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What is the relationship between environmental quality, economic growth and free trade?

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Abstract

This paper tries to examine the links between free trade, growth, and environmental quality in Morocco, Algeria, Tunisia, and Egypt, denoted MATE. During the last years, many agreements are concluded especially with developed countries. These agreements can improve economic growth, which is necessary in response especially to the increasing demand of their populations, and to the improvement of the life's quality of their citizens. But, it can also decrease the environmental quality because there is a causal relationship between these variables. For that, quadratic and cubic functions for each country over the period 1970-2010 are tested to measure this relationship, and to determinate the possibilities of the existence of an inverted U-shaped or inverted N-shaped functions, and, then, a vector auto regression (VAR) or a vector error correction model (VECM) are used to analyze the long-run and short-run relationships between those variables. To complete analysis, it is often useful to know the response of independent variable and it adopts a variance decomposition to explain the magnitude of the forecast error variance determined by the stocks to each of the causal variables over time.

Keywords: *Free trade, economic growth, environmental degradation, EKC, VECM/VAR, variance decomposition, impulse response function*

JEL classification code: *C32, F18, F43, N57*

1. Introduction

The economic growth remains important for developing and developed countries. It affects people's well-being, such as health, education, employment and quality of life. It affects also government's stability, from social and nutritional security to political stability. The recent example of the case of Arabic countries is the "*Jasmine*" revolution started in Tunisia. The principal reasons behind this revolution are, especially, the high rate of unemployment, the high index of corruption, the poor living conditions, the lack of democracy (free election), and the deficiency of freedoms (freedom of the expression and press).

The economic growth is positively linked with, namely, foreign trade. Many studies are confirmed the existence of the long-run relationship between trade openness and economic growth (Michaely (1977); Balassa (1985, 1988); Ahmad and Kwan (1991); Demirhan and Akcay (2005); Wadad (2012); El Alaoui (2015)). However, this relationship can affects quality of the environment, which plays an important role in supporting all economic activities (agriculture, manufacturing and services). It contributes directly and indirectly in these activities. Directly by providing raw materials and minerals required as inputs for the production. Indirectly by providing ecosystems required as river, ocean and air.

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The environment is, therefore, vital for securing a sustainable economic growth and development, not only for the present but also for the future generation. It is defined by the Global Development Research Center as "the environment stock or resources of Earth that provide goods, flows and ecological services required to support life". This concept is used in many studies especially in this of Costanza and Daly (1992).

Since the industrial revolution, the environment has known many changes. These changes can be summarized in three aspects: the ozone layer, the temperature change, and the biodiversity loss (Daniel (1999); Chivian and Bernstein (2010); (Khagram, Clark and Raad (2003); Bass (2006); Martino and Zommers (2007), among others).

The environmental damage will be experienced, especially, by developing countries and the poorest people, such as in Sub-Saharian Africa, South Asia, Southeast Asia, and Latin America regions. In urban area, the risks for peoples, assets, economies and ecosystems have increased such as air pollution, drought and water scarcity (IPCC, 2014, p.15). In rural area, the major impacts are on water availability and supply, food security, infrastructure and agricultural incomes (IPCC, 2014, p.16). In fact, "the harmful effects of the degradation of the ecosystem services are being borne disproportionately by the poor, are contributing to the growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and social conflict", (Bass, 2006).

Everybody has a clear conscience about environmental challenges, from averting dangerous climate changes to halting biodiversity losses and protecting our ecosystems. However, the developed economies have partially reduced the environmental damage by, especially, exporting/installing/relocating/transferring a part of their production as investments/goods/services in developing countries, thus exporting their pollution to these countries. But, these exchanges are important and vital for developing countries; it ensures continued economic growth and helps to reduce poverty, migration and unemployment. For that, the solution is in reducing environmental impacts namely by highlighting the importance of technological innovations in developing countries.

Study of the environment quality has been an important research topic in recent years, it has been considered to be one of the most important consequences of use of the natural resources. Thus, this work tries to examine the relationship between trade, economic growth and environment quality (measured by CO2 emissions per capita) in Morocco, Algeria, Tunisia, and Egypt, denoted MATE, where the main objective for these countries in the coming years is to improve economic growth in a context of economic opening, which is necessary in response to the increasing demand of their populations, the improvement of the life’s quality of their citizens, and to meet the environmental challenges they face.

This paper is organized as follow: The second section reviews a sample of theoretical and empirical studies that focus on the relationships between opening, growth and environment. The third section presents economic and environmental situation in MATE. The fourth section is allotted for the presentation of the methodology and main results. The fifth section serves to conclude.

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2. Theoretical and empirical discussions

The theoretical foundation of the relationship between trade openness and economic growth goes back to the founders of the classical theory. In fact, Smith and Ricardo were the first to identify the advantages that can be drawn by the countries to liberalize their trade. In the new world context, countries cannot live in autarchy. But, this situation has generated a strong pressure on the environment, El Alaoui (2015).

Grossman and Krueger (1991) analyzed the environmental impact of the North American Free Trade Agreement (NAFTA) distinguishing three separate mechanisms that can affect the level of pollution and the rate of depletion of scare environmental resources. These effects are the scale, the composition and the technique effects (Grossman and Krueger, 1991, pp. 3-4). Using a cubic function to estimate the concentration of pollutants in the air[1], the authors found that *(i)* trade liberalization generates some benefits such as increased income growth which tends to alleviate pollution problems and increased specialization in sectors that cause less than average amounts of environmental damage, and *(ii)* "the environmental impacts of trade liberalization in any country will depend not only upon the effect of policy change on the overall scale of the economic activity, but also upon the induced changes in the intersectoral composition of economic activity and in the technologies that are used to produce goods and services", p. 36. Thus, the main finding of Grossman and Krueger (1991) are called the Environmental Kuznets Curve, noted EKC, which refers to the hypothesis of an inverted U-shaped relationship between various indicators of environmental degradation and per capita income. The EKC takes the name of Simon Kuznets (1955)[2] who hypothesized that income inequality first rises and then falls as the economic development proceeds from a certain threshold's economic growth. In the EKC, degradation of the environment increase in the early stages of the economic growth, but beyond a certain level of per capita income, which will vary for different indicators, the trend reverses, so that a high income level of economic growth leads to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of per capita income. Similar findings are reported by Grossman and Krueger (1995); Beckerman (1992); Shafik and Bandyopadhyay (1992); Panayotou (1993, 1997, 2003); Shafik (1994); Selden and Song (1994); and Cropper and Griffiths (1994)[3].

Several studies have focused on relationship between international trade and environmental quality, and have confirmed that the international trade can improve the environmental quality. Accordingly, the international trade would accelerate income; so it can allow a quick passage to the ascending part of the curve. Grossman and Krueger (1991) showed that trade liberalization generates an increase in income levels, then it can strengthen the incentives for 'environmental dumping', p. 21. So they proposed that free trade can protect the environment. Lopez (1994) showed that "economic growth and

[1]The pollutants in the air is measured with SO2, suspended particles and dark matter (thin smoke)) in urban areas allowing to the Global Environmental Monitoring System (GEMS) dataset as part of a study of the potential environmental impacts of NAFTA.

