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TIME-VARYING ECONOMIC CONSEQUENCES OF TERRORISM IN THE USA: EVIDENCE FROM TVP-SVAR MODEL

Abstract. *This study aims to examine the economic consequences of terrorism (the effects on economic growth and its components) in the U.S. as it suffers from the 9/11 attacks, which is a milestone of literature on the economic consequences of terrorism. We analyze the time-varying effects of terrorism on economic growth and its components in the U.S. for the period of 1970:Q1-2020:Q4 with the nonlinear Time-Varying Parameter Structural Vector Autoregression (TVP-SVAR) model. We construct an index over the values of all measurable dimensions (the number of terrorist incidents, the number of deaths, and the number of injured) of the terrorist acts carried out in the USA. The results show that the time factor is important in revealing the economic consequences of terrorism in the USA. In addition, the effects of terrorism on economic growth and its components have changed significantly in the periods before/after 11/9 and in the short/long term. These results point out the importance of designing security policies that limit the effects of insecurity and uncertainty created by terrorism on the spending decisions of economic actors*.

Keywords: *Terrorism, The Components of Economic Growth, Terrorism Index, USA, TVP-SVAR.*

Jel Classification : C51, E20, F41, O47

1. Introduction

From the global perspective, terrorism is defined as threat-violent acts carried out in an organized systematic way to disrupt daily life in order to gain sociological, psychological, political, geopolitical, and economic, etc. advantages. (Enders et al., 2011). In addition, the economic consequences of terrorism are especially emphasized. (Estrada et al., 2015: 1066). Although the importance of economic consequences of terrorism is usually accompanied by some factors such as religious, ethnic, divisive, and ideological, terrorism fundamentally targets the economy based on these factors and it has direct (short-term) and indirect (long-

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term) consequences on the economy (Estrada et al., 2018). Terrorism has its direct and indirect economic consequences through the channels of destruction, disruption, diversion, dis-saving, and portfolio substitution which feed each other and adversely affect the accumulation or distribution of production factors (Gries et al., 2011). Of these channels, destruction has direct consequences on the economy by affecting physical-human capital stock, and disruption, diversion, dis-saving, and portfolio substitution have indirect effects through indirectly affecting the decisions of economic agents. Terrorism destroys the physical-human capital stock in the economy with contingencies, property damage, etc., disrupts the public order, creates uncertainty and insecurity, increases production-operation costs (disruption), shifts resources to relatively inefficient areas such as defense expenditures (diversion), reduces the propensity to save, limits investment capacity-financing (dis-saving) and accelerates capital outflows (portfolio substitution) by reducing the return on physical-financial investments. (Gries et al., 2011; Morris and Gries, 2012). Terrorism reveals its economic consequences by influencing the decisions of economic actors such as households, businesses, the public, and foreign trade agents regarding consumption, investment, government, and commercial expenditures with these channels that feed each other. The changes, indirectly caused by terrorism in the decisions of economic actors regarding consumption, investment, government and commercial expenditures (components of economic growth), have an impact on the level of production (outcome) and economic growth in the long run (Shahbaz et al., 2013; Morris and Schneider, 2021)

This study aims to examine the economic consequences of terrorism (the effects on economic growth and its components) in the U.S. as it suffers from the 9/11 attacks, which is a milestone of literature on the economic consequences of terrorism. We analyze the time-varying effects of terrorism on economic growth and its components in the U.S. for the period of 1970:Q1-2020:Q4 with the nonlinear Time-Varying Parameter Structural Vector Autoregression (TVP-SVAR) model. The TVP-SVAR model considers the non-linear trends of the variables for the analysis period and allows the effects of time (specific periods and short-long terms) to examine. To analyze the effects of terrorism, we calculate an index over the equal and weighted values of all measurable dimensions (the number of terrorist incidents, the number of deaths, and the number of injured) of the terrorist acts carried out in the USA in the period of 1970:Q1-2020:Q4.

The focus and motivation of this study are to test the theoretical economic consequences of terrorism on economic growth and its components in the U.S., which directs the design of anti-terrorism policies at the global level and is the target of terrorist organizations of different identities, after the 9/11 attacks. The contribution of the study is threefold: First, it explains terrorism by constructing an index that covers all measurable dimensions of terrorism with equal and weighted values. Thus, terrorism, which is generally represented by the numerical data of terrorist incidents in the literature, is analyzed with more inclusive variables. Second, unlike previous literature, this study analyzes the effect of terrorism on the

components of economic growth as well as economic growth. Hence, the study expands the focus of the field to all components of economic growth. Third, unlike previous studies that generally analyze the economic consequences of terrorism with linear models within the scope of time series analysis, this study applies linear and nonlinear models, and therefore, we can observe the non-linear trends of terrorism, economic growth, and its components with the TVP-SVAR model and examine whether time has an impact on the economic consequences of terrorism.

The study proceeds as follows: Section 2 summarizes the literature review, section 3 explains data and methodology, section 4 explicate the results and section 5 concludes.

