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Shocks Transmission in the Mediterranean Zone

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Abstract

This paper examines macroeconomic interdependency of the Mediterranean countries and the transmission of shocks. Using a non standard VAR model, we were able to jointly model the direct and indirect transmission mechanisms of economic fragilities and to evaluate contagion effects of shocks by computing functions of instantaneous and cumulative responses, analysing Granger-like causality links, instantaneous causality and indices of shocks transmission for each country. The results indicate that business exchanges play a determining role in transmitting economic turmoil in the short and in the long-run. Shocks transmission effects take between 12 to 34 months depending on the countries, to reach a definite end. European Mediterranean countries show signs of higher effects. Transmission indices are important for big countries reflecting a higher contagion power at play. Nevertheless, shocks transmission remains highly correlated to the trade influence of the country, rather than to its size. A high degree of synchronisation of economic activities is observed for the European Mediterranean countries which are revealed to be producers of economic fluctuations in the zone. The minimal transmission thresholds are observed for the African Mediterranean countries which are revealed to be receptors of shocks.

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1. Introduction

Macroeconomic interdependency and shocks transmission are currently at the heart of researchers' interests. Previous studies show that co-evolution of macroeconomic variables is explained in part by the effects of symmetric and/or asymmetric shocks likely to be transmitted across partner countries through trade exchanges[1]. Forbes (2000, 2001), Krolzig (2001) and Falvey et al. (2004) have examined the contribution of trade exchanges to shocks transmission. A common result between these empirical studies is transmission of fluctuations across countries, independently from the nature of the shock, which may be common or specific. Nevertheless, the transmission mechanism is not significantly explicit. Indeed, it is interesting to distinguish between two transmission mechanisms of shock effects. The direct effect of one country on its partners occurs through bilateral trade exchanges. The indirect effect – in addition to the bilateral trade links – is transmitted through the whole set of trade relationships within a group of countries. The first transmission mechanism is frequently modelled by empirical works like those of Frankel et Rose (1998), Abeysinghe-Forbes (2001) and Forbes (2001). However, the second mechanism knew less interest both at the theoretical and empirical levels. Kwark (1999), Dungey-Fry (2001) and Giuliodori et al. (2004) tried to detect the simultaneous influence of both mechanisms, however, they focused on a limited number of countries, one or two countries. Fabien and Christophe Tavéra (2005) modelled a non-standard VAR estimation taken partially from the work of Abeysinghe-Forbes (2001), to analyse macroeconomic interdependence of a sample of European countries and shocks transmission. Arguing for trade exchanges intensity between these countries, the authors showed that transmission effects increased. They set a transmission index to evaluate the role that each country plays in transmitting domestic effects within Europe. Nevertheless, the authors, despite admitting the relevance of indirect effects of contagion, did not explicitly model the indirect transmission mechanism.

Our view within this stream of studies is to conduct an exploratory study of the macroeconomic interdependencies of a sample of Mediterranean countries. Our analysis, largely focused on shocks transmission, is essentially based on bilateral goods exchange as a contagion vector. Evidence of shocks transmission between these countries is frequently mentioned in the economics and econometric literature. Accordingly, our study takes as a first stage an empirical investigation of the many economic phenomena characterizing the zone. Indeed, the analysis of the transmission of macroeconomic fluctuations allows for examining degree of synchronisation of economic activities of these Mediterranean countries. As a result, detecting fluctuations-producing and shock-sensitive countries is made possible. Moreover, economic shocks transmission will be ultimately revealed in the long and short-terms. So, a non-standard VAR modelling approach is applied over a sample of nine (9) Mediterranean countries and four (4) foreign industrial countries in order to consider common external shocks. We use monthly data on the economic activities of the sample.

The obtained results are empirically interesting. Trade exchanges play a determining role in transmitting fluctuations. Large Mediterranean countries show higher transmission-relaying effects. Nevertheless, we note that shocks transmission ability is strongly correlated with the country's trade influence rather than with its size. A high degree of synchronisation of economies characterizes European Mediterranean countries which are revealed to be producers of fluctuations within the zone. Minimal transmission levels are attributed to African Mediterranean countries which are revealed to be receptors of shocks. These results which prove a kind of economic intuition are worth signalling as the adopted methodology proved unlimited in discerning them.

[1] : several studies tried to evaluate the importance of business exchanges in the process of shocks transmission inside a group of countries: Sims et al. (1999), Forbes (2000,2001), Ambe et al. (2002), Falvey et al.(2004), Fabien and Christophe Tavéra (2005).

This approach, inspired by the work of Fabien and Christophe Tavéra (2005), allows for achieving a number of objectives: (a) to evaluate the contribution of trade exchanges in transmitting shocks through the two direct and indirect transmission mechanisms, (b) to examine the extent to which the mobility of economic activities in one country causes fluctuations in other countries within the zone, (c) to measure the ability of each country to transmit economic fragilities, and more specifically to determine the role of each country in transmitting contagion and ultimately evaluate degree of synchronisation of economic situations of these Mediterranean countries.

In what follows, we present the structure of this paper. Section 2 elaborates the econometric estimation used. A preliminary analysis including a causality estimation of the countries' fluctuations is given at the level of section 3. The estimation of economic shocks transmission is given at the level of section 4. A measure of a transmission potential of each country is reported in section 5. Section 6 concludes.

2. The econometrics of the study

For the purposes of this study, the econometrics used is partially based on the work of Fabien and Christophe Tavéra (2005). It consists of reformulating a non-standard VAR estimation through the following equation $Y_i = A_{it} + \sum_{j=1/j\neq i}^{n} X_{ij} - M_i,\ \ i=1,\dots,n$, which links at moment t, the country's output $i\ (Y_{it}, i=1,\dots,n)$, its internal demand A_i, its imports M_i and its exports X_{ij} with partner countries $(j, j=1,\dots,n, \text{avec}\, i\neq j)$. The task consists of applying the growth rate on the previous equation to obtain

$$\frac{\Delta Y_i}{Y_i} = a_i e_{A_i/Y_i}\frac{\Delta Y_i}{Y_i} + x_i e_{X_i/Y_i^e}\sum_{j=1/j\neq i}^{n}\theta_{ij}\frac{\Delta Y_j}{Y_j} - m_i e_{M_i/Y_i}\frac{\Delta Y_i}{Y_i},$$

with $a_i = A_i/Y_i$; $m_i = M_i/Y_i$; $x_i = X_i/Y_i$ et $\theta_{ij} = X_{ij}/X_i$, θ_{ij} denotes the portion of exports towards country j and from country i of the total exports towards partner countries of the zone, e_{v_1/v_2} denotes elasticity of the variable 1 in relation to variable 2. Moreover, we suppose that e_{X_{ij}/Y_j} is equivalent for all partners $j(j=1,\dots,n)$ and may be attributed to the elasticity of country's i exports in relation to international demand of this country[2], such that $e_{X_{ij}/Y_j} = e_{X_i/Y_i^e}$ where X_i denotes total exports towards all partner countries i and Y_i^e represents the international revenue of country i. Then, by considering $y_i = \frac{\Delta Y_i}{Y_i}$ for $i=1,\dots,n$, we can obtain the equation:

$$y_i = \delta_i \sum_{j=1/j\neq i}^{n}\theta_{ij} y_j \qquad (1)$$

With $\delta_i = (x_i e_{X_i/Y_i^e})\big/(1 - a_i e_{A_i/Y_i} + m_i e_{M_i/Y_i})$. The necessary modifications of equation (1) whose aim is to highlight the time dimension, the adjustment dynamics of country i and its reactions to fluctuations of countries $j(j=1,\dots,n)$, make it the starting point for a VAR estimation of the effect of shocks transmission. More specifically, it consists of formulating the

[2] : This hypothesis, which assumes similarity between exports elasticity with regard to revenues, originates several econometric studies of exportation functions.

equation $\alpha_i(L)y_{i,t} = \beta_i(L)\delta_i \sum_{j=1}^{n} \theta_{ij} y_j + \varepsilon_{i,t}$, for $i, j = 1,\ldots,n$ and $\theta_{ii} = 0$, and by operating the polynomial forms $\alpha_i(L)$ and $\beta_i(L)$ for $i = 1,\ldots,n$, which jointly check for $\alpha_i(L) = 1 - \alpha_{i,1}L - \alpha_{i,2}L^2 - \cdots - \alpha_{i,p}L^p$ and $\beta_i(L) = 1 + \beta_{i,1}L + \alpha_{i,2}L^2 + \cdots + \beta_{i,q}L^q$, L is a lag operator satisfying $L^s y_t = y_{t-s}$, for any integer s. Under a matrix which gathers all countries, we set:

$$\alpha(L)y_t = \beta(L)\delta\theta y_t + \varepsilon_t \qquad (2)$$

ε_t is a white noise that satisfies $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \varepsilon_t') = \Sigma$ is a matrix defined as positive.

$$\alpha(L) = \begin{bmatrix} \alpha_1(L) & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \alpha_n(L) \end{bmatrix} \qquad \beta(L) = \begin{bmatrix} \beta_1(L) & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \beta_n(L) \end{bmatrix}$$

$$\theta = \begin{bmatrix} \theta_{11} & \theta_{12} & \cdots & \theta_{1n} \\ \theta_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \theta_{(n-1)n} \\ \theta_{n1} & \cdots & \theta_{n(n-1)} & \theta_{nn} \end{bmatrix} \qquad \delta = \begin{bmatrix} \delta_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \delta_n \end{bmatrix} \quad \text{and} \quad Y_t = \begin{bmatrix} y_{1,t} \\ \vdots \\ y_{n,t} \end{bmatrix}$$

At this level, we introduce the non-standard VAR model meant to estimate the macroeconomic interdependencies between the Mediterranean countries and shocks transmission:

$$A(L)Y_t = \varepsilon_t \qquad (3)$$

$A(L) = \sum_{s=0}^{r} A_s L^s$ is a polynomial matrix of a $(n \times n)$ dimension that satisfies $A(L) = \alpha(L) - \beta(L)\delta\theta$ and $\det[A(\lambda)] = 0$ if and only if $|\lambda| > 1$, in a way that non-stationary processes are not taken into account. We note that $r = \max(p_i, q_i),\ i = 1,\ldots,n$.