[2] Simon Kuznets (1901-1985) was an American economist, demographer and statistician of Ukrainian origin. He won the Nobel Prize in 1971.

[3] For a chronological presentation of the EKC see Stern (2004). This author confirmed that the EKC concept was popularized through World Bank Development Report (1992).

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trade liberalization decrease the degradation of natural resources if and only if producers internalize their stock feedback effects on production", p. 163. He concluded that the effect of trade liberalization depends on three assumptions: *(i)* the manufacturing sector is protected vis-à-vis to the primary sector, *(ii)* the productive stock effects of the resource occur entirely in the primary sector, and *(iii)* the productive sector is characterized by constant returns to scale technology, (Lopez, 1994, p. 183). Antweiler, Copeland and Taylor (2001) investigated how the openness to trading opportunities affects pollution concentrations by developing a theoretical model to divide trade's impact on pollution into scale, technique, and composition effects. The authors concluded that "free trade is good for the environment", p. 878.

The turning points[1] come somewhere between $4,000 and $5,000 per capita GDP, measured in 1985 U.S. dollars, (Grossman and Krueger, 1991, p 5). 'Similar' results are found by Cropper and Griffiths (1992) which the turning points are $4,760 per capita income for Africa and $5,420 per capita income for Latin America. However, these points vary substantially across environmental indicators[2]. Shafik and Bandyopadhyay (1992) found that the turning points are $3,280, $1,375 and $1,375 (per capita income in 1985 U.S. dollars) for sulfur dioxides, SPM and fecal coliform, respectively.

Other studies[3] have estimated the turning point to be generally higher. The turning points vary for the different pollutants[4], but almost in every case they occurred at an income of less than $8,000 U.S dollars in 1985, (Grossman and Krueger, 1995, p. 369). Selden and Song's estimates are under $10,000 per-head (1985 U.S dollars). These authors tested four indicators of air pollution (SPM, SO_2, NOx and CO) in their model. However, Cole, Rayner, and Bates (1997) used carbon dioxide, carbonated fluorocarbons (CFC) and halons, methane, nitrogen dioxide, sulfur dioxide, suspended particulates, carbon monoxide, nitrates, municipal waste, energy consumption and traffic volumes to examine the EKC. They have estimated the turning points for different pollutants (from a low $5,700 to a high $34,700 in 1985 U.S dollars).

The EKC has been the subject of growing criticism (Arrow et al. (1995); Ekins (1997); Torras and Boyce (1998); Perman and Stern (1999); Stern and Common (2001), and Cole and Neumayer (2005)). Some authors have confirmed that the EKC is just a utopia because the solution of environmental degradation is not related only to an economic growth and a higher income but there are several other factors can play an important role in improving our biodiversity and ecological systems such as education, quality of institution, and civil society[5]. Nevertheless, many critics have argued that the EKC suffers from severe methodological problems that cast doubt on the reliability of EKC results (Cole and Neumayer, 2005, p. 298). The authors documented that the

[1] Stern (2004) presented in table 1 (p. 1425) a summary of turning points for sulfur emissions and concentrations assigned at the several studies. See also table 1 of Cole (1999), p. 92.

[2]For more explication see Shafik (1994).

[3]See for example Selden and Song (1994), Grossman and Krueger (1995), and Cole, Rayner and Bates (1997).

[4] They focused on four types of indicators: concentrations of urban air pollution, measures of the state of the oxygen regime in river basins, concentrations of fecal contaminants in river basins, and concentrations of heavy metals in river basins.

[5] For example, Panayotou (1993) proposed that "the state of natural resources and the environment in a country depends on five main factors" ignoring/ neglecting other factors that impact economic growth. These factors are "(a) the level of economic activity or size of the economy; (b) the sectoral structure of the economy; (c) the vintage of technology; (d) the demand for environmental amenities; and (e) the conservation and environmental expenditures and their effectiveness", p. 2.

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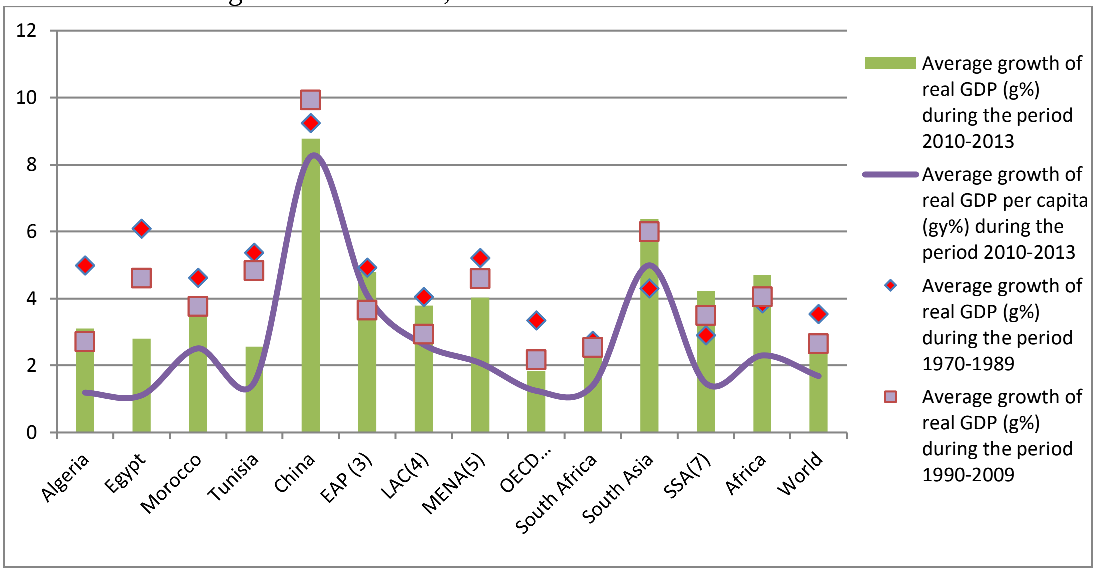
rich countries have become clean up, at least partly, by exporting the dirty production of products to poorer countries. This fact may therefore explain the reductions in local air pollution experienced in most developed countries found in many studies.

3. Trade and environmental situation in MATE

In MATE, economic growth differs significantly from a country to another and within the same country, Figure 1. The best growth rates of real GDP and of real GDP per capita were recorded during the period 1970-1989, and the highest rates were recorded in Egypt. However, Morocco grew speedily by 3.9% during the period 2010-2013 against 3.1%, 2.8% and 2.6% in Algeria, Egypt and Tunisia, respectively. These rates are lower than those recorded in Africa (all countries combined), South Asia, Sub-Saharan Africa (SSA), East Asia and Pacific (EAP) and China.

