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The Long-Run Relationship between Transport Energy Consumption and Transport Infrastructure on Economic Growth in MENA Countries

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Abstract: This paper investigates the impact of transport energy consumption and transport infrastructure on economic growth by utilizing panel data on MENA countries (the Middle East and North Africa region) for the period of 2000-2016. The MENA region panel is divided into three sub-groups of countries: GCC panel (containing the Gulf Cooperation Council countries), N-GCC panel (containing countries that are not members of the Gulf Cooperation Council), and North African countries (called MATE — Morocco, Algeria, Tunisia and Egypt). Using the Generalized Method of Moments (GMM), we find that transport energy consumption significantly adds to economic growth in MENA, N-GCC and MATE regions. Transport infrastructure positively contribute to economic growth in all regions. The Dumitrescu-Hurlin panel causality analysis shows the feedback effect of transport energy consumption and transport infrastructure with economic growth. The empirical results add a new dimension to the importance of investing in modern infrastructure that facilitates the use of more energy-efficient modes and alternative technologies that positively affect the economy with minimizing negative externalities.

Keywords: Transport, Energy Consumption, Infrastructure, Economic Growth, GMM, MENA Countries

1. Introduction

The transport-economic growth nexus is among the most important issues addressed in the recent economics literature. The majority of empirical studies demonstrate the positive impact of transport infrastructure on economic growth and unveil that transport plays a vital role in economic activity either directly or as a complement to other factors of production. Pradhan and Bagchi (2013), Marazzo et al. (2010), Chi and Baek (2013) argue that transport affects economic activity positively and accelerates the development of nations. They also find that private firms decide to agglomerate/disperse based on the interaction between increasing returns to scale and transport costs that affect regional economic growth. Ades and Glaeser (1999) and Hausmann (2001), among others, show the important role of international transport infrastructure (seaports, railroads, airways) in increasing trade openness and accelerating the economic development of countries. They also note that landlocked countries have less access to the global market, which significantly decelerates their economic growth.

Many other studies investigate the long-run relationship among transport, energy consumption, and economic growth and expose the negative externalities of transport by focusing in particular on pollutant emissions (Liddle 2009, Mraihi et al. 2013, Gao et al. 2015, Achour and Belloumi 2016, Llorca and Jamasb 2017). They note that despite the critical role of transport as one of the main economic sectors, it is also one of the major energy-consuming and pollutant emission sectors. According to the International Energy Agency (2012), transport energy consumption represents 27% of global energy demand and accounts for 22% of total carbon emissions. IEA (2013) foresees an increase of 50% in world transport energy consumption and carbon emissions by 2030. For developing and transition countries, which seek to modernize their economies, there are major challenges related to the environmental impact of transport. Similarly, numerous research studies investigate the strong relationship between transport infrastructure and economic growth. For example, Yeaple and Golub (2007), Anam et al. (2016), Brida et al. (2016), Ibrahiem (2017), Maparu and Mazumder (2017) note that transport infrastructure affects economic growth by boosting economic activity in developing and developed countries. In fact, transport infrastructure motivates firms and people to install in the periphery, which increases the urbanization and spatial distribution of households and activities. Moreover, developed transport systems contribute to attracting international investors and support the economic development of host countries (Erenberg 1993, Fernal 1999). In the same line of thinking, Saidi (2016) notes that transport infrastructure contributes to economic growth by improving the attractiveness of a territory to foreign direct investments in MENA countries.

The International Energy Agency (IEA 2012) says that transport consumes 27% of global fossil energy and accounts for 22% of total carbon dioxide emissions. The IEA (2012) also notes that road transport energy consumption rose from 0.7 billion tons of oil equivalent in 1976 to 1.8 billion tons in 2010. During the same period, the global energy consumption and economic growth grew by 1.7% and 3.2%, respectively. In 2012, the IEA argued that the road share of transport energy consumption in China and India grew from 39.6% and 42% to 77.3% and 88%, respectively. Both countries doubled their share, while in South Africa, road transport energy consumption increased from 66.7% to 90.8% of total transport energy consumption. For rail transport, the same source indicates that the share of rail transport in total transport energy usage decreased in three countries during that period. In China, the share grew from 42.3% to 6.9%, in India from 55% to 6.7%, and in South Africa from 31.4% to 2.6%. In that vein, road transport accounts for the highest percentage of transport energy in G7 countries, with 94.7% of total transport energy in Germany, 93.8% in France, and 92.7% in Italy and the United Kingdom. BP (2017) notes that MENA countries are home to more than half the world's crude oil reserves and more than a third of its natural gas. Their production reached more than 20 million barrels a day in 2014, and their per capita energy consumption is forecast to overtake North America by 2035. MENA countries have an increasing consumption of natural gas (+3.5%), oil (+0.9%), nuclear energy (+75.3%) and renewable energy (+42%) and decreasing hydroelectric (-20.5%) and coal (-9.5%) consumption. The World Energy Council (2011) indicates that Middle East countries consume about 0.939 million barrels of gasoline per day and about 1.082 million barrels of diesel per day. This consumption is expected to triple by 2050. Similarly, fossil energy consumption displays the same trend for the North African countries, where transport accounts for the highest consumption. For example, in Egypt, total transport energy consumption increased 4.8% annually for the1981-2013 period. Gasoline and diesel fuel have the largest average annual growth rates, at 5% and 5.2% (ESCWA 2014)[1]. In Tunisia, transport accounted for about 26.9% of total energy consumption and about 30% of total carbon emissions in 2010; in particular, road transport consumed around 70% of total transport energy consumption (IEA 2012).

The linkages between transport and economic growth and, between transport and energy consumption have been examined in the existing literature (Beyzatlar et al. 2014, Gao et al. 2015, Achour and Belloumi 2016, Lee and Yoo 2016, Dale et al. 2017, Zhao, 2017). The majority of these studies have focused on various countries and used a variety of empirical

[1]Economic and Social Commission for Western Asia

techniques for different data periods. Additionally, studies have used different proxy variables to estimate the relationship among transport, energy consumption and economic growth. Their empirical findings are ambiguous and diverse across countries and periods. However, none of the previous studies has explored the relationship among transport energy consumption, transport infrastructure and their impact on economic growth. Therefore, we are strongly motivated to explore the economic impact of transport infrastructure and transport energy consumption for the MENA region. This attempt enables us to investigate whether increasing transport infrastructure stimulates economic growth and energy consumption or economic growth and energy demand act as a stimulus for any consequent growth in transport infrastructure since research in the economics of transport has received little attention in the existing literature. The existing studies in literature examined the effect of transport infrastructure on economic growth (e.g., Achour and Belloumi 2016, Zhao 2017) or transport energy consumption on economic growth but in return (e.g. Beyzatlar et al. 2014, Shahbaz et al. 2015a), economic growth may also affect to transport infrastructure or transport energy consumption. This causes and effects i.e. the direction of causal relationship between the variables also helps policy makers in making policy implications and effective decision-making to develop better transport systems and thus sustainable development based on causal empirical results. Furthermore, we consider the specific impact of transport infrastructure and transport energy consumption in production function to help environmentalists and economists to simultaneously boost transport infrastructure not only to improve environmental quality but also to speedup long-run economic development, contributing to sustainability. The contribution of this study to the existing literature is summarized in four principal points: (i) This study is a pioneering effort in the MENA region to investigate the associations among transport energy consumption, transport infrastructure and economic growth. (ii) The MENA region is divided into three sub-panels: Gulf Cooperation Council countries (GCC), non-members of Gulf Cooperation Council countries (N-GCC) and North Africa, which is also termed the MATE panel. The MATE is formed by Morocco, Algeria, Tunisia, and Egypt. This distinction makes the panel data analysis more homogeneous and helps us to investigate the issue comprehensively. (iii) The Generalized Method of Moments is applied for the dynamic panel data model following the GCC, N-GCC and MATE panels. (iv) The Dumitrescu-Hurlin panel causality test is applied to examine the causal association among the variables. The empirical findings reveal that transport energy consumption contributes to economic growth slightly in the GCC region. Transport infrastructure and capital add to economic growth. In the N-GCC and MATE panels, transport infrastructure, transport energy consumption and capital are determining factors of economic growth. The Dumitrescu-Hurlin panel causality indicates the presence of a bidirectional causal relationship between transport energy consumption and economic growth in all regions.

The rest of paper is organized as following: Section-2 reviews related studies. Section-3 describes the empirical model and data collection. The empirical results are discussed in Section-4. Finally, the conclusion and main policy implications are drawn in Section-5.