Moreover, the matrix $A(L)$ checks for through equation (2) the relationships $A_{ij}(L) = -\beta_i(L)\delta_i\theta_{ij}$, for $i, j = 1,\ldots,n$ and $i \neq j$ and $A_{ii}(L) = \alpha_i(\mathrm{L})$, for $i = 1,\ldots,n$.

Such a model allows for through these alternative estimations exploring the interactions between economic activities within the zone. Firstly, we can estimate Granger-like and instantaneous causality links. In other words, we examine whether the economic activity of a country i ($i = 1,\ldots,n$) causes movements in other countries. Secondly, an evaluation of the effects attributed to shocks transmission is made by computing impulsions response functions. Indeed, under the condition that all components of the vector Y_t are stationary, the form (3) checks for Wold's $VMA(\infty)$: $Y_t = C(L)\varepsilon_t$, where, $C(L) = \sum_{s=0}^{\infty} C_s L^s$. The matrices C_s, $s = 0,1,2,\ldots$ are automatically deduced from form (3) through the following relationships: $C_0 = I_n$ and $C_s = (c_{ij,s}) = \sum_{k=1}^{s} C_{s-k} A_k$; $s = 1,2,\ldots$, with, $A_k = 0$ for $k > r$ and $c_{ij,s}$ is the component ij of the matrix C_s. In this case, $c_{ij,s} = \partial y_{i,t+s} / \partial \varepsilon_{j,t}$ measures the effect of a unitary shock initiated by country j over an economic situation of a country i, after s periods. However, we would like to focus on orthogonal innovations. Indeed, when tow or more error terms are instantaneously correlated, then reactions to innovations become instantaneously correlated and consequently ambiguities affect the interpretation of the dynamic multiplications. In the same line of thinking, once instantaneous correlation of errors is highlighted, we estimate the orthogonal innovations according to Cholesky model. This task consists in choosing an order of variables appropriately determined according to a frame coherent with the study's objectives. Classifying variables is achieved by means of a degree of openness criteria for the countries under examination. Furthermore, a Cholesky-like procedure applied to the errors' variance-covariance matrix yield reactions to impulsions defined by $\Theta_s = (\Theta_{ij,s}) = C_s P$. P, an inferior triangular matrix that checks $PP' = \Sigma$ (Lütkepohl (1990)). Without loss of general information, errors transformations is made possible by $\mu_t = P^{-1}\varepsilon_t$, identifying a new covariance matrix $E(\mu_t \mu_t') = I_n$. In this view, a unitary shock is the size of a standard deviation. Moreover, we estimate the effects of shocks transmission in the long and short terms by computing the cumulative effects. A shock in a country j cumulatively affects the economic activity of a country i after h periods, defined by $\psi_h = \sum_{s=0}^{h-1} \Theta_s$. Given the stationarity of the model's components, the cumulative effects after h periods indicate that $\lim_{h\to\infty} \psi_{\mathrm{h}}$ is a finite matrix.

Thirdly, in order to evaluate the transmission power of each country, we estimate a transmission index. According to Fabien and Christophe Tavéra (2005), a measure of a transmission of economic situations of a country, consistent with our model, is done by a transmission index noted ID_i. It is written as follows:

$$ID_i = 1 - \left[\sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{\psi}_{ij-i}^{(h)} \Big/ \sum_{i=1}^{n} \sum_{j=1}^{n} \psi_{ij}^{(h)} \right] \qquad (4)$$

With ID_i denoting the transmission index for a country (i)[3]. $\psi_{ij}^{(h)}$ denotes the component (i, j) of the initial cumulative effects matrix at h forward periods, where all the zone's countries are represented in the model. $\tilde{\psi}_{ij-i}^{(h)}$ is the component (i, j) of the cumulative effects matrix at h forward periods, where country (i) is not present in the model at the moment of determining the multiplicative effects. It is, then, clear that the transmission index of a country measures the variation of the sum of the components of the cumulative effects initial matrix when we cancel the influence of this very country. More specifically, neutralising the effect of a country relates to eliminating it from the model at the moment of determining the multiplicative effects. It seems then that this transmission index increases when transmission effects increase in a country. It reaches the value of 1 for a country with higher contagion effects to a point of cancelling the components of the cumulative reactions matrix when this country is eliminated from the system. Otherwise, it is 0 for a country with null contagion effects.

3. The Exploratory Analysis

Our analysis treats monthly data of the real industrial output as a proxy for the level of economic activity, as the real GDP series are not available on a monthly basis. The observations of 9 Mediterranean countries – France, Italy, Spain, Turkey, Greece, Egypt, Morocco, Tunisia and Jordan – and 4 industrialized countries outside the zone – USA, UK, Germany and Japan- stretch over the 1993-2010 period. We notice that the industrialized countries are integrated in the model in order to avoid some puzzles frequently met in multivariate modeling of open economies. Moreover, their economic activities are considered as exogenous variables in the VAR model. Accordingly, the retained model takes into account the rest of the world, more specifically external shocks common to the Mediterranean countries. The observations were taken from the *DataStream Base* and *International*

[3] : Fabien and Christophe (2005) have evaluated transmission capacities of European countries in the Euro zone using this index. They computed transmission indices by means of unorthogonal innovations. Computing the indices in this study considers orthogonal innovations. This approach has no consequences on the interpretation of the countries' transmission capacities.

Financial Statistics (IFS) database. Our preliminary analysis consists in studying the stationarity of the time-series under study and in analysing causality in the sense of Granger and instantaneous causality between the Mediterranean countries.

3.1 The series' stationarity analysis

We note that the components of the VAR model are the growth rates of the real industrial output. Growth rates have been determined by the first differences of the initial series' logarithms. The results of the necessary tests of stationarity are reported in table 1. They indicate that the growth rates of the real industrial output are stationary for all Mediterranean countries included in the model. Indeed, the null hypothesis of the presence of the unitary root has been strongly rejected by the two tests and for the two models. The Augmented Dickey-Fuller (ADF)[4] test (1981) is first set to test the null hypothesis of unitary root presence reformulated by $\alpha = 0$ in the following equation:

$$\Delta y_t = \alpha y_{t-1} + \sum_{k=1}^{p} \beta_k \Delta y_{t-k} + \varepsilon_t \qquad (5)$$

For each series the number of lags has been determined by the Schwartz Bayesian Criterion (SBC)[5] by taking 24 months as the number of maximal lags. Then, the Phillips-Perron[6] (PP) test (1988) tests the null hypothesis of unitary root of the form $\alpha = 1$ in the equation:

$$y_t = \alpha y_{t-1} + \varepsilon_t \qquad (6)$$

We retain for each series a lag truncation which was determined by Andrews Bandwidth procedure[7].

Table 1. Unit Root Tests

	ADF (Lags)		PP (Bandwidth)	
	Model 1	Model 2	Model 1	Model 2
Fra	-5,81***(11)	-5,81***(11)	-24,34***(3,23)	-24,25***(3,23)
Ita	-4,77***(12)	-5,37***(12)	-30,81***(2,99)	-30,7***(2,99)
Spa	-11,61***(9)	-11,64***(9)	-30,27***(2,9)	-30,16***(2,9)
Tur	-4,11***(11)	-4,16***(11)	-19,46***(1,11)	-19,4***(1,11)
Gre	-6,31***(11)	-6,52***(11)	-25,46***(2,66)	-25,39***(2,66)
Egy	-13,95***(13)	-13,91***(13)	-13,94***(0,45)	-13,9***(0,45)
Mor	-9,75***(10)	-9,73***(10)	-24,13***(2,52)	-24,06***(2,52)
Tun	-3,93***(12)	-5,11***(11)	-27,33***(3,53)	-27,33***(3,55)
Jor	-5,82***(11)	-5,81***(11)	-18,12***(0,75)	-18,07***(0,76)

Critical Values

	Model 1			Model 2		
	1%	5%	10%	1%	5%	10%
ADF/ PP	-3,469	-2,88	-2,575	-4,013	-3,436	-3,142

Notes: (.) indicate the number and truncation lags for the two tests ADF and PP respectively. Others values, in table, represent the calculated values of test statistics. Critical values are determined by Mackinnon (1996). ***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively.

[4] : The ADF approach allows to test whether the series is stationary or not. The equation (5) will used to test the null hypothesis of unitary root presence reformulated by $H_0 : \alpha = 0$ (non stationary series) against the one-sided alternative $H_1 : \alpha \prec 0$ of stationary series. The null hypothesis of unit root against the one-sided alternative is rejected if the t-statistic value is less than the critical value.