Figure 1. Averages growth of the Real GDP (g)[(1)] and of the Real GDP per capita (g_y)[(2)] in MATE and other regions of the World, in %



Source: Calculated using World Development Indicators (WDI), 2015. *(1) g* is growth rate of the real GDP (2005 US$); *(2)* g_y is growth rate of the real GDP per capita [real GDP per capita =GDP (constant 2005 US$)/total population]; *(3) EAP* is the East Asia and Pacific; *(4) LAC* is Latin America and Caribbean; *(5) MENA* is the Middle East and North Africa; *(6) OECD* is the Organization for Economic Co-operation and Development; *(7) SSA* is Sub-Saharan Africa.

These growths were accompanied by a rapid opening[1] in all regions of the World, Table 1. The highest trades (% of GDP) are recorded in Tunisia. Despite the highest average growths recorded in China (Figure 1), its trade (% of GDP) is lower than that recorded in other regions of the world.

The GDP of developing countries are more depending to trade than developed countries. During 2000-2014, Tunisia's trade presents more than 96%; it is higher than that recorded in Africa, which presents more than 80% of GDP. However, Algeria's, Egypt's and Morocco's trades are lower than that recorded in Africa; they are more than 66%, 50% and 72%, respectively.

[1] The opening is the share of the sum of exports and imports of goods and services in gross domestic product (GDP).

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Table 1. Trade's Averages in MATE and other regions of the World

	1980-1989	1990-1999	2000-2009	2000-2014
Algeria	50.1	50.1	67.2	66.7
Egypt	57.6	50.3	54.2	50.7
Morocco	54.7	52.6	68.5	72.6
Tunisia	80.0	86.5	92.5	96.5
China	19.6	34.1	52.1	50.1
Africa	71.5	71.0	81.2	81.1
ESP	39.4	42.5	56.8	58.4
LAC	32.7	38.5	47.7	48.4
MENA	69.6	64.2	79.6	82.4
OECD members	35.5	37.9	47.0	49.1
SSA	55.1	56.3	65.4	64.7
World	37.7	41.7	52.4	54.2

Source: Calculated using WDI, 2015.

This situation is accelerated by application of many agreements especially since 2000. The annual growth of import is on its upward trend comparatively to the trend of the annual growth of export in MATE, Table 2.

Table 2. Shares' Averages of Exports and Imports in the Real GDP and annual growth (%) of Exports and Imports in MATE by period

	Periods	Algeria	Egypt	Morocco	Tunisia
Exports of goods and services (% of GDP)	1980-1989	23.8	22.2	23.8	36.9
	1990-1999	25.8	21.8	23.9	41.1
	2000-2009	41.8	25.1	31.0	44.9
	2010-2014	35.6	18.5	33.8	48.1
Imports of goods and services (% of GDP)	1980-1989	26.3	35.4	31.0	43.0
	1990-1999	24.2	28.5	28.6	45.3
	2000-2009	25.4	29.1	37.5	47.6
	2010-2014	30.2	25.2	47.1	56.4
Exports of goods and services (annual % growth)	1980-1989	2.6	6.1	5.5	4.9
	1990-1999	2.9	4.3	6.5	5.0
	2000-2009	2.2	13.1	5.3	7.9
	2010-2014	-2.4	-2.1	6.7	5.1
Imports of goods and services (annual % growth)	1980-1989	0.2	-0.4	2.1	3.4
	1990-1999	-2.4	3.3	5.2	4.0
	2000-2009	7.7	10.0	7.1	7.9
	2010-2014	6.5	3.7	4.6	7.8

Source: Calculated using WDI, 2015.

Figure 2 shows that, over the period 2000-2014, the share of imports in real GDP is higher than that of exports in Egypt, Morocco and Tunisia with similar annual growth of imports and exports between 6% and 8%. However, the share of exports in real GDP is higher than that of imports in Algeria, but the annual growth of exports (7.3%) is more important than that of imports (0.7%). This situation can be explained by the structure of trade.

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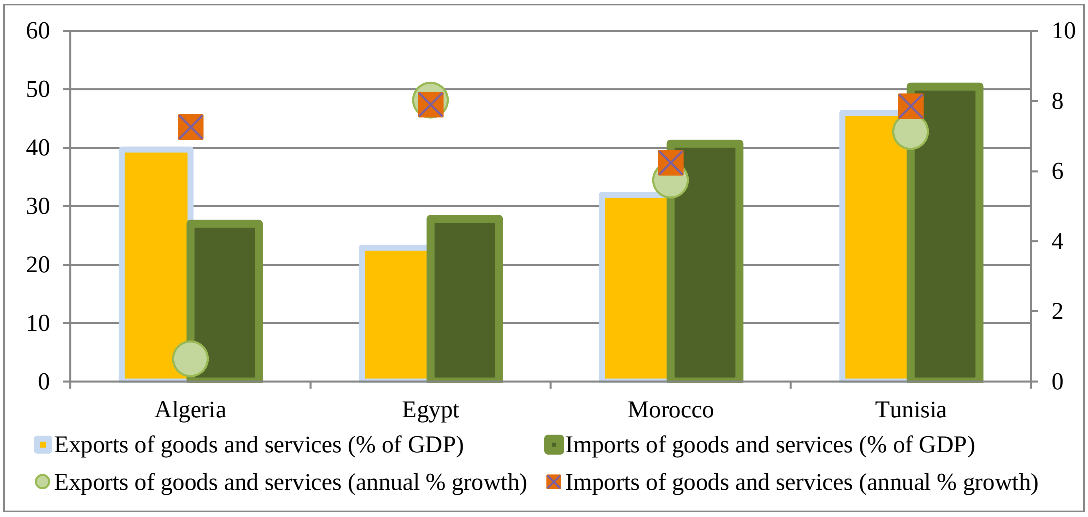
Figure 2. Averages Share of Exports and Imports in the Real GDP and annual growth (%) of Exports and Imports in MATE over the period 2000-2014



Source: Elaborated using WDI, 2015.

The structure of trade in MATE is characterized by the highest share of the merchandise and the lowest export and import of information and communication technology goods (ICT) in GDP. There is a considerable divergence in this structure between MATE. The majority of the energy used in Morocco is imported. It represents more than 89% of total of the energy imports against only more than 18% in Tunisia. However, shares of the energy imported by Egypt and Algeria are negative because these countries are the exporters of these energies.

Table 3. Structure of Trade in MATE during the period 2000-2014, in %

	Algeria	**Egypt**	**Moroc-co**	**Tunisia**
Trade (% of GDP)	66.7	50.7	72.6	96.5
Trade in services (% of GDP)	7.9	19.8	23.4	18.5
Merchandise trade (% of GDP)	59.6	33.2	56.4	80.7
Exports of goods and services (% of GDP)	39.7	22.9	31.9	46.0
Imports of goods and services (% of GDP)	27.0	27.8	40.7	50.5
Energy imports, net (% of energy use)	-348.1	-20.9	89.4	18.2
ICT goods exports (% of total goods exports)	0.0034	0.17	5.08	3.60
ICT goods imports (% total goods imports)	4.8	3.9	6.1	5.0
Manufactures exports (% of merchandise exports)	2.1	36.4	66.1	75.4
Manufactures imports (% of merchandise imports)	72.9	52.8	61.1	71.7
Fuel exports (% of merchandise exports)	97.2	38.6	2.7	13.2
Fuel imports (% of merchandise imports)	2.6	11.4	20.9	13.1
Food exports (% of merchandise exports)	0.3	11.7	19.8	9.2
Food imports (% of merchandise imports)	21.2	21.6	11.9	9.3

Source: Calculated using WDI, 2015.