2. Literature Review

2.1. Transport, Energy Consumption and Economic Growth Nexus

Various research studies try to investigate the relationship between transport and energy consumption and, between transport and economic growth. Almost all of them demonstrate the existence of a positive long-run relationship between the variables. Such studies include Kazim (2007) for the United Arab Emirates, Ceylan et al. (2008) and Ozturk and Acaravci (2013) for Turkey, Farhani and Ben Rejeb (2012) for the MENA region, Al-Ghandoor et al. (2012) for Jordan, Omri (2013) for 14 MENA countries, Salahuddin and Gow (2014) for Gulf Cooperation Council countries, Ben Jebli and Ben Youssef (2015) for Tunisia, Magazzino (2016a) for 10 Middle East countries, Magazzino (2016b) for Gulf Cooperation Council countries, and Ibrahiem (2017) for Egypt.

Akkemik and Göksal (2012), Achour and Belloumi (2016), Anam et al. (2016), Pablo-Romero and De Jesús (2016), and Tsekeris (2017) examine the interrelationship among economic growth, transport and energy consumption. In the majority of these works, economists are interested in the direction of long run causality between these variables. Meanwhile, other academicians expose the specific relationship between energy demand in the transport sector and relative economic development (Liddle and Lung 2013, Azlina et al. 2014). They attempt to explain the impact of transport energy consumption on economic activity. For example, Samimi (1995) employed an energy demand function for the Australian transport sector using quarterly data from 1980_{Q1} to 1993_{Q2} by applying VECM Granger causality approach. The empirical results show that transport energy and economic growth have feedback effects. The unidirectional causality from transport energy consumption to energy prices is also noted. Later on, for the United States, Liddle (2009) examined the causal relationship among mobility demand, income, gasoline prices, and vehicle ownership by applying VECM Granger causality approach. The empirical results show that mobility demand has a long-run systemic causal relationship with income, gasoline price, and vehicle ownership. Using a multivariate cointegrating vector autoregressive model, Pradhan (2010) examined the relationship among transport, energy consumption and economic growth for the Indian economy over the 1970-2007 period by employing Johansen cointegration and VECM Granger causality test. The empirical results indicate that transport increases energy consumption, which leads to economic growth. The relationship between transport energy consumption and economic growth via the emissions function is also investigated by many studies in the empirical energy literature, and studies report adverse impacts of transport energy consumption on environmental quality. For example, Clean Air Asia (2012) notes that in Asia, more than a billion tons of carbon emissions per year are emitted by road transport. Similarly, the carbon intensity of road transport has been estimated to have increased by up to 4.8% annually since 2002. In China and India, road transport emits around 52% and 21% of total carbon emissions, respectively. Concerning the transport energy consumption, UNCTAD (2015) indicates that in 2012, transport consumed nearly 64% of petroleum in the world, which increased total energy consumption by 82% over the 2008-2035 period. Additionally, commercial transportation increased global energy demand by 70% in the 2010-2040 period.

Liddle and Lung (2013) investigated the long-run relationship between per capita transport energy consumption and per capita gross domestic product for 107 countries over the 1971-2009 period by applying heterogeneous panel causality test. They find that transport energy consumption causes per capita gross domestic product, and as a result, per capita gross domestic product causes transport energy consumption. Saboori et al. (2014) examined the long-run relationship between economic growth, transport energy use and carbon emissions for 27 OECD countries by applying the FMOLS cointegration and bidirectional approaches. Their empirical evidence shows the existence of a positive and significant long run bidirectional causal relationship among economic growth, transport energy consumption, and transport carbon emissions. Azlina et al. (2014) used time-series data over the 1975-2011 period to investigate the dynamic linkages among economic growth, energy consumption and carbon emissions in Malaysia by applying Johansen cointegration and VECM Granger causality approaches. Their empirical results indicate that economic growth significantly affects transport energy consumption and renewable energy use. Botzoris et al. (2015) investigated the coupling/decoupling relationship between economic growth and transport energy consumption as well as economic growth and transport-related CO_2 emissions for the EU-28 over the 1995-2012 period. They divided the time period into two periods: a growth period, from 1955 to 2008, and a recession period, between 2008 and 2012. Their empirical findings confirm the existence of the coupling phenomenon for the first period and the decoupling phenomenon for the second period for most of these countries. Xu and Lin (2015) scrutinized the relationship between China's transport sector and its environmental degradation. They used provincial panel data over the 2000-2012 period by applying non-parametric additive regression models. The panel unit root and panel cointegration approach have also applied in order to examine unit root properties and long run relationship between the variables. Their results show the nonlinear effect of economic growth on carbon emissions. They find that energy efficiency, urbanization and private vehicles exhibit an inverted "U-shaped" relationship with carbon emissions. Shahbaz et al. (2015a) reexamined the causal linkage among road transport energy consumption, fuel prices, transport sector value added and CO_2 emissions for the period of 1980-2012 in Tunis. They applied traditional as well as structural break unit root tests to test the stationarity properties of the variables. The cointegration amid the variables is examined by applying the Byer-Hanck combined cointegration approach and ARDL bounds testing to verify the robustness of cointegration. Their empirical findings validate the EKC between transport value-added and economic growth in Tunisia and show that the feedback effect also exists between transport value-added and economic growth.

Similarly, Achour and Belloumi (2016) investigated the linkages among transport infrastructure, transport value added, gross domestic product, carbon dioxide emissions and transport energy demand. They applied the Johansen multivariate cointegration approach, a generalized impulse response function and a variance decomposition technique to examine the relationship for Tunisia over the 1971-2012 period. Their empirical findings indicate that transport energy consumption is positively affected by economic growth but not vice versa. Saidi and Hammami (2017a) expose the causal linkages among transport, economic growth and CO_2 emissions in 75 countries. By applying the GMM estimators, they confirm the existence of a bidirectional causal relationship between transport and economic growth for the 75 countries. Saidi et al. (2017) investigated energy demand function by incorporating economic growth, transport and foreign direct investment using data of 68 developed and developing economies. They applied the Generalised Method of Moments (GMM) and reported the positive effect of transportation on energy demand. Economic growth and foreign direct investment contribute to energy consumption. Naves et al. (2017) applied the bounds testing approach to examine long run and short run relationship between transport energy consumption and economic growth using data of OECD countries for the period of 1995-2014. They found that transportation energy consumption is negatively linked with economic growth. Ibrahiem (2017) investigates the relationship among road energy consumption, economic growth, urbanization and population for Egypt over the 1890-2011 period. Using the Johansen cointegration approach, the author indicates that all variables are cointegrated. Additionally, to determine the causality direction, the author applies Granger causality tests. The results indicate that in the long run, transport energy consumption positively and significantly affects economic growth and urbanization. In the short run, transport energy consumption affects economic growth, and a feedback effect is also detected.

2.2. Transport Infrastructure and Economic Growth Nexus

The impact of transport and communication infrastructure on economic growth is a topic that has attracted considerable attention from researchers, academicians and practitioners in the existing economic literature (Zhou et al. 2002, Esfahani and Ramirez 2003, Pradhan and Bagchi 2013, Kim et al. 2017, Jin and Rafferty 2017). For example, Fernald (1999) affirmed that there is a strong link between investment in transport infrastructure and economic productivity. With data for 29 US industries, the empirical evidence shows that the decline in productivity registered in the United States after 1973 was more important in high-intensity vehicle industries. The results also confirm that these industries benefited disproportionately from investments in road networks. In OECD countries, Roller and Waverman (2001) tested the impact of telecommunications infrastructure on economic growth by applying a micromodel for telecommunication investment with a macro-production function. Their empirical analysis confirmed the presence of a positive causal relationship between telecommunication infrastructure and economic development, i.e., a feedback effect. For countries in Latin America (Guatemala, Honduras, Nicaragua), Escribano and Guasch (2005) indicated that access to the internet increases the productivity of workers from 11% to 15%. Yeaple and Golub (2007) examined the impact of three types of infrastructure (roads, telecommunications, and electricity) on total factor productivity for 18 countries and 10 manufacturing industries over the period of 1979-1997 period. They apply the three-stage least squares (3SLS) estimation strategy and show that roads have the most important impact on productivity in different industries. These results help explain patterns of comparative advantage and international specialization. In addition, Mu and Van de Wall (2007) showed that the extension of rural road networks in Vietnam increases job opportunities by 11% for unskilled workers.

Similarly, Marazzo et al. (2010) and Chi and Baek (2013) argue that transport infrastructure strongly stimulates the economy in the long run, especially in developing countries. In Bangladesh, Khandker and Koolwal (2011) applied the Generalised Method of Moments (GMM) and reported that the construction of rural roads in various villages of Bangladesh increased the schooling of boys and girls by 20% and 14%, respectively. Chakraborty and Nandi (2011) examined the relationship between telecommunication infrastructure and economic growth using data for 93 developing countries by applying Granger causality approach. They noted that the effect of such infrastructure on economic growth depends on the country's development level. They further reported that investment in telecommunication infrastructure are more important in less-developed and emerging countries. Pradhan and Bagchi (2013) applied the vector error correction model (VECM) to investigate the impact of road and rail infrastructure on the development of the Indian economy. They found that a bidirectional relationship exists between road transportation and economic growth. The feedback effect was also found between road transportation and capital formation. The unidirectional causality was found to run from rail transportation to economic growth and from rail transportation to gross capital formation. They concluded that investment in transport infrastructure leads to sustainable growth in the long run for India.