[5] : The ADF procedure allows for higher-order correlation by adding lagged difference terms of the dependent variable as well as equation (5). The SBC determine the optimal number of lagged difference.

[6] : The PP approach allows to test whether the series is stationary or not. The equation (6) will used to test the null hypothesis of unitary root presence reformulated by $H_0 : \alpha = 1$ (non stationary series) against the one-sided alternative $H_1 : \alpha \prec 1$ of stationary series. The null hypothesis of unit root against the one-sided alternative is rejected if the t-statistic value is less than the critical value.

[7] : The PP procedure controls for higher-order serial correlation in a series by adding lagged difference in ε term in equation (6). The Andrews Bandwidth procedure determines the optimal number of lagged difference (lag truncation) in ε .

In Table 1, the two hypotheses, presented above, have been successively rejected for models 1 and 2 which respectively integrate a constant term and a linear time trend in each of the previous equations, as all coefficients of the two test are inferior to the critical values under the different significance levels (1%, 5% et 10%). We conclude that all the time series under study are stationary. Rejecting the unitary root for all the different series of the model reveals two main points for the estimation and interpretation of the results. First, an economic shock of a Mediterranean country will have a temporary effect on the economic situations of other countries in the zone. In other words, the effect of economic innovation is cancelled within the short term and the system ends by recovering its initial equilibrium position. Second, stationarity of the VAR model's components makes determining the functions of the reactions to impulsions automatic and simple by inverting the matrix $A(L)$. Nevertheless, we would like to mention that variables' ranking within the vector is very important. At this level, one can note that different ranks of variables yield different estimations and consequently different interpretations. In this study, the ranks of countries within the vector have been determined following openness degree. Table 2[8] reports the ranks of countries within the VAR model. Against these information, we proceeded to estimating the model. However, before moving to interpreting the results, we wish to evaluate the quality of this estimation. To this end, an analysis of the residuals and causality between the countries is conducted and reported in what follows.

Table 2. Ranking of countries international trade size

	Exports	Imports	Total	Order
France	39979,2	45749	85728,2	1
Italy	33917,3	38133,4	72050,7	2
Spain	18156,3	28065,4	46221,7	3
Turquia	6492	9631	16123	4
Greece	1694,94	5692,6	7387,54	5
Egypt	1108,95	2088,59	3197,54	6
Morocco	961,62	1941,49	2903,11	7
Tunisia	1104,52	1427,9	2532,42	8
Jordan	732,76	904,95	1337,71	9

Notes: Source: International Financial Statistics. Values in second and third column represent the Export and Import volumes in US Millions Dollars, for the 2007:1. The fourth column figure in each cell is the total of export and import. The fifth column figure in each cell is the order of economy with opening degree.

3.2 Causality Analysis

First, we propose some descriptive statistics of the residuals of the model's estimation in table 3. In other words, we determine the asymptotic properties of the residuals of the different equations of the model before analysing causality in the terms of Granger and instantaneous causality. The results in Table 3 show that the null hypothesis of normality of residuals is not rejected for most of the Mediterranean countries. Indeed, most p-values are superior to the 5% significance level. Nevertheless, we note the exception of Greece, Egypt and Morocco which do not check the normality hypothesis of the residuals with Jaque-Bera p-values largely inferior to the 5% significance level. The distribution of the residuals associated with Italy is platykurtic as Kurtosis is inferior to 3.00. However, the other countries show residuals having leptokurtic and skewed distributions. Moreover, the multivariate normality hypothesis of the residuals is rejected with null p-values of the statistics joined for the system. In this case, we apply the Chi-square test to estimate Granger-like causality.

Grange-like causality in a vector process allows for assessing direct causality links between variables. Using the results reported in Table 4, we try to explore interdependencies between

[8] : This ranking was determined by means of international trade size of each country by summing exports and imports at 2007:1. We note that the ranking procedure of the countries using the mean of exports and imports did not change the rank reported in table 2.

economic activities of the Mediterranean countries under study in terms of Granger-like causality.

Table 3. Residual Normality tests

	Jarque-Bera	p-value	skewness	kurtosis
Fra	0,9917	0,609	0,170	3,178
Ita	0,921	0,631	0,159	2,812
Spa	1,263	0,531	-0,093	3,391
Tur	1,271	0,529	-0,205	3,151
Gre	15,98	0,003	0,574	4,027
Egy	117,57	0,000	-0,947	6,720
Mor	41,82	0,000	-0,426	5,339
Tun	0,318	0,852	0,099	3,120
Jor	1,306	0,520	-0,117	3,373

Notes: Second column gives the values of Residual Normality test statistics of Jarque-Bera. In third column figures the p-values of test statistics. The fourth column figure in each cell is the skewness value. The fifth column figure in each cell is the kurtosis value.

Table 4 is divided into three parts. The first, entitled Granger-like causality of country *j* towards a country *i*, represents the chi-square coefficients for the different pairs of the Mediterranean countries in terms of direct time-bound causality. Reading the values related to France, we clearly see that the economic activity of this country causes in the terms of Granger economic mobility in all the other countries. Indeed, the null hypothesis of the absence of causality from France towards the rest of the countries is rejected at the 1% and 5% significance levels. Nevertheless, the first line of this column indicates that France's economic situation is affected only by Italy's and Spain's economic activities. It seems then that fluctuations at the level of France induce economic fluctuations at the level of Mediterranean countries. Although this state of affairs is a one-way phenomenon (from France to the other countries), it seems uniquely bidirectional for Italy and Spain at a 10% significance level. We notice that the Italian economic activities achieve the same shocks transmission phenomenon as France. Indeed, variations of economic activities of this country create some change in the economic situations of the other countries of the zone. This is almost a one-way effect, except the fact that this country shows three Granger-like bidirectional causality relationships as the results related to France, Spa and Greece (Table 4).

Table 4. Analysis of causality

	Granger causality: country j versus country i									Bloc-wise causality	Instantaneous causality
	Fra	Ita	Spa	Tur	Gre	Egy	Mor	Tun	Jor		
Fra	-	14,10*	14,87*	7,99	11,65	6,75	11,49	4,98	8,33	1,635**	94,58**
Ita	18,1**	-	22,74*	6,89	15,12*	7,16	4,49	7,75	7,21	1,834**	174,1***
Spa	24,35***	13,68**	-	8,46	12,31	5,25	12,25	5,08	9,14	1,557*	180,3***
Tur	22,85***	10,8**	9,06*	-	8,49	3,56	7,23	9,93	7,27	1,632*	73,89**
Gre	10,71**	24,31***	19,66**	7,79	-	3,16	4,40	6,41	4,78	1,975**	41,66*
Egy	22,89***	12,89**	14,89*	22,4**	12,29	-	5,53	13,1	11,37	1,017	12,76
Mor	17,67**	16,84**	19,17**	16,8**	12,07	12,3	-	13,6	9,34	1,185	10,33
Tun	15,36***	13,46**	12,87**	8,27*	8,58*	3,38	1,5	-	6,85	1,285	46,35*
Jor	23,1***	7,96*	4,67	7,91*	16,1**	9,3*	1,94	1,11	-	1,084	13,03

Notes: ***, ** and * design the reject null hypothesis (absence of Granger causality) at the 1, 5 and 10 percent levels of significance respectively. The first part of table figures in each cell the χ-square statistic relatively to Causality of Granger sense from the country j to the country i. The Block-wise causality Colum figure in each cell is the Fischer statistic value relatively to null hypothesis: absence of Granger causality from the country i to the all of the countries. The Causality instantaneous Colum figure in each cell is the Chi-square statistic value relatively to null hypothesis: absence of Granger causality instantaneous from the country i to the all of the countries.

These direct Granger-like causality relationships between two Mediterranean countries which might be unidirectional or bidirectional are better viewed in table 5. The results reported in Table 4 are simplified by adding arrows pointing to the bilateral causality direction in Table 5 show Granger-like causality of the Mediterranean countries towards North African countries. However, the opposite direction is not checked. Moreover, Greece's economic activity affects in the terms of Granger African countries and Jordan, though the opposite is not clear in any of the cases. These results point to a time-bound causality highly significant between Mediterranean countries. This adds to the macroeconomic interdependence of these countries and to the evidence of innovation transmission within the zone. At this level, a causality scheme almost totally recursive is evidenced, except for some bidirectional relationships between few European countries.

The second part of Table 4, made up of one column entitled Block-wise Causality, tests the null hypothesis of absence of Granger-like causality of a country *i* towards the set of all the zone's countries. The results reject the null hypothesis for all European countries and also Greece. However, the null hypothesis is retained for the African countries and Jordan.