2. Literature Review

The studies on terrorism and its economic consequences follow a two-dimensional development path that complements each other over time. The first strand of studies focuses on the economic consequences of terrorism at the theoretical level after the Cold War (the 1990s), while the second concentrates on testing the economic consequences of terrorism at the empirical level after 9/11 (2000s). Enders et al., (1990) and Enders and Sandler (1996) are the pioneering theoretical studies on the economic consequences of terrorism. These studies focus on the direct and indirect channels of terrorism on the economy and explain the effects of these channels on economic growth and its components. On the other hand, the studies of Gupta et al., (2002), Blomberg et al., (2004), and Eckstein and Tsiddon (2004) are the milestones at the empirical level. These studies test the theoretical predictions on the economic consequences of terrorism.

Gupta et al., (2002) examine the effects of terrorism on economic growth, from 1980 to 1999 in 60 low- and middle-income countries by applying panel data analysis with the GMM (Generalized Method of Moments) model. The authors find that terrorism reduces economic growth in the sample countries. Blomberg et al., (2004) analyze the effects of terrorism on economic growth and its components in 177 countries including OECD, Africa, Middle East, and Asian countries for the period of 1968-2000. They perform linear models such as OLS (Ordinary Least Squares), GMM, and SVAR (Structural Vector Auto-Regression) and conclude that terrorism reduces economic growth and investment expenditures and increases government expenditures. Eckstein and Tsiddon (2004) examine the effects of terrorism with an index (the number of terrorist incidents, the number of deaths in terrorist incidents,d and the number of injured in terrorist incidents) in Israel from 1980 to 2003. The results show that terrorism reduces economic growth and consumption, investment, and commercial expenditures in Israel.

Following Gupta et al., (2002), Blomberg et al., (2004), and Eckstein and Tsiddon (2004), many studies attempt to test the economic consequences of terrorism by using variables such as the number of terrorist incidents, the number of deaths in terrorist incidents and the number of injured in terrorist incidents (Llussá and Tavares (2011); Gries et al., (2011); Blomberg et al., (2011); Shahbaz et al., (2013); Cevik and Ricco (2015); Mehmood and Mehmood (2016); Sana and Mariuam (2018); Meierrieks and Schneider (2021)). In addition, some studies

construct an index over the numerical data of terrorist acts to represent terrorism, following Eckstein and Tsiddon (2004); Öcal and Yıldırım (2010); Mehmood (2014); Khan et al., (2016); Vorsina et al., (2017)). The majority of studies focus only on the economic consequences of terrorism on economic growth, as in the study of Gupta et al., (2002). For instance, Nasir et al., (2008) examine the effects of terrorism on economic growth in Pakistan with a linear VAR model for the period of 1972-2006 and find that terrorism reduces Pakistan's economic growth. The results are supported by many studies which apply different models (linear VAR, VEC (Vector Error Correction), ARDL (Auto-Regressive Distributed Lag), and non-linear STVAR (Smooth Transition Vector Auto-Regression), Gries et al., (2011; VAR/7 Western European Countries); Khan et al., (2016; VEC/Pakistan); Sana and Mariuam (2018; ARDL/Pakistan).

Öcal and Yıldırım (2010) investigate the effects of terrorism on economic growth in Turkey with the linear GWR (Geographically Weighted Regression) model at the regional level for the period of 1987-2001. They find that terrorism reduces Turkey's economic growth and that the reducing effects of terrorism on economic growth are more in the eastern and southeastern regions. Other studies also have the same conclusions using linear OLS, GMM, ARDL, FMOLS (Fully Modified Least Squares) models with panel data analysis. Analyzing several African countries, Blomberg et al., (2011; GMM), Vorsina et al., (2017) examine the effects of terrorism on economic growth in 117 countries with a linear SUR (Seemingly Unrelated Regressions) model for the period of 2006-2011 and determine that terrorism was not effective on economic growth. However, a limited number of studies analyze the economic consequences of terrorism by considering the effects on the components of economic growth, as in the studies of Blomberg et al., (2004) and Eckstein and Tsiddon (2004).

Mehmood (2014), interprets the effects of terrorism on the components of economic growth in Pakistan with linear Quasi-Structural VAR and VEC models from 1973 to 2010 and concludes that terrorism reduced consumption, investment, government and commercial spending, and economic growth in Pakistan. Similarly, Shahbaz et al., (2013; ARDL/Pakistan) find that terrorism reduces trade expenditures and economic growth with time-series analysis. Mehmood and Mehmood (2016; OLS) find that terrorism reduces investment expenditures in 7 South Asian countries. While Cevik and Ricco (2015; GMM) determine that terrorism increased government expenditures in 153 countries, Llussá and Tavares (2011; OLS) find that terrorism decreases consumption and investment expenditures in 187 countries and does not affect government expenditures and economic growth. Gaibulloev and Sandler (2009; OLS) conclude that terrorism does not affect investment expenditures, increases government expenditures, and reduces economic growth in 42 Asian countries.