Moreover, Pradhan et al. (2016) examine the relationship among telecommunication infrastructure, capital stock, and economic growth in G-20 countries for the 1961-2012 period by dividing the panel into two sub-groups: developed and developing countries. To examine the long-run equilibrium relationship, the authors use the Johansen and Juselius test for individual countries and the Fisher test for the panel level. The results demonstrate the cointegration of the three variables for G-20 as a whole as well as for all individual countries. The Granger causality test shows the positive and significant impact of telecommunication infrastructure and gross capital formation on economic growth for all individual countries. The same impact is found for the global panel and for the two sub-groups. Brida et al. (2016a) investigated the long-run relationship between air transport and economic growth in Mexico for the 1995-2013 period. They applied non-parametric cointegration and non-parametric causality tests after transforming annual data into quarter frequency. Their empirical evidence indicates the presence of a cointegration relationship between air transport and economic growth. The causality analysis reveals the presence of a bidirectional causal relationship between transport and economic growth. Jouili and Allouche (2016) investigated the impact of investment on seaports infrastructure on Tunisian economy from 1982 to 2011. They employed the Cobb-Douglass production function by considering seaports capital stock as an additional production factor along with capital and labor. They empirically confirm the positive impact of investment in seaports on economic growth. Additionally, their empirical evidence reveals that seaports infrastructure investment seem to be even more beneficial to the services sector than the manufacturing sector. Similarly, Brida et al. (2016b) used Italian time series data for the period of 1970-2012 to examine causal relationship between air transport and economic growth by applying Johansen cointegration Granger causality approaches. Their empirical analysis validated the presence of cointegration between the variables and air-transport causes economic growth.

The empirical findings are ambiguous (as reported in Table-1A) which could not help policy makers in designing a comprehensive economic policy for using transportation energy and transport infrastructure as economic tool to promoting economic growth in long run. These empirical findings are inconclusive due to application of various econometric approaches (are not free from criticism) on various data sets in different regions of the globe. This study fills the existing gap in literature by investigating effect of transport energy consumption, transport infrastructure and capitalization on economic growth for MENA region.

3. Model development and data

3.1. Model development

This study contributes to the existing energy economics literature by examining the relationships among transport energy consumption, transport infrastructure and economic growth in MENA countries. We use the Cobb-Douglas production function and reveal that domestic production depends on capital stock and labor force. We augment the Cobb-Douglas production function by adding transport infrastructure and transport energy consumption as additional factors affecting economic growth. For example, Ang (2007), Sharma (2010), Azlina and Nik-Mustapha (2012), Magazzino (2014) and Shahbaz et al. (2015b) report that transport infrastructure and transport energy consumption play a vital role in boosting economic activity, which affects domestic production and economic growth, as well. The general form of the production function is modeled as follows:

$$Y = AK^{\alpha}E^{\lambda}L^{\beta}e^{\mu} \qquad (1)$$

where Y is real income, E denotes energy use, K is capital, and L denotes labor force. The term A refers to technology, and *e* is the error term. α, λ, and β are the production elasticities with respect to domestic capital, energy consumption, and labor force, respectively. Although our study focuses on transport energy consumption and transport infrastructure effects on economic growth, capital is a supporting variable as it plays an important role in building transportation infrastructure. After restricting the Cobb-Douglas technology to $\alpha + \lambda + \beta = 1$, we obtain constant returns to scale. Following Liddle and Tang (2013), Azlina et al. (2014), and Achour and Belloumi (2016), we consider energy consumed the by road transport sector. Substituting E in equation-1 with RTEC gives equation-2:

$$Y = AK^{\alpha}RTEC^{\lambda}L^{\beta}e^{\mu} \quad (2)$$

where RTEC is road transport energy consumption. Several studies have already explained that technological progress is characterized as exogenous by Solow (1957). For instance, Barro (1991), Grossman and Helpman (1991), Barro and Sala-i-Martin (1992) and others affirm that public infrastructure (roads, railways, ports, airports, hydroelectric dams, power stations, telecommunications, etc.) have an important role in increasing economic growth in the long-run via economic activity. We extend the production function by assuming that technological progress can be influenced by public infrastructure, which is presented as transport infrastructure. This leads us to specify *A* as follows:

$$A_t = \theta TIN_t^{\delta} \quad (3)$$

where TIN stands for transport infrastructures, and θ is a time-invariant constant. Substituting equation-3 into equation-2, we find

$$Y = \theta TIN_t^{\delta}K^{\alpha}RTEC^{\lambda}L^{1-\alpha}e^{\mu} \quad (4)$$

We divide both sides of equation-4 by labor to transform the variables into labor per capita and leave the impact of labor constant. By taking the natural-log of equation-4, we model the empirical equation as follows:

$$lnY_{it} = \beta_0 + \beta_{1i}lnTIN_{it} + \beta_{2i}lnRTEC_{it} + \beta_{3i}lnK_{it} + \varepsilon_{it} \quad (5)$$

where ln is a natural-log, Y is real GDP per capita, TIN is transport infrastructure per capita, RTEC is road transport-related energy consumption per capita, K is capital use per capita, and ε is the classical error term. The subscript i = 1, ….., N denotes the country, and t = 1, ……, T denotes the time period. β_{ki} represents the estimated coefficients of all independent variables, where k = 1,…3. Table-1 summarizes all variables to be used in the study.

Table-1. Variable Description

Variables	Description	Measurements	Source
Y	Gross domestic product per capita	constant 2010US$	WDI (2017)*
RTEC	Road transport-related energy use	Kg of oil equivalent	WDI (2017)**
TIN	Road transport infrastructures	Kilometers of roads	WDI (2017)**
K	Capital stock	Constant 2010US$	WDI (2017)*

Note: *http://data.worldbank.org/indicator. **http://www.econstats.com

3.2. Data

This study aims to investigate the relationship among economic aggregates (economic growth, transport energy consumption, and transport infrastructure) in MENA countries for the 2000-2016 period. The yearly data for the panel of 14 countries from the Middle East and North Africa are used for empirical purposes. These countries in the panels are (1) Gulf Cooperation Council countries, consisting of 6 countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates); (2) Non-Gulf Cooperation Council countries, consisting of 4 countries (Iran, Jordan, Lebanon, and Turkey); and (3) MATE countries, consisting of four countries in North Africa (Egypt, Algeria, Morocco, and Tunisia).

This sample was selected for three main reasons. (i) The empirical investigation of the relationship between transport, energy and growth in the MENA region are relatively scarce. (ii) The MENA countries are among the largest producers of energy and have some of the largest energy reserves in the entire world. (iii) Transport and energy consumption are the most significant sources of pollution, and the MENA region needs to industrialize and modernize their economies to address the challenges of sustainable development. The MENA region is the second most polluted region and the highest CO_2 emissions producer per dollar of output. According to descriptive statistics of the mean, median and 10% trim, we find that all variables have a normal distribution, as confirmed by Jarque-Bera statistics. The skewness coefficients indicate that the distribution is skewed to the left, and interquartile range statistics prove the absence of outliers in our sample (Table-2A).

The pair-wise correlation analysis reports the existence of a positive correlation between road transport-related energy consumption and economic growth (Table-3A). Transport energy consumption and transport infrastructure are positively and significantly correlated. The empirical results reveal that economic growth is positively and significantly correlated with transport infrastructure. Capital is positively and significantly with economic growth, transport infrastructure, and transport energy consumption.

3.3 Generalized Method of Moments (GMM)

To examine the effect of transport energy consumption and transport infrastructure on economic growth in the MENA region, we apply a dynamic panel specification. In existing energy literature, researchers applied cointegration and causality tests to examine the stability of structural parameters by using a single equation model. Similarly, the use of ordinary least square (OLS) regressions not only provides biased and inconsistent estimates due to the ignorance of instrumental variables but also violates classical linear regression model (CLRM) assumptions. In such circumstances, the application of such approach by considering the role of instrumental variables may provide consistent and reliable empirical estimates. The linear dynamic panel model presented by equation-6 contains a lagged dependent variable ($\ln Y_{i,\,t-1}$), which is correlated with the error term. This correlation makes the panel ordinary least squares (OLS) estimator, either with fixed or random effects, inadequate to detect the required parameters. In order to solve this issue, we apply the Generalized Method of Moments estimator to take into account the lagged levels of economic growth in production function. Arellano and Bond (1991) developed a Generalized Method of Moments (GMM) estimator that gives consistent parameter estimates.