The trade has an important share in GDP. Consequently, it has an important impact on economic activities. It can boost demand for transport and production, telecommunication technology, manufactured goods …. So, it can indirectly affect styles' life of citizens through the transformation in the population's behavior. The citizens can consume many goods with the best price in the market. Thus, these pressures will increase

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the environmental damage especially in the air and water. In this study, the environmental damage is measured by CO2 emissions per capita.

El Alaoui and Nekrache (2015) found that *(i)* Africa's emissions are lower compared to those of the World; *(ii)* the highest CO2 emissions per GDP are recorded in China and EAP-developing countries; *(iii)* CO2 emissions per capita are recorded in OECD members followed by South Africa; *(iv)* Egypt's emissions per GDP are more important than those recorded in Algeria, Morocco and Tunisia, and those recorded in MENA; *(v)* Algeria's emissions per capita are higher than those recorded in Egypt, Morocco and Tunisia, but lower than those recorded in MENA; *(vi)* MATE's emissions per GDP are higher than those recorded in Africa and the World, but MATE's emissions per capita are lower than those recorded in the World and more important than those recorded in Africa.

4.Methodology and results

4-1. Examination of application of EKC curve

In the first step, we estimate a quadratic function for each country over the period 1970-2010[1] to check the existence of inverted U-shaped function. Then, we estimate a cubic function in the second step to check if N-shaped function can explain the relationship between GDP, trade and CO2 emissions. This form is found by many authors namely Torras and Boyce (1998), List and Gallet (1999) and Bradford et al. (2005). Therefore, two functions are applied and they are presented as follows.

A *quadratic function:* this function is applied to determinate the existence of an EKC, i.e. the determination of the environmental curve in the form of an inverted U, (Figure 3.a). It is specified by the following form.

$$LCO2Y_{it} = a_0 + a_1 LY_{it} + a_2 (LY_{it})^2 + b_1 OPEN_{it} + b_2 (OPEN_{it})^2 + c_1 U_{it} + \varepsilon_t$$

For each i= Algeria, Egypt, Morocco or Tunisia. (1)

t= '1970, 1981 … 2010' year

A *cubic function* is applied to verify the existence of the N-form of the EKC, (Figure 3.b). This function is presented as follows.

$$LCO2Y_{it} = b_0 + a_1 LY_{it} + a_2 (LY_{it})^2 + a_3 (LY_{it})^3 + b_1 OPEN_{it} + b_2 (OPEN_{it})^2 + c_1 U_{it} + \varepsilon_t$$

For each i= Algeria, Egypt, Morocco or Tunisia. (2)

t= '1970, 1981 … 2010' year

Here, *LCO2Y* is the logarithm of the environmental degradation measured by CO2 emission per capita, *LY* is the logarithm of the per capita income, *LOPEN* is an indicator that measure the degree of openness which equal at *(X+M)/GDP* (*X* and *M* represent, respectively, exportation and importation), and *U* presents the urbanization rate because more people especially in cities involve more wastes and consumption of carburant and combustible. The term ε_t is referred to the error term.

[1] Data of CO2 emissions per capita is not available over the period 2011-2015.

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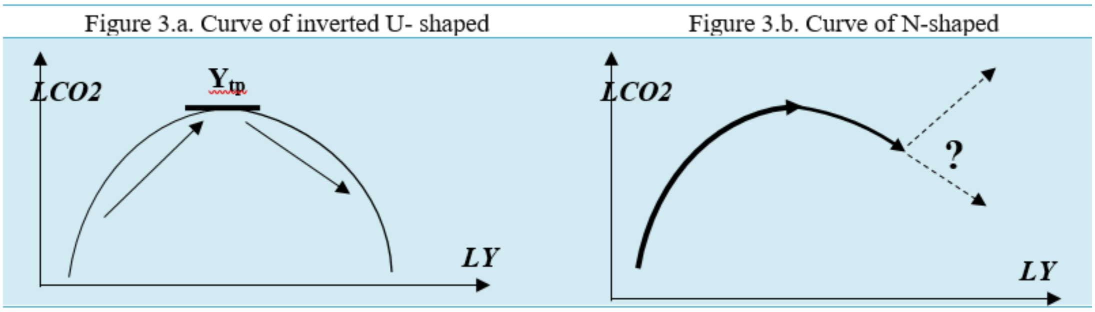
To verify the existence of EKC in equation 1, it implies that the coefficients a_1 and a_2 will be positive and negative, respectively, ($a_1 > 0$ and $a_2 < 0$). In that case, there is a level of real GDP per capita beyond which the environmental indicator begins to improve, the turning point (noted Y_{tp}) which it is determined by: $Y_{tp} = exp(-\frac{a_1}{2a_2})$. To test the N-shaped curve, a_3 in equation 2 will be positive ($a_3 > 0$).

Figure 3. Relationship between real GDP per capita (LY) and the environmental quality (LCO2Y)



Investigation of the relationship between trade (measured by the degree of openness) and environmental quality is motivated by the fact that the trade can increase real income. The environment is considered as luxury and not it is an important good for economic activities and life. So, the increased income from free trade encourages country to scarify à part of its income to protect the environment (Galeotti and Lanza, 1999). The idea behind this relationship is simple. Enrichment of population or country was accompanied by the demand for a cleaner environment. The main preoccupations, normally, for a poor country is to afford the basic necessities for their citizens, leaving any place for other concerns as environmental issues because the income is lower, but when a country becomes rich, it can scarify à part of its income to other concerns as to protect the environment. Consequently, a country tends to follow increasing pollution levels as trade openness proceeds ($b_1 > 0$), and then we can find declining pollution levels at more advanced stage of free trade ($b_2 < 0$).

Table 4 summarizes the regression results for each country based on the two models mentioned above (equation 1 and equation 2).