Although the literature, both time-series and panel data studies, delves into the economic consequences of terrorism, which are represented by the numerical data of terrorist incidents, and examines the effects on economic growth, it mostly neglects the effect of terrorism on the components of economic growth. There are a

few studies that examine the economic consequences of terrorism in Israel, Nigeria, and Pakistan with time series analysis, and in Asian and African countries with panel data analysis. These studies conclude that terrorism generally has negative effects on economic growth or its components, as predicted theoretically.
This study attempts to empirically examine the economic consequences of terrorism in the U.S., which is exposed to the 9/11 attacks, with time series analysis. Accordingly, we construct an index for the time-varying effects of terrorism on economic growth and its components over the equal and weighted values of the numerical data covering all the measurable dimensions of the terrorist acts committed in the USA from 1970:Q1 to 2020:Q4 and apply the non-linear TVP-SVAR model. The TVP-SVAR model allows for the non-linear tendencies of the model variables and enables the effect of timing to reveal the economic consequences of terrorism on economic growth and its components in the USA, before, during, and after 9/11. This study contributes to the literature by analyzing the economic consequences of terrorism and its effects on economic growth and its components over time and taking nonlinear trends in variables into account.

3. Data and Methodology

This section explains the data and econometric methodology of the study, which aims to examine the time-varying effects of terrorism on economic growth and its components in the USA, with the TVP-SVAR model.

3.1. Data

We obtain the data from The Federal Reserve Bank of St Louis FED (FRED Economic Data) and The Global Terrorism Database (GTD) databases from 1970 to 2020 quarterly. The variables are consumption expenditures (CE), investment expenditures (IE), government expenditures (GE), commercial expenditures (TE), economic growth (DP), and terrorism indices (ETI and GTI). Data for the economic variables CE, IE, GE, TE, and DP are available directly from the FRED database quarterly from 1970 to 2020. We calculate the data of the ETI and GTI terrorism index variables using the numerical data of the terrorist acts taken from the GTD database monthly for the period 1970-2020. The data of the economic variables CE, IE, GE, TE, and DP is from the FRED database as real (Billions of Chained 2012 Dollars) and seasonally adjusted (Seasonally Adjusted) values of the variables. While the data of CE, IE, GE, and DP variables is retrieved from the FRED database as Personal Consumption Expenditures, Gross Private Domestic Investment, Government Consumption Expenditures, and Gross Investment and Gross Domestic Product values, respectively. We get the data of the TE variable by collecting the Exports of Goods and Services and Imports of Goods and Services data. We use the annual growth rate of the variables CE, IE, GE, TE, and DP for the changes in economic growth and its components. We retrieve the data of the ETI and GTI terrorism index variables from the GTD database as the monthly values of the terrorist acts by terrorist organizations of different identities. The GTD database, based on the University of Maryland the National Consortium for the Study of Terrorism and Responses to Terrorism (START) project, contains monthly data of 163 countries for the period 1970-2020 as of 2021 and categorizes

terrorist acts carried out in terms of organization, time, place, target, nature, type, weapons, etc.

Developed by Eckstein and Tsiddon (2004), ETI criticizes the representation of terrorism only with numerical data of terrorist incidents in terms of size and scope and attempts to represent it with a composite indicator that uses numerical data covering all measurable dimensions (number of terrorist incidents, number of deaths in terrorist incidents and number of injured in terrorist incidents). ETI is calculated with the following equation: (Araz-Takay et al., 2009)

$$ET = ln[1 + (A + +I)] \quad (1)$$

where (A), (K), and (I) are the number of terrorist acts, killed in terrorist incidents, and injured in terrorist incidents in a given quarter, respectively. ETI is the terrorism index calculated in natural logarithmic form (ln) over the simple average of the total values of (A), (K), and (I) in a given quarter (Eckstein and Tsiddon, 2004).

The GTI, developed by the Institute for Economics and Peace (IEP) GTD, criticizes the equally weighted use of numerical data covering all measurable dimensions of terrorist acts in terms of the degree of impact (destruction dimension) and is based on calculating the weighted effective indicator of the degree of impact. The GTI is calculated as follows: (IEP-GTI, 2020)

$$GTI = \ln[(A * 1) + (K * 3) + (I * 0.5)] \quad (2)$$

where (A), (K), and (I) are the number of terrorist acts, killed in terrorist incidents, and injured in terrorist incidents in a given quarter, respectively. GTI represents the terrorism index calculated in natural logarithmic form (ln), weighted according to the impact degrees of the total values of (A), (K), and (I).

Table 1 tabulates the descriptive statistics of the time series features of the CE, IE, GE, TE, DP, ETI, and GTI variables.