Additionally, the GMM estimation with panel data proves advantageous to the OLS approach in a number of ways. First, the pooled cross-sectional and time-series data allow us to estimate the relationship over a long period of time for several countries. The GMM is a simple estimator compare to maximum likelihood estimator. Second, any country-specific effect can be controlled using an appropriate GMM procedure. The GMM estimator provides robust empirical results without having information for accurate distribution of error term. Third, to ensure the quality of the estimation, we must use the approach introduced by Arellano and Bond (1991), which can solve the problem by first differentiation. Last but not least, GMM provides unbiased and reliable estimator without the use of matrix weights. We propose the model under the following form:

$$lnY_{i,t} = \beta_0 lnY_{i,t-1} + \lambda lnTIN_{i,t} + \text{Ʈ} lnRTEC_{i,t} + \phi X'_{i,t} + \mu_{i,t} + \varepsilon_{i,t} (6)$$

where $\ln Y_{i,t}$ stands for economic growth of country i at time t, β_0 is the parameter to be estimated, X' is a vector of core explanatory variables used to model economic growth (capital stock), μ is the country-specific effects, and ε is the error term. Finally, λ captures the effect of transport infrastructure, and Ʈ captures the effect of transport energy consumption on economic growth.

Before running regressions, we test the over-identifying restrictions using a Sargan test in order to provide evidence of the instrument's validity. A rejection of the null hypothesis indicates that the model or instruments may be mis-specified. The acceptance of the null hypothesis shows that instruments are appropriate and can be implemented. We also use Arellano and Bond's (1991) test (AR (2)) of second-order autocorrelation in the first-differenced errors. By construction, the first-differenced errors are auto-correlated when the regression errors are independent and identically distributed. The statistics of AR(2) test show no evidence of autocorrelation at conventional levels of significance. These results indicate that the dynamic panel model is a good specification for the impact of transport energy consumption and transport infrastructure on the economic growth of MENA countries.

3.4 Dumitrescu-Hurlin Panel Causality Test

We use the Dumitrescu and Hurlin (2012) test to examine causality between the variables used in the econometric investigation. This test, a simplified version of Granger's (1969) non-causality test, is preferred because it takes into account the two dimensions of heterogeneity: the heterogeneity of the regression model used to test the Granger causality and the heterogeneity of the causality relationship. We use the linear model as follows:

$$z_{it} = \alpha_i + \sum_{m=1}^{M} \gamma_i^{(m)} z_{i,t-m} + \sum_{m=1}^{M} \beta_i^{(m)} y_{i,t-k} + \varepsilon_{it} \qquad (7)$$

where y and z are two stationary variables observed for N individuals in T periods. We assume that $\beta_i = (\beta_i^{(1)}, \ldots\ldots\ldots \beta_i^{(m)})'$ and α_i are fixed in the time dimension. We allow $\gamma_i^{(m)}$ and $\beta_i^{(m)}$ to be varied across cross-sections. The null hypothesis is called the Homogenous Non-Causality (HNC) hypothesis; we adopt it if there is no causality relationship for any cross-section of the panel. The HNC is defined as follows:

$$H_0 : \beta_i = 0 \; \forall_i = 1,2,.........,N$$

The alternative hypothesis, called the Heterogeneous Non-Causality (HENC) hypothesis, considers two sub-groups of cross-sectional units. For the first sub-group, there is causality relationship from y to z; however, it is not necessarily based on the same regression model. For the second one, we consider a heterogeneous panel data model with fixed coefficient, where there is no causality relationship from y to z. The HENC is defined as follows:

$$H_a \begin{cases} \beta_i = 0 \;\; \forall_i = 1,2,..............,N_1 \\ \beta_i \neq 0 \;\; \forall_i = N_1 + 1,..............,N \end{cases}$$

We suppose that β_i varies across cross-sections and that there are $N_1 \langle N$ individual processes where z is not caused by y. N_1 is unknown, but it provides the condition $0 \leq N_1 / N \langle 1$. We suppose that β_i varies across cross-sections and that there are $N_1 \langle N$ individual processes where z is not caused by y. N_1 is unknown, but it provides the condition $0 \leq N_1 / N \langle 1$. We propose an average statistic related to the Homogenous Non-Causality hypothesis, presented as follows:

$$W_{N,T}^{HNC} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \quad (8)$$

Under the hypothesis of non-causality, the Wald statistic of each individual converges to a chi-squared distribution with M degrees of freedom for $T \rightarrow \infty$. The standardized test statistics for $T, N \rightarrow \infty$ areas follows:

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2M}} (W_{N,T}^{HNC} - M) \rightarrow N(0,1) \qquad (9)$$

4. Empirical Results and Discussion

To test the unit root properties of the variables, we applied the Levin-Lin-Chu (LLC, 2002) and Im-Pesaran-Shin (IPS, 2003) unit root tests. The results are reported in Table-2. The LLC unit root test has a low explanatory power for small samples caused by the serial correlation. However, it takes into account the heterogeneity of various sections. On the contrary, it is noted that IPS unit root test has a strong ability for testing small samples. This test correctly considers the heterogeneity between the sections and eliminates the serial correlation. The null hypothesis (H_0) of LLC and IPS tests considers the non-stationarity of all series against the alternative hypothesis (H_1), which supports their stationarity. To accept/reject the null hypothesis, we compare the p-value to a threshold level of 1%. We may accept H_0 if the p-value is greater than 1% and reject it if the p-value is less than 1%. The results reported in Table-2 indicate that all the variables have a unit root problem at the level with intercepts and trends. However, at first difference, we reject the null hypothesis and confirm the stationarity of all the variables. This shows that all the variables have a unique order of integration, i.e., I(1).

Table-2. Panel Unit Root Analysis

	Levin-Lin-Chu (LLC)				***Im-Pesaran-Shin (IPS)***			
	Level		***First difference***		***Level***		***First difference***	
Variable	***T-statistic***	***p-value***	***T -statistic***	***p-value***	***T-statistic***	***p-value***	***T-statistic***	***p-value***
Y	-4.8902	0.2207	-7.5180	0.0000*	-1.2940	0.5394	-6.9820	0.0000*
RTEC	-1.6270	0.3940	-5.6280	0.0007*	-1.5973	0.5230	-5.8935	0.0001*
TIN	-0.7812	0.3680	-5.9855	0.0005*	-0.8455	0.4957	-5.5852	0.0003*
K	-3.8615	0.1856	-6.5568	0.0000*	-2.8559	0.1827	-7.5823	0.0000*
Note: * Significant at 1%.								

The LLC and IPS unit root tests provide inconclusive results as these tests do not consider the information of cross-sectional dependence in the data. The cross-sectional dependence may be present in the data as countries are dependent on each other economically, socially and politically in the region. This issue is solved by applying cross-sectional dependence test introduced by Pesaran (2004), which employs the correlation coefficients between the time series for each panel member. The null hypothesis is cross-sectional independence, and it asymptotically follows a two-tailed standard normal distribution. In addition, we present the results of the semi-parametric Friedman test and the parametric testing procedure proposed by Pesaran (2004), which tests the hypothesis of cross-sectional independence in panel data models with a small T and a large N. In Table-3, we note that the null hypothesis of cross-sectional independence is also rejected at the 1% significance level, as confirmed by Friedman, Frees, Breusch-Pagan LM, LM_{adj} and LM_{bais} tests. This confirms the rosbustness of empirical results. Furthermore, Chudik and Pesaran (2015) test also rejects the null hypothesis which reveals that cross-sectional dependence is not weak. This concludes that MEAN region has strong cross-sectional dependence in the data.

Table-3: Cross-Sectional Dependence Analysis

Variables	Friedman	Frees	Pesaran	B-P	LMadj	LM_{bais}	C-P
Y	42.8651 (0.0000)	148.4826 (0.0000)	28.4021 (0.0000)	1201.887 (0.0000)	45.9019 (0.0000)	65.0491 (0.0000)	2.1248 (0.0345)
RTEC	48.3648 (0.0000)	160.2652 (0.0000)	22.0602 (0.0000)	1241.890 (0.0000)	35.9801 (0.0000)	72.3493 (0.0000)	7.0558 (0.0000)
TIN	39.8461 (0.0000)	166.1545 (0.0000)	23.1005 (0.0000)	1570.901 (0.0000)	32.8901 (0.0000)	76.1314 (0.0000)	1.7056 (0.0887)
K	53.2683 (0.0000)	175.6590 (0.0000)	25.2592 (0.0000)	1213.090 (0.0000)	45.8971 (0.0000)	85.3249 (0.0000)	5.7392 (0.0000)

Notes: 1: Friedman test for cross-sectional dependence using Friedman's $\chi 2$ distributed statistic, 2: Frees (1995) for cross-sectional dependence by using Frees' Q distribution (T-asymptotically distributed), 3: Pesaran (2004) cross-sectional dependence in panel data models test, 4: B-P indicates Breusch-Pagan LM test of independence, 5: LM_{adj} shows Pesaran et al. (2008) bias-adjusted LM, 6: Baltagi et al. (2012) bias-corrected scaled LM test. P-values in parentheses. C-P indicates Chudik and Pesaran (2015). Tests include the intercept.