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Table 4. Results of equations 1 and 2 from OLS estimation method, sample 1970: 2010

			Algeria		Egypt		Morocco		Tunisia	
			Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Constant	a0	-231.51	771.17	-4.45	165.18	-13. 90	-370.35	-31.25	95,38
		std. dev	57.17	2850.72	2.81	96.19	10.20	265.13	10.93	184,90
independent Variables	LY	a_1	58.761	-329.745	-0.355	-77.027	2.766	150.098	7.350	-42,823
		std. dev	14.748	1104.434	1.000	43.471	2.800	109.540	2.884	73,188
	LY^2	a2	-3.706	46.457	0.105	11.511	-0.146	-20.420	-0.438	6,181
		std. dev	0.951	142.594	0.075	6.466	0.188	15.070	0.182	9,649
	LY^3	a3		-2.158		-0.564		0.929		-0,290
		std. dev		6.135		0.320		0.690		0,423
	open	b1	-0.025	-0.027	-0.006	-0.007	0.008	0.006	0.011	0,011
		std. dev	0.021	0.022	0.006	0.006	0.008	0.008	0.009	0,010
	$open^2$	b2	0.0002	0.0002	0.0001	0.0001	-0.00003	-0.00002	-0.0001	-0,00004
		std. dev	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0,0001
	u	c1	0.011	0.011	0.059	0.100	0.023	0.027	0.011	0,006
		std. dev	0.004	0.004	0.024	0.033	0.005	0.006	0.005	0,008
		R^2	0,708	0.709	0.984	0.986	0.983	0.983	0.971	0.972
		F-Stat-value	16,946	13.789	439.471	388.848	393.342	335.675	235.861	193.657
		Probability of F-Stat	0,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Validation of mode			Test on residuals							
Correlogram of residuals: Q-Stat, lags=20			All P-value>5%				Almost P-value <5%			
Normally test		test of Jarque Bera Probability	9.0064 (0.011)	6.2254 (0.044)	2.0472 (0.3593)	1.6337 (0.4418)	2.1400 (0.3430)	2.1298 (0.3447)	0.3132 (0.8551)	0.7367 (0.6919)
Breusch Godfrey Serial Correlation LM-test		F-Stat Probability	0.2154 (0.8074)	0.2260 (0.7990)	0.6937 (0.5069)	0.3916 (0.6791)	3.5503 (0.0401)	3.3939 (0.0295)	7.9774 (0.0015)	7.4510 (0.0022)
Heteroskedasticity test ARCH		F-Stat Probability	0.009 (0.9283)	0.091 (0.7651)	0.0134 (0.9083)	1.1355 (0.2933)	2.1370 (0.1520)	1.8496 (0.1820)	9.9887 (0.0031)	7.0128 (0.0117)
		Conclusion	Models are robust despite the residuals are no-Gaussian.		Models are sufficiently robust		Models are not robust		Models are not robust	

Source: Estimated using the available data.

In *model 1*, the real GDP per capita and its square are expected signs in Algeria's ($a_1 > 0$ and $a_2 < 0$). These results can suggest that estimates of the EKC are adequate models. However, the results in cases of Morocco and Tunisia can suggest that estimates of the EKC are inadequate models despite that the coefficients attached to real GDP per capita are expected signs. These results concur with deduction of Stern (2004) which suggested that " the majority of studies have found the EKC to be a fragile model suffering from severe econometric misspecification", p. 1431.

In *model 2*, real GDP per capita in case of Morocco, its square and its cubic have expected signs but the residuals are not normally distributed (no-Gaussian). In cases of Algeria and Tunisia, the coefficients attached to these explanatory variables have not expected sings and also the residuals are not stationary and non-normally distributed. So, these variables cannot exhibit N-shaped relationships with CO2 emissions per capita. Similarly, the coefficients attached to *open* are not expected signs. So, the trade cannot exhibit inverted U-shaped relationship with environmental quality.

In both models, Egypt is a particular case. The models are good models but the coefficients attached to real GDP per capita, its square and its cubic are not expected signs. Therefore, we cannot conclude that there is an inverted U-shaped function or an inverted N-shaped function with CO2 emissions per capita. The coefficients attached to open and its square have a negative and positive signs, respectively. So, these results can expect a U-shaped curve between trade and CO2 emissions per capita (Figure 4). The turning points are between 52% and 55% as indicator of openness. This point is determined by: $Open_{tp} = -\frac{b_1}{2b_2}$

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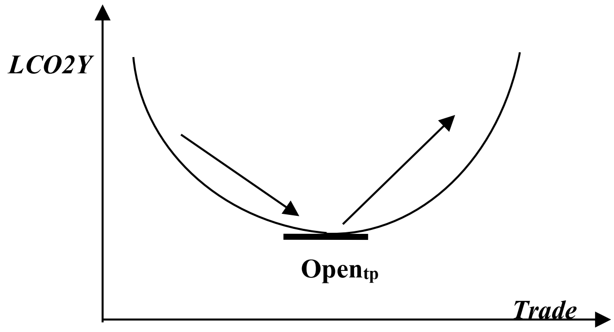
Figure 4. Relationship between trade (open) and the environmental quality (LCO2Y) in case of Egypt



The urbanization rate is linked positively and significantly to CO2 emissions per capita in both models in case of Egypt. This result means that the urbanization increases the environmental damage.

4-2. The VECM or VAR model

To define the kind of relationship between environmental quality, economic growth and trade, it is useful to test a long-run relationship using the VECM. This model involves three important steps. The *first step* studies the stationarity of these variables using ADF test. If the variables are non-stationary and integrated of the same ordered. Then, it is possible to move to the *second step*. This step uses Johansen's test to check possibility of the existence of a long-term stable relationship among these variables. To complete this analysis, it is important to study the sense of their causality with the Granger test. The *third step* depends on the results of the second step. If there is a relation of cointegration between the dependent and explanatory variables, then it is able to deduct the existence of a long-run dynamic relationship between these variables. But, if these variables are not cointegrated, then it is not able to deduct the existence of a long-run dynamic relationship between among variables. In this case, it is possible to check only the existence of a short-run relationship between these variables. In this case, the VAR model is applied. Therefore, under such conditions, two models will be applied for each country of MATE:

(i) If all variables are non-stationary (and interested with same order) and cointegrating vector exists, the VECM can be used as follows.

The long-run equation is:

$$LCO2Y_t = a_0 + a_1 LY_t + a_2 Open_t + \varepsilon_t \quad (3)$$

The short-run equation is:

$$\Delta LCO2Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta LY_{t-i} + \sum_{i=1}^{p} \alpha_{2i} Open_{t-i} + U_t + \alpha_4 ECM_{t-1} + \varepsilon_{1t} \quad (4)$$

Where, Δ represents the difference operator. The symbol of p is the number of lags. ε_t presents the stochastic error term with mean zero and a constant variance. ECM_{t-1} referred to the error correction term (ECT) derived from the long-run relationship.

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(ii) If the variables are non-stationary I(d) and not cointegrated, the Vector auto-regression (VAR) model in the d^{th} difference form and without the ECM can be used and estimated.

To ensure proper specification of this model, it is necessary to determine the optimum lags lengths (p), which are determined using five criterions: the Sequential modified LR test, the Final Prediction Error (FPE), the Akaike Information Criterion (AIC), the Schwarz Information Criterion (SC), and the Hannan-Quinn information criterion (HQ). The results show that the optimal lag order length is p=1 in Algeria, Egypt and Morocco, and p=2 in Tunisia.