Table 1: Descriptive Statistics

Statistics	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
CE	2.88	3.01	7.84	-10.23	2.12	-1.45	9.55	435.98
IE	3.80	4.73	39.19	-26.18	9.74	-0.16	4.50	20.02
GE	1.47	1.59	7.91	-3.89	2.07	-0.02	3.23	0.47
TE	5.17	5.54	19.74	-23.02	6.25	-0.93	5.62	87.97
DP	2.64	2.80	8.58	-9.03	2.35	-0.91	5.86	97.50
ETI	2.05	1.85	9.02	0.00	1.18	1.67	9.15	416.19
GTI	2.94	2.95	9.90	0.00	1.40	0.71	5.53	71.67
Num. of Obs.	**204**	**204**	**204**	**204**	**204**	**204**	**204**	**204**

3.2. TVP-SVAR Model

The TVP-SVAR model, developed by Primiceri (2005), is based on the extension of the linear VAR and SVAR models in Sims (1986) and Shapiro and Watson (1988) by changing the assumptions. The TVP-SVAR model aims to eliminate the possible changes in the parameters and structural shocks according to the order of the endogenous variables of the VAR and SVAR models and changes the assumptions of linear trends in parameters and structural shocks. the TVP-SVAR model assumes that the parameters and structural shocks might show linear or non-linear trends and examines their effects over time. In this respect, the TVP-SVAR model allows the parameters of the endogenous variables and the variance-covariance matrix to change over time and captures the changes and nonlinear trends in the lag structure of the parameters and structural shocks. Equation 3 explains time-varying relationships between endogenous variables, which are assumed to follow a first-order random walk process, in the basic TVP-SVAR model

$$Y_t = c_t + \beta_{1t}y_{t-1} + \cdots + \beta_{st}y_{t-s} + e_t, \qquad e_t \sim N(0, \Omega_t) \tag{3}$$

where (Y_t) and (c_t) in the (k×1) dimension are the endogenous variables and the constant term vector, respectively, while the terms (β_{it}) and (Ω_t)) in the (k×k) dimension are the variance-covariance matrix of the time-varying coefficients and residues, respectively. (Ω_t) denotes recursive identification structural shocks and can be decomposed as in Equation 4:

$$\Omega_t = A_t^{-1}\sum_t \sum_t' (A_t^{-1})' \tag{4}$$

where $(\sum_t)$ denotes the diagonal matrix of the time-varying variance components of the structural shocks of the endogenous variables, and (A_t) is the lower triangular matrix of the covariance components, which enables the determination of the time-varying relationships of the endogenous variables. Also, The diagonal $(\sum_t)$ and (A_t) lower triangular matrices in the equation can be written as in Equation 5:

$$\sum_t = \begin{pmatrix} \sigma_1 & 0 & \dots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \sigma_k \end{pmatrix}, \qquad A_t = \begin{pmatrix} 1 & 0 & \dots & 0 \\ \alpha_{21,t} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{k1,t} & \dots & \alpha_{k,k-1,t} & 1 \end{pmatrix} \tag{5}$$

With this transformation in the equations, the basic regression equation of the TVP-SVAR model in Equation 3 can be rewritten as follows:

$$y_t = X_1\beta_t + A_t^{-1}\sum_t \varepsilon_t, \qquad \varepsilon_t = \sim N(0, I) \tag{6}$$

Here, Primiceri (2005) uses the process $t = s + 1, \dots, n,$ for modeling the time-varying parameters of endogenous variables and $(\alpha_{21}, \alpha_{31}, \alpha_{32}, \dots, \alpha_{k,k-1})'$ clustered vector representation of elements for determining (A_t) the lower triangle

matrix. With this notation, the variance-covariance matrix of the time-varying residues becomes $h_t = (h_{1t}, \dots, h_{kt})'$ and $h_{jt} = log\sigma_{jt}^2, \quad (j = 1, \dots, k,)$. Furthermore, the parameters are assumed to be not stationary in AR(1) but follow a random-walk process. Under all these assumptions, the structural view of (β_t), (α_t) and (h_t) parameters is defined as in Equation 7:

$$\begin{matrix} \beta_{t+1} = \beta_t + \mu_{\beta t}, \\ \alpha_{t+1} = \alpha_t + \mu_{\alpha t}, \\ h_{t+1} = h_t + \mu_{ht}, \end{matrix} \qquad \begin{pmatrix} \varepsilon_t \\ \mu_{\beta t} \\ \mu_{\alpha t} \\ \mu_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \sum_{\beta} & 0 & 0 \\ 0 & 0 & \sum_{\alpha} & 0 \\ 0 & 0 & 0 & \sum_{h} \end{pmatrix}\right) \tag{7}$$

In the equation, $t = s + 1, \dots, n, \quad \beta_{s+1} \sim N(\mu_{\beta 0}, \sum_{\beta 0}), \quad \alpha_{s+1} \sim N(\mu_{\alpha 0}, \sum_{\alpha 0})$ and $h_{s+1} \sim N(\mu_{h0}, \sum_{h0})$. (ε_t) denotes the elements of the covariance matrix of the structural shocks on the diagonal matrix, and (β_t), (α_t) and (h_t) are the time-varying structural shocks in the lagged coefficients, simultaneous coefficients, and standard errors, respectively. (A_t) turns into a lower triangular matrix t with the representation in Equation 7 and transforms the VAR model into a recursive structure and facilitates the estimation of the reduced structure of the SVAR model. In this context, the reduced form of structural shocks in the variance-covariance matrix of the residuals needs to be determined with the constraints on the covariance matrix (ε_t) of the structural shocks in the (A_t) matrix in Equation 7. The TVP-SVAR model in Equation 6 requires the determination of the optimal lag length that eliminates the autocorrelation in the estimated residuals, accompanied by Marginal Likelihood (ML) and ranking the endogenous variables in the (A_t) matrix. By determining the optimal lag length and ranking the endogenous variables in the (A_t) matrix, the TVP-SVAR model is iteratively estimated by the Markov Chain Monte Carlo (Markov Chain Monte Carlo-MCMC) method based on a random walk process and Bayesian algorithm (Nakajima, 2011).