Table 5. Causality scheme and residual correlation matrix

	Fra	Ita	Spa	Tur	Gre	Egy	Mor	Tun	Jor
Fra	__	0,79	0,72	0,02	0,36	-0,05	-0,01	0,30	0,08
Ita	(↓,↑)	__	0,94	0,12	0,36	0,07	0,06	0,33	-0,03
Spa	(↓,↑)	(↓,↑)	__	0,17	0,36	0,06	0,08	0,34	0,01
Tur	(↓,NC)	(↓,NC)	(↓,NC)	__	0,19	-0,03	0,04	0,52	0,52
Gre	(↓,NC)	(↓,↑)	(↓,NC)	(NC,NC)	__	-0,12	0,28	0,29	0,16
Egy	(↓,NC)	(↓,NC)	(↓,NC)	(↓,NC)	(NC,NC)	__	0,14	-0,02	-0,12
Mor	(↓,NC)	(↓,NC)	(↓,NC)	(↓,NC)	(NC,NC)	(NC,NC)	__	0,01	0,11
Tun	(↓,NC)	(↓,NC)	(↓,NC)	(↓,NC)	(↓,NC)	(NC,NC)	(NC,NC)	__	0,52
Jor	(↓,NC)	(↓,NC)	(NC,NC)	(↓,NC)	(↓,NC)	(↓,NC)	(NC,NC)	(NC,NC)	__

Notes: The figures located on the main diagonal represent the correlation coefficients of the residuals of the model, during the 1993:01-2010:01 periods. The figures under the main diagonal draw the Granger-like causality scheme. ↓(↑) denotes the presence of a Granger-like causality of country $j(i)$ towards country $i(j)$. (↓,↑) denote a Granger-like bidirectional causality between the two countries i and j. NC indicates that the null hypothesis is not rejected.

These results highlight the important role of the European countries in shocks transmission within the Mediterranean zone. Indeed, these results show that the economic activity of a European country causes in the terms of Granger economic fluctuations in all the other countries of the zone. Nevertheless, the potential of an African Mediterranean country to cause economic fluctuations remains invisible.

The last column of Table 5 focuses on analysing instantaneous causality between economic activities of the different Mediterranean countries. The Chi-square coefficients indicate that the null hypothesis of the absence of instantaneous causality between the relevant country and the rest of the countries is rejected for all European Mediterranean countries. However, this state of affairs excludes North African countries, except Tunisia. The null hypothesis that the Tunisian economic activity does not affect instantaneously the economic fluctuations of the other countries is rejected. Moreover, the role of European economic fluctuations in affecting mobility of the Mediterranean economic activities is found true and significant. Instantaneous causality seems to prevail here.

Worth noting is that the analysis of causality above is twofold. First, part one of Table 4 allowed for drawing a schematic representation of Granger-like causality between Mediterranean countries. At this level, it seems that analysing Granger-like causality confirms our ranking of the variables of openness degree. Then, analysing block-wise instantaneous causality, we tried to detect the countries with the potential of transmitting shocks within the zone[9]. Statistical proof highlights interdependence between Mediterranean countries and transmission of innovation. At this level we signal the fact that the results in Table 5 point to a significant correlation between residuals. Consequently, such a specification implies that a shock in one country is not necessarily specific to that country. It can be a linear combination of several economic activities and thus not unique to one country. However, we adopt Cholesky decomposition as an identification and construction scheme of innovation specific to each country within a class of countries ranked by their degree of openness.

In conclusion, the preliminary analysis led to the construction and estimation of a stationary VAR model and to solving reactions to impulsions using Cholesky decomposition. Such an endeavour allows us to examine interdependence and shocks transmission within the Mediterranean countries of the study to be proposed in the next section.

4. Shocks Transmission within Mediterranean Countries

The appendix reports the graphics of the functions of reactions to impulsions of each economic activity of the Mediterranean zone. It is about representing the multiplicative effects of each country over a 36-month span. More specifically, evolution of economic activities of each country following a shock in the other Mediterranean countries is drawn instantaneously during 36 months (Graph A1 in the appendix). This allows for measuring the dynamic effects of a Mediterranean country on the economic activities of the countries in the zone. It allows also evaluating the significance and comparing effect size of shocks.

With reference to Graph A1, it is clear that shocks transmission effects are totally operational beyond 12 to 34 months according to country. Nevertheless, the difference between shocks contagion effects for the European and North African Mediterranean countries is obvious. Indeed, effects of North African countries come to an end between 12 and 23 months, while those of European Mediterranean countries come to an end between 24 and 34 months.

Moreover, a shock in one European country generally leads to short-term, different from zero and significant effects. A shock on France generates immediate positive and significant effects on Italy's, Spain's, Greece's and Tunisia's economic activities. Against this shock, the other countries of the zone show immediate reactions which are not significant as Graph A1.1 shows. Still, Italian economic activities extend to the Mediterranean zone achieving thus the same path as for France. They are immediate positive effects of shocks transmission by European countries into the zone. These effects remain in the short and long-run although they become insignificant within this time span. They even prevail in the long-run on the economic activities of the North African countries, however they become insignificant. A shock in France leads to immediate effects, different from zero and significant, on Tunisia. They grow weak and insignificant in as long as 30 months. However, this shock transmission behaviour is not visible for the African Mediterranean countries, except for Tunisia. The economic activity of this country leads to short-term effects different from zero and significant on economic activities in Turkey, Greece, Morocco and Jordan.

Generally speaking, the results of the functions of reaction to impulsions attribute stronger transmission effects for countries with higher degree of openness compared to countries with limited external trade size. Although these results are consistent with economic intuitions, they deserve signalling as we did not, while constructing the model, impose restrictions which might bias shocks transmission behaviour.

Examining the functions of reactions to impulsions points to positive and negative multiplicative effects. Then it seems that the model detects demand and offer effects driven by

[9] : We note that at this level we are interested in detecting the significance of the role of each country in causing Granger-like movements in the economic activities of the other countries in the zone. Moreover, an evaluation of shocks transmission power of each country is given below.

external trade towards the inside of the zone. We note that this state of affairs is likely explained by the fact that these are the effects of external trade which dominate inter-zone contagion mechanisms, in the short and the long-run. In the same line of thinking and by means of an advanced analysis, we point eventually to a relationship between shocks contagion mechanisms affecting the different countries and movements of bilateral exchange rates. We maintain at this level that the Mediterranean zone is characterized by different adjustments of exchange rates regimes. Likewise, adjustment of exchange rates by Purchasing Power Parity theory (PPP) or by the Interest Rate Parity (IRP) theory plays a role in determining shocks transmission mechanisms for the Mediterranean countries. Consequently, it seems interesting to further our interpretation of the results by considering the two types of exchange rate adjustment.

First, we consider an exchange rate regime adjustment where PPP determines bilateral exchange rates. A positive shock in a country (*i*) will have as effects on its economic activities an increasing pressure on inflation rates compared to the other countries of the zone and a depreciation of its currency. Accordingly, demand for importation for this country by the other countries decreases and then effects of transmitting activity increase in country (*i*) is weakened within the Mediterranean zone. We note as well that contagion effect of the activity in this country may be cancelled or even be negative when effects of exchange rates adjustments are high or when price elasticity of external trade of this country are higher.

Second, by considering an exchange rates adjustment where IRP applies, shock transmission probably becomes the reverse. Indeed, such a situation is translated into a difference in exchange rate between country (*i*) and the other countries following a shock in country (*i*) and leads to an appreciation of the currency of this country. Consequently, imports of country (*i*) from the other countries increase. We conclude then that the contagion effect of an activity increase in country (*i*) dominates the zone.

5. Fluctuations Transmission of each Country

In this section, we focus on evaluating the role of each country in transmitting shocks within the zone. To this end, firstly we determine the cumulative effects of each country. Secondly, a ranking of countries according to a transmission index would clearly determine the role of each country in transmitting shocks.

5.1 Shock transmission effect in the short and in the long-run

The previous analysis of the functions of reaction to impulsions showed that shocks transmission effects stretch mostly between 12 to 34 months according to countries. For this case, we choose to analyse the short and long term cumulative effects. Accordingly, determining the cumulative effects of a shock for each country is achieved within 18 months ahead. The results of this analysis are reported in table 6. The statistics of this table indicate that the 18-month ahead cumulative effects of a country (the line country) following a shock in another country (the column country). These effects are normalised in the sense that the value of the 18-month ahead cumulative effects on a country towards itself shock is equal to the unit[10]. This normalisation does not affect the interpretation of results; on the contrary it facilitates their manipulation.

A general view of Table 6 reveals the dominance of the European Mediterranean countries in transmitting fluctuations. Indeed, shocks in large countries may induce higher 18-month ahead cumulative effects over the other Mediterranean countries. A shock on French economic activities induces 18-month ahead cumulative effects equal to 0.556, 0.856, 0.443 and 0.808 on Italy, Spain, Morocco, and Tunisia, respectively. While a shock in Morocco induces weak and insignificant cumulative effects equal to 0.053, -0.069 and -0.039

[10] : It is a procedure to simplify the manipulation of the results. It has been used in econometric studies of the reactions to impulsions like the work of Fabien and Christophe (2005).

respectively on France, Italy and Tunisia. Nevertheless, we notice the exception of Tunisia which is likely to produce 18-month ahead cumulative effects at least comparable with those of large countries like France, Italy and Spain. Indeed, a shock in this country leads to significant cumulative effects equal to -0.412, -0.608, -0.227 and 0.578 respectively on Italy, France, Spain and Jordan. These results reveal the strong relationships of the Tunisian economy with these countries.

In conclusion, trade exchange plays a determining role in transmitting fluctuations rather than size of country. This tendency, which points to the supremacy of European Mediterranean countries in transmitting shocks, is explained by the fact that these countries have the highest openness degrees in the zone. Accordingly, they tend to build strong interdependent macroeconomic relationships. Moreover, as long as bilateral business relationships are higher, macroeconomic interdependence between these pairs of countries remains true and shocks transmission effects are higher. At this level, we detect a strong and significant relationship between openness degree and shocks transmission capacity. These results are interpreted by considering both types of exchange rate adjustment. The first one is that such that the exchange rate is fixed on the basis of the Purchasing Power Parity theory (PPP), witch allows determining the exchange rate in the long run. The second one is that such that the exchange rate is fixed on the basis of the Interest Rate Parity theory (IRP); a short run equilibrium condition. These results are consistent with economics intuition; however, they deserve attention as they were not object of some restrictions. It seems then that a VAR modelling of macroeconomic relationships between Mediterranean countries is potentially efficient in describing contagion phenomenon of shocks following business exchanges.