Table 5 shows that all variables of MATE are stationary in the first difference, i.e. they are integrated of order one I(1). This result suggests a stable long-run relationship between these variables.

Table 5. Stochastic properties of variables, annually series

	Algeria		Egypt		Morocco		Tunisia	
	Variables in		Variables in		Variables in		Variables in	
	level	first difference	level	first difference	level	first difference	level	first difference
CO2Y	0.307*	-7.441	-2.518	-2.518	-1.629	-5.738	-2.923	-7.267
	(-1.950)	(-1.950)	(-3.527)	(-3.527)	(-2.941)	(-2.941)	(-3.527)	(-2.939)
LY	-2.468	-8.775	-0.686	-3.643	0.528	-10.354	-1.087	-6.431
	(-2.960)	(-2.939)	(-2.937)	(-2.939)	(-2.939)	(-2.939)	(-2.937)	(-2.939)
OPEN	-1.529	-4.765	-2.431	-5.454	-1.548	-8.128	-1.944	-6.097
	(-2.937)	(-2.939)	(-2.937)	(-2.939)	(-2.939)	(-2.939)	(-2.937)	(-2.939)

Notes: * indicates the ADF statistic and in ( ) is Critical values of the ADF statistic at 5% level

The results of the Johansen cointegration test imply a long-run relationship between among CO2Y, LY, and OPEN in cases of Algeria and Tunisia, and a long-run association no-exist among these variables in cases of Egypt and Morocco. These results are reported in Table 6.

Table 6. Results of the Johansen Cointegration Test

H0	Eigenvalue	Max-Eigen			Trace			Conclusion
		Statistic	CV at 5%(2)	Prob. (3)	Statistic	CV at 5%	Prob.	
				Algeria				
r=0(1)	0.752	54.380	21.132	0.000	72.015	29.797	0.000	1 cointegration
r=1	0.306	14.262	14.265	0.050	17.635	15.495	0.024	
r=2	0.083	3.373	3.841	0.066	3.373	3.841	0.066	
				Egypt				
r=0	0.362	17.517	22.300	0.204	30.934	35.193	0.134	no cointegration
r=1	0.235	10.433	15.892	0.297	13.416	20.262	0.332	
r=2	0.074	2.983	9.165	0.584	2.983	9.165	0.584	
				Morocco				
r=0	0.362	17.546	21.132	0.148	27.537	29.797	0.089	no cointegration
r=1	0.224	9.868	14.265	0.221	9.991	15.495	0.281	
r=2	0.003	0.124	3.841	0.725	0.124	3.841	0.725	
				Tunisia				
r=0	0.479	24.800	21.132	0.015	38.832	29.797	0.004	1 cointegration
r=1	0.285	12.732	14.265	0.086	14.032	15.495	0.082	
r=2	0.034	1.299	3.841	0.254	1.299	3.841	0.254	

Notes: *(1)* r is the number of the hypothesized cointegrating relationships. *(2)* MacKinnon-Haug-Michelis (1999) p-values. *(3)* Probability at 0.05 level.

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With respect to optimal lag order length, results of the cointegration test can be concluded as the long-run equilibrium between variables in cases of Algeria and Tunisia which are:

$$LCO2Y\_Alg = 2.6654 - 0.2124\,LY\_Alg + 0.0004\,Open\_Alg$$

$$LCO2Y\_Tun = -2.9795 + 0.4197\,LY\_Tun + 0.0031\,Open\_Tun$$

Note: *_Alg* is index of Algeria and *_Tun* is index of Tunisia

We note that the VECM is validated if the coefficient attached to the error correction term (ECT) is negative and statistically significant. This term measures speed of adjustment in the long-run. In Algeria's case, ECT is negative and statistically significant. The size of coefficients of the ECT is 53.4%. In the same way, the coefficient ECT in Tunisia's case is negative and statistically significant meaning that the environmental quality is balanced in the long-run by 47.02%.

The VECM of Algeria and Tunisia not only take into consideration the impact of the long-term factors on the explication of the deviation of dependent variable but it also allows examination of the short-run impacts factors. Table 7 shows these results.

Table 7. Results of VECM estimates applied in cases of Algeria and Tunisia

	D(CO2Y)	D(LY)	D(OPEN)	D(CO2Y)	D(LY)	D(OPEN)
	Algeria			Tunisia		
ECT	-0.5344*	-0.1641*	-2.3538	-0.4702*	-0.2621*	-14.9678
	(0.1148)	(0.0219)	(5.0155)	(0.1532)	(0.0624)	(25.096)
D (CO2Y (-1))	-0.1770	0.0933*	10.7571**	0.0121	0.3828*	22.8205
	(0.1345)	(0.0257)	(5.8787)	(0.2020)	(0.0822)	(33.076)
D (CO2Y (-2))				0.2727	0.2272*	11.8144
				(0.1995)	(0.0812)	(32.669)
D (LY (-1))	0.2507	-0.2701*	10.0633	-0.4815	-0.6428*	-34.9706
	(0.4466)	(0.0853)	(19.5180)	(0.3436)	(0.1398)	(56.280)
D (LY (-2))				-0.4239	-0.2885*	12.5132
				(0.2993)	(0.1218)	(49.018)
D (OPEN (-1))	-0.0083*	0.0005	0.2913**	-0.0018	-0.0009*	-0.0683
	(0.0037)	(0.0007)	(0.1629)	(0.0012)	(0.0005)	(0.2020)
D (OPEN (-2))				-0.0019	-0.0005	-0.2277
				(0.0015)	(0.0006)	(0.2428)
C	-0.2515	-0.0809*	-4.3057	-0.3768*	-0.3517*	-14.1116
	(0.1690)	(0.0323)	(7.3871)	(0.1959)	(0.0797)	(32.0840)
U	0.0054**	0.0018*	0.0817	0.0074*	0.0068*	0.2716
	(0.0032)	(0.0006)	(0.1379)	(0.0035)	(0.0014)	(0.5691)

Notes: Standard errors in ( ). * Significant at 5% level.** Significant at 10% level. ECT is the error correction term.

To insure the directional causality between among these variables, the Granger causality test is used, Table 8. The results show that two ways directional causality exist from real GDP per capita and open to CO2 emissions per capita in case of Algeria and from CO2 emissions per capita and open to real GDP per capita in case of Tunisia.

All these results show that:

- In Algeria's case, the coefficient of the real GDP per capita is not significant, meaning that the real GDP per capita cannot affect CO2 emissions per capita in the

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short period. In addition, the coefficient of OPEN is significant at 5% and its sign is negative. Therefore, trade is found to have a negative short-run relationship with CO2 emissions per capita. If the degree of openness (open) increases by 1%, then CO2 emissions per capita decreases by only 0.8%.

- ➢ In Tunisia's case, the coefficients of the real GDP per capita and open cannot affect CO2 emissions per capita in the short period.

- ➢ The coefficient of exogenous variable (the urbanization rate, *U*) is significant and its sign is positive. This positive relation varies from 0.0018 to 0.0068.