4. Empirical Results

This section discusses the TVP-SVAR model analysis findings for the time-varying effects of terrorism on economic growth and its components in the USA. The endogenous variables in the TVP-SVAR-1 model are ETI CE, IE, GE, TE, and DP. We follow Eckstein and Tsiddon (2004) and Mehmood (2014) to determine the endogenous variables vector variables (y_t) in TVP-SVAR-1 model and tıtsordering in the (A_t) matrix. In the analysis, first, we aim to prevent multicollinearity problems and facilitate the robustness of the empirical findings. Before applying TVP-SVAR models, we determine the linear and non-linear trends of the endogenous variables in the models by applying linearity tests. Determining non-linear and linear variables enables having bias-free test statistics. Thus, we first apply Harvey and Leybourne (2007-HL) and Harvey et al., (2008-HLB) linearity tests. HL and HLB linearity tests might also be used for the variables that are not stationary in level. The test statistics for HL is Wald type (W_T^*) and for HLB is Wald type tipi (W_λ). If the calculated (W_T^*) and (W_λ) test statistics are

greater than the critical table values, the null hypothesis of "variables are linear" is rejected meaning that the variables show nonlinear trends (Harvey and Leybourne, 2007; Harvey et al., 2008).

Table 2: Linearity Test Results

Variables		HR	HLB	
		W_λ	W_T^*	
			% 1	% 5
CE		73.32[a]	83.50[a]	82.88[b]
IE		6.70[b]	10.06	10.05[b]
GE		6.58[b]	13.51[a]	13.48[b]
TE		35.77[a]	36.22[a]	36.00[b]
DP		48.79[a]	47.15[a]	46.87[b]
ETI		9.60[a]	31.03[a]	30.92[b]
GTI		7.44[b]	12.58	12.50[b]
Critical Values	***% 1***	***9.21***	***13.27***	
	% 5	***5.99***	***9.48***	

Note: Test statistics have a degrees of freedom ($\chi^2 = 2$). "[a]" and "[b]" denotes % 1 and % 5 significance level, respectively.

Table 2 tabulates HL and HLB test results of the endogenous variables in the TVP-SVAR models. All variables are not linear at the 1% or 5% significance level according to the HR and HLB linearity tests. Hence we need to perform non-linear unit root tests for stationarity (Cuestas and Garrant, 2011). Kapetanios et al. (2003-KSS) and Kruse (2011-KRS) non-linear unit root tests analyze stationarity of endogenous variables in TVP-SVAR models by considering the symmetrical and asymmetrical properties of the variables and deterministic and stochastic structure. KSS and KRS unit root tests run an exponential and smooth autoregressive process with an auxiliary regression equation extended by first-order Taylor expansion to examine the stationarity of non-linear time series data. T statistic of KSS and KRS tests are demeaned and detrended and the null hypothesis is: "Variable has a unit root". If the t-statistics is greater than the critical value the null is rejected meaning the variables are stationary (Kapetanios et al., 2003; Kruse, 2011).

Table 3: Non-Linear Unit Root Test Results

DD		KSS		KRS	
Variables		**t-Statistics**	**L**	**t-Statisitcis**	**L**
CE		-8.08[a]	2	48.64[a]	2
IE		-5.12[a]	2	26.22[a]	2
GE		-3.50[b]	1	13.55[b]	1
TE		-6.61[a]	3	50.47[a]	3
DP		-8.42[a]	2	72.69[a]	2
ETI		-4.17[a]	1	21.37[a]	1
GTI		-6.51[a]	1	42.62[a]	1
Critical Values	***% 1***	***-3.93***		***17.10***	
	% 5	***-3.40***		***12.82***	

Note: "[a]" and "[b]" denotes % 1 and % 5 significance level, respectively. The "L" column shows the optimal lag lengths of the variables with the Akaike Information Criteria (AIC). The critical values in the table are taken from Kapetanios et al., (2003) and Kruse (2011).

Table 3 shows the results of unit root tests. all variables are stationary at 1% or 5% significance level [I(0)] according to KSSand KRS unit root tests. Next, we estimate the TVP-SVAR model in equation 6 by using the level values of the variables. The optimal lag length of the TVP-SVAR models is 1. Then, we perform a Bayesian MCMC algorithm and run 12.000 iterations (including 2000 time-varying parameter iterations) and get joint posterior distribution efficiency results.