Table-4: Unit Root Analysis with Cross-Sectional Dependence

Variable	CADF (Pesaran 2003)		CIPS (Pesaran 2007)	
	Level	1^{st} Difference	Level	1^{st} Difference
Y	-1.0648 (0.8657)	-7.1280 (0.0000)	-1.1618 (0.8850)	-7.8090 (0.0000)
RTEC	-2.0280 (0.7659)	-5.8695 (0.0000)	-2.1210 (0.7309)	-6.5685 (0.0001)
TIN	-1.6010 (0.8018)	-3.9560 (0.0015)	-1.6712 (0.7989)	-6.9058 (0.0000)
K	-2.0105 (0.7657)	-6.2615 (0.0000)	-2.0015 (0.7717)	-19.2013 (0.0000)

Notes: P-values in parentheses. Intercept and trend are included in testing.

To eliminate the dependence, the standard DF (or ADF) regressions are augmented with the cross-section averages of lagged levels and first differences of the individual series (CADF statistics). The results of CADF unit root test controlling for cross-sectional dependence are reported in Table-4. We find that results contain unit root in the presence of cross-sectional dependence but at fist difference, all the series are found stationary. To test the robustness of empirical results, we have also applied CIPS unit root developed by Pesaran (2007). The empirical results by CIPS unit root test confirm the findings of CADF test. This shows the reliability of unit root analysis. It infers that all the variables are integrated at I(1).

The unique order of integration of the variables reveals to apply cointegration test developed by Pedroni (2004) to examine the long-run relationship between transport energy consumption, transport infrastructure, capital and economic growth. The results of Pedroni (2004) are shown in Table-5. Pedroni (2004) developed two groups containing seven tests for homogeneous and heterogeneous panels. These tests take into account the heterogeneity in the cointegration relationship. The tests of the first group average the results of individual country test statistics. However, tests of second group pool the statistics along the within-dimension. Pedroni (2004) also showed that under appropriate normalization, based on Brownian motion functions, 7 statistics follow a normal distribution centered reduced for N and T important enough. More specifically, we test the cointegration of transport energy consumption, transport infrastructure, capital and economic growth included in equation-4. Indeed, it is clearly indicated by the p-values given in Table-5 that the null hypothesis of no cointegration between variables is rejected at the 1% level of significance. This confirms the presence of cointegration between the variables. We may conclude that transport energy consumption, transport infrastructure, capital and economic growth have the long-run relationship in the MENA region.

Table-5. Pedroni Cointegration Test

Variables	**Tests between dimensions**				**Tests within dimensions**		
Y, RTEC, TIN, K	V-stat	Rho-stat	Pp-stat	Adf-stat	Rho-stat	Pp-stat	Adf-stat
MENA Panel	-3.16270 (0.0043)*	-3.5685 (0.0018)*	-5.4053 (0.0000)*	-3.5812 (0.0022)*	-6.5954 (0.0000)*	-5.7860 (0.0001)*	-4.7591 (0.0017)*
GCC Countries	-2.9815 (0.0123)**	-3.2015 (0.0043)*	-5.1594 (0.0000)*	-3.2634 (0.0040)*	-5.9681 (0.0000)*	-5.2367 (0.0000)*	-4.5622 (0.0021)*
Non-GCC Countries	-3.1086 (0.0045)*	-3.3629 (0.0038)*	-4.8950 (0.0015)*	-3.3695 (0.0035)*	-6.5010 (0.0000)*	-4.8900 (0.0017)*	-4.6610 (0.0019)*
North African Countries	-3.4208 (0.0034)*	-3.6254 (0.0031)*	-5.2310 (0.0000)*	-2.9800 (0.0127)**	-5.5808 (0.0000)*	-4.5646 (0.0020)*	-5.1054 (0.0000)*
Note: Panel cointegration tests include intercept; * significant at 1%, ** significant at 5%.							

We have applies the Johansen, Kao and Westerlund cointegration tests to examine robustness of empirical results[2]. The results of Johansen cointegration are reported in Table-4A (in Appendix). We find that empirical results confirm the presence of three cointegrating vectors in MENA, GCC and N-GCC panels. In case the of MATE panel, two cointegrating vectors are

[2] The results of Kao cointegration results are not reported to conserve space but available upon request from authors. The empirical results of Kao cointegration also confirm the [presence of cointegration between the variables for all the regions.

present in production function. This leads to reject hypothesis of no cointegration between the variables and may conclude that cointegration is present between the variables in all the regions. The Pedroni, Johansen and Kao are unable to count cross-sectional dependence in data and provide vague empirical results. This issue is solved by apply the Westerlund cointegration, which can be applied in the presence of cross-sectional dependence in the data. The results of the Westerlund cointegration test are reported in Table-6. We find that the null hypothesis of no cointegration is rejected at 1% and 5% levels respectively, which confirms the existence of cointegration between the variables for MENA, GCC, N-GCC and MATE regions. This further confirms that empirical results are robust and reliable.

Table-6: Westerlund Cointegration Analysis

MENA Panel			
Statistics	Value	Z-value	p-value
G_t	-3.628**	-2.624	0.054
G_a	-12.904*	-4.878	0.000
P_t	-6.978*	-3.035	0.001
P_a	-5.390*	-2.086	0.000
GCC Panel			
G_t	-3.618**	-2.630	0.055
G_a	-12.890*	-4.895	0.000
P_t	-6.980*	-3.115	0.001
P_a	-5.401*	-1.986	0.000
N-GCC Panel			
G_t	-3.595**	-2.635	0.051
G_a	-10.914*	-4.808	0.000
P_t	-7.098*	-3.235	0.000
P_a	-5.505*	-2.506	0.000
MATE Panel			
G_t	-3.628**	-2.624	0.054
G_a	-12.904*	-4.878	0.000
P_t	-6.978*	-3.035	0.001
P_a	-5.390*	-2.189	0.000
Note: * and ** show significance at 1% and 5% levels respectively.			

Table-7: GMM Regression Analysis

Dependent Variable: Y_t				
Variables	**Coef**	**Std err.**	**t-statistic**	**p-value**
MENA Panel				
Constant	0.2540	0.1036	2.4500	0.0000*
(Y_{t-1})	0.2855	0.1091	2.6152	0.0180**
RTEC	0.1982	0.0900	2.2015	0.034**
TIN	0.2120	0.0954	2.2203	0.0000*
K	0.3007	0.1006	2.8961	0.0000*

Sargan test (p-value)	46.80 (0.812)			
AR2 test (p-value)	-0.507 (0.705)			
GCC Panel				
Constant	0.1902	0.00948	2.0061	0.0260**
(Y_{t-1})	0.3361	0.0952	3.5280	0.0025*
RTEC	0.0502	0.0063	0.7853	0.1390
TIN	0.1252	0.0658	1.9001	0.0139**
K	0.2830	0.1102	2.5667	0.002*
Sargan test (p-value)	39.265 (0.812)			
AR2 test (p-value)	-1.264 (0.328)			
Non-GCC Panel				
Constant	0.2078	0.0936	2.2195	0.0000*
(Y_{t-1})	0.3151	0.1005	3.1350	0.0000*
RTEC	0.2357	0.0986	2.3890	0.0000*
TIN	0.1005	0.0534	1.8803	0.0390**
K	0.1935	0.0961	2.0123	0.0024**
Sargan test (p-value)	51.207 (0.562)			
AR2 test (p-value)	-0.771 (0.439)			
MATE Panel				
Constant	0.3115	0.0995	3.1280	0.0000*
(Y_{t-1})	0.2563	0.1037	2.4693	0.0002*
RTEC	0.2811	0.1096	2.5630	0.0000*
TIN	0.2057	0.0927	2.2172	0.0000*
K	0.1428	0.0731	1.9530	0.0317**
Sargan test (p-value)	62.03 (0.126)			
AR2 test (p-value)	-0.691 (0.248)			
Notes: Values in parenthesis are the estimated p-values. The Sargan test refers to the over-identification test for the restrictions in the GMM estimation. The AR (2) test is the Arellano-Bond test for the existence of the second-order autocorrelation in first differences. * Significant at 1%, and**significant at 5%.				

