourism is quite responsive to major economic events. Finally, it is worth emphasizing the dependency of the tourism sector of the less developed economies on the economies of the already developed countries.

Our findings imply that the less developed, non-dominant economies are more dependent on tourism expenditures. However, they are also vulnerable to shocks in tourism expenditures since, in most cases, these shocks tend to have a negative impact on their GDPs. This finding is consistent, among others, with the work of De Vita and Kyaw (2017), and validates the view of bilateral causality between tourism and economic activity through the mechanism described in Wu et *al.* (2016): "national income can be used to improve the level of tourism infrastructure and sites that are available in these countries in order to attract tourism to their destination so that there will be an increase in the level of economic activities in the sector, which will thereby accelerate long-run economic growth". See also Antonakakis et *al.* (2016); Kareem (2013); Zortuk (2009).

Therefore, the policy implications of our analysis support the view that the long-term growth planning of the less developed economies should not be based exclusively on tourism development (i.e. tourism-led growth) but should rather be directed in expanding and strengthening their economic base in order to be capable of absorbing shocks generated in the global tourism market due to unexpected events. According to our analysis, such a policy not only seems to make a country less vulnerable to shocks from other economies, but also makes it more likely for them to benefit from tourism development.

5. CONCLUSION

In this work, using the network economy described in Acemoglou et *al.* (2012), as well as the generalization of pervasiveness described in Pesaran and Yang (2016), we developed a GVAR model, which characterizes the general equilibrium price equation of the network model. In this context, we expressed a selected panel of world economies as a network system, whereas using data on the GDP and Tourism expenditures for these economies, we estimated the respective price equations for each economy in a general equilibrium framework. Additionally, we examined the degree of pervasiveness of each economy, which relates to the possible existence of dominant entities in the GVAR model. Based on our findings, the application of the proposed methodology to the economies of USA, EU17, Brazil, Russia, India, China, Japan, Australia and Canada, gave the following results:

(i) The economies of US and EU17 are the most central ones and may, thus, be considered as being dominant in the model, irrespectively of the criterion used for the selection process (i.e. δ-value characterization of pervasiveness, centrality measures of vertex theory).

(ii) A unit shock in the tourism expenditures of the BRIC economies does not have any statistically significant impact on the economies of US, Australia, Canada and Japan.

(iii) A unit shock in Brazil's and China's tourism expenditures affects positively EU17's GDP, whilst Russia's tourism expenditures do not have any statistically significant impact on the GDP of EU17.

(iv) The GDP of one dominant economy in our analysis, i.e. USA, is not affected by any unit shock in tourism expenditures of the countries examined. However, the other dominant economy of our model, i.e. EU17, is positively affected by unit shocks in the tourism expenditures of Brazil, China and Canada, and is negatively affected by unit shocks in the tourism expenditures of India and Australia.

(v) Regarding the impact of the tourism expenditures of the dominant economies on the GDP of other countries, we found that a unit shock in US's tourism expenditures has statistically significant negative impact on the GDP of Brazil, India and China, whilst a unit shock in EU17's tourism expenditures has a negative impact on India's GDP.

(vi) A unit shock in Russia's tourism expenditures positively affects India's GDP. Finally, a unit shock in Australia's (Canada's) tourism expenditures negatively (positively) affects EU's GDP.

These results seem to give credit to the view that the less developed economies are more vulnerable to changes in the tourism expenditures of the dominant economies, whilst the dominant economies, and especially US, seem to remain unaffected from unit shocks in tourism expenditures of the less developed economies. Thus, our findings tend to imply that the long-term growth planning of the less developed countries should be directed to strengthening their economic base in order to become less vulnerable to unexpected/unanticipated shocks from other economies, and, in this way, benefit from tourism development. In this context, taking into consideration the fact that the relationship between tourism and economic activity is a long-term process that takes place gradually over time, it is evident that a dynamic framework analysis could shed light to more aspects of this relationship when compared to a static framework.

Future research efforts could involve the use of bilateral data on tourism expenditures and the comparison of effects with the approach adopted in the present work. In addition, future efforts should also focus on the disaggregation of tourism expenditures on their respective counterparts (e.g. tourism expenditures for leisure activities, tourism expenditures for business purposes, etc) constituting another good example for future investigation.

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