Table 6. 18 months ahead cumulated effects of each country

	Fra	Ita	Spa	Tur	Gre	Egy	Mor	Tun	Jor
Fra	1*	-0,186	-0,114	0,236*	-0,26*	0,006	0,053	-0,41*	0,012
Ita	0,566*	1*	-0,34*	0,202*	-0,67*	0,131	-0,069	-0,60*	-0,043
Spa	0,856*	0,687*	1*	0,648*	-0,28*	0,011	-0,250	-0,22*	-0,080
Tur	-0,102	0,106	0,181*	1*	0,186*	-0,047	0,034	-0,115	0,118*
Gre	0,415*	0,313*	0,305*	0,219*	1*	0,055	-0,126	0,094	-0,001
Egy	-0,03	-0,053	-0,053	-0,005	-0,167	1*	0,045	-0,063	-0,003
Mor	0,443	-0,089	-0,089	0,251*	0,258*	-0,022	1*	-0,020	-0,050
Tun	0,808*	-0,50	-0,500	0,496*	0,124*	0,075	-0,039	1*	-0,007
Jor	-0,189	0,120	0,269	0,699*	0,526*	-0,178	-0,028	0,578*	1*

Notes: This table shows the values of cumulated effects, 18 months ahead, for an activity choc from country in column to country in line. ***, ** and * indicate significance of cumulated effects relatively to a pair of countries at the 1, 5 and 10 percent levels respectively. The confidence interval associated to each value of cumulated effects was represented in Table A1 in the Appendix.

5.2 Ranking of countries according to shocks transmission capacity

The previous analysis allowed us to detect a strong relationship between openness degree of a country and its capacity in transmitting shocks. In what follows, we try to measure shocks transmission capacity of each country by means of a transmission index computed by cumulative multiplicative effects. A ranking of Mediterranean countries according to its shocks transmission capacity allows for detecting on the one hand shocks-producing countries in the region and on the other hand inter-zone innovations-sensitive countries.

Following the introduction of the transmission index in section 2, applying this technique to measure contagion allows for reformulating the following indices:

$$ID_i = 1 - \left\lfloor \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{\psi}_{ij-i}^{(18)} \Big/ \sum_{i=1}^{n} \sum_{j=1}^{n} \psi_{ij}^{(18)} \right\rfloor$$

which quantify shocks transmission capacity of the different countries. ID_i is the transmission index of a country (*i*). The last equation will then work for $i = 1, \dots, 9$ so as to include all the countries in the zone. The results of the transmission indices are reported in Table 7. The second column in this table represents the ID_i coefficients in terms of percentage. The third and fourth columns respectively represent ranking of countries in terms of their indices and openness degree.

Table 7. Results of the transmission indices

countries	IDi (%)	Rank (IDi)	Initial rank
France	41,99	1	1
Italy	39,51	3	2
Spain	40,56	2	3
turkey	28,71	4	4
Greece	20,61	5	5
Egypt	4,5	8	6
Morocco	2,5	9	7
Tunisia	19,08	6	8
Jordan	13,07	7	9

Notes: Initial rank: countries are classified by their openness degrees.

With reference to table 7, the Mediterranean European countries are ranked first in terms of fluctuations transmission. France takes up almost 42% of shocks transmission effects on the other countries of the Mediterranean region. Italy's and Spain's economic activities take around 40% of contagion effects. Nevertheless, North African countries do not reveal such higher transmission capacity. In the case of these countries, we note minimal transmission power reaching a level of 2.5% for Morocco. The contribution of African countries in transmitting shocks to the zone does not go beyond 19.08% (The case of Tunisia). The most important transmission power in the zone clearly belongs to the European countries.

Viewing the last two columns of Table 7, there is clearly a minimum difference between ranking of countries according to openness degree and their ranking according to shocks transmission capacity. France is first as the most open and shocks-producing economy in the zone. Tunisia takes the eighth position in terms of openness degree and sixth in terms of shocks transmission in the zone. Egypt takes the sixth position in terms of openness degree and the eighth position in terms of shocks transmission. Furthermore, the relationship between openness degree and shocks transmission capacity remains robust. Business exchanges and openness degree play a determining role in shocks contagion behaviour and degree rather than the size of country.

6. Conclusion

This paper examined macroeconomic interdependence of a sample of Mediterranean countries. An analysis, largely focused on shocks transmission and mainly founded on bilateral exchanges of goods as a contagion vector, is conducted using a non-standard VAR model. This approach, which is revealed to be relevant to model interactions between economic activities within the Mediterranean zone, allowed for meeting the objectives set for this study. Indeed, the empirical results yielded statistical proof on shocks transmission through business exchanges between countries. The most important contagion effects are visible in the countries with the highest business exchanges (France, Italy, and Spain). On the whole, fluctuations initiated by Mediterranean European countries extend towards African countries (Tunisia, Morocco and Egypt). The most important transmission capacity within the zone clearly belongs to the European countries. However, African countries show very weak transmission capacities. Furthermore, the results point to a higher degree of synchronisation of fluctuations for the European countries which are revealed to be shocks-producing countries within the zone in the short and long run.

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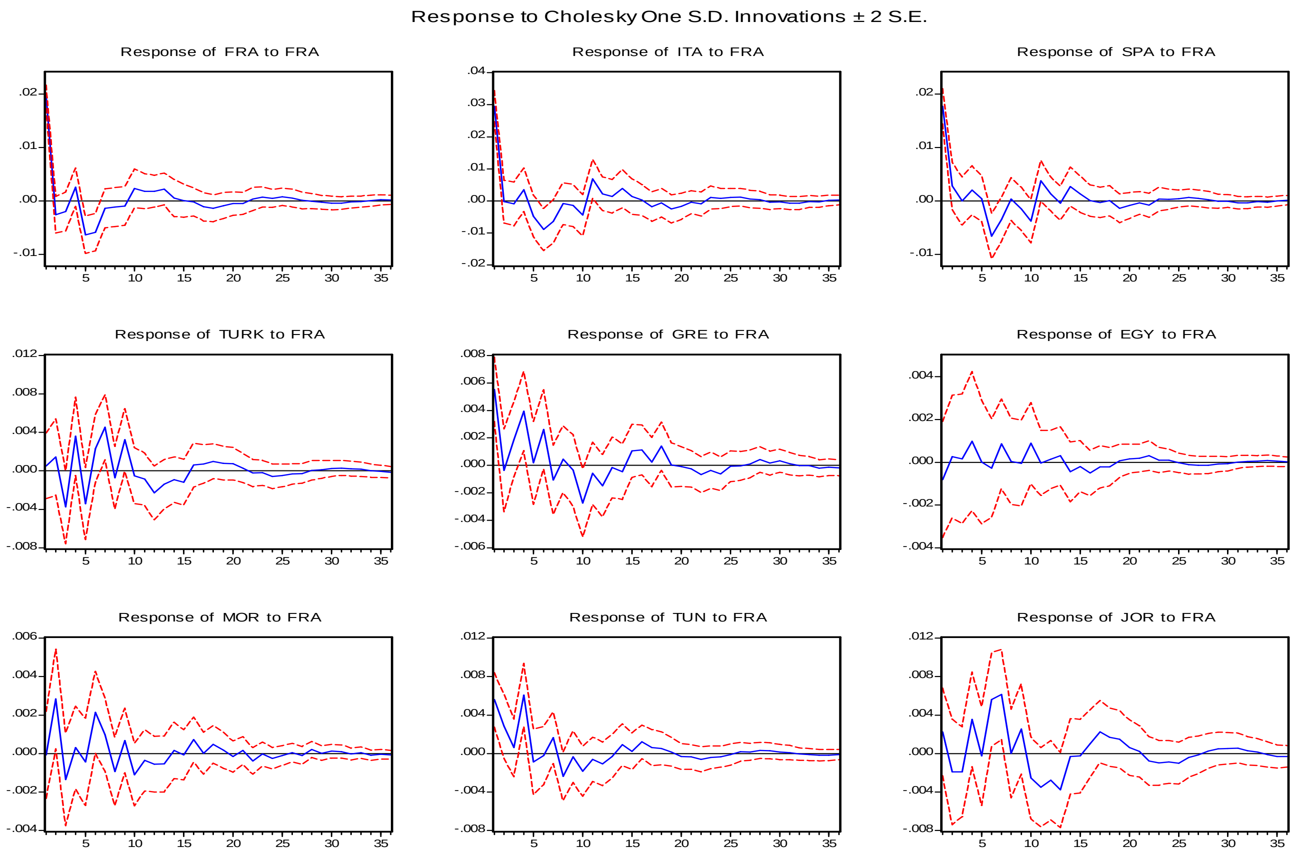
Appendix :