After confirming cointegration between the variables, we apply a GMM regression analysis to examine the effects of transport infrastructure, transport energy consumption and capital on economic growth. The results of all panels are shown in Table-7. We find that economic growth is significantly determined by its lag. Moreover, road transport energy consumption adds significantly to economic growth. A 1% increase in energy consumption by road transport leads to economic growth of 0.198% in the MENA region. Mondal et al. (2014) argue that the energy consumption in UAE increases enormously in the recent decades due to subsidies energy, economic development and high growth of population. Furthermore, they note that the UAE has 9.3% of the world's proven oil reserves and 4.1% of the world's proven gas reserves. However, the energy demand forecasts, coupled with current and future shortages of oil and natural gas, encourage the policy makers to improve diversified energy mix that allows energy generation from all conventional resources including coal, renewable energy sources and nuclear energy. These strategies allow the satisfaction of increasing demand of energy and sustain economic development for the UAE. In addition, due to the limited reserves of oil and natural gas, Morocco has embarked in 2008 an ambitious renewable energy program for the period of 2010-2020. The Moroccan authorities aim to use solar, wind and hydroelectric sources to supply 42% of their total energy needs. Also, they aim to enhance their energy efficiency by 12% for the same period. To obtain these results, Morocco adopts numerous measures to realize the program including the establishment of renewable energy and efficiency agencies, legislations and the engagement of different domestic and international stakeholders. This empirical evidence is consistent with Chandran and Tang (2013), who reported a significant and long-run relationship between transport energy use and economic growth in Asian economies (Malaysia, Indonesia, Singapore, the Philippines, and Thailand). The positive and significant relationship also exists between transport infrastructure and economic growth. Economic growth increases 0.212% with a 1% increase in transport infrastructure development. Rizzo (2014) argues that since the 1970s, Qatar has attempted to implement urban planning in an effort to manage rapid urban growth. Qatar has implemented several megaprojects to develop the public infrastructure essentially that of transport. These projects improve strongly its territorial attractiveness of FDI, high-skilled workers, and tourists which positively affect economic development. Also, transport infrastructure is among the main determinants of the territorial management for the policy makers in Qatar. It is seen as a priority to reduce congestion and provide opportunities for more and better public transport. This empirical result is similar to those of Kim et al. (2017) for Indonesia, Mondragón-Ixtlahuac et al. (2017) for Mexico, and Palei (2015) for 124 economies. Capital is positively and significantly linked with economic growth. A 1% increase in capital leads to economic growth of 0.300%. Convinced by the important role of capital stock to boost economy, five countries from the MENA region (Algeria, Egypt, Morocco, Syria, and Tunisia) have launched various measurements to accelerate the financial reforms and improve the financial system efficiency, which stimulates saving/investment and, consequently, long-run economic growth since the mid 1980s. For Tunisia, the Investment Incentives Code, implemented in January 1994, provides numerous incentives in the form of tax exemptions, investment benefits and support for infrastructure costs. This strategy helps investors, domestic and foreign, to increase their investments and expand their businesses, which in turn boosts economic growth. Also, similar measurements were applied in Morocco, Egypt, and Jordan to increase the FDI inflows and economic growth. This empirical evidence is similar to that of Omri and Kahouli (2013) for 13 MENA countries, Omri and Sassi-Tmar (2014) for North African countries (Tunisia, Morocco, and Egypt), Farhani et al. (2014) for MENA countries, and Saidi and Hammami (2017b) for developing countries.

Table-6 also represents the results of the Gulf Cooperation Council countries (GCC). The results note that economic growth in these countries depends slightly on transport energy consumption. Indeed, a coefficient of 0.050 means that economic growth increases by 0.050% with a 1% increase in energy consumed by road transport. The result is in accordance with that of Magazzino (2016b), who says that economic growth in GCC countries depends moderately on transport energy consumption. Transport infrastructure affects economic growth positively. This suggests that a 1% increase in transport infrastructure raises economic growth by 0.125%. Concerning capital stock, our empirical findings are similar to those of Noor and Siddiqi (2010), Shahbaz et al. (2011), Wang et al. (2011), Olumuyiwa (2012) and Omri et al. (2014). A 1% increase in GCC capital leads to GCC economic growth of 0.283%.

The results for non-Gulf Cooperation Council countries (N-GCC) show that transport energy consumption has positive and significant effect on economic growth. A 1% increase in transport energy consumption leads to a 0.235% increase in economic growth, keeping other things constant. The positive role of transport energy consumption in economic growth is in line with Magazzino (2016b), who reports that transport energy consumption plays a vital role in economic growth for N-GCC countries. Moreover, Erdal et al. (2009) and Kaplan et al. (2011) for Turkey, Abosedra et al. (2009) and Dagher and Yacoubian (2012) for Lebanon, and Naji-Meidani and Zabihi (2014) for Iran also confirm that transport energy consumption is positively linked with economic growth. In N-GCC countries, transport infrastructure affects economic growth positively and significantly at the 5% level. The empirical results show that a 1% increase transport infrastructure increases economic growth by 0.1005%, keeping other things constant. The stimulating role of transport infrastructure in economic growth is also reported by Pradhan and Bagchi (2013) for India, Anam et al. (2016) for Pakistan, Song and Van-Geenhuizen (2014) for China, and Oladipo and Olomola (2015) for Nigeria. Capital stock has a positive impact on economic growth. In North African or MATE countries (Morocco, Algeria, Tunisia, and Egypt), road transport sector's energy consumption affects economic activity. Keeping other things constant, a1% increase in transport energy consumption enhances economic growth by 0.281%. There is a positive and significant relationship between transport infrastructure and economic growth. These empirical findings are in accordance with Shahbaz et al. (2015a), Achour and Belloumi (2016), and Saidi and Hammami (2017b). Economic growth in Morocco, Algeria, Tunisia, and Egypt is strongly affected by capital stock.

Table-8 summarizes the results and demonstrates the impact of exogenous variables on economic growth for the four panels. For the global panel, we find that economic growth depends positively on its lagged values at the 1% level of significance. Transport infrastructure and capital stock also have a positive and significant impact on economic growth. The positive impact of transport energy consumption on economic growth is also significant. For the GCC panel, economic growth is positively affected by transport infrastructures and capital stock. For the N-GCC and MATE panels, the relationship between transport infrastructure and economic growth is positive and significant. Capital also leads to economic growth in both regions.

Table-8. Summary of Empirical Analysis

	MENA Panel	**GCC panel**	**N-GCC panel**	**MATE panel**
Y_t	+①	+①	+①	+①
REC	+❺	+Ø	+①	+①
TIN	+①	+❺	+❺	+①
K	+①	+①	+❺	+❺
Note: (+) indicates that it has positive effect on economic growth, ① significant at 1%, ❺ significant at 5%, Ø insignificant effect on economic growth.				

To examine the causal associations among the variables, we applied the Dumitrescu-Hurlin panel causality, and the results are shown in Table-9. We find the bidirectional causality between economic growth and road energy consumption in the global, GCC and N-GCC panels. This finding implies that economic growth causes road energy consumption, and as a result, road energy consumption causes economic growth, i.e. a feedback effect. This empirical evidence is consistent with Al-Ghandoor et al. (2012), Gao et al. (2015), and Llorca and Jamasb (2017). In the MATE panel, road energy consumption causes economic growth but not vice versa. This implies that road energy consumption plays an important role in economic growth, i.e., the energy-led growth hypothesis. This empirical evidence is similar to that of Ibrahiem (2017) for Egypt and Mraihi et al. (2013) for Tunisia. The feedback effect is noted between road energy consumption and capital in the global and GCC panels. This shows that road energy consumption and capital are interdependent. This empirical finding is consistent with those of Erdal et al. (2009), Kaplan et al. (2011), Achour and Belloumi (2016), and Magazzino (2016b). In the N-GCC panel, the unidirectional causality is found to run from capital to road energy consumption, and a neutral effect is noted between road energy consumption and capital for the MATE panel. A bidirectional causal relationship is noted between capital and transport infrastructure in the global and N-GCC panels, and transport infrastructure causes capital in the GCC panel. A unidirectional causal relationship runs from transport infrastructure to capital in the global, N-GCC and MATE panels. Capital causes economic growth in the global and GCC panels. Road energy consumption causes transport infrastructure but not vice versa in the global and GCC panels.