Table 8. Granger Causality-Wald statistics

	Algeria			**Tunisia**			
	Dependent variable:						
	D(LCO2Y)	**D(LY)**	**D(OPEN)**	**D(LCO2Y)**	**D(LY)**	**D(OPEN)**	
D(LCO2Y)		13.171	3.348		21.881		χ^2 statistics
		0.000	0.067		0.000		Prob.
D(LY)	0.315		0.266	2.802		0.476	χ^2 statistics
	0.575		0.606	0.246		0.788	Prob.
D(OPEN)	4.923	0.507		3.700	3.592	0.706	χ^2 statistics
	0.027	0.476		0.157	0.166	0.703	Prob.
All	4.983	13.171	4.166	4.767	21.955	1.036	χ^2 statistics
	0.083	0.001	0.125	0.312	0.000	0.904	Prob.
	Egypt			**Morocco**			
	LCO2Y	LY	OPEN	LCO2Y	LY	OPEN	
LCO2Y		11.079	0.655		0.008	2.347	χ^2 statistics
		0.001	0.418		0.927	0.126	Prob.
LY	7.106		0.515	6.666		0.888	χ^2 statistics
	0.008		0.473	0.010		0.346	Prob.
OPEN	1.941	13.130		0.002	15.608		χ^2 statistics
	0.164	0.000		0.963	0.000		Prob.
All	9.361	24.048	1.062	6.927	18.261	6.665	χ^2 statistics
	0.009	0.000	0.588	0.031	0.000	0.036	Prob.

As mentioned above, there are not a cointegrating equation in cases of Egypt and Morocco. So, the VAR are used in these cases, Table 9. Using Pairwise Granger causality test, Table 8, the results show that *(1)* open and GDP can jointly influence at 5% dependent variable (CO2 emissions per capita) in cases of Egypt and Morocco; *(2)* open cannot individually influence CO2 emissions per capita; *(3)* open and CO2 emissions can jointly influence real GDP per capita in case of Egypt; and *(4)* real GDP per capita and CO2 emissions per capita cannot jointly influence trade.

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Table 9. Vector Autoregression estimates

	Egypt			Morocco		
	Dependent variable:					
	LCO2Y	LY	OPEN	LCO2Y	LY	OPEN
LCO2Y (-1)	0.458*	0.208*	-19.707	0.521*	-0.010	25.942
	[2.433]	[3.329]	[-0.810]	[3.469]	[-0.091]	[1.532]
LY (-1)	0.532*	0.769*	18.514	0.394*	0.683*	16.213
	[2.666]	[11.612]	[0.717]	[2.582]	[5.861]	[0.942]
OPEN (-1)	0.001	0.001*	0.696*	0.000	0.004*	0.332*
	[1.393]	[3.623]	[5.621]	[0.047]	[3.951]	[2.036]
C	-3.830*	1.849*	-279.564	-3.342*	1.819*	-30.573
	[-1.946]	[2.828]	[-1.098]	[-2.996]	[2.133]	[-0.243]
U	0.009	-0.009	4.116	0.010*	0.006	-0.990
	[0.364]	[-1.103]	[1.277]	[1.812]	[1.310]	[-1.582]
R-squared	0.979	0.997	0.648	0.984	0.979	0.782
F-statistic	399.057	3455.304	16.115	528.106	413.608	31.474
Prob (F-statistic)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: t-statistics in [ ]. * Significant at 5% level.** Significant at 10% level.

In both cases, the estimated coefficients of real GEP per capita in the preceding term can increases CO2 emissions per capita. However, the estimated coefficients of the trade are not significant in the equation of LCO2.

In the last step of this study, we use the variance decompositions (VDCs) and the impulse response functions because Granger causality test is strictly limited to within-sample tests and does not show the relative magnitude of these variables. So, the variance decomposition method measures the percentage of the forecast error variance of a variable that occurs as the result of a stock from each of the variables into contributions arising from its own and the other variance of the variables. Table 10 summarizes the results of variance decomposition for MATE over a 20-year period.

In Algeria's case, the forecast error of LCO2Y is considerably explained by its own innovation by about 87% at the end of 20 years. The real GDP per capita (LY) has a weaker influence on CO2 emissions per capita (LCO2Y) after 20 years from the shocks. The variance of OPEN increases rapidly after 3th year to 18th year approximately accounted for 12% to the total variance. In the short period, the free trade measured by open can considerably effect CO2 emissions per capita. This result coincides with the analysis of the coefficients of VECM, **Table 7**.

In Tunisia's case, the variance of OPEN increases rapidly after 6th year. At the same time, GDPs share increase slowly. At the end of 20 years, the forecast error variance for CO2 emissions per capita explained by its own innovations is 22.83%, by GDP is 5.69% and by open is 71.49%. This result coincides with the analysis of the coefficients of VECM, **Table 7**.

In Egypt's case, the variance of OPEN increases rapidly after 3th year. At the same time, GDPs share increase slowly as in the case of Tunisia. At the end of 20 years, the forecast error variance for CO2 emissions per capita is considerably explained by open by more than 45% and feebly explained by GDP (8.79%). In these three countries, OPEN considerably effects CO2 emission in the long-run. Furthermore, in the long-run, trade absolutely influences CO2 emission.

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In Morocco's case, the variance of real GDP per capita and trade increase rapidly after 3th year. At the end of 20 years, the forecast error variance for CO2 emissions per capita is considerably explained by its own innovations by 61.56% and inconsiderably explained by GDP and open by 17.79% and 20.67% respectively.

Table 10. The results of variance decomposition for MATE of LCO2Y over a 20-year period