Table A1. IC of 18 months a head cumulated effects

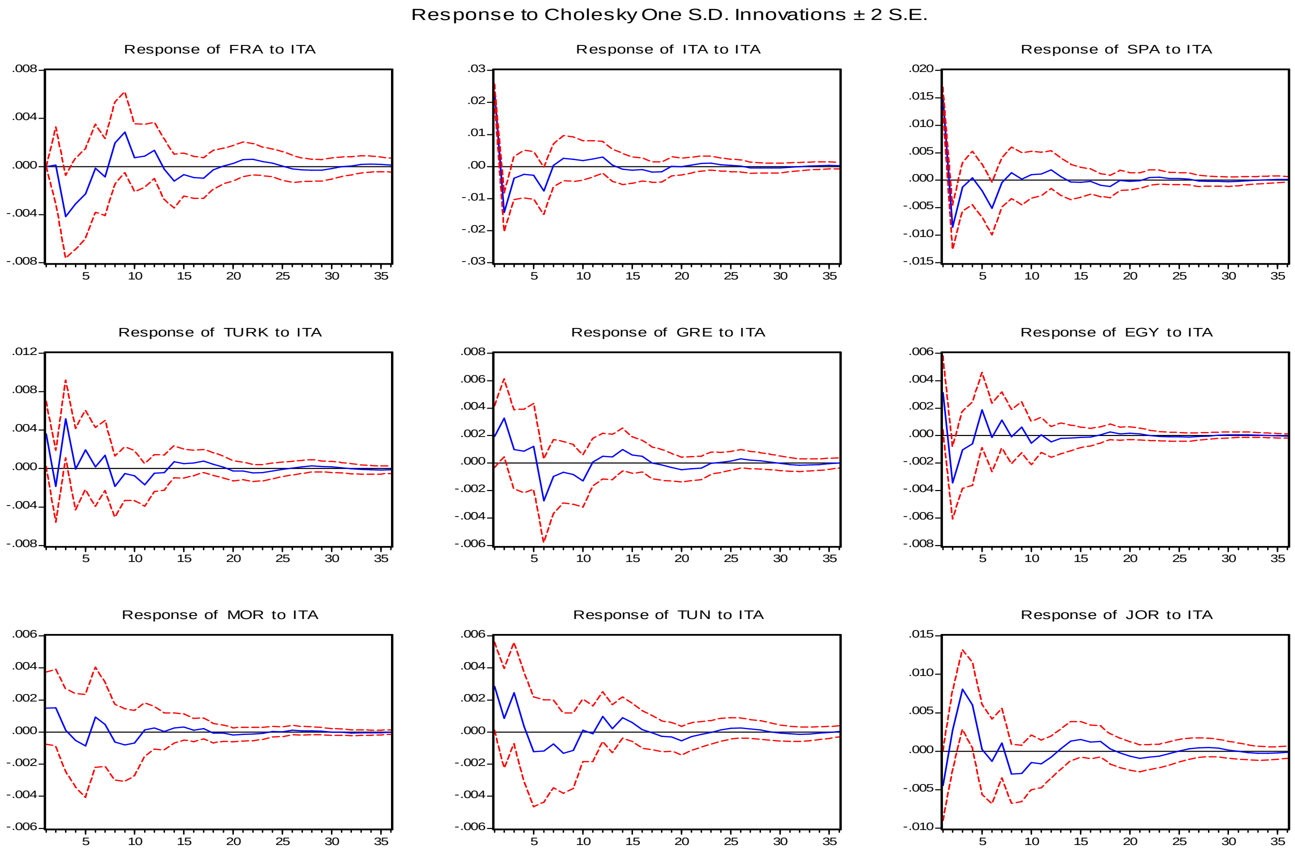
	Fra	Ita	Spa	Tur	Gre
Fra	[0,021;0,03]	[-0,005;0,001]	[-0,007;0,001]	[0,004;0,01]	[-0,01;-0,002]
Ita	[0,033;0,046]	[0,014;0,026]	[-0,013;-0,002]	[0,001;0,01]	[-0,017;-0,006]
Spa	[0,021;0,029]	[0,001;0,02]	[0,001;0,007]	[0,001;0,006]	[-0,01;-0,004]
Tur	[-0,004;0,001]	[-0,001;0,007]	[0,001;0,007]	[0,017;0,023]	[0,002;0,007]
Gre	[0,003;0,008]	[0,001;0,006]	[0,002;0,006]	[0,001;0,005]	[0,01;0,015]
Egy	[-0,003;0,002]	[-0,004;0,002]	[-0,004;0,002]	[-0,003;0,003]	[-0,006;0,001]
Mor	[-0,002;0,003]	[-0,001;0,004]	[-0,004;0,001]	[0,001;0,007]	[0,001;0,006]
Tun	[0,006;0,01]	[0,000;0,005]	[-0,003;0,003]	[0,007;0,011]	[0,001;0,004]
Jor	[-0,005;0,002]	[-0,003;0,007]	[-0,001;0,011]	[0,008;0,02]	[0,004;0,016]

	Egy	Mor	Tun	Jor
Fra	[-0,004;0,005]	[-0,002;0,005]	[-0,012;-0,006]	[-0,002;0,002]
Ita	[-0,003;0,01]	[-0,005;0,003]	[-0,017;-0,005]	[-0,005;0,002]
Spa	[-0,002;0,007]	[-0,004;0,002]	[-0,009;-0,002]	[-0,003;0,002]
Tur	[-0,004;0,002]	[-0,001;0,003]	[-0,004;0,001]	[0,001;0,004]
Gre	[-0,001;0,003]	[-0,003;0,001]	[-0,001;0,002]	[-0,001;0,002]
Egy	[0,013;0,021]	[-0,001;0,002]	[-0,003;0,001]	[-0,002;0,002]
Mor	[-0,004;0,003]	[0,014;0,018]	[-0,002;0,002]	[-0,003;0,001]
Tun	[-0,001;0,004]	[-0,003;0,001]	[0,007;0,011]	[-0,001;0,001]
Jor	[-0,008;0,003]	[-0,005;0,004]	[0,007;0,016]	[0,016;0,024]

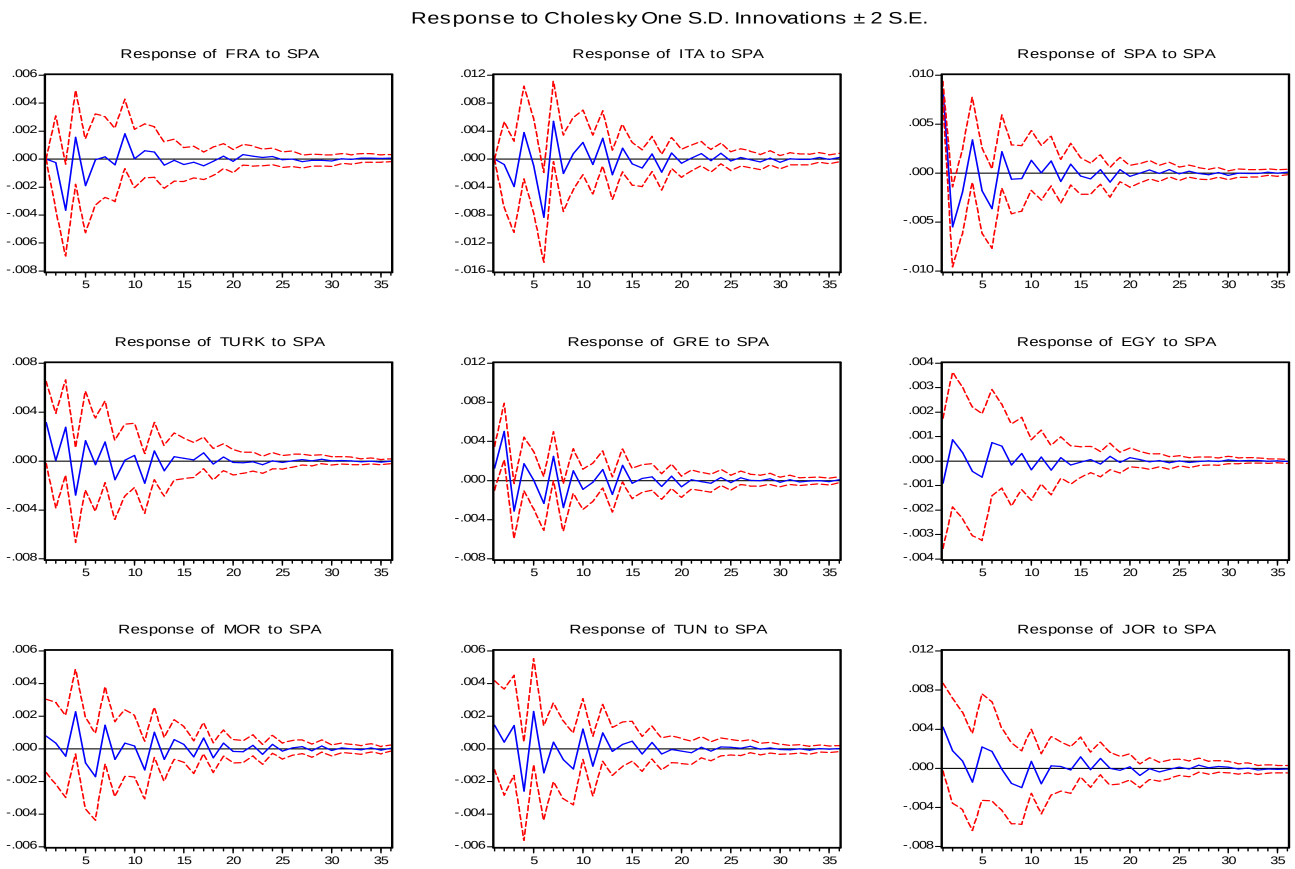
Graph A1. Sted. Dev. IRF on economic activity of Mediterranean country
Graph A1.1 Responses to French economic shock.