Table-9: Dumitrescu-Hurlin Panel Causality Analysis

Pairwise Dumitrescu-Hurlin Panel Causality Tests			
NullHypothesis	W-Stat.	Zbar-Stat.	Prob.
MENA Panel			
REC does not homogeneously cause Y	5.2672	3.2081	0.0013
Y does not homogeneously cause REC	5.8974	3.9386	8.E-05
TIN does not homogeneously cause Y	5.5779	3.5682	0.0004
Ydoes not homogeneously cause TIN	2.6164	0.1350	0.8926
K does not homogeneously cause Y	4.4330	2.2409	0.0250
Y does not homogeneously cause K	3.0919	0.6862	0.4925
TIN does not homogeneously cause REC	3.1609	0.7662	0.4435
REC does not homogeneously cause TIN	22.7184	23.4394	0.0000
K does not homogeneously cause REC	5.1860	3.1139	0.0018
REC does not homogeneously cause K	4.0712	1.8215	0.0685
K does not homogeneously cause TIN	4.2645	2.0456	0.0408
TIN does not homogeneously cause K	4.7160	2.5691	0.0102
GCC Panel			
REC does not homogeneously cause Y	5.3338	2.1507	0.0315
Y does not homogeneously cause REC	6.6288	3.1335	0.0017
TIN does not homogeneously cause Y	2.1479	-0.2671	0.7893
Ydoes not homogeneously cause TIN	3.1998	0.5311	0.5953
K does not homogeneously cause Y	6.2350	2.8347	0.0046
Y does not homogeneously cause K	1.8159	-0.5197	0.6036
TIN does not homogeneously cause REC	3.5024	0.7607	0.4468
REC does not homogeneously cause TIN	48.6445	35.0215	0.0000
K does not homogeneously cause REC	6.2935	2.8791	0.0040
REC does not homogeneously cause K	5.0772	1.9560	0.0505
K does not homogeneously cause TIN	4.1202	1.2296	0.2188
TIN does not homogeneously cause K	5.0049	1.9011	0.0573
N-GCC Panel			
REC does not homogeneously cause Y	4.8191	1.4371	0.1507
Y does not homogeneously cause REC	9.3841	4.2659	2.E-05
TIN does not homogeneously cause Y	6.2772	2.3406	0.0192
Ydoes not homogeneously cause TIN	3.3305	0.5146	0.6068
K does not homogeneously cause Y	1.8779	-0.3858	0.6999
Y does not homogeneously cause K	3.2843	0.4860	0.6270
TIN does not homogeneously cause REC	3.7978	0.8042	0.4212

REC does not homogeneously cause TIN	4.0574	0.9650	0.3345
K does not homogeneously cause REC	7.6568	3.1955	0.0014
REC does not homogeneously cause K	3.1068	0.3760	0.7069
K does not homogeneously cause TIN	5.5750	1.9055	0.0567
TIN does not homogeneously cause K	5.2650	1.7134	0.0866
MATE Panel			
REC does not homogeneously cause Y	5.6155	1.9306	0.0535
Y does not homogeneously cause REC	1.3135	-0.7352	0.4622
TIN does not homogeneously cause Y	10.0236	4.6621	3.E-06
Ydoes not homogeneously cause TIN	1.0273	-0.9125	0.3615
K does not homogeneously cause Y	4.2850	1.1061	0.2686
Y does not homogeneously cause K	4.8137	1.4337	0.1516
TIN does not homogeneously cause REC	2.0118	-0.3024	0.7623
REC does not homogeneously cause TIN	2.4896	-0.0064	0.9949
K does not homogeneously cause REC	1.0538	-0.8963	0.3702
REC does not homogeneously cause K	3.5267	0.6362	0.5246
K does not homogeneously cause TIN	3.1705	0.4155	0.6778
TIN does not homogeneously cause K	3.7338	0.7645	0.4445

5. Conclusion and Policy Implications

This paper investigates the impact of transport energy consumption and transport infrastructure on economic growth for MENA countries. The MENA region is divided into three sub-panels: Gulf Cooperation Council countries (GCC), Non-Gulf Cooperation Council countries (N-GCC) and North African countries, or MATE countries. The Generalized Method of Moments is applied to examine the relationship between the variables over the period of 2000-2016. The causal relationship between the variables is investigated by applying the Dumitrescu-Hurlin panel causality test. The empirical results show that transport energy consumption stimulates economic activity and hence economic growth in N-GCC and MATE countries. In GCC countries, transport energy consumption affects economic growth insignificantly. A positive and significant association is found between transport infrastructure and economic growth in all regions of MENA countries. Capitalization, which is a supporting variable, also adds to economic growth in GCC, N-GCC and MATE countries. The Dumitrescu-Hurlin panel causality analysis shows that road energy consumption and economic growth have bidirectional causality association in the global, GCC and N-GCC panels, and the energy-led-growth hypothesis is confirmed in the MATE panel.

There are three-fold implications for policymakers. First, the positive association between transport energy consumption and economic growth in the N-GCC and MATE regions reveals that economic growth depends on road transport energy use. This suggests that more road transport energy consumption means more economic growth by engaging in better economic activities such as the effective flows of complex logistics operations supporting imports and exports. Although logistics activities supported by transport energy consumption contribute to economic growth, managers and policymakers have been urged (by laws and regulations) to use more energy efficient ways of transportation, so the harmful effects of transportation energy consumption can be reduced (e.g., CO_2 emissions). In this regard, advanced technology can play a vital role. Contemporary vehicles are built with the focus on less energy consumption features (e.g., automatic stopping of engines at lights or at temporary stops) that may significantly reduce transportation energy consumption. The more transport energy consumption the better economic growth may not sustain in the long-run as new legislation and agreements emphasize sustainability and climate change policy (e.g., Paris-Agreement). It is consequently encouraged to use less energy, despite many studies (including our findings) show that transportation energy consumption has a significant link with economic growth (e.g., an increased value of the goods and services produced over time). An alternative source of energy could also be useful for the 21st century logistics operations (e.g., solar trucks) against new CO_2 restrictions introduced by governments, rather than decreasing transportation energy consumption as it strongly contributes to economic growth (i.e., economic growth increases 0.212% with a 1% increase in transport infrastructure development). New challenges arise for policymakers attempting to develop the economies of their countries and decrease energy consumption and environmental degradation.

Second, the construction of new road infrastructure indeed helps in decreasing congestion and energy use by augmenting energy intensity. The new constructions may facilitate the use of energy-efficient transport modes and alternative technologies. This may save economies from negative externalities (e.g., greenhouse gas emissions, congestion and environmental degradation). Government might build advanced infrastructure that can simultaneously produce energy using modern technology. For instance, advanced devices can be installed on road sides or in the middle of roads and these devices can generate energy from vehicle moments, which can be used for many purposes. Even existing infrastructure can be updated with such devices when they repair roads. Thus, congestion can be made useful and optimized rather than reducing it. Policymakers need to think around these new ideas in development. Moreover, the strong influence of transport demand on economic growth pushes the local authorities to integrate the environmental dimension in their development strategies. They should think about the decoupling phenomenon in both its absolute and relative approaches. Decision makers have various policy options, such reducing travel, increasing the effectiveness of the spatial organization of industrial activities, and integrating transport, for town and country planning. Shifting to public transport is among the effective solutions of urban transport planning. To encourage the substitution of private cars with public transport, local authorities may use economic instruments such as fuel taxation and introducing more cost effective policy for utilizing public transport.

Thirdly, transport infrastructure has a positive effect on economic growth via attracting foreign direct investment inflows. In recent years, multinational companies have considered transport as a new FDI determinant of growing importance. The MENA countries should therefore improve their transport quality by developing their transport infrastructure and adopting new technologies, which can attract more multinational companies to invest and grow in MENA countries. This can also increase overall capital in targeted countries. The development of national transport networks increases connectivity between the different regions of a country and increases private investment, bring in more foreign capital. Roads and railways increase the attractiveness of regions and attract more investors. In addition, MENA countries need to develop their international multimodal and intermodal transport networks (i.e., rail, road, waterways and air) to improve their economic openness to the world market. This may unlock their practical barriers that hinder their trade with multinational companies and international players working in more advanced countries. Such developments can resolve more connectivity issues and promote globalization. The resulting impacts can then be improved international connections — supporting local economic growth, resolving logistical bottlenecks and improving services. Moreover, the geographical position of the Middle East region is strategically advantageous and allows countries to play an important role in international trade if they develop their transport infrastructure and adopt new technologies. Indeed, the development of multimodal/intermodal and intelligent transport systems allows the MENA countries to improve the management of their transport infrastructure, which effectively contributes to economic growth. Indeed, the multi-model transport network allows the private sector to increase efficiency and reduce production costs by decreasing transport costs. Additionally, they can settle near the raw material and convey the product to consumers easily. The same advantages are possible for multinational companies that considerably participate in the economic development of their host countries. Also, vehicles manufacturing technology is advancing and future vehicles may be equipped with modern features so these vehicles be able to travel in water, on roads and rail-tracks concurrently, even they can fly as well if integrated with drone technology. Thus, advanced multimodal and intermodal transport networks could be very useful and environment-friendly, and companies can eliminate extra processes such as cross-docking. Finally, MENA countries should obtain an effective logistics function, which is considered an indispensable element to obtain a competitive multimodal transport system, to augment the positive externalities of transport, and to decrease the negative impact on the economy and especially environment.

For future research, this study can be extended by decomposing transport energy consumption into sectors i.e. highway and non-highway transportation energy consumption for examining its impact on economic growth and carbon emissions as well. This sectoral analysis would help policymakers in designing comprehensive and sectoral energy policy to use energy availability for sustainable long-run economic development by improving environmental quality. In future, globalization and de-globalization may affect transportation such as ground, air, ship transportation and transportation as well by boosting or reducing economic activity. Transportation energy demand function can be reinvestigated by incorporating trade openness as additional determinants which may affect transportation energy demand via income, scale, techniques and composition effects, following Shahbaz et al. (2017) among others latest studies. Income, scale, technique and composition effects can be considered potential factors contributing to transportation and hence, transportation energy demand will be affected. The role of urbanization can also be considered while examining the determinants of transport energy intensity, as urbanization directly and indirectly is linked with transportation energy demand via economic activity. Last but not least, the empirical investigation of the rebound effect by looking at the concept of environmental efficiency can be another future and potential research direction in for MENA countries.