Table 4: The TVP-SVAR-1 Model Parameter Estimation Results

Parameters	Mean	Standard Deviation	Confidence Intervals (% 95)	CD	IF
$(\sum_{\beta})_1$	0.0228	0.0026	[0.0184-0.0287]	0.244	13.88
$(\sum_{\beta})_2$	0.0227	0.0026	[0.0183-0.0286]	0.166	12.17
$(\sum_{\alpha})_1$	0.0605	0.0176	[0.0360-0.1037]	0.816	52.86
$(\sum_{\alpha})_2$	0.0838	0.0355	[0.0439-0.1788]	0.246	90.18
$(\sum_{h})_1$	0.6868	0.1303	[0.4580-0.9694]	0.658	63.80
$(\sum_{h})_2$	0.4897	0.1097	[0.3062-0.7418]	0.808	47.76

Table 4 outlines the estimation results. According to Table 4 successive distributions of the parameters in the TVP-SVAR-1 model converge and the MCMC algorithm is effective. This is evident from the CD test (Geweke, 1992). We reject the null hypothesis at the 5% significance level. Also, the IF (Inefficiency Factors) values are relatively low. The time-varying structural change parameter of lagged coefficients $(\sum_{\beta})_2$ hast the lowest value (12.17%) in the TVP-SVAR-1 model. On the other hand, the time-varying structural change parameter of simultaneous coefficients $(\sum_{\alpha})_2$ has the highest value (90.18%).

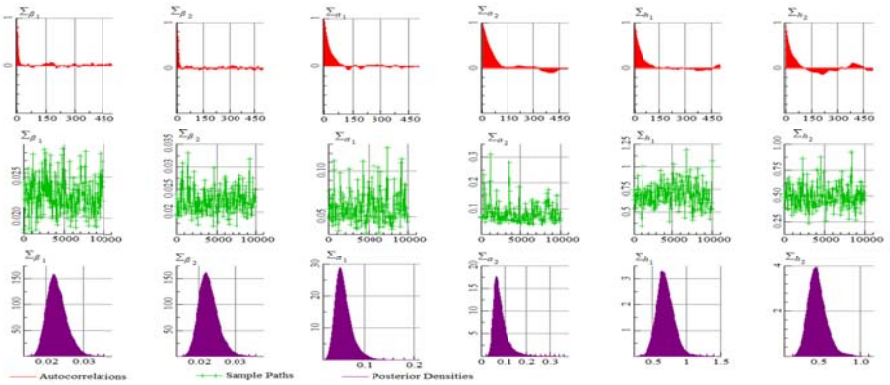

Figure 1: The TVP-SVAR-1 Model Parameter Estimation Results

Figure 1 picturizes the results of TVP-SVAR-1 model estimation results. According to figure 1, $(\sum_{\beta})_1$, $(\sum_{\beta})_2$, $(\sum_{\alpha})_1$, $(\sum_{\alpha})_2$ $(\sum_{h})_1$ and $(\sum_{h})_2$ are efficient. Figures 2,3, and 4 tabulate the progress, stochastic volatility, and the extent of

simultaneous relationships of the variables ETI, CE, IE, GE, TE, and DP in the TVP-SVAR-1 model.

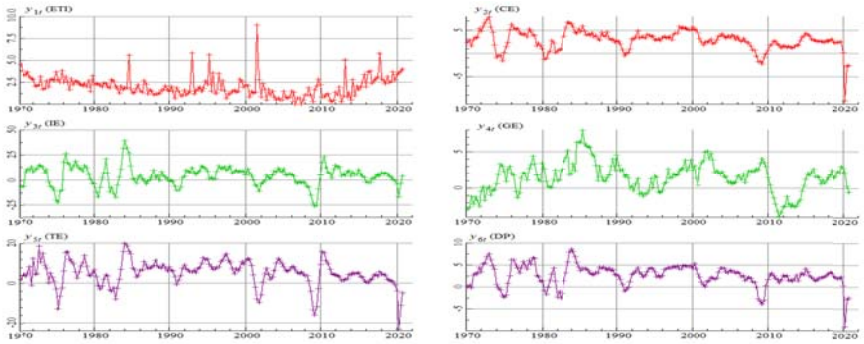

Figure 2: Time-Series Graphics of the Variables in the TVP-SVAR-1 Model

According to Figure 2, ETI follows a fluctuating progress trend, with its highest values in 1993-2001 and its lowest values in 2007-2008. Besides, CE, IE, GE, TE, and DP follow a similar path and take their highest and lowest values on almost the same dates.