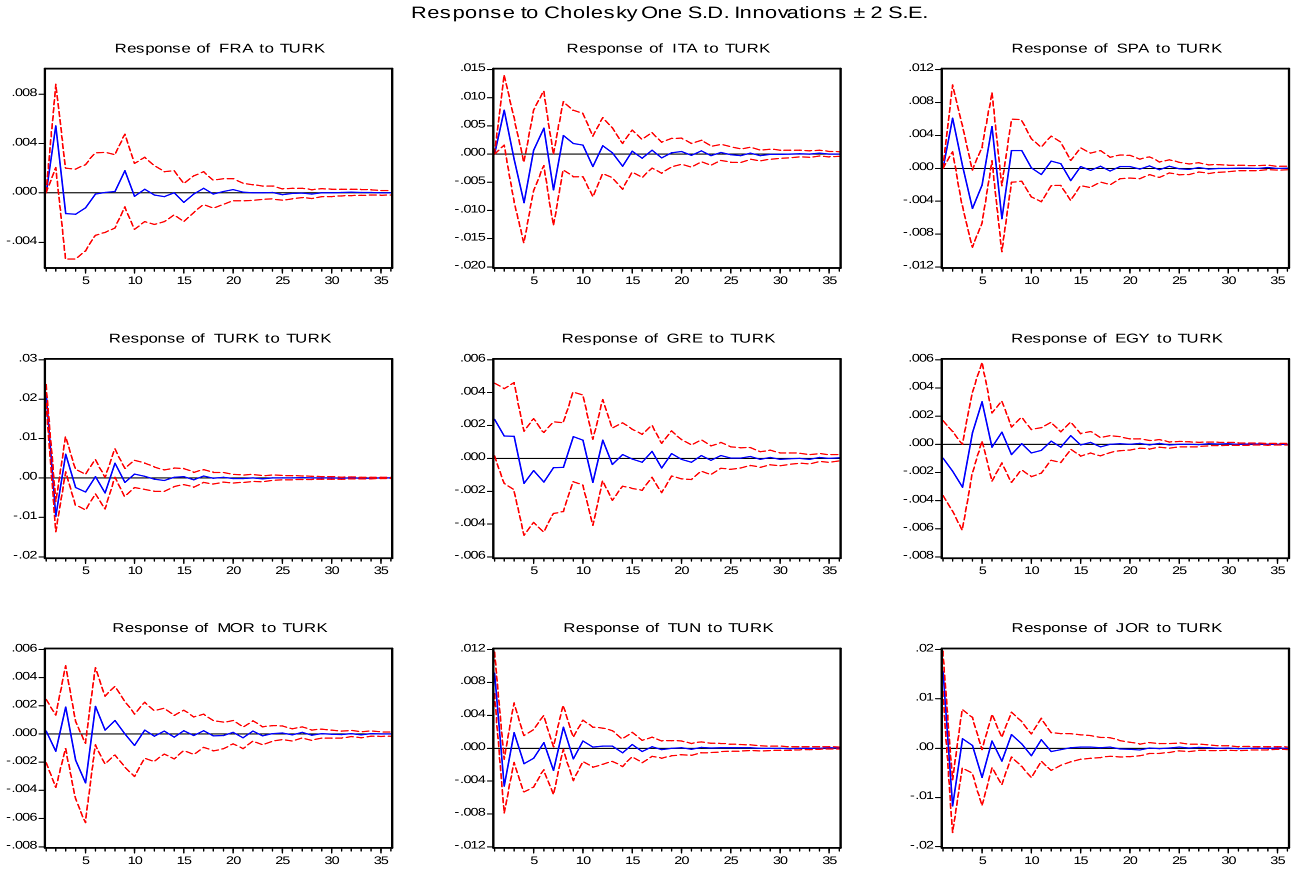
Graph A1.2 Responses to Italy economic shock.



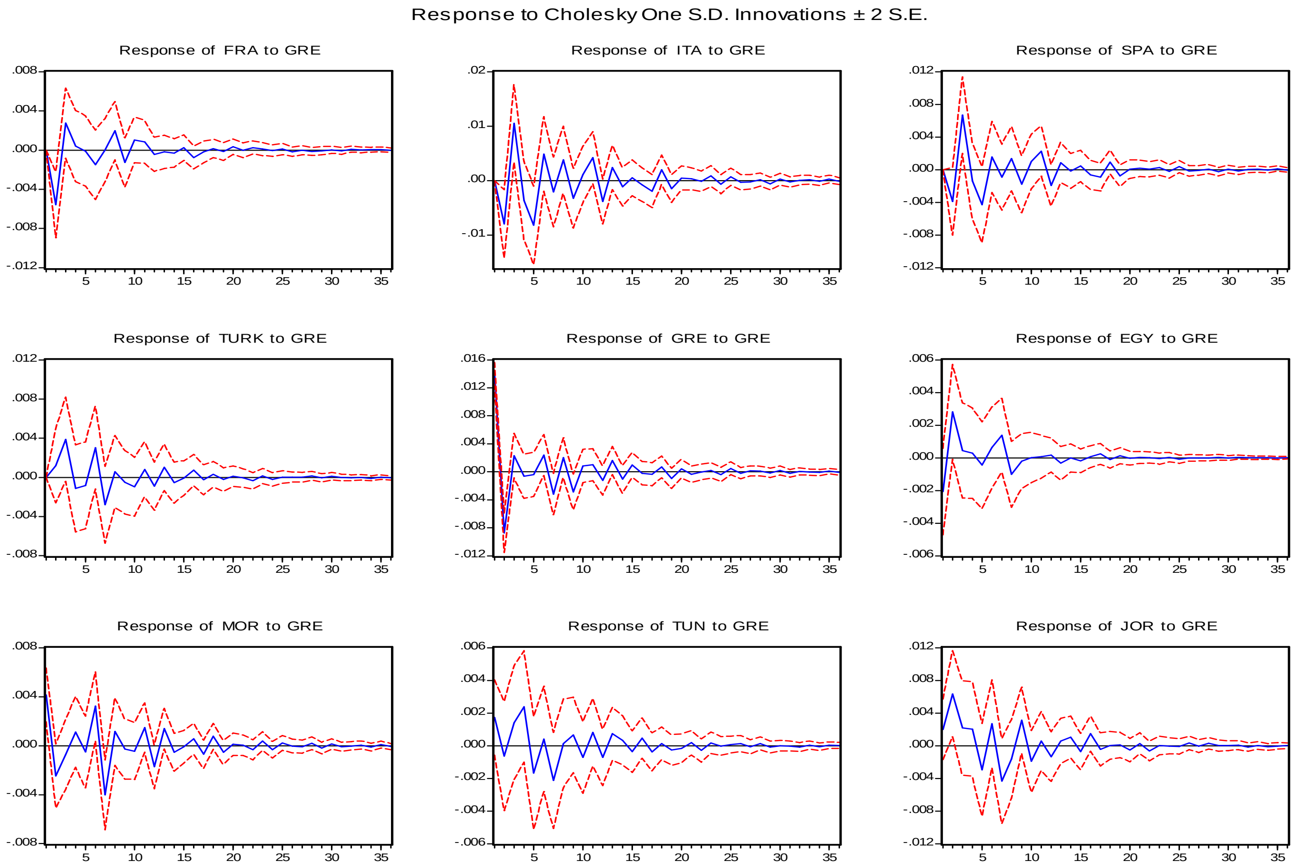
Graph A1.3 Responses to spain economic shock.