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Appendix-A

Table-1A: Summary of Exiting Studies in Literature

	Authors	Countries	Period	Method(s)	Findings
1	Maparu and Mazumder (2017)	India	1990-2011	Time series	* Long-run relationship exists between transport infrastructure and economic development. *EG granger causes transport infrastructure.
2	Azlina et al., (20104)	Malaysia	1975-2011	Time series	*The inverted U-shape EKC hypothesis is rejected for Malaysia. *CO2 causes GDP, EC, RE. *GDP causes EC and RE. *RE causes REC.
2	Ozturk and Acaravci (2013)	Turkey	1960-2007	Time series	*Long-run relationships exist between CO2, EC, EG, TO, FD. *Validity of EKC hypothesis.
4	Farhani and Ben Rejeb (2012)	15 MENA countries	1973–2008	Panel data	* No causal link between GDP and EC; and between CO2 emissions and EC in the short run. * Uni-directional causality running from GDP and CO2 emissions to EC in the long-run.
5	Al-Ghandoor et al. (2012)	Jordan	1985-2009	Time series	* Transport energy demand is expected to increase at % 4.9 yr^{-1} from years 2010–2030.
6	Omri (2013)	14 MENA countries	1990-2011	Panel data	* Unidirectional causality runs from EC to CO2 emissions. * Bidirectional causal relationship is between EG and CO2.
7	Salahuddin and Gow (2014)	Gulf Cooperation Council countries	1980-2012	Panel data	* Positive and significant association is between EC and CO2; EG and EC both in LR and SR. * No significant relationship is found between EG and CO_2. *EC and CO_2 emissions Granger cause each other. *EG causes EC.
8	Ben Jebli and Ben Youssef (2015)	Tunisia	1980-2009	Time series	*Trade, GDP, CO2 and NRE cause RN in SR. *NRE and trade affect CO2 in LR. *The inverted U-shaped ECK hypothesis is rejected.
9	Magazzino (2016a)	10 Middle East countries.	1971-2006	Panel data	* For the GCC countries the response of EG to CO2 is negative. *EC causes CO2. *For the N-GCC, EG is not affected by EC and CO2.
10	Magazzino (2016b)	GCC countries	1960-2013	Panel data	* Long-run relationship exists between EC, EG, and CO2 only for Oman.

					* For Kuwait, Oman, and Qatar, EC drives EG. *For Saudi Arabia, no long-run relation exists between EG and EC.
11	Ibrahiem (2017)	Egypt	1980-2011	Time series	* Long-run relationship exists between REC, EG, URB, and POP. *in the long-run, REC causes URB and EG. * In the short-run, REC and EG cause each other.
12	Saidi and Hammami (2017a)	75 countries	2000-2014	Panel data	* Feedback effect exists among income and transport. *For HIC, bidirectional causality exists between CO2 and EG. *Transport causes the CO2 emissions. *For MIC and LIC, EG and transport cause CO2.
13	Shahbaz et al. (2015a)	Tunisia	1980-2012	Time series	*EC, TIN, and TVA increase CO2 emissions. *Fuel price decreases CO2 emissions. *Bidirectional causality exists among the variables.
14	Xu and Lin (2015)	China	2000-2012	Panel data	*EG has a nonlinear effect on CO2 emissions. *URB has a nonlinear effect on CO2 emissions.
15	Saboori et al. (2014)	27 OECD countries	1960-2008	Time series	* Positive and significant long-run bi-directional relationship exists between EG, REC, and CO2.
16	Keho and Echui (2011)	Cote d’Ivoire	1970–2002	Time series	*Long-run unidirectional causality runs from economic growth to transport investment.
17	Pradhan and Bagchi 2013	Côte d’ivoire	1980-2013	Time series	*The economy performance, foreign direct investment and domestic investment are significant in explaining the productivity of port sector.
18	Jin and Rafferty, (2017).	United States	1990-2000	Panel data	*Traffic congestion growth negatively affects income growth and employment growth.
19	Brida et al. (2016)	Mexico	1995-2013	Time series	*Co-integration, linear relationship exists between air transport and economic growth.
20	Pradhan et al. (2016)	G-20 countries	1961-2012	Panel data	*Telecommunication infrastructure, gross capital formation and economic growth are co-integrated. * Telecommunication infrastructure, gross capital formation granger cause economic growth.
21	Pradhan (2010b)	India	1970-2007	Time series	*Unidirectional causality runs from transport infrastructure to economic growth, and from transport infrastructure to gross capital formation.
22	Marazzo et al. (2010)	Brazil	1966-2006	Time series	*Gross Domestic Product and Air transport demand are co-integrated. *Causality runs from GDP to Air transport demand in the long-run.
23	Fedderke et al. (2006)	South Africa	1875-200	Time series	* Investment in infrastructure causes economic growth.

Table-2A. Descriptive Statistics

Variables		Mean	Median	SD	Skewness	Kurtosis	Inter-Quartile Range	10-Trim	Jarque-Bera
Global Panel	Y	6.8452	6.5842	0.5178	-1.6245	5.4692	0.8905	7.6270	5.1240
	RTEC	6.1458	6.0045	0.7889	-2.1270	7.6201	1.0025	6.1540	3.8705
	TIN	0.0010	0.0014	0.0034	-1.9950	5.3940	1.5200	5.6348	5.7950
	K	5512.860	5480.230	3.1492	-1.6824	6.1248	2.4120	2.9820	4.5506
GCC countries	Y	9.2481	8.9912	0.6991	-1.5680	5.4291	0.9125	10.5167	5.1548
	RTEC	6.1542	5.8951	0.8627	-2.0267	7.6257	1.1248	9.1022	4.6245
	TIN	0.0013	0.0011	0.00459	-1.896	4.5628	1.2450	4.6248	5.9854
	K	7060.146	6969.20	3762.15	-1.6572	5.6249	1.6511	1.4856	5.3485
	Y	6.5128	6.2985	0.4957	-1.5486	6.9571	0.7458	9.4859	6.9968

Non-GCC countries	RTEC	4.0248	3.9248	0.8127	-1.9857	7.6289	1.2273	8.1574	3.8720
	TIN	0.0027	0.0021	0.0041	-2.4864	6.8427	1.6975	6.9578	3.4500
	K	5124.846	5002.597	3684.88	-1.4782	8.4872	2.0571	2.4216	2.0784
North African countries	Y	4.9985	4.2596	0.5258	-2.0478	4.6230	1.2602	4.5297	4.9950
	RTEC	5.1596	4.9890	0.7183	-2.6281	7.9570	0.9801	5.1548	2.0014
	TIN	0.0031	0.0029	0.0038	-2.6541	5.6427	2.9483	5.1500	4.8659
	K	3.1597	3.1220	4.8546	-1.9980	5.6482	2.4580	3.1543	3.5680
SD and CV indicate standard deviation and coefficients of variation (standard deviation-to-mean ratio), respectively.									

Table-3A. Correlation Matrix

Variables	GDP	RTEC	TIN	K
Y	1.0000			
RTEC	0.5263* (0.0000)	1.0000		
TIN	0.7260* (0.0000)	0.7589* (0.0000)	1.0000	
K	0.7040* (0.0000)	0.7820 * (0.0000)	0.5100* (0.0000)	1.0000
Note: * Significant at 1%.				

Table-4A: Johansen Fisher Panel Cointegration Analysis

MENA Panel				
Hypothesized	Fisher Stat.*	P. value	Fisher Stat.*	P. value
$R=0$	511.3	0.0000	834.3	0.0000
$R\leq 1$	218.9	0.0000	149.1	0.0000
$R\leq 2$	98.67	0.0000	79.73	0.0000
$R\leq 3$	19.11	0.2015	19.11	0.2015
GCC Panel				
$R=0$	169.9	0.0000	135.9	0.0000
$R\leq 1$	70.24	0.0000	50.38	0.0000
$R\leq 2$	33.19	0.0009	29.81	0.0030
$R\leq 3$	17.60	0.1284	17.60	0.1284
N-GCC Panel				
$R=0$	97.31	0.0000	84.07	0.0000
$R\leq 1$	55.40	0.0000	38.46	0.0000
$R\leq 2$	27.70	0.0005	24.44	0.0019
$R\leq 3$	12.08	0.1475	12.08	0.1475
MATE Panel				
$R=0$	77.09	0.0000	61.49	0.0000
$R\leq 1$	26.85	0.0008	15.70	0.0469
$R\leq 2$	17.67	0.0239	10.23	0.2491
$R\leq 3$	8.03	0.2593	8.03	0.2593
* Probabilities are computed using asymptotic Chi-square distribution				