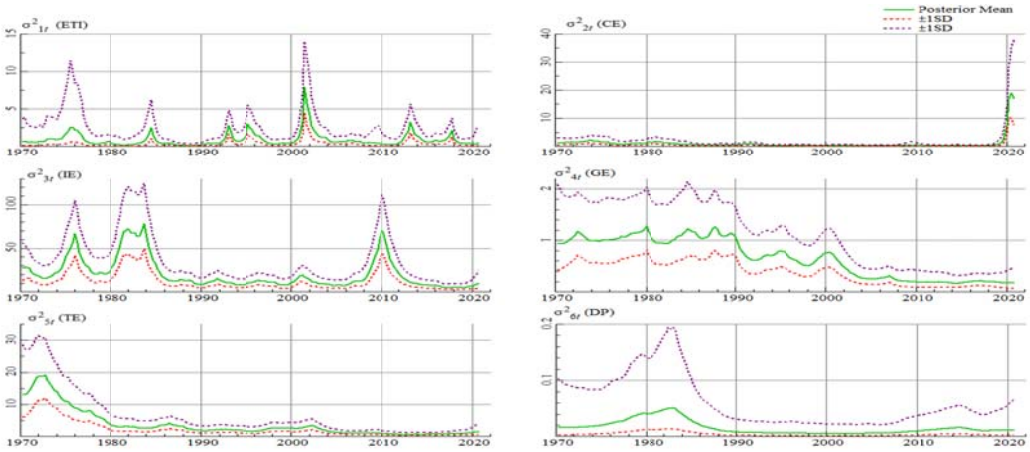

Figure 3: Stochastic Volatility of the Variables in the TVP-SVAR-1 Model

Figure 3 plots the stochastic volatilities (mean values of structural shocks) of the ETI, IE, GE, DP, CE, and TE. ETI, IE, GE and DP have a highly unstable trend whereas, CE and TE follow a relatively stable trend. However, in terms of the magnitude of the changes in stochastic volatility, variables are ranked as ETI, IE, GE, TE, DP, and CE.

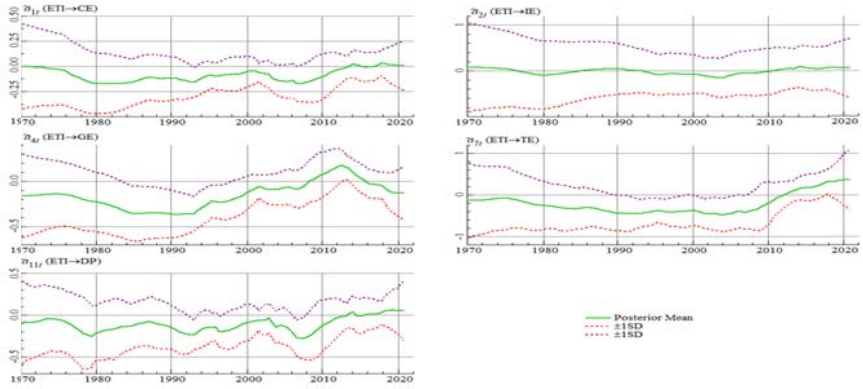

Figure 4: Simultaneous Relations of the Variables in the TVP-SVAR-1 Model

Figure 4 outlines the simultaneous relations of the variables in the TVP-SVAR-1 Model The simultaneous relationships arising from the recursive structural shocks between ETI and CE, IE, GE, TE, and DP follow a similar trend. The simultaneous relationships between ETI and CE, IE, GE, TE, and DP are generally negative/strong in the 1970-2013 period and positive/weak in the 2014-2020 period.

Figure 5 presents the results of the impulse-response analyzes using the variance-covariance matrix of the parameters. Figure 5 plots the structural shocks originating from the terrorism-ETI, consumption expenditures-CE, investment expenditures-IE, government expenditures-GE, commercial expenditures-TE, and economic growth-DP variables over time and shows the degree (direction/magnitude) of their changing response.

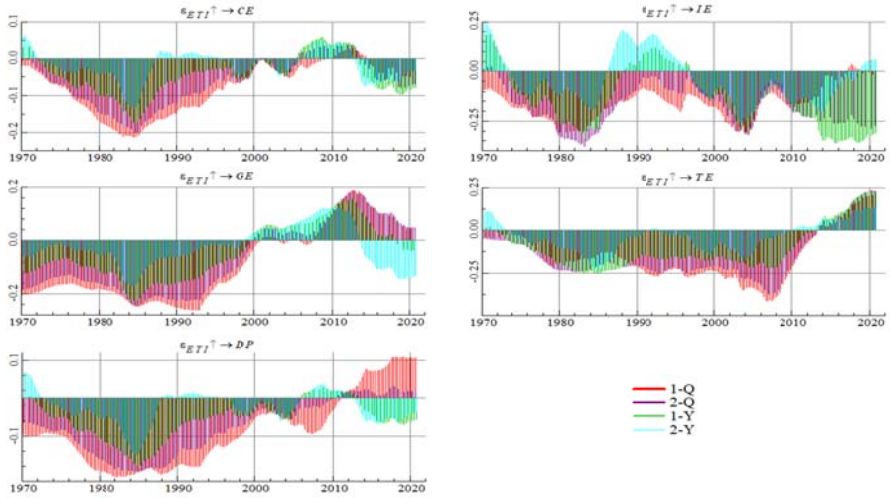

Figure 5: TVP-SVAR-1 Model: Time-Varying Responses to Terrorism Shocks

According to figure 5, CE reacts positively and with relatively similar magnitudes to the ETI structural shocks in 2006-2014 with 1-Q, 2-Q, and 1-Y terms, and in 1970-1972, 1987-1997, and 2006-2014 with 2-Y terms. In all other periods, CE reacts negatively and its degree varies over different terms. CE has its greatest responses in 1970-2020, 2008-2013, and in 1982-1985 with a decreasing trend in the positive or negative direction. These findings show that ETI structural shocks have a decreasing effect on consumption expenditures during the 1970-2020 period. Also, the magnitude of the effect decreases as the term gets longer. Furthermore, the effects differ significantly before and after 2001.