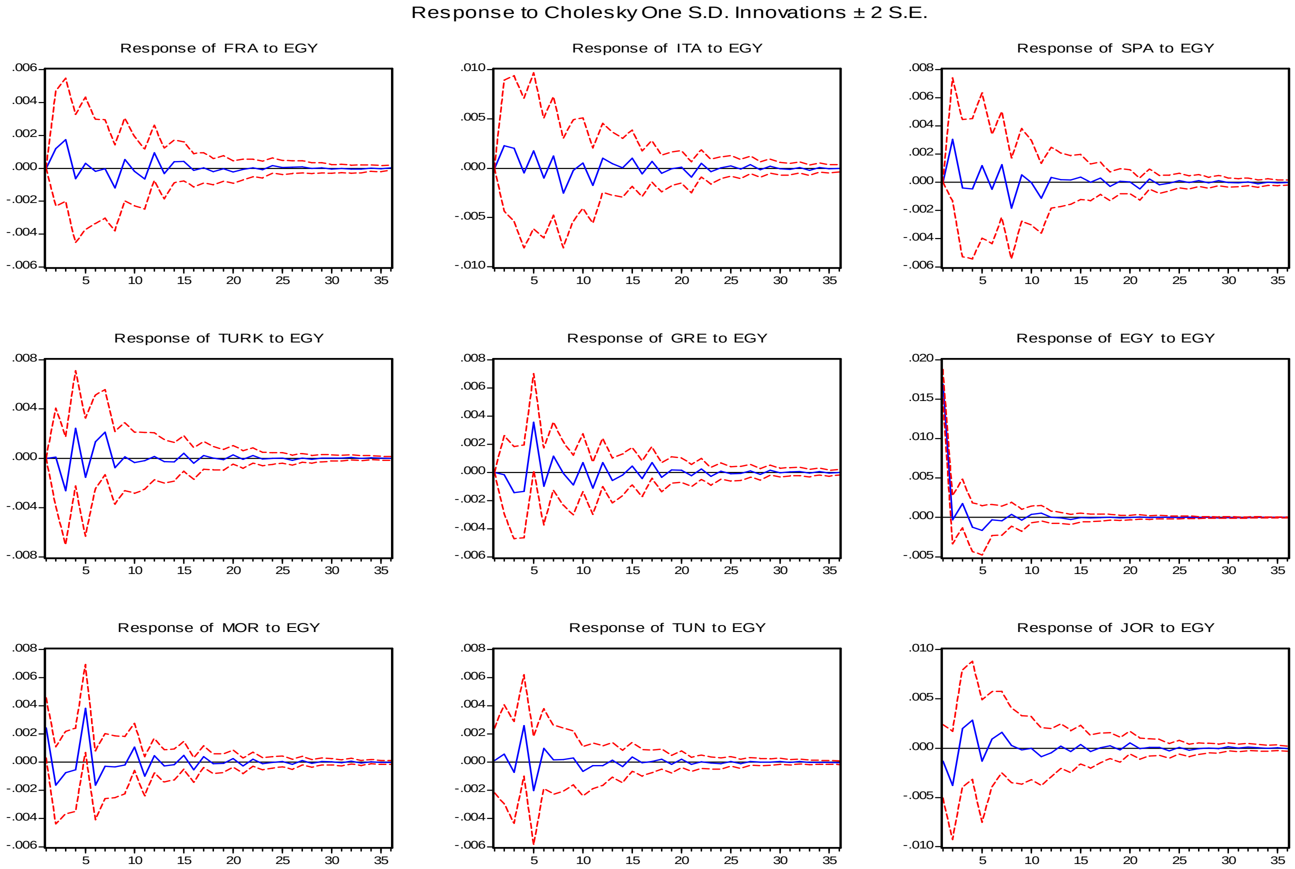
Graph A1.4 Responses to Turkey economic shock.



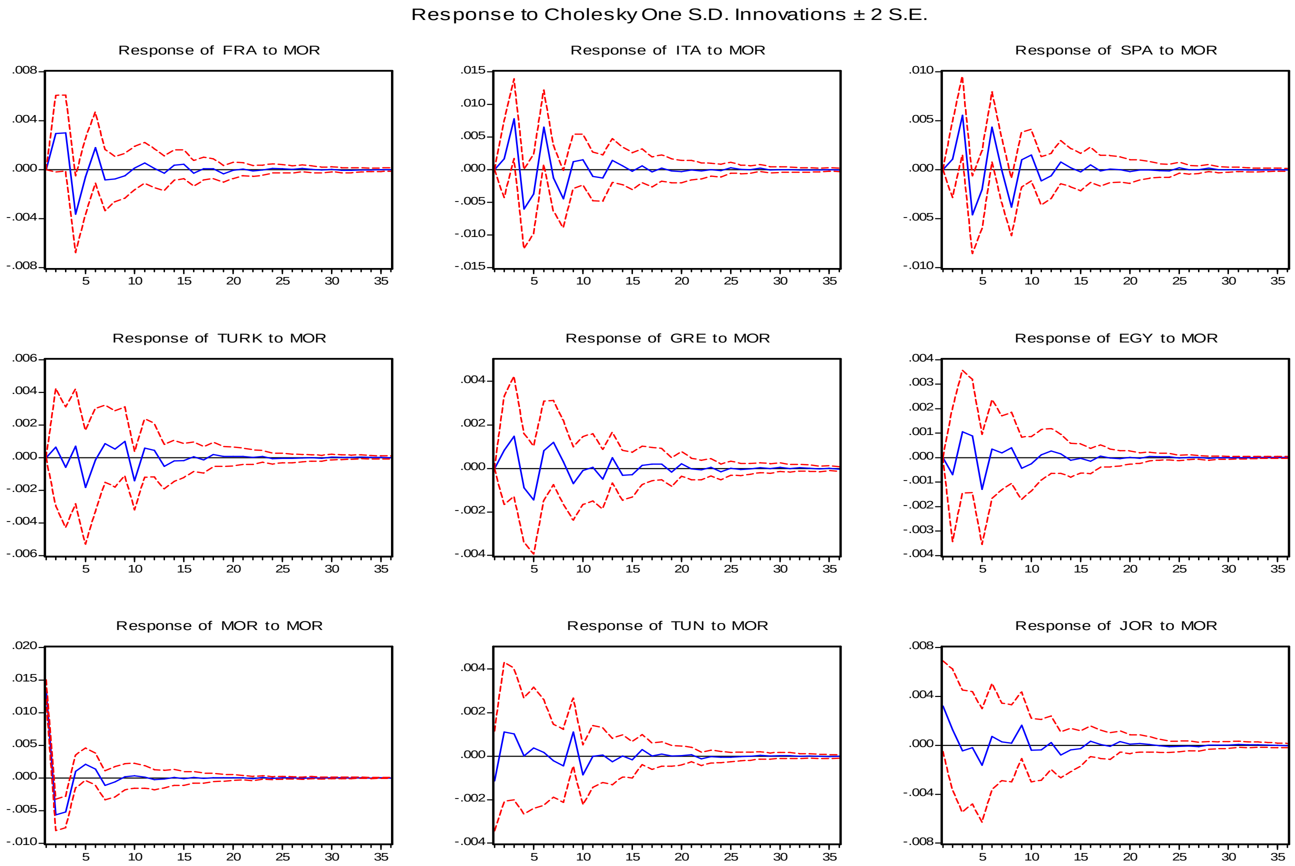
Graph A1.5 Responses to Greece economic shock.



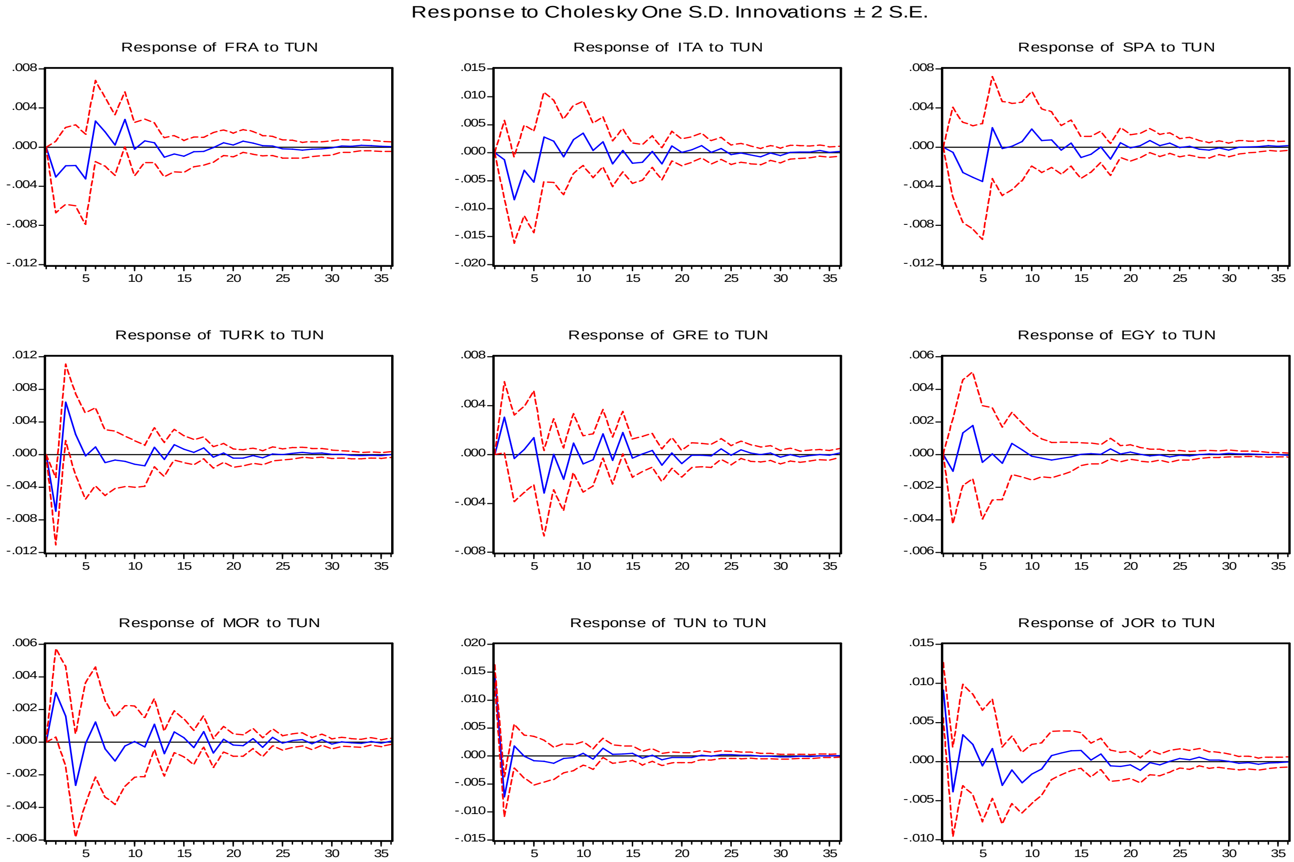
Graph A1.6 Responses to Egypt economic shock



Graph A1.7 Responses to Morocco economic shock



Graph A1.8 Responses to Tunisian economic shock



Graph A1.9 Responses to Jordany economic shock