	Algeria				Tunisia			
Period	**S.E.**	**LCO2Y**	**LY**	**OPEN**	**S.E.**	**LCO2Y**	**LY**	**OPEN**
1	0.134	100.00	0.000	0.000	0.048	100.00	0.000	0.000
2	0.149	90.002	0.511	9.487	0.055	98.665	1.051	0.284
3	**0.154**	**88.007**	**0.482**	**11.510**	0.060	97.783	1.400	0.817
4	0.157	87.509	0.468	12.023	0.061	96.085	1.466	2.449
5	0.158	87.342	0.471	12.188	**0.064**	**92.132**	**1.377**	**6.491**
6	0.159	87.253	0.484	12.263	0.067	86.004	1.575	12.420
7	0.159	87.218	0.510	12.271	0.070	79.480	1.811	18.710
8	0.160	87.201	0.543	12.255	0.073	71.707	2.217	26.076
9	0.160	87.189	0.582	12.230	0.078	63.912	2.627	33.461
10	0.160	87.175	0.623	12.201	0.083	56.592	3.078	40.330
11	0.161	87.160	0.668	12.172	0.088	50.132	3.500	46.368
12	0.161	87.143	0.714	12.143	0.094	44.558	3.891	51.551
13	0.161	87.125	0.761	12.114	0.099	39.851	4.237	55.912
14	0.161	87.106	0.808	12.086	0.105	35.916	4.542	59.542
15	0.162	87.086	0.856	12.058	0.112	32.644	4.807	62.549
16	0.162	87.066	0.904	12.030	0.118	29.924	5.036	65.040
17	0.162	87.045	0.952	12.003	0.124	27.659	5.234	67.107
18	**0.162**	**87.024**	**1.000**	**11.976**	0.130	25.765	5.405	68.830
19	0.162	87.004	1.047	11.949	0.136	24.173	5.554	70.273
20	0.163	86.983	1.095	11.922	0.142	22.827	5.684	71.490
	Egypt				**Morocco**			
Period	**S.E.**	**LCO2Y**	**LY**	**OPEN**	**S.E.**	**LCO2Y**	**LY**	**OPEN**
1	0.060	100.00	0.000	0.000	0.046	100.00	0.000	0.000
2	0.070	96.201	1.637	2.162	0.056	94.491	5.506	0.003
3	**0.077**	**90.108**	**3.463**	**6.429**	**0.062**	**87.984**	**10.026**	**1.989**
4	0.084	83.586	4.888	11.526	0.067	81.932	12.517	5.550
5	0.090	77.545	5.902	16.553	0.071	77.292	13.869	8.839
6	0.096	72.294	6.612	21.093	0.075	73.932	14.712	11.356
7	0.102	67.857	7.116	25.027	0.079	71.459	15.313	13.229
8	0.107	64.145	7.482	28.372	0.082	69.570	15.775	14.655
9	0.112	61.045	7.755	31.199	0.084	68.080	16.144	15.776
10	0.117	58.447	7.964	33.588	0.086	66.876	16.443	16.681
11	0.121	56.258	8.129	35.614	0.089	65.885	16.690	17.425
12	0.125	54.400	8.260	37.340	0.090	65.059	16.896	18.045
13	0.129	52.812	8.368	38.820	0.092	64.363	17.070	18.568
14	0.132	51.444	8.458	40.098	0.093	63.770	17.217	19.013
15	0.136	50.259	8.534	41.207	0.095	63.262	17.344	19.394
16	0.139	49.224	8.599	42.177	0.096	62.823	17.453	19.724
17	0.141	48.315	8.655	43.029	0.097	62.442	17.548	20.010
18	0.144	47.513	8.705	43.782	0.098	62.109	17.631	20.260
19	0.146	46.800	8.748	44.452	0.099	61.817	17.704	20.479
20	0.149	46.164	8.787	45.049	0.100	61.560	17.768	20.672

Using the Cholesky impulse functions response, Figure 5 shows how much LCO2Y would change in response to one standard deviation of innovation to LY and OPEN in each

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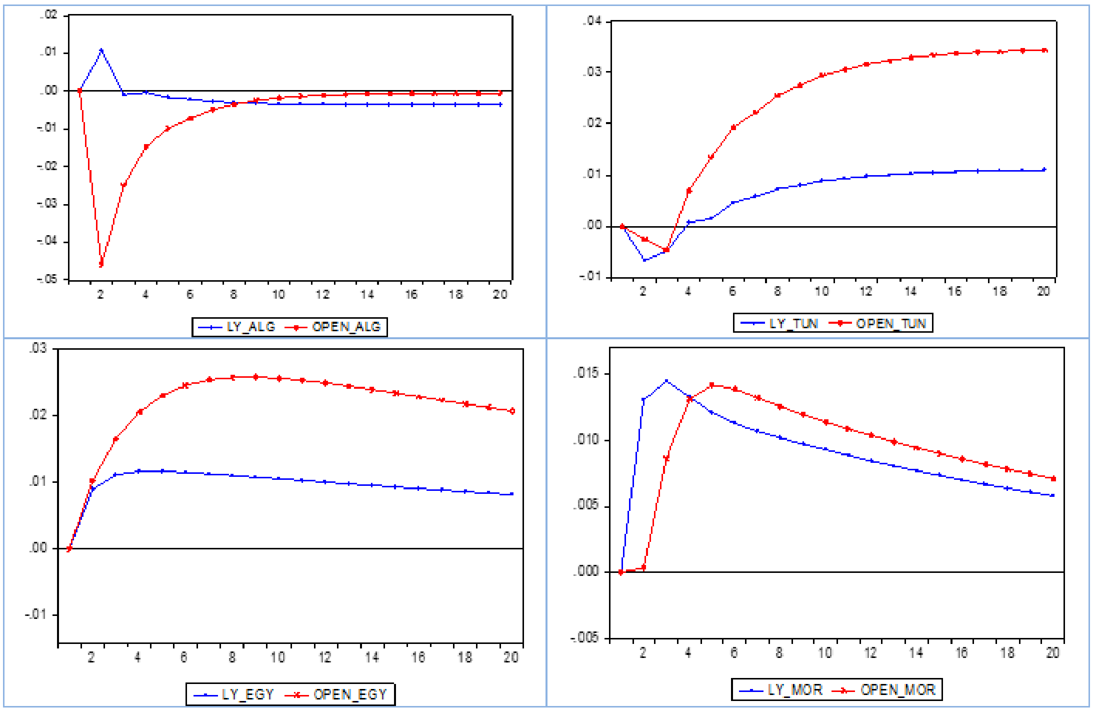
country. In Algeria's case, the response of innovation of LCO2Y to LY increases until period 2. After then, it drops and it is negative in the long-run. In the short-run, LCO2Y and OPEN have a negative relationship. Nevertheless, the response of LCO2Y to real GDP per capita and open are very closely. These results correspond to the previous results. In Tunisia's case, LCO2Y to LY and LCO2Y to OPEN have a very similar pattern. These three variables have negative relationships and there would be a positive response after period 3. This is also in line with the previous results.

Both cases Egypt and Morocco, LCO2Y to LY and LCO2Y to OPEN have positive relationships after period 2. However, these patterns will be decrease after period 4 in case of Morocco. All variables have a long-run relationship.

Figure 5. Response to Cholesky One S.D. Innovations



5. Concluding remarks

Free trade is an important component of growth for developed and developing countries. But, preserving, saving and improving the environmental quality is also an important objective to realize for all countries especially for the countries of Africa. These countries are more sensible to the global environmental changes. Currently, the primordial question is: Can the capitalism become green?

This study tried to analyze the nature of the relationship between free trade, growth and environmental quality. The main findings are that this relationship is complex and ambiguous. MATE showed very different EKC patterns and a dynamic relationship is unclear. Each country must apply adequate measures to reduce environmental damage under conditions it is important to benefit experiences of the other countries especially the developed countries

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Despite there are some limitation in this study, most notable is the use of only the annual time series data on individual countries especially of the CO2 emissions per capita. It will be important if we use other indicators of the environmental damage. The methods used throughout this study (the OLS method, VECM, variance decomposition and impulse response functions) are given very different results between MATE. Thus, reducing CO2 emissions is not a straightforward solution linked with only increasing the income or improving trade because if the older pollutants are cleaned up, the new ones will emerge; thereby the environmental quality will not be reduced.

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