IE reacts positively and weakly to ETI structural shocks in 1970-1971 and 2017-2019 with 1-Q and 2-Q terms, and negatively and strongly in all other periods. Also, there are positive responses with similar magnitudes in the 1970-1974, 1986-1996, and 2019-2020 periods with 1-Y and 2-Y terms, and negative in all other periods. IE has its greatest responses in 1988-1994, 1980-1985, and 2000-2005 with a decreasing trend in the positive or negative direction. On the other hand, ETI structural shocks are positive and low-magnitude in the 1970-1974, 1986-1996, and 2017-2020 periods, and negative and high-magnitude in all other periods, especially in 1980-1985 and 2000-2005. Also, the magnitude of the effects decreases as the term lengthens and differs to a certain extent during the 1970-2020 period. Likewise, ETI structural shocks have a decreasing effect on (GE) government expenditures as the term gets longer during the 1970-2020 period. Also, The effects differ before and after 2001. While the shocks have a diminishing effect in the 1970-2001period, they have generally increasing effects in the 2001-2020 period.

The responses of the TE to the ETI structural shocks are generally negative in the 1974-2013 period and positively in the 1970-1973 and 2014-2020 periods with 1-Q, 2-Q, 1-Y, and 2-Y terms. TE has its greatest negative or positive reactions in the 1970-2020, 2001-2009, and 2018-2020 periods with a decreasing trend from short to long-term. Moreover, the response differs between 1974-2013 and 2014-2020 intervals with a negative direction and high-magnitude in 1973-2013 and a positive and low-magnitude in 2014-2020. Thus, ETI structural shocks have a decreasing effect on commercial expenditures as the term gets longer during the 1970-2020 period. Also, The effects differ before and after 2013-2014. While the shocks have a diminishing effect in the 1974-2013 period, they have increasing effects in the 2014-2020 period. Similarly, ETI structural shocks have a decreasing effect on (DP) economic growth as the term gets longer during the 1970-2020 period. Also, The effects differ before and after 2001. While the shocks have a diminishing effect in the 1970-2001period, they have generally decreasing effects in the 2001-2020 period

5. Conclusion

This study aims to examine the economic consequences of terrorism (the effects on economic growth and its components) in the U.S. as it suffers from the 9/11 attacks, which is a milestone of literature on the economic consequences of terrorism. We analyze the time-varying effects of terrorism on economic growth

and its components in the U.S. for the period of 1970:Q1-2020:Q4 with the TVP-SVAR model. The TVP-SVAR model considers the non-linear trends of the variables for the analysis period and allows the effects of time (specific periods and short-long terms) to examine. Our findings show that the effects of terrorism on consumption, investment, government and commercial expenditures, and economic growth in the U.S. differ significantly over time (in the periods before/after 11/9 and from short-term to long-term). While terrorism has decreased consumption expenditures continuously and significantly in the 1970-2001 period, it has increased generally and to a limited extent in the 2001-2020 period. As the term lengthens the effect of terrorism on consumption expenditures loses its effectiveness and the reducing and increasing effects of terrorism on consumption expenditures by affecting the expectations of the households become more evident in the 1982-1985 and 2008-2013 periods, respectively. In addition, terrorism has increased investment expenditures generally and to a limited extent in the 1970-2001 period, it has decreased continuously and significantly in the 2001-2020 period. The effects of terrorism on investment expenditures by affecting the expectations of the business world and become more evident in the periods of 1988-1994 and 2000-2005, respectively. Moreover, terrorism has reduced government expenditures continuously and significantly in the 1970-2001 period but has generally and limitedly increased in the 2001-2020 period. Besides, the 1984-1993 and 2010-2014 stand out as the effects of terrorism on public expenditures by affecting the expenditure composition of the government are stronger. Furthermore, terrorism generally and significantly has reduced commercial expenditures in the 1970-2013 period, and has increased it continuously in the 2014-2020 period. Terrorism has affected commercial expenditures through the production-transaction costs in foreign trade and these effects, become clearer in the 2001-2009 and 2018-2020 periods, respectively. Finally, terrorism generally and significantly has reduced economic growth in the 1970-2001 and 2001-2020 periods.

To sum up, our results indicate that the time factor is important in revealing the economic consequences of terrorism. In addition, the economic consequences of terrorism may change symmetrically/asymmetrically over time depending on the insecurity and uncertainty level in the economic environment and the effects of terrorism on consumption, investment, public and commercial expenditures and economic growth may not always be the same. Besides, the results point to the necessity of designing security policies in the U.S. in a way that limit the effects of insecurity and uncertainty caused by terrorism in the economic environment on the spending decisions of economic actors and on economic growth. In this context, it is necessary to design national security policies in the U.S. with a proactive approach, which makes more use of foresight and preventability-based methods in the fight against terrorism and prioritizes the decline of possible terrorist acts. Future research might examine the economic consequences of terrorism on different countries by using different comprehensive terrorism variables.

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